The Convergence in Global Living Standards from 1870 to 1914

Dr Andrew Godley,

Department of Economics, University of Reading,
Reading, RG6 6AA UK
Tel.: ++44 (0) 118 987 5123 (x4051)
Fax.: ++44 (0) 118 975 0236
E-mail: a.c.godley@reading.ac.uk

Word Count: 8,284 (including all notes, tables, charts and abstract).

The Convergence in Global Living Standards from 1870 to 1914

ABSTRACT

The convergence debate has focused primarily on postwar trends, with pre-1914 convergence until recently understood as being less strong. Newly derived estimates of global real wages have, however, suggested that convergence before 1914 was more dramatic than at any time since. This paper begins by considering how the understanding of late nineteenth century global convergence depends on which series of estimates is used. While each has its weaknesses, the paper presents a new dataset which seeks to capture trends in international consumption by tracking the diffusion of the sewing machine from 1870 to 1914. The results offer support for the view that convergence was stronger before 1914 than previously believed, but suggest that its determinants may have been broader than currently thought.

I. INTRODUCTION

Historians have long accepted that large parts of the world economy experienced some degree of convergence in the decades after 1850, although both its geographical spread and the extent to which living standards in the laggards caught up with the leaders have only been hinted at until relatively recently. This uncertainty has been caused primarily by a dearth of data on historical living standards outside a select few advanced industrialized nations for any period up to 1914. Matters were transformed with the 1982 publication of Maddison's series of per capita GDP estimates. Using this data, Baumol (1986) showed that global convergence accelerated only after World War II. While subsequent extensions and revisions to the dataset (Maddison, 1991, 1994, and 1995) have modified this picture, the overall result remains that pre-1914 convergence was relatively weak.

Williamson's (1995) recently published real wage series has, however, provided a different perspective on late nineteenth century globalization. Williamson's evidence suggests that not only was real wage convergence much stronger in the late nineteenth

century[1] than hitherto believed, but that, "Wage convergence between the mid-1840s and 1913 was at least as dramatic as it has been since 1950, and probably more so" (Williamson, 1995, p.161). This conclusion is of enormous significance because, as Williamson (1997) emphasizes, were late nineteenth century convergence similar in scope to that of the late twentieth century, then a systematic comparison of the two periods ought to yield a firmer insight into the determinants of global economic convergence.

The discrepancies between these two principal series of historical estimates therefore assume some importance. Depending on which series represents reality more closely is not just a straightforward empirical fact, but, as O'Rourke and Williamson make clear (1999), an entire research agenda embracing economists and historians and with potentially enormous policy implications.

This paper seeks to present an alternative indicator of global living standards during the years of pre-World War I convergence, one derived from international patterns of sewing machine consumption - the world's first standardized, mass produced and mass distributed consumer durable (Godley, 1999a and 2000a). The paper first summarizes the most salient points from the burgeoning convergence scholarship, before going on to examine the two sources of evidence for late nineteenth century convergence - the Maddison and Williamson series - outlining each one's strengths and weaknesses, and concluding that neither series is a fully reliable indicator of global living standards. The paper then goes on to explain that regardless of how desirable such a series would be, in all probability one will never become available. The paper then continues with an explanation of why the global diffusion of sewing

[1] The historian's typical license with dates is operational here. The term 'late nineteenth century' describes the period from 1870 to 1914.

machines may be a suitable proxy for consumption patterns. Some of the more obvious problems with using such a proxy are then outlined, but a detailed comparison of this series with both Williamson's and Maddison's data suggests that there may be some basis for proceeding. The penultimate section then compares the convergence in global living standards from 1870 to 1914 as shown by Maddison's, Williamson's and the dataset under consideration here.

The results suggest that late nineteenth century convergence in global consumption levels was at least as strong as in real wages and considerably stronger than in per capita GDP. While lending considerable support to Williamson's view of a strong pre-1914 convergence, the full results actually suggest that this spread beyond the Atlantic economy and that parts of the Near East and Asia in particular were catching up with western living standards in the years before the end of World War I. The paper concludes with some further speculations about the determinants of the late nineteenth century convergence focusing on two potentially important forces which have hitherto received insufficient emphasis by economic historians. These are the stimuli to consumption levels from emigrant remittances and to development more generally from foreign direct investment.

II. THE CONVERGENCE DEBATE

While much of the economics literature has focused on clarifying the concept, two principal categories of convergence stand out; namely *catch-up* and *homogenization* (Baumol, Nelson and Wolff, 1994, chapter 1). Whereas in catch-up the laggards reduce the gap between themselves and the leaders, in homogenization it is the reduction in the overall dispersion among a set of nations that indicates convergence in whatever indicator is being measured. Historians have mostly ignored this analytical

distinction because, by and large, both catch-up and homogenization appear to have been present in late nineteenth century convergence, although until the degree of any kind of convergence can be confirmed, conceptual sophistication remains something of a tantalizing intellectual morsel, eagerly anticipated but not yet enjoyed.

Despite the ultimate interest being in measuring relative poverty, most of the economics literature has focused on measuring convergence in productivity (Baumol, 1986; De Long, 1988; Dollar and Wolff, 1988; Summers and Heston, 1988). Theoretically this is eminently sensible, given that it is reasonable to assume a close relationship between average and marginal value products, real wages and, the ultimate objective, living standards. Moreover, given that relative productivity is far easier to track than relative living standards, such a focus is empirically defensible also. Finally, the original architects of the economics of global convergence, such as Alexander Gerschenkron (1952) and Simon Kuznets (1973), believed that technological transfer was its major determinant. Comparing trends in productivity was, therefore, not only closely linked to the principal object of interest, relative living standards, but also the proposed motor of transformation, new technology migrating from rich to poor countries. Nevertheless, historians remain aware that productivity measurements in the long run tend to be exclusively based on manufacturing, and these may be a poor proxy for per capita living standards (Broadberry, 1993). The principal conclusions for historians to draw from the convergence debate are, therefore, first, that the priority must be to determine the true contours of late nineteenth century convergence, and second, that credible proxies for post-1950 living standards may be less useful for the earlier period.

III. MEASURING CONVERGENCE IN THE LONG RUN

The first attempts to quantify convergence since industrialization followed the economists' preference and measured long term trends in output per worker across as many nations as it was possible to get data for (Abramovitz, 1986; Baumol, 1986; Baumol, Blackman and Wolff, 1989). While national accounts are widely available for the postwar period, for the earlier years, and especially for the pre-1914 era, no data was available beyond a select few nations until Angus Maddison's 1982 publication *Phases in Capitalist Development*. Armed therefore with Maddison's estimates of per capita income, and the various official and semi-official estimates for later periods, trends in relative productivity were measured for the first time and showed that the pre-1914 era witnessed both catch-up and homogenization convergence, followed by a period of very weak homogenization convergence to 1950, and then very strong catch-up and homogenization convergence in the postwar 'golden age' to the mid-1970s (Maddison, 1994).[2]

As Williamson (1995, 1997) has earlier pointed out, however, per capita GDP is not the same as the standard of living enjoyed by the typical family in any given nation. In his eyes, tracking real wages is a far better indicator of trends in median family living standards because it measures returns to labor alone rather than the average of returns to all factors. In a well-integrated and advanced world economy, such a distinction verges on pedantry, but, maintains Williamson, most of the late nineteenth century convergence arose precisely from changes in relative factor prices as the global economy became more fully integrated than ever before (O'Rourke and

[2] Maddison's sample included were Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, United Kingdom, Australia, Canada, USA, Czechoslovakia, Hungary, Portugal, Spain, Soviet Union, Argentina, Brazil, Mexico, China, India, Indonesia, Japan, and Thailand from 1870. These were joined by Greece, Ireland, Chile, Columbia, Peru, Bangladesh, Korea, Pakistan, Taiwan, Ghana, and South Africa for 1913 (Maddison, 1994, Table 2.1). Maddison's 1913 sample further expanded to 47, but the only credible addition is Switzerland (1995, Appendix B).

Williamson, 1994). As the relative returns to labor varied so much over time and across nations before 1914, so per capita GDP simply misses much of the likely adjustments in real wages between Old World and New. Maddison's estimates of historical GDP are rightly lauded for their rigor and likely accuracy. In a world of mass migration, however, trends in per capita GDP may be only a very partial indicator of trends in relative living standards.[3]

While Williamson is entirely correct to suggest that focusing on long run trends in international real wages would be a conceptual improvement, the empirical difficulties are not to be underestimated. Williamson focused mostly on urban unskilled wage rates, constructing nominal wage time series for seventeen Old and New World nations.[4] Deflated by changes in consumer prices and translated into a common currency at purchasing power parity, the resulting real wage time series represented a considerable step forward in measuring living standards across more than just a handful of nations. Moreover, the resulting convergence was much more dramatic.

The real wage data suggested that global convergence between 1870 and 1914 was at least as strong as in any period since 1950 as the poorer nations on the periphery of Europe caught up with the richer. The reduction in the dispersion of real wages, and so the increased homogenization in global living standards, seems to have been remarkable. In their subsequent analysis, O'Rourke and Williamson (1999) place much of the burden of late nineteenth century convergence on the effect of mass migration from Old to New World countries. As unskilled workers left the overstocked

[3] There are also difficulties in using Maddison's data (and followers like Prados de la Escosura, 2000, for example) to measure convergence because of the need to interpolate between benchmark years. Given that late nineteenth convergence appears to have been especially rapid after 1890, Maddison's actual benchmark observations are relatively few.

[4] These were Argentina, Australia, Canada, USA, Belgium, Denmark, France, Germany, Great Britain (revised), Ireland, Italy, Netherlands, Norway, Spain, Sweden, Brazil, and Portugal (Williamson, 1995, GB revised in 'Erratum').

Old World labor markets and arrived in the New World, so real wages fell there (relative to other factors) and rose (relative to other factors) in the depleted Old World labor markets.

The elegance of this new interpretation of late nineteenth century economic development is not confined to an explanation of the principal determinants of convergence, because O'Rourke and Williamson go on to delineate how the effects of early twentieth century mass immigration in New World societies prompted increasingly restrictionist policies. Globalization thus sowed the seeds of its own destruction. Deglobalization resulted from deliberate policy changes in rich countries leading unintentionally to welfare losses in poorer ones. It was this, not the coincidence of World War I, that reversed decades of gains in global development (compare with Desai, 1999).

Just as the suitability of Maddison's per capita GDP estimates for measuring convergence in late nineteenth century living standards has been questioned, so ought Williamson's real wages time series be subjected to detailed qualification. This paper is not the place for such an exercise, but some obvious potential hazards can briefly be mentioned. Williamson's dataset is based mostly on the nominal wages of urban male unskilled building workers deflated by changes in the prices of food and rent. There are legitimate questions concerning the reliability of the underlying data on wages and prices, and concerning the comprehensiveness and representativeness of the basket of consumer goods (and some of the original authors are more equivocal about the data than Williamson [see Scholliers and Zamagni, 1995, pp. ix-xiv]), as well as concerning the difficulties of establishing correct PPP exchange rates.[5] What is of greater concern

[5] Williamson (1997) and O'Rourke and Williamson (1997) state that they have amended the Spanish series from that originally published in Williamson (1995) based on Simpson (1995, pp. 250-2).

here, however, is whether trends in urban male unskilled building workers relative wages were representative of trends in the typical families' relative living standards.

There are some obvious pitfalls which may distort the representativeness of the building workers series. The urban-rural wage gap was considerably greater in Spain than in Britain or the United States, for example (Simpson, 1995; Sicsic, 1995; Hatton and Williamson, 1991), making urban wages less representative of the median family's living standards there. Additionally, international variations in the male-female and adult-child wage gaps, allied to relative female and child participation rates within households of varying sizes will all affect household income; never mind any variations in the provision of goods and services in kind, a noteworthy feature of rural communities. Given that the most desirable indicator is the amount consumed by the median family over time and across nations, the actual convergence in late nineteenth century living standards potentially might have varied quite considerably from that in urban building workers' wages.

IV. MEASURING LIVING STANDARDS

Williamson focuses on the income approach to measuring living standards. Conceptually preferable would be the consumption approach; the material standard of living is, after all, represented by what is consumed not by what is earned. If Williamson's underlying data require something of a leap of faith (in common, let it be emphasized, with almost all historical datasets), the prospects of substantial improvements are reasonably likely over the course of the next decade or two (Scholliers and Zamagni, 1995, pp. xiii-xiv). The same cannot be said, however, for the

---

However, it is not clear which of the three series published by Simpson has been used, or, if an average, how it has been weighted. The Spanish real wages reported here remain the series from

construction of realistic estimates of trends in median family consumption levels across an equivalent range of nations and going back to at least 1870. While the not inconsiderable hurdles of constructing realistic baskets of goods and services consumed for the representative families may well, in time, be overcome for the odd benchmark year, discovering anything close to annual consumption patterns and prices, accurately pricing the goods and services produced in the informal sector, and making realistic assessments of median family saving rates in societies with restricted banking facilities would each require several years of research effort for each individual country, even assuming that some actual raw evidence still exists. As Feinstein has remarked for the most well documented nation, Britain, this last problem is not merely hypothetical (1995, 1998).

The approach adopted here has been to seek a 'quick-fix' solution for historians. Rather than investing scarce research time in discovering trends in consumer preferences for late nineteenth century families across a range of market and non-market goods and services, this paper relies on the assumption that as family income increased beyond a subsistence threshold, so discretionary expenditure was likely to be disproportionately concentrated on consumer goods. Were historians able to measure relative consumption of consumer goods across late nineteenth century societies, then the resulting index ought to be a close proxy for trends in relative living standards. After all, economists and historians have examined the relative diffusion of twentieth century consumer durables in order to better understand international differences in the quality of life (Bain, 1964; Blundell, 1988; Bowden and Offer, 1994).

It is a matter of historical fact that the world's first mass produced and mass marketed consumer durable to attain a global spread was the sewing machine (Davies,

---

Williamson, 1995.

1976; Carstensen, 1984). From its invention in 1850 to 1914 between 50-55 million family sewing machines were sold around the world, the overwhelming majority after 1880. Given its very low replacement rate, this crudely translates into a global household diffusion rate of around 15-20%. Perhaps one-fifth of all households throughout the world had bought a sewing machine by 1914.[6]

The extraordinary global spread of the sewing machine was, remarkably, associated with just one firm, the Singer Manufacturing Company, which manufactured three-quarters of all the sewing machines sold over this period, and which, moreover, sold ninety percent of all family machines outside North and South America (Carstensen, 1984, Davies, 1976, Godley, 2000a). As there are no reliable series of statistics for international sales of sewing machines as consumer goods, plotting sales of Singer's family sewing machines ought to give a fairly reliable guide (especially outside the Americas). Moreover, this is easily adjusted to include all non-Singer family machines and exclude all industry sales (Godley, 2000a. Godley, 1995, 1996a, 1996b on the garment industry). Annual sales of sewing machines are transformed into diffusion estimates by aggregating total sales over time and dividing through by population. It is this series which is used here as an indicator of trends in global living standards.

While it might be thought that the best indicator of relative consumption might be annual per capita sales, because the sewing machine was a durable good, and hence a non-repeatable purchase, it is the total diffusion of sewing machine sales which is the better indicator. In the more mature markets annual sales became very volatile as the

[6] Total sales based on Godley, 1999a, Table 2 and assuming Singer sold 75% of total world sales (Godley, 2000a). World population in 1914 was c1.25-1.5bn and mean household size must have been greater than five, thus fifty million sewing machines into 250 million households gives a rough idea of total diffusion.

size of potential markets began to diminish. Diffusion then captures trends in consumption because it measures the ever increasing number of families in each economy whose household income crossed over some relevant threshold and so purchased a machine. Its drawback as an indicator of consumption is that it underrecords any drops in living standards. During this period, however, this disadvantage is unlikely to distort the outcome. Incomes were typically rising everywhere.

While the disadvantages of using international sewing machine diffusion as an index of living standards are fairly obvious, it is the considerable advantages of such an indicator that make it so attractive. Most obviously it represents an indicator of real consumption by real families. Moreover, such demand came from precisely those median families whose consumption patterns are of greatest interest to economic historians. The poorer families could not afford the machines, richer families bought bespoke garments (Godley, 1997a, 1997b). In addition, so extensive was Singer's international retail organization that the sales data encompasses thirty nations, far more than Williamson's real wages series, almost as many as Maddison's 1913 GDP estimates.[7] If sewing machine diffusion is a reliable guide to consumption levels, then the sheer geographical spread of sewing machine sales will give historians new information about relative living standards in late nineteenth century economies about

[7] Using 1923 boundaries, these are Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Germany, Great Britain, Hungary, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Russia, Sweden, Turkey, Greece, Serbia, Bulgaria, Romania, Australia, New Zealand, Philippines, India, China, Japan, South Africa, and the USA. In the subsequent analysis below, the USA has been omitted because the series ends in 1880. China and Japan have been omitted because demand for stitched garments was muted before 1911 for cultural reasons, thus reducing the value of the series as a proxy. Austria, Hungary and Czechoslovakia have been combined as Austria-Hungary (omitted here because of some missing observations); Denmark, Norway and Sweden as Scandinavia; Finland and Russia as Russia; Turkey, Greece, Bulgaria, Serbia, and Romania as the Ottoman Empire and Balkans; and Australia and New Zealand as Australasia; all because of the pooling of data by sales subsidiaries in the original documents prior to 1905. For this paper, the emphasis has been on

which little is known. Furthermore, the sewing machine dataset incorporates sales both by volume and value. It has been shown elsewhere that Singer, somewhat remarkably, pursued no price discrimination or other marketing strategies that might have led to consumption being disproportionately high (or low) relative to any given income level. The company's international marketing strategies appear to have been crude and underdeveloped even for the late nineteenth century. Investments in distribution channels and advertising followed revenues according to a simple algorithm (Godley, 2000b).[8] With few model and technological changes after the mid-1880s, it is reasonable to assume that changes in supply conditions were minimal.

The global diffusion of the sewing machine will not, of course, give an exact representation of trends in consumption. It would strain credulity to assume that the median families' sewing machine demand schedules were identical across all lands and cultures in the late nineteenth century. Whether for demographic, climatic, or cultural reasons, sewing machines are likely to have been more desirable in some countries than others. Nevertheless, the actual variations in sewing machine consumption relative to income levels across most nations was fairly small.

Rather than plotting Engel curves for each nation, Figure 1 presents a snapshot of Williamson's real wages series at the moment when 2% of the population in these European nations had purchased a sewing machine, a diffusion threshold which corresponds roughly with 10% of households. This approach avoids the possible distortions to the relative income to sewing machine consumption ratios either from variations in Singer's strategies in entering different markets (which meant that the

---

retaining the most reliable structure of the sewing machine dataset, although sufficient regional sales data are extant to construct reliable diffusion series for all thirty nations listed here.

timing of early sales was contingent more on investment in distribution channels than income), or from the growing presence of substitutes in richer nations when diffusion was higher in later periods.

Given near constant prices, what would be expected is for the different nations to have had roughly similar real wage levels when crossing the 2% diffusion threshold. With some allowance for firm-specific learning in economizing in marketing, or price-neutral product improvements, the overall trend ought to be for later nations to be matching the sewing machine diffusion at slightly lower income levels.

<Figure 1 here>

Figure 1 shows that for most European nations this was very clearly the case. For Britain, Ireland, Germany, France, Scandinavia and the Low Countries (referred to in the chart as the Euro-core) the trend line is very nearly horizontal. The slope of -0.0445 suggests that efficiency gains and model upgrades were unimportant in most of Europe.

The chart also highlights how the Latin countries were outliers. Spain, Portugal and Italy appear to have consumed proportionately more sewing machines relative to income. This may have arisen because of differences in demand conditions, perhaps related to the Latin culture highlighted by Tortella (1994) as being of particular importance in that region's development. Equally, the estimates of real wages may considerably understate Latin living standards, either because the real wage estimates themselves are inaccurate or unrepresentative, or because Latin consumption levels

[8] Godley, 2000b, shows that Old World prices were broadly constant over time and across markets. Prices in the New World (USA, Australia and New Zealand) were both considerably higher and more volatile.

were especially influenced by factors not captured by market wages; perhaps emigrant remittances, perhaps activity in the informal sector.

Regardless of the determinants of any possible Latin exceptionalism, Figure 1 suggests that across most nations the ratio of income to sewing machine diffusion was broadly constant.[9] There are reasonable grounds, therefore, for accepting sewing machine diffusion as a proxy for global living standards, in particular bearing in mind that alternative measures of relative consumption during this period are unlikely to be forthcoming. Recalling the problems associated with the alternative proxies, it is important both to proceed with an analysis of convergence in living standards based on sewing machine diffusion, and, first, to see how similar the results are to the existing estimates of global living standards, namely Maddison's and Williamson's series.

Table 1 compares the three different proxies of international living standards across the largest comparable ranges of countries for 1913. The coverage is not identical from series to series. While Maddison's series encompasses the most nations, real wage data are scarce for eastern Europe, and uncertainty about the level and volatility of Singer's market share in North and South America reduces the reliability of results of the sewing machine series there.[10] Moreover, for several of the smaller markets, Singer's sales subsidiaries were interregional rather than national until a reorganization in the early 1900s, and so the actual sales figures for the Scandinavian, Australasian, Ottoman and Balkan nations have been pooled into regional series. In consequence, both Maddison's and Williamson's results for Scandinavia, Australasia,

[9] Godley (1999b) models sewing machine demand as a function of per capita real income, household size, temperature range, and the availability of ready-made clothing retail outlets (proxied by increases in urbanization, see Fletcher and Godley, 2000a, 2000b, and Godley and Fletcher, 2001a, 2001b) as a substitute. The only independent variable to have any significant relationship was per capita income.
[10] Williamson, 2000, has developed real wage series for some East European nations, but it is unclear how these indices relate to those for other nations.

and the Ottoman region have also been recalculated as population-weighted regional averages.[11]

<Table 1 here>

The three series are highly correlated. The Maddison and Williamson series has a coefficient of 0.787 across the range of comparable nations (excluding the Americas). Encouragingly, the sewing machine series meets this initial benchmark of reliability, being just as strongly correlated with both the other series, with a coefficient of 0.757 between it and the real wages series, and 0.861 between it and the per capita GDP series.

<Figure 2 about here>

Figure 2 lists the three series' comparable observations, illustrating where each diverges from the others. Sewing machine consumption appears, for example, to have been relatively low in India, South Africa and, especially, Belgium by 1913 relative to real wages and per capita GDP.[12] In India and South Africa this may well have reflected cultural differences in fashion or the status of women. Singer's agents reported their frustration in India resulting from canvassers' inability to gain access to women, their target consumer. The majority of South Africans were pejoratively dismissed by the Singer agent there as remaining in the "blanket stage" before 1914. Neither of these problems can have caused the apparent deviation in Belgian diffusion, where management weaknesses may have led to Singer's Belgian subsidiary losing

[11] This actually only represents a loss of the Scandinavian nations as individual observations. Williamson has no Ottoman and Balkan nations, Maddison only Greece, and neither report New Zealand. In addition, Finland (reported by Maddison) is lost being combined with Russia.
[12] A range of +/- 33% from the middle of the three observations is the crude means used to identify the outliers.

market share relative to other European nations (Davies, 1976, p.175; Singer archives, J. Dalgleish [S. African agent] to London, 13 July, 1894, p.1 [Box 106, folder 3]; and E. Sang and A. Watelet [Belgian agents] to G. McKenzie [Singer President], 3 June, 1881; 21 October, 1881; 1 December, 1883 [Boxes 94/1 and 79/10]).

By contrast, Williamson's real wage series appears relatively high for Belgium, Germany, Scandinavia, and Ireland. This may be related either to inconsistencies in the underlying data or to unrepresentativeness of building workers' wages. Williamson's Belgian series, for example, is derived on a different time basis to the others (Williamson, 1995, p.146), and subsequently results in underpredicting Belgian emigration (O'Rourke and Williamson, 1999, p.134), suggesting that the wage series may be too high. His Scandinavian data have also been criticized as overstating catch-up (O'Rourke and Williamson, 1999, p.155). The underlying source for the German series appears not to be wages *per se* but reported wages from public accident insurance claims (Hohls, 1995). Given the problems of moral hazard, it is noteworthy that insurance historians are always skeptical of the representativeness of the amounts claimed from insurance companies and assume that they were typically inflated (Westall, 1994). Finally, while the Irish series is likely to reflect male urban real wages accurately, it is perhaps also the nation where this series is likely to be least representative of median family living standards, owing to the emigration-induced distortions to the Irish labor market. Urban unskilled males were perhaps scarcer in Ireland than anywhere else, thus bidding up their wages relative to the average wage level. Finally, Maddison's estimates suggest that Ireland and Portugal had much lower living standards than suggested from the other two series, although, as he accepts (1995, p.138) there is a considerable margin of error here.

This comparison of the three series suggests, in conclusion, that while each series undoubtedly contains flaws, overall they seem remarkably similar, and that most of the outliers appear to have some underlying explanation. Moreover, and importantly for the purposes of this paper, with the single exception of Belgium, the sewing machine series appears to be sufficiently close to both the other series to be taken seriously as an indicator of global living standards.

V. CONVERGENCE COMPARED

Following Maddison's and Williamson's reporting of late nineteenth century convergence in living standards as a measure of the dispersion in either per capita GDP or real wages, Table 2 reports the coefficients of variation for both these series as well as the sewing machine series from 1870 to 1913.

<Table 2 here>

The results are striking with both the real wage and the sewing machine series showing much stronger convergence by 1913 than Maddison's per capita GDP series, a result reported graphically in Figure 3.

<Figure 3 here>

This result has a number of important implications. First, and most obviously, Williamson's claim that the late nineteenth century witnessed much more dramatic convergence in living standards than implied from Maddison's series receives support here. Homogenization in global sewing machine diffusion was rapid and pronounced.

Given the sewing machine's late introduction into some markets, no doubt variations in diffusion overstate dispersion in the 1880s, but it is likely to be a good

indicator of trends in living standards from the 1890s. Moreover, given that the sewing machine series covers a wider geographic area, incorporating much of Eastern Europe, the Near East and Asia, the results show is that early twentieth century catch-up incorporated Russian, Greek, Turkish and even Filipino living standards. The convergence 'club', in other words, spread well beyond the 'Atlantic Economy', emphasized by O'Rourke and Williamson (1999), and also beyond the OECD nations, within which convergence has been somewhat exclusive since 1950 (Baumol et al, 1994). This is an important finding given that transatlantic migration receives so much weight in explaining convergence in O'Rourke and Williamson's model. If in fact pre-1914 convergence was more widespread, then its causes may equally have been more diverse.

VI. CONCLUDING COMMENTS

Global convergence in living standards, according to Williamson's recent revision, was far more dramatic in the years before World War I than hitherto imagined. The rapid integration of the global economy and consequent factor price adjustment increased living standards in poorer Old World nations more quickly than any time either before or since. The evidence reported here supports Williamson's overarching conclusion and thereby confirms his emphasis on the need to focus research attention on deriving more accurate measures of late nineteenth century living standards than per capita GDP and for more nations.

This paper has attempted to derive a conceptually defensible and empirically measurable indicator of global trends in late nineteenth century consumption. The diffusion of the sewing machine, the world's first mass produced, mass distributed consumer durable, represents perhaps the best short term indicator of relative

consumption and may well stand as the best proxy for many years to come, given the empirical difficulties of measuring historical living standards across such a large range of nations.

The results also show that convergence was rapid in economies not included in Williamson's sample. Russia, for example, experienced very rapid catch-up in sewing machine consumption (see Figure A1), well beyond the convergence in per capita GDP (Good, 1994). Greece and Turkey as well as the Philippines (especially from 1910 to 1918) also experienced much faster rates of growth in consumption than income.[13]

While O'Rourke and Williamson present an elegant explanation of late nineteenth century convergence, the extension of observed convergence to regions of the world not covered by their dataset suggests that their emphasis on international migration as its principal determinant may need to be moderated. It is after all noteworthy that this contrasts with most explanations of more recent convergence. These almost universally emphasize technology transfer as the principal determinant (see the various contributions in Baumol, Nelson, and Wolff, 1994).

This is not the place to develop alternative suggestions systematically, but some comments on two obvious forces for convergence in living standards might be permitted. First is the need to disaggregate the effect of emigrant remittances. O'Rourke and Williamson treat remittances entirely as a determinant of subsequent emigration. That they led to more tickets being purchased is undoubtedly true, but the rate of growth in consumption in Italy and Russia after 1900 coincided with, and continued on from, the period of peak emigration (see Godley 2000c, chapter 4, for Russia). This suggests that emigrant remittances may have led to increased

[13] Filipino diffusion was 23 by 1918 relative to Great Britain's 1913 level (see Table A1), somewhat higher than South East Asian relative per capita income in 1913 (Maddison, 1994, T.2.1).

consumption in the two home economies. Data in remittances are rare, rarer still is any idea how these moneys were actually spent. Additional research on the flow and impact of remittances would shed welcome light here.

Second, is the role of foreign direct investment (FDI). Despite the widespread recognition that the impact of FDI is of a different order of magnitude compared to foreign portfolio investment (Dunning, 1993), economic historians have often been guilty of assuming both capital flows to be essentially similar. O'Rourke and Williamson summarily dismiss FDI in two pages of frankly ill-informed comment (1999, pp. 215-7). Yet the best estimates of global FDI suggest that the total stock in 1914 was at least 9% of global GDP. Despite this share not having been subsequently reattained until the mid-1990s (Jones, 1996, p.30; Corley, 1994), its impact in post-1950 convergence is undisputed.

While its magnitude was undeniably impressive, the nature of pre-1914 FDI was different to post-1950. Three-quarters went into exploiting raw materials and natural resources. Almost half originated from the UK, mostly invested by firms christened free standing companies by Mira Wilkins (1988). This is a different pattern to most FDI in recent years, with most flows going into establishing manufacturing capacity in advanced economies. The impact of this pioneering FDI on global convergence, however, was likely to have been far greater than that of recent decades given that it flowed overwhelmingly from rich to poor nations.

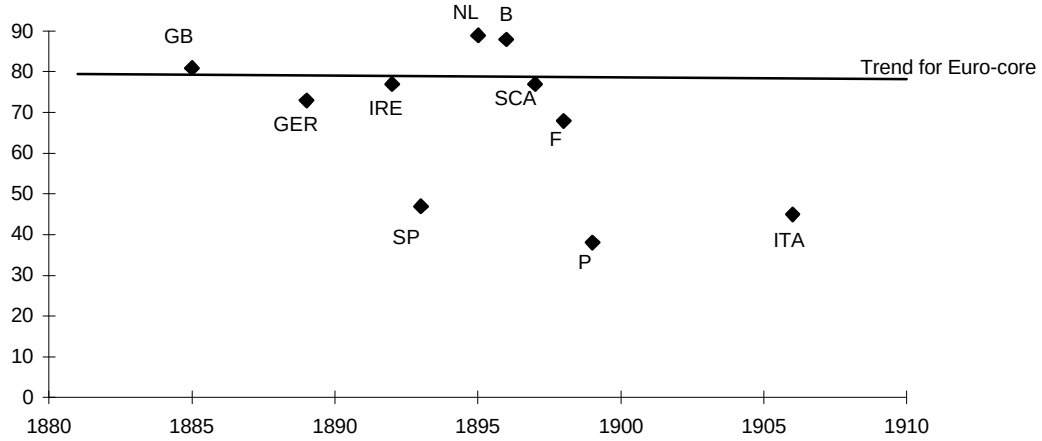
FDI takes place when transaction costs in international markets are higher than within a firm. In the late nineteenth century, whether within a firm or market, when these costs were too high transactions simply did not take place. Such failure in international markets arose for many reasons, including inadequate property rights, immature legal and banking systems, and entrepreneurial deficiencies in developing

countries. The ability of late nineteenth century corporations to overcome such market failure was therefore a powerful stimulus for growth.

A fuller explanation of late nineteenth century global convergence in living standards will therefore need to disaggregate foreign portfolio from foreign direct investment, recognizing that both the direct and spillover benefits to host economies in the two types of capital flows were substantially different. Incorporating measurements of the impact of the transaction cost economizing of these early multinationals is likely to give economic historians a fuller explanation of the convergence of living standards throughout both the transatlantic economy and beyond.

Given that the evidence presented here reaffirms the strength of late nineteenth relative to late twentieth century convergence, the convention calling for further research by economic historians is presented here with more than the customary emphasis. After all, a more complete understanding of the determinants of economic convergence carries far more than just historical significance.

Figure 1. Diffusion (2% threshold) and Real Wages in Europe (GB = 100 in 1905), 1880-1910



Source: Table A1 and Williamson (1995).

Table 1. Relative Indices of Global Living Standards in 1913 (Britain =100).

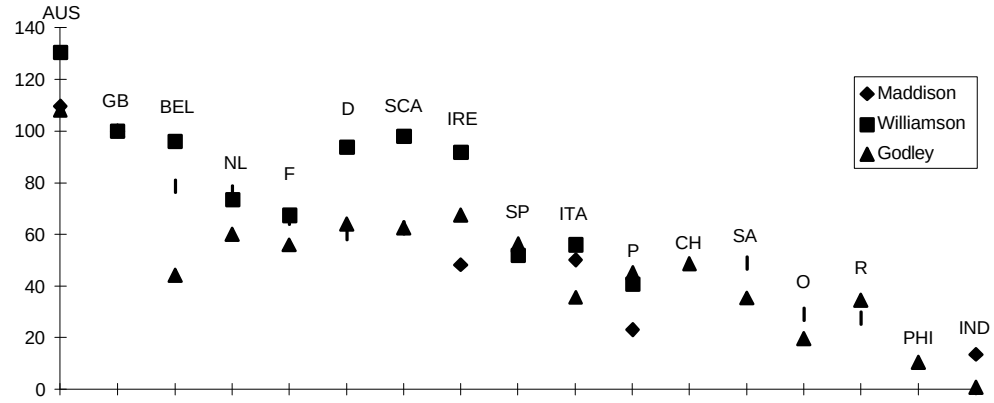
Economy	Maddison [N=15]	Williamson [N=11]	Godley [N=17]
Australasia	110	131	108
Britain	100	100	100
Belgium	79	96	44
Netherlands	77	73	60
France	66	67	56
Germany	60	94	64
Scandinavia	62	98	63
Switzerland			49
Ireland	48	92	67
Spain	53	52	56
Italy	50	56	36
Portugal	23	41	45
South Africa	49		36
Ottoman & Balkans	29		20
Russia	27		35
Philippines			10
India	13		1

Correlation Coefficients between Indices

Maddison/ Williamson	Maddison/ Godley	Godley/ Williamson
0.787	0.861	0.757

Source: Table A1 and see text.

Figure 2. Indices of Relative Living Standards in 1913 (GB = 100)



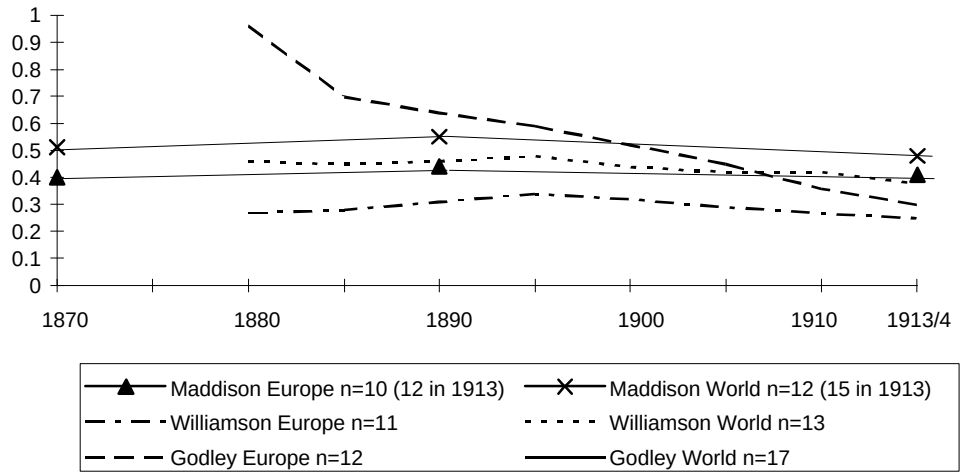
Source: Table 1.

Table 2. Convergence Compared. Dispersion in Global Living Standards: the Maddison, Williamson and Godley indices, coefficients of variation, 1870-1913

CV	Maddison		Williamson		Godley	
Year	Europe n=10 (12 in 1913)	World n=12 (15 in 1913)	Europe n=11	World n=13	Europe n=12	World n=17
1870	0.40	0.51				
1875						
1880			0.27	0.46	0.96	1.00
1885			0.28	0.45	0.70	0.92
1890	0.44	0.55	0.31	0.46	0.64	0.85
1895			0.34	0.48	0.59	0.76
1900			0.32	0.44	0.52	0.70
1905			0.29	0.42	0.45	0.65
1910			0.27	0.42	0.36	0.62
1913/4	0.41	0.48	0.25	0.38	0.30	0.54

Source: Maddison, 1994, Table 2.1; Williamson, 1995 (and Erratum), Table A2.1; Table A1.

Figure 3. Convergence in Global Living Standards, 1870-1914



Source: Table 2.

APPENDIX

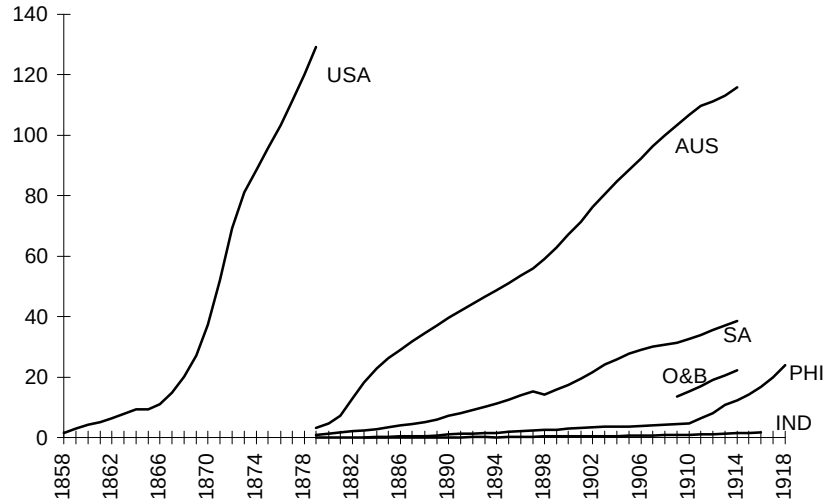
Table A1. The Global Diffusion of the Sewing Machine, 1850-1914 (machines per thousand population).

Year	USA	Australasia	South Africa	India	Philippines	Ottoman	Britain	Ireland	Russia	Spain	Portugal	France	Italy	Belgium	Switzerland	Germany	Scandinavia	Netherlands
1858	1.61																	
1859	3.07																	
1860	4.20																	
1861	5.16																	
1862	6.44																	
1863	7.75																	
1864	9.39																	
1865	9.44																	
1866	10.92																	
1867	14.87																	
1868	20.19																	
1869	27.16																	
1870	37.21																	
1871	52.10						0.71	0.21				0.11						
1872	69.19						1.35	0.42				0.22						
1873	81.20						2.00	0.64				0.33						
1874	88.60						2.83	0.92				0.55						
1875	95.69						3.83	1.27				0.95				4.04		
1876	103.33						4.99	1.68				1.35				5.15		
1877	111.47						6.29	2.15	0.07			1.76				6.23	0.11	0.26
1878	120.09						7.75	2.68	0.20			2.16				7.36	0.25	0.56
1879	129.17	3.21	0.83	0.00			9.34	3.28	0.40	3.09	2.33	2.62		1.83	0.71	8.51	0.43	1.00
1880		4.68	1.18	0.00			11.21	4.04	0.62	4.21	3.16	3.22	0.80	2.73	1.44	9.85	0.64	1.48
1881		7.27	1.80	0.00			13.16	4.82	0.88	5.61	4.31	3.87	1.11	3.64	2.38	11.36	0.95	2.11
1882		12.93	2.10	0.01			15.57	5.75	1.17	6.68	5.44	4.56	1.45	4.57	3.22	13.17	1.62	3.44
1883		18.27	2.35	0.01	0.05		18.08	6.74	1.49	7.86	6.37	5.25	1.87	5.50	4.05	15.07	2.45	4.82
1884		22.94	2.77	0.02	0.16		20.68	7.94	1.81	9.05	7.08	5.91	2.30	6.44	5.11	17.15	3.47	6.34
1885		26.22	3.39	0.02	0.25		23.15	9.07	2.15	10.03	7.80	6.65	2.71	7.42	6.26	18.56	4.34	7.48
1886		28.96	4.05	0.03	0.34		25.36	10.18	2.40	11.08	8.53	7.39	3.10	8.41	7.43	19.47	5.04	8.34
1887		31.77	4.50	0.04	0.46		27.81	11.49	2.64	12.13	9.24	8.16	3.46	9.41	8.53	19.75	5.52	8.79
1888		34.42	5.06	0.05	0.59		30.37	12.88	3.06	13.31	10.03	8.94	3.80	10.41	9.54	19.69	6.06	9.23

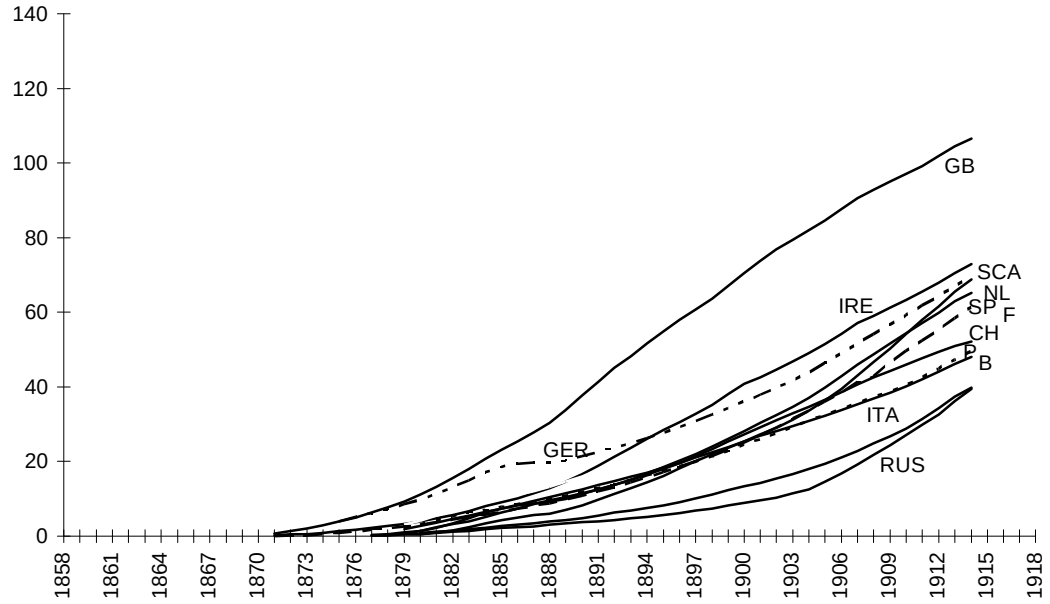
1889		37.08	6.07	0.06	0.79		33.75	14.54	3.42	14.62	10.91	9.85	4.30	11.45	10.46	20.25	6.98	10.06
1890		39.53	7.17	0.07	0.98		37.70	16.60	3.72	16.07	11.82	10.89	4.86	12.63	11.46	21.49	8.36	11.35
1891		41.86	8.17	0.09	1.15		41.39	18.94	4.01	17.66	12.83	12.01	5.49	13.71	12.56	22.61	9.77	12.49
1892		44.27	9.18	0.11	1.30		45.04	21.37	4.34	19.19	13.96	13.18	6.25	14.74	13.77	23.76	11.37	13.69
1893		46.58	10.24	0.13	1.47		48.26	23.73	4.75	20.45	15.12	14.44	6.91	15.89	15.02	25.06	12.93	15.10
1894		48.76	11.25	0.09	1.67		51.69	26.04	5.22	21.72	16.31	15.78	7.58	17.06	16.45	26.31	14.44	16.80
1895		50.99	12.48	0.18	1.88		54.95	28.42	5.70	22.99	17.53	17.14	8.26	18.27	17.95	27.80	16.20	18.52
1896		53.48	13.88	0.21	2.11		57.89	30.46	6.20	24.24	18.78	18.60	9.09	19.62	19.59	29.33	18.13	20.31
1897		55.96	15.36	0.24	2.31		60.73	32.69	6.80	25.30	20.07	20.10	10.12	20.98	21.39	30.88	20.02	22.09
1898		59.19	14.25	0.28	2.51		63.64	35.14	7.43	26.32	21.42	21.60	11.14	22.38	23.33	32.53	21.86	24.01
1899		62.86	15.88	0.32	2.72		67.13	38.11	8.10	27.77	22.89	23.36	12.25	23.88	25.35	34.32	23.69	26.01
1900		67.07	17.55	0.36	2.94		70.56	40.94	8.84	29.27	24.58	25.22	13.32	25.37	27.34	36.18	25.47	28.18
1901		71.40	19.33	0.41	3.17		73.80	42.59	9.60	30.99	25.99	27.15	14.28	26.82	29.20	37.99	27.27	30.38
1902		76.32	21.68	0.45	3.40		76.89	44.56	10.37	33.17	27.62	29.22	15.41	28.16	31.01	39.79	29.09	32.46
1903		80.50	24.18	0.50	3.57		79.51	46.76	11.45	35.50	29.37	31.41	16.63	29.49	32.84	41.81	31.17	34.63
1904		84.75	25.90	0.56	3.66		81.89	49.04	12.64	37.61	31.06	33.65	18.03	30.88	34.60	43.93	33.56	37.07
1905		88.52	27.65	0.62	3.78		84.52	51.48	14.52	39.42	32.64	35.99	19.46	32.32	36.55	46.29	36.27	39.73
1906		92.29	29.08	0.67	3.87		87.71	54.25	16.76	41.39	34.22	38.46	21.01	33.81	38.59	49.03	39.53	42.89
1907		96.33	30.05	0.74	4.03		90.73	56.99	19.18	43.38	35.79	41.16	22.87	35.36	40.68	51.69	43.09	45.99
1908		100.00	30.64	0.80	4.21		92.84	59.08	21.71	45.31	37.31	42.83	24.83	36.87	42.47	54.22	46.65	48.74
1909		103.30	31.39	0.87	4.43	13.64	95.09	61.23	24.38	47.22	38.94	46.80	26.72	38.53	44.25	56.68	50.32	51.59
1910		106.76	32.58	0.94	4.80	15.14	97.16	63.34	27.10	49.52	40.58	49.58	28.82	40.26	46.01	59.18	54.15	54.38
1911		109.58	33.94	1.03	6.29	17.04	99.25	65.46	29.91	52.24	42.55	52.34	31.36	42.07	47.69	61.75	57.87	57.05
1912		111.22	35.44	1.14	8.09	18.99	101.93	67.86	32.66	55.63	44.96	55.41	34.34	44.08	49.43	64.38	61.64	59.95
1913		112.94	37.12	1.28	10.83	20.66	104.55	70.49	36.11	58.83	47.35	58.52	37.28	46.19	50.90	66.88	65.46	62.94
1914		115.80	38.55	1.40	12.35	22.29	106.61	72.93	39.48	61.74	49.49	61.31	39.82	48.00	52.13	69.78	68.78	65.16
1915				1.56	14.32													
1916				1.75	16.72													
1917					19.94													
1918					23.94													

Source: Godley, 2000a.

Figure A1. The Global Diffusion of Sewing Machines, 1858-1914 (machines per thousand population).
a) World.



b. Europe



Source: Table A1.

REFERENCES

Abramovitz, M. (1986), "Catching Up, Forging Ahead, and Falling Behind." *Journal of Economic History* 46, 385-406.

Abramovitz, M. (1994), "Catch-up and Convergence in the Postwar Growth Boom and After." In W. Baumol, R. Nelson, and E. Wolff (Eds.), *Convergence of Productivity: cross-national studies and historical evidence*. Oxford and New York, NY: Oxford Univ. Press.

Bain, A. (1964), *The Growth of Television Ownership in the UK*. Cambridge: Cambridge Univ. Press.

Baumol, W. (1986), "Productivity Growth, Convergence, and Welfare: What the Long Run Data Show." *American Economic Review* 76: 1072-85.

Baumol, W., Blackman, S., and Wolff, E. (1989), *Productivity and American Leadership: The Long View*. Cambridge, MA: MIT Press.

Baumol, W., Nelson, R., and Wolff, E. (1994), (Eds.), *Convergence of Productivity: cross-national studies and historical evidence*. Oxford and New York, NY: Oxford Univ. Press.

Blundell, R. (1988), "Consumer Behavior: Theory and Empirical Evidence - A Survey." *Economic Journal* 98: 16-65.

Bowden, S., and Offer, A. (1994), "Household Appliances and the Use of Time: the United States and Britain since the 1920s." *Economic History Review* 47: 725-48.

Broadberry, S. (1993), "Manufacturing and the Convergence Hypothesis: What the Long-Run Data Show." *Journal of Economic History* 53: 772-95.

Carstensen, F. (1984), *American Enterprise in Foreign Markets: Singer and International Harvester in Imperial Russia*. Chapel Hill: Univ. North Carolina Press.

Corley, T. (1994), "Britain's Overseas Investments in 1914 revisited." *Business History* 36: 71-88.

Davies, R. (1976), *Peacefully Working to Conquer the World: Singer Sewing Machines in Foreign Markets, 1854-1920*. New York: Arno.

De Long, B. (1988), "Productivity Growth, Convergence and Welfare: Comment." *American Economic Review* 78: 1138-54.

Desai, M. (1999), "Globalization and Deglobalization." Unpublished paper given to the annual conference of the European Association of Evolutionary Political Economy, Prague.

Dollar, D., and Wolff, E. (1988), "Convergence of Industry Labor Productivity Among Advanced Economies, 1963-1982." *Review of Economics and Statistics* 70: 549-58.

Dunning, J. (1993), *The Globalization of Business*. London: Routledge.

Feinstein, C. (1995), "Changes in nominal wages, the cost of living and real wages in the United Kingdom over two centuries, 1780-1990." In P. Scholliers and V. Zamagni (Eds.), *Labour's Reward: Real wages and economic change in 19th- and 20th-century Europe*. Aldershot: Elgar.

Feinstein, C. (1998), "Pessimism Perpetuated: Real Wages and the Standard of Living in Britain during and after the Industrial Revolution." *Journal of Economic History* 58: 625-58.

Fletcher S., and Godley, A. (2000a), "Foreign Direct Investment in British Retailing, 1850-1962." *Business History* 42: 43-62.
Fletcher S., and Godley, A. (2000b), "Foreign Entry into British Retailing, 1850-1994." *International Marketing Review* 21: forthcoming.
Gerschenkron, A. (1952), "Economic Backwardness in Historical Perspective." In B. Hoselitz (Ed.), *The Progress of Underdeveloped Areas*. Chicago: Univ. Chicago Press.
Godley, A. (1995), "The Development of the UK Clothing Industry, 1850-1950: Output and Productivity Growth." *Business History*. 37: 46-63.
Godley, A. (1996a), "Immigrant Entrepreneurs and the Emergence of London's East End as an Industrial District." *London Journal* 21: 38-45.
Godley, A. (1996b), "Singer in Britain: the diffusion of sewing machine technology and its impact on the clothing industry in the United Kingdom, 1860-1905." *Textile History* 27: 59-76.
Godley, A. (1997a), "The Development of the Clothing Industry: technology and fashion." *Textile History* 28: 3-10.
Godley, A. (1997b), "Comparative Labour Productivity in the British and American Clothing Industries, 1850-1950." *Textile History* 28: 67-80.
Godley, A. (1999a), "Pioneering Foreign Direct Investment in British Manufacturing." *Business History Review* 73: 394-429.
Godley (1999b), "The Convergence in Working Class Living Standards, 1850-1914: the sewing machine in North America and Europe." Unpublished paper given to the annual conference of the European Association of Evolutionary Political Economy, Prague.
Godley, A. (2000a), "The Global Diffusion of the Sewing Machine, 1850-1914." *Research in Economic History* 20: forthcoming.
Godley, A. (2000b), "Selling the Sewing Machine around the world: Singer's International Marketing Strategies, 1850-1914." *Enterprise and Society* 2: forthcoming.
Godley, A. (2000c), *Enterprise and Culture: Jewish Immigrants in London and New York, 1880-1914*. London, Basingstoke and New York: Macmillan Press, forthcoming.
Godley, A., and Fletcher, S. (2001a), "Foreign Multinationals in British Retailing: 1850-1961." *Economic History Review* 54: forthcoming.
Godley, A., and Fletcher, S. (2001b), "International Retailing in Britain, 1850-1994." *Service Industries Journal* 21: forthcoming.
Good, D. (1994), "The Economic Lag of Central and Eastern Europe: Income Estimates for the Habsburg Successor States, 1870-1910." *Journal of Economic History* 54: 869-891.
Hatton, T., and Williamson, J. (1991), "Integrated and Segmented Labor Markets: Thinking in two sectors." *Journal of Economic History* 51: 413-25.
Hohls, R. (1995), "The sectoral structure of earnings in Germany, 1885-1985." In P. Scholliers and V. Zamagni (Eds.), *Labour's Reward: Real wages and economic change in 19th- and 20th- century Europe*. Aldershot: Elgar.
Jones, G. (1996), *The Evolution of International Business: An Introduction*. London: Routledge.

Kuznets, S. (1973), *Population, Capital, and Growth: Selected Essays*. New York, NY: Norton.

Maddison, A. (1982), *Phases of Capitalist Development*. Oxford: Oxford Univ. Press.

Maddison, A. (1991), *Dynamic Forces in Capitalist Development*. Oxford: Oxford Univ. Press.

Maddison, A. (1994), "Explaining the Economic Performance of Nations, 1820-1989." In W. Baumol, R. Nelson, and E. Wolff (Eds.), *Convergence of Productivity: cross-national studies and historical evidence*. Oxford and New York, NY: Oxford Univ. Press.

Maddison, A. (1995), *Monitoring the World Economy*. Paris: OECD.

O'Rourke, K., and Williamson, J. (1994), "Late Nineteenth-Century Anglo-American Factor-Price Convergence: Were Heckscher and Ohlin Right?" *Journal of Economic History* 54: 892-916.

O'Rourke, K., and Williamson, J. (1997), "Around the European Periphery 1870-1913: Globalization, schooling and growth." *European Review of Economic History* 1: 153-91.

O'Rourke, K., and Williamson, J. (1999), *Globalization and History: The Evolution of a Nineteenth Century Atlantic Economy*. Cambridge, MA: MIT Press.

Prados de la Escosura, L. (2000), "international Comparisons of Real Product, 1820-1990: An Alternative Data Set." *Explorations in Economic History* 37: 1-41.

Scholliers, P., and Zamagni, V. (1995), (Eds.), *Labour's Reward: Real wages and economic change in 19th- and 20th- century Europe*. Aldershot: Elgar.

Sicsic, P. (1995), "Wage dispersion in France, 1850-1930." In P. Scholliers and V. Zamagni (Eds.), *Labour's Reward: Real wages and economic change in 19th- and 20th- century Europe*. Aldershot: Elgar.

Simpson, J. (1995), "Real wages and labour mobility in Spain, 1860-1936." In P. Scholliers and V. Zamagni (Eds.), *Labour's Reward: Real wages and economic change in 19th- and 20th- century Europe*. Aldershot: Elgar.

Singer Archives, State Historical Society of Wisconsin, Madison, WI.

Summers, R., and Heston, A. (1988), "A New Set of International Comparisons of Real Product and Price Levels: Estimates for 130 Countries." *Review of Income and Wealth* 34: 1-25.

Tortella, G. (1994), "Patterns of economic retardation and recovery in south-western Europe in the nineteenth and twentieth centuries." *Economic History Review* 47: 1-21.

Westall, O. (1994), "Marketing strategy and the competitive structure of British general insurance, 1720-1980." *Business History* 36: 20-46.

Wilkins, M. (1988), "The free-standing company, 1870-1914: an important type of British foreign direct investment." *Economic History Review* 41: 259-85.

Williamson, J. (1995), "The Evolution of Global Labor Markets since 1830: Background Evidence and Hypotheses." *Explorations in Economic History* 32: 141-96, and Erratum: 553.

Williamson, J. (1997), "Globalization, Convergence and History." *Journal of Economic History* 56: 277-306.

Williamson, J. (2000), “Real Wages and Relative Factor Prices around the Mediterranean Basin, 1500-1940: Appendix.” Unpublished working paper, Harvard University, HIER #1842, available from http://www.economics.harvard.edu/~jwilliam/