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Higher Education and the Business Cycle 1870-1990

*A Cross-National Comparison**

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ABSTRACT

The expansion of higher education is analyzed between 1870 and 1990 in five countries (Germany, Italy, France, United States, and Japan). Spectral analysis is applied for the first time to analyze the long-term causal relationship between the economic and the educational system. Two hypotheses are tested to explain the expansion: that of human capital and that of individual status competition. The analysis concentrates on the interaction between the educational and the economic systems, particularly during times of economic crisis. Spectral analysis is used to explore the cyclical character of the expansion and the relationship between economic growth and the increasing enrollment rates in higher education. For European countries the data support the theory of status competition: universities expanded particularly rapidly during times of economic recession. In the United States and Japan higher education expanded more or less apace with the economic system.

1. Long Cycles

INDUSTRIALIZATION, THE EXPANSION OF CAPITALISM, and regularly recurring economic recessions began as early as the late nineteenth century to turn the attention of social scientists to the *cyclical* nature of economic and political processes. Juglar, in 1889, published the results of his empirical study into the business cycle in France, Great Britain, and the United States. Pareto in his "Trattato di sociologia" postulated periodically alternating eras of faith and scepticism as influencing societal value systems.[1] And Dehio (1948) identified a cyclical structure in the outbreak of major European wars—periods characterized by nations striving for balance alternating with periods dominated by a will to hegemony.

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Cycles are more than mere fluctuations. Whereas the latter represent random oscillations lacking any ostensible pattern, cycles consist of fairly regular "waves" resembling those of a pendulum in their to-and-fro movement. Societal processes that are characterized by such cyclical waves follow a certain structural pattern, with a largely unvarying course that can be ascertained and measured. It is the goal of those analyzing economic and political cycles to identify and explain these structures (Wallerstein 1984, p. 559).

The principal model of such regularity in events over the long term is Kondratieff's (1926) concept of "long cycles." This model sees the expansion of the capitalist economic system as interrupted periodically by crises, which have occurred every 50 to 60 years from the beginning of industrialization until the present day. These crises are international in scope and grip all capitalist industrial nations more or less simultaneously. Kondratieff's model has inspired the search for empirical evidence of such a hypothesized pattern underlying various economic indicators (Ewijk, 1982; Metz, 1984) as well as analyses into the periodic alternation between progressivism and conservatism as dominant political ideologies. As regards the latter, Namenwirth (1973) and Weber (1981) uncovered a cycle encompassing conservative, parochial, progressive, and cosmopolitan phases which repeats itself after 50 to 60 years, and which runs parallel to Kondratieff's long cycles. The possibility of analyzing processes of long-term change on the basis of such long cycles has retained its fascination for social scientists down to the present (for a review, see Goldstein, 1988; Spree, 1991; Bürklin, 1987).

On the other hand, however, the notion that historical processes are determined by long-term cycles has met with rejection from a number of directions. Kondratieff and his successors (Schumpeter, 1939; Mandel, 1980) have been criticized particularly for their lack of an *explanation* for the long-term nature of the cycles. While the existence of a business cycle, with alternating periods of recession and prosperity, is universally acknowledged, most economists reject the plausibility of explanations for the specific duration of cycles at 50 to 60 years (Kuznets, 1940; Garvy, 1943; Eklund, 1980). This duration cannot be explained in terms of processes of technological innovation or of the functional survival time of long-lived capital goods. At the most, long cycles find a basis in descriptive statistics, in some cases merely as a statistical artifact.[2]

Kondratieff's concept of long cycles has also been criticized on methodological grounds. In his critique of historicism, Popper (1972, p. 298) emphasized the dynamic nature of science: we do not know today what the state of tomorrow's knowledge will be. Since our future knowledge will affect the course of history, it is impossible to make *long-term* predictions. In this view, to claim that wars or crises occur—with law-like regularity—in cycles of 50 to 60 years is to deny the influence of politics and rational policy making upon society. Max Weber regarded theories claiming to have discovered objective laws behind historical events as in any case spurious (Mommsen, 1974, p. 258).

With the help of Keynesian economic policies, Western industrial nations were able after World War II to attain stable economic growth. Economic crisis appeared a thing of the past, the concept of long cycles lost relevance, and Kondratieff was forgotten. However, the economic recession of the 1980s and the dramatic rise in unemployment came almost exactly 50 years after the worldwide economic depression of the 1930s. Interest then renewed in the concept of long cycles, and Kondratieff once again became a frequently cited author (Petzina and Roon, 1981; Bornschier and Suter, 1990).

2. Higher Education and the Business Cycle: Independence or Interrelationship?

Over the past century the system of higher education in many countries has undergone periods of expansion and periods of stasis or contraction, and the duration of the cycle across such periods has generally been 20 to 30 years.[3] The present study employs the technique of spectral analysis to examine the relationship between cyclical patterns in the educational and those in the economic system. The purpose of the analysis is not to establish the existence of long cycles as described above but to assess whether the cycles that can be identified in either system (a) follow an exclusively system-specific pattern or (b) influence each other reciprocally.

Empircally determined cycles of approximately the same duration in the educational and the economic system would suggest a causal relationship between the two systems. The indicator taken here for the state of the economic system is gross national product and that for expansion of the education system is the number of students enrolled in universities.[4]

However, such evidence of similar duration of the cycles in the two systems and thereby of a relationship between the systems does not in itself indicate the *direction* of the relationship. It is, therefore, necessary not only to determine the duration of cycles but also to locate them precisely on the time axis and, thus, to identify a possible phase shift of one vis-à-vis the other. If expansion in universities, for example, is observed some two or three years after growth in the economy, one could conclude that the former results from the latter. In this case a period of "cooling off" in the process of educational expansion following one of accelerated growth in student numbers can be interpreted as a response to the state of the nation's business cycle.[5]

Thus, the two most important parameters in this analysis are the *duration of cycles* in different systems and the *phase shift* between these cycles. Comparison of the duration of cycles in different systems indicates whether the systems are independent of one another or are potentially interrelated. If the cycles do show similar duration and may therefore be interrelated, examination of the phase shift between them may clarify the nature of the relationship.

Analyses of this sort can be made regarding the relationship between any social systems as long as sufficient data are available for long-term time series. An example is offered by the controversial relationship between labor union organization and the inflation rate, long a subject of debate in the social sciences and in politics. In a study of British labor unions, Bain and Elsheikh (1976) used regression analysis to demonstrate a significant relationship between the level of union organization and the inflation rate over the period 1893 to 1970. Their explanation of this relationship (p. 62) is as follows: when prices rise, increasing numbers of workers join unions to protect their threatened income, in response to which wages then rise.

However, spectral analysis of these three sets of time series data (union density, wages, prices) shows the phases of the respective cycles to be shifted vis-à-vis one another in a way that is not consistent with the thesis of Bain and Elsheikh.[6] While the duration of each cycle is shown to be approximately 30 years, which is a basis for the significant regression coefficients obtained by these authors, the variable that emerges as temporally primary (i.e., with a phase lead) is that of union organization, with a subsequent increase in wages and in prices after about three years. This demonstrates that unions are first able to increase their relative influence on the basis of increased worker organization, that they then make use of this increased influence during wage negotiations with management, and that the resulting wage increases lead to an immediate rise in the prices of goods produced. The analysis of phase shifts in these cycles consequently discloses a relationship that is at variance with the conventional view in labor union research.

3. Trend, Cycle, and Chance

University enrollment rates in Germany and the United States are presented in Figure 1 for the period between 1870 and 1985.[7] Certain differences are evident in the curves for the respective countries, particularly in specific periods of this century. Prior to World War I, the rate of growth in enrollment levels was relatively moderate and roughly similar in the two countries. During the interwar period, while universities in the United States continued their steady and rapid expansion, the enrollment curve for Germany showed dramatic reversals, reflecting the economic and political developments in the Weimar Republic and falling eventually to the 1913 level. Only in the 1960s did (West)Germany reach the levels attained by the United States between the wars, and with the slowing of expansion in the latter during the 1970s the German university enrollment rate finally came to equal that in the United States.[8]

A time series such as that presented in Figure 1 can be divided into three components: a trend, a cycle, and a (random) chance of "disturbance" (Borchardt, 1977). The *trend* refers to a long-term, often secular tendency underlying the observed variations over time. In the present case, those factors make up the trend which over the past century have led to the virtually uninterrupted growth in university enrollment despite substantial "disturbances" and periods of short-term stagnation. In Germany, the two world wars and the upheavals of the interwar years delayed this expansion, which manifested itself thereafter at an accelerated rate.

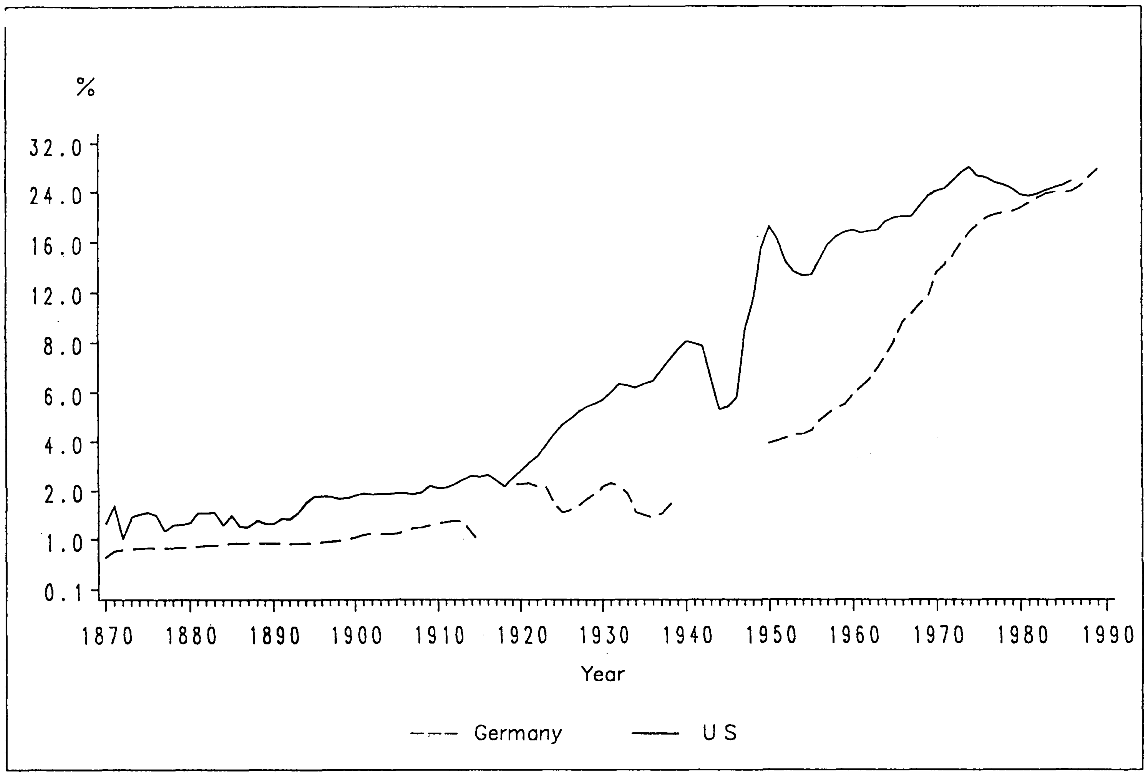

Figure 1. University enrollment rates in Germany and the United States

The second component, that of the *cycle*, represents a regular, wavelike variation along the trend. Introduction of this component into the analysis takes into account the fact that expansion of educational institutions has not followed a smooth, continuous course but one resembling waves, with times of expansion giving way to those of stagnation which, in turn, are followed by times of renewed expansion. To speak of cycles in this context is to perceive a *regularity* in the variations around the trend which show a roughly constant and measurable duration. Figure 1 demonstrates that the curve of educational expansion over time has indeed not been smoothly upward but has included phases characterized by stagnation or short-term decline; the question is whether these variations describe a regular, repetitive structure, or whether they represent mere random chance and "disturbance."

The third component, *chance*, comprises merely the remaining variation. The trend here is first substracted from the time series, yielding the residuals. These are then used to estimate a harmonic function (see Figure 3). Estimated values calculated from a sinusoidal curve are subtracted from the residuals; this gives the "chance" element.

These conceptual distinctions can be used to analyze the time series presented in Figure 1. Separating out the trend allows one to focus specifically on the factors that influence the secular growth in university enrollment. Determining the deviations from this trend allows one to uncover waves of a regular cyclical nature. That which remains as unexplained residual variation is regarded as "chance disturbance," explicable only by recourse to concrete historical reconstruction.

The past century has seen an almost continuous expansion in both the educational and the economic system. In the time series the trend component provides no evidence as to whether or to what extent the expansion of these systems has been interrelated; it demonstrates only that progressive industrialization and modernization have been accompanied by parallel expansion in universities and in the economy. Rather, it is the cyclical pattern that furnished insight into the dynamic processes of growth. The cycles show the varying *rates* of growth in the respective systems. The existence of a similar pattern in two systems over a long period of time, with changes in their relative growth rates varying in pace with one another, suggests either that they influence one another, or that both are influenced by a third system which determines the rate of growth in both. The analysis in Sections 5 and 6, therefore, focusses specifically on the cyclical component of the time series.

4. Theories of Educational Expansion

Three theories have been advanced in education research that deal with educational expansion. Each of these has been developed almost exclusively on the basis of short-term growth processes in the educational system. However, they permit the formulation of hypotheses regarding the long-term trend and cyclical variations in educational expansion (Meyer and Hannan, 1979).

The theory of *human capital* was developed in the context of modernization theories and maintains that universities expand in step with economic growth and technical progress, meeting the societal need for qualified personnel (Freeman, 1976). This view perceives a straightforward, market-related relationship between the need for trained personnel and the expansion of universities: university enrollment expands in times of economic growth and contracts in those of economic recession. This model regards the job market and the university as mutually regulating systems, and university expansion is therefore seen as limited by the actual demand for technical qualifications in the economy. Although conditions of oversupply or undersupply may occur in the short term, balance will eventually be restored between educational system and job market. This model, thus, offers an exogenous explanation: educational expansion results not from forces within the educational system itself but from those outside it, in the economic system. The educational system here is seen as reacting to demands in the job market.

As early as the turn of the century, the Prussian statistician Eulenburg cast doubt upon explanations of university expansion based on the business cycle—the view still adhered to in the 1960s by proponents of the human capital theory. Eulenburg's skepticism was founded on his observation that, "even favorable economic conditions may tend to impede university attendance and unfavorable conditions to encourage it."[9] This observation does not accord easily with modernization theories that trace university expansion to increased demand for qualifications on the part of industry.

If Eulenburg's view is correct, a plausible explanation must be found for the encouragement which educational expansion may find, not in economic growth, but in economic recession. This seeming paradox, in terms of modernization theory, received renewed attention in the early 1970s with the chronic overproduction of university graduates. It was argued that the educational decisions of individual actors may lead to undesirable side effects for society in general. Educational expansion was then hypothesized to stem not from demand in the job market but from *individuals' competition for social status*, which, in contrast to demand-related factors, develops a dynamic that is difficult to control (Boudon, 1982; Collins, 1971). Since in meritocratic societies the level of educational achievement that one attains constitutes an important precondition for social advancement and the pursuit of a career, individuals behave in terms of the maxim: "the more, the better." While this behavior appears rational from the standpoint of the individual, it becomes increasingly irrational from the standpoint of society as a whole. Uncontrolled educational aspirations lead to a chronic oversupply of university graduates in the job market, and the educational system becomes ever-further removed from an equilibrium with the needs of the economy.

The theory of human capital and that of status competition are not necessarily mutually exclusive. An individual who accumulates as many credentials as possible in order to improve his/her competitive situation is also helping to meet the societal need for trained personnel. However, the respective theories lead to differing predictions in periods of economic depression and high unemployment. While the human capital theory predicts here a decline in the number of students, the theory of status competition predicts continued, even accelerated, expansions as youthful competitors for dwindling employment opportunities seek all the more to improve their comparative advantage in obtaining employment.

The past century has seen three periods of economic depression, each characterized by the following: (a) they lasted a relatively long time; (b) they not only halted economic growth but led to a real decline in living standards; and (c) they affected almost all Western capitalist nations. The three periods were the long depression of 1876-1893 (Rosenberg, 1943), the worldwide crisis of the 1930s following the stock market crash, and the economic recession of the 1980s that has substantially increased unemployment in all Western European countries. What happened to the universities in these countries during these periods? Did their expansion continue despite the economic downturn?

Both theories of educational expansion provide an explanation for the trend and for the regularly recurring cycles in this expansion. Furthermore, both posit a relationship between educational and economic expansion, albeit of differing nature. The theory of human capital maintains a direct relationship, that is, that educational expansion accompanies *pari passu* that in the economy. The theory of status competition, on the other hand, maintains an inverse relationship: economic recession and unemployment bring increased university enrollment while economic boom and high employment lead to stagnating enrollment figures (not necessarily to declining levels, since status competition remains a problem for the individual actors).

In contrast to both these theories, the third *"political" theory* of educational expansion maintains that this expansion has little if anything to do with the business cycle. This theory also begins with the fact of competition—not individual competition, however, but the collective competition among social groups for political and cultural advancement and for participation in political decision making.

University education imparts not only technical and cultural capabilities. In many countries it also bestows the credentials necessary for filling a higher level position in the state bureaucracy or in large business corporations. As the role of bureaucratic control in modern democracy becomes more important and more central, class conflict expresses itself increasingly over the issue of guaranteeing the access of specific social groups to the bureaucracy. The struggle over the right to university admission represents a part of the collective conflict over political and cultural hegemony (Windolf, 1990), and social groups excluded from the privileges of university education have fought for an opening of educational institutions. Thus, in the nineteenth century the university became a weapon that the bourgeoisie used against the nobility; in the twentieth century one that the working class used against the bourgeoisie; and in recent decades one that women have used against men. The success which these groups have enjoyed has accelerated the expansion of educational institutions.

The cyclical curve representing this expansion over time reflects the collective conflicts for political and cultural emancipation, with periods of institutional "opening" and "restriction" being expressed, respectively, in alternating phases of progressivism and conservatism.

Since at present there are no valid indicators for specifically political cycles, the study presented below concentrates on the first two of the three hypotheses presented in this section and seeks for the first time to employ spectral analysis in analyzing the relationship between educational and economic systems. The lack of an empirical relationship between educational and economic cycles will be taken as evidence of the "independence" of university expansion from economic influence. The hypothesis regarding political cycles can be approached here only in an indirect way, inasmuch as the lack of an empirical relationship between educational and economic systems would suggest "political" influence upon the former.

5. Results of Spectral Analysis

The study of (long-term) cyclical variations is of central concern in research on the business cycle. Econometric analyses concentrate, for instance,

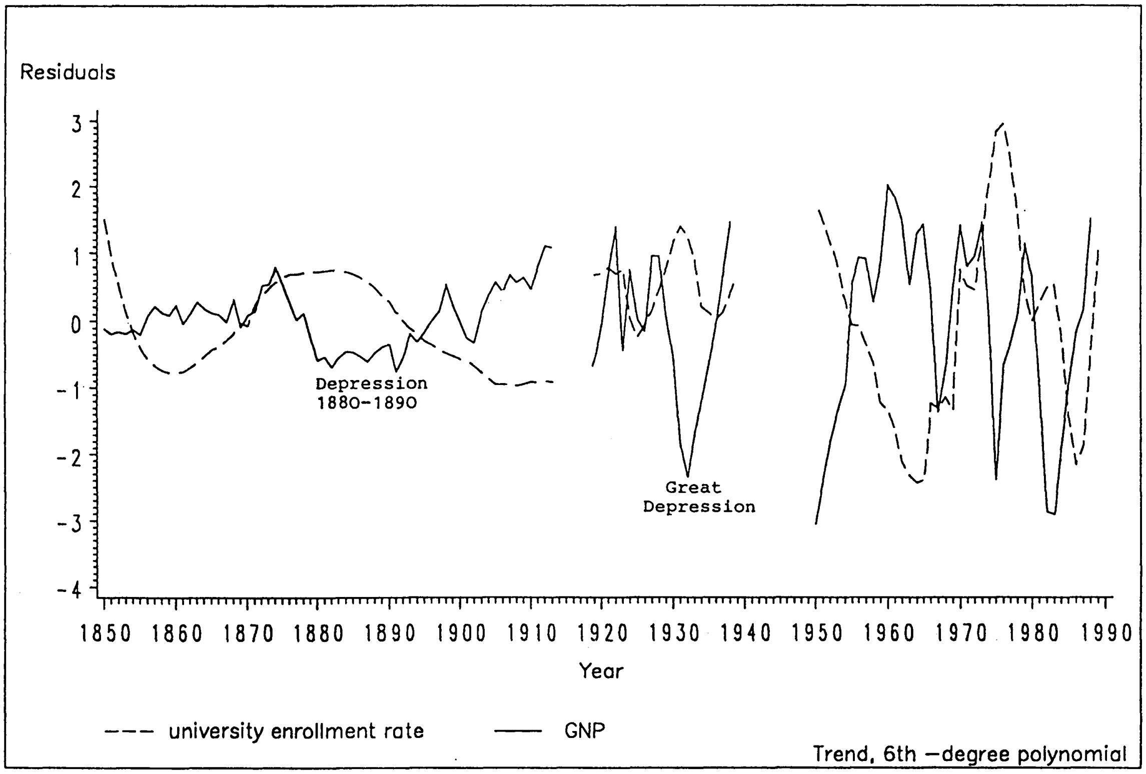

Figure 2. Residuals: Germany (1850-1989)

on the question of whether variations show a regular, cyclical structure, and, if so, what duration these cycles have. Regarding the duration of cycles one distinguishes between those of the long term (40-60 years, "Kondratieff cycles"), medium term (15-40 years; "Kuznets cycles"), and short term (7-11 years; "Juglar cycles"). Here we ask whether the phases of educational expansion show a cyclical nature, and, if so, what is the duration of a cycle, and what is the relationship between these cycles and those in the economy? This analysis considers the following nations: Germany, Italy, France, the United States, and Japan.

Figure 2 presents the variations (residuals) from the sixth-degree polynomial term (trend) for university enrollment and GNP.[10] This shows in the case of Germany an expansion of universities particularly in those periods of below-average GNP. This anticyclical relationship is evident during the depressions of 1878-1890 and 1928/1929-1933; in these periods the university growth curve (residuals) is above the zero point while the economic growth curve is beneath it.

Spectral analysis can be used to *decompose any time series into a set of harmonic waves*. In other words, the method seeks to approximate a cyclical process—as shown in Figures 2-4 (residuals)—by a set of harmonic functions (sinusoidal waves) which may have generated the cyclical process. This method can be

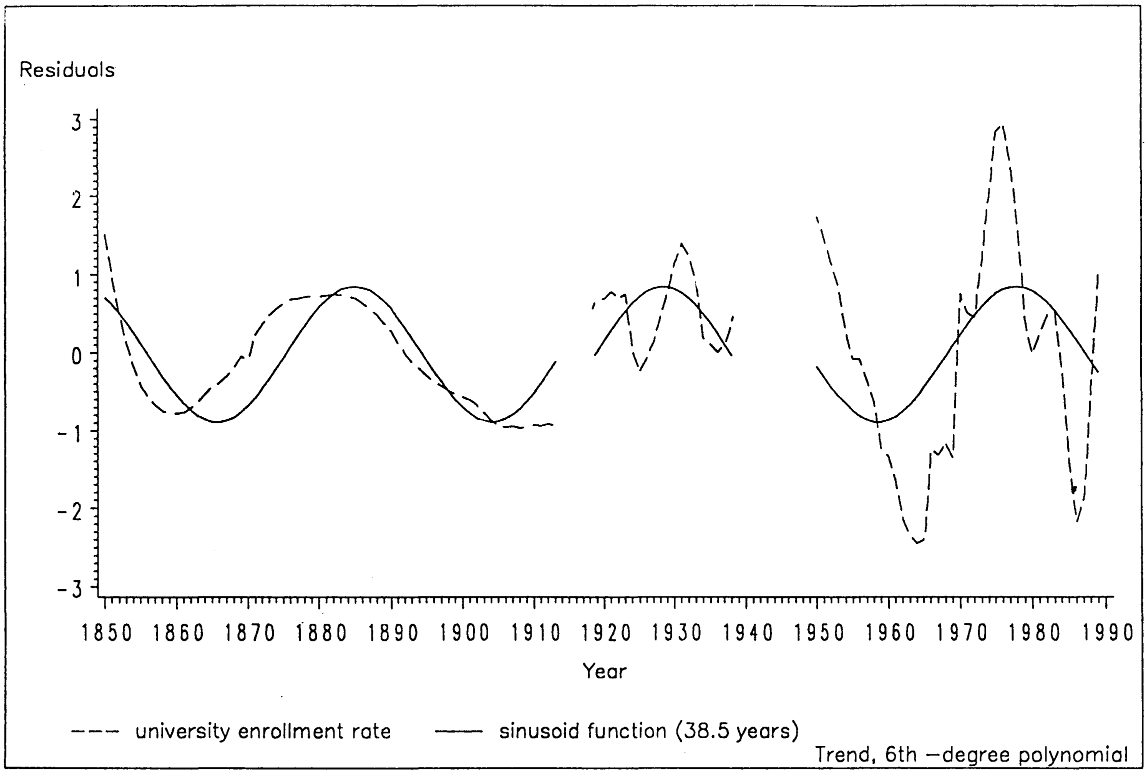

Figure 3. Residuals: Germany (1850-1989)

compared to regression analysis. However, rather than a linear regression approach a sinusoidal curve is used as the estimation function. The curve in Figure 3 is fitted to the residuals for educational expansion and has a cyclical duration of 38.5 years (=period). This curve (estimation function) accounts for 36% of variance in the residuals. What remains is "chance." That a curve with this duration represents the optimal solution is indicated by results in Figure 5, which presents the spectral density function across the range of possible frequencies (recall that the frequency is the reciprocal of period). The height of the spectral density function represents the relative amount of residual variance explained by a sinusoidal function with the corresponding frequency. The spectral density function reaches its highest value (0.57) at a frequency of 0.16, that is, a period of about 38.5 years.[11]

Figure 5 also reveals that not only the cycle for university expansion but also that for the economic system (GNP) has a duration of 38.5 years. Although of the same duration, the cycles in these two systems show a phase shift relative to one another, with that for educational expansion following that for GNP by 15.1 years (see Figure 2).[12] Due to the degree of this phase shift, the difference cannot be interpreted as a phase lag in the adjustment of university enrollment to the state of the business cycle but suggests, rather, an anticyclical behavior on the part of students.

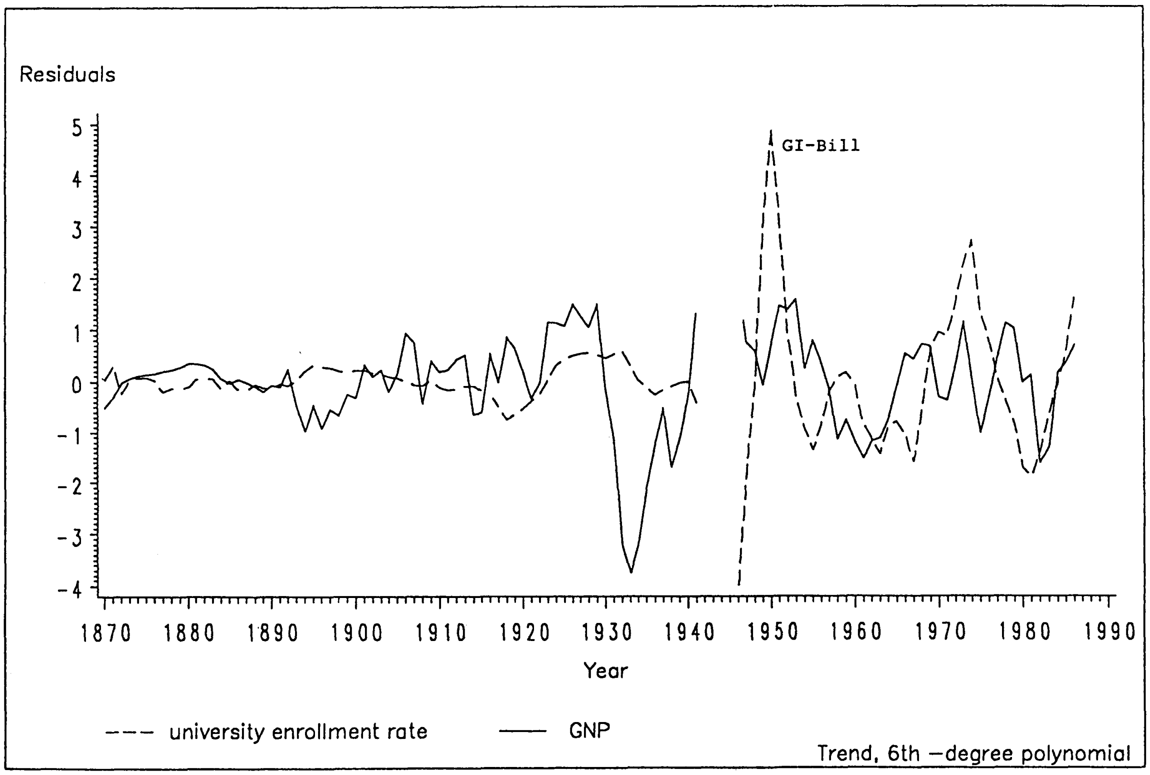

Figure 4. Residuals: United States (1870-1986)

An additional cycle appears in the time series data on the German economy, having a duration of 8.1 years; there is very little evidence of a corresponding cycle for the educational system. Whereas the major cycle (38.5 years) accounts for 36% of variance in the data on the educational system, it accounts for only 19% in the case of the economic system. Including cycles of both lengths (8.1 and 38.5 years) in the regression analysis increases the proportion of explained variance in the former only from 36% to 37%, but that in the latter from 19% to 31%.

In the case of Germany, therefore, these results lend support to the theory of status competition. Both systems, the educational and the economic, show expansion that occurs in cycles of some 38 years duration (Kuznets cycles) but phase-shifted by 15 years (anticyclical behavior). That the secondary cycle of 8 years (Juglar cycle) is relevant only in the context of the economic system shows, on the other hand, the independence of university enrollment vis-à-vis *short-term* fluctuations in the business cycle.

Results of analyses corresponding to those for Germany are presented below for Italy, France, the United States, and Japan. This cross-national comparison should determine whether there are differences among countries regarding the relationship between educational and economic expansion that may perhaps be due to characteristics specific to the educational institutions in the respective countries.

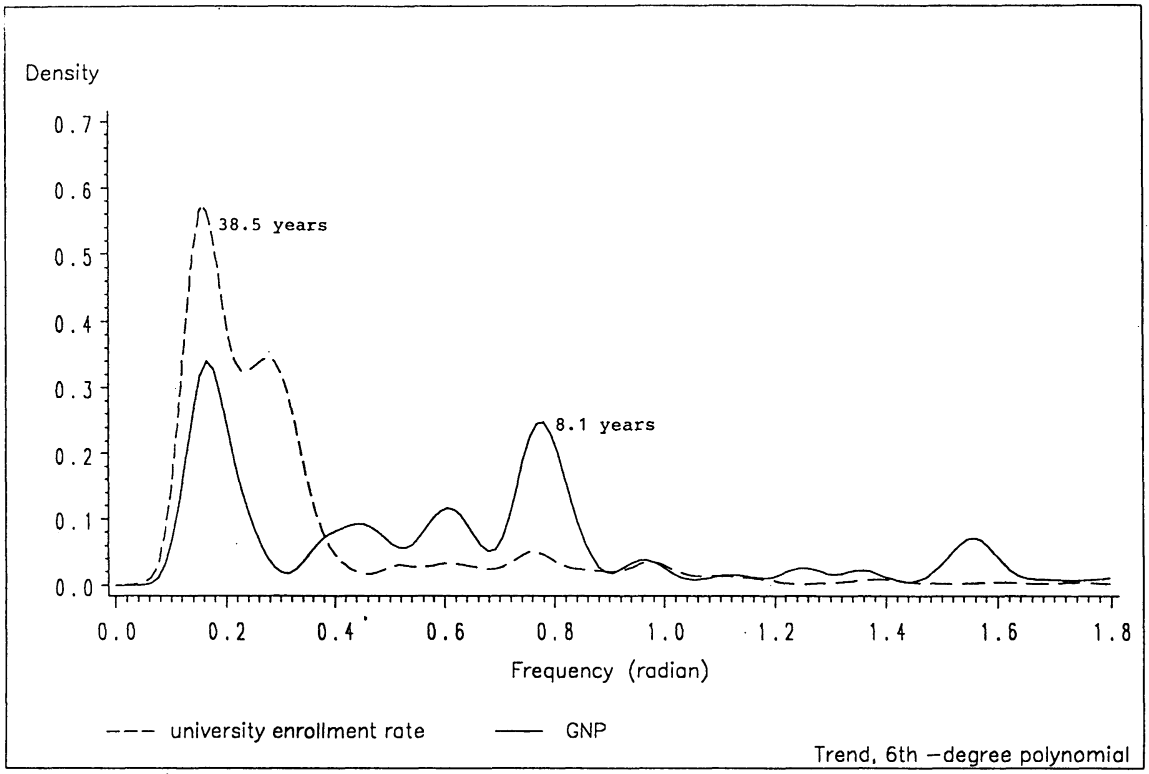

Figure 5. Spectral density function: Germany

The data for Italy show cycles in university enrollment and in GNP that have a duration of 27.8 years in each case, with a phase shift in which educational expansion follows that in the economy by 9.5 years (Figure 6). Here, too, there is a further cycle, but one that is of only minor significance, particularly as regards the universities; the duration of this (Juglar) cycle is 14.7 years, with a lag of 4.7 years.

In France the duration of cycles for the two systems is not identical, that for educational expansion being 23.8 years and that for economic expansion 19.2 years (data not presented graphically). As this difference is relatively small, the phase shift was calculated; the lag was approximately half the duration of the cycles (11 years) and can be interpreted as an instance of anticyclical behavior. As far as can be determined in this analysis, short-term fluctuations in the business cycle are not of relevance for the level of university enrollment.

Results in each of the three European countries considered here, therefore, support the theory of status competition. In contrast, however, those for the United States can be interpreted better in terms of the theory of human capital. Here there are two cycles in the educational system of approximately equal strength (20 and 11.6 years duration) as well as two of virtually the same duration in the economic system (21.7 and 12.2 years; Figure 7). The phase shift of only 2.4 years in the Kuznets cycle indicates a short-term reaction of

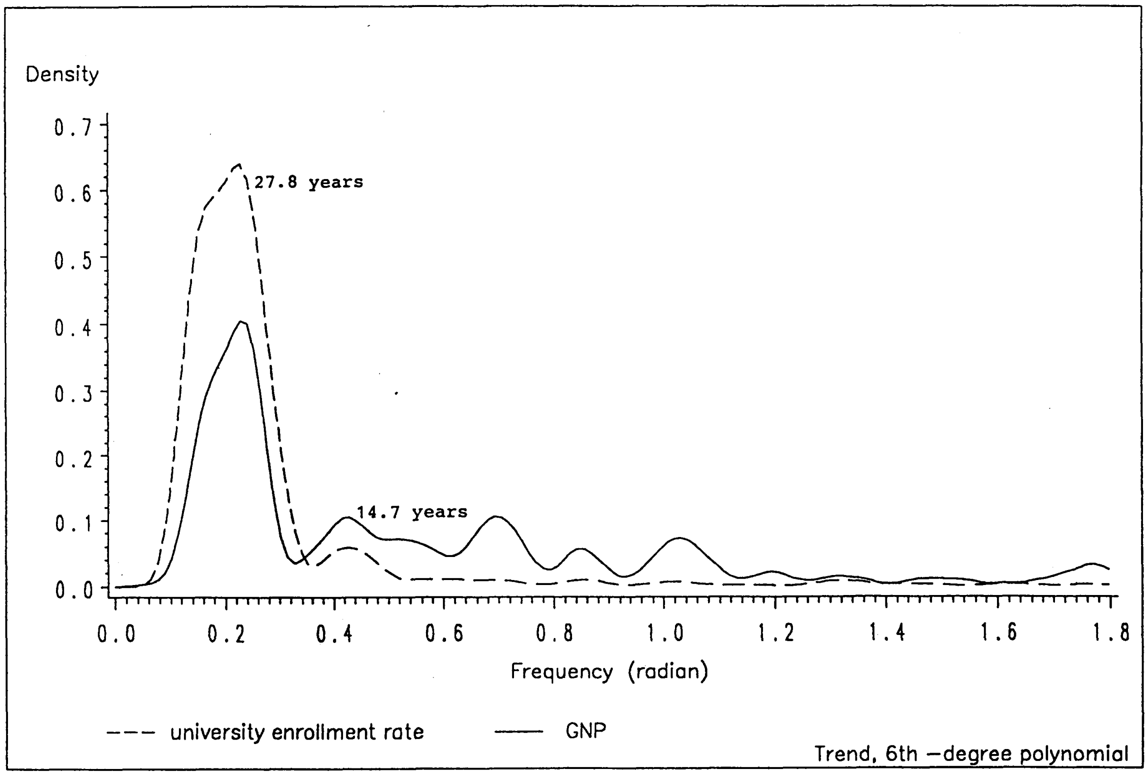

Figure 6. Spectral density function: Italy

students to altered conditions in the job market. It seems that enrollment rates in the United States are strongly influenced by the business cycle. Regarding the Juglar cycle, on the other hand, university enrollment shows a phase lead of 4.1 years over the economic conditions. As this phase lead is difficult to interpret we do not follow it up here.

The relationship between educational and economic expansion in the United States distinguishes itself from that in Europe in two respects. First, the process of educational expansion is more clearly characterized by cycles of medium-term duration (20 years). Secondly, the phase shift in cycles between the two systems is shorter. This shorter lag in adjusting to economic conditions represents a greater sensitivity on the part of American students to an altered job market.

The expansion of universities in Japan is influenced by two cycle components of approximately similar strength—one of 35.7 years (Kuznets) and one of 11.1 years (Juglar; data not presented graphically). The corresponding cycle components for expansion of the economy show a duration of 31.3 years and one of 14.7 years. The Kuznets lag in educational expansion of 6.9 years may still be interpreted as a delayed adjustment to market conditions though the adjustment time is longer than in the United States (2.4 years). The Juglar lag,

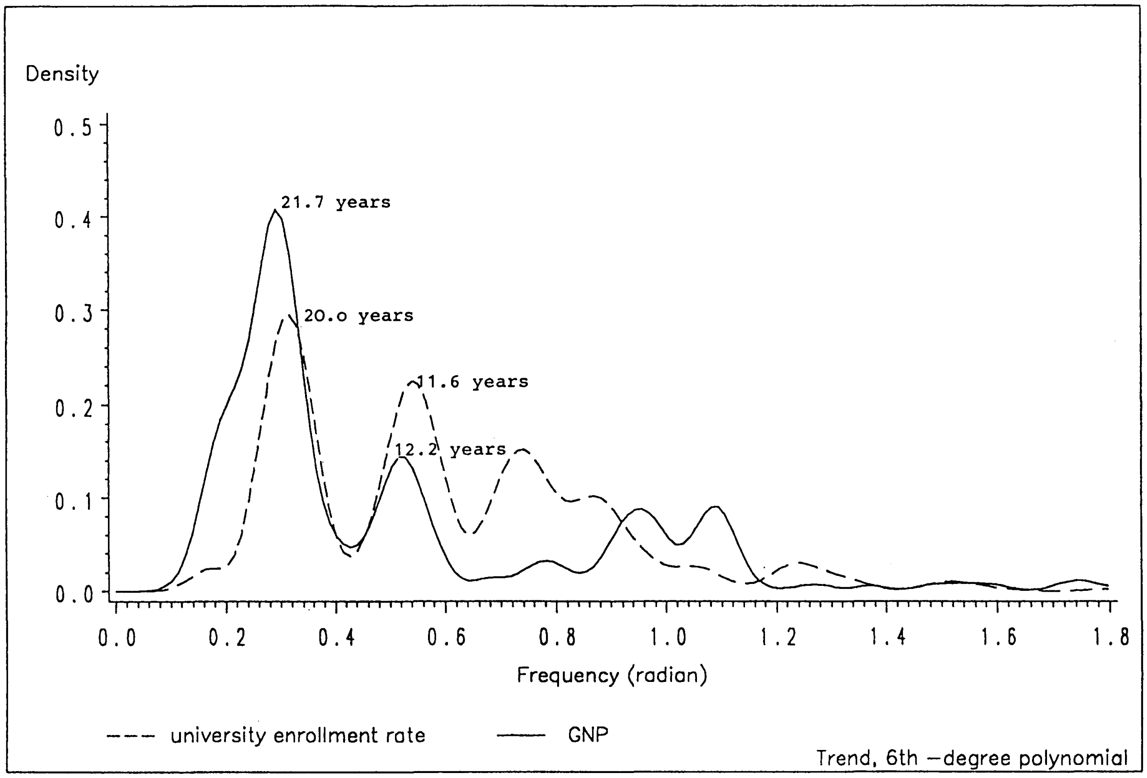

Figure 7. Spectral density function: United States

on the other hand, does not remain stable over time and varies between 6.9 and 1.9 years and, therefore, eludes interpretation.

Cross-national comparisons such as that presented here point up the respective institutional features in the various countries. Regarding the system of higher education a principal difference between institutions in Europe and those in the United States is that, whereas universities in the former are subject to a central public bureaucracy, those in the latter depend more closely upon the private economy. Due to the greater private burden of financing higher education in the United States, students there tend to respond more to signals emanating from the general economic condition of the country. As the results of this time series analysis confirm, the greater the proportion of educational costs that is borne by the state, the less the educational system responds to economic conditions.

In this respect the institutional structure of higher education in Japan can be compared to that in the United States. While Japanese universities are more closely regulated by a central bureaucracy, the expansion of student enrollment figures depends largely upon private institutions. Since private colleges and universities charge relatively high tuition, students at these institutions probably react more sensitively to economic downturns.

6. Variation of the Filter

In each of the analyses described in the preceding section, the secular trend in the time series data has been subtracted by means of a sixth-degree polynomial. Selection of a particular trend term simultaneously limits the possible duration of any cycles that may be identified in the data, and no mathematical procedure is available for making the selection. The issue of why we used a sixth-degree polynomial to separate the trend from the cyclical variations belongs to the thorniest problems of spectral analysis. Its selection is plausible on the basis of certain specific characteristics in the data set (Metz, 1988). Two considerations guide the choice. On the one hand, the data manipulation should not entail the loss of any observations (as occurs, for instance, in procedures using a moving average). On the other, cycles of longer duration are to be eliminated, as these cannot be analyzed with the existing time series data set (encompassing a period of 104-125 years). Applying the rule of thumb that a cycle should have the chance to repeat itself at least two or three times within the period covered means that cycles with a duration longer than 35-40 years must be filtered out. This is achieved with a sixth-degree polynomial, whereas a polynomial of lower degree often does not eliminate cycles spanning 40 years or more.

This section deals with the influence on the results of spectral analysis that results from *variation of the filter*. Table 1 presents the results for three countries obtained by 6 different filters for the level of university enrollment and GNP. In all, 36 spectral analyses are included here, each instance being considered with a polynomial and with a high-pass filter. Polynomials are conventional filters, for which, however, no transfer function can be calculated. A high-pass filter suppresses low frequencies (stop band) while allowing cycles of higher frequency (pass band). The transfer functions for high-pass filters indicate the frequencies that are filtered out and those that are permitted to pass. For each type of filter three variants are calculated (Gottman, 1981; Schlittgen and Streitberg, 1984).

In the analyses using polynomials, the degree is varied, taking the third-, sixth- and seventh-degree polynomials. In those using high-pass filters, the end of the stop band and beginning of the pass band are varied so as to filter out cycles of progressively longer duration (lower frequency). The first high-pass filter suppresses cycles lasting longer than 90 years (stop band); cycles of 80-90 years are partially permitted (transition band); and those of less than 80 years are completely permitted (pass band). In the second high-pass filter, the stop band is set at 60 years and the pass band at 55; in the third high-pass filter, the stop band is set at 50 years and the pass band at 45.[13]

For each country the first set of figures refer to results based on the polynomial and the second set to those based on the high-pass filter. The set of figures for each include: duration (in years) of the educational cycle, duration of the economic cycles, and the length of the respective phase shift (of the educational cycles relative to the economic cycles, negative values indicating a

Table 1. Results of spectral analysis

type of filter:	type of cycle:	GERMANY / FRG						ITALY						USA					
		polynomials			high-pass filter			polynomials			high-pass filter			polynomials			high-pass filter		
		UER	GNP	lag/ lead	UER	GNP	lag/ lead	UER	GNP	lag/ lead	UER	GNP	lag/ lead	UER	GNP	lag/ lead	UER	GNP	lag/ lead
3rd polynomial/ 1st high-pass filter	Kondrat.	55.6	50.0	–12.9	62.5	62.5	–10.7	–	55.6	–	–	55.6		62.5	50.0	–	50.0	55.6	+4.3
		(.84)	(.93)	(.92)	(1.1)	(1.1)	(.92)		(.79)			(1.0)		(.33)	(.28)		(.15)	(.37)	(.84)
	Kuznets	–	–	–	–	–	–	27.8	–	–	25.0	–	–	20.8	21.7	–2.0	20.8	20.8	–0.4
								(.56)			(.68)			(.31)	(.38)	(.82)	(.43)	(.34)	(.82)
	Juglar	–	–	–	–	–	–	–	9.6	–	11.9	–	–	12.2	11.9	+4.1	12.8	6.2	–
									(.05)		(.10)			(.09)	(.13)	(.93)	(.15)	(.05)	
	R^2:																		
	cycle 1	.47	.54		.70	.72		.26	.50		.42	.67		.29	.23		.25	.24	
	cycle 2/3	–	–		–	–		–	.51		.49	–		.49*	.48*		.44*	.46*	
6th polynomial/ 2nd high-pass filter	Kondrat.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	50.0	41.7	–
																	(.16)	(.32)	
	Kuznets	38.5	38.5	–15.1	41.7	38.5	–14.3	27.8	27.8	–9.5	25.0	26.3	–12.0	20.0	21.7	–2.4	20.8	20.8	–0.4
		(.57)	(.34)	(.95)	(.59)	(.80)	(.87)	(.64)	(.40)	(.88)	(.74)	(.47)	(.93)	(.30)	(.41)	(.83)	(.42)	(.41)	(.86)
	Juglar	8.2	8.1	–3.1	21.7	–	–	14.7	14.7	–4.7	11.9	11.9	–5.5	11.6	12.2	+4.1	12.8	6.2	–
		(.05)	(.25)	(.93)	(.34)			(.06)	(.10)	(.77)	(.12)	(.13)	(.96)	(.23)	(.14)	(.87)	(.15)	(.06)	
	R^2:																		
	cycle 1	.36	.19		.41	.47		.37	.19		.47	.31		.17	.25		.25	.23	
	cycle 2/3	.37	.31		.54	–		.38	.25		.54	.39		.29	.32		.45*	.51*	
7th polynomial/ 3rd high-pass filter	Kondrat.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Kuznets	20.8	35.7	–	41.7	38.5	–14.7	26.3	27.8	–10.5	25.0	26.3	–12.0	20.0	21.7	–2.2	20.0	20.8	–0.4
		(.46)	(.25)		(.66)	(.80)	(.81)	(.63)	(.43)	(.92)	(.76)	(.48)	(.92)	(.29)	(.41)	(.84)	(.46)	(.48)	(.83)
	Juglar	8.1	8.1	–3.0	21.7	–	–	13.5	14.7	–4.2	11.9	11.9	–5.5	11.6	11.9	+4.2	12.8	6.1	–
		(.07)	(.27)	(.98)	(.31)			(.09)	(.12)	(.91)	(.11)	(.12)	(.92)	(.23)	(.15)	(.88)	(.17)	(.07)	
	R^2:																		
	cycle 1	.20	.14		.46	.48		.30	.21		.48	.33		.16	.23		.26	.27	
	cycle 2/3	.22	.30		.58	–		.32	.27		.55	.40		.29	.32		.35	.32	

Definition of high-pass filters: 1st high-pass filter: 90/80 years; 2nd high-pass filter: 60/55 years; 3rd high-pass filter: 50/45 years. First figure gives end of stop band in years; second figure gives beginning of pass band in years. Number of years (=N) for which data are available for each country: Germany N = 125; Italy N = 122; USA N = 111. UER: university enrollment rates; GNP = gross national product. *R^2 for 3 cycles.

Example for Germany, 6th polynomial: Two cycles were found in the residuals of UER: 38.5 years (Kuznets) and 8.2 years (Juglar). The Kuznets-cycle explains 36% of variation in the residuals of UER (R^2=0.36). Two cycles were found in the residuals of GNP: 38.5 years (Kuznets) and 8.1 year (Juglar). The first cycle explains 19% of variation; both cycles together explain 31% of variation in the residuals. The Kuznets-cycle for UER lags 15.1 years behind the Kuznets cycle for GNP (lag: −15.1 years). Figures in parentheses give values of spectral density function for each cycle. Figures in parentheses in the column "lag/lead" give the value of coherence.

Example for US, 2nd high-pass filter: Three cycles were found in the residuals of UER: 50.0 years (Kondratieff); 20.8 years (Kuznets); 12.8 years (Juglar). The first cycle explains 25% of variation in the residuals of UER; the three cycles together explain 45% of variation. Three cycles were found in the residuals of GNP: 41.7 years (Kondratieff); 20.8 years (Kuznets); 6.2 years (Juglar). The first cycle explains 23% of variation in the residuals of GNP; the three cycles together explain 51% of variation. The Kuznets-cycle for UER lags 0.4 years behind the Kuznets cycle for GNP (lag: −0.4 years).

lag and positive figures a lead). Figures in parentheses beneath the cyclical durations represent the value of the spectral density function (the higher, the more significant); those beneath the phase shift refer to the coherence (corresponding to a correlation coefficient, varying between 0 and 1 and measuring the magnitude of the relationship between educational and economic cycles). The proportion of explained variance in the residuals (R^2), calculated on the basis of non-linear regression, is given for one sinusoidal function (major cycle) and for the combination of two sinusoidal functions (two cycles). Values marked by an asterisk are those combining three sinusoidal functions (variance explained by three cycles). Because the results for Italy using a high-pass filter violate rather substantially the assumption of stationarity, a logarithmic version was calculated here, in contrast to the cases of Germany and the United States (a logarithm itself constituting in a formal sense a filter, for which a transfer function cannot be calculated).

For example, the results for the United States using the third-degree polynomial reveal the following. The university enrollment rate expanded in a cyclical pattern consisting principally of three harmonic waves (sinusoidal waves) lasting, respectively, 62.5, 20.8, and 12.2 years. The major cycles (62.5 years) account for 29% of the variance in the residuals, while the combination of three cycles accounts for 49%. Growth in the GNP also shows a cyclical pattern of three such waves, with durations of 50.0, 21.7, and 11.9 years, respectively. Here the combination of three cycles accounts for 48% of the variance in residuals.

Spectral analysis enables one to evaluate fairly clearly the differential effect of the various filters, demonstrating the cycles in the residuals that are filtered out as opposed to the cycles that remain. As Table 1 shows, the higher the degree of the polynomial, the shorter the duration of the cycles; the effect of the high-pass filter is similar, with the duration declining from the first to the third such filter. Thus, in either case a *decision* must be made: with the polynomial regarding the degree and with the high-pass filter regarding the beginning of the pass band. In both cases the decision determines the differentiation between what variance is to be assigned to the trend and what variance to cyclical waves. This decision cannot be made on the basis of an objective formula but depends on the features of the given times series and on the purpose of the analysis. The goal of this section is to demonstrate the way in which the choice of filter to be used in the spectral analysis results in a modification of results obtained from it.

The numerous details in Table 1 can be assembled into an overall mosaic, providing a more or less complete picture of the set of frequencies that make up the original time series. What is important is not the question of whether varying the filter affects the results of spectral analysis (which is almost always the case), but whether the composite picture provides insights into the relationship between the educational and economic systems, and whether these coincide with what is already known about the institutions of higher education in each country.

As both the duration of cycles and the phase shifts between them vary according to the filter used in the analysis, we therefore select below only the specific results that are replicated by at least a second filter. We can regard such cycles as showing a certain "resistance" to influence by filter-specific effects and, thus, as indicating with greater probability the actual pattern in the time series.

Kuznets Cycles (15-40 years). In this frequency band a typical pattern can be ascertained in each of the three European countries analyzed here: the educational and economic systems expand in cycles of roughly the same duration. Growth in the numbers of university students follows growth in the GNP with a considerable phase lag, sometimes amounting to one-half the length of the cycle. In Germany this pattern is found using the sixth-degree polynomial and the second and third high-pass filters (cycle duration approximately 40 years; lag 14-15 years). In Italy it is obtained with the sixth- and seventh-degree polynomial and with the second and third high-pass filters (cycle duration approximately 26 years; lag 10-12 years). Similar results are yielded by the analysis in the French case (results not shown) using the sixth- and seventh-degree polynomial. These findings support the theory of status competition.

The cycle in the United States shows a duration of 20 years but a short phase lag between university enrollment and GNP across *all* filters. A comparable pattern emerges in Japan (results not shown[14]) using the sixth-degree polynomial and the third high-pass filter (cycles duration about 35 years; lag 6 years). These figures, on the other hand, support the theory of human capital.

Kondratieff Cycles (40-70 years). Spectral analysis shows long cycles in virtually all time series considered here. A similar pattern is also observed in most countries regarding the phase shift, with university expansion showing a lead over growth in GNP of some 2-4 years. However, in cycles of such long duration, such a relatively minor phase shift is of little significance. In Italy, France, the United States, and Japan an expansion in both systems is evident over long cycles, and one that is approximately synchronous in the two systems. Only in Germany does the analysis reveal a considerable phase lag in educational expansion (10-12 years).

The existence of long cycles in the original time series can be readily confirmed by the high-pass filter, for the characteristics of their representation are controlled by the transfer function. Figure 8 presents the filter output for the German educational system using the first high-pass filter and a sinusoid curve with a period of 62.5 years. This cycle accounts for 70% of the variance. In terms of long cycles the growth in German universities appears above average in the period 1905-1910 and again in that of 1975-1980. As seen in Table 1, the R^2 coefficient is generally higher for long than for short cycles, which may indicate that long cycles have a more strongly cyclical (i.e. regularly recurring) character than do short cycles.

Although one can reliably determine the existence of long cycles by means of the high-pass filter, the time series considered here presents a particular problem for their analysis, as a period of 55-60 years is difficult to confirm in a data set covering only some 110 years. Cyclical waves spanning 60 years can,

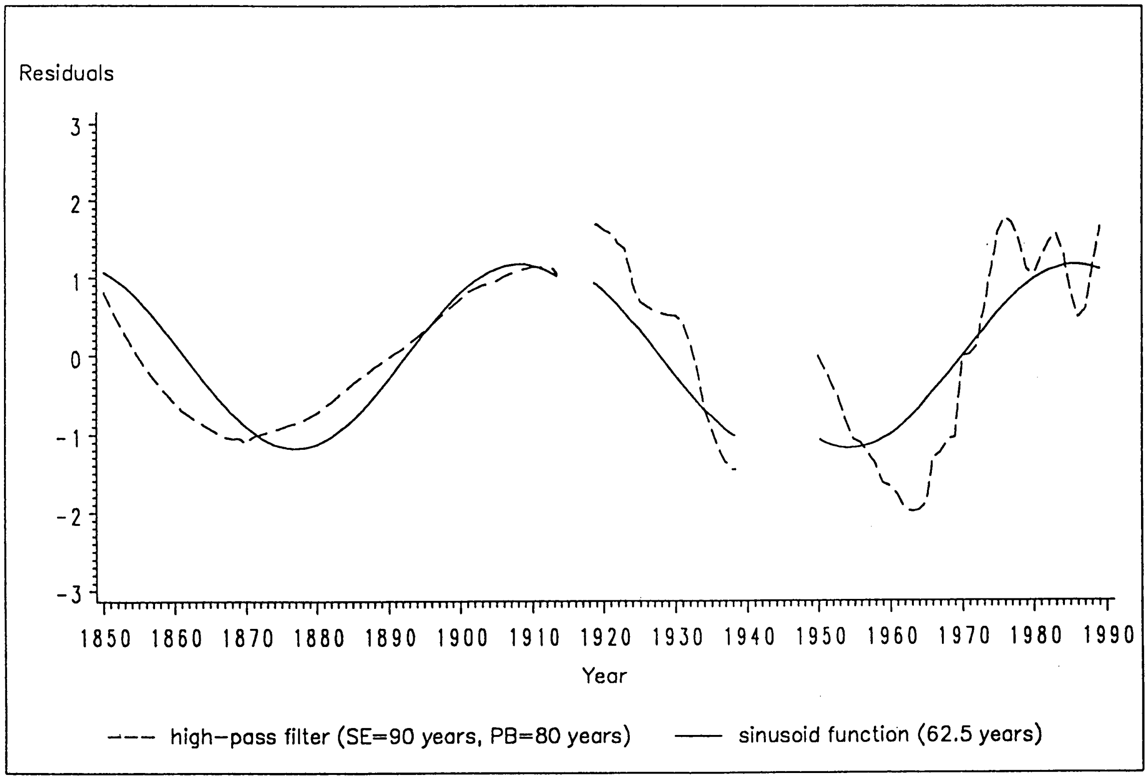

Figure 8. Long cycles in university enrollment rate: Germany

on the other hand, be regarded as belonging to the overall secular trend and, thus, not as comprising cyclical variations within the time series. In the present analysis such long waves fall in the transitional stage between "trend" and "cycle" and therefore are not examined further.

Juglar Cycles (7-11 years). Significant Juglar cycles seldom emerge from these spectral analyses. Only in the United States and Japan does the spectral density function for university enrollment rates reach a higher value for cycles of 10-12 years (e.g., 0.23 for the sixth- and seventh-degree polynomial in the United States). As noted in Section 5, the results demonstrate that European universities (those in Germany, France, and Italy) do not appear to react to short-term fluctuations in the business cycles but are influenced exclusively by longer term cycles in the economic system.

Does the set of empirical findings presented in Table 1 demonstrating the filter-specific variability of results, recommend spectral analysis as a method for *any* hypothesis (presuming that one chooses the "correct" filter)? Or, on the other hand, do the findings appear as mere statistical artifacts projected into the residuals by the filter (e.g., the sixth-degree polynomial)?

Virtually any time series of relevance to the social sciences shows a trend. For example, the process of industrialization and modernization has been characterized in all sectors of society by a continuous growth in "goods" (the positive trend) and by a continuous decline in "evils" (the negative trend; e.g., infant mortality). Strongly trend-dominated data of this sort cannot be analyzed by spectral analysis;[15] the application of this technique for data analysis almost always requires trend-controlled data. The question is, therefore, what the correct trend to control for is.

As noted above, there is no definitive way to answer this question, and the problem of "imprecision" in interpreting the results of spectral analysis cannot in principle be eliminated. However, the use of various different filters for subtracting the trend allows one to evaluate whether the results offer the possibility of interpretation within a given theoretical context. The example of spectral analysis applied to the process of educational expansion shows that most, albeit not all, of the specific results can be interpreted in terms of competing theories.

7. Conclusion

Over the past decade, historical data sets have been published in many countries containing long-term time series documentation of numerous social indicators. These data sets offer social scientists an important source for the development of theories and the verification of hypotheses. Many hypotheses which could hitherto be tested only in regard to cross-sectional data can now be re-evaluated in terms of variance in indicators over time. The controversy between competing theories of educational expansion, to take the case of the present analysis, cannot be resolved on the basis of data from only a limited period. This is also the case in other areas, such as the relationship between labor union membership and inflation and that between the expansion of social welfare and economic growth.

Spectral analysis can provide important insights into the processes of change in social systems and the relationships among various systems. In particular, three features can be evaluated: (a) the cyclical components (frequencies) that make up the pattern of changes in a social system over time; (b) the duration of major cycles in the changes and the comparison of patterns in different systems; and (c) the degree of synchronicity or of phase shift (lag/lead) between the cycles in different systems.

One must, however, also recognize the limitations of spectral analysis. Any variation in the definition of the trends leads to different results, and only the resulting *set of relationships* is appropriate for interpretation. The technique is not suitable for examining long-term cycles; one can set a filter for virtually any time series that produces "long cycles". Therefore, the goal of the present analysis is to ascertain not the duration of cycles in educational expansion but the relationship of these to cycles in the economic system, and whether this relationship remains stable despite variation of the filter. As the results in Table 1 demonstrate, variation of the filter alters both the duration of cycles and the structure of relationship in the data (e.g., phase shifts).

In spite of this a relatively stable "tendency" can nevertheless be identified in the data. This can be summarized fairly concisely as follows. In the domain of Kuznets cycles, enrollment at European universities shows an anticyclical behavior, but at American and Japanese universities a procyclical behavior. In the domain of short-term cycles (Juglar) university enrollment in the three European countries shows no response to such fluctuations. The nature of the relationship between the cycles in the two social systems therefore varies with the length of the cycles. In terms of long-term cycles (low frequencies) the systems react differently than in terms of short-term cycles (high frequencies).

These findings illustrate the type of relationships that may be uncovered only with the help of spectral analysis.

NOTES

1 "In history a period of faith will be followed by a period of scepticism, which will in turn be followed by another period of faith, this by another period of scepticism, and so on" (Pareto, 1983, p. 1692).

2 As early as 1937 Slutzky demonstrated that the application of appropriate filters (e.g., moving average, first differencing) can construe cycles out of "white noise" (i.e., random fluctuations).

3 The period of 20-30 years may perhaps be explained by the effect of succeeding generations. It has been argued that working class children who attend university will themselves have children with higher enrollment rates. This increase continues from generation to generation, albeit on a lower level. For example, Figure 4 shows the effect of the GI-bill allowing veterans of World War II to become college students (Jencks and Riesman, 1977, p. 94). Between 1950 and 1952 there is a sharp increase in the proportion of an age cohort graduating from college. This effect is repeated 20 years later (around 1972) although at a lower level. For Germany see Titze (1990).

4 A number of alternative indicators of course exist for cycles in both the economic and the educational system, such as unemployment rate and enrollment in secondary education. Borchardt (1976) maintains that indicators which at a certain time are important for society become modified by political intervention. This is the case, for example, with stock exchange rates at the turn of the century (then crucial for the upper middle class) and with GNP after World War II. Due to limitations of space the present analysis restricts itself to university expansion and growth in the GNP.

5 An alternative hypothesis can be formulated on the basis of the Cobb-Douglas production function: an (independent) expansion in the educational system leads to accelerated economic growth, even though with a considerable time lag. University graduates become integrated into the economic system and bring with them an increased efficiency due to their higher qualifications (Hage *et al.*, 1988; Walters, 1984).

6 These preliminary results derive from a study of cyclical fluctuations in the number of labor union members, carried out at the Department of Sociology, University of Heidelberg.

7 Enrollment rates were defined as follows: Germany, proportion of *all* students as a percentage of those aged 20-24 years (five cohorts); United States, proportion of university graduates (bachelor's degree) as a percentage of one cohort (calculated as an average of those aged 20-24 years).

8 Figure 1 shows clearly that the course of expansion differs substantially before World War I, in the interwar period, and after World War II. Each of these periods should, in fact, be analyzed separately since the trend, cycle duration, and phase shift probably differ across periods. Spectral analysis, which requires at least 100 observation points, cannot be applied

here. Due to limitations of space, an alternative technique for analysis is not possible here (see Isaac and Griffin, 1989; Stock and Watson, 1988).

9 Eulenburg (1904, p. 256). For a similar conclusion regarding Italian universities before World War I, see M. Barbagli (1974, pp. 134-136).

10 The sixth-degree polynomial uses the following function to estimate the trend (t=year): $\hat{Y}=a_1t + a_2t^2 + a_3t^3 + a_3t^4 + a_5t^5 + a_6t^6$. The value thereby estimated for the trend is subtracted from the time series, yielding the residuals, an operation referred to as filtering. The time series is filtered to eliminate certain frequency bands, in the present case cycles with a duration longer than 35-40 years are filtered out. One distinguishes here between the "filter input" (observed data, based on annual levels) and "filter output" (trend, polynomial, or moving average). Since an additive model is used here, the filter input minus filter output yields the residuals.

11 For simplification, details are not presented in terms of the frequency domain but only in terms of the time domain (years). It should be noted that the "peaks" of the spectral density function are to be interpreted as frequency *bands*. The frequency is the reciprocal of period. A spectral density function with a "peak" at, for example, a cycle duration of 38.5 years means that the cyclical component that is being sought (that explaining the greatest variance) lies in a band of variable width around 38.5 years. The longer the time series, the narrower this band is. In Figures 5-7 the frequency is given in terms of radians. The cycle duration (=period) can be calculated by the following formula: 6.28/frequency=cycle duration (in years).

12 The lag/lead is calculated as the *average* phase shift for the overall time series. Differing lag/lead structures may occur in the various subperiods. Here we have not used the technique of complex demodulation (Bloomfield, 1976, p. 118) to determine the phase shift in these sub-periods, for a suitable computational program is not available. Figures 2 and 4 give an impression, however, of the extent of the phase shift in individual sub-periods (Complex demodulation regards cycle duration and phase shift as variables dependent upon time).

13 With a high-pass filter the amplitudes for all frequencies in the domain of the stop band are set to zero. The output consists of a time series containing only the frequencies in the domain of the pass band. Therefore, the output of the high-pass filter corresponds to the residual term obtained by subtraction of the trend. It is important for the present analysis that the filter does not produce a phase shift. The filter program used here is Nulfil, developed by Metz and Stier (1991). I wish to thank Rainer Metz for making this program available for the present analysis. Müller-Benedict (1991, p. 188) uses a "notch filter" to filter the (absolute) number of students (in Germany).

14 A number of details covering this analysis cannot be presented here due to limitations of space but are available upon request from the first author. These include: lists of sources, time series raw data, significance tests for values of the spectral density function, 'white noise' tests, characteristics of the window employed (Daniell window), results of two further filters (fifth polynomial and a further high-pass filter) and residuals and graphic presentations for France and Japan.

15 The residuals must be "stationary," i.e., their mean and standard deviation must remain constant over all sub-periods of the time series (Schlittgen and Streitberg, 1984, p. 79).

REFERENCES

BAIN, George S. and Frank ELSHEIKH

1976 *Union Growth and the Business Cycle: An Econometric Analysis.* Oxford: Blackwell.

BARBAGLI, Marzio

1974 *Disoccupazione intellettuale e sistema scolastico in Italia.* Bologna: Mulino. (English: *Educating for Unemployment: Politics, Labor Markets, and the School System: Italy 1859-1973.* New York 1982: Columbia University Press.

BLOOMFIELD, Peter

1976 *Fourier Analysis of Time Series: An Introduction.* New York and London: Wiley.

BORCHARDT, Knut

1976 "Wandlungen des Konjunkturphänomens in den letzten hundert Jahren." *Bayerische Akademie der Wissenschaften, Philosophisch-Historische Klasse*, Sitzungsberichte, no. 1, München: Beck.

1977 "Trend, Zyklus, Strukturbrüche, Zufälle. Was bestimmt die deutsche Wirtschaftsgeschichte des 20. Jahrhunderts?" *Vierteljahrschrift für Sozial und Wirtschaftsgeschichte* 64: 145-177.

BORNSCHIER, Volker and Christian SUTER

1990 "Lange Wellen im Weltsystem." Pp. 174-197 in *Theorien der internationalen Beziehungen*, edited by Volker Rittberger. Opladen: Westdeutscher Verlag, Politische Vierteljahresschrift, special issue no. 21.

BOUDON, Raymond

1982 *The Unintended Consequences of Social Action*, London: Macmillan Press.

BÜRKLIN, Wilhelm P.

1987 "Why Study Political Cycles?" *European Journal of Political Research* 15: 131-143 (Special issue on "Cycles in Politics").

COLLINS, Randall

1971 "Functional and Conflict Theories of Educational Stratification." *American Sociological Review* 36: 1002-1018.

DEHIO, Ludwig

1948 *Gleichgewicht oder Hegemonie*. Krefeld: Scherpe. (English: *The Precarious Balance: Four Centuries of the European Power Struggle*, New York 1962: Vintage Books.)

EKLUND, Klas

1980 "Long Waves in the Development of Capitalism?" *Kyklos* 33: 383-419.

EULENBURG, F.

1904 *Die Frequenz der deutschen Universitäten*. Leipzig: Teubner.

EWIJK, Casper van

1982 "A Spectral Analysis of the Kondratieff Cycle." *Kyklos* 35: 468-499.

FREEMAN, Richard B.

1976 *The Overeducated American*. New York: Academic Press.

FULLER, Wayne A.

1976 *Introduction to Statistical Time Series*. New York: Wiley.

GARVY, George

1943 "Kondratieff's Theory of Long Cycles." *The Review of Economic Statistics* 25: 203-220.

GOLDSTEIN, Joshua S.

1988 *Long Cycles: Prosperity and War in the Modern Age*. New Haven and London: Yale University Press.

GOTTMAN, John M.

1981 *Time-Series Analysis*. Cambridge: Cambridge University Press.

HAGE, Jerald, Maurice A. GARNIER, and Bruce FULLER

1988 "The Active State, Investment in Human Capital, and Economic Growth." *American Sociological Review* 53: 824-837.

ISAAC, Larry W. and Larry J. GRIFFIN

1989 "Ahistoricism in Time-Series Analyses of Historical Process." *American Sociological Review* 54: 873-890.

JENCKS, Christopher and David RIESMAN

1977 *The Academic Revolution*. Chicago and London: The University of Chicago Press.

JUGLAR, Clément

1889 *Des crises commerciales et de leur Retour Périodique en France, en Angleterre et aux Etats-Unis*. Paris: Guillaumin.

KONDRATIEFF, N.D.

1926 "Die langen Wellen der Konjunktur." *Archiv für Sozialwissenschaft und Sozialpolitik* 56: 573-609. (Complete English version: Review 2 (1979): 519-562.)

KUZNETS, Simon

1940 "Schumpeter's Business Cycles." *American Economic Review* 30: 257-271.

MANDEL, Ernest
1980 *Long Waves of Capitalist Development.* Cambridge: Cambridge University Press.

METZ, Rainer
1984 "Zur empirischen Evidenz 'langer Wellen'." *Kyklos* 37: 266-290.
1988 "Ansätze, Begriffe und Verfahren der Analyse ökonomischer Zeitreihen." *Historical Social Research* 13: 23-103.

METZ, Rainer and Winfried STIER
1991 "Filter Design in the Frequency Domain." *New Findings in Long Wave Research*, edited by Alfred Kleinknecht, Ernest Mandel and Immanuel Wallerstein. London (forthcoming).

MEYER, John W. and M.T. HANNAN
1979 *National Development and the World System: Educational, Economic and Political Change 1950-1970.* Chicago: University of Chicago Press.

MOMMSEN, Wolfgang J.
1974 "Max Weber als Kritiker des Marxismus." *Zeitschrift für Soziologie* 3: 256-278.

MÜLLER-BENEDICT, Volker
1991 *Akademikerprognosen und die Dynamik des Hochschulsystems.* Frankfurt: Campus.

NAMENWIRTH, Zvi J.
1973 "Wheels of Time and the Interdependence of Value Change in America." *Journal of Interdisciplinary History* 3: 649-683.

PARETO, Vilfredo
1983 *The Mind and Society: A Treatise on General Sociology.* New York: Harcourt, Brace & Co.

PETZINA, Dietmar and Ger van ROON
1981 *Konjunktur, Krise, Gesellschaft: Wirtschaftliche Wechsellagen und soziale Entwicklung im 19. und 20. Jahrhundert.* Stuttgart: Klett-Cotta.

POPPER, Karl R.
Objective Knowledge: An Evolutionary Approach. Oxford: Clarendon.

ROSENBERG, Hans
1943 "Political and Social Consequences of the Great Depression of 1873-1896 in Central Europe." *The Economic History Review* 13: 58-73.

SCHLITTGEN, Rainer and Bernd H. STREITBERG
1984 *Zeitreihenanalyse.* München: Oldenbourg.

SCHUMPETER, Joseph A.
1939 *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process, Vol. I-II.* New York: McGraw-Hill.

SLUTZKY, Eugen
1937 "The Summation of Random Causes as the Source of Cyclic Processes." *Econometrica* 5: 105-146.

SPREE, Reinhard
1991 "Lange Wellen wirtschaftlicher Entwicklung in der Neuzeit." *Historical Social Research*, special issue no. 4: 1-138.

STOCK, James H. and Mark W. WATSON
1988 "Variable Trends in Economic Time Series." *Journal of Economic Perspectives* 2: 147-174.

TITZE, Hartmut
1990 *Der Akademikerzyklus.* Göttingen: Vandenhoeck and Ruprecht.

WALLERSTEIN, Immanuel
1984. "Long Waves as Capitalist Process." *Review* 7: 559-575.

WALTERS, Pamela B.
1984 "Occupational and Labor Market Effects on Secondary and Post-Secondary Educational Expansion in the United States 1922 to 1979." *American Sociological Review* 49: 659-671.

WEBER, Robert
1981 "Society and Economy in the Western World." *Social Forces* 59: 1130-1148.

WINDOLF, Paul
1990 *Die Expansion der Universitäten 1870-1985.* Stuttgart: Enke.