The Height of Conscripts and National Income: Apparent Relations and Misconceptions*

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In 1988, H. J. Brinkman, J. W. Drukker and B. Slot published in this journal "Height and Income: A New Method for the Estimation of Historical National Income Series" (25, 227-264). The authors argue that Dutch national income in the nineteenth century can be estimated on the basis of the measured height of potential conscripts at the time of their first medical examination. This theory is criticized in this article, and it is demonstrated that the close relation they found between height and the lagged values of national income must be viewed as an artifact of the statistical method they used. In addition, the quality and the representativeness of the data they used are criticized. © 1993 Academic Press, Inc.

I. INTRODUCTION

In 1988, H. J. Brinkman, J. W. Drukker, and B. Slot published "Height and Income: A New Method for the Estimation of Historical National Income Series" (Brinkman *et al.*, 1988). The authors argue that it is possible to estimate Dutch national income in the 19th century on the basis of the measured height of potential conscripts at the time of their first medical examination.

In short, Brinkman *et al.*, reasoned as follows:

1. On the basis of a theoretical assessment, they arrived at a presumed relation between the development of the conscripts' height (H) and national per capital income (Y).

2. On the basis of Y in the period 1900-1940 and the median of H in 1918-1940, they estimated the relation between one normal and 18 lagged values of Y as independent variables for the years T_t and T_{t-1} - T_{t-18} and H as the dependent variable for the year T_t . After some experimentation, Brinkman *et al.* chose a third degree polynomial distributed

* Our thanks go to A. Callewaert and R. Yntema for translating the Dutch version into English.

lag equation (or Almon-lagged equation) for the functional representation of the relation.

3. They considered the R^2 of the relation high enough to feel justified in rewriting the equation "in such a way that it can be used to estimate yearly figures of real per capita income for those years where data on income are lacking, but statistical information on the height of recruits is not" (Brinkman *et al.*, 1988, p. 227). Aided by this "inverse" relation, they "predicted" national income for the period 1900–1921. On the basis of the series of Y for the years 1922–1939 and the median height in 1939, they first predicted the value of Y for 1921. Next, the value found for 1921 was used, together with the known values of Y for the years 1922–1938 and the median height for the year 1938, to predict national income in 1920. This process was repeated until they reached the year 1900.

4. These results were then compared to the national income data which they first used, and they concluded that the values they obtained corresponded sufficiently well with the initial series to use the equation; with the series of national income they calculated for the years 1900–1918 and the known median height of the conscripts in the period 1863–1918, they then "predicted" national per capita income for the years 1845–1899.

In our opinion, the relation they found between height and national income is to a large extent based on misconceptions and a misunderstanding of the properties of the relevant statistics. This is the primary, and for us sufficient, reason why we do not accept the results of their national income calculations. In addition, we will discuss what we view as the incorrect use of the data on height and national income upon which they base their model.

The critique is presented as follows: First, the supposed theoretical relation between national income and the conscripts' height is scrutinized. Second, we direct criticism at the way in which Brinkman *et al.* used the data. In particular, we analyze the data on height and present an alternative series for the median height of the conscripts in the Appendix. Third, the statistical relation they posit between height and national income is subjected to a critical assessment. This section has been divided into three parts: (a) an evaluation of the national income figures they used; (b) an investigation into the value of the relation they found; and (c) the construction of new extrapolations for the 19th century.

II. THE RELATIONSHIP BETWEEN HEIGHT AND NATIONAL INCOME

On the basis of a study regarding height in medical literature, Brinkman *et al.* concluded that "the median age and sex-specific height is affected in a complex way by changes in housing conditions, genetic factors, contagious illnesses, medical care, hygienic conditions, length of the labouring

day, and last but not least the quantity and quality of nutrition. As far as the genetic factors are concerned it might be clear that this influence is probably small and in respect of one country . . . negligible." (Brinkman *et al.*, 1988, p. 238). Brinkman *et al.* feel justified in using national income as a kind of catch-all variable for the aforementioned factors. Also of importance is their presupposition that "one and the same growth promoting stimulus" has greater importance in a period of fast growth, such as the age of two or three, then in a period of relatively slow growth, such as at the age of 11 or 12 (Brinkman *et al.*, 1988, p. 233).

As far as the relation between material circumstances and the conscripts' height is concerned, Brinkman *et al.* rely primarily on the dissertations written by Oppers (1963) and van Wieringen (1972). One should question why they did not rely more on the extensive literature concerning human growth in the 20th century (e.g., Tanner, 1981; Eveleth and Tanner, 1976), especially because much of this literature concerns underdeveloped countries which are quite comparable with the situation of the Netherlands for the period until about 1870. Brinkman *et al.*, however, fail to understand that insofar as Oppers and van Wieringen find a relation, it is a relatively short-term one. For example, van Wieringen noted a clear connection between the unfavorable material circumstances during the First World War and the heights of the recruits in 1918–1921 and between the economic crisis of the 1930s and the heights of the recruits in 1931–1934 (van Wieringen, 1972, pp. 117–119). The clearly visible effects of the Second World War on height had already disappeared in 1950. Van Wieringen concluded that "It is not probable that the crisis period had a special effect on the conscripts' height in 1950" (van Wieringen, 1972, pp. 117–118). Oppers established that the lack of food during the Second World War only affected the conscripts' height between 1948 and 1953, and ceased to have an effect after that. (Those who were examined in or after 1954 were 10 years old or younger in 1944–1945.) A retardation in growth at a young age is no longer relevant at the time of the medical examination (Oppers, 1963, pp. 30–37). Therefore, if material circumstances improve, an arrears in growth can be made up. For the 19th century there is an analysis made by de Meere which also demonstrates that the fluctuations in the share of undersized conscripts generally coincided with the food situation in the years immediately preceding the examination (de Meere, 1982, pp. 100–108).

If the above is correct, then we fail to see how a slowdown in growth at an early age can influence the ultimate height measured at the time of the examination other than through shifting the growth to a later age, and in particular to the stage of growth known as the adolescent growth phase. Although we agree with Brinkman *et al.* that human growth is primarily determined by material circumstances, and especially nutrition,

we have very strong doubts about the link which they make between material circumstances in all of the 19 years preceding the measurement and the result of that measurement.

Furthermore, we do not agree with their view that national income can be used as a kind of "catch-all" for the material circumstances of the population. Whether national income is viewed from the demand side or the supply side, it includes many more factors than just the production and consumption of "primary and secondary" necessities. In addition to this, there is the problem of changes in the distribution of wealth and income. For example, the agricultural depression during the 1880s resulted in a decline in food prices which led to an increase in the real wage of urban laborers and to the impoverishment of the agricultural population.

III. THE USE OF DATA ON THE HEIGHT OF CONSCRIPTS

With respect to the use of the data on the conscripts' height, Brinkman *et al.* state the following: "In the first place the use of the data of conscripts is obvious: every man must be measured—although not always at the same age— . . . In the second place it is necessary to take median height, because the height of the conscripts is published in tables that have open classes at their upper—and lower—ends. As a consequence average height cannot exactly be derived from the tables, but for median height this is possible." (Brinkman *et al.*, 1988, pp. 238–239). Our critique is first directed at the question of whether these data can be used, in other words, precisely who was measured? Second, we examine the procedures they used in calculating median height.

Who was measured? Brinkman *et al.* are mistaken when they state that the median height they calculated is the average of each man who was to be examined. In the second half of the 19th century, far from all of the conscripts were present to be measured on the lotting-day (*lotingsdag*); around 15% were absent. The question is to what extent this influenced the average measured height. In another article, Brinkman, Drukker, and Stuuroop (1989) defend the representativity of their material. In spite of the many good arguments which they present to support the assumption that the measurements are representative for the entire population, it is our view that there is a certain bias which results in an average measured height which is too low.

In the first place, it seems to us beyond doubt that the higher classes tended to stay away more than the lower classes. Bruinsma describes the lotting-day as follows: "While in the countryside and among the working classes the lotting-day is regarded as a special event, from which no one is absent, several considerations lead many citizens and especially the well-to-do in the cities not to personally attend the lotting and have their height measured" (Bruinsma, 1907, p. 217; see also pp. 207–208 and 218). On the basis of data for Utrecht (in the period 1900–1909), Enklaar

calculated that if the difference in class attendance is eliminated, the average height is 1 mm greater. Moreover, and probably more important, there is the phenomenon—which Enklaar also noted—that nearly *all* of the conscripts who were undersized, or almost undersized, would have been present, irrespective of their social class (Enklaar, 1912, pp. 35–36 and 46–48). One of the arguments put forward by Brinkman, Drukker, and Stuuroop in support of their contention that their data are representative is that young men from the upper classes also showed up, in the hope of being rejected, because the legally required substitute would cost 500 guilders. In addition, they demonstrated that approximately one-fifth to one-third of the absentees were professional soldiers, all of whom were, of course, over the minimum length (Brinkman *et al.*, 1989, Chap. 5; Table 4).

All in all, the aforementioned factors lead the actual average height of the population to be underestimated. Even though this does not amount to very much with respect to the total average height, one must realize that (a) a minimal systematic underestimation of 3 mm already accounts for almost 10% of the total median growth of 35 mm between 1863 and 1900; and (b) that a systematic *underestimation* of the height is reflected in the model through a systematic *overestimation* of the growth of the national income in the 19th century.

Finally, we have serious doubts about the way in which Brinkman *et al.* calculated the conscripts' median height. In another paper we have shown that a more accurate estimation of the median height almost always gives higher figures, especially during the 19th century and the first decade of the 20th century. Moreover, the extreme changes in median height which occur in the estimates of Brinkman *et al.* in 1864, 1881, and 1937, disappear in our series (Mandemakers and van Zanden, 1990). The revised series is presented in the Appendix.

All of our criticisms point in one direction: a varying though systematic *underestimation* of median height in the 19th century results in a varying, yet systematic *overestimation* of economic growth, and, in all probability, in incorrect parameters for the Almon-lagged regression equation with which Brinkman *et al.* calculated their national income estimates.

IV. NATIONAL INCOME DATA

For their calculations, Brinkman *et al.* needed data on national per capita income in constant prices for the period 1900–1940. In the appendix to their article, they present two series of estimates for national income, one derived from Van Stuyvenberg and de Vrijer (VSV) and another one (primarily) derived from Mitchell. It is remarkable that they were evidently not bothered by the availability of two series. They do not even treat the question of which series is the most reliable and can best be

used. Moreover, only via indirect evidence can the reader infer that Brinkman *et al.* must have chosen to use the VSV series.

They also totally disregard Griffiths and de Meere's critique of the series. This made it clear that the data for the years 1900–1921 cannot be taken seriously. For example, to deflate the series of nominal national income, because an appropriate deflator was not available, use was incorrectly made of a price index of the cost of living. In addition, both series show improbably slow growth between 1900 and 1913. In these years of fast economic expansion, real per capita national income would only have increased by 0.65% per year according to the VSV series (while the Mitchell series only shows a growth of 0.28% per year).

In 1987 the Dutch Statistical Office (CBS, 1987), which acknowledged the aforementioned problems, published new and highly improved national income estimates for the period 1921–1939. These show a much faster rate of growth in national income than had been previously assumed, and especially for the 1920s. Brinkman *et al.*, however, have not used (or could not use) these figures. The corrected figures which we use in our calculations in the next section consist of the new CBS statistics for 1921–1939 and the population data provided by Maddison (1982, pp. 249–251). For the period 1900–1920 we (grudgingly) have had to make use of the VSV series. Only by repeating the calculations made by Brinkman *et al.*, and by expanding on them, could we investigate the significance of their results.

V. THE ALMON-LAGGED REGRESSION EQUATION

Presumably the most convincing part of the research done by Brinkman *et al.*, and which would seem to stifle even the strongest criticism, is their analysis of the statistical relation between the conscripts' height and national per capita income in the period 1918–1940. The R^2 found in this analysis is impressively high (greater than .99). Furthermore the coefficients which are used in the Almon-lagged equation produce a pattern that resembles Oppers' YASSIS-curve (Yearly Age and Sex-Specific Increase in Stature) (see Fig. 1).

In this section we test the validity of their result by making use of the corrected data for national income and median height. The Almon-lagged equation is determined by three variables (Brinkman *et al.*, 1988, pp. 239–249):

- (1) the number of lagged years (n); Brinkman *et al.* chose $n = 18$, on account of the fact that the conscripts are measured in their 19th year;
- (2) the degree of the chosen polynomial (p); Brinkman *et al.*, heeding the movement of the YASSIS-curve, chose for a third degree equation;
- (3) whether a head or tail restriction is introduced, e.g., a consequence of a head restriction is that the influence of the preceding year ($t - 1$) reaches zero.

FIG. 1. The YASSIS-curve and the coefficients of the Almon-lagged equation according to Brinkman *et al.* (1988).

By making these three choices, which together determine the structure of the Almon-lagged equation, a certain conformity develops between the coefficients of the Almon-lagged equation and the YASSIS-curve. It would then appear that their result, namely, that both curves resemble each other (Brinkman *et al.*, 1988, pp. 242–244), is largely the result of these choices. Brinkman *et al.*, obtained a YASSIS-curve because they chose n , p , and the head restriction in such a manner that the result had to be a YASSIS-curve.

If the Brinkman *et al.*'s hypothesis is correct, then the regression equation with $n = 18$, $p = 3$, and a head restriction must produce better results than regression equations with other combinations of the Almon-lagged variables. We have attempted to empirically test this hypothesis by making the same calculation with a large number of combinations of these variables and with the corrected figures for height and national income. The possibilities are naturally almost endless, and for practical reasons we have confined our experiment to the following possibilities: $p = 1, 2, 3$, and 4 ; $n = 5, 10, 13$, and $15-21$; and with and without a head restriction. Only the relevant results have been presented in Table 1.

As Table 1 indicates, equations *not* making use of the ideal combination posited Brinkman *et al.* ($n = 18$; $p = 3$ with a head restriction) can give very satisfactory results. Very often high F values and high R^2 values in

TABLE 1
Results of Estimation of the Almon-Lagged Equation between Height and Income and Different Combinations of n and p
with/without Head Restriction

	$n = 5$										18	19	20	21
$p = 1$ with head	R^2								.959		.961	.960	.962	.965
	F								449		463	461	480	527
	DW								.59		.52	.56	.65	.60
$p = 1$ without head	R^2			.986					.9903		.9918	.9915	.9907	.9915
	F			692					972		1149	1104	1013	1103
	DW			1.47					2.10		2.24	2.23	2.24	2.16
$p = 2$ with head	R^2			.973					.979		.981	.982	.982	.982
	F			347					443		496	514	519	526
	DW			.89					1.11		1.15	1.19	1.23	1.20
$p = 2$ without head	R^2			.9899					.9901		.9913	.9909	.9903	.9910
	F			622					636		725	694	646	696
	DW			1.93					2.18		2.24	2.23	2.25	2.17
$p = 3$ with head	R^2	.54		.9897					.9903		.9916	.9895	.9875	.9880
	F	177		610					645		750	595	501	523
	DW	.31		1.90					2.36		2.29	2.08	1.99	1.74
$p = 3$ without head	R^2	.53		.9894					.9897		.9911	.9904	.9901	.9905
	F	125		444					455		531	490	478	497
	DW	.29		1.94					2.31		2.30	2.23	2.22	2.22
$p = 4$ with head	R^2	.53		.9907					.9909		.9915	.9913	.9915	.9904
	F	125		508					516		552	544	552	491
	DW	.26		2.18					2.33		2.36	2.37	2.31	2.28
$p = 4$ without head	R^2			.9901					.9907		.9912	.9918	.9914	.9899
	F			382					408		429	459	438	373
	DW			2.19					2.49		2.43	2.64	2.42	2.25

Note. F : F-statistic; DW: Durbin-Watson statistic; R^2 : Adjusted for degrees of freedom.

combination with a reasonable outcome for the Durbin-Watson test are found. In other words, the results of Brinkman *et al.* are not exceptional for this type of analysis. It is remarkable that $n = 18$ scores best in almost all of the series; the values of F and R^2 (which, of course, are connected) nearly always reach the highest level with this number of lags, but the differences with other values of n (17, 19) are small. This part of the hypothesis is in a certain sense supported by this analysis.

However, for the head restriction and the degree of the polynomial this is less clear. One can conclude that a large number of combinations of Almon-lagged variables give a good fit and, therefore, are well suited for extrapolating the relation between height and national income. The results of this research give a large number of possible growth paths for national income in the 19th century; this, in fact, only increases the uncertainty about the actual level of national income. However, with some good will, in Table 1 we can discern two clear toppers, namely, $n = 18$, $p = 3$ with a head restriction (the choice of Brinkman *et al.*) and $n = 18$, $p = 1$ without a head restriction. A number of other very good combinations (for example, $n = 18$, $p = 2$ without a head restriction; $n = 18$, $p = 4$ with a head restriction) differ only marginally from these two toppers. In order to work out the problems raised here, in the following paragraphs we extrapolate national income during the 19th century using these two toppers.

This exercise in working with Almon-lagged regression equations has made us slightly wary of the results. According to the rules of normal regression analysis, very significant and highly explained variances are found in almost all cases. It must be questioned to what degree this can be ascribed to the Almon-lagged equation itself. After all, this technique selects the structure of the lagged variables in such a way that the outcome is optimal (the R^2 is as high as possible). A high R^2 in an Almon-lagged regression equation can therefore not simply be compared with the same R^2 in a normal regression equation, a fact which Brinkman *et al.*, in our opinion, have completely overlooked.

This suspicion can easily be investigated by replacing national income in the Almon-lagged regression equation with two arbitrarily chosen series as explanatory variables for the conscripts' height in the period 1921–1940. These are (1) a series of randomly chosen numbers, ranging from 0–100, and (2) a series with an (arbitrary) trend of 3% per year (starting with 1900 = 100) and a random disturbance, ranging from –5% to +5% of the series' value. We have confined our exercise to $n = 10$, 13, and 15–21, and $p = 3$ without a head restriction (see Table 2).

Table 2 shows that the random series already produces significant results, with R^2 values around .88, even though the results of the Durbin-Watson test are constantly too low. The second series explains the variance in the height of conscripts even better. The R^2 is consistently greater than

TABLE 2
Results of the Estimation of the Almon-Lagged Equation between Height and Two Arbitrary Series and Various Combinations of n

n		10	13	15	16	17	18	19	20	21
$p = 3$ without head restriction	R^2	.28	.78	.85	.88	.90	.89	.87	.88	.94
	F	3	18	28	36	43	38	32	37	70
	DW	.32	.81	.60	.86	.95	.74	.55	.66	.89
	R^2	.981	.989	.988	.982	.983	.986	.986	.987	.987
	F	253	412	392	267	272	348	357	363	373
	DW	1.24	1.69	1.66	1.42	1.39	1.67	1.61	1.67	1.82

.98 and the Durbin–Watson test is satisfactory. Because the Almon-lagged regression analysis shows such significant relations between the conscripts' height and two *arbitrary* series, we can conclude that connection found by Brinkman *et al.* between height and national income on the basis of this technique must largely be attributed to the technique itself.

VI. THE EXTRAPOLATION

The series of real per capita national income for the Netherlands in the period 1846–1921 calculated by Brinkman *et al.*, which is based on an extrapolation of the relation they found between height and national income, has two striking features (Brinkman *et al.*, 1988, Fig. 4, p. 249). In the first place, the series is characterized by *extreme fluctuations* in national income and, in the second place, by remarkable *trend movements*.

The national per capita income estimates presented by Brinkman *et al.* show wide fluctuations in growth, for example, in 1846 (per capita) income increased by 181% (!), in 1863 by 30%, and in 1894 by 28%. Moreover, in contrast to these years of remarkable growth, we find years in which the economy must have collapsed dramatically: in 1861 per capita income declined by 26%, in 1877 by 22%, and in 1892, once again, by 22%. Brinkman *et al.* attempt to side step this problem by ascribing the extreme fluctuations to “the premodern” or “early modern” society (Brinkman *et al.*, 1988, p. 255), but this is only a guess on their part and is not supported by any empirical study. The extreme fluctuations in their series, for that matter, can partially be explained through the mistakes they made in calculating the conscripts' median height (see Section III). For example, the extreme growth in 1846 (or rather, the extremely low figure for 1845) disappears when the corrected figures for 1863 and 1864 are used.

The trend movements which can be distinguished in the series presented by Brinkman *et al.* also raise questions. Generally speaking, the following trends can be discerned (also see Brinkman *et al.*, 1988, pp. 254–255): a decline between 1846 and 1861; strong growth between 1861 and 1869; decline or stagnation between 1869 and 1886; strong growth between 1886 and 1894; and stagnation between 1894 and 1913. Such a periodization of the economic history of the Netherlands is, however, difficult to accept. It might be possible to accept the stagnation in the 1850s and the growth in the 1860s, but after 1869 the series loses all contact with reality. The 1870s are generally regarded as years of relative prosperity; the agricultural depression only became acute toward the end of the 1870s (or even only after 1882) and the urban sector was expanding rapidly (van Zanden, 1985, p. 246). There are indications that the depression of 1873–1879, which originated in Germany, was not felt in the Netherlands, where the building cycle peaked in the late 1870s and heavy public expenditure on the infrastructure (railways, canals) stimulated international trade and shipping. (de Jonge, 1968, pp. 200–205). The economy of Amsterdam,

for instance, boomed thanks to the opening of the North Sea Canal in 1876 and the spectacular expansion of the diamond cutting industry, the result of a sharp increase in the supply of diamonds from South Africa (van Zanden, 1987, pp. 52–54). The volume of international trade and shipping in the Netherlands almost doubled between 1870 and 1880, and the output of all major industries for which data are available increased rapidly during these years, except for the sugar refining and shipbuilding industries (Griffiths, 1890, pp. 13–14 and 23–25).

The period 1886–1894, when the depression in the agricultural sector and some industries reached rock bottom, was in contrast unfavorable (see, for instance, van Tijn, 1979, pp. 238–239). But no Dutch historian would dare to assert that the Dutch economy stagnated between 1894 and 1913. These were the years in which J. A. de Jonge, in his impressive study on industrialization in the Netherlands, dated Rostow's take-off and in which R. T. Griffiths dated Greschenkron's "big spurt" (de Jonge, 1968; Griffiths, 1980). The industrial growth in the period after 1895 has been well documented in these studies. The expansion of the agricultural sector, which recovered from the "Great Depression" after 1895, was perhaps just as impressive. Recent calculations made by M. Knibbe show that agricultural production grew annually by 2.2% in the period 1895–1913 (in contrast to 0.6% in the period 1870–1895) (Knibbe, forthcoming; also van Zanden, 1985). The revival of the trade with Indonesia and the rapid growth of the German economy were the main engines of the growing output in the international service sector during these years (Griffiths, 1980). In short, all available evidence points to a very rapid expansion of the Dutch economy in the period after 1895, and this must have led to a rapid rise in per capita income.

The results of the extrapolation made by Brinkman *et al.* are, therefore, not satisfactory. It is the question, however, if their result can be improved upon by using the corrected series for the recruits' length and per capita income in first estimating the model and then in making the extrapolation. To show step by step the consequences of the changes in the data and the model for the estimated per capita income in the period 1845–1920, five different extrapolations have been carried out, of which the data (and results) increasingly differ from those of Brinkman *et al.*

The results of these extrapolations are shown in Table 3 and compared with the series of Brinkman *et al.* (series 0). This comparison shows that series 1, in which only the corrected series for the heights was used in an extrapolation made with Brinkman *et al.*'s model, almost does not differ from series 0; only the coefficient of the variance is somewhat smaller because the most extreme fluctuations have been eliminated. The reason for this is that the trend of the corrected series of the height data almost does not deviate from the trend of the series used by Brinkman *et al.* The degree to which series 2 (estimated with the new income series) and

TABLE 3
The Comparison of the Various Extrapolated Series with the Original Series

Series	Series for estimating model (1900-1940)		Series for back- casting (1845-1920)	Parameters	Average annual growth rate 1846/1855-1905/1913	Coefficient variation ^a
	Length	Income				
0	Brinkman	Brinkman	Brinkman	$n = 18/p = 3$ Head restriction	1.17	.27
1	Brinkman	Brinkman	Corrected	Idem	1.13	.25
2	Brinkman	Corrected	Brinkman	Idem	1.53	.36
3	Corrected	Brinkman	Corrected	Idem	1.09	.29
4	Corrected	Corrected	Corrected	Idem	1.80	.46
5	Corrected	Corrected	Corrected	$n = 18/p = 1$ No head restriction	2.49	.71

^a Standard deviation/average 1846-1920.

FIG. 2. The deviations of series 2 (solid line), 3 (dotted line) and 4 (dashed line) from the original series (1847–1921); because the deviations in 1845–1846 are extremely large, the figure starts in 1847.

series 3 (estimated with the new height series) differ from the original series 0 can be seen in Fig. 2. In series 2 especially the *trend* deviates because the new income series shows a stronger trend for the period 1920–1930, while in series 3 the *fluctuations* around the trend have a different pattern than in series 0. Series 4, the second topper in the previous section, clearly combines both deviations from series 0 (Fig. 2). As a result, the fluctuations around the trend are considerably larger than in the original series. Finally, series 5, the first topper in the foregoing section, shows much faster growth and very extreme fluctuations (Fig. 3). Because of the extreme fluctuations in the last two series, it is not meaningful to further analyze the trends of these series; consequently, at this point, we

FIG. 3. Estimates of national per capita income 1846–1921; series 5 (dotted line) compared with series 0 (solid line) from Brinkman *et al.* (1988).

have stopped in making a comparison of the results of Brinkman *et al.* Summarizing the results of the extrapolation, it can be concluded that using different height series matters little, and that the main differences were the result of the use of corrected income series, which showed a higher growth rate, and of course the choice of the different set of parameters of topper 1.

The extreme fluctuations of national income in the new series need to be explained. In our view this can be explained as follows: The Interbellum, the starting point of the extrapolation, is characterized by large fluctuations in national income, with peaks in 1920, 1929, and 1939. Because the extrapolation starts with these figures, the fluctuations in the extrapolated series will depend on the *structure* of the lags (a phenomenon which has been part of the theory of business cycles since Tinbergen). There are three possibilities:

- (1) the series explodes: the fluctuations become greater;
- (2) the series oscillates: the fluctuations remain constant;
- (3) the series implodes: the fluctuations become smaller.

The two series we extrapolated are examples of exploding series. The fluctuations in the second series even become so large that negative values appear for national income (and this is even impossible in a premodern society). The series of Brinkman *et al.* (1988, Fig. 4, p. 249), however, also shows a certain explosive development, although much less so than in our series. The extreme fluctuations they find in the nineteenth century must then primarily be explained through the *mathematical characteristics* of the model and are not related to the type of society.

In summary, it must be concluded that it is impossible to project relations as complicated as that between height and income into the past. Such an exercise is not much more than a shot in the dark: it may result in a bull's eye, but any other result seems just as likely. In short, in our opinion, it has no value at all.

VII. SUMMARY AND CONCLUSION

Our criticism of the new method presented by Brinkman *et al.* for estimating national income rests on several points. In the first place, we questioned whether there is a theoretical connection between the conscripts' median height and national per capita income 18 years earlier. In our opinion, the relation demonstrated by several authors between the material circumstances (and especially nutrition) in the 5 years preceding the examination and the result of the examination *cannot* be extended in order to calculate national income 18 years earlier. In the second place, we criticized their use of the data: we questioned the quality of the data they used for the conscripts' height and national income.

The most important part of our criticism is the assertion that the very

highly explained variance of the Almon-lagged regression equation must be viewed as an artifact of the statistical method they used. We demonstrated this by (a) using different, and sometimes highly divergent, parameters and still obtaining just as acceptably explained variances and levels of significance as those on the basis of which Brinkman *et al.* decided to make their projections; and (b) by using two random series as explanatory variables for height in the Almon-lagged regression equation and also obtaining very significant and highly explained variances (up to an R^2 as high as .98).

The series of national income extrapolated by Brinkman *et al.* was subsequently compared with what we know presently about the Dutch economy in the 19th century. The conclusion had to be that their results, especially for the period after 1870, are highly improbable. We also consider the yearly fluctuations they found to be highly unlikely.

Finally, we also made several extrapolations on the basis of an Almon-lagged regression analysis. For these calculations we used our corrected data for median height, the national income series we corrected using the new CBS data for the period 1921–1939, and the two Almon-lagged regression equations which we judged to be the best (the two toppers). The results were disconcerting: The fluctuations around the trend were enormous and one of the projected series of national income even became negative. The only conclusion which can be drawn is that the method employed by Brinkman *et al.* cannot be used to estimate national income.

APPENDIX: STATISTICAL ANNEX
Median Height of Dutch Conscripts (mm), 1863–1940

Year	(1)	(2)	Year	(1)	(2)	Year	(1)	(2)
1863	1640	1640.89	1889	1665	1667.54	1915	1694	1694.07
1864	1647	1642.70	1890	1665	1668.47	1916	1694	1694.04
1865	1645	1646.38	1891	1667	1670.50	1917	1696	1695.27
1866	1646	1647.85	1892	1667	1670.05	1918	1695	1698.36
1867	1645	1646.76	1893	1665	1668.50	1919	1698	1697.94
1868	1646	1648.09	1894	1667	1669.22	1920	1699	1699.54
1869	1647	1648.53	1895	1666	1669.46	1921	1701	1702.35
1870	1647	1648.40	1896	1669	1672.39	1922	1702	1703.48
1871	1647	1649.48	1897	1669	1671.60	1923	1704	1705.84
1872	1648	1649.75	1898	1671	1673.52	1924	1705	1707.56
1873	1648	1650.79	1899	1673	1675.78	1925	1707	1709.29
1874	1649	1650.75	1900	1675	1678.21	1926	1707	1709.64
1875	1650	1652.48	1901	1676	1679.47	1927	1709	1711.61
1876	1653	1655.07	1902	1677	1680.02	1928	1710	1713.80
1877	1653	1656.00	1903	1680	1682.47	1929	1712	1715.18
1878	1653	1655.52	1904	1680	1682.51	1930	1715	1719.91
1879	1652	1655.33	1905	1684	1686.10	1931	1716	1721.48
1880	1655	1657.56	1906	1684	1686.21	1932	1715	1719.61

APPENDIX—Continued

Year	(1)	(2)	Year	(1)	(2)	Year	(1)	(2)
1881	1658	1659.46	1907	1684	1685.69	1933	1718	1723.34
1882	1658	1660.58	1908	1687	1689.03	1934	1718	1723.84
1883	1660	1662.68	1909	1688	1689.46	1935	1719	1725.16
1884	1661	1663.99	1910	1686	1687.86	1936	1720	1727.22
1885	1663	1665.82	1911	1689	1690.92	1937	1728	1728.18
1886	1664	1666.92	1912	1692	1693.08	1938	1730	1730.20
1887	1666	1668.79	1913	1690	1691.38	1939	1732	1731.53
1888	1665	1669.17	1914	1692	1692.99	1940	1734	1734.32

Note. Column 1: Brinkman *et al.* (1988, 229–261); column 2: revised figures, Mandemakers and van Zanden (1990).

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