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6: The Comparative Structure of the Growth of the West German and British Manufacturing Industries

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For those who have a firm belief in the potential of economic growth for raising overall economic welfare and reducing poverty, the study of comparative growth performance is a vital area of research. However, such study has not been noted for its successes. For example, no convincing theory has been developed elucidating the sluggish economic growth of the United Kingdom relative to its European neighbors. The lack of a general theory does not imply a paucity of ad hoc explanations for the U.K.'s performance; rather there is a surfeit of such explanations. However, these explanations are not ones that economists are eager to embrace. To quote one leading exponent of modern economic growth theory:

> Every discussion of the relatively slow growth of the British economy compared with the Continental economies ends up in a blaze of amateur sociology. The difference is the bloody-mindedness of the English worker, the slowness of English management to adopt new products or new processes or new ideas, the elaborately amateur character of English business practice, the excessive variety of English goods corresponding to a finely stratified society, or the style of English education and the attitudes it imprints on graduates, or the difference is all of these in unspecified proportions. This may just be a complicated way to admit ignorance. More likely it suggests that the

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identifiable purely economic factors do not account for the full difference between the growth of productivity in Britain and in, say, Germany or Sweden.[1]

The disquieting notion that an important economic problem has slipped into the domain of "amateur sociologists" is not the only cause for dissatisfaction. A list of observations on the British character does not constitute a unified theory. Moreover, the link between differences in character and differences in rates of economic growth is supported only by casual observation rather than by formal empirical tests.

Much of the foregoing criticism of economic knowledge of comparative growth will be made moot if Olson's challenging new theory gains acceptance. The starting point of Olson's theory is his earlier analysis of the formation of common-interest groups;[2] using this analysis, one can make predictions about relative growth rates:

> Associations that provide collective goods are for the most fundamental reasons exceedingly difficult to establish, especially for larger groups; none will attract a significant percentage of scattered groups like consumers, taxpayers, the unemployed, or the poor; associations that can promote the common interests of some groups will be able to establish themselves, but only in favorable circumstances and thus often only long after the common interest arises; as associations with monopoly control or political power accumulate, they delay the innovations and reallocations of resources needed for rapid growth, though this need not occur if the associations encompass a substantial percentage of those who bear the costs of the delays.
>
> It follows that countries whose special-interest groups have been emasculated or abolished by totalitarian government and foreign occupation should grow relatively quickly *after* a free and stable legal order is established.[3]

The theory does not focus solely on formal organizations. Rather, Olson suggests that social norms and social behavior patterns can be viewed from the same perspective:

1. Robert M. Solow, "Science and Ideology in Economics," *The Public Interest* 21 (Fall 1970): 102–03.
2. Mancur Olson, *The Logic of Collective Action* (Cambridge, Mass.: Harvard University Press, 1965), and "The Political Economy of Comparative Growth Rates," ch. 1, above.
3. Olson, "The Political Economy of Comparative Growth Rates," pp. 24–25.

> Social incentives will not be very effective unless the group that values the collective good at issue interacts socially or is composed of subgroups that do. . . . This means that special-interest groups will tend to have socially homogeneous memberships and that they will have an interest in using some resources to preserve this homogeneity. . . . The forces that have just been mentioned, operating simultaneously in thousands of professions, crafts, clubs, and communities, could by themselves explain some degree of class consciousness and even cultural caution about the fluctuating incomes and status of the businessman and entrepreneur.[4]

Thus, the theory not only helps to explain why the U.K. has a much lower growth rate than West Germany but also unifies the observations of the amateur sociologists. The relatively poor growth performances of the U.K. are no longer related to features intrinsic in the "British character"; rather, the U.K.'s relatively slow growth rate can be explained using descriptions of normal socioeconomic behavior in nations that had contrasting experiences in the years before 1948.

My purpose here is to test the Olson hypothesis on the outstanding example of its implications: the comparative growth performances of West German and British manufacturing industries. Before the theoretical basis for the tests is developed, I will discuss a set of statistical results whose theoretical basis has as yet eluded adequate explanation. It will be shown that these results can be explained by theoretical implications of the Olson hypothesis that are developed in the ensuing pages.

The Relationship between Output Growth and Productivity Growth

A number of studies have shown that there is a strong relationship between growth of output and growth of labor productivity in manufacturing. Kaldor emphasized that this relationship could be found in intercountry comparisons.[5] Intracountry, interindustry studies for the United States and the U.K. have given similar results.[6] On the surface, the relationship between

4. Ibid., p. 29.
5. Nicholas Kaldor, *Causes of the Slow Rate of Growth of the United Kingdom: An Inaugural Lecture* (London: Cambridge University Press, 1966).
6. K. D. George and T. S. Ward, *The Structure of Industry in the EEC* (London: Cambridge University Press, 1975); and J. W. Kendrick, *Productivity Trends in the United States* (Princeton: Princeton University Press, 1961).

productivity growth and output growth is not surprising; one would expect that increases in productivity would lead to a fall in prices and an increase in output. The significant feature lies in the strength of the relationship between output growth and productivity growth. Kendrick's data for thirty-three industries in the United States show that

> one fourth of the variance in relative output changes may be explained by relative changes in the prices (unit values) of the products of the thirty-three groups over the long period [1899–53]; . . . one-half of the variance in relative price changes may be explained by relative changes in productivity. Yet the degree of association between relative changes in output and in productivity is greater than might be inferred from these correlations.[7]

In order to explain the strength of the relationship between changes in output and in productivity, Kaldor and Kendrick turn to the same source: economies of scale. They argue that there are significant increasing returns to scale in production so that when output increases, labor productivity will also increase. This argument implies that increases in input use cause the increase in labor productivity. Therefore, tests of the Kaldor-Kendrick economies-of-scale hypothesis should examine the relationship between changes in labor input and changes in labor productivity.

Kendrick's analysis provides only weak support for his own hypothesis. Of 35 correlation coefficients between productivity growth and increases in labor input, only 6 are statistically significant.[8] George and Ward have examined the economies of scale hypothesis using interindustry data for the U.K. and West Germany in the postwar period.[9] Their results would lead one to reject the economies-of-scale hypothesis for both countries. Moreover, they find that the relationship between growth of output and growth of labor productivity is not statistically significant for West Germany for the time period from 1953 to 1969.

Cripps and Tarling and Rowthorne have examined the economies-of-scale hypothesis by using international comparisons.[10] Cripps and Tarling obtain, at best, weak support for it; Rowthorne's results argue persuasively for the rejection of the hypothesis. By increasing the sample size and by

7. Kendrick, *Productivity Trends*, pp. 205–06.
8. Ibid., p. 216.
9. George and Ward, *The Structure of Industry*, pp. 62–63.
10. T. F. Cripps and R. J. Tarling, *Growth in Advanced Capitalist Economies: 1950–70* (London: Cambridge University Press, 1975); and R. E. Rowthorne, "What Remains of Kaldor's Law?" *Economic Journal* 85 (March 1975): pp. 10–19.

pointing out the overwhelming importance of the Japanese observation to previous results, Rowthorne shows that there is no significant relationship between employment and productivity growth rates.

One may summarize the aforementioned results as follows:

1. There is a significant relationship between growth of output and growth of labor productivity in both interindustry and intercountry analyses. This relationship is much stronger than the one which would be implied by a causal relationship leading from relative productivity increases to relative price decreases and then to output increases.
2. The relationship between growth of output and of productivity is not present in interindustry studies for West Germany.
3. The economies of scale explanation for the relationship indicated in item 1 has not been supported by statistical tests.

In the ensuing sections, I will develop implications of the Olson hypothesis which can be used to show that the preceding results are predictions of that hypothesis; they will, therefore, serve to lend credence to the Olson hypothesis.

Patterns of Industrial Growth

An immediate implication of the Olson hypothesis is that, in the postwar era, the influences of formal and informal common-interest groups, social classes, social norms, and traditionalism are much stronger in the U.K. than in West Germany. (For brevity's sake I will refer to all such growth-inhibiting forces as inertial forces or inertial influences.) Since the U.K. has experienced continuing political stability in the modern era, inertial forces will be strong in older industries in that country. In contrast, one would expect inertial forces that are industry-specific to be weaker in new industries.

The events of 1933 to 1948 destroyed many inertial forces in West Germany. As the actions that destroyed the inertial forces were unrelated to the age structure of industry, one can posit that in 1948 the strength of any industry-specific inertial forces in West Germany was independent of the age of an industry. The independence of age and strength of inertial forces in German industry would be a continuing feature of postwar development because, as Olson emphasizes, inertial forces arise very slowly. Thus, from the point of view of inertial influences, one may regard all West

German industries as "new." In contrast, the U.K. has both old and new industries. One would expect that this pattern of inertial influences would be reflected in the pattern of industrial development in the two economies.

In testing the foregoing theory, one faces a crucial question: how can one measure the age of an industry? Many variables would seem to be candidates as measures of industry age: length of time since initiation of production, age of plant and equipment, average length of time that employees have been in their present jobs, amount of stock issued in previous twenty years as a proportion of all stock issued. I have chosen to use the relative change in importance of a particular industry in overall industrial production as a variable to measure age. Thus, industry A is defined as newer than industry B at time t if the growth of output of industry A in some time period immediately preceding time t is greater than the growth of output of industry B in the same time period.[11]

At this juncture, the reader may suspect that the use of growth rates to measure industry age will impart a bias to the tests. For example, the foregoing theory predicts that in the U.K. industries that have grown relatively fast in the past will grow relatively fast in the future. While this implication is not quite tautological, it is uninteresting and is certainly explicable in terms of theories other than Olson's. However, the possible bias introduced by using growth rates as a measure of industry age will be avoided in this study by formulating all tests in comparative terms. Thus, the tests will compare the U.K. and West Germany and show that effects which are present in the U.K. are not present, or not as strong, in West Germany. Therefore, one can presume that growth rate could be replaced by a surrogate measure of industry age and the test results would not change.

The use of growth rates to measure industry age rests solely on the observation that when there has been growth of output, changes must have taken place in the industry. These changes may have occurred in management, labor force, capital stock, or, more likely, in a combination of all these elements. Thus, the higher the growth rate of output has been, the more some productive elements will have changed. Industries in which these changes have been more sizeable will have had less time in which inertial forces could have developed. Also, one can expect these changes themselves to have been destructive of inertial forces. Thus, in the U.K., industries that experienced higher rates of growth before 1948 would have been less subject to inertial forces after 1948.

11. It should be noted that a new industry, as defined by this measure, has not necessarily just come into existence. Rather, a new industry is one that must have gone through a large number of changes in recent years, which implies that a large proportion of the components of that industry are new.

Ideally, to apply the foregoing theory, one would require information on industrial growth rates before 1948. However, this information is difficult to obtain, especially so in a form which gives comparable statistics for West Germany and the U.K. This difficulty is not present for the postwar period to the same degree; therefore, tests will be formulated using post-1948 data. It is possible to use the post-1948 data because of an important implication of the Olson hypothesis.

The Olson hypothesis predicts that if industry A has grown faster than industry B before 1948, then, in the U.K., inertial forces will be stronger in industry B than in industry A. Thus, *ceteris paribus*, industry A will grow faster than B after 1948. A measure of industry age using post-1948 growth rates will be a surrogate measure of industry age in 1948. Reinforcing the argument for the use of post-1948 growth rates is the fact that factors which influence the structure of industrial growth rates, such as income elasticities of demand and susceptibility of industrial processes to technological change, will have similar influences both pre- and post-1948.

The foregoing reasoning provides a framework within which all the results discussed earlier can be explicated. That discussion would lead one to predict that, in countries with a stable recent history, industries that are growing fast are the ones in which inertial forces are less strong. Therefore, these industries are much more likely to be receptive to technological change and will show higher rates of productivity increase. One would expect in turn to see a strong correlation between growth of output and growth of productivity in interindustry studies for both the U.S. and the U.K. The similar correlation for West Germany would be expected to be much weaker. These are in fact the very results which were reported previously. The economies-of-scale explanation for these results, which foundered when faced with a direct test of its veracity, also could not account for the differences between the results for West Germany and the U.K.; the Olson hypothesis explains them. Thus, the results reported in the previous section are all supportive of the Olson hypothesis. In the ensuing section, much stronger tests of this hypothesis are formulated.

The United Kingdom and West Germany Compared

Let G_j^i be the growth rate of industry j in country i: i will correspond to the U.K. or West Germany (W.G.) and $j = 1, \ldots, n$, where n is the total number of industries. Let us assume that industry j is newer than industry k in both countries. In the previous section, it was concluded that inertial forces would be stronger in old than in new industries in the U.K., whereas the strength of inertial forces would be more likely to be equal across German industries. Thus, newer industries in the U.K. would be relatively more successful in comparison with overall U.K. economic performance than would new industries in West Germany, as compared with overall German economic performance. However, because both economy-wide and industry-specific inertial forces are stronger in the U.K. than in West Germany, one would expect that $G_j^{UK} < G_j^{WG}$ and $G_k^{UK} < G_k^{WG}$. Thus, in order to test the Olson hypothesis, one must examine the performance of industry k relative to industry j in each country and test whether this relative comparison is different for both countries.

In testing the Olson hypothesis, one needs a null hypothesis that predicts the comparative structure of growth rates when inertial forces are of no significance. There is one such null hypothesis which seems intuitively the most plausible. The West German aggregate growth rate is proportionately higher than the British aggregate growth rate so that the growth rate in a particular West German industry is higher than the growth rate in the equivalent British industry by the same proportion:[12]

$$G_j^{UK} = \beta G_j^{WG}, \text{ where } \beta < 1 \text{ and } j = 1, \ldots, n. \tag{1}$$

In the next section I will examine arguments why equation 1 could be expected to be correct in the absence of inertial forces. Also in that section, possible biases in the tests that use equation 1 will be examined, and alternative but less plausible forms of the null hypothesis will be used.

Presently, I will develop implications of the Olson hypothesis on the assumption that equation 1 would be satisfied if inertial influences were of no significance. In interpreting test results, one should remember that this assumption is implicit in the construction of the tests. An evaluation of the power of the test results reported in this section relies on the acceptability of equation 1 as a null hypothesis.

In order to formulate tests, one must examine relative growth performance for industries j and k when industry j is newer than k in both countries. If equation 1 were true and inertial forces were of no significance, one would expect that

12. In the ensuing pages, I have omitted error terms which, if included in equations and inequalities, would represent all influences on comparative growth rates not examined in this study.

$$\frac{G_j^{UK} - G_k^{UK}}{G_A^{UK}} = \frac{G_j^{WG} - G_k^{WG}}{G_A^{WG}}, \tag{2}$$

where G_A^i is the growth rate of all industry and i corresponds to U.K. or W.G. If the comparative structure of growth rates independent of inertial forces could be described by equation 1, then those inertial forces would produce an effect such that

$$\frac{G_j^{UK} - G_k^{UK}}{G_A^{UK}} > \frac{G_j^{WG} - G_k^{WG}}{G_A^{WG}}. \tag{3}$$

Thus, in order to test the null hypothesis versus the Olson hypothesis, one must examine whether expression 2 or 3 provides the closer description of actual growth rates.

Having suggested that tests comparing expressions 2 and 3 are based on the most reasonable alternative to the Olson hypothesis, it is appropriate at this juncture to explain the intuition behind the expressions. Suppose, for the sake of explanation, that industry j has a higher rate of technological change than industry k and that West German manufacturers exploit this technological differential more fully than British manufacturers. Therefore,

$$GR_j^{WG} - GR_k^{WG} > GR_j^{UK} - GR_k^{UK},$$

even though industry j is newer than industry k. The Olson hypothesis would say that industry j in the U.K. is relatively receptive to technological change compared with industry k in the U.K., although not necessarily so compared to industry j in West Germany. Thus, in order to compare the differences between growth rates, one must adjust the differences between British industry growth rates by a factor that measures the growth performance of British industry. Differences between West German growth rates must be similarly adjusted. The use of aggregate growth rates as denominators in expressions 2 and 3 provides the appropriate adjustments.

With industry j newer than industry k, support for the Olson hypothesis is obtained if inequality 3 is correct and support for the null hypothesis is obtained if inequality 3 is incorrect. If the Olson hypothesis is incorrect and the null hypothesis adequately describes the structure of growth rates, the expected value of the number of times that inequality 3 is verified is one-half. If inertial influences are significant, the expected value of the number of times that 3 is verified is greater than one-half.

The United Nations *Yearbook of Industrial Statistics* provides the basic data for the tests. Coverage is from 1953 onwards, and indexes of industrial production provide the information to calculate growth rates.[13] In formulating tests, one must measure newness of industries. From the point of view of pure theory, one needs only measure age by looking at British growth rates; however, such a procedure would introduce a bias into the tests. Thus, industry *j* is defined as newer than industry *k* if and only if industry *j* has grown faster than industry *k* in *both* West Germany and the U.K. Tests were carried out for two different time periods. Thus, the time period for growth rates used to define industry age was either 1953–63 or 1953–68.

Once age of industry has been defined using growth rates for 1953–68 (1953–63), the foregoing theory can be tested by examining the structure of growth rates during the interval 1969–73 (1964–73). The growth rates used are those for twenty-seven manufacturing industries. For these industries comparable data from both countries are available.[14] For the test of inequality 3 versus equation 2, two sets of data are used. First, aggregate growth rates for the twenty-seven industries are tested. Second, since the United Nations has published data on the production of a wide range of industrial commodities, data on 235 commodities for the period 1969–73 could be used, where each of the 235 commodities was produced in one of the twenty-seven industries. In tests using commodity data, age of industry was defined using the 1953–68 growth rates of the industry in which the commodity was produced.[15] In the tests using the commodity production data, when industry *j* was defined as newer than industry *k*, comparisons based on inequality 3 were carried out for each commodity produced in industry *j* versus each commodity produced in industry *k*.

Results of these initial tests are presented in the first three lines of table 6.1. In order to clarify the construction of this table, I will interpret the first line in it. The test described on the first line matches the null hypothesis of equation 1 against inequality 3 as the alternative hypothesis. The growth rates from 1953 to 1968 of all twenty-seven industries are used in order to

13. United Nations, Statistical Office, *Yearbook of Industrial Statistics* (New York: United Nations, annual). (Formerly *The Growth of World Industry*.)

14. The ISIC codes for the industries included in the sample are: 311, 313, 314, 321, 322, 323, 324, 331, 332, 341, 342, 351, 353, 354, 355, 356, 361, 362, 369, 371, 372, 381, 382, 383, 384, 385, and 390. For some industries the published data does not extend as far back as 1953; in such cases, the growth rate over a shorter time period is used to define industry age.

15. Commodity production growth rates before 1969 could not be used to define industry age because coverage of commodities is much less complete in the decade before 1969 than in the years after 1969.

Table 6.1. Tests of the Significance of Inertial Influences

Industries Included	*Age Defined By*	*Data Used for Comparisons*	*Number of Comparisons Made*	*Number Supporting Olson Hypothesis*	*Proportion (col. 5/col. 4)*	*95 Percent Significance Level*
All	Growth rates 1953–68 for 27 industries	Growth rates 1969–73 for 235 commodities	21,216	11,636	0.5485	0.528
All	Growth rates 1953–63 for 27 industries	Growth rates 1964–73 for 27 industries	283	182	0.6431	0.620
All	Growth rates 1953–68 for 27 industries	Growth rates 1969–73 for 27 industries	285	164	0.5754	0.620
Heavy	Growth rates 1953–68 for 15 industries	Growth rates 1969–73 for 140 commodities	7,701	4,344	0.5641	0.539
Heavy	Growth rates 1953–63 for 15 industries	Growth rates 1964–73 for 15 industries	82	67	0.8171	0.673
Heavy	Growth rates 1953–68 for 15 industries	Growth rates 1969–73 for 15 industries	88	68	0.7727	0.665

define the age of any industry relative to another. Comparisons of growth performance during the interval 1969–73 are made using data on the growth rates of production of 235 commodities. If industry *j* has a higher rate of growth than industry *k* in one country and a slower rate of growth in the other country from 1953 to 1968, then no comparisons were made between industries *j* and *k*.[16] Thus, the number of comparisons was not strictly determined by the number of commodities in the sample. The actual number of comparisons made is given in column 4. In column 5, the number of comparisons which supported the Olson hypothesis (the number for which inequality 3 was verified) is given. In column 6, this number is interpreted as a proportion of all comparisons made. The appropriate test is one in which the null hypothesis is accepted if the proportion in column 6 is not significantly greater than one-half.

In order to conduct significance tests, it is necessary to calculate the standard errors of the proportions in column 6. As an understanding of the procedure of calculation of standard errors is not necessary for interpretation of the test results, discussion of the calculation of the standard errors is relegated to an appendix. For reasons given in that appendix, the standard errors have an upward bias. Thus, the test results appear slightly less favorable to the Olson hypothesis than would be the case if unbiased standard errors were used. Employing the assumption that the proportions are normally distributed, the standard errors were used to calculate 95 percent significance levels which are given in column 7. The Olson hypothesis is accepted at the 95 percent significance level if the proportion in column 6 is greater than the proportion in column 7.

The results reported in the first three lines of table 6.1 give firm support to the hypothesis that old industries fare less well in the U.K. than do equivalent industries in West Germany. The extension of the Olson hypothesis proposed in the foregoing pages certainly provides an explanation for these results. There is some possibility that alternative explanations for the test results could exist—explanations independent of interest-group behavior. However, by examining a subset of the data, one can obtain further results that point very strongly to the conclusion that inertial forces produce the effects found in the first test results.

Industries included in the manufacturing sector are heterogeneous in character. In particular, the manufacturing sector contains both heavy and

16. These comparisons were excluded from the analysis in order to remove any bias that would be embodied in the tests if only British growth rates were used to define industry age.

light industry. Although the distinction between heavy and light industries is usually based on a heuristic classification, that distinction does rest on some very basic notions of the qualitative characteristics of industries. Heavy industries have high capital-labor ratios, high concentration ratios, high unionization rates, and large factories (in terms of size of workforce).[17]

The characteristics of heavy industries would make these industries more susceptible to the influence of inertial forces. Higher concentration ratios facilitate noncompetitive behavior. Higher unionization rates imply that heavy industries are more susceptible to the formation of formal and informal common-interest groups. Larger enterprise size means, in terms of employment, that an employee's social interaction is much more likely to be in social groups dominated by fellow employees. Such social interaction would tend to facilitate the cohesion of group interests and strengthen existing inertial forces present in the industry. Therefore, if inertial influences are present their effect on heavy industries is likely to be greater than on light industries. Tests on a sample of heavy industries would give stronger results than tests on all industries together.

Using International Standard Industrial Classification codes, one can divide manufacturing industry into heavy and light. Industries with codes below 350 are light industries: food processing, beverages, textiles, etc. Those with codes above 350 are heavy industries: chemicals, iron and steel, transportation equipment.[18] There are fifteen heavy industries. Lines 4 through 6 of table 6.1 contain the results for an analysis of these fifteen industries.[19]

17. See Frederic L. Pryor, *Property and Industrial Organization in Communist and Capitalist Nations* (Bloomington, Ind.: Indiana University Press, 1973), pp. 59–60, for a discussion of the characteristics of heavy and light industries. Pryor, Appendix B-7, and George and Ward, *The Structure of Industry*, ch. 3 and 4, have evidence showing which industries have the characteristics attributed to heavy industries.

18. See Pryor, *Property and Industrial Organization*, for a classification of industries into heavy and light. Pryor's classification covers only twenty industries; thus, it could not be used formally to divide the twenty-seven industries of this study into two groups. I chose the ISIC codes to classify industries because such a classification seems to fit heuristic notions of the distinction between heavy and light industries very well. Use of a strict definition based on the ISIC, rather than a looser definition, has the advantage that the definition is not framed to be favorable to any particular hypothesis. The classification based on ISIC codes conforms to Pryor's classification where they overlap.

19. One industry that would be classified as heavy has been omitted. The performance of the "petroleum and coal products sector" (the name is somewhat of a misnomer since products of petroleum refineries appear in another sector) in the tests is anomalous. In the tests summarized on lines 2 and 3 of table 6.1, only seven out of forty-seven comparisons for this sector satisfied inequality 3. Thus, both the null hypothesis and the alternative hypothesis are inadequate as interpretations of the comparative behavior of this sector. (The proportion 7/47 is significantly less than one-half.)

The reason for the anomalous performance of the petroleum and coal products sector may be

By comparing lines 1 through 3 with lines 4 through 6 of table 6.1, one can see that the proportion of comparisons supporting the existence of inertial forces is greater for the tests using only heavy industries than for the tests using all industries. This is exactly the prediction one would make using knowledge of the characteristics of heavy industries combined with the implications of Olson's hypothesis. Any competing hypothesis must explain not only why old industries fare relatively worse in the U.K. than in West Germany but also why this effect is more pronounced when only heavy industries are analyzed. The extremely strong test results of this section were obtained using the assumption that if inertial forces were of no significance equation 1 would be satisfied. I now turn to a justification of the use of that assumption.

The Null Hypothesis Considered

In this section, I assume that inertial forces are of no significance and examine the likely relationship between the growth rates of an industry in two countries that are growing at different rates. In order to conduct such an examination, one must make specific assumptions about the cause of the two countries' differing growth performances. Here, two such assumptions are used in two different analyses. In each case, one can make firm conclusions about the relationship between the growth rates of specific industries. For both cases, equation 1 describes the comparative structure of growth rates.

In the analysis which follows, strong simplifying assumptions must be made since the analysis involves comparison between two complete economic systems. Therefore, the general argument is one of analogy from these simple examples. The strength of the argument lies in the extent to which the assumptions are not contrived and are, in fact, commonly used in the economics literature. It is the ease with which equation 1 can be derived

explained by the effects of inertial influences. The products in this sector are produced primarily in nationalized industries in the U.K. Therefore, in the U.K., this sector was less subject to the dictates of the market than were other sectors. This sector was in absolute decline in West Germany. In old, nationalized industries, interest-group behavior may lessen the possibility that growth will be negative. Thus, the results for this sector may, in fact, reflect the power of interest groups in nationalized industries to reverse an absolute decline in the growth of that industry.

Given that the anomalous performance of this industry can be explained by reversion to the effects of inertial forces, after noting special characteristics of this industry, I have decided to omit this sector from the heavy-industry analysis.

from simple, common assumptions that is persuasive in the decision to employ it as the null hypothesis for testing the effects of inertial forces.

The strongest simplifying assumption in the following analysis is the assumption that the two countries with differing growth rates start from identical positions: identical prices, production levels, and consumption levels. To assume that the two countries are in different positions would necessitate additional assumptions on how these countries came to be in different positions: exactly the phenomenon which I am examining. In order to avoid the problem of directly assuming that which is being examined, I assume that initial production conditions are the same in both countries but that the countries are moving to different positions. The difference between the following scenarios lies in the specifications of the cause of the two countries' differing growth rates.

Scenario One

The rate of saving is higher in country A than in country B. Perfect markets exist in both countries and all industries have identical production functions. Capital is instantaneously transferable between industries so that there are no relative price changes. Hence in each country total income, total investment, and total consumption are all rising at the same rate as total output. Thus, the change in output of each industry is equal to the change in consumption due to movement along an Engel curve.

Assuming that consumers have the same preferences in both countries, one can write

$$c_j^k = c_j(w^k),$$

where c_j^k represents consumption of good j in country k and w^k represents total income in country k. Using the notation $\frac{dc}{dt} = \dot{c}$, one can write

$$\frac{\dot{c}_j^k}{c_j^k} = \left(\frac{\frac{\partial c_j}{\partial w^k} \cdot w^k}{c_j^k} \right) \cdot \left(\frac{\dot{w}^k}{w^k} \right).$$

Thus,

$$\frac{\dot{c}_j^A}{c_j^A} = \frac{\beta \dot{c}_j^B}{c_j^B}, \tag{4}$$

where β is the rate of growth of output in country A divided by that of country B. Equation 4 is the null hypothesis used in the previous section.

Scenario Two

Technological change produces growth. At any time, in any industry, there is a set of technological changes which are ripe for discovery. In some industries this set is larger than others, solely because of technological and scientific factors. In each industry, some technological changes will be more difficult to accomplish than others. Managers in country A are more successful in research and development than managers in country B. Thus, in a certain time period, W percent of the feasible changes in all industries are implemented in country A, while only U percent (less than W percent) are implemented in country B. Thus,

$$\dot{\Pi}_i^A = \gamma \dot{\Pi}_i^B, \text{ where } \gamma > 1 \tag{5}$$

where Π_i^k is a productivity index for industry i in country k and γ is an increasing function of W/U.

Let us assume that there are constant returns to scale in all industries and that perfect markets cause prices to fall to costs instantaneously. For each country,

$$p_i y_i = \sum_{j=1}^{n} p_j x_{ji}$$

and $\quad y_i = F_i(x_{1i}, \ldots, x_{ni}, \Pi_i),\ i = 1, \ldots, n$

where p_i is the price of good i, y_i is the output of good i, and x_{ji} is the input of good j into the production of good i. Thus, on the assumption that there is no international trade (an assumption which will be dropped later),

$$\dot{p}_i y_i + \sum_{j=1}^{n} p_i \frac{\partial y_i}{\partial x_{ji}} \left(\sum_{k=1}^{n} \frac{\partial x_{ji}}{\partial p_k} \dot{p}_k \right) + \sum_{j=1}^{n} p_i \frac{\partial y_i}{\partial x_{ji}} \left(\sum_{k=1}^{n} \frac{\partial x_{ji}}{\partial \Pi_k} \dot{\Pi}_k \right)$$

$$= \sum_{j=1}^{n} \dot{p}_j x_{ji} + \sum_{j=1}^{n} p_j \left(\sum_{k=1}^{n} \frac{\partial x_{ji}}{\partial p_k} \dot{p}_k \right) + \sum_{j=1}^{n} p_j \left(\sum_{k=1}^{n} \frac{\partial x_{ji}}{\partial \Pi_k} \dot{\Pi}_k \right),$$

where $i = 1, \ldots, n$.

Although simplification of this equation is possible, it is not necessary. By inspection one can see that any solution of the n equations will have any single price change equal to a weighted sum of the productivity changes. The weights will be a function of the present state of the economy, not of the rate of change of any variables. Hence, the weights will be the same in both countries. Therefore, from equation 5,

$$\frac{\dot{p}_j^A}{p_j^A} = \frac{\gamma \dot{p}_j^B}{p_j^B},\ j = 1, \ldots, n. \tag{6}$$

Since total amount sold is a sum of consumption plus intermediate use,

$$y_j = c_j(p_1, \ldots, p_n) + \sum_{i=1}^{n} x_{ji}$$

$$\dot{y}_j = \sum_{k=1}^{n} \frac{\partial c_j}{\partial p_k} \dot{p}_k + \sum_{k=1}^{n} \sum_{i=1}^{n} \frac{\partial x_{ji}}{\partial p_k} \dot{p}_k + \sum_{i=1}^{n} \frac{\partial x_{ji}}{\partial \Pi_i} \dot{\Pi}_i. \tag{7}$$

Assuming the same demand functions in each country and noting that the weights attached to the rates of change of prices and productivities in equation 7 are independent of rates of change, one can combine equations 5, 6, and 7 to obtain

$$\frac{\dot{y}_j^A}{y_j^A} = \frac{\gamma \dot{y}_j^B}{y_j^B}, \tag{8}$$

which is identical to equation 1, the null hypothesis.

The assumption that the economies are closed is unreasonable. When one assumes that foreign trade is possible, the foregoing analysis must be modified because all prices in country A will be declining faster than equivalent prices in country B. Thus an exchange rate adjustment will be required in order to balance trade. Let q_j^A be the price of good j in country A measured in country B's currency units. Therefore,

$$q_j^A = p_j^A s,$$

where s is the relevant exchange rate. It is known that

$$\frac{\dot{q}_j^A}{q_j^A} = \frac{\dot{p}_j^A}{p_j^A} + \dot{s}/s$$

and $\dot{s}/s > 0$. Using equation 6,

$$\frac{\dot{q}_j^A}{q_j^A} = \frac{\gamma \dot{p}_j^B}{p_j^B} + \dot{s}/s.$$

Thus, in industries in which productivity changes have induced only small price changes, the following inequalities will be satisfied:

$$\frac{\dot{q}_j^A}{q_j^A} > 0 > \frac{\dot{p}_j^B}{p_j^B}.$$

In industries in which price changes have been large,

$$\frac{\dot{q}_j^A}{q_j^A} < \frac{\dot{p}_j^B}{p_j^B} < 0.$$

Assuming that own-price effects dominate cross-effects, industries with small price changes will be those that are growing most slowly. Therefore, taking into account foreign trade transactions, one would modify equation 8 to conclude that

$$\frac{\dot{y}_j^A}{y_j^A} < \frac{\gamma \dot{y}_j^B}{y_j^B}$$

if industry j is slow growing, and

$$\frac{\dot{y}_k^A}{y_k^A} > \frac{\gamma \dot{y}_k^B}{y_k^B}$$

if industry k is fast growing.

The above inequalities can be embodied in a simple operational equation of the following form (using the notation of the previous section):

$$G_j^A + \sigma(G_k^A - G_j^A) = \gamma G_j^B,\ 1 > \sigma > 0.$$

Comparing two industries,

$$(G_j^A - G_i^A)(1 - \sigma)/\gamma = G_j^B - G_i^B,$$

or

$$(G_j^A - G_i^A)/\gamma > G_j^B - G_i^B. \tag{9}$$

Inequality 9 contains the same terms as inequality 3; however, the signs are reversed. Since the process which leads to inequality 9 can be expected to operate at the same time as inertial forces, it tells us that the tests of the previous section will be biased toward acceptance of the null hypothesis.

The test in the previous section requires as evidence for the existence of inertial forces when industry j is newer than industry i

$$(G_j^A - G_i^A)/\gamma < G_j^B - G_i^B. \tag{10}$$

A better test would require as evidence for the existence of inertial forces

$$(1 - \sigma)(G_j^A - G_i^A)/\gamma < G_j^B - G_i^B. \tag{11}$$

Thus, the tests in the text assume that when equation 10 is incorrect the

Olson hypothesis is not supported, even though equation 11 may be true in such a case. Consequently, the tests using equation 1 as null hypothesis provide strong evidence for the Olson hypothesis because they are biased against acceptance of this hypothesis.

The foregoing analysis has attempted to interpret the importance of the test results by justifying the use of equation 1 as a reasonable null hypothesis. An alternative method of assessing the results is to examine their robustness by formulating different tests which, under any reasonable assumption about the structure of comparative growth rates in the absence of inertial forces, would be biased against acceptance of the Olson hypothesis. These tests would begin with the general null hypothesis

$$G_j^{WG} = \alpha + \beta G_j^{UK},\ \alpha > 0,\ \beta > 1,\ j = 1, \ldots, n. \tag{12}$$

If α is significantly greater than zero, this hypothesis implies, for example, that an industry which is growing slowly in West Germany would be declining in the U.K. Because of such implications, equation 12 seems to be inferior to equation 1 as a candidate to describe the comparative structure of growth rates.

If inequality 11 were correct and inertial forces were of no significance, one would expect that

$$(G_j^{WG} - G_i^{WG})/\beta = G_j^{UK} - G_i^{UK}. \tag{13}$$

If industry j is newer than industry i and inertial forces were of some significance, these forces would produce an effect such that

$$(G_j^{WG} - G_i^{WG})/\beta < G_j^{UK} - G_i^{UK}. \tag{14}$$

Thus, in order to test the null hypothesis equation 12 versus the Olson hypothesis, one must examine whether 13 or 14 provides the closer description of actual growth rates.

In order to formulate such a test, one must obtain an unbiased estimate of β. However, β can only be estimated in the absence of inertial forces. If inertial forces exist, then an estimate of β which assumes an absence of inertial forces will be biased downward. If this estimate is then used in tests of equation 13 versus inequality 14, the results must be biased toward acceptance of the null hypothesis whatever the true value of β is in the absence of inertial forces.

In the test results presented in table 6.2, the estimate of β is a number that satisfies inequality 14 half the time when the data for all twenty-seven manufacturing industries are used. This estimate is then used to test the

Table 6.2. Tests of Equation 13 versus Inequality 14 Using Estimates of β Derived from Data for All Twenty-seven Manufacturing Industries

Industries Included	*Age Defined By*	*Data Used for Comparisons*	*Number of Comparisons Made*	*Number Supporting Olson Hypothesis*	*Proportion (col. 5/col. 4)*	*95 Percent Significance Level*
Heavy	Growth rates 1953–68 for 15 industries	Growth rates 1969–73 for 140 commodities	7,701	4,134	0.5368	0.539
Heavy	Growth rates 1953–68 for 15 industries	Growth rates 1969–73 for 15 industries	88	64	0.7273	0.669
Heavy	Growth rates 1953–63 for 15 industries	Growth rates 1964–73 for 15 industries	82	54	0.6585	0.672

hypothesis that inertial forces exist in heavy industry. Thus table 6.2, whose structure is identical to that of table 6.1, contains results for heavy industries only. In interpreting the results, one should remember that there are two senses in which the tests favor the null hypothesis. First, if the alternative hypothesis is true, the proportion in column 6 will be biased downward. Second, the 95 percent significance level in column 7 will be biased upward for reasons presented in the appendix. Given these biases, the fact that the proportions are all close to, or greater than, the 95 percent level of significance (the percent levels of significance are 94.0, 98.7, and 93.6) is strong evidence for the existence of inertial forces.

Conclusion

The foregoing results point strongly to the existence of significant effects due to inertial forces within British industry. Not only do the tests give significant results when the null hypothesis used is the one justified by a theoretical analysis, but significant results are also obtained when the null hypothesis used is such that the tests are biased against acceptance of the conclusion that inertial forces are significant. Moreover, in all cases, test results are much stronger for heavy industries than for all industries combined. The stronger effect of inertial forces in heavy industry is exactly the prediction one would make having assumed that inertial forces are due to group behavior.

One mark of the worth of a new theory is the ability which that theory has to explain observations which have previously eluded adequate explanation. Studies that have shown productivity growth and output growth to be strongly related in Britain and the United States constitute one set of such observations. These studies become comprehensible once one realizes that output growth is a surrogate measure of newness of industry that is positively related to productivity growth owing to the effect of inertial forces. Thus, the tests I outline can be interpreted as providing support for a theory which explains the causal mechanism underlying the results obtained by Kaldor, Kendrick, and others.

The importance of a new theory is not only in helping to explain past statistical regularities but also in providing a guide for future action. Many predictions emanate from the foregoing analysis: I will focus on one such prediction as an example. The foregoing results point to the importance of entry into an industry for the promotion of dynamic efficiency. New firms entering an industry (assuming that inertial forces which pose barriers to entry can be overcome) are less likely to be troubled by inertial forces than old, established firms. Thus, the new firms will be more likely to promote technological change and adopt aggressive growth policies than old firms. Hence, positive encouragement for new firms entering an industry would seem to be a vital element of any policy aimed at promoting growth.

In advanced industrial economies, declining industries are often the recipients of government aid. That aid often takes the form of a subsidy for research and development, given because declining industries are observed to be technologically backward relative to foreign competitors. The analysis which lies behind the choice of policy ignores the causal mechanism that produces the technological backwardness. If the backwardness is due to inertial forces, then research and development aid might have little effect unless that aid flowed toward new entrants into the industry. Olson's theory, together with the extension developed in this paper, shows not only why aid to new entrants will provide a high economic return but also why such aid will attract well-organized political opposition.

APPENDIX

One can view the amount $(G_j^{UK}/G_X^{UK}) - (G_j^{WG}/G_A^{WG})$ as an observation on the jth industry. Suppose that there are n such observations. For the moment, assume that one can order the industries by age. The tests of equation 2 versus expression 3 or 13 versus inequality 14 use every possible pairwise comparison from the n observations. The test statistic is the proportion of these comparisons for which the observation for the newer industry is greater than the observation for the older industry.

As no standard formula for the calculation of the standard errors of the test statistics could be found, a numerical procedure was adopted. All possible orderings of a set of observations were enumerated, the test statistic was calculated for each ordering, and the standard deviation of these statistics was calculated. In using this standard deviation as the standard error of the test statistic, one is assuming that all orderings of the n observations are equally likely. This assumption is equivalent to the assumption that equation 1 has an additive error term which has an expected value of zero and homoscedastic variance.

When there are n industries, $n(n - 1)/2$ comparisons are generated. However, for reasons explained in the text, not all comparisons could be made. For example, in one case (table 6.1, row 2) there were observations on

twenty-seven industries, and only 283 of the possible 351 comparisons were generated. This is approximately the number of comparisons which would be generated by twenty-four industries. Thus, for this case, if the standard error for twenty-seven industries (351 comparisons) were used, one would be using a downward-biased statistic. If the standard error for 283 comparisons (twenty-four industries) were used, one would be using an upward-biased statistic (because the amount of dependence among all comparisons for twenty-four industries will be greater than the amount of dependence among 283 comparisons from twenty-seven industries). The latter option was chosen so that the tests of significance would have a conservative bias, that is, a bias toward acceptance of the null hypothesis.

A second problem arising in the calculation of the standard errors was that the number of comparisons for the commodity data was so great that computational limitations prevented the calculation of exact standard errors. However, after the exact standard errors were generated for thirty different sample sizes, estimates of the standard errors for the commodity data could be found using regression techniques. The estimated regression equation was

$$\text{Standard error} = (0.469)\ (\text{number of comparisons})^{-0.333}.$$

This equation had an R^2 of 0.99. Predictions using this equation were used to obtain the standard errors given on lines 1 and 4 of table 6.1 and line 1 of table 6.2. For reasons given in the previous paragraph, the standard errors are biased upward.