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CONVERGENCE IN THE AGE OF MASS MIGRATION

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ABSTRACT

Between 1870 and 1913, economic convergence among present OECD members (or even a wider sample of countries) was dramatic, about as dramatic as it has been over the past century and a half. The convergence can be documented in GDP per worker-hour, GDP per capita and in real wages. What were the sources of the convergence? One prime candidate is mass migration. In the absence of quotas, this was a period of open international migration, and the numbers who elected to move were enormous. If international migration is ever to play a role in contributing to convergence, the pre-quota period surely should be it. This paper offers some estimates which suggest that migration could account for very large shares of the convergence in GDP per worker and real wages, though a much smaller share in GDP per capita. One might conclude, therefore, that the interwar cessation of convergence could be partially explained by the imposition of quotas and other barriers to migration. The paper concludes with caution as it enumerates the possible offsets to the mass migration impact which our partial equilibrium analysis ignores, and with the plea that convergence models pay more attention to open-economy forces.

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Introduction

In the century before 1913 some 50 million Europeans emigrated. The vast majority, about 46 million, left Europe for the New World and the numbers increased over time. The Old World population rose from about 192 million in 1800 to about 423 million in 1900, so annual gross emigration rates averaged about 10 per thousand over the century, and even higher after 1880 (Kenwood and Lougheed 1992). This "mass" emigration was on a scale not witnessed before nor since, and it generated debate on the impact of the migrations in sending and receiving regions, the relative power of "push" and "pull," the distributional consequences of the migrations (who gained and who lost), and whether the migrations should have been controlled or free (Hatton and Williamson 1994 forthcoming-a). A central premise everywhere in the debate has, of course, been that migration improved the lot of those who moved and that real wages were higher in the destination regions. Emigration to the labor-scarce and resource-abundant New World offered, if you will, a vent for surplus labor in the resource-scarce Old World. The simplest explanation for the flows has therefore always been that migrants from poor Old World countries were chasing after higher rewards, their productivity being higher on the margin in the New World or even in richer parts of the Old World.

Unless it was offset by other forces, mass migration must have eased global labor market disequilibrium in the late nineteenth century; labor endowments shifted from poor sending to rich receiving regions thus helping erase some of the wage and labor productivity gaps between them. The process reached its apex when migration rates surged around the turn of this century (Table 1).[1] The age of uncontrolled mass migration ceased, of course, after the U.S. quotas were imposed in the 1920s, and whatever contribution the migrations made to economic convergence must have ceased as well.

The question of convergence has long captivated theorists and empiricists, but the aim of this paper is to show how the convergence literature must take international migration on board if our explanations are to be sufficiently comprehensive to cover historical experience since 1850. Closed-economy growth-convergence models are certainly inappropriate for any discussion of the late nineteenth century world economy, since it was characterized by a remarkably free flow of goods, capital and people.[2] Indeed, this paper documents an important contribution of mass migration to convergence 1870–1910: a very large share of the significant convergence observed would have been erased had migration been suppressed. The estimated contribution of the mass migration is so large, in fact, that its impact on convergence must have been complemented (on net) by a variety of countervailing forces: independent disequilibrating forces of technical change (faster in rich countries); and dependent offsetting forces of capital-accumulation (international capital chasing after the migrants or native capital accumulation stimulated by the presence of migrants), of trade (migrant labor favoring the expansion of labor-

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[1] Migration rates M=(net flow)/POP shown in Table 1 are derived from data in the appendix, and reflect adjustments for unobserved return migration. It is well known that historical data from the period systematically underenumerate return migration. We cannot know how serious the errors are, but we can apply sensitivity analysis to establish what impact such errors might have. It is not unreasonable to think of underreporting in the range of 0%–30%. Specifically, if M is the net migration rate in the raw data for inflows and outflows, we estimate the true net migration rate to be $M(1-\rho)$ where ρ is a return-rate correction factor, taken to be 0.1 (10%) in our "baseline" estimates. The labor force migration rates $\gamma(1-\rho)M$ correct for the relative labor content of the migrant flow relative to the population stock, γ. Cumulative impacts on stocks over 40 years 1870–1910 are given by the formula exp(40×rate)–1.

[2] Growth and convergence models that allow for open-economy market linkages (for labor, capital, or goods) are not unknown: see, for example, Ben-David (1993) or Barro and Sala-i-Martin (1994).

intensive activities in rich countries) or of productivity advance (migrant-labor induced scale economies).

Convergence: Theory and The Late Nineteenth Century Facts

The central questions in the convergence debate are two: first, do we observe convergence in the world economy? second, what explains convergence or its absence?

Theory

Theoretical work is in plentiful supply and ambiguous empirical evidence has allowed the development of models that might generate convergence or divergence. Convergence models include the venerable first-generation contributions and their recent refinements (Uzawa 1965; Ramsey 1928; Swan 1956; Solow 1956; Koopmans 1965; Cass 1965; Abramovitz 1956; Mankiw, Romer and Weil 1990). Models that allow for divergence exploit long-run increasing returns, from learning-by-doing (following Arrow) or various externalities, or by adding additional accumulable factor such as human capital (Arrow 1962; Barro and Sala-i-Martin 1992; Barro and Sala-i-Martin 1994 forthcoming; Lucas 1988; Lucas 1990; Romer 1986; Romer 1989). Others have refined the notion of convergence to include local and global variants (Durlauf and Johnson 1992).The "new" growth theory has also focused attention on generating endogenous growth, without appeal to a *deus ex machina* like exogenous technological change or exogenous savings rates to explain long-run growth.

Empirical work has proliferated, led by the pioneering contributions from Moses Abramovitz (1986) and William Baumol (1986) that built on the macroeconomic data collected by Angus Maddison (1982; 1989; 1991). Abramovitz related the observed "catching up" of postwar Europe (vis-à-vis the U.S.) to a more general principle reminiscent of the "leader's handicap" theory of Veblen (1915) or the "advantages of backwardness" theory of Gerschenkron (1962): namely, a country with lower productivity may exploit the technological gap with respect to the leader, import or imitate best practice technology and, hence, raise labor productivity and living standards.

Abramovitz found GDP per worker dispersion has generally diminished over the last century or so (Table 2, column 1), with an implied average convergence speed of about 1% per annum, with particularly rapid convergence in the post-WWII period. Although Abramovitz characterized the convergence before 1913 as weak, it turns out that the speed of convergence then was very close to the long-run average. The interwar evidence seemed to suggest lost opportunities for catching up arising from autarkic tendencies in the world economy that obstructed capital, labor and technology flows.[3]

Abramovitz (1986) anticipated many refinements contained in the subsequent literature. He noted further the distinction to be drawn between the convergence hypothesis and the catch-up hypothesis: economic growth may depend on other factors besides technologically driven catch up, for example, physical or human capital deepening (Mankiw, Romer and Weil 1990; Dowrick and Nguyen 1989). Furthermore, catch-up would be "self-limiting"—declining to zero as the productivity gap diminished.[4] Abramovitz also cited "trade and its rivalries" (including international factor flows) as important ingredients in the convergence process, although he did not pursue the subject in depth. Abramovitz contrasted convergence as measured by dispersion levels—now termed "σ-convergence"—with convergence measured by the extent to which poor countries grow faster than rich ones, as given by a Baumol-style (partial) correlation of growth rates and initial per capita income or productivity, now termed "β-convergence" (Barro and Sala-i-Martin 1992). He also noted many of the statistical problems later to plague convergence analysis, such as sample-selection bias (a tendency to falsely accept

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[3] The convergence speed is measured by the rate of decline of log (σ/μ), where σ is the standard deviation and μ is the mean. The justification for this is as follows. Consider a group of countries converging on a mean level (of real wages, or GDP per person, or GDP per capita) of μ. Let the level at time t be $y_i(t) = \mu + \alpha_i \exp(-\lambda t)$, where $\Sigma\alpha_i = 0$. It is easily shown that the dispersion measure known as the coefficient of variation ($CV{=}\sigma/\mu$) is given by $CV(t) = CV(0)\exp(-\lambda t)$. The argument proceeds without undue loss of generality since a trend may easily be superimposed (CV is invariant to multiplicative transformations) and since trajectories y_i converge to their mean over time if and only if they converge to some (arbitrary) reference country trajectory y_0.

[4] That is, a "strong convergence" property where productivity or welfare levels converge over time, to be differentiated from "weak convergence" where only growth rates converge over time, with possible permanent gaps in levels.

the convergence proposition by dint of using only a sample of now-rich countries in Maddison's database) and the errors-in-variables problem (a tendency for a growth rate versus initial income regression to generate false acceptance if there is measurement error in the historical data, a problem avoided in Abramovitz's non-parametric tests). Such problems were cause for criticism of Baumol's exploratory econometric analysis (De Long 1988).

More recent empirical contributions have explored another data source in search of convergence, the post-WWII International Comparisons Project (ICP) data gathered in the series of Penn World Table (PWT) publications (Summers and Heston 1991). Dowrick and Nguyen (1989) formalized Abramovitz's catch-up in a carefully specified econometric model applied to the OECD for 1960–85, and applied to broader data for PWT samples that included poor as well as rich countries. The authors concluded that strong catch-up forces were at work everywhere, both in the OECD and elsewhere. Still, "conditional" controls were important: poor countries would have exhibited convergence had not catching up been offset by high population growth and low investment rates. Mankiw, Romer and Weil (1990) offered a different interpretation of similar results, however. Their Solovian model was augmented to include human capital accumulation and it led them to estimate equations almost identical to those of Dowrick and Nguyen, with a proxy for human capital investment rates (the enrollment rate) as an added explanator. Here the initial productivity term was also found to be significant, but in this context was interpreted not as technological catching up, but as an adjustment speed in the model's transitional dynamics. Still, the basic Dowrick-Nguyen finding on convergence was affirmed: on the one hand, Baumol and others had suggested the convergence club was "exclusive," based on a low correlation between growth and initial income in raw data that included less developed countries (weak "unconditional convergence"); however, when controls were included strong convergence was apparent in the partial correlation of growth and initial income (strong "conditional convergence").

The Late Nineteenth Century Facts

We have touched on convergence theory—what about fact? Tables 2 and 3 show exactly what it is we wish to explain. There we offer four measures of σ-convergence across the late nineteenth century. The last column is based on a 17-country sample that includes the twelve current European OECD countries listed in Table 3 plus three New World members, Australia, Canada and the USA, and two New World non-members, Argentina and Brazil. The first three columns exclude Ireland. The rate of convergence 1870-1913 in the first column was about 1% per annum, roughly equal to the long-run convergence rate over the past century or so. The degree of convergence depends greatly, however, on the measure used and on the purchasing-power parity (PPP) comparison adopted. All three newer estimates in columns 2 through 4 record lower rates of convergence 1870-1913. Note also the extent to which late 19th century convergence is diminished by the switch from Maddison's 1982 data set (Table 2, column 1, the same data used by Abramovitz) to Maddison's 1991 data set (Table 2, column 2). The sensitivity stems from the estimation methodology: using individual country growth rates, Maddison projects backwards from the 1970s or 1980s GDP benchmarks constructed from PPP comparisons, an approach that, of course, invites concern about long-run index-number problems and doubts about the accuracy of the implicit back-projected PPPs assumed to be stable over the past century and even longer. Thus, the availability of a new data set based on real wages, and using additional PPP benchmarks from the 1920s and 1900-13, provides a welcome consistency check on Maddison's aggregates (Williamson 1994 forthcoming). In short, our study uses three measures of convergence performance: Maddison's newest GDP per capita data, Maddison's newest GDP per worker data and Williamson's real wage data.

Migration and Convergence in Partial Equilibrium

Although technological catching up may well have been operative in the late nineteenth century, we identify instead another powerful convergence force. The paper takes seriously the possibility that "trade and its rivalries" mattered for late-nineteenth century convergence, a possibility already supported by other work on the Atlantic economy (O'Rourke and Williamson 1992; O'Rourke, Taylor and Williamson 1993). In particular, it takes seriously the possibility that significant migration flows can generate significant convergence (Hamilton and Whalley 1984; Barro and Sala-i-Martin 1992; Barro and Sala-i-Martin 1994). If such is true generally, then it certainly ought to hold for the late nineteenth century when mass migrations reached a crescendo.

Did migration lower wages in receiving countries while raising them in the sending countries?[5] The debate is at least as old as the industrial revolution, appearing first in Britain in the 1830s where witnesses before Parliamentary committees asserted that Irish immigrants were crowding out native unskilled workers. The assertion has been repeated often enough since. As Michael Greenwood and John McDowell (1986, 1745–47) point out, it certainly has a long history in the United States. The debate reached a crescendo there in 1911 after the Immigration Commission had pondered the problem for five years. The Commission concluded that immigration contributed to low wages and poor working conditions. What was said in the sending countries? The migrants and their children clearly benefitted, but what about those left behind? In the early 1880s, it was readily apparent where Knut Wicksell stood on this issue. Wicksell asserted that emigration would solve the pauper problem which then blighted labor-abundant and land-scarce Swedish agriculture. The 1954 Irish Commission on Emigration appears to have shared Wicksell's view, at least as applied to Ireland. The Commission concluded that a century of mass emigration had had a very positive effect on Irish wages. In the words of the Irish Commissioners, "emigration...has reduced the pressure of population on resources...and thus helped to maintain and even to increase our income per head" (1954, 140).

[5] The following four paragraphs draw on Hatton and Williamson (1994 forthcoming-a, 20–21).

How did these authorities reach their conclusions? Historical correlations between rates of labor force growth, migration, the real wage and labor productivity are unlikely to offer any clear answer to the question. True, from 1870 to 1913 there is a *positive* correlation between migration and population increase on the one hand and real wages on the other, but such correlations tell us more about labor supply responses than about the presence or absence of diminishing returns. In the absence of increasing returns, and in the presence of a given technology and at least one fixed factor (like land), all comparative static models in the classical Wicksellian tradition predict that migration tends to make labor cheaper in the immigrating country and scarcer in the emigrating country, especially in the short run when dynamic responses can be ignored. A familiar partial equilibrium analysis of the assertion is offered in Figure 1. New World real wages and marginal value productivities are on right and Old World real wages and marginal value productivities on the left. The "world" labor force is distributed between the two regions along the horizontal axis. Derived labor demand in the Old World is denoted by OW and in the New World by NW. L* is the distribution of labor that is consistent with wage parity between the two regions, while the actual distribution at two points in the late 19th century is denoted by L_{70} and L_{90}. The wage gaps in 1870 and 1890 are indicated by GAP_{70} and GAP_{90}. While estimation of Harberger triangles is not our goal in this paper, one has been identified for 1890 by the shaded area. One could easily calculate the dead-weight loss, however, as did Hamilton and Whalley (1984) for the contemporary world economy. One could also calculate the mass migration that would have been required to eliminate wage gaps entirely. However, our purpose is instead to account for the measured convergence across the late nineteenth century. Suppose all the labor force redistribution over these two decades was attributable to mass migration. Suppose at the same time there were independent Solovian accumulation events, Abramovitzian technological catch-up, and Heckscher-Ohlin price shocks, all of which, at least on net, favored the Old World, and thus induced a relative shift in Old World labor demand upward to OW′. In that case, the observed convergence would have been measured by the fall in the wage gap from GAP_{70} to GAP_{90}', and mass migration would have accounted for a share $(GAP_{70} - GAP_{90})/(GAP_{70} - GAP_{90}')$ of that fall.

There is no reason why the derived demand functions cannot be estimated. Given data on wage gaps and labor force distributions, there is also no reason why counterfactual analysis cannot be applied to a diagram like Figure 1. Indeed, Figure 1 has been drawn to be consistent with such late-nineteenth century estimates. Furthermore, there is no reason why the two-region case in Figure 1 cannot be expanded to include our 17-country real-wage sample, allowing a decomposition of the contribution of mass migration to the σ-convergence observed before WWI.

Measuring the Impact of Migration on Convergence

Our multi-country study uses a counterfactual simulation approach. We first discuss the counterfactual and then explain the simulation technique. Our purpose is to assess migration's role in accounting for convergence as measured by the decline in dispersion between 1870 and 1910. The relevant data is shown in Table 3: real wage dispersion declines by 28% over the period, GDP per capita dispersion by 13% and GDP per worker by 24%.[6] What contribution did international migration make to that measured convergence? To answer the question, we ask another: what would have been the measured convergence 1870–1910 had there been no (net) migration? The no-migration counterfactual invokes the *ceteris paribus* assumption: in each country, we adjust population and labor force taking into account the average net migration rate observed during the period, and we assume that technology, capital stocks, prices and all else remain constant. Such assumptions may impart an upward bias to our calculations, but before pondering that possibility, let's see whether the magnitudes are large enough to warrant further scrutiny.

[6] The dispersion measure is variance divided by mean squared; cf Table 1 where the square root of this measure was adopted for consistency with Abramovitz (1986).

A country with an observed cumulative net migration rate M, will be assumed to experience a counterfactual population change of $POP^* = M(1-\rho)$ in the terminal year, where we use X^* to denote dX/X, and where ρ is a return-rate correction factor introduced to allow for underenumerated return migration.[7] *Ceteris paribus*, migration affects long-run equilibrium output and wages through its influence on aggregate labor supply L^*. We assume a standard aggregate production function for output, $Y = F(L,\ldots)$. Under long-run full employment conditions, with competitive wages equal to labor's marginal product, and inelastic labor supplies, the marginal productivity condition $dY = F_L(L,\ldots)\,dL$ yields the proportional output change equation $Y^* = (wL/Y)L^* = \theta L^*$, where θ is labor's share in output, since $(w/P) = F_L(L,\ldots)$. Differentiating the marginal productivity condition yields the producer real wage impact $(w/P)^* = \eta^{-1}L^*$, where $\eta = F_{LL}^{-1}(w/L)$ is the elasticity of labor demand with respect to the wage holding all other inputs fixed. Under the *ceteris paribus* assumption, the price structure is invariant under the counterfactual so that the impacts on the nominal wage, the producer real wage, and the consumer real wage are identical: $w^* = (w/P)^* = (w/CPI)^*$, where CPI is the consumer price deflator.

Thus, the long-run migration impact on wages and output may be derived if migrant streams of population measured by $M(1-\rho)$ can be converted into labor supply shocks L^*. Suppose, therefore, that for a given country a share α_M of its migrant stream is active in the labor force, whilst its total population has an active share α_{POP}. Moreover, assume that migrants have an effective-worker (or worker-quality) ratio of μ with respect to the total labor force—for example, a wage gap exists between the migrant stream and the resident labor force due to, say, skill premia. Hence, the labor content of the population is $L = \alpha_{POP}\,POP$, and the labor content of the migrant flow is $dL = \mu\,\alpha_M\,M(1-\rho)\,POP$. Defining $\gamma = \alpha_M/\alpha_{POP}$ (the migrant-to-population ratio of labor-force participation rates) we obtain the expression $L^* = \mu\,\gamma\,M(1-\rho)$.

[7] Thus, M equals the unadjusted cumulative population impact, and is given by $\exp(40\times[\text{average net migration rate 1870–1910}])^{-1}$. Recall that Table 1 shows $M(1-\rho)$, correcting for underenumerated return migration with a "baseline" parameter estimate of $\rho=0.1$.

We can now derive the simulation equations used to calculate the impact of migration on GDP per capita (*Y/POP*), per worker (*Y/L*), and real wages (*w/CPI*):

(1) $(w/CPI)^* = \eta^{-1} L^* = \mu \gamma \eta^{-1} M(1-\rho)$

(2) $(Y/POP)^* = Y^* - POP^* = \theta L^* - M(1-\rho) = (\mu \gamma \theta - 1) M(1-\rho)$

(3) $(Y/L)^* = Y^* - L^* = \theta L^* - \mu \gamma M(1-\rho) = \mu \gamma (\theta - 1) M(1-\rho)$

The simulations use the above equations to assess the impact of the mass migrations 1870–1910 on convergence in our sample of countries.

The data requirements for the counterfactuals are described in appendix 2, but we offer a brief summary here. For real GDP, population and labor force estimates we use Maddison's (1991) latest study, with extensions, adjustments and modifications to bring Argentina, Brazil, Portugal, and Spain into the study, and to split the United Kingdom into Great Britain and Ireland. For real wages we use Williamson's (1994 forthcoming) long-run database on internationally comparable real wages. For migration time series we use Willcox (1929–31) and other standard sources.

We know much more about some parameters than others. Return migration is poorly documented in most official data, but we know that it ranged from very high for Italians to almost zero for the Irish and the Scandinavians.[8] The baseline assumption invoked here is that an appropriate correction for underenumeration of return migration is to set ρ at 0.1, with sensitivity analysis in the range 0.0–0.3. Migrant quality is also poorly documented, and the same movers may have exhibited different quality relative to stayers in the sending and receiving countries. The baseline assumption has been to set the effective worker ratio $\mu = 0.8$ since, although we have little evidence relating to the size of migrant-versus-local wage or productivity gaps, we know that immigrants were

[8] A useful comparative picture of migration with some discussion of "best guess" return rates for various countries is provided by Nugent (1992). Our assumptions are not inconsistent with such estimates, as the return rates in our raw data suggest (see appendix 2).

considered low quality in the United States and that they typically entered at the bottom of the job ladder.[9] Still, given other scholars' concerns that Europe suffered a brain drain by the loss of the best and the brightest, we later subject μ to sensitivity analysis in the range 0.8–1.2. Note that an understatement of μ or γ tends to understate the impact on GDP per capita while overstating the impact on the real wage and labor productivity. Thus, sensitivity analysis is especially important for these two parameters given the several measures of convergence being studied.

The parameter γ (relative labor participation rates) is based on detailed studies of Anglo-American experience (Kuznets 1952; O'Rourke, Williamson and Hatton 1994 forthcoming). *A priori*, we expect γ to exceed unity, since migrant streams self-select and have a relatively high proportion of young adult males. Thus, the labor content of the migrant stream will be skewed by the presence of an over-representation of working-age adults, and by the over-representation of males with high participation rates. Guided by activity rates alone, we might guess α_M to have been around 90%, α_{POP} around 60%, and, hence, γ around 1.5 for most countries. Estimates of γ from the United States and Britain document a range of 1.53–1.78 for the late nineteenth century, and a mid-point estimate of 1.65 was chosen as the baseline parameter subject to sensitivity analysis in the range 1.55–1.75. Labor's share (θ) is documented in various country-studies of factor distribution, most of which were done in the 1960s. These estimates of θ were supplemented by constructing alternative estimates of $\theta = wL/Y$ from data on average nominal wages (w), nominal output (Y) and labor force (L). Independent estimates of θ were thus derived for almost all countries, with the remainder covered by contiguous-country estimates (for example, Brazil uses Argentina's θ estimate).

Lastly, an estimate of η was obtained using standard estimation techniques for aggregate labor demand (Hamermesh 1993). Appendix 1 discusses in detail the

[9] Note that the concern here is with migrants' raw productivity, not adjusted for skills, experience or other characteristics.

estimation of η. For any (degree one) homogenous two-factor production function it can be shown that $\eta = -\sigma/(1-\theta)$. The elasticity of substitution σ was estimated econometrically with a late nineteenth century panel of 14 countries, with four decadal observations for each country. Under a CES production function, $Y = (aL^{\rho} + bK^{\rho})^{1/\rho}$ it can be shown that producer wages w/P are related to aggregate output per worker according to $\ln(Y/L) = \sigma \ln(w/P)$, where $\sigma = 1/(1-\rho)$ is the elasticity of substitution. Estimates of σ may be taken from a number of estimating equations (Hamermesh 1993; Arrow, et al. 1961):

(4) $\ln(Y/L) = \sigma \ln(w/P)$

(5) $\ln(w/P) = (1/\sigma) \ln(Y/L)$

(6) $\ln(L) = \rho \ln(Y) - \sigma \ln(w/P)$, testing the restriction $\rho = 1$.

Appendix 1 reports the estimation of these equations using panel fixed-effect econometric techniques on a 14-country subsample over the four decades 1870-1910. The three estimates of σ so derived were 0.22, 0.62 and 0.87. The middle value of 0.62 was used in the baseline estimates of η, but all three values were used in the sensitivity analysis.

The Contribution of Mass Migration to Convergence

Table 4 presents our baseline results. The upper panel shows counterfactual real wages, GDP per capita, and GDP per worker in 1910 under the counterfactual assumption of zero net migration after 1870 in all countries. The second panel indicates the proportionate impact with respect to the actual levels for each country shown in Table 3. The third and fourth panels report counterfactual convergence or divergence.

The results certainly accord with intuition: in the absence of migration, wage and labor productivity levels would have been much higher in the New World and much lower in the Old; and in the absence of migration, income per capita levels would typically (but not always) have been marginally higher in the New World and typically (but not always) marginally lower in the Old. Not surprisingly, the biggest counterfactual impact is seen in the countries that experienced the biggest migrations: by 1910, Irish wages would have been lower by 31%, Italian by 23% and Swedish by 10%; and Argentine wages would have been higher by 36%, Australian by 22%, Canadian by 25% and American by 12%. Labor productivities would have been similarly affected: up in the New World from 7% (U.S.) to 21% (Argentina), and down in the Old World by as much as 20% (Ireland) or 15% (Italy).

There are only a few such country-specific estimates reported in what is otherwise an enormous literature on the mass migrations, but what few there are seem to be roughly consistent with those reported in the second panel of Table 4. For example, about two decades ago one of the present authors (Williamson 1974, 387) used a computable general equilibrium model to estimate that in the absence of immigration U.S. real wages would have been 11% higher in 1910 (here estimated to be 12% higher), and income per capita 3% higher (matching the present estimate). More recently, another computable general-equilibrium application to the U.S. found the impact to have been 34% in 1910 (O'Rourke, Williamson and Hatton 1994 forthcoming). Britain offers another example: O'Rourke, Williamson and Hatton estimate that emigration served to raise the real wage by 12% in 1910 (here estimated to be 7%). A Norwegian study (Riis and Thonstad 1989, Table 8.6) found the impact of emigration to have raised income per capita in 1910 by 6% (here estimated to be 2%). A study for Sweden (Karlstrom 1985, Table 6.4) found the 1890 impact of emigration to have raised wages by 9% and income per capita by 2% (our figures, for 1910, are 10% and 2% respectively). While estimates obviously vary somewhat in the literature, generally there seems to be a fair degree of agreement among them and with our own, especially given that they were estimated in very different ways and under widely different assumptions.

Overall, the results in Table 4 lend strong support to the hypothesis that mass migration made an important contribution to convergence in the late nineteenth century.

Starting with the third panel first, we observe that real wage dispersion would have *increased* 25% 1870–1910, in contrast to the actual 28% decline seen (Table 3). GDP per worker dispersion would have declined only 7% (versus actual, 24%), and GDP per capita dispersion would have declined only 7% (versus actual, 14%). New World-Old World wage gaps actually declined from 96% in 1870 to 79% in 1910, but in the absence of mass migration they would have *risen* to 134% in 1910 (19% counterfactual rise versus 9% actual decline).

Pairwise comparisons are also easily constructed using Table 4 and compounding the percentages. Wage gaps (measured here as New World premia) between many Old World countries and the U.S. fell dramatically as a result of mass migration: without Irish emigration (some of which went to America) and U.S immigration (some of which was Irish), the American-Irish wage gap would have risen from 134% to 201%, while in fact it fell to 86%; without Italian emigration (a large share of which went to America) and U.S. immigration (much of it Italian), the American-Italian wage gap would have risen from 342% to 387%, while in fact it fell to 240%; without British emigration and Australian immigration, the Australian-British wage gap would have fallen only from 84% to 68%, while in fact it fell to 29%; and without Italian emigration and Argentine immigration, the Argentine-Italian wage gap would have risen from 135% to 231%, while in fact it fell to 90%. Furthermore, the mass migrations to the New World had an impact on economic convergence within the Old World: without the Swedish emigration flood and the German emigration trickle, the German-Swedish wage gap would have inverted from 107% (German higher) to 6% (Swedish higher), while in fact it inverted as far as 15% (in favor of the Swedes); and without the fact that Irish emigration exceeded British emigration by far, the British-Irish wage gap would have risen from 41% to 55%, while in fact it fell to 15%. Although the impact of mass migration *within* the Old World was much smaller than between the Old and New World, remember the caveat that migrations within Europe were underenumerated, a bias working against our migration-convergence hypothesis.

A summary of results is shown in Table 5. Notably, GDP per capita dispersion is least affected in our analysis. In terms of the convergence accounted for by migration, the counterfactuals suggest that more than all (168%, log measure of dispersion) of the real wage convergence 1870–1910 was attributable to migration, and almost three-quarters (73%) of the GDP per worker convergence. In contrast, maybe one half (50%) of the GDP per capita convergence might have been due to migration.

The contribution of mass migration to convergence in the full sample and in the New and Old World differ, the latter being smaller and in some cases even negative. There is, we think, no cause for concern. Indeed, it is consistent with intuition. First, it should come as no surprise that New World impacts are small or even negative by some measures, given the segmentation in the global labor market. To some extent, immigrant flows were not efficiently distributed, since barriers to entry limited destination choices for many southern Europeans, a point central to discussions of Latin migration experience, and invoked as an important determinant of Argentine economic performance (Díaz-Alejandro 1970; Hatton and Williamson 1994 forthcoming-b; Taylor 1992; Taylor 1994 forthcoming). Thus migrants did not always obey some simple market-wage calculus; kept out of the best high-wage destinations, or having alternative cultural preferences, many went to the "wrong" countries. The South-South flows from Italy, Spain and Portugal to Brazil and Argentina were a strong force for local (Latin), not global, convergence. Second, barriers to exit were virtually nil in the Old World, but policy (like assisted passage) still played a part in violating any simple market-wage calculus.[10] However, the small contribution of migration to convergence in each region illustrates our opening point: the major contribution of mass migration to late nineteenth

[10] Beyond our sample barriers to exit did exist—most emigration from Russia was illegal. On this, and for a more detailed discussion of migration policy, see Foreman-Peck (1992) and Nugent (1992).

century convergence was the enormous movement of almost 50 million Europeans to the New World, and the impact this movement had on convergence between the two regions. The real wage convergence, as noted elsewhere, is in large part due to a narrowing of New World-Old World wage gaps, which fall from 96% in 1870 to 79% in 1910. The New World-Old World story stands in contrast to the quantitatively less important convergence within each region, an effect only further obscured by the imperfect wage-flow correlation (Williamson 1994 forthcoming).

The relative insensitivity of GDP per capita convergence to migration is a result of countervailing effects inherent in the algebra. For real wages or GDP per worker, higher values of γ (the migrant-to-population ratio of labor-force participation rates) amplify the impact of migration, but with GDP per capita the impact is muted. Why? In the former two cases, migration has a bigger impact on GDP, wage levels and labor force, the bigger is the relative labor content of the migrations. In the case of GDP per capita, the impacts are less clear. For example, with emigration, population outflow generally offsets diminishing returns in production, leaving a net positive impact on output per capita; but skewed demographics in the emigrant stream ($\gamma > 1$) will take away a disproportionate share of the labor force, lowering output via labor supply losses, a negative impact on output per capita. The two exactly cancel out when, in equation (2), $\mu \gamma \theta = 1$. Indeed, for even higher γ, emigration will, perversely, lower GDP per capita through the then-dominant negative labor supply effect. In our sample, $\mu = 0.8$ by assumption, $\gamma = 1.65$ is the baseline value, and so $\theta = 0.758$ is the critical value. The sample θ range from 0.41 (Belgium) to 0.64 (U.S.), so muted GDP per capita effects are no surprise. By our calculation, four decades of immigration lowered GDP per capita by only as much as 7% anywhere in the New World (Argentina), and by as little as 3% in the U.S., to be contrasted with GDP per worker impacts of 21% and 7% respectively. This labor-supply compensation effect operated in addition to the usual human-capital transfer effects invoked to describe the net benefit to the U.S. of the millions received before

WWI (Uselding 1971; Neal and Uselding 1972). Similar reasoning applies to the Old World: Ireland, for all its emigration, and perhaps about a 30% resulting rise in wages, only gained about 10% in GDP per capita through the labor so vented; Swedish emigration after 1870 may have raised wages by about 10%, but it served to raise GDP per capita by only 2%.

Table 6 explores the sensitivity of our results to various parameter values. The results seem robust for real wages and GDP per worker: for most parameter combinations, actual convergence is more than half explained by migration, and frequently overexplained. As a conservative estimate, we could assert that mass migration accounted for at least half the real wage convergence and at least one third of the GDP per worker convergence, even assuming an extreme adjustment for return-rate underenumeration of about 30% ($\rho = 0.3$), which we think implausibly high except for one or two countries (for example, Italy). Using a more moderate correction of $\rho = 0.1$, our estimates suggest that migration contributed at least 100% of the real wage convergence and at least 70% of the GDP per worker convergence.

Finally, note the extreme sensitivity of the GDP per capita impact to parameter assumptions. This should now come as no surprise given the previous discussion. When μ or γ are allowed to rise (so that $\mu \gamma \theta > 1$), the perverse divergence effect of migration appears for GDP per capita. Thus, our results raise another qualification to the convergence debate: when modeling migration and convergence, demographic considerations suggest care be taken in the selection of variable documenting convergence.

Qualifying the Bottom Line

Our baseline results argue that the mass migrations accounted for 168% of the real wage convergence observed in our sample of 17 New World and Old World countries between 1870 and 1910. Have we overexplained late nineteenth century convergence? Perhaps, but the fact is hardly surprising given that there were *other* powerful pro- and anti-convergence forces at work. Four of these deserve stress. First, what about Solovian capital accumulation forces? We know that capital accumulation was faster in the New World, so much so that the rate of capital deepening was faster in the U.S. than in any of her competitors (Wolff 1991), and the same was probably true of other rich New World countries. There is evidence therefore that the mass migrations may have been at least partially offset by capital accumulation, and a large part of that capital widening was being carried by international capital flows which reached magnitudes unsurpassed before or since (Edelstein 1982; Zevin 1992). Second, what about the forces of trade of which so much was made by Eli Heckscher in 1919 and Bertil Ohlin in 1924 (Flam and Flanders 1991)? Their idea was that spectacular transport innovations in the late 19th century caused commodity prices to converge and trade to boom. As exports expanded among trading partners, the derived demand for their abundant factors boomed while that for their scarce factors slumped. Factor prices (like real wages) tended to converge as a result. Samuelson (1948) got us thinking about the strong assumptions needed for factor price *equalization*, but factor price *convergence* requires weaker assumptions and they are supported by the late nineteenth century evidence (O'Rourke and Williamson 1992; O'Rourke, Taylor and Williamson 1993). Third, what about the forces of technological catch up stressed by Gerschenkron (1962) and Abramovitz (1986), but documented only poorly for the late 19th century (Wolff 1991)? Finally, what about the forces of human capital accumulation so prevalent in the new growth theory, and which have been suggested as an important force for convergence in the late 19th century (Easterlin 1981; Sandberg 1979)?

Insofar as that schooling is a good proxy for human capital accumulation, we can reject at least one of these four forces quickly: schooling was not an important force accounting for real wage or labor productivity convergence in the late 19th century (O'Rourke and Williamson 1994; Prados de la Escosura, Sanchez and Oliva 1993). But what about the other three forces? Although the evidence is still fragile, we do know something about the relative importance of Heckscher-Ohlin trade-related forces: they may have accounted for as much as a third of the real wage convergence in the late 19th century (O'Rourke, Williamson and Hatton 1994 forthcoming; O'Rourke, Taylor and Williamson 1993; O'Rourke and Williamson 1992).[11] The evidence on the role of global capital market responses is even more tentative, but it suggests that perhaps as much as two-thirds of the mass migrations were offset by international capital chasing after labor.

Figure 2 offers a stylized treatment of these informed guesses. Here we consider dispersion for a group of countries whose level indicator y (say, real wages) is converging on the group mean $y(0)$ according to $y_i(t) = y_0(t) + \Sigma_i \alpha_i e^{-\lambda t}$, where λ is the convergence speed, and $\Sigma_i \alpha_i = 0$ by assumption. $CV(t) = CV(0)e^{-\lambda t}$ is the coefficient of variation (standard deviation divided by the mean), and our dispersion measure $DISP$ is a CV^2 index, so that $DISP(t) = DISP(0)e^{-2\lambda t}$. What determines λ? As we have argued above, several forces contributed positively to convergence in the late 19th century, not only mass migration (labor market integration forces, labeled LMI in Figure 2), but also commodity price convergence (commodity market integration forces, labeled CMI), and any number of residual forces (RESID) such as technological catch up, unmeasured intra-European migration, human capital accumulation and the like. Conversely, and as we pointed out above, our partial-equilibrium assessment of mass migration's impact does not account for the mass migration of capital from Old World to New, some of it chasing after labor and all of it chasing after abundant natural resources. The dual scarcity of labor and capital in the open spaces of the New World was the key international factor market disequilibrium of that era, and it implied massive flows of both mobile factors (Green and Urquhart 1976). International capital market integration was probably as well developed by the turn of the century as it is now (Neal 1985; Neal 1990; Zevin 1992). Yet, the capital flows of the late nineteenth century were an anti-convergence force, in

[11] A related point has been made by Richard Nelson and Gavin Wright regarding U.S. industrial leadership since 1870, with an early resource advantage gradually eroded by the increased tradability of oil and minerals, to be replaced by a later advantage built on human capital (Nelson and Wright 1992; Wright 1990).

that they raised wages and labor productivity in the rich New World, while lowering wages and labor productivity in the poor Old World (capital market integration, KMI, in Figure 2). Hence, in our stylized setting we decompose λ, with $\lambda = \lambda_{LMI} + \lambda_{CMI} + \lambda_{KMI} + \lambda_{RESID}$, with $\lambda_{LMI}, \lambda_{CMI}, \lambda_{RESID} > 0$, and $\lambda_{KMI} < 0$.

Concluding Remarks

This paper suggests that the convergence literature has missed two crucial features of the late 19th century world economy. First, the key axis around which convergence centered was between old World and New: along that axis hangs most of the convergence story for real wages 1870-1913 (Williamson 1994 forthcoming). Second, the conventional closed-economy assumption is simply inappropriate given the degree of integration in the world economy at that time, whether in goods markets, labor markets or capital markets. These insights have been applied elsewhere. In other papers, Kevin O'Rourke and the present authors have shown that integration in product markets arising from spectacular ocean and railroad freight declines could account for much of the Anglo-American real wage convergence; and for a broader group of countries, terms-of-trade effects and endowment changes could account for a large share of the convergence in the wage-rental ratio. In short, an open-economy perspective is vital to understanding late 19th century convergence (O'Rourke and Williamson 1992; O'Rourke, Taylor and Williamson 1993; O'Rourke and Williamson 1994; O'Rourke, Williamson and Hatton 1994 forthcoming).

Will our partial equilibrium analysis of late 19th century mass migration hold up to closer scrutiny? It certainly will need more sophisticated analysis to help confirm it: general-equilibrium capital-chasing effects could offset more of the mass migration impact than we allow in Figure 2, in which case technological catching-up might be claim more than the residual role history appears to have assigned it. Still, we expect our results to offer a new perspective on the convergence debate, one relevant for economic historians and macroeconomists. The convergence power of free migration, when it is tolerated, is likely to be substantial given the late 19th century evidence. Cheap labor did not wait for foreign capital to seek it out, nor did it ignore distant immobile natural resources that beckoned labor to move; it did not wait for human capital accumulation or spillovers to initiate catching up at home, it just went. Convergence explanations based on technological or accumulation catching-up in closed-economy models miss this point. The millions on the move in the late 19th century didn't.

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Table 1
Summary Data: Net Migration Rates and Cumulative Impact, 1870–1910

	Persons Adjusted Net Migration Rate 1870–1910	*Persons* Adjusted Cumulative Population Impact 1910	*Labor Force* Adjusted Net Migration Rate 1870–1910	*Labor Force* Adjusted Cumulative Labor Force Impact 1910
Argentina	10.57	53%	13.95	75%
Australia	5.95	27%	7.85	37%
Belgium	1.50	6%	1.98	8%
Brazil	0.67	3%	0.88	4%
Canada	6.23	28%	8.22	39%
Denmark	-2.42	-9%	-3.20	-12%
France	-0.09	0%	-0.12	0%
Germany	-0.65	-3%	-0.86	-3%
Great Britain	-2.02	-8%	-2.67	-10%
Ireland	-10.12	-33%	-13.35	-41%
Italy	-6.47	-23%	-8.54	-29%
Netherlands	-0.53	-2%	-0.71	-3%
Norway	-4.73	-17%	-6.24	-22%
Portugal	-0.96	-4%	-1.26	-5%
Spain	-1.04	-4%	-1.38	-5%
Sweden	-3.78	-14%	-4.99	-18%
United States	3.62	16%	4.78	21%
New World	5.41	25%	7.14	35%
Old World	-2.61	-9%	-3.45	-12%

Notes and Sources:
Adjustments according to "baseline" parameter estimates. Rates per thousand per annum. Minus denotes emigration. See text and appendix 2.

Table 2
Summary Data: Convergence, 1870–1980s

Variable:	GDP/work hr.	GDP/capita	GDP/work hr.	Realwages
References:	Abramovitz Maddison *PCD* (ICP Phase II)	This study Maddison *DFCD* (ICP Phase V)	This study Maddison *DFCD* (ICP Phase V)	This study Williamson "Evolution"
Sample size:	N=16	N=16	N=16	N=17
A. Coefficient of Variation (CV)				
1870	0.51	0.38	0.44	0.50
1913	0.33	0.33	0.37	0.43
1950	0.36	0.36	0.43	0.45
1987	0.15*	0.11†	0.13	0.33
B. Implied convergence speed (p.a.)				
1870-1913	1.01%	0.34%	0.36%	0.35%
1913-1950	-0.24%	-0.23%	-0.37%	-0.07%
1950–1987	3.02%*	2.91%†	3.14%	0.79%
Overall	1.12%*	1.00%†	1.01%	0.36%

Notes:
In this table the coefficient of variation (CV) is standard deviation divided by the mean. Implied convergence speed is rate of decline of ln(CV). Alternate terminal dates are *=1979, †=1989.
Sources:
Abramovitz (1986); Maddison (1982; 1991); Williamson (1994 forthcoming).

Table 3
Summary Data: Convergence, 1870–1910

	Real wages		GDP per capita		GDP per worker	
	1870	1910	1870	1910	1870	1910
Levels:						
Argentina	61	95	1,238	2,417	3,206	6,263
Australia	127	135	3,123	4,586	7,811	10,573
Belgium	60	87	2,104	3,171	4,836	7,059
Brazil	39	85	425	549	1,101	1,422
Canada	99	205	1,365	3,263	3,781	7,876
Denmark	36	99	1,624	3,005	2,943	5,900
France	50	71	1,638	2,503	3,336	5,031
Germany	58	87	772	1,424	2,996	5,510
Great Britain	69	105	3,055	4,026	7,132	9,448
Ireland	49	91	—	—	—	—
Italy	26	50	1,244	1,933	2,309	3,920
Netherlands	52	70	2,064	2,964	5,322	7,795
Norway	28	70	1,190	1,875	2,800	4,719
Portugal	32	42	612	901	1,346	2,024
Spain	51	52	1,308	1,962	3,194	4,919
Sweden	28	100	1,316	2,358	2,814	5,019
United States	115	170	2,254	4,559	5,925	10,681
Dispersion (1870=100):						
All	100	72	100	86	100	76
New World	100	76	100	79	100	77
Old World	100	73	100	70	100	61
New World/Old World:						
Gap (Parity=100):	196	179	109	129	123	132

Notes and Sources:
Dispersion measure is variance divided by the square of the mean (or CV squared), using an index with 1870=100. See text and appendix 2..

Table 4
Counterfactual Convergence, 1870–1910 with Zero Net Migration

	Real wages		GDP per capita		GDP per worker	
	1870	1910	1870	1910	1870	1910
Levels:						
Argentina	61	129	1,238	2,590	3,206	7,579
Australia	127	165	3,123	4,855	7,811	11,988
Belgium	60	93	2,104	3,253	4,836	7,367
Brazil	39	87	425	551	1,101	1,440
Canada	99	255	1,365	3,480	3,781	9,025
Denmark	36	90	1,624	2,921	2,943	5,576
France	50	71	1,638	2,500	3,336	5,019
Germany	58	85	772	1,409	2,996	5,413
Great Britain	69	98	3,055	3,939	7,132	9,030
Ireland	49	63	—	—	—	—
Italy	26	39	1,244	1,777	2,309	3,346
Netherlands	52	68	2,064	2,937	5,322	7,677
Norway	28	62	1,190	1,828	2,800	4,357
Portugal	32	40	612	901	1,346	2,024
Spain	51	50	1,308	1,962	3,194	4,919
Sweden	28	90	1,316	2,311	2,814	4,709
United States	115	190	2,254	4,684	5,925	11,442
Change (counterfactual versus actual):						
Argentina		36%		7%		21%
Australia		22%		6%		13%
Belgium		7%		3%		4%
Brazil		2%		0%		1%
Canada		25%		7%		15%
Denmark		-9%		-3%		-5%
France		0%		0%		0%
Germany		-3%		-1%		-2%
Great Britain		-7%		-2%		-4%
Ireland		-31%		-10%		-20%
Italy		-23%		-8%		-15%
Netherlands		-2%		-1%		-2%
Norway		-12%		-2%		-8%
Portugal		-4%		-1%		-2%
Spain		-4%		-1%		-3%
Sweden		-10%		-2%		-6%
United States		12%		3%		7%
Dispersion (1870=100):						
All	100	125	100	93	100	93
New World	100	84	100	78	100	74
Old World	100	83	100	72	100	66
New World/Old World:						
Gap (Parity=100):	196	234	109	138	123	154

Notes and Sources:
Dispersion measure and actual data as in Table 3. On counterfactual, see text.

Table 5
Summary: Counterfactual Convergence, 1870–1910 with Zero Net Migration

Dispersion (1870=100)	Actual 1910	Counterfactual 1910	Convergence explained 1870–1910 (change in ln[dispersion])
Real wages:			
All	72	125	168%
New World	76	84	37%
Old World	73	83	41%
GDP per capita:			
All	86	93	50%
New World	79	78	-4%
Old World	70	72	7%
GDP per worker:			
All	76	93	73%
New World	77	74	-11%
Old World	61	66	15%

Notes and Sources:
See text and Table 4. Convergence explained is counterfactual-actual ratio of change in ln[dispersion].

Table 6
Sensitivity Analysis

A. Real wage convergence 1870-1913 explained by migration

γ=	1.55	1.55	1.75	1.55	1.65	1.75	1.55	1.75	1.75
$\Delta\theta$=	0.10	-0.10	0.10	0.10	0.00	-0.10	-0.10	0.10	-0.10
μ=	0.80	0.80	1.20	0.80	0.80	1.20	0.80	1.20	1.20
ρ=	0.30	0.30	0.30	0.00	0.10	0.30	0.00	0.00	0.00
σ=0.87	54%	85%	91%	110%	121%	142%	170%	182%	275%
σ=0.62	76%	118%	127%	152%	168%*	196%	232%	248%	365%
σ=0.22	206%	309%	328%	381%	414%	468%	533%	557%	731%

B. GDP per capita convergence 1870-1913 explained by migration

	20%	50%	-37%	43%	50%*	4%	109%	-67%	9%

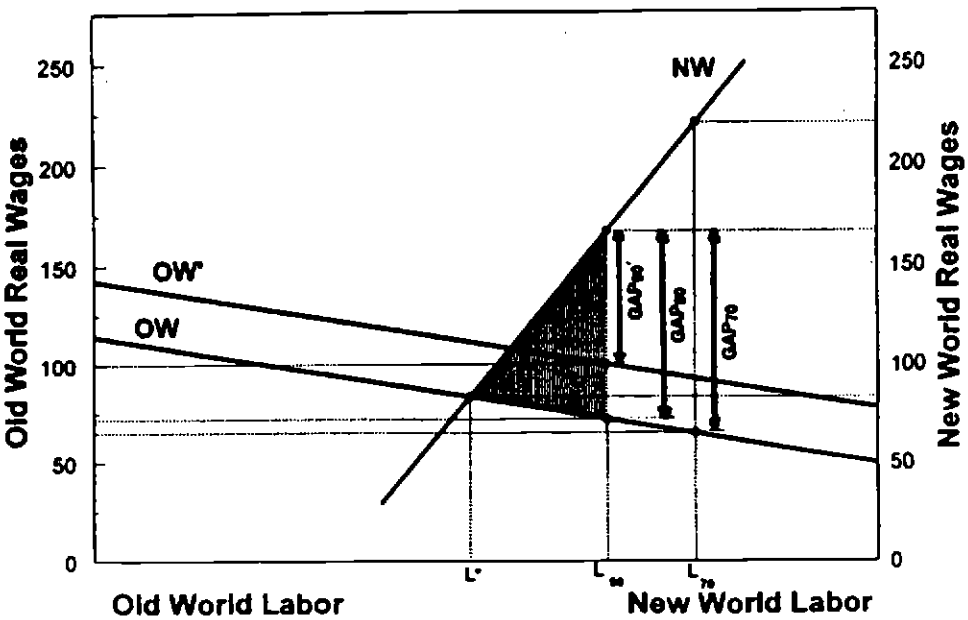
C. GDP per worker convergence 1870-1913 explained by migration

	30%	49%	53%	64%	73%*	88%	108%	115%	192%

Notes:
See text. Sample is all countries (N=17). Variable shown is convergence explained by migration (change in ln[dispersion]) from Table 5 calculations performed for various parameter combinations. "Baseline" estimates (Table 5) shown by asterisk.

Figure 1

Labor Demand and Wages in the Old and New World, 1890



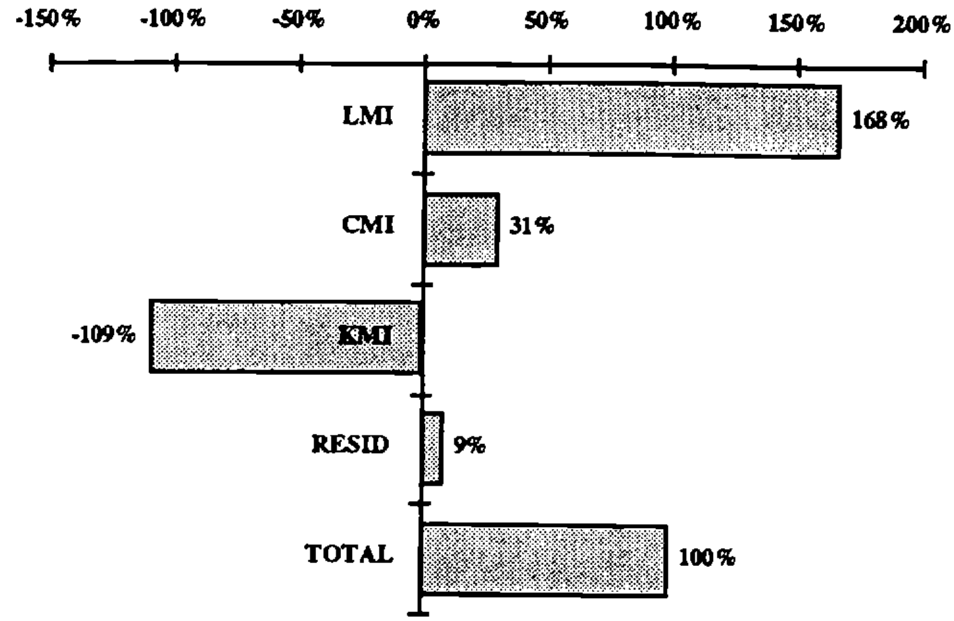


Figure 2
Explaining Convergence: An Example 1870–1910

		Cvgce. Speed λ	Cum. Cvgce. Speed λT	Convergence impact: (disp change)	Convergence explained: (ln disp)
Labor-market integration	LMI	.0054	0.22	-54%	168%
Commodity-market integration	CMI	.0010	0.04	-8%	31%
Capital-market integration	KMI	-.0035	-0.14	24%	-109%
Residual	RESID	.0003	0.01	-2%	9%
Total	TOTAL	.0032	0.13	-29%	100%

Notes:
See text. T=40 years. Dispersion index is variance divided by mean squared.

APPENDIX 1: LABOR DEMAND ECONOMETRICS

The underlying objective of our regression analysis was to estimate the elasticity of substitution, σ, in both the New World and Old World. The estimate of σ was used, along with independent information on θ, labor's share of income (see Appendix 2), to provide an estimate of $\eta = F_{LL}^{-1}(w/L)$, the short-run wage elasticity of labor demand ***holding all other inputs fixed***, and, thus, an estimate of the impact of migration-induced labor-supply shocks on wages.

In this first appendix we discuss the econometric methodology. Data sources for the econometric estimation (and for the rest of the paper) are documented in the second appendix. Data for the econometrics consisted of a 14 country sample with annual estimates of real GDP, labor force, and real wages, from which "decadal" averages (1870-79, 1880-89, 1890-99, and 1900-13) were derived to generate a panel with four observations for each country.

Estimation Strategy and Results

For any (degree one) homogenous two-factor production function $Y = F(L,K)$, it is the case that $F_L L + F_K K = Y$ and $F_{LL}L + F_{LK}K = 0$. It is easily shown that

$$F_{LL} = -F_{LK}\frac{K}{L} = -\frac{F_L F_K}{\sigma Y}\frac{K}{L} =, \qquad \text{where } \sigma = \frac{F_L F_K}{\sigma F_{LK}} \text{ by definition}$$

Thus, under competitive conditions,

$$\eta = F_{LL}^{-1}\frac{w}{L} = -\frac{\sigma Y}{F_L F_K}\frac{L}{K}\frac{w}{L} = -\frac{\sigma Y}{wr}\frac{w}{K} = -\frac{\sigma Y}{rK} = -\frac{\sigma Y}{Y-wL} = -\frac{\sigma}{(1-\theta)}$$

Estimates of θ were directly constructed. In order to estimate σ econometrically we utilized a late 19th century panel of 14 countries, with four decadal observations for each country (see Appendix 2), and a set of CES-derived estimating equations.

Under a CES production function, $Y = (aL^\rho + bK^\rho)^{1/\rho}$ it can be shown that producer wages w/P are related to aggregate output per worker according to $\ln(Y/L) = \sigma \ln(w/P)$, where $\sigma = 1/(1-\rho)$ is the CES elasticity of substitution. Estimates of σ may be taken from a number of estimating equations:

(A1) $\ln(Y/L) = \sigma \ln(w/P)$

(A2) $\ln(w/P) = (1/\sigma)\ln(Y/L)$

(A3) $\ln(L) = \tau \ln(Y) - \sigma \ln(w/P)$, testing the restriction $\tau = 1$.

Two different theoretical frameworks formed the basis for our estimation strategy. The first follows the example of Arrow, Chenery, Minhas, and Solow (ACMS), by estimating log value-added per worker as a function of the log real wage, as in (A1).[12] The basic estimation equation in this case was:

(ACMS) $\ln(Y/L)_i = \alpha_i + \sigma \ln(w/P)_i + \varepsilon_i$

where Y is real GDP (in millions of 1985 US dollars), L is the labor force (in thousands), W is the nominal wage, and P is an output deflator. (ACMS) was estimated using country fixed effects since our output deflators were not PPP comparable across countries:

σ: point estimate (t-statistic)	0.623 (10.2)
fit: R^2 (adjusted R^2)	.697 (.594)
restriction test (p-value):	
intercepts equal	$F(13,41) = 30.57$ (.000)
intercepts and slopes equal	$F(13,28) = 0.802$ (.653)

[12] Arrow, K. J., H. B. Chenery, B. S. Minhas, and R. M. Solow, "Capital-Labor Substitution and Economic Efficiency," *The Review of Economics and Statistics*, 43, 1961, 225-250.

We could reject the hypothesis that the constant terms are constant across countries. Allowing the slope coefficients to differ across countries as well, however, did not yield significantly different estimates.

The second theoretical framework used to generate estimates of σ was based on a version (A3) of the marginal productivity condition (MPC):

$$\text{(MPC)} \quad \ln(L)_i = \alpha_i + \tau \ln(Y)_i - \sigma \ln (w/P)_i + \varepsilon_i$$

The same strategy was used to implement this estimation equation, using country fixed effects.[13] Estimates did vary substantially from those obtained using (ACMS). In this case, however, one cannot reject the hypothesis that coefficients on both the constant and slope terms differ across countries:

σ: point estimate (t-statistic)	0.223 (4.4)
τ: point estimate (t-statistic)	0..624 (17.2)
fit: R^2 (adjusted R^2)	.922 (.893)
restriction test (p-value):	
intercepts equal	$F(13,40) = 102.6$ (.000)
intercepts and slopes equal	$F(26,14) = 4.814$ (.002)

Limitations of Our Estimation Approach

Given the limitations of late 19th century and early 20th century data, we were forced to rely on estimation approaches which did not require information on capital stock prices or quantities. This means that care must be taken in interpreting our results—we are actually estimating the gross elasticity of labor demand, rather than the constant-output demand elasticity. This implies that we are measuring substitution along an iso-labor curve, rather than along an iso-output curve. In general, one would expect that the gross elasticities will be lower in absolute value than the constant-output elasticities, as an increase in the wage would likely lead to a reduction in the labor employed.[14]

There is also the problem that we ignore the simultaneous determination of labor supply. Because we do not have a fully specified model we must make a decision as to whether the price or quantity of labor should be considered exogenous. Given that we are using highly aggregated data, it is somewhat implausible to assume that labor supply is highly elastic. If labor supply is instead relatively inelastic, it is better to use specifications in which the quantity of labor is exogenous.[15] OLS estimates using wages as a regressor will yield inconsistent parameter estimates if factor prices are indeed endogenous.[16] An alternative is to use the reciprocal relationship (RR) of the ACMS equation, i.e., (A3), as the basis for an estimation equation:

$$\text{(RR)} \quad \ln(W/P)_i = \alpha_i + (1/\sigma) \ln (Y/L)_i + \varepsilon_i$$

Estimates based on this estimation equation did in fact differ substantially from those obtained using real wages as a regressor:

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[13] It should be noted that estimates of η obtained using this dual approach are comparable to our earlier estimates only if the share of labor in total costs, equals the share of labor in income, σ. This is true under the assumptions of perfect competition and linear homogeneous production and cost functions.

[14] Hamermesh, D. S., *Labor Demand*, Princeton, N.J.: Princeton University Press, 1993, p.67

[15] Ibid., p. 71

[16] Berndt, E. R., "Reconciling Alternative Estimates of the Elasticity of Substitution," *Review of Economics and Statistics*, 58, 1976.

$1/\sigma$: point estimate (t-statistic)	1.15 (10.2)
fit: R^2 (adjusted R^2)	.716 (.620)
restriction test (p-value):	
intercepts equal	$F(13,41) = 16.94$ (.000)
intercepts and slopes equal	$F(13,28) = 2.260$ (.035)

We can barely accept the restriction that the slopes do not vary across countries. The implied value of σ is 0.87.[17]

Comparison to Existing Estimates of σ

There already exists a large empirical literature which attempts to estimate the elasticity of substitution, both in the context of labor demand and production functions. These studies have generated estimates of σ which vary substantially and depend very strongly on the choice of the estimation equations and data.

Hamermesh extensively surveys the empirical labor demand literature.[18] Those studies which are most comparable to our estimates are 15 studies of homogeneous labor demand utilizing data at the aggregate or large industry level to estimate σ. Most of these studies directly estimated σ using some variant of the marginal productivity condition. Estimates of σ ranged from 0.21 to 6.86, although σ was between 0.3 and 0.8 in two-thirds of the studies. Hamermesh surveyed approximately 70 studies which utilized aggregate data, and concluded that the mean estimate of σ was 0.75.[19]

The other major branch of the literature is based on the CES production function and estimation equations similar to ACMS. According to Berndt, those studies which have utilized cross-sectional data have generated estimates close to one, while estimates based on time series data have generally been lower. Berndt was able to reconcile these differences by improving the quality of the time series data, resulting in estimates of σ closer to one.[20]

Our σ estimates generally fall within the ranges estimated in previous studies and also demonstrate the same dependence on the choice of functional form. Our best estimates are probably those obtained using the fixed effects model with uniform slopes.[21] An estimate of σ equal to 0.22 was obtained based on the marginal productivity condition. The estimate based on the ACMS approach was closer to the middle of the range at 0.62, while the reciprocal relationship generated an estimate of 0.87.

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[17] Berndt (ibid.) shows that estimates of σ based on the reciprocal relationship will systematically be higher than those obtained using equation 1, and our estimates follow this pattern.

[18] Hamermesh, op. cit.

[19] The only study which utilized data from more than one country was that of Drazen, Hamermesh, and Obst. The study did not utilize a cross-country panel, but instead estimated separate time series regressions for 10 OECD countries. Estimates of $-\eta$ ranged from .448 in Australia to -.184 in France, and averaged .222. Drazen, A., D. S. Hamermesh, and N. P. Obst, "The Variable Employment Elasticity Hypothesis: Theory and Evidence" in R. G. Ehrenberg (ed.), *Research in Labor Economics*, volume 6, Greenwich, Conn.: JAI Press, 1984.

[20] Hamermesh does not include these studies in his survey, as they were not primarily interested in determining labor demand elasticities. For a survey of this literature see Berndt, op. cit.; and Berndt, E. R., *The Practice of Econometrics, Classic and Contemporary*, Reading, Mass.: Addison-Wesley, 1991, pp. 449-486.

[21] It should be noted, however, that in the case of both the marginal productivity relation (MPC) and the reciprocal production function (RR), we could reject the hypothesis that both the slope coefficients and constant terms are constant across countries (though for RR the rejection is borderline). Estimating a total of 28 or 42 parameters based on only 56 observations seems inadvisable at best.

APPENDIX 2: ECONOMETRIC AND SIMULATION DATA

ECONOMETRIC DATA

The 14 countries in our econometric sample were those countries included in Williamson's "Evolution of Global Labor Markets" (*Explorations in Economic History*, 1994, forthcoming) for which real GDP data was also available. The countries are: Belgium, Denmark, France, Germany, Great Britain, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Australia, Canada, and the United States. Annual estimates for real GDP, labor force, and real wages were calculated, and then decadal averages (1870-79, 1880-89, 1890-99, and 1900-13) were utilized to generate the four observations for each country. The idea was to focus on benchmark observations, ignoring short-run annual variations, thus emerging with a panel totaling 56 observations. In each case, we attempted to exclude the impact of territorial changes.

SIMULATION DATA

The simulation exercises utilized the above data and additional data on real wages (at the benchmark years 1870 and 1910), GDP per capita (at benchmark years), GDP per worker (at benchmark years), labor's share in income (best estimates available) and avergage migration rates (between benchmark years) for all 17 countries—the above mentioned 14 plus Argentina, Brazil and Ireland.

ABBREVIATIONS

EHS Mitchell, Brian R., *European Historical Statistics, 1750–1975*, 2nd ed., New York: Facts on File, 1980.

IHSAA Mitchell, Brian R., *International Historical Statistics, The Americas and Australasia*, Detroit: Gale Research, 1983.

IHSE Mitchell, Brian R. *International Historical Statistics, Europe, 1750-1988*, 3rd ed., New York: Stockton Press, 1992,

Real GDP (Y)

For all but three of the countries in the sample (Great Britain, Portugal, and Spain), estimates of real gross domestic product (GDP) were based on the estimates of Angus Maddison, *Dynamic Forces in Capitalist Development*, Oxford: Oxford University Press, 1991, Tables A.1, A.6, and A.8. For those countries for which we used Maddison's estimates, 1985 real GDP (at 1985 U.S. relative prices) was taken from Table A.1, p. 197. Maddison's GDP indices (1913 = 100) for the years 1870-1985 were then used to generate estimates of real GDP (in 1985 U.S. relative prices) for the years 1870-1913. GDP at benchmark years (1870 and 1910) was sought for Argentina and Brazil.

ARGENTINA

Real GDP in 1913 in millions of 1985 U.S. dollars from Maddison, op. cit. Table 1.5, p. 24. The estimate for 1910 utilizes a chain index with the real output index from G. Della Paolera, "How the Argentine Economy Performed During the International Gold Standard: A Reexamination," Ph. D. dissertation, University of Chicago, December 1988, p. 186. Estimate for 1870 utilizes a chain index with the real output index from A. Maddison, "A Comparison of Levels of GDP per Capita in Developed and Developing Countries, 1970–1980," *Journal of Economic History*, 43 (March 1983), p.33.

BRAZIL

Real GDP in 1913 in millions of 1985 U.S. dollars from Maddison, op. cit. Table 1.5, p. 24. Estimates for 1870 and 1910 utilize a chain index with the real GDP series from Mitchell, *IHSAA*, Table K1, p. 898.

GREAT BRITAIN

Maddison's estimates of real GDP for the United Kingdom correct for Irish independence but still include Northern Ireland. Because we are interested in focusing on Great Britain, we wanted to exclude Northern Ireland's contribution to output from our data series. In order to exclude the output contribution of the Republic of Ireland we utilized the "compromise" GDP index of C. H. Feinstein (*Statistical Tables of National Income, Expenditure and Output of the U.K. 1855-1965*, Cambridge: Cambridge University Press, 1972, T18-20). Maddison includes two estimates of 1913 real GDP (in millions of 1985 U.S. dollars) for the U.K., one which is adjusted for border changes (i.e., excludes the Republic of Ireland), and another which is unadjusted. Feinstein's index was combined with both of these GDP estimates to calculate 1920 GDP for the UK both including the Republic of Ireland ($174,154 million) and excluding it ($167,724 million). This provides us with an estimate of Irish GDP in 1920 of $6,430 m. Combined with information on the population of the Irish republic (3,103,000 in 1920, from Feinstein, op. cit., T120-1), we can also calculate GDP per head in Ireland ($2,072). If we then assume that GDP per head was the same in Northern Ireland as in the Republic of Ireland (an understatement of Northern Ireland's relatively favorable economic condition), this implies that Northern Ireland accounted for $2,607 million of the U.K.'s output in 1920 (given a population of 1,258,000). We can then subtract this figure from $167,724 million (UK GDP after Irish independence) to generate an estimate of Great Britain's GDP in 1920: $165,118 million. Given a population of 42,460,000, this implies a GDP per person of $3,889. This implies that each inhabitant of Great Britain produced 1.877 times more output than each inhabitant of Ireland in 1920. We assumed that this productivity differential was constant throughout the 1870-1920 period. We therefore divided the population of Ireland by 1.877 to calculate a productivity-adjusted population (where each "population unit" in Ireland and Great Britain produces the same output). Great Britain's share of the productivity-adjusted population in each year was then multiplied by total U.K. output to derive an estimate of GDP in Great Britain for the years 1870-1913.

PORTUGAL

The real GDP index for 1870 to 1985 was taken from A. B. Nunes, E. Mata, and N. Valerio, "Portuguese Economic Growth 1833-1985," *Journal of European Economic History* 18, 2 (Fall 1989), Table 1, pp. 292-5. This was then combined with OECD estimates of 1985 Portuguese real GDP at current PPP exchange rates. (OECD, Department of Economics and Statistics, *National Accounts, 1960-1989, Main Aggregates: Volume I*, Paris: OECD, 1991, p. 145).

SPAIN

The real GDP index for 1870 to 1985 was derived from L. Prados de la Escosura, "Spain's Gross Domestic Product, 1850-1990: A New Series," Dirección General de Planificación, Documentos de Trabajo, D-93002, March 1993, Table D.1, pp. 101-103. This was then combined with OECD estimates of 1985 Spanish real GDP at current PPP exchange rates. (OECD, op. cit., p. 145).

Population (POP)

Population estimates were sought at the 1870 and 1910 benchmark years. For most countries we used mid-year estimates from Maddison, op. cit., Table B.2. For consistentcy with the GDP data, 1870 figures for France exclude Alsace-Lorraine, for Germany include Alsace-Lorraine, and for Italy include Rome, all as per Maddison's data.

ARGENTINA

Total population from Vicente Vázquez-Presedo, *Estadísticas historicas argentinas*, vol. 1, Buenos Aires: Ediciones Macchi, 1971, pp. 15–16.

BRAZIL

Total population from Mitchell, *IHSAA*, Table B1, p. 51. Interpolation applied along an exponential growth trend between census years.

GREAT BRITAIN

Total population from Feinstein, op. cit., T120–1.

PORTUGAL

Total population from M. I. B. Baganha, *Portuguese Emigration to the United States, 1820-1930*, New York: Garland Publishing, 1990, Table IV:III, pp. 213–4.

SPAIN

Total population derived from Prados de la Escosura, op. cit, Tables D.1 and D.2, pp. 101-106.

Labor Force (L)

Labor force estimates for most countries were based on Maddison, op. cit., although we were unable to replicate his data and it is unclear how he determined the proportion of the working age population which was in the labor force. Estimates of the working age population were obtained for census years, and annual observations were then obtained by interpolation. If necessary, mid-year observations were calculated by averaging the annual estimates of working age population. Maddison's estimates of the labor force in 1870 and 1913 were then compared to the working age population in those years. The average ratio of the labor force over the working age population in those three years was then calculated. This ratio was then multiplied by our annual estimates of the mid-year working age population to generate annual estimates of the labor force.

ARGENTINA

1870 and 1910 (benchmark years): Labor's share in population in 1913 from IEERAL (Instituto de Estudios Económicos sobre la Realidad Argentina y Latinoamericana), "Estadísticas de la Evolución Económica de Argentina 1913–1984." *Estudios* 9 (July/September 1986), p. 118. Share assumed constant and applied to population data in benchmark years.

AUSTRALIA

1870-1901: Sum of total workforce in Victoria, New South Wales, Southern Australia, Queensland and Enders' workforce in Tasmania; G. Withers, unpublished database, n.d. 1902-1913: Civilian employment (mid-year), linked to Withers' data using a factor of 1.0376 (the ratio of Withers' 1901 total workforce to Butlin's 1901 civilian employment); R. Maddock and I. W. McLean (eds.), *The Australian Economy in the Long Run*, Cambridge: Cambridge University Press, 1987, Statistical Appendix, Table 1, p. 353.

BELGIUM

1866-1920: Working age population (15-64 years old) for census years 1866, 1880, 1890, 1900, 1910, and 1920; United Nations, Department of Economic and Social Affairs, *The Aging of Populations and its Economic and Social Impliciations*, New York: United Nations, 1956, p. 123. Border adjustment factor of 1.008 derived from Maddison, op. cit, Tables B.2 and B.7. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

BRAZIL
1870 and 1910 (benchmark years): Labor's share in population assumed constant, equal to Argentine value in 1913, and applied to population data in benchmark years.

CANADA
1861-1921: Population aged 15-64 years old for census years 1861, 1871, 1881, 1891, 1901, and 1911; M. C. Urquhart and K. A. H. Buckley, *Historical Statistics of Canada*, Cambridge: Cambridge University Press, 1965, p. 16. Border adjustment factor of 1.026 derived from Maddison, op. cit, Tables B.2 and B.7. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

DENMARK
1870-1913: Mid-year total labor force ("Ialt Arbejdsstyrken"); S. A. Hansen, *Økonomisk vækst i Danmark*, vol. ii, Copenhagen: Akademisk Forlag, 1974, pp. 202-3. Border adjustment factor of 1.026 derived from Maddison, op. cit, Tables B.2 and B.7.

FRANCE
1861-1911: Working age population (15-64 years old) for census years 1861, 1872, 1881, 1891, 1901, and 1911; United Nations, op. cit, p. 132. 1912-1914: Working age population is assumed to have grown at the same rate as total population for the years 1911-1914. Total population from Maddison, op. cit, Tables B.2 and B.3. Annual border factors for all years calculated as the ratio of population given present borders to the population given 1871 borders; République Française, Institut National de la Statistique et des Études Économiques, *Annuaire Statistique de la France*, Paris: INSEE, volume 72, 1966, pp. 68-71. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

GERMANY
1871-1910: Working age population (15-64 years old) for census years 1871, 1880, 1890, 1900, and 1910; United Nations, op. cit, p. 135. 1911-1914: Working age population is assumed to have grown at the same rate as total population for the years 1870-1871 and 1910-1914. Total population from Maddison, op. cit, Tables B.2 and B.3.
Border adjustment factor of 0.60953 derived from Maddison, op. cit, Tables B.2 and B.7. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

GREAT BRITAIN
1870-1914: Total in civil employment (for United Kingdom); C. H. Feinstein, op. cit., T125-7. Annual border adjustment factor to exclude Ireland equals proportion of total U.K. population in Great Britain (England, Scotland and Wales); Feinstein, op. cit, T120-1.

ITALY
1861-1911: Working age population (15-64 years old) for census years 1861, 1871, 1881, 1901, and 1911; United Nations, op. cit, p. 132. 1912-1914: Working age population is assumed to have grown at the same rate as total population for the years 1911-1914. Total population from Maddison, op. cit, Tables B.2 and B.3. Annual border factors for all years calculated as the ratio of population given present borders to the population given actual borders; Istituto Centrale di Statistica, *Sommario di statistiche storiche del Italia, 1861-1975*, Rome: ISTAT, 1976, p. 16. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

NETHERLANDS
1869-1909: Working age population (15-64 years old) for census years 1869, 1879, and 1889. The 1899 and 1909 censuses included an age group for 10-19 year olds. It was assumed that the proportion of the population aged 15-19 in those years was equal to the average proportion of the population aged 15-19 in

the 1889 and 1920 censuses (9.63% of total population); United Nations, op. cit, p. 147. 1909-1914: Working age population is assumed to have grown at the same rate as total population for the years 1909-1914. Total population from Maddison, op. cit, Tables B.2 and B.3. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

NORWAY

1865-1910: Working age population (15-64 years old) for census years 1865, 1875, 1891, 1900, and 1910; United Nations, op. cit, p. 150. 1910-1914: Working age population is assumed to have grown at the same rate as total population for the years 1910-1914. Total population from Maddison, op. cit, Tables B.2 and B.3. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

PORTUGAL

1864-1910: Working age population (aged 15-64) for census years 1864, 1878, 1890, 1900, and 1910; United Nations, op. cit, p. 153. 1910-1914: Working age population is assumed to have grown at the same rate as total population for the years 1910-1914. Total population from M. I. B. Baganha, op. cit., Table IV:III, pp. 213-4. Economically-active population for years 1890, 1900, and 1911; Mitchell, *IHSE*, p. 151. The average proportion of the working age population which was economically active was then calculated for the years 1890, 1900, and 1911 (73.8%). This proportion was then multiplied by the mid-year working age population to generate the labor force estimate.

SPAIN

1870-1877: Working age population is assumed to have grown at the same rate as total population for the years 1870-1877. Total population derived from Prados de la Escosura, op. cit, Tables D.1 and D.2, pp. 101-106. 1877-1910: Working age population (aged 15-64) for census years 1877, 1887, 1900, and 1910; Carlos Barciela, et al. (eds.), *Estadisticas Historicas de España, Siglos XIX-XX*, Madrid: Fundacion Banco Exterior, 1989, Table 2.6, p. 69. 1910-1914: Working age population is assumed to have grown at the same rate as total population for the years 1910-1914. Total population derived from Prados de la Escosura, op. cit, Tables D.1 and D.2, pp. 101-106. Economically-active population for years 1877, 1887, 1900, and 1910; Barciela, et al. (eds.), op. cit, Table 2.14, p. 77. The average proportion of the working age population which was economically active was then calculated for the years 1877, 1887, 1900 and 1910 (65.1%). This proportion was then multiplied by the mid-year working age population to generate the labor force estimate.

SWEDEN

1870-1910: Working age population (aged 15-64) for census years 1870, 1880, 1890, 1900, and 1910; United Nations, op. cit, p. 159. 1910-1914: Working age population is assumed to have grown at the same rate as total population for the years 1910-1914. Total population from Maddison, op. cit, Tables B.2 and B.3. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

UNITED STATES

1870-1910: Working age population (15-64 years old) for census years 1870, 1880, 1890, 1900, and 1910; U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970*, Washington, D.C.: U.S. Department of Commerce, Bureau of the Census, 1975, Series A123-132, p. 15. Border adjustment factor of 1.0039 derived from Maddison, op. cit, Tables B.2 and B.7. Labor force estimates for 1870, 1890, and 1913; Maddison, op. cit, Table C.7.

Consumer Real Wages (W/CPI)

The consumer real wages for each country are based on the international real wage indices developed in Williamson, op. cit. Internationally-comparable real wages were calculated for several base years by utilizing purchasing-power-parity (PPP) exchange rates. These series were then deflated by consumer price indices (CPIs) to obtain the international real wage series. We used the 1870-1913 indices with the real wage in Great Britain in 1905 equal to 100. The data was used to give consumer real wages in the benchmark years of 1870 and 1910, and to enable estimation of producer real wages (see below).

Producer Real Wages (W/P)

In estimating labor demand the correct deflator for the nominal wage is the output deflator, i.e., we needed an estimate of producer real wages. To that end we adjusted Williamson's international real wages for most countries: we essentially reflated most of the real wages using a CPI, and then deflated them once again utilizing wholesale price indices (WPI). Unless otherwise noted, WPI were taken from B. R. Mitchell's *IHSE* (Table H1, pp. 840-2) and *IHSAA* (Table I1, pp. 835-839). In order to make the WPI comparable to the consumer price index (CPI) utilized in Williamson (1994), the WPI were re-based so that the index in 1900 was equal to 100. The ratio of the CPI to the WPI was then multiplied by Williamson's international real wage, effectively deflating the nominal wage by the WPI while maintaining the international comparability of the data.

AUSTRALIA

Williamson's international real wage series for Australia was based directly on real rather than nominal wages. No continuous CPI or WPI were available, so we utilized Williamson's real wage series without an adjustment.

GERMANY

Williamson's international real wage series for Germany was based directly on real rather than nominal wages, so there was not an associated CPI. Real wages were therefore reflated using the CPI from Mitchell, *IHSE* (Table H2, p. 847) and then deflated using Mitchell's WPI.

NETHERLANDS

There is not a continuous WPI covering the entire 1870 to 1913 period for the Netherlands, so the CPI-deflated real wage series from Williamson was utilized.

NORWAY

There is not a continuous WPI covering the entire 1870 to 1913 period for Norway, so the CPI-deflated real wage series from Williamson was utilized.

PORTUGAL

There is not a WPI for Portugal prior to 1927, so we utilized the GDP deflator from Nunes, Mata, and Valerio (op. cit, Table 1, pp. 292-5) after reflating Williamson's real wage series.

SPAIN

Wholesale price index from Barciela, et al. (eds.), op. cit, Table 12.11, p. 518.

SWEDEN

Williamson's international real wage series for Sweden was based directly on real rather than nominal wages, so there was not an associated CPI. Real wages were therefore reflated using the CPI from Mitchell, *IHSE* (Table H2, p. 847) and then deflated using Mitchell's WPI.

Labor's Share of Income (θ)

Three approaches were used to obtain estimates of θ:

(a) any existing direct estimates of θ were examined;

(b) an implied $\theta = wL(1-u)/Y$ was calculated using estimates of wage rates, labor force, assumed unemployment rates, u, and output;

(c) if all else failed, "neighbor" country estimates were used.

In method (b) the urban unskilled nominal wage was used, it being assumed that this would be a proxy for the average nominal wage. This is reasonable, given that rural wages ought to be less, and urban skilled wages somewhat more, with a typical 1900 distribution of labor being at least 40% rural for most countries. To the extent that this overstates θ we apply an acceptable negative bias to our impact calculations. Sensitivity analysis will allow for ±0.10 variations in θ for each country.

ARGENTINA

(b) Implied θ = 0.620. Labor force of 3,162,000 and GDP of $mn 4,200 million in 1914, from IEERAL, op. cit. Unskilled wage in 1914 of $mn 2.83 per day, from Williamson, op. cit. Assume 50 work weeks per year, 6 work days per week, 3% unemployment. Considerably higher than the estimate of 0.365 in Laura Randall, *An Economic History of Argentina in the Twentieth Century*, New York, Columbia University Press, 1978.

AUSTRALIA

(b) Implied θ = 0.556. Labor force of 1,950,000 and GDP of $734 million in 1911 from Maddock and McLean, op. cit. Average total annual earnings in manufacturing of $209 in 1912, Wray Vamplew, *Australians: Historical Statistics*, Broadway, N.S.W.: Fairfax, Syme and Weldon, 1987, p. 161.

BELGIUM

(b) Implied θ = 0.400. Labor force of 3,461,000 in 1910 and GDP of F6,500 million in 1913 from Mitchell, *IHSE*. Unskilled wage of F15.5 per week from Williamson, op. cit. Assume 50 work weeks per year, 3% unemployment.

BRAZIL

(c) Implied θ = 0.620. Use Argentine estimate.

CANADA

(b) Implied θ = 0.540. Labor force of 2,724,000 in 1911 from Mitchell, *IHSAA*. GDP of $2,233 in 1911 from M. C. Urquhart, "Canadian Economic Growth 1870–1980," Queens' University, Institute for Economic Research, Discussion Paper no. 734, 1988, p. 9. Average annual wages in manufacturing of $456 in 1910 from O. J. Firestone, *Canada's Economic Development, 1867–1953*, London: Bowes and Bowes, 1958, p. 207. Assume 3% unemployment.

DENMARK

(b) Implied θ = 0.510. Labor force of 1,231,000 in 1911 and GDP of Kr2,051 million in 1911 from Mitchell, *IHSE*. Unskilled wage of Kr0.34 per hour from Williamson, op. cit. Assume 50 work weeks per year, 50 hours per week, 3% unemployment.

FRANCE

(a) Implied θ = 0.484. Pre-war data for France was limited to observations for 1890 and 1913, and implied an average share of 48.4%. Jacques Lecaillon, "Changes in the Distribution of Income in the French Economy," in Jean Marchal and Bernard Ducros (eds.), *The Distribution of National Income*, (New York: St. Martin's Press, 1968), pp. 41-73.

GERMANY

(a) Implied θ = 0.428. German estimates for the Reich in 1893 and 1913: 39.1% and 46.5%, respectively, for an average of 42.8%. There were also estimates for several of the länder (Saxony, Württemberg, Baden and Bavaria) which were broadly comparable to the Reich-wide data for 1893 and 1913. Albert Jeck, "The Trends of Income Distribution in West Germany," in Marchal and Ducros (eds.), op. cit., pp. 78-114.

GREAT BRITAIN AND IRELAND

(a) Implied θ = 0.529. Annual data was available only for the United Kingdom. These figures imply an average of 52.9% over the period of 1870-1913. Feinstein, op. cit.

ITALY

(b) Implied θ = 0.485. Labor force of 16,401,000 and GDP of L19,700 million in 1911 from Mitchell, *IHSE*. Unskilled wage of L12 per week from Williamson, op. cit. Assume 50 work weeks per year, 3% unemployment.

NETHERLANDS

(c) Implied θ = 0.400. Use Belgian estimate.

NORWAY

(a) Implied θ = 0.645. Bjerke estimates a range 0.61 to 0.68 for 1865-1930, an average of 0.645 over the period. Riis and Thonstad suggest he did it carefully making sure it covered all labor incomes. Riis and Thonstad themselves estimate a production function 1865-1939 and their best guess (p. 124, estimate 8.5b) has labor's share = 0.640, close to Bjerke's 0.645. J. Bjerke, "Estimating Consumption Functions from National Accounts Data," Artikler, no. 53, Oslo: Central Bureau of Statistics of Norway, 1972 (in Norwegian with English summary). C. Riis and T. Thonstad, "A Counterfactual Study of Economic Impacts of Norwegian Emigration and Capital Imports," in I. Gordon and A. P. Thirlwall (eds.), *European Factor Mobility: Trends and Consequences*, London: Macmillan, 1989.

PORTUGAL

(c) Implied θ = 0.468. Use Spanish estimate.

SPAIN

(b) Implied θ = 0.468. Labor force of 6,997,100, unskilled wage of pes 2 per day, and GDP of pes 8,695 million in 1887 from Prados de la Escosura, op. cit, and Barciela, op. cit. Assume 50 work weeks per year, 6 days per week, 3% unemployment.

UNITED STATES

(a) Implied θ = 0.600. There are several available estimates of labor's share in the United States, although the pre-War data is of questionable quality. W. King calculated the earliest estimates, and these were subsequently revised (generally downward) by Budd. King's estimate of 53.5% in 1890 is roughly comparable to that of Haley for the 1900-1909 period (55.0%), although King's figures show labor's share contracting in both 1900 and 1910. Martin's data (taken from D. G. Johnson (1954)) represents an upper bound (59.5% for 1899-1908 and 59.7% for 1909-1918). We considered estimates of 50% (the average of King's data for 1870-1910) and 55% (Haley's 1900-09 and 1905-14 figures). We chose 60% as an upper-bound based on Martin. Edward C. Budd, "Factor Shares, 1850-1910" in National Bureau of Economic Research, *Trends in the American Economy in the Nineteenth Century*, Studies in Income and Wealth, Volume 24, Princeton, N.J.: Princeton University Press, 1960, pp. 365-98; Edward F. Denison, "Comment" on Edward C. Budd, "Factor Shares, 1850-1910" in National Bureau of Economic Research, *Trends in the American Economy in the Nineteenth Century*, Studies in Income and Wealth, Volume 24, Princeton, N.J.: Princeton University Press, 1960, p. 399; Bernard F. Haley, "Changes in the Distribution of Income in the

United States," in Marchal and Ducros (eds.), op. cit., pp. 3-29; D. Gale Johnson, "The Functional Distribution of Income in the United States, 1850-1952," *Review of Economics and Statistics* 34, March 1954, pp. 175-182; Stanley Lebergott, *Manpower and Economic Growth* (N.Y.: McGraw-Hill, 1964), p. 200.

Migration Rates (M)

Decadal averages are shown in Table A1. Where only gross flows were available additional assumptions were made to allow estimates of net flows:

> *Ireland*: since return migration was rare, and there were no inflows from other countries, we set net equal to gross.
>
> *Italy*: the ratio of net to gross falls from .78 to .72 between the 1890s and 1900s, a modest fall given the surge in return migration; a crude linear projection backwards might have that ratio at .84 in the 1880s and .90 in the 1870s; hence, we assume the net rate to have been 3.86 in the 1870s and 5.12 in the 1880s.
>
> *Sweden*: we project net to gross ratio backwards to the 1870s to be 0.95; hence, we assume net rate in 1870s was 2.81.
>
> *Norway*: we assume net to gross ratio is like Sweden; we apply Swedish net/gross ratios by decade 1870–1910.
>
> *Portugal*: we assume net to gross ratio is like Spain; we apply Spanish net/gross ratios by decade 1880–1910, and we assume 1870s ratio was equal to the 1880s ratio.
>
> *Spain*: we assume rates the same as Portugal in the 1870s.
>
> *Brazil*: we use the net to gross ratio from the 1890s (0.17) for 1870s and 1880s.

Data was sought on gross and net migration rates for all countries. Annual migratory flows were converted into rates using interpolated census estimates of population. Data for 1870-1910 extracted from the following sources, with exceptions as indicated below:

Emigration and immigration from Willcox, Walter F., (ed.), *International Migrations*, New York: National Bureau of Economic Research, 2 vols, 1929.

Population at census years from *EHS* or *IHSAA*.

AUSTRALIA

Net immigration from Vamplew, op. cit, pp. 6–7.

PORTUGAL

Emigration: Baganha, op. cit, Table IV:III, pp. 213–4, adjusted for clandestine emigrants. Population: ibid., using intercensal interpolation along exponential trends.

Table A1
Basic Data: Migration Rates

	M Gross 1870s	M Gross 1880s	M Gross 1890s	M Gross 1900s	M Net 1870s	M Net 1880s	M Net 1890s	M Net 1900s	Raw Return Rate
Argentina	12.26	24.76	15.78	25.47	4.94	19.07	7.17	15.78	40%
Australia	-	-	-	14.43	9.56	15.07	1.85	-0.02	54%
Belgium	-2.03	-2.18	-1.96	-2.32	0.93	1.06	1.80	2.88	178%
Brazil	1.81	3.41	7.78	3.16	0.32	0.60	1.36	0.70	82%
Canada	8.42	18.84	7.50	22.64	-1.14	5.94	5.54	17.35	52%
Denmark	-1.97	-3.74	-2.60	-2.80	-1.95	-3.68	-2.55	-2.58	3%
France	-0.16	-0.28	-0.18	-0.15	-0.09	-0.19	-0.11	-0.01	48%
Germany	-1.35	-2.91	-1.18	-0.43	-1.34	-2.89	-1.12	2.45	50%
Great Britain	-3.87	-5.71	-3.92	-7.08	-1.52	-3.23	-0.93	-3.31	56%
Ireland	-11.28	-16.04	-9.70	-7.93	-11.28	-16.04	-9.70	-7.93	0%
Italy	-4.28	-6.09	-8.65	-17.97	-3.86	-5.12	-6.78	-13.01	22%
Netherlands	-2.66	-4.06	-4.62	-5.36	-0.10	-0.81	-1.16	-0.31	86%
Norway	-4.33	-10.16	-4.56	-7.15	-4.11	-8.99	-3.23	-4.68	20%
Portugal	-2.91	-3.79	-5.04	-5.67	-0.73	-0.95	-0.46	-2.12	76%
Spain	-2.91	-3.91	-4.63	-6.70	-0.73	-0.98	-0.42	-2.50	74%
Sweden	-2.96	-8.24	-5.32	-4.48	-2.81	-7.30	-3.77	-2.93	20%
United States	6.24	9.43	5.66	10.10	3.73	6.32	2.33	3.72	49%

Notes and Sources:
Raw return rate is 1 - (avg. net rate/avg. gross rate) for 1870–1910. Rates per thousand per annum. Minus denotes emigration. See appendix text.

Table A2
Basic Data: GDP, Population and Labor Force

	Y 1870	*Y* 1910	*POP* 1870	*POP* 1910	*L* 1870	*L* 1910
Argentina	2,328	16,610	1,881	6,871	726	2,652
Australia	5,059	20,063	1,620	4,375	648	1,897
Belgium	10,640	23,584	5,056	7,438	2,200	3,341
Brazil	4,052	12,690	9,533	23,113	3,680	8,922
Canada	4,969	22,859	3,641	7,006	1,314	2,902
Denmark	2,913	8,225	1,793	2,737	990	1,394
France	60,397	98,955	36,870	39,540	18,106	19,670
Germany	31,512	91,944	40,805	64,568	10,518	16,687
Great Britain	78,936	163,181	25,838	40,531	11,069	17,271
Ireland	—	—	—	—	—	—
Italy	33,670	68,647	27,062	35,519	14,584	17,511
Netherlands	7,463	17,492	3,615	5,902	1,402	2,244
Norway	2,065	4,470	1,735	2,384	737	947
Portugal	2,656	5,324	4,340	5,909	1,973	2,630
Spain	21,196	38,838	16,200	19,790	6,635	7,895
Sweden	5,480	12,847	4,164	5,449	1,948	2,560
United States	89,933	421,266	39,905	92,407	15,180	39,442

Notes and Sources:
GDP in millions of 1985 US$. Population and labor force in thousands. See appendix text.

Table A3
Basic Data: "Baseline" Parameters

	Labor's share	Elas of subsn	Elas of lab dem	M-POP L share	M-POP eff wkr	Return rate
	θ	σ	η	γ	μ	ρ
Argentina	0.62	0.62	-1.63	1.65	0.80	0.10
Australia	0.56	0.62	-1.40	1.65	0.80	0.10
Belgium	0.40	0.62	-1.03	1.65	0.80	0.10
Brazil	0.62	0.62	-1.63	1.65	0.80	0.10
Canada	0.54	0.62	-1.35	1.65	0.80	0.10
Denmark	0.51	0.62	-1.27	1.65	0.80	0.10
France	0.48	0.62	-1.20	1.65	0.80	0.10
Germany	0.43	0.62	-1.08	1.65	0.80	0.10
Great Britain	0.53	0.62	-1.32	1.65	0.80	0.10
Ireland	0.53	0.62	-1.32	1.65	0.80	0.10
Italy	0.49	0.62	-1.20	1.65	0.80	0.10
Netherlands	0.40	0.62	-1.03	1.65	0.80	0.10
Norway	0.65	0.62	-1.75	1.65	0.80	0.10
Portugal	0.47	0.62	-1.17	1.65	0.80	0.10
Spain	0.47	0.62	-1.17	1.65	0.80	0.10
Sweden	0.65	0.62	-1.75	1.65	0.80	0.10
United States	0.60	0.62	-1.55	1.65	0.80	0.10

Notes and Sources:
See text and appendix text.

Table A4
Econometric Data

Country	Period	*Y*	*L*	*Y/L*	*W/P*
Australia	1870–79	6,376	768	8.26	119.93
Australia	1880–89	10,147	1,092	9.26	139.56
Australia	1890–99	11,676	1,402	8.35	141.75
Australia	1900–13	16,767	1,764	9.43	129.25
Belgium	1870–79	11,637	2,274	5.11	69.16
Belgium	1880–89	14,293	2,489	5.74	77.77
Belgium	1890–99	17,377	2,788	6.23	92.55
Belgium	1900–13	22,089	3,209	6.87	88.67
Canada	1870–79	5,466	1,442	3.79	108.06
Canada	1880–89	7,666	1,719	4.45	133.43
Canada	1890–99	9,911	1,974	5.01	162.41
Canada	1900–13	19,224	2,611	7.26	178.71
Denmark	1870–79	3,295	1,051	3.13	44.81
Denmark	1880–89	3,857	1,096	3.52	54.28
Denmark	1890–99	5,038	1,179	4.27	78.07
Denmark	1900–13	7,423	1,344	5.50	99.22
France	1870–79	66,778	18,202	3.67	42.86
France	1880–89	74,444	18,704	3.98	61.36
France	1890–99	83,782	19,057	4.40	72.41
France	1900–13	99,150	19,500	5.08	70.29
Germany	1870–79	35,855	10,889	3.29	55.20
Germany	1880–89	42,997	11,843	3.63	73.83
Germany	1890–99	58,152	13,305	4.36	87.37
Germany	1900–13	84,014	15,853	5.28	96.29
Great Britain	1870–79	86,829	11,452	7.13	68.92
Great Britain	1880–89	103,909	12,575	7.90	83.91
Great Britain	1890–99	127,306	14,473	8.51	101.87
Great Britain	1900–13	157,227	16,555	9.29	104.09
Italy	1870–79	34,909	14,716	2.37	25.16
Italy	1880–89	39,067	15,466	2.53	34.91
Italy	1890–99	42,472	16,087	2.64	40.51
Italy	1900–13	61,701	17,122	3.59	48.17
Netherlands	1870–79	7,463	1,402	5.32	52.03
Netherlands	1880–89	9,324	1,535	6.07	66.68
Netherlands	1890–99	11,674	1,714	6.81	75.94
Netherlands	1900–13	16,539	2,148	7.68	71.58
Norway	1870–79	2,331	759	3.07	35.47
Norway	1880–89	2,630	782	3.36	40.40
Norway	1890–99	3,203	835	3.83	59.53
Norway	1900–13	4,130	928	4.44	73.84
Portugal	1870–79	6,236	2,047	3.04	35.41
Portugal	1880–89	7,136	2,163	3.30	50.26
Portugal	1890–99	8,791	2,252	3.90	73.04
Portugal	1900–13	11,861	2,482	4.77	92.76

Spain	1870–79	25,392	6,723	3.78	51.30
Spain	1880–89	30,629	7,007	4.37	53.92
Spain	1890–99	32,269	7,273	4.44	55.57
Spain	1900–13	38,966	7,738	5.03	50.71
Sweden	1870–79	2,914	2,027	1.44	32.10
Sweden	1880–89	3,884	2,176	1.78	42.33
Sweden	1890–99	4,340	2,337	1.86	36.99
Sweden	1900–13	4,893	2,546	1.92	38.03
United States	1870–79	106,008	17,304	6.11	112.05
United States	1880–89	170,021	22,507	7.55	137.05
United States	1890–99	229,235	28,296	8.08	168.18
United States	1900–13	380,661	36,695	10.32	160.28

Notes and Sources:
See appendix text.