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Contours of the World Economy and the Art of Macro-measurement 1500-2001

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The Ruggles lecture is a suitable occasion for surveying the progress achieved, in the past 60 years, in quantifying world economic development, and analysing the causal influences which determine the pace and pattern of growth. This was a major objective of the founding fathers and leading activists in the first phase (1949-63) of IARIW's existence. The initiative for creating an association including both academics and official statisticians came from Simon Kuznets (1901-85), the pioneer of quantitative economic history, who had played both roles himself and had created a US association on the same lines (Conference on Income and Wealth) in 1936. Milton Gilbert (1909-79) and Richard Stone (1913-1991) were strategic partners with enormous international leverage in creating and diffusing standard procedures for constructing comparable national accounts (1).

I

Creating Standardised Estimates of GDP Growth for 1950 onwards

Gilbert had been responsible for the official US accounts during the war and from 1950 to 1961 was head of statistics and national accounts in OEEC. The Marshall Plan required criteria for aid allocation, and NATO needed them for its burden-sharing exercises. Gilbert met these requirements by pushing official statistical offices of the 16 OEEC member countries to adopt a standardised system of accounts, constructed by Richard Stone. At Gilbert's request, Stone set up a programme in Cambridge to train official European statisticians to implement the standardised system. A set of national handbooks was prepared to explain the problems of adjustment to the standardised system, and a first comparative set of accounts for the 16 countries for 1938 and 1947-52 was published by OEEC in 1954, with extensive notes explaining the adjustments which had been made to achieve comparability (the major author was Geer Stuvel, Gilbert's deputy in OEEC).

Richard Stone, together with James Meade, had created the first integrated set of national accounts for the UK in 1941. Stone and Gilbert met in 1944 at a wartime conference in Washington to harmonise the national accounts of the US, UK and Canada (see Denison, 1947), and became close friends. In 1953, Stone extended the operational impact of his OEEC experience as chairman of the United Nations Committee which first established a standardised system of accounts for worldwide application.

The standardised accounts provide a coherent macroeconomic framework covering the whole economy, crosschecked in three ways. From the income side, they are the total of wages, rents and profits. On the demand side, they are the sum of final expenditures by consumers, investors and government. From the production side, the sum of value added in different sectors-agriculture, industry and services, net of duplication.

Box 1 The International Association for Reseach in Income & Wealth, 1949-2004

Management: 1949-63: Simon Kuznets and Phyllis Deane; 1963-87 Richard and Nancy Ruggles; 1988-2004 Ed Wolff and Jane Forman.

Conferences

1949, Cambridge England; 1951, Royaumont France; 1953, Castel Gandolfo Italy; 1955, Hindsgavl Denmark; 1957, Arnhem Netherlands; 1959, Portoroz Yugoslavia; 1961, Tutzing Germany; 1963, Corfu Greece; 1965, Lom Sweden; 1967, Maynooth Ireland; 1969, Nathanya Israel; 1971, Ronneby Sweden; 1973, Balatonfüred Hungary; 1975, Aulanko Finland; 1977, York England; 1979, Portschach Austria; 1981, Gouvieux France; 1983, Luxembourg; 1985, Nordwijkerhout Netherlands; 1987, Rocca di Papa Italy; 1989, Lahnstein Germany; 1992, Flims Switzerland; 1994, St. Andrews Canada; 1996, Lillehammer Norway; 1998, Cambridge England; 2000, Cracow Poland; 2002, Stockholm Sweden; 2004, Cork Ireland.

Publications

Income and Wealth, Bowes and Bowes, Cambridge (11 books, 110 contributions):

Series I, (ed) Eric Lundberg; Series II, (ed) Simon Kuznets; Series III (ed) Milton Gilbert; Series IV (eds) Milton Gilbert and Richard Stone; Series V (ed) Simon Kuznets; Series VI (eds) Milton Gilbert and Richard Stone; Series VII author O. J. Firestone; Series VIII (eds) Raymond Goldsmith and Christopher Saunders; Series IX (ed) Phyllis Deane; Series X (ed) Colin Clark and Geer Stuvel; Series XI (eds) Simon Goldberg and Phyllis Deane.

Review of Income and Wealth, 1966-mid 2004 (154 issues, 1,000 articles)

1966-1987, Yale; 1988-2004, New York. Editors 1966-1971 Odd Aukrust and Per Sevaldsen; 1971-1973 John Kendrick and Jacques Mayer; December 1973-December 1987 Nancy Ruggles and Richard Ruggles; 1988-2004 Ed Wolff.

History Carson, C. S. (1999), "50-Year Retrospective of the IARIW: the Early Years", *Review of Income and Wealth*, September, pp. 379-396; Ruggles, R. (1999), "The Middle Years of IARIW, 1962-87" *Review of Income and Wealth*, September, pp. 397-440; Blades, D. (1999), "The Recent Period of the IARIW, 1988 to 1998", *Review of Income and Wealth*, September, pp.409-417. Berndt, E. R. and J. E.Triplett, (1990), *Fifty Years of Economic Measurement: The Jubilee of the Conference on Income and Wealth*, NBER, University of Chicago Press.

The UN could not exert as much leverage on its member countries to conform to the standardised system as Gilbert could in OEEC countries. There were two major areas of weakness. One of these was the adherence of the communist countries to the Marxist SMS (system of material accounts) which had a narrower definition of productive activity (excluding many service activities) and involved serious double counting (measuring Ggross output without deducting inter-sector transfers of inputs). The price system and tax-structures were different from those in capitalist countries, and measurement conventions gave incentives to exaggerate quality change when new products were introduced. These problems were greatly alleviated by Abram Bergson (1914-2003) who pioneered procedures for re-estimation of Soviet GDP on a basis corresponding approximately to Western conceptions in coverage, with elimination of double-counting, and repricing on an "adjusted factor cost" basis with imputation for capital costs which were not considered in Soviet accounting. These corrective procedures were applied to Soviet statistics by a team of CIA Sovietologists in Washington. In New York, Thad Alton and his colleagues did the same for Bulgaria, Czechoslovakia, East Germany, Poland, Romania and Yugoslavia. This work was financed for intelligence purposes, but was publicly available in annual reports to the US Congress (see Maddison 1998b).

Although there has been a major official commitment in the former communist economies to switch their national accounts to the standardised SNA system, the task has been complicated by the massive change in ownership structure, in the level and structure of prices, allocation of resources between consumption and investment, and statistical reporting procedures. It will take some years before these problems can be fully resolved. For China, international agencies, notably the IMF and World Bank continue to use the official measure of GDP growth, showing growth averaging 8.5 per cent a year for 1970-2001, whereas my adjusted measure shows a growth rate of 6.5 per cent.

Another main area of weakness is Africa, where there was and still is a great shortage of skills and money for such work in a large number of newly created countries. The gap in estimates of GDP growth was filled in substantial degree by the OECD Development Centre which compiled annual estimates of real GDP growth 1950-90 for 51 African countries. The Centre benefited from the expertise of Derek Blades, who had been chief statistician in Malawi for eight years, and by David Roberts who had similar experience in Gambia. Hugo Krijnse Locker (1928-1990), head of the Eurostat international comparisons division, helped increase inter-country comparability by expanding the ICP exercises for 1980 and 1985 to include PPP and real product levels for 22 African countries (see Eurostat 1989). Unfortunately, the latest Eurostat level comparisons for Africa 1993 were a fiasco, using adjusted exchange rates instead of PPPs. The best quality estimates of African GDP levels recently available are those of Summers and Heston (PWT 6.1, October 2002).

A third problem in the assessment of GDP growth performance in the higher income countries derives from changes in measurement conventions from 1998 onwards.

This involved adoption of hedonic indexes to adjust for assumed changes in quality of product, use of chain indices, and treatment of consumer software as investment.

Hedonic indices are perfectly respectable in small doses, but one can be skeptical about the widespread assumption that quality changes have been so large and monotonically positive. In the USA, where the switch to hedonics was most significant, their net impact was to raise the measured rate of growth to a somewhat greater degree than in Western Europe and Japan. US official estimates go back to 1929, and the changes in measurement technique had their biggest impact for 1929-50, raising the GDP growth rate for that period from 2.6 percent a year to 3.5. There was no counterpart to this long retrospective readjustment in other countries, and I have stuck to the earlier US official measure for 1929-50 (for reasons explained in Maddison, 2001, p. 138, and Maddison, 2003, pp.79-80). One would like to see a more rigorous examination of alternative measures and a smaller dose of euphoric reassurance that the new results are robust. More than 40 years ago, Milton Gilbert warned that adjustments for quality change could open Pandora's box: "In the end, they would make it impossible to construct measures of output and price changes that are useful to the study of economic growth" (Gilbert, 1961, p. 287). The danger which arises from an overdose of hedonics is well illustrated by Nordhaus (1997) and DeLong (1998 and 2000). Both have made the leap from hedonics to hallucinogenic history (2).

Ed Denison expressed similar reservations about quality adjustments in 1989, and opposed changes in national accounting practice which treated accretions of knowledge as investment. He considered this a "misclassification" which made "growth analysis chaotic" (see Denison, 1989, p. 10). In fact, the only form of knowledge which has been treated this way is computer software. Given the fact that hedonic indexation already makes generous allowance for quality changes in computers which derive in large part from computer software, there is an element of double counting in the new procedure. It is also odd to treat this rapidly depreciating knowledge as investment, whilst ignoring the more durable influence of books. Gates gets greater respect than Gutenberg.

Creation of Purchasing Power Converters for Cross-country Comparison of GDP Levels and Construction of Regional and World Aggregates

Once standardised accounts of real GDP growth in national currencies had been established for all OEEC countries, Milton Gilbert took another major step to facilitate interspatial comparability and multi-country aggregation by developing purchasing power parity converters (PPPs) to measure real expenditure levels, rather than relying on exchange rate comparison. The first PPP study, co-authored by Irving Kravis (1916-92). appeared in 1954, a second (co-authored with W. Beckerman, J. Edelman, S. Marris, G. Stuvel, and M. Teichert) in 1958. These studies compared real expenditure levels in 8 OEEC countries. A third volume by Paige and Bombach (1959) used a different approach in comparing real output levels in the UK and USA. Kravis and his colleagues, Alan

Heston and Robert Summers improved the methodology of PPP estimation in their ICP project at the University of Pennsylvania from 1968 onwards.

The OEEC studies were binary comparisons. The three options were i) a Paasche PPP, with "own-country" quantity weights; ii) a Laspeyres PPP with the quantity weights of the numeraire country-the United States; iii) a compromise geometric (Fisher) average of the first two measures. The corresponding measures of real expenditure were: i) Laspeyres comparisons of GDP levels based on the prices (unit values) of the numeraire country; ii) Paasche level comparisons based on "own-country" prices (unit values); iii) a Fisher geometric average of the two measures. Binary comparisons, e.g. Germany/USA and UK/USA, could then be linked with the USA as the star country. Such star comparisons could provide a proxy Germany/UK comparison, but it was not "transitive" (i.e. the result would not be identical to that derived from a direct Germany/UK comparison). This was not a great drawback for OEEC countries where the inter-country deviation in performance levels was not too wide. But Kravis, Heston and Summers were engaged in comparisons over a much wider range of per capita income. They therefore adopted the Geary-Khamis method (invented by Roy Geary and Salem Khamis), which multilateralised the results, provided transitivity and other desirable properties. They used it in conjunction with the commodity product dummy method (CPD), invented by Robert Summers, for filling holes in the basic dataset. Their masterpiece was their third study, the 1982 volume *World Product and Income*, which contained estimates for 34 countries (in Africa, the Americas, Asia and Europe) in 1975 prices and international Geary-Khamis dollars. These countries accounted for 64 per cent of world GDP in 2001.

The UN Statistical Office extended the ICP work and had covered 84 countries by 1985. UNSO then dropped this endeavour, though some of the regional UN bodies continued with it. The OECD recommenced its comparisons on a regular basis in 1982. Its latest work covered the 28 OECD countries and 20 others (in Eastern Europe, the 15 successor states of the USSR, and Mongolia). Alan Heston and Robert Summers produce short-hand estimates of PPPs and real income levels for countries for which full-scale ICP type measures are not available. As a result, we now have reasonably acceptable PPP adjusted measures available for over 99 percent of world GDP.

Table 3b summarises the nature of the PPP estimates I used to create my 1990 benchmark estimates of world GDP. Table 4a illustrates the difference between PPP and exchange rate conversion for the benchmark year 1990 for the world's 10 largest economies (which represented 65 percent of world GDP in 2001). It also compares the result when the two alternative benchmarks are used as an anchor for inter-temporal comparison of performance for the period 1950-2001.

The exchange rate conversions on the right hand side of Table 4a show much lower levels per capita GDP for the poorer countries (China, India, Russia and Brazil) and somewhat higher levels for the west European countries and Japan relative to the

numeraire country-the USA-than the PPP converters. The degree of difference is clear from inspection of Table 4b which shows the ratio between the exchange rate and the PPPs in the benchmark year 1990. In the case of China the deviation was very large-purchasing power was more than 5 times higher than the exchange rate. In India the ratio was more than 3 times higher, in Russia twice as high and in Brazil more than 50 per cent higher. In Japan and the west European countries, the exchange rate overvalued the purchasing power relative to the US dollar. In fact the big differential for poorer countries is a fairly systematic outcome in such comparisons. For the west European countries and Japan the differential is smaller and has varied above and below parity in the past two decades. There is of course a margin of error in all the PPP comparisons, but they are far more reliable as measure of purchasing power than exchange rate conversion. This is clear from the inter-temporal comparison in Table 4a, which shows a Chinese per capita GDP in 1950 of $85, and an Indian of $172 (both in 1990 prices) when exchange converters are used. These levels are much too far below subsistence level to be credible.

There has been great reluctance on the part of many poorer countries to accept PPP conversion, because they felt it might weaken their case for foreign aid or favourable loan programmes of the IDA type (the cheap loan window of the World Bank). In fact, the World Bank provided substantial financial support for the ICP programme, and continues to support this type of research, but it has generally avoided explicit use of PPP adjusted measures in its analytical work or in its loan decisions. The IMF, the Economic and Social Affairs Department of the UN, the UN Human Development Report, and the World Bank's annual Development Report now show cross-national income comparisons on a PPP as well as an exchange rate basis, with no indication of their relative merits.

In spite of the creeping acceptance of PPP adjusted estimates, there continues to be significant error in comparative economic analysis because of ignorance of the pitfalls of exchange rate conversion. This is true in journalism, in political discourse, and also amongst some economists. Newspapers frequently refer to Japan as the world's second largest economy, though its GDP is less than 60% of the Chinese, and some British politicians continue to believe that their economy is bigger than China's (3).

In this situation, it is highly desirable that statistical offices be more vigorous in explaining the merits of PPP adjustment and in pushing for reinvigoration of this work on a worldwide basis. It would also be useful to augment the academic research effort to cross-check the results of ICP expenditure studies with ICOP comparisons of production and productivity (see below).

Reasons for the Worldwide Adoption of Macro-measurement since 1950

The main reason for the massive increase in coverage and quality of official national accounts from 1950 onwards was the realisation of their usefulness as a tool of macroeconomic policy. Denison, Gilbert, Kaldor, Kuznets, Ruggles, Stone, and others in the UK and USA, knew from personal experience that such accounts were also an

extremely important tool for resource mobilisation in wartime (4). In the 1950s, Keynesian analysis had a powerful influence on economic policy in many Western countries and its fundamental concern was with macroeconomic magnitudes (Keynes was the godfather of the first British accounts created by his pupils, Meade and Stone). Harold Macmillan, soon to be prime minister, discovered national accounts in 1956, when he became Chancellor of the Exchequer. He compared them to a railway timetable, without which you wouldn't know when the trains were running.

This new macroeconomic perspective was very different from pre-war conceptions, echoed by Hayek and Schumpeter. The latter considered *"total output a figment which, unlike the price level, would not as such exist at all, were there no statisticians to create it. We seem indeed to be faced by a meaningless heap--- for most purposes, a highly inconvenient composite"* (Schumpeter, 1939, pp. 484, 561).

The operational significance of national accounts became obvious in OEEC, when Milton Gilbert became responsible for economic policy analysis from 1955 to 1961, and greatly improved its quality. His earlier work on national accounts was the bedrock on which analysis of comparative growth performance was based. It provided a yardstick for assessing the success of policy which had never existed before. We served as the secretariat for a new Group of Economic Experts which included Otmar Emminger from the Bundesbank, Etienne Hirsch, head of the French Plan, Jan Tinbergen from the Netherlands, Arthur Burns, chairman of the US Council of Economic Advisors, under the chairmanship of Robert Hall, chief advisor to the UK Treasury. In 1955, Hall described the significance of their work as follows: *"These meetings are really something quite exceptional for economists and I should think are quite new in the history of the world, in the sense that economic experts, if they existed at all as Government advisers, were not generally very important people until Keynes's ideas had been commonly accepted in the West. So that there were not the people to meet as we do: now we have 7 or 8 or 9 people who are by and large the chief professional advisers of the main Western Governments --- all have more or less the same professional training in that they understand how to maintain the level of activity and what forces operate on it."* (Cairncross, 1991, p.35).

II

Quantifying and Interpreting World Economic Growth in the Capitalist Epoch

Simon Kuznets did more than anyone else to push back the quantitative time horizon beyond 1950 by promoting the development of historical evidence on "modern" economic growth and interpreting its driving forces. This revolutionized the analytical scope of economic history by giving it a quantitative underpinning. For him, the starting point for modern economic growth was 1760. The evidence now available suggests strongly that it began around 1820 (see below).

His initial interest, in the 1920s, was in business cycles, long waves and their international diffusion. When he emigrated to New York in 1922, he was already a sophisticated and well-trained economist (University of Kharkov), with practical

statistical experience in the Central Soviet of Trade Unions. At that time, analysis in this field was more sophisticated in Russia than in the United States. Mikhael von Tugan-Baranowsky (1865-1919) and Eugen Slutsky (1880-1948) were both teaching in the Ukraine when Kuznets was a student and he was very familiar with the work of Nikolai Kondratieff (1892-1938) on long waves. Kuznets' research in this field was of fundamental significance, and should be kept in mind in assessing his subsequent approach to the measurement of economic growth.

Kuznets' first book (1930) tested long wave theory by decomposing time series. He de-trended a cocktail of 59 indicators of physical commodity output and prices for Australia and Argentina (1 each); Belgium (5), Canada (2), France (8), Germany (8), Japan (2), UK (9) and USA (23). He found 15-20 year cycles in USA, but not elsewhere. There was no overall pattern of long cycles. What he found were "specific historical occurrences". In effect he demolished Kondratieff's long wave theory.

He also made a devastating critique of Schumpeter's *Business Cycles* (1939). He found his cyclical schema unacceptable and rejected the notion of waves of technical progress. Schumpeter used statistics for "purely illustrative purposes". His "failure to follow articulate methods of time series analysis reduces the statistical methods to a mere recording of impressions of charts, impressions with which it is often difficult to agree." Technical progress did not come in big Schumpeterian waves, but was a smoother more diffused process: "Why should we not conceive these applications of high entrepreneurial ability, whether represented by one man or several, as flowing in a continuous stream, a stream magnified in a constant proportion by the efforts of imitators" (Kuznets 1940). This way of thinking he transmitted to his students, Schmookler and Fogel, who gave it fuller articulation. Some of Kuznets' fans, notably Moe Abramovitz and Arthur Lewis continued to cherish the notion of Kuznets cycles. Kuznets himself did not subscribe to this idea (see Abramovitz, 2000, p. 111).

Kuznets abandoned the business indicator approach early in the 1930s, and switched permanently to comprehensive macro-analysis. The switch came when Wesley Mitchell (1874-1948) asked him to take charge of national income analysis at the National Bureau of Economic Research (NBER). However, his fastidious analysis of cycles and experience in decomposing time-series to distinguish trends from cycles had a lasting influence on his work. He remained reluctant to use annual synchronic analysis. Instead he smoothed the growth record for the whole period of modern growth by using estimates for overlapping decades. This made it difficult to assess the degree of international synchronicity, and to identify phases of development.

In the 1930s and 1940s he made a massive scholarly contribution to the quantitative macroeconomic history of the USA (growth and structure of GDP, capital stock, employment, immigration, distribution of income and foreign trade). He made the first official accounts (with his former student, Robert Nathan), and created a team in the NBER to make interrelated historical studies. It included Moses Abramovitz (1912-2000)

on inventories, Solomon Fabricant (1906-89) on manufacturing, Harold Barger and Hans Landsberg on agriculture, Barger on distribution. In 1936, with help from his young research assistant, Milton Friedman, he was instrumental in creating the CRIW. In the 1950s and 1960s he played a major role in encouraging the construction of internationally comparative historical national accounts. He did this in sessions he organised in IARIW, with close support from Phyllis Deane; he was a driving force in creating the Yale Growth Center, whose graduate students produced basic growth studies on Argentina, Egypt, Korea, Sri Lanka, Taiwan and the USSR; he chaired a US Social Science Research Council Committee which provided financial support for construction of basic historical national accounts in China, France, Germany and Italy, and a subsequent project with Moses Abramovitz on factors influencing economic growth in France, Germany, Italy, Japan, Sweden and the USSR.

Kuznets spent more than four decades as a university teacher, 1930-54 at the University of Pennsylvania, 1954-60 at Johns Hopkins, and 1960-71 at Harvard. He induced many brilliant students to enter the field of comparative, quantitative, historical, macroeconomic analysis. Milton Gilbert and Irving Kravis were outstanding contributors to scientific analysis of economic growth and comparative levels of performance. Jacob Schmookler (1918-67) and Robert Fogel both made fundamental breakthroughs in illuminating the nature of technical progress. Dwight Perkins produced a masterpiece on Chinese agricultural development over six centuries. Richard Easterlin continued Kuznets' work on population, migration and income distribution. Noel Butlin (1921-91) constructed meticulous Kuznetsian-style national accounts for Australia for 1820-1939, with "multicultural" estimates for the aborigine and white settler economies for the century before 1870, a demographic analysis of the different vectors of aboriginal mortality as a result of white settlement, and a more speculative analysis of the characteristics of the stone-age economy of Australia before white settlement.

Kuznets synthesised the international evidence on economic growth in 10 major articles on "Quantitative Aspects of the Economic Growth of Nations" in *Economic Development and Cultural Change* between 1956 and 1967, in *Modern Economic Growth* (1966) and *Economic Growth of Nations* (1971). The last volume examined the performance of 21 countries as shown in table 2. His analytical and interpretative work in this domain was very different in character from his earlier research on the US economy. This was embedded in monographs, reference works with large appendices where sources and procedures were fully and transparently described. Thereafter, he became a brilliant essayist. Four volumes containing 43 of his interpretative essays were published between 1953 and 1989, as well as 2 small volumes of lectures. They made modest use of tabular material. The technique of exposition virtually never made use of algebra or regressions. The approach was basically inductive. He was a cautious "interpreter" of economic growth, very sensitive to the quality of the quantitative evidence, and the multilayered

complexity of causality. He did not try to "explain" economic growth with the exactitude to which econometricians and growth accountants often aspire.

He concentrated on the nation state as the unit. He did not strive to create world aggregates, as the coverage of the accounts in his day was Eurocentric and not really adequate for this. He stuck to respectable macroeconomic measures whose scope and significance were clear and well defined. He had no time for proxy measures, metaphors, stylised facts, leading sector analysis, or real wage indicators. However he was not averse to what Paul David (1967) called controlled conjectures.

Kuznets' persuasive power and influence stemmed mainly from his professional integrity and depth of scholarship. He was free from partisanship, avoided polemical confrontations, open to new ideas and willing to comment sympathetically in detail on the work of others. His influence was reinforced by his style of analysis-use of ideas and concepts that could be clearly expressed in literary form, implementable with relatively simple statistical techniques. Thus he encouraged a band of scholars all over the world to consider that such an enterprise was feasible, exciting, important and rewarding.

His interest was concentrated on what he called "modern economic growth" from 1760 onwards, though most of the quantification he did personally or encouraged others to do started from the mid nineteenth century. The epochal innovation that distinguished modern economic growth was "the extended application of science to problems of economic production" and the secularisation of thought. He rejected the idea that modern economic growth was essentially a process of industrialisation. He found this terminology "misleading because it suggested that technological and institutional changes in agriculture were less important and less autonomous" than those in non-agriculture.

Modifications to Kuznets' findings

There are five points on which Kuznetsian analysis requires revision.

a) The evidence now available suggests that the transition from "merchant capitalism" to "modern economic growth" took place around 1820 rather than in 1760. The work of Crafts and others on British performance in the eighteenth century helped demolish the old notion of a sudden take-off in the second half of that century. The important point about Britain's exceptionalism is not an industrial revolution, but a much longer process of ascension, with per capita growth faster from 1500 onwards than in the rest of Europe.

Research in the past forty years on the quantitative economic history of other West European countries has produced further evidence for dating the transition from 1820. It has discredited the Gerschenkron-Rostow belief that there had been a series of "take-offs" in different countries, whose timing was staggered throughout the nineteenth century. Kuznets also endorsed their view, in a milder form: *"modern economic growth spread gradually and began at different dates in the currently developed countries - these dates (rough approximations only) ranging from the late eighteenth century in pioneering England, to the 1840s for several European countries and the United States"* (Kuznets

1979, p.131). This interpretation is no longer tenable. Hansen's (1976) two volumes on Denmark showed evidence of substantial advance in the early nineteenth century; Tilly (1978) found evidence for the same conclusion for Prussia; Levy-Leboyer (1985) and Toutain (1987) did the same for France; Hjerppe and Associates (1987) reached a similar conclusion for Finland; Krantz (1988) for Sweden: Hodne and Grytten (1994) for Norway; Smits, Horlings and van Zanden (2000) for the Netherlands. Their research strongly suggests that the acceleration of economic growth was quite general in Western Europe after the Napoleonic wars (though for Italy and Switzerland there is as yet no hard evidence). It was slower in 1820-70 than it became in 1870-1913. Nevertheless the pace of advance in Western Europe in 1820-70 was clearly much faster than in the eighteenth century and earlier.

b) In analysing changes in growth momentum within the capitalist era, it is useful to demarcate different phases, in which the momentum of growth and fashions in economic policy differed substantially. Kuznets did not break down modern growth into phases, and was more interested in modern economic growth as a whole. However, in his critique of Rostow's stages (1963, p.24) he suggested useful criteria for distinguishing "phases" of development within the capitalist epoch. The three most important requirements were that (i) they must be identifiable by characteristics that can be verified or quantified; (ii) the magnitude of these characteristics must vary in some recognisable pattern from one phase to the other; (iii) there should be some evidence of when phases begin and terminate and why the turning points occur. He considered Rostow's stages to be fuzzy conceptually, and lacking statistical rigour.

My estimates of performance in five distinctive phases of phases of world development since 1820 are shown in table 5. The years 1950-1973 were a golden age of unparalleled prosperity. World GDP rose at an annual rate of 5 per cent, per capita GDP near 3 per cent and world trade almost 8 per cent a year. There was a significant degree of convergence in per capita income, with most regions growing faster than the USA (the lead economy). After 1973, there was a marked slowdown in world growth, with substantial divergence between different regions, and performance in many of them below potential. Nevertheless, on a world basis this latest phase was the second-best since 1820. Table 5 also shows clearly that "modern economic growth", in all its phases, has been much faster than in the preceding centuries. From the year 1500 to 1820, world per capita income rose .05 per cent a year. From 1820 to 2001, it averaged 1.23 per cent, nearly 25 times as fast.

c) Kuznets' interspatial analysis was based mainly on exchange rate conversions, with only brief speculation on what difference purchasing power converters might make (5). He made no estimates of aggregate world performance.

d) In interpreting historical growth performance it is important to distinguish between "lead" countries whose economies operate nearest to the technical frontier, and "follower" countries, which have a lower level of labour productivity (or GDP per

capita). Since 1500 there have been four lead countries, Northern Italy in the sixteenth century, the Netherlands from the sixteenth century until the Napoleonic wars, when the UK took over. The British lead lasted until around 1890, and the USA has been the lead country since then. Kuznets did not emphasise the special role of lead countries.

e) I prefer to call the last epoch "capitalist", rather than "modern". "Capitalist" is a descriptive term, neither pejorative nor apologetic. It is appropriate for economies whose growth performance and technological advance were so heavily dependent on capital formation, and where the finance of investment depended largely on decisions taken by the private sector. "Modern" has a fuzzy temporal connotation with shades of meaning that are more appropriate for art dealers and sociologists. In any case, if one differs from Kuznets on timing, it is better to use different terminology.

Improving the Evidence for Non-Western Countries

Most of the evidence assembled by Kuznets dealt with performance of advanced capitalist countries. Until the early 1960s this was my own main interest, because I wanted to put their exceptionally rapid post-war growth in historical perspective. In Maddison (1964), I compared the performance of 12 countries from 1870 onwards to identify previous phases of development in the capitalist epoch, examine the nature of their interaction in time of peace and war, explore the reasons why Europe fell behind the lead country-the USA, and analyse the process of catch up after the second world war. In 1964-5, I spent some time in Moscow and Tokyo to gather material for analysis of Russian and Japanese experience in trying to catch up with the West over the same period (Maddison, 1969).

I became heavily involved in analysis of "developing" country performance from 1960 to 1971 (1960-1961 as secretary to the OEEC's Development Assistance Group producing the first comprehensive statistics on aid flows; 1963 administering OECD technical assistance to Greece and Turkey; 1964-66 research in the OECD Development Centre, and advisory work in Greece, Brazil and Mexico; 1967-9 research project of the 20th Century Fund on world development in historical perspective; 1969-71 with the Harvard University Advisory Service in Pakistan and Ghana).

In the Development Centre, Raymond Goldsmith and I set up a systematic reporting procedure for post-war official national accounts of developing countries. We were also interested in encouraging scholarly research to push macro-measurement back into the nineteenth century. Between 1964 and 1967, I visited statistical offices in 12 Asian countries (Cambodia, India, Iran, Israel, Malaysia, Mongolia, Pakistan, the Philippines, Sri Lanka, Taiwan, Thailand, Turkey), 4 in Latin America (Argentina, Brazil, Chile, Mexico), and 3 in Africa (Egypt, Ghana, Guinea) to see the state of the national accounts and establish a relationship with the Centre. I also went to China for two weeks in 1965, but there were no believable official statistics and I failed to establish contact with any statistician, economist or historian. The immediate results were very patchy for comparative analysis of economic growth, but useful contacts were

established. The statistical unit in the Centre (Derek Blades, Michele Fleury, Witold Marczewski, and David Roberts) built up a useful data base over the years and held several regional seminars for national accountants (6).

There was an obvious need for measures of real income *levels* in developing countries in order to assess their aid needs, relative growth potential, and degrees of divergence from the income levels of the richer countries. The only estimates adjusted for variations in purchasing power then available were those of Colin Clark (7). To see what could be done to improve the situation, I organised a meeting (Wilfred Beckerman, Irving Kravis, Jim McGibbon, Manfred Teichert, Nancy and Richard Ruggles) in the Centre in April 1965. Beckerman (1966) provided a survey of the literature and proxy measures using non-monetary indicators. Nancy and Richard presented estimates of per capita consumption levels in 19 Latin American countries, using ECLA data collected by Stanley Braithwaite. These showed Chile with the highest level (6 times that in Haiti, the lowest country). Most of the participants had experience of expenditure studies of the type OEEC had pioneered. Beckerman's report raised the alternative possibility of an output approach like that in the UK/US comparison of Paige and Bombach, and suggested that it might be easier to apply in developing countries than the expenditure approach. The participants felt that it would not be significantly easier and the option was not seriously explored. There was some discussion of criteria for choice of countries for an expenditure comparison. Kravis, who was eager to set up such a project, emphasised the need to pick countries representative of all continents and a wide range of income levels, and to choose countries willing to link up with subsequent regional comparisons. He also wanted to include some of the higher income countries and would have preferred to set up a project in liaison with OECD, which had experience in this field. However, the OECD Economics and Statistics Directorate had changed its priorities after the departure of Gilbert, and did not reactivate its basic expenditure comparisons until 1982. The Ford Foundation (represented at the meeting by Peter de Janosi) gave Kravis a $300, 000 grant to start the ICP in 1968. It was located in the University of Pennsylvania in cooperation with the UN statistical office. The first ICP report came out in 1975, and the final one, covering 34 countries, in 1982.

In 1970, I published a comparative survey (*Economic Progress and Policy in Developing Countries*) of the growth experience the six biggest OECD countries, the USSR and 22 developing countries in the period 1870-1968. It was select enough to permit consistent quantitative analysis and big enough (75 per cent of world GDP) to allow conclusions of general validity. Thanks to work at the centre, I had amassed a good deal of material on GDP growth of developing countries.

The biggest statistical challenge was the absence of comparative measures of GDP *levels*. I constructed benchmark estimates for 1965, using the industry-of-origin approach, with measurement of real value added by sector at US prices. I calculated gross output for farming, fisheries, and forestry, from detailed and fairly comprehensive FAO estimates,

deducted inputs of feed and seed and non-farm inputs. For mining, manufacturing and utilities, the source was Shinohara (1966). He had a sample of 70 commodities, weighted by value added derived from the US Census of Manufactures. For services, direct measurement was not possible, so I used estimates of employment and a conjectured level of labour productivity, which I assumed to be related fairly systematically to that in the commodity sector (i.e. agriculture plus industry). I assumed the productivity level in services to be a quarter of the US level in India (the country where commodity sector productivity was lowest) and three-quarters of the US level in France (where commodity sector productivity was nearest to that in USA). For the other countries it was prorated between these limits.

Shortly after Kravis, Heston and Summers (KHS) had finished their ICP project, I published a detailed confrontation my GDP level estimates, by the product method, with theirs (Maddison, 1983). For the advanced capitalist countries, my results were on average about 4 per cent lower, but for developing countries diverged much more. Their expenditure approach yielded per capita GDPs averaging 16.7 per cent of the USA, the product method 11.3, a difference of more than 40 percent.

My estimates were cruder than theirs, the quantity and quality of the basic data and the sophistication in processing it were weaker. Nevertheless, I did not think the results of the production approach could be dismissed, simply because they differed from the expenditure approach. I concluded that the difference arose primarily from the treatment of services. This is the most measurement-resistant area in both approaches, For teachers and civil servants, KHS assumed that average labour productivity in developing countries was about the same as in the USA. For developing countries, my average was one third of the US level.

A second point was their lack of adjustment for the distributive component in consumption: KHS explained their procedure as follows: *"The ICP method of international comparisons simply compares the extent to which each economy delivered meat and potatoes, shoes and stockings, and other commodities to its residents without regard to the extent or nature of the accompanying services. The extent and nature of the bias that results from the omission of these general quality factors are difficult to judge"*. Their basic procedure was the potato-is-a-potato rule. *"A potato with given physical characteristics was treated not only as the same product but also as the same quantity, whether it was purchased in the country, or in the city, in January, or in June, by the piece or by the bushel, and whether it was purchased at a retail market or consumed out of own production"*.

My provisional conclusion was that the KHS type of comparison may tend systematically to overvalue developing country real product levels because of its treatment of comparison-resistant or disguised services. I also felt that my 1970 study needed to be updated in more detail and cross-checked more carefully with the results of expenditure comparisons before drawing authoritative conclusions. By that time, I had

returned to academic life was able to set up the ICOP programme (International Comparisons of Output and Productivity) at the University of Groningen in 1983. It has since produced more than 80 research papers, a dozen Ph. D. theses, and established a world-wide network of researchers in this field. The biggest improvement on Maddison (1970) has been in detailed comparisons of real product and productivity in manufacturing, based on detailed scrutiny of industrial censuses. The methodology and research results for the Brazil/US and Mexico/ US comparisons are explained in Maddison and van Ark (1988 and 1989), and for Japan/US and Korea/US in Pilat (1994). Maddison and van Ooststroom (1995) is an update of my earlier estimates for agriculture and a survey of the literature. Most of the ICOP comparisons have been binary, as was my 1970 work, but Maddison and Prasada Rao (1996) presented a Geary-Khamis version of the results for agriculture, and used the CPD technique of Robert Summers to fill gaps in basic data instead of the shadow-price approach used in Maddison and van Ooststroom. Mulder (2002) was able to make more sophisticated estimates and detailed estimates for services. The overall results of the ICOP project are surveyed in Maddison and van Ark (2002). The only whole-economy results as yet available on an ICOP basis are for Brazil, Mexico, Korea, Japan and the United States for 1975. The average per capita GDP for the 4 countries relative to the USA was 34.8 per cent for the ICOP measure, and 36.9 for ICP, a much smaller discrepancy than I found in my 1983 confrontation of ICP and ICOP results. However, confrontation/reconciliation between the two methods needs to be done more rigorously and for a larger number of countries.

Analysing the Causes of Growth, Slowdown and Divergence: Growth Accounts

As quantitative evidence on comparative GDP growth accumulated, it became feasible to sharpen analysis by quantifying the reasons for inter-temporal and interspatial variance in performance.

The first step in growth accounting was to measure labour productivity. Great importance was attached to this measure in the USA in the 1930s by the Works Project Administration, the Bureau of Labor Statistics and the National Bureau of Economic Research. At that time, when there was massive unemployment, such measures were needed to analyse what potential the economy might have if unemployment were reduced to more normal levels. Clark (1940) made extensive use of sectoral labour productivity measures in his pioneering comparative study of “economic progress”, and Rostas (1948) used them in his pathbreaking comparison of British and American performance levels, which was the first conclusive documentary evidence of the extent of the lead which the USA had developed over the UK. It is still a very useful device for measuring performance, because labour input has grown unevenly over time and between countries. It has been very different from the movement of population. Since 1820, working hours of the average person employed have fallen by half; labour input has increased less than population; and labour productivity a good deal faster than GDP per capita.

Early post-war analysts laid great stress on the role of capital in economic growth, though for lack of accurate information, some assumed that the capital-output ratio was stable, some used incremental investment-output ratios (ICORs), or wealth surveys, insurance valuations or company book-keeping or stock exchange values as a proxy. Kuznets (1961) published a massive study on investment in the USA, and this made it possible to make a much more accurate assessment of US capital-output ratios and growth of capital stock. A major breakthrough came when Goldsmith (1951) pioneered the "perpetual inventory" method in which stock estimates were derived by cumulating historical series on past investment at constant prices, and deducting assets scrapped, written off or destroyed by war. In the course of the 1970s and 1980s, several OECD countries developed official capital stock estimates on a perpetual inventory basis, when they had accumulated a long enough run of investment data to permit their construction. Academic researchers such as Feinstein (1988) and Gallmann (1986 and 1987) pushed these capital stock estimates much further back in time.

These modern official estimates are usually similar conceptually but are not easily comparable because of different assumptions about asset lives, differences in coverage, and the difficulty of deriving suitable purchasing power parity coefficients to convert them into a common currency. I made standardised estimates of fixed non-residential capital adjusted to deal with these problems for France, Germany, Japan, the Netherlands, UK and USA in Maddison (1995c) broken down into structures, and machinery. This is a very pertinent distinction, as the rate of growth of the latter component has been much faster than the former, and technical progress is probably more rapidly embodied in machinery investment than in structures.

Once measures of capital stock were available, the next step was to develop measures of joint factor productivity, i.e. the ratio of output to combined inputs of capital and labour. Tinbergen (1942) made the first international comparisons of this kind with very rough measures of capital. Kendrick (1961) was a much more sophisticated exercise by sector of the economy from 1869 to 1953 which took account of both capital and labour inputs, but covered only one country.

Schultz (1961) suggested that inputs of “human capital” should also be regarded as a factor of production. The main component he had in mind was the increase in the educational levels, but improvements in skill through working with sophisticated equipment, and improvements in health were also relevant. The idea proved attractive and measures of joint factor productivity were soon constructed in which education was treated as part of factor input. In growth accounts, the normal procedure is to treat increases in education as an improvement in labour quality, rather than as an independent factor of production analogous with physical capital (8).

A climate propitious for the development of more ambitious growth accounts was created by the ferment of discussion on US performance in the 1950s and early 1960s, and there was closer interaction of quantifiers and theorists. The latter were encouraged by the

likelihood that their ideas could be tested empirically. The key writings in this first wave of modern growth analysis were by Abramovitz (1956) and Solow (1956).

Abramovitz provided a brilliant recapitulation of what was then known about the quantifiable causes of US growth. He stressed the degree of ignorance in these matters and put forward the idea of including education and research in the growth accounts.

Solow's 1956 article was of major importance. He broke with the Harrod-Domar models which had dominated the post-war literature, and had included the notion of constant capital-output ratios. He constructed a model with two inputs, labour and the productive services derived from the capital stock. He assumed constant returns to scale, diminishing returns to each input, and exogenous technical progress. Solow stressed the likelihood that a substantial part of technical progress was embodied in successive vintages of the capital stock and he put forward some tentative guesses as to how big this impact might have been.

Denison (1962) adopted the key ideas of Solow and Schultz in creating expanded "growth accounts" to explain twentieth-century American economic performance. He published three other books refining and extending his US analysis, the last dealt with the period 1929-82. In 1967 he applied the technique to explain differences in growth rates and levels of achievement in eight West European countries and the USA for 1950-64. Denison and Chung (1976) incorporated Japan into the sample.

Denison adopted the basic neo-classical features one finds in the Solow model, i.e. income shares as factor weights, and the assumption of exogenous technical progress, but his procedures were eclectic and he also allowed for economies of scale. He rejected Solow's suggestions for embodying technical progress in successive vintages of capital. He wanted it to be the major item in his final performance measure, the "residual". This, as he acknowledged, was not confined to measuring technical progress but also reflected the effect of unmeasured influences and possible mismeasurement.

In addition to the augmented factor inputs, Denison included other, supplementary, elements of explanation. These included foreign trade effects, the impact of structural change, economies of scale in domestic markets, as well as some other influences, such as government regulation and crime, changes in capacity use, labour hoarding, etc.

Denison always presented the derivation of his estimates transparently, so that readers could reproduce or modify them in case of disagreement. He was also careful to point out possible errors, and to distinguish harder evidence from softer conjectures. He could do this all the more readily because the accounting approach is a very flexible device for organising evidence on causal influences affecting the growth process. It is possible to modify the accounts by changing the weights of different items, by adding new items or dropping old ones.

Denison's framework is a very congenial tool of "proximate" causal analysis, which can always be used in conjunction with other less-measurable influences. I used it with substantial modifications, dropping his assumption that work intensity increases as hours decline, using a different concept of output, bigger weights for capital and foreign trade

effects, lower weights for domestic economies of scale, and embodying part of technical progress in successive vintages of capital. I constructed modified Denison-type growth accounts for 22 countries in Maddison (1970) for 1950-1965, estimating labour input, with quality adjustment by level of education, and capital stock (with a benchmark conjecture for 1950 levels, updated thereafter from investment data on a perpetual inventory basis). Maddison (1987) surveyed the growth accounting literature, and presented more detailed and much better quality growth accounts for six advanced capitalist countries for 1913-1984. Maddison (1995a and 2001) pushed the accounts for the UK and USA back to 1820, and for Japan, they covered virtually the whole period of its "modern economic growth" (see Table 6).

In Groningen, I encouraged my graduate students to pursue this line of research. Pilat (1994) constructed growth accounts for Japan, Korea and the United States for the postwar period and a detailed quantitative perspective for a longer period. Hofman (2000) made a similar analysis for six Latin American countries (Argentina, Brazil, Chile, Colombia, Mexico and Venezuela), with completely new estimates of capital stock on a standardised basis. My friend, Siva Sivasubramonian (1929-2002), constructed similar growth accounts for India 1950-2000, which were published in 2004.

Parallel with the growth accounting literature there was a steady flow of' articles after 1966 by Dale Jorgenson and his associates. These were mainly on the US economy but covered several other advanced capitalist countries. Jorgenson's approach was more rigorously neo-classic than Denison's in excluding economies of scale. He defined output and capital somewhat differently, included immediate inputs in the analysis, concentrated on the private sector of the economy and disaggregated in much finer detail by branch and sector. He was more ambitious in trying to squeeze the residual in the growth accounts to zero, whereas Denison was willing to live with the fact that his growth accounts left a substantial part of growth unexplained. There was a useful interaction between the two approaches in the *Survey of Current Business* 1969-72 with three articles by Jorgenson and Griliches, and two lengthy comments by Denison, which led Jorgenson and Griliches to concede that they had exaggerated their initial degree of explanation. The great virtue of Jorgenson's approach is that it helps to identify the locus of technical progress by showing in detail how productivity has changed in different sectors and branches of the economy (9).

What have we learned about economic growth since 1820?

a) *The Contours*: Tables 1-5 show how far we have come in the past 65 years in establishing the contours of modern economic growth. In 1940 only 10 countries had some sort of official national income estimates. They were not standardised and covered only a very short run of years. From academia there were the estimates of Clark (1940) for 16 countries. These were rough proxies in several cases, and the average number of years covered was 19. By 1956, Kuznets had assembled better quality estimates for 19 countries. On average, he showed estimates for 13 overlapping decades. Some of these were incomplete, so average coverage was about 60 years. In 1971, when he presented a second

overview, he had estimates for 21 countries, for an average around 75 years. Maddison (2003) included all 27 countries appearing in one or other of the Clark/Kuznets studies, with an average coverage of 127 years. Table 3a shows the coverage of my GDP sample. It included 179 countries for 2001, 163 for 1950 52 for 1913, 25 for 1820, 15 for 1700 and 10 for 1500. The sample included most of the big countries; The proportionate coverage of world GDP was 89 per cent in 1870, more than three-quarters for 1820, and 65 per cent for 1500. Table 3b shows the kind of PPP converter I was able to use in arriving at world aggregates. Here again we are much better placed, as a result of the massive research effort which the pioneers Clark, Gilbert and Kravis inspired.

The resulting estimates of GDP, population and per capita GDP levels are shown in Table 5a in summary form for six benchmark years of modern economic growth, for three high-income regions of the "West", and four regions in the rest of the world. This gives some idea of the divergence of experience in different parts of the world. Table 5b gives a comparative picture of growth rates in five different phases of development since 1820 for the same array of countries. Both tables also contain quantitative estimates for the years 1000 and 1500, which contain a larger degree of conjecture and are more contestable (see below). The full array of country estimates and sources can be found in Madison (2003).

b) *Quantifiable Causality***:** Table 6 quantifies the strategic factors determining the growth experience of the two successive lead countries, the UK and the USA, and Japan, the most successful of the follower countries, over the whole period of their "modern" economic growth.

The first striking feature is the huge increase in the stock of physical capital, which was significant for non-residential structures, but sensational for machinery and equipment. The ratio of the latter to GDP rose 13-fold in the UK and USA between 1820 and 1998, and nearly 14-fold in Japan from 1890. This increase was linked to the acceleration of technical progress, much of which had to be embodied in machinery. The increase in human capital, measured by years of formal educational experience of those in employment (weighted by the earnings differential associated with years of primary, secondary and tertiary) was also linked to technical progress. The increasing complexity of production processes required better educated people to make it operational, and the involvement of educated people in R&D helped institutionalise the process of innovation. Here again, there was spectacular change. The education level rose nearly eightfold in the UK, eleven-fold in the USA and Japan. There was also a very large rise in international specialization. The ratio of foreign trade to GDP rose from 3 to 25 percent in the UK, from 0.2 to 13 percent in Japan and from 2 to 10 per cent in the USA. Natural resource scarcities were not a constraint; the land area per capita fell fourteen-fold in the USA, about four-fold in Japan and the UK. Thanks to technical progress, the increase in energy inputs was relatively modest-a threefold increase per capita in the USA, six-fold in the UK and eightfold in Japan; much smaller proportionately than growth in the stock of machinery. However, the composition of energy inputs changed drastically. In 1820, 94 per cent came from organic matter. In 1998, mineral

fuels accounted for 89 percent per cent (see table 7). The input of human energy was very significantly reduced. Hours worked per head of population dropped by 40 percent in the UK and Japan, and 20 percent in the USA.

In fact, most of these changes appear to have been necessary for realising the potential for "modern" economic growth. There is confirmatory evidence for other advanced capitalist countries for a shorter period (see Maddison 1998, pp. 41 and 42) and for countries where rapid catch-up has been achieved (see Pilat, 1994). Apart from countries which have had windfall gains from oil, it is virtually impossible to find a country which has achieved the living standards of the advanced capitalist group without massive increases in human and physical capital inputs.

(c) Non-quantifiable Causality: Growth accounts are only part of the story. They are very useful in explaining the success of the West and the catch-up countries. They do not explain the failure of the communist countries to get similar results from increases in human and physical capital.

If we are to explain why the economic growth experience of nations has been so diverse, and why income spreads are now so wide, it is necessary to go beyond proximate and measurable elements of causality and consider institutional, societal or policy influences which retard or encourage economic development. Economic "backwardness" is a topic which has concerned economic historians for decades. Gerschenkron (1965) drew attention to this problem and correctly stressed the need for historical perspective. North and Thomas (1973), North (1990) and Abramovitz (1986) made the same point, but they, like Gerschenkron, dealt with a limited range of backwardness, i.e. varieties of European experience.

As country experience is so varied, it is difficult to reach general conclusions about the influence of deeper layers of causality. For this we really need individual country studies. Maddison (1995a, pp. 50-7) provided some tentative judgements about the nature of institutional constraints in different parts of the world. Maddison (1988) suggested an analytical schema for assessing proximate and ultimate causality. Maddison (2001) combined the analytic tools of quantitative history and the narrative detail of traditional historiography to identify the driving forces, the idiosyncratic institutions and policies, and the role of the Venetian republic, Portugal, the Dutch republic and the UK in the ascension of Western Europe in the eight centuries before 1820. I used the same approach in analysing the Japanese attempt to catch up with China and then the West, between the seventh and the nineteenth century (pp. 252-258).

III

Economic Growth in the Merchant Capitalist Epoch: 1500-1820

Quantitative investigation of this earlier period has been relatively neglected for three reasons a) it is clear that growth was much slower than it has been in the last two centuries; b) quantitative evidence is harder to find, and c) many thought the results would be uninteresting-a long litany of stagnation interrupted by catastrophe.

a) *Smith and Malthus*

There were already two very different views at the end of the eighteenth century. Adam Smith (1776) took a mildly euphoric position and Malthus (1798) was deeply pessimistic.

Smith was not a quantifier in the Kuznetsian sense and was rather dismissive about political arithmeticians (the pioneers of national accounts), but acknowledged substantial progress in the West since 1500. He regarded the discovery of the Americas and the Southern route to the Indies as a major turning point. He emphasised the role of capital deepening in economic growth, the opportunities for economies of scale and specialization. He broadened the significance of the historical approach for growth analysis by using it comparatively. His ordinal array of countries by level of development corresponded closely to the evidence now available from historical national accounts. His ordering was as follows, Netherlands, England, France, North American colonies, Scotland, Spanish America, China and Bengal. For him, policy and institutions were a major reason for the inter-country variance in levels of development.

Malthus' growth schema had only two factors of production-natural resources and labour-with no allowance for technical progress, capital formation or gains from international specialisation. He portrayed the general situation of humanity as one where population pressure put such strains on the ability of natural resources to produce subsistence that equilibrium was attained only by various catastrophes-wars, famine, and disease-which brought premature death on a large scale and which he described as "positive" checks. The only policy measures he envisaged to check catastrophe were "preventive" checks to lower the birth rate. His influence has been strong and persistent, largely because his forceful rhetoric and primitive argument appeal to simple minds.

b) *Modern Malthusianism*

Amongst historians, the most distinguished and sophisticated of the modern Malthusians was Le Roy Ladurie (1966 and 1978) who considered the French economy stagnant (*immobile*) from 1300 to 1720.

Real-wage pundits were more deeply pessimistic. Phelps Brown and Hopkins (1956) suggested that English living standards in 1820 were 44 per cent lower than in 1500. Abel (1978) suggested that real living standards in central Europe fell from the first half of the fourteenth to the first half of the eighteenth century. These ultra-pessimists had a fleeting influence. Under their spell, Braudel and Spooner (1967) suggested that "from the late fifteenth century until well into the beginning of the eighteenth century, the standard of living in Europe steadily declined"; Braudel (1985, p. 314) reversed this judgement: he perceived "clear continuities in European history. The first of these is the regular rise in GNP come hell or high water". For England, Wrigley and Schofield (1981) accepted the Phelps Brown analysis as "an approximate guide to fluctuations in the standard of living" from 1500 to 1800. Since then, Wrigley has developed a very different interpretation. In (1988, p. 39) he concluded his penetrating new analysis thus

"The single most remarkable feature of the economic history of England between the later sixteenth and early nineteenth century was the rise in output per head in agriculture". Wrigley (2004. pp.38 and 43) concluded that agricultural output per head doubled between 1600 and 1800, and that "output per head overall may well also have doubled".

c) *The Kuznets Conjecture*

Kuznets' 1965 paper to the third IEHA (international economic history association) conference in Munich (reprinted in Kuznets, 1973) took a position which resembled that of Adam Smith. He advanced an influential conjecture about the rate of population and per capita GDP growth in Western Europe "from the end of the fifteenth to the second half of the eighteenth century". Judging from the demographic evidence then available (Carr-Saunders, 1936 and Urlanis, 1941), the work of Deane and Cole (1962) on British per capita income growth in the eighteenth century, and adjusting for the likelihood of better-than average performance in the UK, which had also had faster demographic advance, he "set the possible (and perhaps maximum) long-term growth in per capita product for 1500-1750 in developed countries of Western Europe at about 0.2 per cent per year". He felt that a higher rate was unlikely as the 1750 level was low, and that a lower growth rate was plausible. Kuznets did not advance a conjecture about growth rates in the rest of the world, but he clearly thought that they were lower than in Western Europe, and that their 1750 level was lower than that in Europe.

David Landes (1969) had a similar judgement. He concluded that European real income per head may have tripled between the year 1000 and the eighteenth century, and described the growth process over that period as "promethean".

In Maddison 1982, 1983 and 1991, I adopted the Kuznets conjecture for per capita growth from 1500 to 1820, to provide perspective for analysis of the much faster growth from 1820 onwards. Maddison (1995a) also dealt with growth from 1820 onwards, but contained a conjecture (p.19) for world population and GDP back to 1500. For Western Europe, I used Kuznets' 0.2 per capita, assumed 0.1 per cent for the rest of Europe and Latin America, and no change in Asia and Africa. The evidence was pretty flimsy, though I had, at that time, some evidence (from my own research) for the Latin American and Asian conjectures.

The nature of the evidence for 1500-1820 in Maddison (2001 and 2003)

Maddison (2001) was much more ambitious in its temporal scope and involved a major effort to test the Kuznets' conjecture and muster quantitative evidence on world economic performance before 1820. I tried to encourage other researchers to extend their time horizons backward, and engage in interactive networking of the type which proved so fruitful in building up reasonably comprehensive and comparable quantitative evidence for 1820 onwards. Between 1985 and 1994, I organized several workshops on quantitative economic history (two in Groningen, and IARIW sessions in Rocca di Papa and Flims), and two IEHA sessions in cooperation with Herman van der Wee. Several of the papers involved exploration of pre-modern growth. These included Blomme and van

der Wee on Belgium from 1400 to 1800; Booth and Reid on trade and growth in South-East Asia 1400-1990; Bowman on the Roman Empire; Malanima on Italy 1600-1800; Moosvi on Moghul India; Persson's comparison of English and Italian agricultural performance in the 14th century; Snooks' linkage of English evidence for 1086 in Domesday book with Gregory King's estimates for 1688; Yun on Castile 1580-1800. There were also two papers on long-term performance in Szirmai, van Ark and Pilat (1993): van Zanden on the Netherlands 1500-1805, and Boomgaard on Indonesia 500-1990. These studies were very useful in providing a much longer temporal perspective. For 1500, my 10 country sample represented 65 per cent of world GDP (see Table 3a).

Western Europe:

My estimates for Western Europe were based on a sample of five countries: Belgium, France, Italy, the Netherlands and the UK. The five represented 62 per cent of my estimate of West European GDP in 1500; estimates for the rest were conjectures, disaggregated by type of country (see Maddison, 2001, pp. 229-265, and Maddison, 2003, p. 244 for a modification of my 2001 estimate for France). For Western Europe as a whole , I concluded that the Kuznets conjecture exaggerated the pace of per capita growth. My estimate for 1500-1820, was a per capita growth of 0.14 per cent a year instead of his 0.2 percent. Average per capita GDP was estimated to rise from $771 in 1500 to $1,204 in 1820.

Western Offshoots

For this group (USA, Canada, Australia and New Zealand), my measure was "multicultural", with separate estimate for white settlers, black slaves and the indigenous population. For the latter (who were 100% of the population in 1500), I used a stylised per capita estimate of $400 (intended to represent a level slightly above subsistence). Average per capita income in Western Offshoots rose from $400 in 1500 to $1.202 in 1820, a growth rate of 0.34 per cent a year.

Japan

Japan modelled its economy, society, literature and institutions on China from the seventh century. The official commitment to catch up with the West started in 1867, but the Chinese model was abandoned in the eighteenth century, at about the time Japan had caught up with China. In 1720 the shogun lifted the ban on European books. In 1771, two Japanese doctors compared the body parts of a dissected corpse with those described in a Chinese and a Dutch book on anatomy. The Dutch text corresponded to what they found, and the Chinese text was inaccurate. As a result translations of Dutch learning (*rangaku*) became an important cultural influence and had a significant impact in transmitting knowledge of European science and technology to Japan.

I first went to Japan in 1961, and later published a comparative study of Japanese and Russian performance in attempting to catch up with the West from the 1860s onwards. At that time I established a good relationship with the quantitative economic historians at Hitotsubashi University, particularly Kazushi Ohkawa and Miyohei

Shinohara. Between 1966 and 1988 they produced the 14 volume *Long-term Economic Statistics of Japan since 1868*, but there were no macroeconomic estimates of performance in preceding centuries. In 1998, I spent a couple of months in Hitotsubashi and Keio Universities and at the Nissan Institute in Oxford to work on the economic history of the Tokugawa period. I was able to interact with Osamu Saito and Akira Hayami, Japan's most distinguished historical demographers, whose time horizon is much longer than that of most Japanese economic historians. This research was the basis for the brief survey of Japanese quantitative history from 1600 in Maddison (2001, pp. 204-206 and 252-260).

Between 1500 and 1820, Japanese per capita income grew at 0.09 per cent a year, rising from a level of $500 (well below China) to $660 (well above China).

The "West"

In tables 5a and 5b, I have made a dichotomy between the "West" (Western Europe, Western Offshoots and Japan) and the "Rest" (all other countries). Average per capita growth of the first group was 0.14 percent a year from 1500 to 1820, seven times as fast as the second group where growth was only 0.02 per cent a year. The divergence in growth momentum has continued. The "West" grew 1.7 per cent a year from 1820 to 2001, and the "Rest" by 1.0 per cent. As a result the divergence in levels has widened from 2:1 in 1820 to nearly 7:1 in 2001.

Causal Influences affecting performance in most countries of the "West"

My conclusions on Western performance and the nature of the dichotomy between the "West" and the "Rest" was not derived simply by aggregation of estimates for individual countries. Two types of trans-national phenomena were significant from 1500 to 1820, which affected growth performance significantly in virtually all the countries of Western Europe and in Western Offshoots, but had a much weaker impact on the rest of the world. These were the development of secular knowledge and science which had a direct impact on production potential, and interaction between continents, through trade and ecological transfers. I kept these influences in mind in making inferences for developments in the non-sample countries.

(i) *Development of Secular Knowledge and Science*

Kuznets stressed the importance of secular knowledge and science as a basic cause of Western economic ascension, and there is evidence, from about 1500, of a new awareness of human capacity to transform the forces of nature through rational investigation and experiment. This had no counterpart in other parts of the world in this period.

The first European university was created in Bologna in 1080. By 1500 there were 70 such centres of secular learning in Western Europe (see Goodman and Russell, 1991, p. 25). Until the mid-fifteenth century, most of the instruction was oral, and the learning process was similar to that in ancient Greece. Things changed after Gutenberg printed his first book in Mainz in 1455. By 1500 220 printing presses were in operation throughout

Western Europe and had produced eight million books (see Eisenstein, 1993, pp.13-17). The productivity of universities and their openness to new ideas was greatly enlarged.

The main centre of European publishing was Venice where printed books were first produced in 1469. Before then, scribes, bookbinders and specialists in ornamental calligraphy and illustration produced sacred books or translations of Greek and Latin classics for city archives or wealthy private collectors. Productivity in book production was revolutionised and costs had fallen dramatically by the 1470s. In 1483 the Ripoli press produced 1,025 copies of Plato's *Dialogues*. A scribe would have taken a year to produce one volume. Assuming that the Ripoli Press had higher capital outlays on equipment than institutions employing scribes, and needed one man-year of skilled labour input to produce its 1025 copies, one can infer that productivity in book production increased at least 200-fold. By the middle of the sixteenth century, the Venetian presses had produced some 20,000 titles, including music scores, maps, books on medical matters, and a flood of new secular learning. The latter point is of great significance. Before printing, books were cherished for their artistic or iconic value, and their content mainly reflected the wisdom and dogma of the past. Printing made books much cheaper. Publishers were much more willing to risk dissemination of new ideas and to provide an outlet for new authors. The proportion of the population with access to books was greatly increased, and there was a much greater incentive to aspire to literacy. It should also be stressed that, with the exception of China, the European printing revolution had no counterpart in most other parts of the world until the beginning of the nineteenth century. The major difference between Europe and China was the competitive character of European publishing, and the international trade in books. This frustrated the attempts of the Papacy to achieve thought control through the Inquisition and censorship. China was a centralized state, with vestigial foreign contacts. The education of its bureaucracy was devoted to ancient classics, and they were able to exercise thought-control by more subtle and effective methods than the Papacy in Europe.

Further changes in intellectual horizons occurred between the sixteenth and seventeenth centuries, when medieval notions of an earth-centred universe were abandoned. Thanks to the Renaissance, the seventeenth century scientific revolution and the eighteenth century enlightenment, Western elites gradually abandoned superstition, magic, and submission to religious authority. The scientific approach gradually impregnated the educational system. Circumscribed horizons were abandoned. A Promethean quest for progress was unleashed. The impact of science was reinforced by the creation of scientific academies and observatories which inaugurated empirical research and experiment. Systematic recording of experimental results and their diffusion in written form were a key element in their success.

(ii) *Interaction between Continents through Trade, Ecological and Technical Transfer*

Dramatic progress in Western shipping and navigation permitted a 20-fold increase in world trade between 1500 and 1820. It brought gains from specialization of the type

stressed by Adam Smith. It provided European consumers with new products-tea, coffee, cacao. sugar, potatoes, tomatoes, tobacco, porcelain, silk and cotton textiles. In relative terms this globalisation process was a more important component of growth in these centuries than in the twentieth (see Table 8). It was also possible to extract a colonial surplus: the Spanish and Portuguese from the Americas in the sixteenth century, the Dutch in Asia from 1600, the British and French in the eighteenth century. Spanish plunder was mainly in the form of precious metals. These were very important in financing European trade with Asians, who were not interested in buying European products.

Improvements in shipping and navigation led to conquest and transformation of the Americas. There was an ecological transfer of novel American products: maize, potatoes, manioc, sweet potatoes, groundnuts, beans tomatoes, cacao etc. to Europe, Africa and Asia where the consumption pattern improved and productive power of agriculture was substantially increased. The productive power of the Americas was given an even bigger boost by the introduction of new crops (wheat, rice, sugar, vines, olives cabbage, bananas, coffee etc.) and animals (horses, cattle, pigs, chickens sheep and goats). The stone-age economy of the Americas had no wheeled vehicles, draught animals, sailing ships, metal tools, weapons or ploughs. The European conquest brought a rapid introduction of all these. The second consequence was initially much less benign, the transfer of new diseases which killed off two thirds of the population in the Americas, and was compensated by a huge shipment of African slaves which lasted for more than four centuries.

The "Rest"

I drew largely on my own research to make quantitative measures for India, China, Brazil and Mexico. These four countries represented 65 percent of my estimate for GDP in the "Rest" in 1500. From 1700, coverage was a bit higher as I estimated Indonesian GDP from then onwards. For 1820, my 5 country sample represented 69 per cent of the GDP of the "Rest". Average per capita GDP of the "Rest" rose from $538 in 1500 to $578 in 1820.

India

Maddison (1971) on India and Pakistan contained an analysis of the social structure and institutions of the Moghul empire and the British raj. For the Moghul period, I relied heavily on the economic survey made by Abul Fazl for the emperor Akbar at the end of the sixteenth century (see Jarrett and Sarkar, 1949). Between 1600 and the 1860s, the quantitative evidence is not so good, but the two leading historians of Moghul India, Habib and Moosvi (at Aligarh Muslim University), adduce evidence which led them to conclude, I think rightly, that there was some decline in per capita income after the collapse of the Moghul Empire and the takeover by the East India Company. Since 1971, a lot of new material and analysis has become available which made it possible to check and revise my earlier estimates (see Maddison, 2001, pp.108-116 and p. 252). The

two large volumes of the *Cambridge Economic History of India* appeared in 1982-3 and covered the period from 1200. Gordon Johnson organised a very useful workshop in Cambridge in 1984 which brought most of the authors together to confront their conclusions, and he has been the general editor of more than twenty monographs in the *New Cambridge History of India* since 1987. Deepak Lal's (1988) interpretation of the Hindu equilibrium added new insights. For the link with the present, we have Alan Heston's (1983) estimates for 1868-1900, and Sivasubramonian (2000) for the whole of the twentieth century.

Indonesia

As I was teaching a course on Asian economic history to Dutch students for more than ten years, I felt it necessary to remedy my ignorance of a country which was a Dutch colony from 1600 to the 1950s. I visited Indonesia twice, but conditions in academia are not yet very propitious for quantitative economic history. My main sources of enlightenment were: a) the Royal Tropical Institute in Amsterdam which produced 14 volumes of quantitative economic history (*Changing Economy in Indonesia*) between 1977 and the 1990s, based mainly on colonial archives. This project was started by Peter Creutzberg and continued by Peter Boomgaard of the University of Leiden; b) the Research School of Pacific Studies at ANU (Australian National University) in Canberra. It has a large research programme on Indonesian history, excellent contacts with Indonesian and European and American historians, and the best library in this field. My main contact was Anne Booth who organised a workshop on Indonesian history in Canberra in 1983, and I, together with Ge Prince, organised a follow-up in Groningen in 1984. The proceedings of both were published. My contribution, Maddison (1987b), covered the period 1700-1870. The approach was similar to my analysis of India, i.e. assessment of the impact of colonialism on the social structure. It also involved an estimate of income per capita for the indigenous population, Chinese and Dutch settlers. My graduate student, Pierre van der Eng wrote his Ph. D. thesis on Indonesian history, has been working on Asian economic history since then at ANU, and has been my guide on this topic ever since. However, quantitative evidence for measurement of per capita income in Indonesia before 1700 is very flimsy. For 1500-1700, I simply assumed that per capita income did not change (see Boomgaard, 1993 for a brilliant and detailed survey of the evidence for 500 to 1990).

China

Maddison (1998) on China was the most satisfactory of my country studies of long-term performance, because the evidence was better and went much further back in time. China had a strong central bureaucracy for more than a thousand years and records of population and agricultural performance which had no counterpart in India. It was homogeneous in its written language. It started to use printing 500 years before Europe and 800 years before India. There is also a great deal of scholarly work on China. Needham's (1954-97 and 1970) massive work on the development of Chinese

technology, Ho (1959) on Chinese demography, and the interpretative analysis of Balazs (1931-33) and Elvin (1973) have no counterpart in India. In 1969, Kuznets' pupil, Dwight Perkins, published a magisterial study of Chinese agricultural development from 1368. His findings were based on scrutiny of a large collection of regional gazetteers produced by the physiocratic bureaucracy. They showed grain output rising about fivefold from 1400 to 1820-more or less in line with population. The cultivated area rose threefold and yields per hectare about 80 per cent. The increase in yields was due to use of better seeds, double cropping, introduction of new crops from the Americas, and increased per capita labour inputs. Rozman's analysis of the demographic records shows no significant change in the relative size of the urban population over this period. Earlier, it is clear that that China did experience a growth in per capita agricultural output and GDP in the Sung dynasty (960-1280).

It was necessary to link the long term contours of Chinese development with the present. For this reason I reconstructed the estimates of Chinese GDP growth for the communist period (with the cooperation of Harry Wu), and established an ICOP type measure of benchmark GDP levels in 1987 (with the cooperation of Ren Ruoen).

Brazil & Mexico

I spent a good deal of time in Brazil and Mexico in 1964-66 and 1984-88. On the first of these assignments I was an advisor to the Minister of Planning in Rio and the Bank of Mexico, mainly on the supply of skills to the industrial sector, problems of their education systems and the role of foreign aid. Maddison (1965) was a comparative study of these problems. The second assignment was a comparative study of economic and social development of the two countries as part of an ambitious World Bank project (directed by Deepak Lal) to compare performance of 20 countries (7 in Asia, 7 in Latin America and 6 in Africa). Most of these were binary comparisons of pairs of countries. Maddison and Associates (1992) on Brazil and Mexico was one of the eight studies which emerged. My main associates were Victor Urquidi, Annibal Villela and Paul Lamartine Yates. As the project progressed there were a dozen workshops to compare the analysis and results, and interact with economists and historians in the different countries under study. Several of the participants were economic historians, including Guido di Tella, Dharma Kumar and Perry Anderson, whose function was to animate the discussion rather than write the books. In fact, the time horizon was mainly the twentieth century, but I spent quite a lot of time collecting material on developments from 1500 and the impact of Spanish and Portuguese colonialism on the indigenous societies as they existed at the time of the conquest. The Brazil study is on my website, the Mexican study is in Maddison (1995b). Brazil and Mexico together, represented about half of my estimate of Latin American GDP in 1500 and in 1820. In making estimates of performance for the premodern period it is essential to ensure that the benchmark estimate of GDP level in 1990 and in 1820 is as good as one can make it. In the case of Brazil and Mexico, we were able to check the ICP estimate with a full ICOP comparison, financed largely by the

World Bank. Maddison and van Ark (1989) shows our procedure and results for manufacturing, Mulder (2002) shows the results for services, and Hofman (2000) presented historical growth accounts, GDP and capital stock estimates for six Latin American countries, including Brazil and Mexico.

Demography

In estimating long-term economic performance, demography is of primary importance. Per capita growth before 1820 was slow by modern standards and the bulk of GDP movement was due to population increase. In China, population increased more than threefold from 1650 to 1850, and the evidence suggests that living standards did not drop. This is an impressive example of *extensive* growth. In the same period, West European population rose a little more than twofold, i.e. a smaller dose of *extensive* growth; but per capita income rose by 70 per cent. Chinese GDP rose by 0.60 per cent a year, European by 0.64 per cent. Ester Boserup (1965) made an enormous contribution to historical demography and economics, by explaining how population growth in the rice economies of Asia induced increased labour inputs per capita, and more intensive use of land by double-cropping, improved seeds, and fastidious collection and application of manure. She played a major in demolishing the Malthusian spectre, which inhibited earlier analysts from conceiving the possibility of extensive growth.

Demographic material is also important in providing clues to per capita income development. One striking example is the urbanisation ratio. Thanks to the work of de Vries (1984) for Europe and of Rozman (1973) for China and Japan, one can measure the proportion of population living in towns with more than 10,000 inhabitants. In 1500 , this ratio was 6 per cent in Western Europe and 3.8 percent in China. By 1800 the West European urban ratio was 10.6 per cent and the Chinese still 3.8 per cent. When countries are able to expand their urban ratios, it indicates that there was a growing surplus beyond subsistence in agriculture, and that the non–agricultural component of economic activity was increasing. These ratios are a useful check on estimates or conjectures of per capita growth and levels of income. Another useful clue to living standards is provided by changes in life expectation; in Western Europe, life expectation at birth rose from 24 to 36 years from 1500 to 1820, in the rest of the world there was no evidence of improvement (see Maddison 2001, pp. 29-31).

What have we learned about economic growth, 1500-1820 ?

Between 1500 and 1820, West European per capita income rose by more than half, there was a threefold increase in the Western offshoots (in North America and Australasia), and a rise by a third in Japan. The average for the "West" was about sixty per cent. In the "Rest", there was a very small rise of 7 percent. Population rose to a similar extent in the West and the Rest. In both parts of the world, growth was very much faster from 1820 to 2001, when per capita income rose 20-fold in the West and six-fold in the Rest. In 1500, the per capita income level was already higher in the West than the

Rest. By 1820 the gap had widened, and the West had become almost twice as prosperous as the Rest. This process of divergence has continued and the gap is now nearly 7:1.

It is not possible to quantify the proximate causes of Western growth before 1820 in the detail shown in table 6, but it is clear that investment in machinery and equipment was modest except in shipping. Investment in human capital was also modest, but the quality of human capital was transformed by the invention of printing, fundamental advances in science, and the spread of secular university education for the elites. Technical progress was slower than it is now, and much less capital-intensive. Some of it derived from trial-and-error, but institutional support for scientific research had a very direct impact on technology, particularly in shipping and navigation. Technical progress in this period was not energy-intensive. It relied on more effective wind-power, improvements in the efficient use of horse traction, and an increase in hours worked per capita. There was very modest use of mineral fuels and heavy reliance on wood and other organic matter. In proportionate terms, globalisation was much more important from 1500 to 1870 than it has been since. A great part of the increase in productivity was due gains from increased specialisation and increases in the scale of production-gains of the type which were stressed by Adam Smith in his analysis of the causes of economic progress up to 1776. The closer integration of the world economy was an important source of progress, but the mercantilist commercial policy of the leading European countries were mutually discriminatory and restrictive. Beggar-your neighbour policies were buttressed by wars. Between 1700 and 1820, the UK was involved in five major wars (for a total of 55 years) due in large degree to its pursuit of worldwide commercial supremacy.

The evidence for quantifying world development between 1500 and 1820 is a good deal weaker than that for modern economic growth. There is clearly great scope for further research, which may modify my conclusions. Some of my results have already been contested, and I have described my evidence transparently in order to facilitate such contestation (10). However, I think this exercise in quantitative economic history has demonstrated clearly that two widely held views are wrong: .

a) the view that the world was caught in a "Malthusian trap", with living standards oscillating around subsistence levels for millennia because of technological stagnation and that deliverance came from a sudden takeoff, an "industrial revolution", originating in Lancashire in the last quarter of the eighteenth century (11).

b) the view that income levels in Asia and Europe were similar around 1800, and that divergence in their income levels emerged only within the past two centuries (12).

What happened before 1500?

For this period, my per capita estimates are much weaker than for 1500 onwards, though I think the population estimates are fairly robust. In going back so far I was inspired largely by my experience in finding very long-term evidence for China in Maddison (1998), and the estimates of Raymond Goldsmith for the Roman Empire (13).

There is no space here to analyse the measurement problems for this period, but they are discussed at some length in Appendix B of Maddison (2001), and in chapter HS 8 of Maddison (2003)

Footnotes

(1) The other founder members were Colin Clark, J.B.D. Derksen (head of national accounts in the UN Statistical Office), Erik Lundberg, Francois Perroux (founder of ISEA, and creator of a French team-Marczewski, Toutain and Markovitch-to construct a quantitative economic history of France), R.K.R.V. Rao (a pioneer of Indian national accounts, pupil of Colin Clark), and Jan Tinbergen (see Carson, 1999).

(2) Nordhaus (1997) was an ambitious attempt to measure long-term changes in the price of light using the hedonic approach. He estimated that the "true" i.e. hedonic price of artificial light *fell* by 4.2 per cent a year (about 3,450-fold) between 1800 and 1992 in the USA, whereas the annual *rise*, using the conventional consumer price approach, was 1.2 per cent a year.

He also illustrated the implications of this approach in measuring the movement of real wages. The conventional measure showed a 13-fold increase between 1800 and 1992. The "true" rise, using his approach, was between 40 and 190 fold. He derived this result by converting conventional price indices into hedonics for three economic sectors. For "run-of-the-mill" activities, where the characteristics of goods and services have changed relatively little, he felt that conventional price indices needed a downward corrective adjustment for "bias" of 0.5 per cent a year. For "seismic" sectors where the goods and services of 1800 have changed, but are still recognisable, conventional price indices needed a downward adjustment equal to half of his measure of bias for light. For "tectonic" sectors, where the nature of the good or service has changed drastically, or did not exist in 1800, he applied his bias-adjustment for light. He assumed that 75 per cent of goods and services were in the first category in 1800, and that this proportion fell to 28 per cent in 1992, when 36 per cent were seismic and 37 per cent tectonic. I estimate that US per capita GDP rose 21-fold from 1800 to 1992 from $1,087 to $23,169. If the true increase were 40-fold, the 1800 level would have been $579, which is within the bounds of possibility. An increase of 190 fold would mean an 1800 level of $122 which would be well below subsistence. The Nordhaus approach is ingenious, but highly subjective and neglects the fact that the supply of daylight did not change between 1800 and 1992. Taking his cue from Nordhaus, Bradford DeLong (1998), argued that the Maddison (1998) estimates of the rise in world GDP per capita involved massive understatement because of uncaptured quality improvements. To correct this alleged mismeasurement he assigned "somewhat arbitrarily…an additional fourfold multiplication to output per capita since 1800". As I did not show an estimate for 1800, it is difficult to follow his arithmetic for that year. However, one can confront his results and mine for 1500-1990 where I showed a 9-fold increase in world GDP per capita. His adjustment transforms this into a 45-fold increase and lowers the average level of world income in 1500 to $115 per capita

(in 1990 PPP dollars). This is a fifth of my estimate of $566 in 1500. He assumed that world per capita income remained at $115 from 1500 back to 1 million BC. He also presented two alternative scenarios, of which, the "ex-Nordhaus", is the most plausible, but its derivation is not clear.

(3) Christopher Patten, the last British governor of Hong Kong, stated in an article in the *Economist* newspaper of 4th January 1997. that "Britain's GDP today is almost twice the size of China's". If he had been briefed on PPP converters, he might have said that Britain's GDP was one third the size of the Chinese. On 29th April 2004, Michael Howard, the leader of the conservative party was quoted as saying that "China's GDP is now close to that of Britain". On 21 April 2004, there was a discussion in the British House of Lords on the government's reaction to the report of the International Panel on Climate Change. Lord Taverne asked the Minister whether her department were aware of the criticisms of the emissions scenarios by Ian Castles, former head of Australia's Bureau of Statistics and David Henderson, former head of the OECD Economics and Statistics Department. They had pointed out that it was quite inappropriate to use market exchange rates "for measuring the difference between rich and poor countries; it exaggerates them. Some questionable assumptions are also made about the rate of closure of the gap between rich and poor nations" The minister replied that "we owe it to future generations to err on the side of caution. The noble Lord's reference to Castles and Henderson would lead us in the direction of perhaps being too far laid back in our attitude to the future". Towards the end of the debate, Lord Desai, professor of economics at LSE, asked "does my noble friend not agree that whether one takes one measure of GDP or another is very much a matter of taste? After all, nobody pays their bills in purchasing power parity; they pay it in real money, which is based on market exchange rates".

(4) Kaldor (1945) concluded that "Germany made no serious attempt to exploit her own war potential fully, except for a brief period in August and September 1944, when it was too late to be of any consequence". Galbraith (1971) made the same point. Kaldor's analysis was drawn from material gathered as a staff member of the US Strategic Bombing Survey (1945), and interrogation of Saur, Albert Speer's deputy. The survey team was directed by Galbraith, and included Paul Baran, Ed Denison, Burton Klein, and Tibor Scitovsky (under the nom-de-guerre "Thomas Dennis"), with Jürgen Kuczynski as a hanger-on. Kaldor and Scitovsky interrogated Saur in Austria, the day the war ended. He indicated where they could find the wartime production records in Leipzig, and they whisked them away just before the Russians arrived. Denison and Haraldson made a detailed estimate of German GNP, 1936-44, to put military mobilization in perspective. Ruggles served with the US Office of Strategic Services in London, inferred German production of tanks, trucks, and planes by decoding information on serial numbers of captured equipment (see Tobin, 2001). Stone worked with British intelligence and predicted the date of Italian entry in the war, by tracking movement of ships in the Mediterranean. Kuznets used national accounting to help organise the massive expansion

of US military output in the Planning Committee of the War Production Board (see Kapuria-Foreman and Perlman (1995), with help from Moe Abramovitz. The moral of this digression is that the initial stage in construction of national and historical accounts is not a boring bureaucratic business. It requires detective work and imagination, and can be as exciting as the adventures of Sherlock Holmes.

(5) He did discuss exchange rate/PPP divergence with some tentative illustration of its significance in Kuznets (1966), pp. 374-399, and he discussed relative price structures in Kuznets (1973), pp. 333-339.

(6) The 1968 Centre publication *National Accounts of Less Developed Countries 1950-1966* set up the first database on growth performance of developing countries. It included time series for GDP and its components for 42 countries. Between 1969 and 1991 23 annual updates were issued. It was superseded by the World Bank publication, *World Tables*, started in 1976, when it became annual in 1987. Unfortunately, it was discontinued in 1995. Those seeking similar coverage of the developing world have to rely on regional publications, i.e. Asian Development Bank, *Key Indicators*, Oxford University Press; Economic and Social Commission for Asia for Western Asia, *National Accounts Studies of the ESCWA Region*, Beirut; ECLAC, *Statistical Yearbooks for Latin America and the Caribbean*, Santiago. There is nothing comparable for Africa, but summary information on annual changes in GDP in virtually all African countries can be found in the IMF *World Economic Outlook*.

(7) see Maddison (2004), for an extensive analysis of Clark's work and career.

(8) Estimation of the stock of human capital is analogous to the procedure for estimating physical capital. A useful starting point is scrutiny of successive population censuses. This was done for 19 OECD countries where respondents had reported the age at which their formal education ended, by sex and age-cohort in OECD (1975, pp. 31-108 of vol. 1). These benchmark estimates can be updated by annual cumulation of increments to the stock as revealed by subsequent school enrolment, (available from the OECD annual *Education at a Glance* and its predecessor volumes), and deduction for people who retire from the labour force. Estimates of the value of the stock can be derived from estimates of earnings by level of education, primary, secondary and higher (see Psacharopoulos, 1975).This is the procedure I used for my growth accounts for advanced OECD countries in Maddison (1987a). In where I made human capital estimates for 22 developing countries, the approach was similar, but the estimates were of lower quality (see Maddison. 1970, pp.45-50).

(9) Growth accounting can also be used to test the findings of econometricians who use the regression approach for causal analysis. They experiment with new ideas about what is important in the growth process, and may come up with exciting results. Often the most exciting ones come from simple regressions. If some elements are left out, those which remain may take over a large part of their "explanatory" power, because of the close interactions of most elements in the growth process. It is therefore useful to cross-check

explanatory items favoured by econometricians in the stodgier but more transparent framework of growth accounts. When a new or more heavily weighted item is added to the accounts, one may find that growth is over-explained, and then there is reason to rework the regression.

(10) In an extensive review of Maddison (2001), Giovanni Federico (2002) suggested that I may have exaggerated West European performance, citing alternative estimates of Robert Allen which imply that aggregate West European income per capita actually fell in this period, and those of Jan Luiten van Zanden which imply a growth rate of only 0.06 per cent a year. I do not regard their gloomier conclusions as a serious challenge to my estimates for the reasons explained below.

Allen (2001) presents real wage estimates for Europe, 1500-1913. He shows nominal wages (in grams of silver per day) for building craftsmen and labourers in 18 European towns, and consumer price indices based on 12 items, two-thirds of which were bread, beer and meat. The results are presented for fifty-year time segments. His basic data are for daily wages, which he converts to an annual basis by assuming a working year of 250 days (this multiplier was apparently applied uniformly to his inter-temporal and cross-country data). For the 14 towns where he has results for craftsmen for both 1500-49 and 1750-99, the average real wage in the latter period was 66 per cent of that in 1500-49,London was the only case where the real wage was higher, with a rise of less than 1 percent. In the 12 towns for which he had results for building labourers for the two periods, there was a rise of about 3 per cent in Amsterdam and a fall everywhere else. The average real wage for labourers was 76 percent of the 1500-49 level in the end period (p. 428). This is less gloomy than Phelps Brown, but the clear implication is that living standards in Western Europe declined substantially from 1500 to 1800. Allen (2000) was "an exercise in historical reconstruction based on simple economic theory" which presented estimates of the movement in agricultural output per capita for nine countries for 1500-1800. He shows a fall in all nine countries between these two points of time, and in most cases they are very substantial. For England, he shows a 32 per cent drop (see p. 19). This is very different from Wrigley's estimate that English agricultural output per capita doubled in the shorter period 1600 to 1800. It also differs substantially from the estimates presented by van Zanden and Horlings (1999b, p. 28). Allen does not measure agricultural output directly. He derives it econometrically from his estimates of occupational structure and the assumption that his real wage measures are a valid proxy for total output per capita.

Van Zanden (2002) presents estimates of real GDP for five countries which imply that, from 1500 to 1820, average West European per capita income grew less than less than half than as fast as I estimated in Maddison (2003). Table 9 compares his estimates with mine.

For the UK, he shows slightly slower growth, because he uses a different source for agriculture. We both agree that growth was most rapid in the UK, and I see no reason to modify my estimate. For the Netherlands, our estimates are quite similar for 1570 onwards.

the main difference is that he assumes Dutch per capita income have been stagnant from 1500 to 1570, whereas I assume a substantial increase. Between 1470 and 1570 the Dutch merchant fleet increased nearly fourfold- a growth rate of 14 per cent a year (see p.77 of Maddison 2001), and urbanisation was increasing substantially. Van Zanden agrees with me that Dutch per capita income in 1500 was lower than that in what is now Belgium. Nevertheless his estimates show the opposite situation in 1500. To mitigate this he adjusted the Blomme-van der Wee growth rate for Belgium downward, whereas I accepted it. Van Zanden and I agree that Italy was the highest income country in 1500, but he assumes an 18 fall in per capita GDP from 1500 to 1820, whereas I assumed stagnation. He quotes Malanima's (1994) estimate for northern Italy as his source. In fact, Malanima (1994 and 1995) suggested a fall of 7 per cent, but van Zanden's estimate is near that of Malanima (2003), and shows a fall of about a fifth. The evidence for Italy as a whole is not very good and there are two schools of thought on performance in this period. Malanima's judgement resembles that of Cipolla (1976), whereas Rapp (1976) and Sella (1979) argued that per capita income was stagnant from 1500 to 1820. I lean towards their judgement, but as the urbanisation rate was slightly higher in 1800 than in 1500, I assumed a very slight rise. For Spain, Van Zanden shows a growth rate of 0.02 per cent a year for 1570-1820, which he derives by modifying the estimate of Yun (1994) for Castile, 1580-1800. In fact, Yun's estimate (p. 105) shows growth twice as fast as this. In Maddison (2001, p. 249), I explained my reasons for modifying Yun's estimate, which omits the years 1500-80 when Spain's economy received a major boost from the conquest of the Americas.

Van Zanden (1999) presented real wage estimates for unskilled building labourers in 14 European cities/regions, using cereal prices (rye or wheat) as a deflator. He shows a fall in all the 10 cases where he had estimates for 1500-20 and 1780-1800, the average for the latter period was 60 per cent of that in 1500-20, an annual average change of -0.17 per cent a year. This is more pessimistic than the Allen (2001) results for labourers, but is similar to the findings of Phelps Brown and Hopkins (1956, p.29-30) for English building craftsmen for the same period. Van Zanden feels that real wage estimates are "an important source of information on living standards", even though they are in sharp conflict with a large body of other evidence. He suggests that a reconciliation may be possible. His estimates are for daily wages, and he suggests that there may have been a substantial increase in average annual working time of labourers over the period covered and that their family income may have been supplemented by increased labour force activity of women and children. It seems likely that there were changes in this direction as indicated in de Vries (1993), but van Zanden does not attempt to quantify them, and it is highly doubtful that their effect would be big enough to achieve a reconciliation. Van Zanden's desire for reconciliation may have introduced a downward bias in his (2002) estimates of real per capita GDP for 1500-1820.

The founder of real wage analysis, Thorold Rogers (1823-90), Was professor of economics in Oxford and a liberal member of parliament who argued that the condition of English wage earners could be improved by extending the franchise and encouraging trade

union activity. For him, low wages were the result of exploitation of the labourer by the ruling elite. He made a sharp distinction between wage income and national income, as is clear from his citation of Gregory King's estimates of inequality in 1688 (Rogers, 1884, pp. 463-465). He summarised his position, saying (p.355): "society may make noticeable progress in wealth, and wages remain low …relatively speaking, the working man of today is not so well off as he was in the fifteenth century".

Some of the real wage revivalists have forgotten this and use real wages for a small group of workers as a proxy for GDP per head. Lindert and Williamson (1982, p. 393) show that only 5.3 per cent of families derived their livelihood from the building trades in 1688. In the Phelps Brown-Hopkins study, whose sources were meticulously documented, there were about 3 wage quotations a year for building labourers, and for 1500 to 1800 there were 82 years without an estimate. Over such a long period there may have been big changes in the nature of building work, e.g. a shift from decorative ecclesiastical stonework to bricklaying.

(11) This view has had various advocates since Arnold Toynbee first popularised the industrial revolution metaphor in 1884. The most recent and sophisticated devotee is Joel Mokyr (2002) who considers that modern economic growth was initiated by a sudden leap in industrial technology. He provides a detailed, erudite, illuminating but complex history of the interaction of "propositional" and "prescriptive" (useful) knowledge since the mid eighteenth century, with a more cursory acknowledgement of what happened earlier. He suggests (pp.31-2) that "most techniques before 1800 emerged as a result of chance discoveries, trial and error". He makes a grudging acknowledgement of the importance of printing (p.8), and only a fleeting reference to advances in shipping and navigation technology but is dismissive about their impact: "these earlier mini-industrial revolutions had always petered out before their effects could launch the economies into sustainable growth. Before the Industrial Revolution, the economy was subject to negative feedback; each episode of growth ran into some obstruction or resistance that put an end to it…The best known of these negative feedback mechanisms are Malthusian traps, in which rising income creates population growth and pressure on fixed natural resources". He is very insistent on the narrowness of the "epistemic base" before 1800, and argues that positive feedbacks between the two types of knowledge have increased hugely in the course of three industrial revolutions since the eighteenth century. There has been a cascading interaction (p. 100) and we have now arrived at a point where modern information technology has produced "an immensely powerful positive feedback effect from prescriptive to propositional knowledge" (p. 115). His analysis of the economic impact of knowledge is based on assertions rather than quantitative evidence. These are presented with characteristic fervour, e.g. his assessment of the impact of his second industrial revolution: "The pivotal breakthrough in the propositional knowledge set was the identification of the structure of the benzene molecule by the German chemist August von Kekulé in 1865…the discovery of the chemical structure is a paradigmatic example of a broadening of the epistemic base of an existing technique" (p. 85). My problem with Mokyr's analysis is with his judgement on the

impact of science and not with his model which can be useful in explaining why the scientific revolution of the 17th century had a delayed payoff, and why the innovative impact of science and technology accelerated in the past two centuries. The problem is that he assumes no net improvement in living standards before 1800, and a constantly accelerating cornucopia since then. This contradicts the quantitative findings of historical national accounts in the Kuznetsian tradition for the period before and after 1800. Mokyr is of course aware of this. In his defence (pp. 116-117) he suggests that "aggregate output figures and their analysis in terms of productivity growth may be of limited use in understanding economic growth over long periods. The full economic impact of some of the most significant inventions over the past two centuries would be entirely missed in that way." Instead he opts for the Silicon-valley serendipity of Bradford DeLong (1998) see footnote 2 above.

(12**)** The main advocates of this view were Paul Bairoch (1981), Fernand Braudel (1984), Andre Gunder Frank (1998), and Kenneth Pomeranz (2000) who all asserted that China was ahead of Europe until 1800. The first two changed their opinion. Pomeranz presented the most elaborate analysis of the nature and timing of the "great divergence" between China and Western Europe. He suggests that Western Europe was "a non-too-unusual economy: it became a fortunate freak only when unexpected and significant discontinuities in the late eighteenth and especially nineteenth centuries enabled it to break through the fundamental constraints of energy and resource availability that had previously limited everyone's horizons". I have explained my disagreement at length in Maddison (2003), pp. 248-251.

(13) Raymond Goldsmith, a pupil of Werner Sombart in Berlin in the 1920s, a financial analyst on Wall Street in the 1930s, a close associate of Kuznets, active IARIW participant, a colleague of mine in Paris in 1964-1966, was a scholar with great energy, erudition and imagination. In 1984, he published an article in RIW on the level of income in the Roman Empire, and in 1987 a comparative historical survey of financial systems, population, area, urban ratios, income distribution, national income and wealth per head in gold or grain units in 9 places: Periclean Athens (430 BC); Augustan Rome (14 AD); the Abbasid Caliphate (800AD); the Ottoman Empire at the death of Suleiman I (1556); Moghul India at the death of Akbar (1605); Tokugawa Japan (1616); Medici Florence (1427); Elizabethan England (1565 & 1603); the Netherlands (1648). He squeezed his source material with a temerity few could equal, but it and his conjectures were transparently described. In his last chapter he confronted the results for the 9 countries, but warned that the comparison of national product per head in gold units could not be adjusted for differences in purchasing power "the price of gold in terms of other commodities is not known and cannot be assumed to have been the same, or even similar, in the different cases" (pp. 232-3).

Table 1
First Official National Income Estimates

Australia	1886	New Zealand	1931
Canada	1925	USA	1934
USSR	1925	Turkey	1935
Germany	1929	Yugoslavia	1937
Netherlands	1931	Switzerland	1939

Source: Studenski (1958), p.151.

Table 2 Coverage of "Modern Economic (GDP) Growth" in Clark, Kuznets & Maddison

	Clark 1940		Kuznets 1956		Kuznets 1971	Maddison 2003
	period covered	number of years shown	period covered	overlapping decades	period covered	period covered=1820-2001 years shown
Argentina					1900-1967	104
Australia	1886-1938	29	1886-1954	11	1861-1967	182
Belgium					1900-1967	158
Canada	1903-1936	19	1870-1954	17	1870-1967	137
Denmark	1913-1933	10	1870-1954	17	1865-1967	182
Egypt					1895-1966	59
France	1850-1937	23	1810-1953	20	1831-1966	182
Germany	1854-1938	41	1860-1954	18	1850-1967	154
Ghana					1891-1967	58
Hungary			1899-1949	9		81
India	1867-1929	4			1861-1967	120
Ireland			1860-1953	9		84
Italy	1893-1901	2	1862-1954	19	1861-1967	143
Jamaica					1832-1966	61
Japan	1887-1936	26	1878-1954	15	1874-1967	133
Mexico					1895-1967	106
Netherlands	1913-1934	11	1900-1954	11	1860-1967	182
New Zealand	1901-1938	14	1901-1954	7		137
Norway	1913-1937	15	1900-1954	9	1865-1967	139
Philippines					1902-1967	102
Russia	1870-1937	9	1870-1954	6*		73
South Africa			1911-1953	9		55
Spain			1906-1953	9		153
Sweden	1861-1936	31	1861-1954	19	1861-1967	182
Switzerland	1924-1934	11	1890-1953	8	1910-1967	153
UK	1688-1937	23	1860-1953	18	1695-1967	182
USA	1850-1937	35	1869-1954	17	1800-1967	137
Total/ Average	16	19	19	13	21	Total=27 Average 127

Source: Cols. 1-2 (16 countries) from Clark (1940), pp. 78-145, col. 2 refers to the number of individual years for which estimates were shown. Cols 3-4 (19 countries) from Kuznets (1956), pp. 53-94, col 4 refers to the number of overlapping decades shown, the average is 13, i.e. approximately 65 years. For Russia it refers to number of years shown. Col 5 (21 countries) from Kuznets (1971), pp. 11-14 & 30-31; in 1971, Kuznets showed the average of his overlapping decades without indicating how many he had for each country. He obviously had more decades availablethan in col.4 because he updated all the country estimates to 1966/7, and in some cases he had more information for earlier years.Col. 6 is from www.eco.rug.nl/~Maddison/

Table 3a Coverage of Maddison (2003) GDP Sample and Proportionate Role of Proxy Measures
(GDP in billion international dollars and number of countries)

	1500		1700		1820		1870		1913		1950	
	Number of Sample Countries &Size of their GDP											
W. Europe	27.2	*5*	60.3	*7*	135.4	*9*	326.9	*14*	898.5	*15*	1,394.8	*20*
W. Offshoots		*0*	0.7	*2*	12.7	*2*	110.6	*3*	577.2	*3*	1,635.5	*4*
E. E. & f. USSR		*0*		*0*	6.5	*1*	101.9	*3*	290.9	*3*	694	*7*
Latin America	3.6	*2*	3.1	*2*	8.2	*3*	17.5	*6*	101.9	*9*	315.6	*39*
Asia	130	*3*	196.3	*4*	383.5	*10*	392.3	*11*	644.6	*17*	969	*39*
Africa		*0*		*0*	0	*0*	0	*0*	30.7	*5*	202.1	*54*
World	160.8	*10*	260.5	*15*	546.2	*25*	985.2	*37*	2,543.8	*52*	5,310.9	*163*
	Total GDP including Proxy Component											
W. Europe	44.2		81.3		160.1		367.6		902.3	*28*	1,396.2	*29*
W. Offshoots	15.2		0.8		13.5		111.5		582.9	*4*	1,635.5	*4*
E. E. & f. USSR	6.7		27.6		62.6		133.8		367.1	*8*	695.3	*8*
Latin America	7.3		6.3		15		27.5		119.9	*47*	415.9	*47*
Asia	161.3		229.5		412.9		427		680.3	*55*	983.7	*57*
Africa	19.3		25.7		31.2		45.6		80.9	*57*	203.1	*57*
World	248.3		371.3		695.3		1,113.0		2,733.5	*199*	5,329.7	*202*
	Coverage of sample, percent of Regional and World GDP											
W. Europe	61.6		74.2		84.5		98.7		99.6		99.9	
W. Offshoots	0		84.9		94.2		99.2		99		100	
E. E. & f. USSR	0		0		10.4		76.2		79.2		99.8	
Latin America	49.2		49.4		54.5		63.6		85		99.9	
Asia	80.6		85.5		92.9		91.8		94.8		98.5	
Africa	0		0		0		0		37.9		99.5	
World	64.8		70.2		78.6		88.5		93.1		99.6	

Table 3b Nature of PPP Converters to Estimate GDP Levels in the Benchmark Year 1990
(billion 1990 Geary-Khamis dollars and number of countries)

	Europe & W. Offshoots		Latin America		Asia		Africa		World	
ICP	15,273	(28)	2,131	(18)	8,017	(24)	0	(0)	25,421	(70)
PWT	59	(3)	71	(14)	524	(16)	891	(51)	1,516	(84)
Proxies	16	(10)	38	(15)	87	(17)	14	(6)	155	(48)
Total	15,349	(41)	2,240	(47)	8,628	(57)	905	(57)	27,122	(202)

Table 4a World's 10 Largest Countries: Comparative Ranking of GDP Levels, 1950,1990 & 2001, at constant 1990 prices, using 1990 Geary-Khamis PPP converters and 1990 Exchange Rates

	1950	1990	2001	1950	1990	2001
GDP	$billion, with 1990 PPP conversion			$billion, with 1990 exchange rate conversion		
USA	1,455.9	5,803.2	7,965.8	1,455.9	5,803.2	7,965.8
China	239.9	2,109.4	4,569.8	46.5	408.9	885.9
Japan	161.0	2,321.2	2,624.5	206.0	2,970.2	3,358.3
India	222.2	1,098.1	2,003.2	61.9	305.9	558.1
Germany	265.4	1,264.4	1,536.7	337.0	1,605.6	1,951.4
France	220.5	1,026.5	1,258.3	261.2	1,215.9	1,490.5
UK	347.9	944.6	1,202.1	362.7	984.9	1,253.4
Italy	165.0	925.7	1,101.4	190.6	1,069.4	1,272.4
Brazil	89.3	743.8	990.1	57.5	479.2	637.8
Russia	314.5	1,151.0	790.6	154.4	565.2	388.2
GDP per head						
	$ with 1990 PPP conversion			$ with 1990 exchange rate conversion		
USA	9,561	23,201	27,948	9,561	23,201	27,948
China	439	1,858	3,583	85	360	541
Japan	1,921	18,789	20,683	2,458	24,042	26,466
India	619	1,309	1,957	172	365	545
Germany	3,881	15,929	18,677	4,928	20,227	23,717
France	5,271	18,093	21,092	6,244	21,432	24,985
UK	6,939	16,430	20,127	7,266	17,131	20,985
Italy	3,502	16,313	19,040	4,046	18,846	21,996
Brazil	1,672	4,923	5,570	1,077	3,165	3,588
Russia	3,086	7,773	5,435	1,515	3,817	2,669

Table 4b 1990 Exchange Rates, Geary-Khamis PPPs & ER/PPP Ratios

	units of national currency per US $		
	Exch Rate	PPP	ER/PPP
USA	1.0000	1.0000	1.0000
China	4.7832	0.9273	5.1580
Japan	144.7900	185.2700	0.7815
India	17.5040	4.8769	3.5892
Germany	1.6160	2.0520	0.7875
France	5.4450	6.4500	0.8442
UK	0.5630	0.5870	0.9591
Italy	1,181.1000	1,384.1100	0.8656
Brazil	68.3000	44.0000	1.5523
Russia	1.0590	0.5200	2.0365

Table 5a
Levels of Per Capita GDP: World and Major Regions, 1000-2001

(1990 international dollars)

	1000	*1500*	*1820*	*1870*	*1913*	*1950*	*1973*	*2001*
Western Europe	400	771	1 204	1 960	3 458	4 579	11 416	19 256
Western Offshoots	400	400	1 202	2 419	5 233	9 268	16 179	26 943
Japan	425	500	669	737	1 387	1 921	11 434	20 683
West	**405**	**702**	**1 109**	**1 882**	**3 672**	**5 649**	**13 082**	**22 509**
Asia (excluding Japan)	450	572	577	550	658	634	1 226	3 256
Latin America	400	416	692	681	1 481	2 506	4 504	5 811
Eastern Europe & f. USSR	400	498	686	941	1 558	2 602	5 731	5 038
Africa	425	414	420	500	637	894	1 410	1 489
Rest	**441**	**538**	**578**	**606**	**860**	**1 091**	**2 072**	**3 377**
World	436	566	667	875	1 525	2 111	4 091	6 049
Interregional Spread	1.1:1	1.9:1	2.9:1	4.8:1	8.2:1	14.6:1	13.2:1	18.1:1
West/Rest Spread	0.9:1	1.3:1	1.9:1	3.1:1	4.3:1	5.2:1	6.3.1	6.7:1

Population: World and Major Regions, 1000-2001

(million)

	1000	*1500*	*1820*	*1870*	*1913*	*1950*	*1973*	*2001*
Western Europe	25	57	133	188	261	305	358	392
Western Offshoots	2	3	11	46	111	176	251	340
Japan	8	15	31	34	52	84	109	127
West	**35**	**75**	**175**	**268**	**424**	**565**	**718**	**859**
Asia (excluding Japan)	175	268	679	731	926	1 299	2 140	3 527
Latin America	11	18	22	40	81	166	308	531
E. Europe & f. USSR	14	30	91	142	236	267	360	411
Africa	32	47	74	90	125	227	390	821
Rest	**233**	**363**	**867**	**1 004**	**1 367**	**1 959**	**3 198**	**5 290**
World	268	438	1 042	1 272	1 791	2 524	3 916	6 149
% West/World	13.0	17.2	16.8	21.1	23.7	22.4	18.3	14.0

Levels of GDP: World and Major Regions, 1000-2001

(billion 1990 international dollars)

	1000	*1500*	*1820*	*1870*	*1913*	*1950*	*1973*	*2001*
Western Europe	10.2	44.2	160.1	367.6	902.3	1 396	4 096	7 550
Western Offshoots	0.8	1.1	13.5	111.5	582.9	1 635	4 058	9 156
Japan	3.2	7.7	20.7	25.4	71.7	161	1,243	2,625
West	**14.1**	**53.0**	**194.4**	**504.5**	**1 556.9**	**3 193**	**9 398**	**19 331**
Asia (excluding Japan)	78.9	153.6	392.2	401.6	608.7	823	2 623	11 481
Latin America	4.6	7.3	15.0	27.5	119.9	416	1 398	3 087
E. Europe & f. USSR	5.4	15.2	62.6	133.8	367.1	695	2,064	2,072
Africa	13.7	19.3	31.2	45.2	79.5	203	550	1 222
Rest	**102.7**	**195.3**	**501.0**	**608.2**	**1 175.2**	**2 137**	**6 626**	**17 862**
World	116.8	248.3	695.3	1 112.7	2 732.1	5 330	16 024	37 194
% West/World	12.1	21.3	28.0	45.3	57.0	59.9	58.6	52.0

Source: Maddison (2003), pp. 256-262.

Table 5b
Growth of Per Capita GDP, Population and GDP: World and Major Regions, 1000–2001

(annual average compound growth rates)

	1000–1500	*1500–1820*	*1820–70*	*1870–1913*	*1913–50*	*1950–73*	*1973–2001*
				Per capita GDP			
Western Europe	0.13	0.14	0.98	1.33	0.76	4.05	1.88
Western Offshoots	0.00	0.34	1.41	1.81	1.56	2.45	1.84
Japan	0.03	0.09	0.19	1.48	0.88	8.06	2.14
West	**0.13**	**0.14**	**1.06**	**1.57**	**1.17**	**3.72**	**1.95**
Asia (excluding Japan)	0.05	0.00	–0.10	0.42	–0.10	2.91	3.55
Latin America	0.01	0.16	-0.03	1.82	1.43	2.58	0.91
Eastern Europe & f. USSR	0.04	0.10	0.63	1.18	1.40	3.49	–0.05
Africa	–0.01	0.00	0.35	0.57	0.92	2.00	0.19
Rest	**0.04**	**0.02**	**0.06**	**0.82**	**0.65**	**2.83**	**1.75**
World	0.05	0.05	0.54	1.30	0.88	2.92	1.41
				Population			
Western Europe	0.16	0.26	0.69	0.77	0.42	0.71	0.32
Western Offshoots	0.07	0.44	2.86	2.07	1.25	1.54	1.09
Japan	0.14	0.22	0.21	0.95	1.32	1.14	0.55
West	**0.15**	**0.27**	**0.86**	**1.07**	**0.78**	**1.05**	**0.64**
Asia (excluding Japan)	0.09	0.29	0.15	0.55	0.92	2.19	1.80
Latin America	0.09	0.07	1.25	1.63	1.96	2.73	1.96
Eastern Europe & f. USSR	0.15	0.35	0.89	1.19	0.33	1.31	0.47
Africa	0.07	0.15	0.40	0.75	1.64	2.37	2.69
Rest	**0.09**	**0.27**	**0.29**	**0.72**	**0.98**	**2.15**	**1.82**
World	0.10	0.27	0.40	0.80	0.93	1.93	1.62
				GDP			
Western Europe	0.29	0.40	1.68	2.11	1.19	4.79	2.21
Western Offshoots	0.07	0.78	4.31	3.92	2.83	4.03	2.95
Japan	0.18	0.31	0.41	2.44	2.21	9.29	2.71
West	**0.27**	**0.41**	**1.93**	**2.66**	**1.96**	**4.81**	**2.61**
Asia (excluding Japan)	0.13	0.29	0.05	0.97	0.82	5.17	5.41
Latin America	0.09	0.23	1.22	3.48	3.42	5.38	2.89
Eastern Europe & f. USSR	0.21	0.44	1.53	2.37	1.74	4.85	0.01
Africa	0.07	0.15	0.75	1.32	2.57	4.43	2.89
Rest	**0.13**	**0.29**	**0.39**	**1.54**	**1.63**	**5.04**	**3.61**
World	0.15	0.32	0.93	2.11	1.82	4.90	3.05

Source: Maddison (2003), pp. 257-263.

Table 6
Proximate and Measurable Determinants of Growth since 1820

	UK	USA	Japan	UK	USA	Japan
	Gross Stock of Machinery & Equipment Per Capita (1990$)			Gross Stock of Non-Residential Structures Per Capita (1990 $)		
1820	92	87	n. a.	1,074	1,094	n. a.
1870	334	489	94 a	2,509	3,686	593a
1913	878	2,749	329	3,215	14,696	852
1950	2,122	6,110	1,381	3,412	17,211	1,929
1973	6,203	10,762	6,431	9,585	24,366	12,778
1998	11,953	25,153	29,987	21,066	35,810	49,042

	UK	USA	Japan	UK	USA	Japan
	Primary Energy Consumption Per Capita (tons of oil equiv.)			Average Years of Education* Per Person Employed		
1820	.61	2.45b	0.20	2.00	1.75	1.50
1870	2.21	2.45	0.20	4.44	3.92	1.50
1913	3.24	4.47	0.42	8.82	7.86	5.36
1950	3.14	5.68	0.54	10.60	11.2	9.11
1973	3.93	8.19	2.98	11.66	14.58	12.09
1998	3.89	8.15	4.04	15.10	19.46	16.03

	UK	USA	Japan	UK	USA	Japan
	Land Area Per Capita (hectares)			Exports Per Capita (1990 $)		
1820	1.48	48.1	1.23	53	25	n.a.
1870	1.00	23.4	1.11	390	62	1.5
1913	0.69	9.6	0.74	862	197	33
1950	0.48	6.2	0.44	781	283	42
1973	0.43	4.4	0.35	1,684	824	875
1998	0.41	3.5	0.30	4,680	2,755	2,736

	UK	USA	Japan	UK	USA	Japan
	Hours Worked Per Head of Population			GDP Per Man hour (1990 $)		
1820	1,153	968	1,598	1.49	1.30	0.42
1870	1,251	1,084	1,598	2.55	2.25	0.46
1913	1,181	1,036	1,290	4.31	5.12	1.08
1950	904	756	925	7.93	12.65	2.08
1973	750	704	988	15.97	23.72	11.57
1998	657	791	905	27.45	34.55	22.54

	UK	USA	Japan	UK	USA	Japan
	Capital-Output Ratio Machinery & Equipment/GDP			Capital-Output Ratio Non-Residential Structures/GDP		
1820	.05	.07	n. a.	.63	.87	n .a.
1870	.11	.20	.10a	.79	1.51	.59a
1913	.18	.52	.24	.65	2.77	.61
1950	.31	.64	.72	.49	1.80	1.00
1973	.52	.64	.93	.80	1.46	1.12
1998	.64	.92	1.47	1.13	1.31	2.40

	UK	USA	Japan	UK	USA	Japan
	Labour Productivity			Total Factor Productivity		
	(annual average compound growth rates)					
1820-70	1.10	1.10	0.18	0.15	-0.15	n. a.
1870-1913	1.22	1.93	2.00	0.31	0.36	-0.05c
1913-50	1.66	2.47	1.79	0.81	1.62	0.20
1950-73	3.09	2.77	7.75	1.48	1.75	5.12
1973-98	2.19	1.52	2.70	0.83	0.60	0.58

a) 1890; b) 1850; c) 1890-1913; *) in equivalent years of primary education.

Source: Appendix K of MADDISON (1995,PP. 252-55), amended and updated.

Table 7a
World Supply of Primary Energy, 1820-2001
(metric tons of oil equivalent)

	Modern Sources (million tons)	Biomass (million tons)	Total (million tons)	Population (million)	Per Capita (tons)
1820	12.9	208.2	221.l	1,041.1	.21
1870	134.5	254.0	388.5	1,270.0	.31
1913	735.2	358.2	1,093.4	1,791.0	.61
1950	1,624.7	504.9	2,129.6	2,524.5	.84
1973	5,368.8	673.8	6,042.6	3,913.5	1.54
2001	9,071.5	1,093.5	10,165.0	6,149.0	1.65

Source: Modern sources (coal, oil, natural gas, water and atomic power); biomass (wood, peat, dung, straw and other crop residues). Conversion coefficients, one ton of wood = .323 of oil; one ton of coal = .6458 tons of oil. 1973 and 1998 modern sources and biomass from International Energy Agency, *Energy Balances of OECD Countries 2000-2001,* 2003, Paris; and *Energy Balances of Non-OECD Countries 2000-2001***,** 2003, Paris. Modern sources 1870-1950 derived from Woytinsky and Woytinsky (1953), 1820 from Mitchell (1975). Biomass 1820-50 assumed to be .20 tons per head of population, see Smil (1994), pp.185-7 for rough estimates of biomass back to 1700. My estimate of biomass 1820-1950 is somewhat lower than Smil suggests. In 1973 world per capita supply of biomass was .17 and in 1998 .18 of a ton.

Table 7b Energy Use per $1000 of GDP (tons of oil equivalent, GDP in 1990 Geary-Khamis dollars)

	1820	**1973**	**2001**
USA	1.95	0.49	0.29
UK	0.36	0.29	0.20
Japan		0.26	0.20
China		0.57	0.25
India		0.39	0.27
Other Asia		0.22	0.17
f. USSR		0.57	0.70
Africa		0.39	0.40
Latin America		0.20	0.20
World	0.32	0.38	0.27

Source as for Table 7a

Table 8 Globalisation Ratio: Comparative Growth in Volume of World Trade and GDP, 1500-2001

(annual average compound growth rates)

	World Trade	World GDP	col.1/2
1500-1820	0.96	0.32	3.0
1820-70	4.18	0.93	4.5
1870-1913	3.40	2.11	1.6
1913-50	0.90	1.82	0.5
1950-73	7.88	4.90	1.6
1973-2001	5.22	3.05	1.7
1820-2001	3.93	2.22	1.8

Source: World trade volume 1500-1820 derived from estimated growth in tonnage of the world merchant fleet (see Maddison, 2001) with a 50 per cent upward adjustment for technical improvements which augmented effective carrying capacity; 1820-70 from Maddison (1982), p.254; 1870-2001 from Maddison (2001), p.362, updated from 1998 to 2001.World GDP from Maddison (2003). See O'Rourke and Williamson (2002), for an estimate of the growth in intercontinental trade volume for 1500-1800, obtained by a totally different approach.

Table 9

Alternative Estimates of West European GDP per capita in 1500 (1990 int Geary-Khamis $)

	Maddison		**Van Zanden**	
	1500	**1820**	**1500**	**1820**
Austria	707	1,218		
Belgium	875	1,319	989	1,319
Denmark	738	1,274		
Finland	453	781		
France	727	1,135		
Germany	688	1,077		
Italy	1,100	1,117	1,353	1,117
Netherlands	761	1,838	1,252	1,838
Norway	640	1,104		
Sweden	695	1,198		
Switzerland	632	1,090		
UK	714	1,706	792	1,706
12 country average	798	1,245		
Portugal	606	923		
Spain	661	1,008	946*	1,008
Other	472	711		
W. Europe Average	771	1,204		
Average for van Zanden's 5 countries	882	1,345	1,116	1,345

Source: cols. 1, 2 and 4 from Maddison (2003), p.262, col. 3 derived from growth rates implicit in the index numbers in Van Zanden (2002), p. 76. Van Zanden expresses his estimates as ratios to the UK per capita GDP level in 1820, as estimated by Maddison (1984 or 1994). Here, I have benchmarked his growth rates on my 2003 estimates of 1820 levels. Asterisked figure for Spain assumes that van Zanden's 1580-1820 growth rate also applies for 1500-1820. The

figures in the last row are weighted averages; for 1500-1820, the van Zanden average is 0.058 per cent per annum, mine is 0.132 per cent for the same 5 countries.

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