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Trend, Cycles and Chance

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Prepared for *Kondratieff Waves*

Abstract: This paper is about the book *Trend, Zyklus und Zufall. Bestimmungsgründe und Verlaufsformen langfristiger Wachstumsschwankungen* (2002) written by Rainer Metz. It rehabilitates Metz's somewhat forgotten milestone in the quantitative history literature on economic cycles. For me, it represents an indispensable standard work for anyone who wants to work in this field.

Keyword: Cliometrics, Economic history, Time series.

JEL Codes: C01, C22, C32, C82, N01, N14.

Content

The 533-page book is divided into six chapters, followed by a 95 pages appendix, which contains a presentation of the basics of the theory of stochastic processes, spectral analysis and outlier analysis in ARIMA models.

The aim of the book is the critical presentation of different explanatory hypotheses of long-term growth fluctuations, especially in their importance for the development of the national product in Germany from 1850 to 1990. The contrast between traditional explanatory hypotheses and stochastic trend models, in which chance plays a central role, proves to be fundamental, since in previous economic history research chance as an unsystematizable component was at least excluded from model-oriented consideration. Such studies have not yet been available for German economic history.

In the introduction (Chapter I) Rainer Metz discusses the economic-historical background of his topic and gives a brief overview of traditional explanations of long-term growth fluctuations, which have recently been challenged by the hypothesis of stochastic trends. After an explanation of this concept, the author points out that, with few exceptions, the modern tools of time series analysis have so far not been taken into account by historical business cycle and growth research. Especially in German-language economic historiography, corresponding studies are currently not available.

In the second chapter, Rainer Metz discusses the standard growth, reconstruction, catching-up, and structural break hypothesis as well as the hypothesis of the Kondratieff and Kuznets cycles and finally (and most extensively) the hypothesis of stochastic trends.

Already in this chapter, the author's working method, which is characteristic for the whole book, becomes apparent. He does not content himself with an abstract presentation and criticism of the respective explanatory approaches, but rather examines their empirical explanatory power on the basis of the series of the German gross domestic product (GDP) per capita of the population from 1850–1990. Characteristic of his working style is furthermore that he takes care of a meticulous clarification of even seemingly trivial matters, such as the concrete calculation of growth rates. Using GDP/capita as an example, he shows that it is quite possible to arrive at different rates depending on the calculation mode used (*e.g.,* OLS estimation of a log-linear trend, arithmetic mean, median, or potential growth).

After the author has shown with the help of regression and spectral analyses that only a limited explanatory value can be attributed to the standard growth hypothesis, the reconstruction hypothesis, the catching up hypothesis, and the structural break hypothesis, he turns to 'long waves' (according to Kondratieff and Kuznets), a field of research to which he has already contributed significantly with his own publications. Here the explanations are also illustrated by calculation for the German GDP series, and the problems of these approaches are illustrated. However, the central part of this chapter is a presentation of stochastic trends, which takes about 25 pages. The author introduces this concept step by step, illustrates it by simulated random walks with drift, simulates the German GDP series with an ARIMA (0,1,1) model, goes into detail about the essential differences between DS (difference-stationary) and TS (trend-stationary) processes and shows that stochastic trends play an essential role in the theory of real business cycles. The fact that traditional methods of trend adjustment can lead to statistical artifacts is illustrated by a random walk with drift and linear trend adjustment.

This chapter also contains a first, introductory application of a unit root test (a detailed discussion of these tests is provided in the next chapter).

Regarding the random shocks constitutive for a stochastic trend, the question of their persistence, that is their extent and duration, arises. The author discusses different operationalizations of persistence, compares persistence in TS and DS processes, and illustrates different persistence properties of both process types for the German GDP series, firstly via the cumulative impulse-response function, and secondly via a decomposition of a series into non-observable components. For the latter approach, alternatively the Beveridge/Nelson decomposition or the decomposition of a series into trend and cycle according to the structural component model according to Harvey is chosen. The different results are then compared for the German GDP series.

A major result of this chapter is that the author succeeds in systematically comparing the traditional and stochastic explanatory hypotheses with the help of the terms trend component and trend rate. The fact that the traditional models imply only a low persistence of random shocks compared to the stochastic ones proves to be decisive. An approximately 20 pages long section *Summary and Comparison* summarizes the concepts and essential results of this chapter in a clearly arranged form. Since each of the further chapters concludes with such a summary, this will not be specifically mentioned in the following.

After the basic ideas of the identification of stochastic trends by means of unit root tests have already been addressed in the previous chapter and demonstrated by means of an example, Chapter III is dedicated to a detailed presentation and critical appraisal of unit root tests. First the classical Dickey/Fuller test is discussed, then tests with more general AR(p) models. This is followed by the ADF (Augmented Dickey/Fuller) test and the (non-parametric) Phillips/Perron test. In addition to the prerequisites, special problems are pointed out which have to be considered when using these tests. Also alternative unit root tests (Hall 1989; Pantula and Hall 1991; Sargan and Bhargava 1983; Durlauf 1993; Choi and Phillips 1993; Kahn and Ogaki 1990) are briefly touched upon, but are not pursued further, since they have hardly played a role in empirical studies so far and, in contrast to the ADF and Phillips/Perron tests, little is known about their quality. In addition to these tests, which are used to discriminate between an I(1) and an I(0) process, *i.e.* a difference-stationary and a trend-stationary process, unit root tests, which are suitable for an analysis of an extended model class, are briefly

discussed (Dickey and Pantula 1987; Ouliaris *et al.* 1989). This includes ARFIMA models, that is fractionally integrated ARIMA models.

The problem of the persistence mass, already mentioned in the previous chapter, is taken up again and a measure (variance ratio) proposed by Cochrane is presented. Furthermore, the important difference of DS and TS processes in the frequency domain at frequency =0 is pointed out. The practical application problems that arise in unit root tests (choice of model, test, determination of the period of investigation and the maximum number of lag) are demonstrated by the author by means of a detailed and critical summary of the investigations of Nelson and Plosser (1982), Stock and Watson (1988), Perron and Phillips (1987) and Perron (1988, 1989). As Metz states in a summary of recent studies, their general conclusion is that macroeconomic time series follow a stochastic trend, which is why this trend has been given the quality of a stylized fact in econometrics and macroeconomics. The author discusses the fact that this also has consequences for historical research on economic cycles and growth from both methodological and substantive points of view. If economic history is to be taken seriously from a methodological point of view, it must deal with these arguments. This is precisely what Rainer Metz clearly sees and is one of the main concerns of the present paper. However, the broadest space (70 pages) in this chapter is devoted to a critical appraisal of the standard root tests. It deals in detail with quasi-trend stationary and quasi-integrated processes, the empirical equivalence of DS and TS processes in finite samples, the numerous published studies on the power of unit root tests. The most important finding is that stochastic trends cannot be clearly detected with the currently available test procedures and that therefore the characterization of stochastic trends as a stylized fact of macroeconomic time series is highly questionable.

By comparing the results of the numerous methods using the same data (the Nelson/Plosser dataset), Rainer Metz succeeds in clearly showing the methodological conditionality of the results. He thus succeeds in providing stringent proof that it is not statistical tests and mass that can decide on the model suitable for analysis, but rather primarily substance-scientific considerations. This is of the greatest relevance for future research because it contradicts the currently accepted idea that it is possible to decide on the structure of the data-generating process solely on the basis of empirical knowledge.

Chapter 4 is dedicated to different possibilities of trend estimation. After introducing the basic concepts of filter theory and a short discussion of different filter design approaches including the Hodrick and Prescott filter (1980), the possible applications and limitations of filter-theoretical trend estimations are examined on the basis of simulated series and the US GDP series of 1909–1970. The author shows that even an 'ideal' filter is no guarantee that statistical artifacts will not be generated. For this one would have to know, for example, whether the series have a component structure and whether the spectra of this component overlap. The fact that linear time-invariant filters have different transmission characteristics depending on the degree of integration of the components to be filtered has been clearly pointed out by Rainer Metz with reference to the latest research results. This is followed by the treatment of stochastic trends in ARIMA(p,1,q) models, with special attention being paid to the Beveridge/Nelson decomposition (1981). After a presentation of the theoretical foundations of this decomposition principle, exemplary simulated series and the US GDP series are decomposed into trend and cyclical components. The problems associated with such a decomposition are discussed and the dependence of the resulting components on the selected ARIMA model is demonstrated. The author shows that the estimation procedure corresponds to a one-sided FIR filter, which can lead to considerable phase shifts and thus artificial cycles. He therefore advises against the use of this method in business cycle and growth research.

As an alternative to trend estimation in ARIMA models, stochastic trends are to be regarded in the context of the so-called structural time series models, which go back to Harvey, and to which the author then turns his attention. After a presentation of the corresponding theoretical foundations as well as the estimation and diagnostic problems of these models, practical trend and cycle estimates are again carried out using simulated series as well as the US GDP series and the results are critically evaluated. The author succeeds in unmistakably pointing out the weaknesses of this method. Nevertheless, it proves to be superior to ARIMA modeling in some respects, which is why the author considers it for historical analysis.

In the final section of this chapter, the author addresses several problem areas that are particularly relevant to the present topic: problems of model selection (especially ARIMA versus structural models), problems of independence of trend and cycle as well as artificial cycles, problems of distinguishability of I(1) and I(2) trends, and finally the properties of difference filters. All these topics are not only treated theoretically, but also illustrated with examples. From this discussion Rainer Metz derives important general conclusions which

future research in this field (but also empirical macroeconomics) must take into account. Based on the properties of different methods, he states first of all that, due to differences of a series, it cannot be determined whether processes are important for the series course in the long run, if a component model is assumed. If, on the other hand, integrated processes are assumed, there is a risk of generating artifacts. The author convincingly demonstrates that the idea that the data-generating process can be determined solely on the basis of the data is incorrect; therefore this dilemma cannot be solved. Thus, and this is a central result of this discussion, it is neither possible to discriminate between alternative statistical models in a purely 'data-driven' way, nor can unambiguous statements about causal theories be derived in this way. Model selection is therefore always dependent on a priori assumptions, whose validity must be assessed outside of statistics.

In chapter 5, Rainer Metz first of all deals with the fact that the DS and TS processes, which have so far been the focus of the investigation, can be understood as special cases of a more extensive model class, for example the so-called segmented trend models, especially the linear one. After the formal presentation of various trend break models, the effects of such alternative models on the unit root tests are discussed and it is pointed out in particular that, in contrast to the classical Nelson/Plosser result, the null hypothesis of a unit root must often be rejected if the linear segmented trend model with a break is considered as an alternative hypothesis. In this paper, the re-analyses of the Nelson/Plosser data set by Perron, Zivot and Andrews (1992) are discussed in detail (while Perron allows only one break point, which has to be given a priori, the unit root test after Zivot and Andrews estimates the break point from the data). Again, the author proves that the results derived with these methods are based on the a priori model assumptions. He also emphasizes that these methods are too restrictive for empirical research, although they are extensions of the original tests. Detailed comments are then made on the results of recent empirical studies on the existence and extent of stochastic trends in long series of the national product, taking into account a total of twelve countries. A critical comparison of the numerous empirical studies makes it clear that the existence of a unit root and the extent of persistence in finite time horizons have nothing to do with each other. Moreover, the author shows that for one and the same time series, substance-scientific interpretation is no longer possible. All in all, after a critical review and appreciation of the numerous studies, the author draws the conclusion that the unit-root hypothesis for macroeconomic time series, which has so far been regarded as secure, is more than questionable if trend breaks (more generally: outliers) are taken into account. In a critical

summary of Section 4, Rainer Metz questions the usefulness of unit root tests in general. From the situation designated as 'unit root trap' and the 'death blow' for the unit root tests resulting from it the author derives the demand for a critical revision of the present research practice, in other words, he regards a further occupation with these tests as little meaningful. In his final study of the German GDP series of 1850–1990, the author therefore does not perform unit root tests and instead formulates the hypothesis that GDP growth rates follow a stationary stochastic process overlaid by irregular random shocks, which he estimates using outlier analysis within the ARIMA models (Darné and Diebolt, 2004). As a novelty, the author divides the irregular shocks into persistent and transitory shocks. Thus, he succeeds in identifying the significance of irregular shocks for growth and the business cycle, again naturally depending on the model. This analysis leads to several economically historically interesting results: above all, the two world wars cause a permanent change in the level of GDP; the high growth rates of the period after 1949 prove to be temporary deviations from a long-term equilibrium and are therefore not compatible with the 'long waves' hypothesis. For the first half of the 20th century, the author demonstrates a sustained increase in the rate of growth in Germany, while it is currently back at the level prevailing at the beginning of the century. Furthermore, the author also succeeds in deriving systematic results. For example, ignoring outliers in component models leads to an overestimation of the business cycle component and an underestimation of the growth component and thus erroneously to a systematic interpretation of historically determined irregular influences.

The final chapter offers a summary of the main questions and results of the entire work, again highlighting their special importance for the interpretation of growth and business cycle of German GDP.

Evaluation

Rainer Metz has set himself the goal with his work of providing a presentation and critical evaluation of various explanatory approaches to long-term growth fluctuations, particularly with regard to their significance for the interpretation and analysis of the development of the national product in Germany in the period of 1850–1990. That he has succeeded in this in an outstanding manner is absolutely beyond doubt for me. His remarks show that he has mastered the truly difficult subject matter and the methodological tools necessary to deal with it. His argumentation is consistently stringent and never superficial. The individual arguments

are carefully weighed against each other. His thought processes are consistently concise, without digressions or discussions of minor issues.

However, this work is a 'hard nut to crack' for traditional economic historians, as it cannot generally be assumed that this reading group has such extensive knowledge of time series analysis. The attached appendix, which introduces basic concepts of time series analysis in an understandable way, should therefore be a welcome and useful aid for many readers. Apart from that, other tools important for the presented study, such as unit root tests, are discussed in detail in the text. However, it should be emphasized that the problems discussed by the author cannot be treated with elementary and a priori generally understandable tools. Any attempt in this direction would be doomed to failure from the outset or would not be taken seriously by any statistician/econometrist.

Although the author's economic-historical explanations are essentially limited to a series, that of the GDP/capita of the population in Germany, in my opinion the book also represents an extremely fruitful work and a breakthrough for historical economic and growth research in more than one respect. However, the fact that the range of the results is limited by the quality of the series used can hardly be at the author's expense. The BIP series used by the author represents the best that is currently available for such research. The revision of the series would not only be the subject of a separate work, but would completely exceed the scope of the primarily methodologically oriented work presented here.

Apart from the demanding methodological level, the work also bears witness to the author's immense diligence. This is demonstrated not only by the many own studies and calculated examples, but above all by the large amount of processed (and not only in the list of publications) literature, which reaches up to the immediate present. For any reader interested in this subject, the work proves to be a real treasure trove in this respect. In addition, the author has pointed out unsolved problems in quite a few places and has already begun to design further research, so that some more activities in this field can be expected from his side. With this book, Rainer Metz has succeeded in writing a work of high scientific quality, for which there is no comparable work in the Anglo-Saxon, French or German language areas.

In conclusion, I would like to point out that the work by Metz, which is exemplary in bridging the gap between economic history and econometrics, is absolutely topical because I believe that cliometrics will become more and more important in the future of social sciences. In some way, the award of the 1993 Nobel Prize to Fogel and North marked only a step, even major, for the success of the marriage between theory, history and statistics (Diebolt, 2016, Diebolt and Haupert, 2019).

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