Development and Globalization Theory

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DEVELOPMENT THEORY AND GLOBALIZATION,

THE FIRST WAVE: A REINTERPRETATION

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Abstract: The first wave of globalization, commonly dated from 1870 to 1913, was not only a more gradual phenomenon throughout the 19th century, but closely related with the emergence of most the Western European Offshoots (USA, Canada, Australia and New Zealand) as developed economies. The massive transfer of human capital and transplant of European institutions to the Offshoots is a natural experiment of the relevance of those factors to economic growth-cum-globalization, which has been overlooked by the literature. The rise of the US as a leading industrial economy and its role in international trade proves how important are these factors in the so called transplant economies. Simultaneously, there was a large expansion (about a third) in the world production possibility set due to the land and natural resources coopted into the world economy, as well as one of the highest rates of world technological progress. Another major contribution of our paper is to give an integrated index of trade costs at national and international level that reflects technological progress. Coupled with the increasing differentiation and geographical reallocation in factor endowments across the world, they fully explain globalization. The analysis calls for further integration of growth and trade theories.

Key Words: Globalization, Economic Growth, Economic History, Nineteenth Century Economic History, United States History, Britain History, Industrial Organization

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1. Introduction

Globalization measured by the ratio of trade over GDP increased gradually from 1820 to 1870 and then accelerated in the 1870s. It stagnated in the next two decades to accelerate again at the beginning of the 20th century. However, we know that the ratio has a number of flaws, besides the limited quality of data, mainly before 1870. Data on commodity price differentials across the globe, collected by O´Rourke and Williamson (1999) shows a slow convergence before 1850 followed by acceleration in the 1860s with a progressive deceleration until the early 1900s. The evolution of price convergence is closely correlated with GDP per capita of West Europe and Western Offshoots (WE+EO). There was a slight increase in the GDP per capita growth rate from 1820-1870 average (1%) to the next four decades - 1870-1910 average (1.3%), period that is usually associated with the first wave of globalization. However, there was a clear acceleration in GDP per capita, relative to the century before 1820, when Western Europe only increased at 0.15% per year.[1]

Table 1

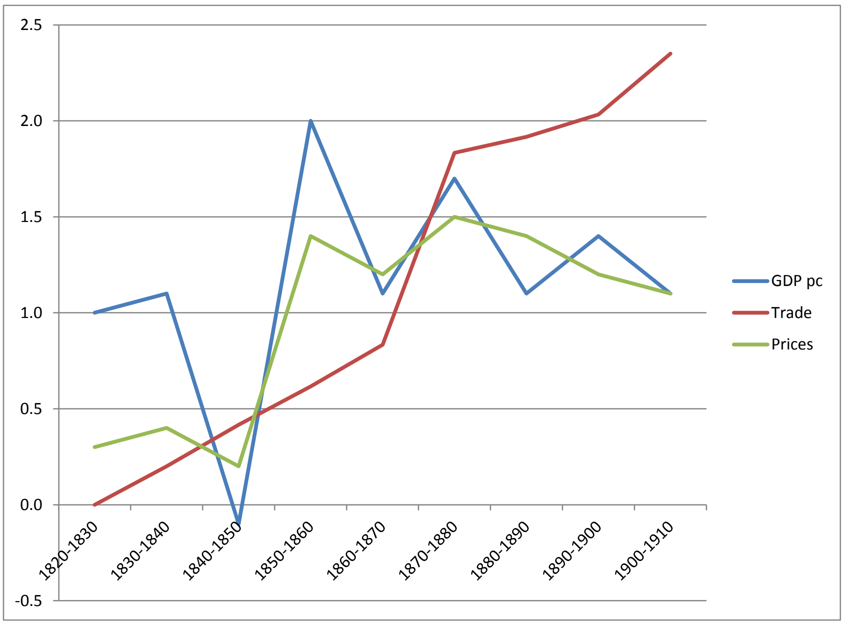
		Globalization and Growth				
	GDP per capita				Globalization	
	UK	US	Germany	WE+EO	Trade	Prices
1820-1830	0.7	1.3		1.0	0.060	100
1830-1840	1.3	0.9		1.1	0.072	96
1840-1850	-0.8	0.9		-0.1	0.085	94
1850-1860	2.0	1.9	1.4	2.0	0.097	80
1860-1870	1.2	0.9	1.1	1.1	0.110	68
1870-1880	0.9	2.7	0.8	1.7	0.170	53
1880-1890	1.4	0.6	2.0	1.1	0.175	39
1890-1900	1.1	1.9	2.1	1.4	0.182	27
1900-1910	0.3	2.0	1.1	1.1	0.201	16

Source: GDP from Project Maddison (2001), Trade from Mitchell (2007), Prices from O´Rourke and Williamson and author´s estimates

[1] Data based on Maddison (2001).

Figure 1

Globalization and Growth



What was the most important threshold: the 1850s or the 1870s? The 1870s are usually considered the threshold of the first wave of globalization. In historical terms, it marks the end of the Franco-Prussian War in 1870-71, immediately followed by the unification of Germany; the aftermath of the US Civil War in 1865 and the Japan´s Meiji Restoration in 1868. It also marks the unification of Italy in 1870 with the capture of Rome. Rostow (1990) also dates the beginning of the "drive to technological maturity" of the US, France and Germany around that date, although Great Britain experiences it earlier, fruit of the industrial revolution. However, the 1850s is also an important watershed. On the technological front, the railway and steamship revolution was starting to impact the economy and the telegraph was also starting to make a mark. GDP per capita accelerated. Iron and steel production in Britain, Germany and US (before the civil war) accelerated production. And the rate of patent registration jumped about three times.

The integration of development (growth) theories with theories of international trade is still in its infancy.[2] The "new" new trade theories based on micro models of monopolistic competition and trade provide a good basis for that integration,[3] however it is very difficult to model dynamics in a way that is relevant to identify major transformations in world resource allocations. Moreover, there is also a strong geographical dimension: development spurts in some poles and then spreads/pulls other regions at national and international level – the process of growth diffusion with a territorial dimension is even more complex to model.

[2] A companion paper addresses the reinterpretation of the first wave of globalization in light of the more recent theories of international trade, in particular the neo-Ricardian models.

[3] See, e.g., Eaton, J. and S. Kortum (2004) or Chaney, T. (2008).

International trade plays a major role in the global process of specialization and division of labor by the interchange of goods, factors and ideas. The growth of trade is dependent on the physical and contractual infrastructure in which it runs (transaction approach). Thus, reduction in trade costs (transportation, communication and barriers to trade from tariffs to taxes) will expand domestic and international trade. But the contractual and institutional infrastructures are equally important, in order to ensure the fulfillment of the conditions of the transaction and to give judicial security. Another factor that is also important for developing trade is setting-up of production and knowledge networks that will connect firms across borders and across continents providing information about market opportunities.

But growth is always uneven within nations and across nations. Leading nations have high growth rates and also lead in the globalization process. In the first wave West European countries and their Offshoots fulfilled that role. Within these nations, urban areas and some regions like New England in the US or London in the UK experienced the highest income levels.

Literature on globalization has most of the ingredients but lacks a coherent picture (what are the most important factors and what are the relevant channels of causation). Moreover, we also need to establish a link with modern growth (development) theories

What drives globalization? We consider three major types of drivers:

(A) Inter-sector trade: **differential endowments** in natural resources, in production factors and costs; intra-sector trade: **economies of scale, product variety and externalities**.
(B) Lower **trade costs**: transport, communications and barriers to trade.
(C) Facilitating **institutions**, contractual certainty and business networks.

There are three main components of growth theories:

(A) Process of accumulation of **human capital** (stock of knowledge – ideas – embodied in a given population at a given time and place), and in particular the level of **technological knowledge** (engineering and managerial/organizational). How new technological knowledge is generated? How does it spread? Note that only part of this knowledge is generated by R&D in laboratories or universities, most of it is generated by "mass flourishing", carried out by independent individuals, in the shop floor, by learning-by-doing, etc.. It is also transmitted (diffused) through a multitude of channels (from face-to-face conversations, learning in schools to newspaper reading).
(B) The design of **institutions** and their transformation and evolution. These institutions, including the political system, economic power structure and distribution, rule of law, property rights, etc. frame basic economic decisions: to get education, to save, to invest, to work, to emigrate, etc. which influence the process of accumulation of knowledge and the growth engine.
(C) The process of **accumulation** of physical capital (factories, infrastructures, cities) is recognized by the neoclassical school as the growth engine. At the center is the Solow process of savings/investment in all types of capital. It should also include externalities and agglomeration process, as recognized by the modern theories of geography and growth.

How to marry these growth theories with trade theories to explain globalization?

First, there are common factors for trade and growth. First, technological progress leads to both: e.g. improvements in transportation technologies not only lead to lower transport costs and more trade, but the increase in productivity in infrastructure will lead to higher growth. An improvement in domestic institutions not only promotes national development but also facilitates trade among nations: e.g. a more efficient court system decreases the uncertainty in business relations and the efficiency of transactions not only at national but also extends naturally to international trade.

But there are also important feedbacks. Technological progress: a technological innovation springs up somewhere in a given country (usually a developed country), it is diffused to other economies. When that diffusion crosses borders there is technology transfer. Either through trade, use of a patent or FDI a new product is first produced and then traded to the rest of the world. Nowadays, underlying this process there are production chains and networks at international level with vertical and horizontal integration that produce the good or spread the new technique or innovation. Thus, speed and quality of networking is fundamental, in terms of trade costs, communication costs (that have been neglected by most historians) and interaction of individuals (transaction of ideas).

Trade and openness spurs growth through different channels: (i) specialization, reaping economies of scale and pecuniary and technological externalities leads to higher levels of productivity, and access to inputs of better quality and lower cost for the final production of goods in which the country specializes (ii) reallocation of resources from the less to the more productive sectors, (iii) increase in variety of products at the different levels of the production chain, (iv) technology transfer from imported capital goods and imitation of products as well as access to patents and other innovations at world level, (v) intensification of the process of agglomeration that enables the country to further increase productivity and welfare, and (vi) enlargement of the domain of competition to the international dimension that reduces monopoly power and presses firms to increase productivity.

And economic growth also spurs trade through different channels: (i) accumulation of human and physical capital feeds the dynamics of comparative advantage and enables the country to export goods of higher value added and substitute imports of the same higher value, (ii) technological progress increases the technology content of its trade and the value of its exports and import substitution, (iii) spreading of technological development from the country of origin to other countries further increases the world production frontier and trade possibility frontier, and (iv) new resources have the same impact.

What are the most relevant factors that explain the first wave of globalization-cum global growth?

(A) Mass migrations of relatively skilled persons from Europe to the Western Offshoots plus the opening-up and incorporation in the world economic system of massive natural resources expanded the world production set and allowed increase in productivity and expansion of productions at world level with the reallocation of activities at international level (from land scarce Europe to labor scarce New World). The process of technological innovation and transfer of the liberal era – spread of the first and rise of the second industrial revolutions - led to rapid technological progress. Alas the US becomes the center of technological leadership, relatively to Britain, just in 40 to 60 years – this transfer of a center of technological progress is unique in the last 200 years history.

(B) Institutional building in the New World was immediate because of the transfer of European institutions: democracy, legal systems, culture. A completely different process is institution building in nations of quite different cultures like in the Asian or African continents.

(C) By all accounts, engines of growth worked in high gear in the Western Offshoots.

The 19th century was an epoch of unprecedented technological progress. Thus, the identification and role of technological change is important in the study of this period. New (higher productivity or new products) technologies are central to the growth/trade process. However, as Comin (2010) recognizes, there was until recently a lack of empirical models and studies to study the process of technological change. There were major innovations in General Purpose Technologies like in the production of energy and in basic materials like iron and steel. It is difficult to identify the date of the beginning of a new technology – usually is a succession of innovations that allow first the technology to start and after to be fully effective – and subsequently its adoption date. We usually use as proxy the production levels of the product or industry, but its unit cost and quality is also important. Also of relevance is the date of maturity, defined when it reaches a plateau (e.g. in infrastructures when it has reached most of its full potential capacity – railways, telephone wires).

We start by reviewing the literature on the first wave of globalization from the perspective of modern economic models. In section 3.1 we study the process of massive transfer of human capital from Europe to the Western Offshoots. In conjunction with sections on institutions and transfer of technology constitutes evidence of the natural experiment that these factors are crucial for growth-cum-trade. Section 3.2 studies the enlargement of the world production possibility set by the new land and natural resources incorporated in the world economic system. Section 3.3 studies the market expansion process discovered by Adam Smith and not always recognized in the literature. We show that it occurred in terms of acceleration of population growth and deepening of integration processes in Germany and Italy as well as the integration of Asian economies in the world economic system. Section 3.4 addresses the other factor of production: capital – in terms of international capital flows and the internationalization of financial capital.

In section 4.1 we underline the importance of technological progress in terms of technological innovation and the exchange of ideas, tabulating the main industrial contributions and the characterization of technologies following Comin (2010). Section 4.2 addresses technological diffusion and its role in globalization, while section 4.3 refers the main points of the other domain of technological progress that deals with the organization of production and management techniques with the rise of the modern corporation. Then, section 4.4 underlines the institutional building in the New World by the transplant of Western European institutions, the major factor usually identified in modern growth theory.

Section 5 focus on the study of factors of growth and globalization. It uses econometric models, by taking the US as a case study. Section 6 refers briefly the convergence process in Continental Europe.

Section 7 studies trade costs as a major factor of globalization in a unified way, considering domestic and cross-border transportation costs, communication and other barriers to trade, like tariffs and quantitative restrictions as well as other transaction costs. The unification of trade costs in a quantitative index is new in the literature and shows the overwhelming importance of transportation and communication costs in the first wave of globalization.

Section 8 tries to identify the major factors of globalization in an econometric model, which is also new in the literature. It shows what are the most relevant factors and the difficulty in identifying specific factors due to cross-correlations among a substantial number of them. Section 9 concludes and indicates some avenues for further research.

2. Review of Literature

Two of the most important sources relevant for this paper are the landmark books by O´Rourke and Williamson (1999) and Pomeranz (2000). The first book studies the globalization as the evolution of the Nineteenth century Atlantic economy, a thesis that we also embrace, since the globalization-cum-growth known as the first wave of globalization took place mainly between Western Europe and North America. We find evidence that it also extends to other regions like Australia and New Zealand as well as Argentina. Globalization is defined in terms of acceleration of trade, labor and capital flows which led to convergence in commodity prices. Globalization led to economic convergence defined in terms of reduction in gaps among real urban wages. One of the central thesis of the book is to prove the Heckscher-Ohlin theory between Britain and USA, demonstrating that Britain would specialize in manufactures/labor intensive goods and the USA in agricultural goods/land intensive goods. The authors, in our sense wisely, do not attempt to prove rigorously the general equilibrium model of the H-O model or the Leontief Paradox, due to the lack of reliable data. Furthermore, they illustrate the convergence in commodity prices would induce convergence in factor prices: land rents-wage ratios would increase in the New World and decrease in the Old World and converge. We concur with the authors that a major factor behind globalization was the decrease in transportation costs. They also recognize the importance of labor migration and capital flows from the Old to the New World. However, we give much more importance to technological progress as the source of both growth and globalization, and was the interaction of technological change with labor, human capital and capital massive transfers that is at the root of the first wave of globalization cum convergence in the second half of the nineteenth century up to the eve of the IWW. We also emphasize the importance of institutions, in this case the transplant of cultures and institutions from Europe to the Western Offshoots, a factor neglected by the authors. In contrast, O´Rourke and Williamson concentrate on the incentives to emigrate and the impact of labor migration in the countries of origin, instead of emphasizing the interaction between technological change, reduction in transport costs and increase in economic opportunities for human capital transfer to the New World. Capital just followed human capital and the huge profits to be made in the new frontier.

Pomeranz (2000) explains the great divergence of economic growth in Britain compared with the Yantze region in China by the coal-iron-colonies paradigm. It was the access of Britain to the large coal and iron reserves that broke with the ecological constraints of wood production.[4] Access to cotton production in the USA also allowed the expansion of textiles as well as to the captive markets of the British Empire. Using "ghost accounting" the author estimates that already in 1815 coal provides an acreage equivalent to the total arable land in Britain. Moreover, the importance of coal not only resides in its capacity to generate heat as fuel and cokes to produce iron, but also in its capacity to provide steam power. While Britain enjoyed of large coal reserves with a network water channels close to major production and consumer centers, China only had reserves far in the Northeast and with large transportation costs. In modern economic terms the author had in mind a production function with land and depleteable natural resources. There were fixed amounts of land and natural resources available, with decreasing marginal returns, but Britain was able to expand production by technological change that used production of coal and iron that overcame the limitations of arable land, wood and forests. Colonies, and in particular the USA, expanded production capacity of land-intensive goods and provided the market for its finished goods. It also expanded reserves of coal and iron. The most important agricultural goods were foodstuffs like cereals and meat and major inputs, raw-materials like cotton and wool. Pomeranz estimated cotton´s ghost acreage in 1830 at 123% of total Britain acreage. But the phenomena that led to that expansion were the massive migrations from Europe and the associated capital flows from Old to New World.

Also relevant to our analysis are models of industrial revolutions. We do not distinguish between the first or second industrial revolution because there are enough similarities in both phenomena. What are the minimum factors required for the sprung and sustainability of an industrial revolution? There are dozens of theoretical models developed to answer this question, which help us organize our thoughts and shift among the numerous factors to highlight the essential ones. Here we take only a small sample.

Stokey (2001) assumes first that agricultural technology has progressed enough to overcome the Malthusian trap of population growth. Then, there were three important processes that led to the industrial revolution: (i) dramatic improvement in the technology for producing energy, (ii) moderate improvement in the technology for producing manufactured products, (iii) large increase in the volume of foreign trade. The model is a standard growth model with exogenous population growth, capital accumulation and technological change. It also considers an intermediate good: energy. It is an open economy model with three sectors of production: agriculture, manufacturing and services. The GDP expansion that the model tries to explain is 42%, with manufacturing increase of 89% - its share in GDP increases about 10 pp with a slightly larger decrease in agriculture. The model considers three types of shocks that trigger the industrial revolution: (i) technological change that expanded energy, (ii) technological progress in manufacturing, and (ii) expansion of availability of food by imports

[4] "Thus, chapter 6 locates the significance of the Atlantic trade not in terms of financial profits and capital accumulation, nor in terms of demand for manufactures – which Europe could have probably generated enough of at home – but in terms of how much they relieved the strain on Europe´s supply of what was truly scarce: land and energy." Pomeranz (2000, p. 23)

paid by manufacturing exports. The expansion of sources of energy in the form of steam-power, with everything else impacting, led to an equivalent decrease in energy prices of 50%, which led to an expansion of manufacturing output. Otherwise, energy prices would have increased by 25%. The impact on GDP would be 29% lower. Technological progress in manufacturing had an even larger impact, contributing to about 77% of the GDP growth. Imports of food had a contribution of about 8%. Expansion of foreign trade is responsible for half of the increase of real wages (37%). However, the calibrated model is able to explain only about half of the large decrease in land rates (36%). As a standard neoclassical model growth, exogenous technological progress drives most of the growth. However, as an exogenous variable, it is no explained within the model. However, important ingredients of the evolution of the European and North American economies in the 1870-1913 period: (i) technological progress in industry and energy, (ii) international trade, (iii) and capital accumulation.

The model of Desmet and Parente (2009) is rooted in the new Industrial Organization literature by considering a variety of goods a la Lancaster: an expansion of goods leads to an expansion of markets (Adam Smith specialization), an increase in competition and firms have to become larger which sustains a larger R&D and higher product and process innovation. The model emphasizes the importance of market size, not in terms of population, but in terms of industrial market size, which depends, besides population, on transport costs, internal and external trade barriers, agricultural productivity, income level and institutions. By specifying a different type of households, agricultural-rural with a higher fertility ratio and industrial-urban with a lower fertility, they are able to move from a Malthusian state to a sustained growth state that they call Industrial Revolution. “Innovation endogenously takes off and living standards start to rise only after the market reaches a critical size and competition becomes sufficiently intense” (p. 1). And “our experiments suggest that the Industrial Revolution might have been delayed by several centuries had England had fewer agricultural innovations, slightly inferior institutional arrangements, and more national and international trade barriers” (p. 4). The authors use the model to justify that the industrial revolution took place in Britain rather than in Continental Europe because of the larger industrial market, although the evidence is still sketchy.

Model simulations gauge the importance of the different factors for the industrial revolution which is considered the switch from a Malthusian steady state with low improvement in the standards of living (1400-1775) to a balanced growth path of sustained growth driven by industry in urban areas (1775-2000). The first factor is the lack of the “agricultural revolution” that preceded the industrial revolution: a reduction by 40% of the TFP in agriculture delays the industrial revolution by 175 years. A similar impact would be generated by an increase of 57% in the fixed operating costs – representing the importance of the increase in firm size that led to lower marginal costs, or a 16% increase in the innovation costs – representing the improvement in institutions. Finally, the importance of the reduction in transportation costs is evidenced by the similitude in the market expansion that occurred before 1775 and a 50% reduction in transportation costs.

Hansen and Prescott (2002) construct a model for the transition from a Malthusian to a Solow model replicating an industrial revolution. The authors build a model with 2 sectors: a Malthusian sector where the production function depends on labor, capital and land (fixed factor) with land-intensive technology and a Solow sector where production depends on capital and labor with a capital intensive technology. Population growth depends on income per capita, but peaks after a certain period.[5] They show that the Solow sector will start to produce after total productivity is above a minimum level determined by factor costs. Thus, it is technological progress, determined exogenously, that will trigger the industrial revolution. As the economy is not limited by a fixed factor and technological progress is maintained the economy starts to grow indefinitely. History showed that technological revolution in energy use and basic metals substituted for limited natural resources.

In the Lucas model (1998) it is a (exogenous) change in the rate of return of human capital accumulation, within an endogenous growth model, that marks the transition between a Malthusian and steady-state growth path.[6] Lucas also emphasizes the importance of international trade and technology transfer.[7]

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[5] What makes fertility rate to decline? Gary Becker proposed long ago that this factor be identified with the *quality* of children: As family income rises, spending on children increases, as assumed in Malthusian theory, but these increases can take the form of a greater number of children or of a larger allocation of parental time and other resources to each child. Parents are assumed to value increases both in the quantity of children and in the quality of each child's life. It is the possibility of using inheritable capital to improve the quality of children's lives or the possibility of accumulating human capital needs that leads to fundamental departures from the predictions of the classical model. These additional features do offer the possibility of non-Malthusian dynamics, because the process of industrialization involves a dramatic increase in the returns to human capital. People are moving out of traditional agriculture, where the necessary adult skills can be acquired through on-the-job youngsters training. More and more people are entering occupations different from their parents' occupations that require skills learned in school as well as those learned at home. New kinds of capital goods require workers with the training to operate and to improve upon them. In such a world a parent can do many things with time and resources that will give a child advantages in a changing economy, and the fewer children a parent has, the more such advantages can be given to each child. There are internal and external effects. The external effects introduce a kind of feedback into human capital theory: Something that increases the return on human capital will stimulate greater accumulation, in turn stimulating higher returns, stimulating still greater accumulation and so on.

[6] The story underlying the Lucas model is the following. Technological advances occurred that increased the wages of those with the skills needed to make economic use of these advances. These wage effects stimulated others to accumulate skills and stimulated many families to have fewer children, with more time and resources invested in each. The presence of a higher-skilled workforce increased still further the return to acquiring skills, keeping the process going. Why diminishing returns to skill-intensive goods did not take hold? "Someone has to dig potatoes, after all." In certain cases it happened and aborted incipient industrial evolutions. But according to Lucas it was international trade/globalization that helped England attain critical mass by letting English workers specialize in skill-demanding production while food was imported.

[7] No successes have been observed for autarchic, produce-everything-ourselves strategies (though such strategies can possibly work well for a few years: think of Russia in the 1920s or India in the 1950s). Trade has the benefit of letting a smaller country's industries attain efficient scale, but I think an even more important factor is the need to get up to world standards, to learn to play in the big leagues. The only way learning and technology transfer can take place is for producers to compete seriously internationally. Learning-by-doing is perhaps the most important form of human capital accumulation.

In Galor and Weil (2000) identify demographic transition with a decrease in mortality rates due to increase in income per capita (nutrition) followed only later by a decrease in fertility.[8] It is population growth that leads to an increase in skill-biased technological progress that then leads to an increase in the rate of return to the accumulation of human capital. A crucial element of their theory is the assumption that the level of human capital of a given generation increases with education but decreases with technological progress – technology raises the rate of return to education. More population and a higher level of human capital leads to a higher rate of technological progress, and this progress overcomes the population growth, fixed land and a subsistence level of consumption. An alternative assumption is that the returns to education would rise with the level of technology, which would imply that technology is skill-biased, an assumption that to us seems valid in the first and second industrial revolution. The authors also make a very interesting observation that the large migrations from Europe to the Western Offshoots and the importation of food led to the easing of the demographic transition in Europe and also the easing of the setting of decreasing returns to the fixed factor – land. The same point that Pomeranz uses above.

Jones (1999) builds an endogenous growth model with a production function exhibiting constant returns to scale in labor and land, but increasing returns with knowledge (human capital). Utility is derived from consumption and children in a model similar to Becker. There are 2-sectors: consumption goods and production of ideas that increase knowledge. The production of knowledge depends on resources allocated to it that Jones identifies with property rights, and its productivity. Demographic transition appears because he postulates a minimum level of subsistence. When wages increase above that level there is a substitution effect between consumption and children: fertility rises and then falls as wages increase. In order to generate an industrial revolution increasing returns to scale in technological progress has to be sufficient to overcome the decreasing returns implied by fixed land. Assume that a given moment in history a new idea (technological improvement) appears. This leads to an increase in consumption and in population. More people mean that the probability of new discoveries with applicable knowledge increases and so on. But this does not generate a significant increase in the GDP growth rate. For this to happen there has to be some improvement in institutions that allow creators to reap more benefits from their inventions (property rights in particular). To generate the industrial revolution in the 20th century Jones has to assume that the resources allocated to the generation of knowledge increases from less than 1% before to 5% in the 20th century.

Why the USA had the technological and economic leadership of the world in the 19th century? Why the USA got so far ahead of Argentina? Crafts and Venables (2001) use "new geography" models to give an answer based on externalities/agglomeration economies and the larger market of the USA than any other nation in focus. In 1870 the USA were already 37% larger in terms of population relative to Britain and more than 22 times Argentina. By 1913 the USA

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[8] Galor and Weil (1996) propose an alternative mechanism. Increasing levels of income entail higher relative wages for women thus raising the opportunity costs of children.

were more than the double (2.3) of Britain and 12.7 larger than Argentina. These arguments are capable of explaining the divergence even with similar institutions. The model assumes three regions: Europe where population migrates from, and two Western Hemisphere regions, North America and South America. It starts by assuming high transportation costs. In this situation wages are high in the Americas and low in Europe and the gap is high. Trade and migration would intensify as transportation costs come down.

Why a land-abundant country, the USA, became a net exporter of manufactures? And why other land-abundant countries like Argentina and Australia did not follow? Globalization in this theory is related with urbanization, a phenomena at subnational level. The extent of division of labor is limited by the extent of the market. Reduction in transportation costs and more intense trade of goods enables production to take place at larger scale and reap the benefits of division of labor (specialization), enabling cities to form and reap agglomeration benefits. As transport costs decrease cities become larger, but larger cities are also associated with higher wages. Thus, there is a trade-off between both factors that define an optimal city size. Bairoch and Goetz (1986) have shown that the main factors behind European urbanization in the 19th century were growth of industrialization, international trade and agricultural productivity. Crafts and Harley (2001) give evidence that the country with the strongest forces in this model was Britain.

There are several authors (Chandler (1977), James (1983)) that have pointed out the importance of economies of scale in the development of manufacturing in the 1870-1913 period. These were associated with labor-saving and materials-using technological progress that in the USA was exploited in a rapidly expanding consumer market. Hutchinson (2000) also notes that there was already a significant amount of intra-industry trade in the later part of that period, associated with economies of scale in the use of labor and materials. These are conditions unexplainable with a Hecksher-Ohlin model.

The Crafts and Venables model considers 3 regions and 2 sectors: agriculture and manufacturing. All the leading action takes place in manufacturing with economies of scale and monopolistic competition where there is not only final production but also derived demand for intermediate products. They start with a large proportion of world population in Europe and with a wage differential in favor of the New World that is higher as transportation costs are higher. Let us suppose that the USA has at a starting point (sometime by the early to mid-19th century) a larger market than South America. Then, migration will start to the New World, but manufacturing will start in the USA because it is a larger market. But once it has started, if two locations differ only in the market dimension, then firms will choose the larger market. Furthermore, feedback mechanisms will start to play, as backward and forward linkages through the production chain in manufacturing will operate. These forces are reinforced as migration from abroad and from the countryside will further expand the market, and also keeping down the pressure on wages to increase. But, in the medium term, wage increases will also take hold further expanding the market.

The authors present the interesting case of low transportation costs. In such case manufacturing starts in the USA sooner (at lower level of population) than if the costs are higher, and South America (e.g. Argentina) will never industrialize because the agglomeration effects described above. In a less extreme interpretation would be the case that will never become net exporters of manufactures since quite a substantial volume of manufacturing would still be demanded by the home market. Two other observations are important: first, that a larger endowment of land and natural resources (case of the USA) would lead to a larger wage gap in favor of the country and lead to a larger migration volume; second, a tariff on manufacturing imposed by the USA will increase the wage in the country and also lead to higher level of migration and an acceleration in domestic market expansion. This shows a very different perspective of tariff policy that is rarely pointed out by economists, that the most relevant policy is an open migration policy, and that the outcome of a tariff policy depends largely on the associated policies regarding factor mobility.

3.1. Process of accumulation of human capital: Mass migrations of relatively skilled persons from Europe to the Western Offshoots

From 1820 to 1913 the largest migration flows ever witnessed in history took place from Europe to the Western Offshoots. According to some estimates about 60 million Europeans set sail to the New World, with about three-fifths settling in the US.[9] Our estimates, matching emigration and immigration, based on O´Rourke and Williamson (1999), give 36 million between 1850 and 1910. Official US statistics registered 30.7 million immigrants mainly from Europe.

Usually, historians concentrate on models of the decision to emigrate and the impact on wages of the immigration to the US and other economies where the migrants came from. More important than those is the impact on the production possibility set both of the USA, other Western Offshoots and of the World Economy.

Let us start to study the impact on populations and the labor force of the Western Offshoots and Europe. The highest suppliers of emigrants were Britain, Italy, Germany, Ireland and Spain. The highest emigration rates were observed for Ireland after 1880 and Italy at the beginning of the 20th century. Britain supplied a consistently high level for the British Empire and USA.

[9] O´Rourke and Williamson (1999), p.119.

Table 2: International migration from Europe to New World (1851-2010)

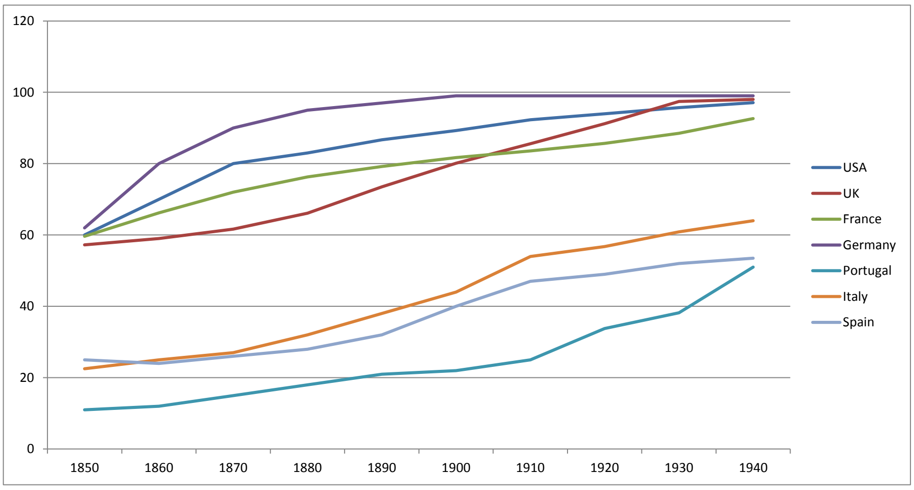
	1851-1860	1861-1870	1871-1880	1881-1890	1891-1900	1901-1910	Total
Emmigration flows per decade							
Austria-Hungary	1,200	7,770	27,669	124,953	198,062	638,744	998,398
Belgium				50,534	22,537	43,768	116,838
Britain	1,606,426	1,558,610	1,655,086	2,528,253	1,717,880	2,806,659	11,872,914
Denmark			40,644	86,128	53,453	76,422	256,647
Finland			12,500	28,974	57,606	150,529	249,609
France	40,700	45,624	57,332	123,172	52,127	57,246	376,201
Germany	951,667	787,468	718,182	1,452,970	505,152	341,498	4,756,937
Ireland	914,119	435,778	432,732	699,856	403,560	307,050	3,193,096
Italy	9,231	11,725	300,615	1,029,638	1,640,988	3,770,685	6,762,882
Netherlands	16,175	20,414	17,425	52,595	24,015	28,310	158,934
Norway	35,792	97,344	85,282	185,069	93,527	192,340	689,353
Portugal	23,000	79,819	128,836	182,970	264,922	320,745	1,000,293
Spain	107,000	123,000	325,000	627,093	795,277	1,082,928	3,060,297
Sweden	14,881	125,477	102,507	326,946	201,715	298,735	1,070,261
Switzerland			35,750	92,672	43,907	73,364	245,694
Immigration flows per decade							
Argentina	42,350	177,984	210,132	748,459	769,183	1,652,755	3,600,863
Brazil	35,000	62,500	147,574	883,668	1,155,354	676,101	2,960,197
Canada	246,512	280,301	223,091	365,814	300,901	1,033,422	2,450,040
Cuba	9,700	12,500	32,000	72,000	105,000	228,157	459,357
United States	2,475,211	2,314,824	2,812,191	5,246,613	3,692,564	8,795,386	25,336,789
Australia	587,000	123,500	83,200	86,500	127,500	156,700	1,164,400
Total	3,395,773	2,971,608	3,508,187	7,403,055	6,150,502	12,542,521	35,971,646

Source: Based on O´Rourke and Williamson (1999) and author´s estimates

The late 19th century migrants were typically working age (76% entering the US were between ages of 15 and 40, and 64% were male). While emigrants to the US were predominantly from Britain, Germany and Ireland up to 1880, after that date the share of emigrants from Italy and Spain rose substantially.

Notwithstanding the relevant distortions, emigrants reflected the structure of population of countries of origin. As we see in Figure 2, the level of literacy in Northern European countries was about three times higher than Southern Europe. But within a short period the US was among the countries with the highest levels, only surpassed by Germany, which means that the effort of education of immigrants and especially of their children was particularly efficient in the host country.

Figure 2: Literacy rates



Evaluating the human capital of each immigrant to the US at its present value, in 1890, at 93.5 thousand 2009 US dollars,[10] computed by the income/replacement method, would be equivalent to 2.9 trillion dollars.[11] But this is the direct impact. This population interacting with the existing population and also by its own dynamics,[12] added an additional 60 million persons[13] representing an additional 5.8 trillion dollars.[14]

These populations brought to the Western Offshoots the levels of education and culture of Europe, the technological knowledge and scientific repository of the Old Continent. Moreover, they also enabled the establishment of business networks between firms in Europe and those territories that facilitated trade.

This factor is often overlooked but it is of a major economic significance. Assume that due to some tectonic force a new continent springs up in the South Atlantic with rich mineral resources and that one quarter of the Western European inhabitants transfer to those lands. Will it increase substantially world wealth and globalization? Almost from the beginning the new nations will jump to the league of developed countries since will be populated with individuals with a high level of human capital.[15] The increased capital and use of new natural resources would also add to the world wealth and production capacity, increasing world GDP. World trade indicators would certainly increase. An additional important aspect that was characteristic of Europe in the 19th century was that a significant part of the population emigrating was in low-labor productivity jobs in agriculture, cottage manufacturing or services, so transferring to other regions with higher productivity would have increased world productivity. The all process will be accelerated if it takes place within a wave of technological progress.

3.2. Discovery and incorporation in the world economic system of massive natural resources expanded the world production set

In a world still relying substantially in agriculture for subsistence, arable land was a very important factor of production. Table 3 shows the land use in the USA. Farm land increased from 119 million hectares in 1850 to 355 million in 1910, and cropland was multiplied by a

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[10] We used the estimate of Private Human Wealth for 1969 by Jorgenson and Fraumeni of 54 184 Billion dollars and converted to 2009 prices, which represents about 17 times the value of GDP. The 1890 estimate is obtained by rescaling with Maddison GDP. At 2009 prices, the human capital estimate of Jorgenson and Fraumeni is 418 449 USD per person.
[11] US GDP in 1890 was about 350 billion USD.
[12] The yearly world population growth rate for the period was 0,58%. Given the difference in income per capita between regions, we assume a population growth rate of 1,5% for the USA without immigration. The growth rate for Europe was 0,78%.
[13] This is an estimate of the spillover effect.
[14] Using the ratio of years of schooling the estimate of human capital for 1890 would be much higher at 160 thousand dollars.
[15] Assuming no indigenous population.

factor of 3. Considering data from 2010 published by the FAO the area of arable land[16] of the New World[17] is 339 million hectares 4.6 times the area of Western Europe.[18] This ratio gives

Table 3

				USA Land Use in Thousands of Hectares								
	Total Area			Farm Land					Non-farm land			
				Thousands Hectares								
	Grand Total	Land	Inland water	Total	Cropland	Farm past	Woodlanc	Other				
1910	783,876	770,117	13,759	355,719	140,426	114,931	77,295	23,067	430,586	242,811	121,810	49,776
1900	783,876	770,117	13,759	339,531	129,095	111,693	77,295	21,448	430,586	252,929	128,690	48,967
1890	783,876	770,117	13,759	252,119	100,362	58,275	76,890	16,592	517,998	331,033	139,212	47,753
1880	783,876	770,117	13,759	216,911	76,081	49,372	76,890	14,569	553,205	357,337	148,924	46,944
1870	783,876	770,117	13,759	165,112	76,486		88,626		605,005			
1860	783,876	770,117	13,759	164,707	65,964		98,743		605,410			
1850	776,187	762,428	13,759	118,978	45,729		73,248		643,450			

Source: BEA, Historical Statistics of the United States

an order of magnitude of the expansion of agricultural land at the end of the first wave of globalization for the Western Offshoots compared with Western Europe.

The expansion in the US of the value of land, as a factor of production in agriculture, was also remarkable. According to historical statistics this value expanded about 74 times from 1805 to 1912, having expanded by 18 times between 1805 and 1880 and then 4 times between that date and 1912.

Similarly, natural resources in mining expanded of the world economic system expanded in similar order of magnitude. Table 4 reports the value of assets in mining in the US: they multiplied by 6 between 1880 and 2012.

Table 4

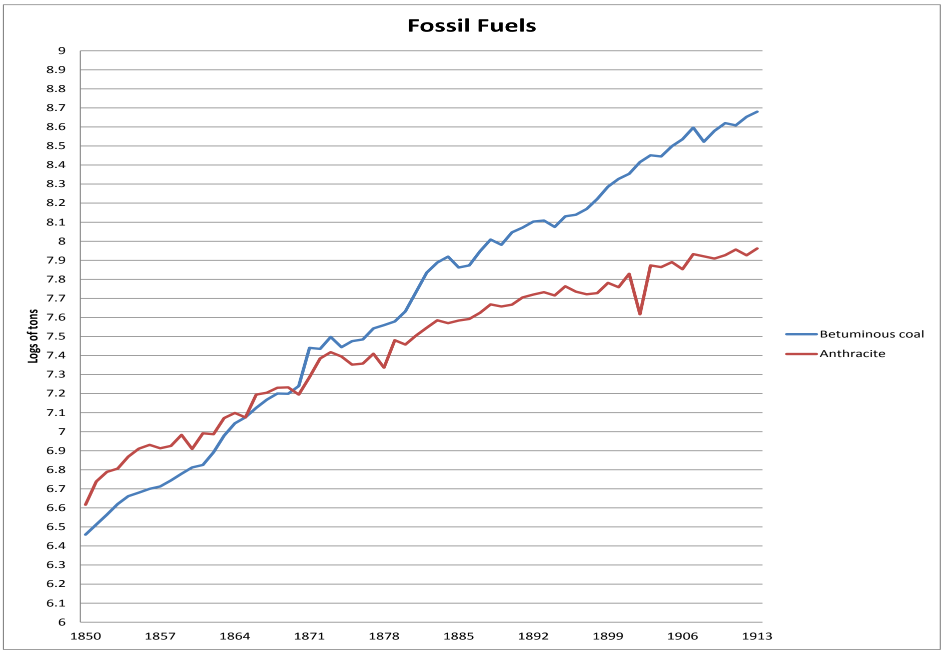
National Wealth USA						
In millions of current dollars						
Source: Historical Statistics						
	Agriculture			Mining		
	Land	Improvements	Equipment	Land	Improvements	Equipment
1922	41,541	11169	2,292	3,362	1,120	2,001
1912	31,574	6,889	1,392	2,109	644	980
1900	13,058	3,557	750	1,189	325	399
1890	10,623	2,656	494	818	201	202
1880	8,158	2,039	407	364	91	143
1805	234					
At 1980-82 Prices						
1922	395,629	106,371	21,829	32,019	10,667	19,057
1912	328,896	71,760	14,500	21,969	6,708	10,208
1900	160,418	43,698	9,214	14,607	3,993	4,902
1890	120,442	30,113	5,601	9,274	2,279	2,290
1880	82,321	20,575	4,107	3,673	918	1,443
1805	4,418					

[16] Should be compared with cropland in Table 3. The area reported in Table 3 has remained almost stable since 1920.
[17] US, Canada, Mexico, Brazil, Argentina, Australia.
[18] UK, France, Germany, Italy, Spain, Austria, Hungary, Czech Republic and Portugal.

Source: BEA, Historical Statistics of the United States

Taking one of the most important minerals, which was different types of fossil fuels extracted (bituminous and anthracite coal) (Figure 3) we could see they increased by 166 and 22 times between 1850 and 1912.

Figure 3



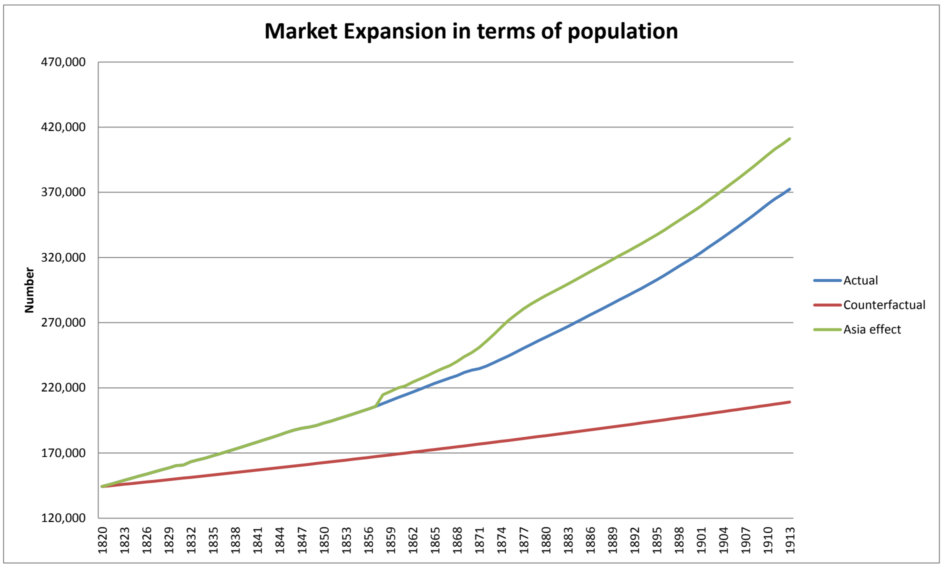
Source: BEA, Historical Statistics of the United States

3.3. Market expansion and Smith´s effects

While the previous section emphasizes the expansion of the production possibility set, this section underlines the importance of the expansion of the consumption feasibility set commonly known as the market expansion mechanism associated with Adam Smith growth model. Historians usually associate the leadership of the US with these effects were the world largest markets of the 19th century led not only to specialization and productivity increase but also to methods of mass production and interchangeability of production. How to quantify?

We estimate the expansion of markets under several simulated factors. First, there was the impact of demographic transitions in Europe and migrations to the Western Offshoots. Taking the trend of the previous century, with a population increase of .4%, European population in Europe and Western Offshoots, accelerated its growth to 1%, adding 163 million to the market by 1913 (Figure 4). Second, the impact of opening of Asia to Western trade, discussed below, added an estimated 39 million by 1913. Third, there was the impact of regional integration in Europe, and in particular the German customs union and unification and Italian unification. There are also other important factors like the construction of railroad and other transport networks as well as the communication networks. An overall estimate of market expansion can be obtained by using the world GDP, estimated by Maddison. In the previous century was increasing at a rate of .5% a year. In the 1820-1913 period it accelerated to 1.5%. Thus, the counterfactual generates an addition of 1.6 trillion USD (1990 PPP dollars) corresponding to a multiple of 2.47.

Figure 4



Source: Author´s estimates based on Maddison (1995).

There were also important market effects due to the abolishing of borders among European countries. First and foremost was Germany unification which led to the take-off of that country and its industrial leadership in Europe by the beginning of the 20th century. Napoleonic occupation produced important institutional reforms. Reforms included the abolition of feudal restrictions on the sale of large landed estates, the reduction of the power of the guilds in the cities, and the introduction of a new, more efficient commercial law. The German Confederation, founded in 1815, was the association of 39 states to coordinate the economies of separate German-speaking countries. The population of the German Confederation grew 60% from 1815 to 1865, from 21 to 34 million. The era saw the demographic transition take place in Germany. The introduction of sugar beets, turnips, and potatoes yielded a higher level of food production enabled a surplus rural population to move to industrial areas. The beginnings of the industrial revolution in Germany came in the textile industry and were facilitated by eliminating tariff barriers through the Zollverein, starting in 1834.[19] According to recent estimates by Keller and Shiue (2013) the customs union reduced grain price gaps by about one third.

The take-off stage of economic development came with the railroad revolution in the 1840s, which opened up new markets for local products, created a pool of middle managers and technical personnel and stimulated investments in coal and iron. Political disunity of three

[19] At the beginning of the 19th century there were 300 different administrative political borders within the later Germany state (Keller and Shiue (2013)).

dozen states and a pervasive conservatism made it difficult to build railways in the 1830s. However, by the 1840s, trunk lines did link the major cities; each German state was responsible for the lines within its own borders. Transport and communication infrastructure plus the customs union eliminated most of the commodity price gaps.

By the 1830s mathematics, physics, chemistry, and biology had emerged with world class science in German universities, led by Berlin. Important contributors were Alexander von Humboldt (1769–1859) in natural science and Carl Friedrich Gauss (1777–1855) in mathematics. Unification was achieved with the formation of the German Empire in 1871 under the leadership of Prussian Chancellor Otto von Bismarck.

Another political development with market significance was the unification of Italy. It started after the Congress of Vienna in 1817 and was mostly accomplished by 1871 when Rome became the capital of the Kingdom of Italy. Combining Germany and Italy, the market impact of market unification, in terms of GDP, by 1913 was around 40% of Western Europe. Further market integration occurred in France and Sweden.[20]

The greatest 19th century "globalization shock" in Asia was political. Under the persuasion of Commodore Perry's American gun-ships, Japan switched from virtual autarky to free trade in 1858. It is hard to imagine a more dramatic switch from closed to open trade policy, even by the standards of the recent Asian miracle. In the fifteen years following 1858, Japan's foreign trade rose from nil to 7 percent of national income (Huber 1971). The prices of (labor intensive) exportables soared, rising towards world market levels; the prices of (land and machine intensive) importables slumped, falling towards world market levels. One researcher estimates that Japan's terms of trade rose by a factor of 3.5 between 1858 and the early 1870s (Huber 1971); another thinks it rose even more, by a factor of 4.9 (Yasuba 1996, p. 548). The combination of declining transport costs and the dramatic switch to free trade contributed to the integration of Japan and other Asian economies in the world economic system. China, Siam, Korea, India and Indonesia followed the liberal path, most forced to do so by colonial dominance or gunboat diplomacy. This shift had largely taken place from the 1860s; from then on, commodity price convergence was driven entirely by sharply declining transport costs in Asia without much change in tariffs one way or the other. Asia's commitment to globalization, forced or not, started more than a century ago.

After the First and Second Opium Wars that lasted until 1860 the British-French demands were met, which included opening all of China to Western merchants, , exempting foreign imports from internal transit duties, suppression of piracy, regulation of the coolie trade and legalizing the opium trade. In India, the British Raj started in 1858 contributing to the domestic and international market integration of this large economy. By 1870 the rail network linked already major cities like Madras, Bombay, Delhi and Calcutta. Large scale capital investments by Britain in infrastructure: railways, canals and irrigation works, shipping and mining; the commercialization of agriculture with the development of a cash nexus; the establishment of an education system in English and of law and order creating suitable conditions for the growth of industry and enterprise; led to the integration of India into the world economy. The

[20] See Federico (2011) and Persson (1999).

route mileage of this network increased from 1,349 kilometers in 1860 to 25,495 kilometers in 1880 – mostly radiating inland from the three major port cities of Bombay, Madras, and Calcutta. Most of the railway construction was done by Indian companies supervised by British engineers. In fact many of the major changes in transport and communications (that are typically associated with Crown Rule of India) had already begun before the Mutiny. The production of raw materials, such as cotton, from India's hinterland could now be transported more efficiently to ports, such as Bombay, for subsequent export to England. Imports of British cotton covered 55% of the Indian market by 1875. Industrial production as it developed in European factories was unknown until the 1850s when the first cotton mills were opened in Bombay, posing a challenge to the cottage-based home production system based on family labor. The importance of the Asian markets to world trade is usually underestimated in the literature. In fact, in 1870, exports of Asian economies represented 10.5% of world total, compared with 13.7% of the Western Offshoots, according to Maddison data. However, due to the rapid development of the Western Offshoots, by 1913 their market share had increased to 20.6% while Asia remained at 11.2%.

3.4. Transnational and Intercontinental Capital Flows

From 1870 to 1913 Britain exported 33% of its savings, France 15.7% and Germany 11.8%.[21] According to Feis (1930) 44.8% of the capital exported by Britain went to North America and Australasia and 25.9% to her colonies in Africa and Asia. France directed 25% of its capital to Russia and 21% to Asia and Africa. Germany directed 20% to Eastern Europe. Latin America represented also one of the most important destinations. All estimates of O´Rourke and Williamson (1999) show that those flows represented more than the double of the intensity in the rest of the 20th century.

The most common estimate for the global stock of foreign assets in 1913 is about 8–9 billion pounds or 40–45 billion US dollars (at historical prices) (Maddison, 1995; O'Rourke and Williamson, 2000; Obstfeld and Taylor, 2003) with the largest share belonging to the United Kingdom, France, Germany, and the United States. With a historical world GDP of about 210 billion US dollars on the eve of WW1, the level of international financial integration (the ratio of gross international assets to world GDP in 1913) was around 20% (Crafts, 2000; Obstfeld and Taylor, 2003).

In the last quarter of the 19th century, British capital equivalent to 5% of host-country GDP flowed out each year to the United States, Canada, Australia and Argentina, all labor-scarce and natural resource cum human capital-rich countries. The flows paid for a large part of the investment undertaken in the capital-importing countries, the majority in railroads and other infrastructure, helping to push the frontier of the world economic system. Table 5 shows the main suppliers and recipients of Foreign Direct Investment, estimated by the sources indicated and tested for consistency with Maddison (2001) GDP data. The major suppliers were United Kingdom, France and Germany, were net foreign assets represented in 1913/14 from 153 to

[21] Based on Jones and Obstfeld (1997).

36% of GDP (Table 5). The major recipients were USA, Russia and Canada in absolute terms, which represented about 20.7% of the total stock. The next set of countries (Argentina, Austria-Hungary, Spain, Brazil, Mexico, India, South Africa and Australia) received a similar share, between 6.3 and 4.5% of the total.

Table 5

Main suppliers of Foreign Direct Investment (1913/14)
In Billions 1990 USD PPP

Countries	Gross Foreign Assets	In % GDP	Net Foreign Assets	In % GDP
United Kingdom	712	315	346	153
France	252	188	130	97
Germany	281	139	73	36
Netherlands	75	312		
Switzerland	91	567	22	139
Italy	99	104	0	
USA	358	75	-43	-9
Canada	26	79	-45	-135
Total	1,893	92	483	20

Source: Historical data from Goldsmith (1985), Woodruff (1966)
Twomey (2000), Schularick (2006)

Main recipients of Foreign Direct Investment (1913/1914)
In Billions 1990 USD PPP

Countries	USD Billions Annual	%	USD Billions Cumulative	%
USA	7.1	15.8	97	14.7
Russia	3.8	8.4	54	8.2
Canada	3.7	8.2	53	8.0
Argentina	3.0	6.7	41	6.3
Austria-Hungary	2.5	5.6	33	5.0
Spain	2.5	5.6	34	5.2
Brazil	2.2	4.9	37	5.6
Mexico	2.0	4.4	30	4.6
India and Ceylon	2.0	4.4	32	4.9
South Africa	1.7	3.8	33	5.0
Australia	1.7	3.8	30	4.5
China	1.6	3.6	18	2.8
Total	44.6	75.2	660	74.7

Source: Wilkins (1989)

The stock of foreign investments was 7% of world GDP in 1870 (Obstfeld and Taylor 2004) but almost 30% on the eve of World War I, a figure that was not equaled until the first decade of the 21st century.[22] This expansion in capital flows was supported by the development of a multilateral payment system and the gold standard. According to Lothian ( ), the period of 1875 to 1914 saw the lowest level of world-wide dispersion of short and long-term interest rates, even lower than the 1970-1998 period. E.g., the standard deviation for short-term rates decreased from 3.9 in 1860-1874 to 1.5 in 1875 to 1914, and the long-term rates from 3.5 to 1.17, a high level of financial integration indeed.

The growth of intercontinental trade, the extension of the New World frontiers[23] with the expansion of grain and cattle production, the world factor flows and the multilateral payment

[22] Our estimates are larger than Obstfeld and Taylor, which have already found to underestimate capital flows by other authors. (See Schularick (2006)).
[23] Britain added to its territorial empire from 1820 to 1913. There were major acquisitions from the 1870s in Africa, which included Egypt, Ghana, Kenya, Nigeria, Rhodesia, Sudan, Transvaal, the Orange Free State and Uganda. In Asia, Aden and the sheikdoms around Arabia, Burma, the Malay states, Hong Kong and some Pacific islands were added, and the British raj took control of the whole of India. The population in the African territories was about 52 million in 1913, in Asia about 330 million, in the Caribbean about 1.6 million, and in Australia, Canada, Ireland and New Zealand about 18 million. The

system were closely interrelated. Taking the British overseas investment, 70% in the 1890s went into railroads (41% of the total) and other infrastructure in the frontier regions.[24] Frontier expansion responded to increase in wheat prices that preceded expansion in railroad construction, which was facilitated by the expansion of intercontinental factor flows. These outflows were possible due to the liberal capital systems prevailing in the Old World as investors looked for better returns in New Orleans, Chicago, Bombay and Sidney: estimates by Edelstein (1982) showed that the spread between foreign and home rates of return was 6.08 in equity for the period 1877-1886 and 8.62 in 1897-1909, and for debt instruments was 2.28 and 2.42, respectively. This process was facilitated by the emergence of the new communication technologies, in particular the telegraph. London that emerged as the leading international financial center of the world at the beginning of the nineteenth century was up to the First World War the epicenter of the financial world and the clearing-house of the gold standard, since the 1870s. London was followed, since the 1840s by Paris and some secondary financial centers in Amsterdam, Brussels, Frankfurt and Geneva. According to Cassis ( ) the first big businesses of the industrial era were the railway companies and the joint-stock banks: the second mobilized their vast client´s deposits and the product of securities issuance to finance the large investments of the first. Foreign capital invested outside the country of origin grew from 1 billion pounds in 1855 to 7.7 billion in 1870, at current prices. After the British government bonds, securities issued by railway companies occupied the second place with 17% of all securities. From 1853 to 1873, the nominal value of the British railway companies listed in the London Stock Exchange went from 194 to 374 million pounds, and the value of foreign railway companies from 31 to 354 million pounds, with major roles played by Barings and J. S. Morgan.[25] Paris financiers (in particular Credit Mobilier) were mostly involved with railways in France and the rest of Europe. The large merchant banks, Barings and Rothschild, dominated the international finance by issuing bills of exchange and providing foreign loans, up to the 1860s. Overseas banks, with their registered office in London also appeared by then, like HSBC, spreading throughout the British Empire, taking local deposits and financing trade. New York started to challenge the leadership of London at the beginning of the 20th century.[26] J. P. Morgan & Co. provided an early credit to the French government against gold deposited in the vault of the Morgan Harjes bank in Paris. In 1916 three leading American banks, the Guaranty Trust, the Bankers Trust and J. P. Morgan, organized a syndicate under which 175 American banks made loans under acceptance credits to 75 French firms.

As is now currently recognized and empirically proven (see e.g. Flandreau () and Borda ( )), the intensification of financial flows at international level would not be possible without the prevalence of the gold standard across most of the developed world. It provided certainty and

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total population of the Empire was 412 million — ten times as big as Britain itself. The hard core of the Empire was India, with three quarters of its population. Indian taxation financed a large army under British control, which could be deployed to serve British objectives elsewhere in Asia, the Middle East and eventually in Europe. The security of the Empire was guaranteed by British naval supremacy and a network of military/naval bases in Gibraltar, Malta, Cyprus, Egypt, the Suez Canal, Aden and Hong Kong.

[24] Feis (1930).

[25] Cassis (1992) p. 56. The American companies absorbed 45% of all placements by private companies.

[26] Kindleberger (1984), p. 78.

stability in exchange rates, a common world means of transaction and a relative low cost payment system.

4.1. The process of technological innovation and interchange of technologies in the liberal era – spread of the first and rise of the second industrial revolutions – led to rapid technological progress.

The shape of the world production possibility frontier was radically changed, in an unprecedented way in the time scale of about a century and half, with the first and second industrial revolutions taking full effect. The following table shows the major innovations that took place in the second half of the 19th century, corresponding to the Second Industrial Revolution (Table 6). They swept through almost all industries, including iron and steel, chemicals, textiles, shipbuilding, railways, automobiles, telecommunications, agriculture and food industries. Also significant was the acceleration in the rate of diffusion.

Table 6: Major innovations in the Second Industrial Revolution

Type of innovation	Date and country innovation	Main countries of diffusion
Henry Bessemer process for iron and steel: patented "a decarbonization process, utilizing a blast of air"	1856 Britain (Sheffield)	USA, Germany, France
Siemens-Martin open hearth process	1862-65Britain -France	USA, Germany
Percy Gilchrist and Sidney Thomas solved problem posed by the presence of phosphorous ores	1878 Britain	USA, Germany, France
Electric arc steel	1900 France	Germany, USA, UK
Chemists succeeded in developing indigotin (synthetic indigo) and sulphuric acid	1875 Germany	Britain, USA, France
Ernest Solvay discovered soda-making process	1860s Belgium	France, Britain, Germany, USA
Alfred Nobel invented dynamite	1867 Sweden	USA, Britain, Germany, France
Fritz Haber and BASF chemists Carl Bosch and Alwin Mittasch developed process to make ammonia	1908 Germany	USA, Britain, France
The thermal cracking method was invented by Russian engineer Vladimir Shukhov and	1891, 1908 Russia, USA	Britain, Germany, France

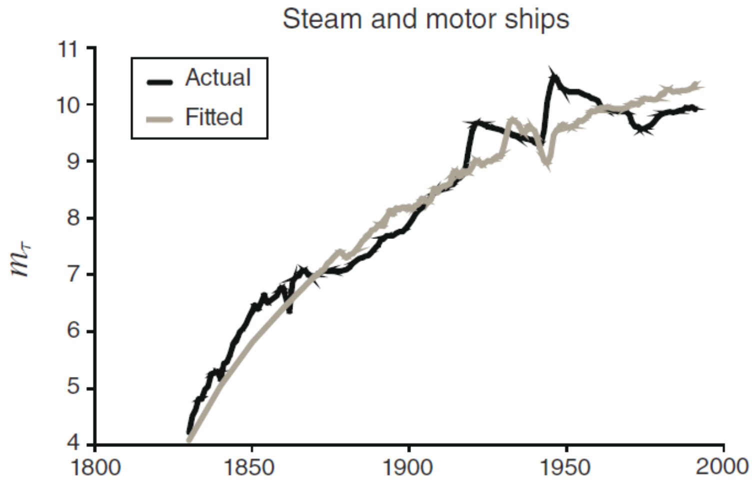
patented in 1891.Later modified by the American engineer William Burton in 1908.		
Production of nitrates for fertilizers and explosives	1909 Germany	France, Britain, USA
Leo Baekeland discovered bakelite, the first synthetic material	1907 USA	Germany, Britain
Pharmaceuticals like anesthetics, antiseptics and disinfectants and aspirin (Bayer)	Early 1900s, Germany	USA, Britain, France
The first commercial electrical telegraph was co-developed by William Cooke and Charles Wheatstone, independently developed by Samuel Morse	1837 Britain, USA	Germany, Argentina, France
First successful submarine cable was laid by Thomas Crampton's Company between Dover and Calais	1851 Britain	USA, Germany, Argentina, France
The Atlantic Telegraph Company was the first to construct a transatlantic telegraph cable by 1858. However, only in 1866 a commercial operation started	1858-1866 Britain, USA	Germany, Argentina, France
The telephone was invented by Thomas Edison	1875-79 USA	Sweden, Switzerland, Norway, New Zealand, Britain, Germany, France
First long-distance telephone line was installed	1877 USA	Sweden, Australia, New Zealand, Britain, Germany
Marconi and Braun invented radio transmission	1901 USA	UK, Germany, France
Under the leadership of Jacob Schoellkopf, the first hydroelectric generating station was built on Niagara Falls	1881 USA	Norway, Germany
Invention of the modern lightbulb by Joseph Swan in England and Thomas A. Edison in the United States	1880s, USA and Britain	Germany, France
Self-excited generator invented by C.F. Varley and Werner von Siemens; Z. T. Gramme built in 1870 a ring dynamo, which produced a steady continuous current	1860-70 Germany and Belgium	Germany, France, USA, Britain
An electric polyphase motor using alternating current was built by the Croatian-born American Nikola Tesla in	1889 USA	Britain, France, Germany

1889, and improved subsequently by Westinghouse		
Transformer originally invented by the Frenchman Lucien Gaulard and his British partner John D. Gibbs and later improved by the American William Stanley who worked for Westinghouse	1890 USA, Britain, France	Germany
Adoption of metal hulls and steam propulsion in ships	1850 USA, Britain	Germany, France, Norway
The invention of the steam turbine by Gustav de Laval and Charles Parson and its subsequent improvement led to the rotary motion of the turbine which could develop enormous speed, leading to their adoption in marine engines	1884-1990 Britain	USA, Germany, France, Norway,
A working model of a gas engine was first constructed by the Belgian Jean-Etienne Lenoir in 1859 and perfected in 1876, when a German traveling salesman, Nicolaus August Otto, built a gas engine using the four-stroke engine	1859-1876 Belgium, Germany	France, Britain, USA
Gottlieb Daimler and Karl Benz, succeeded in building an Otto-type, four-stroke gasoline-burning engine. Rudolf Diesel invents the diesel-powered motor.	1885, 1892 Germany	France, Britain, USA
Technical improvements added to the automobile around 1900 included the radiator, the differential, the crank-starter, the steering wheel, and pedal-brake control	1900 Britain, USA, Germany	Britain, Germany, France
Threshing and winnowing machines with combustion engines	After 1900 Britain, USA	Britain, Germany, France
Fungicides such as Bordeaux mixture, invented in 1885 by the French botanist M. Millardet	1885 France	Britain, Germany, USA
Mechanical refrigeration was gradually developed and improved upon between 1834 (when the first patent for the manufacture of ice was issued in Britain) and 1861 (when the first frozen beef plant was set up in Sydney, Australia)	1834-1861 Britain, Australia	USA, Argentina, New Zealand
Christopher L. Sholes of Milwaukee, reputedly the 52nd person to invent the typewriter, was able to solve most of the	1874 USA	Britain, Germany, France

remaining problems. Sholes sold his patent to the Remington Company in 1874, and a small revolution in the office began		
Printing industry revolutionized by the rotary press, introduced in Philadelphia in 1846, complemented in 1890 by the German linotype machine	1846, 1890 USA Germany	France, Britain, Sweden, Norway
The sewing machine had a dramatic increase in the apparel industry and household crafts after being perfected by Howe and Singer in the second part of the 19th century	1870 Britain, USA	Germany, France, Italy, Spain
Combing wool, ring spinning and the first automatic loom was invented by Northrop in 1894 and quickly spread to the US and Continent	1894 Britain	Australia, New Zealand, USA, Germany, Denmark, France
Food canning and pasteurization played an important role already in the American Civil war, as well the invention of powder-milk by Borden	1860-1890 USA	France, Germany, Britain

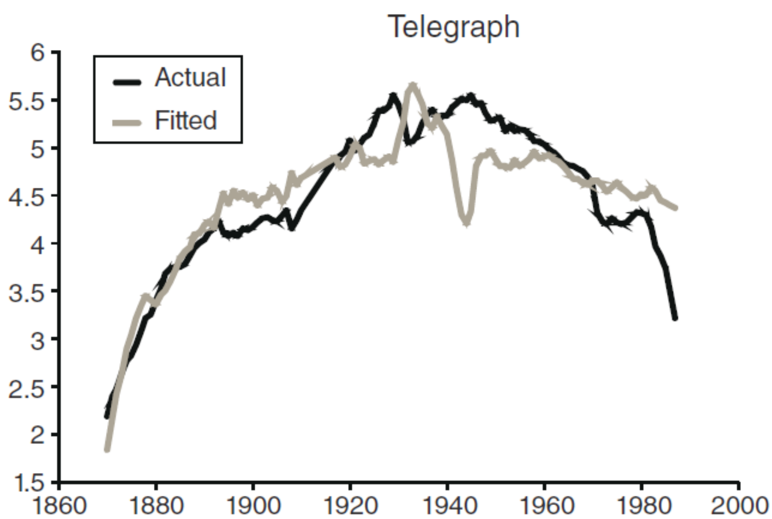
The two major innovations in transport infrastructures around the world that contributed to the first wave of globalization were railways and steam and motor ships. According to the studies of Comin and others (2008) he puts the invention of railways in 1825 and steam and motor ships in 1788. He dates the adoption of steam and motor ships in 1817 in the US, around 1830 in the Britain, 1837 in Australia, 1848 in Germany, 1852 in Argentina and 1869 in Brazil, 1877 in China, 1879 in India and 1901 in Japan. It took 57 years for 10% of its 51 country sample to adopt this technology. For railways-freight it took 33 years and for railways-passengers systems 60 years for 10% of countries to adopt that technology, quite a long time. The adoption of railways is put between 1850 and 1870 for the more advanced countries. Cars and trucks are also invented during the first wave around 1885 and their adoption starts to impact land transportation in the first decade of the 20th century. Figure 5 shows the evolution of the new technology in sea transport, measured by the tonnage transported worldwide.

Figure 5: Tonnage of steam and motor ships



The most important innovation behind the reduction in costs and improvement in quality of communication was the telegraph and in the final decades of the first wave telephone. The invention of telegraph is dated at 1835 and of telephone at 1876 by Comin and others (2008). The adoption of telegraph (Figure 6) is dated between 1840 and 1850 for Australia, United Kingdom and Germany and around 1870 to the US and Brazil. The adoption of telephones is put between 1870 and 1880 for US, Germany and Australia and 1890 for Britain.

Figure 6: Telegraph stations



The origins of industrial R&D and institutional innovation can be traced to the 1880s. Two of the most important institutional innovations in the science-technology system were introduced in Germany and the United States: the "in-house" industrial R&D laboratory and the "Institute of Technology" for the professional education of engineers.[27] They were a response to the increased complexity of the emerging technologies in chemicals and electrical

[27] See C. Freeman (2008).

sectors in the second half of the 19th century. They increased the scope and speed of process and product innovation and are certainly behind overtaking Britain by the US and Germany in technological leadership leading up to the I World War. Historians have noted that although Britain maintained a productivity lead in older established industries, it lost the lead in the newer sectors (electrical power and motors, organic chemistry and synthetics, internal combustion engine and automobiles, precision engineering and assembly line) by the end of the 19th century.[28]

Britain lost the leadership not for lack of scientific discoveries or radical innovations, but for the inability of institutions to diffuse and scale up these innovations. Moreover, Freeman stresses that it was the lack of professional engineers and other skilled people which gave the advantage to German and American industry. Hobsbawn (1968) estimates that Germany was educating 3000 graduate engineers per year by 1913, whereas Britain was producing only 350 in all branches of science, technology and mathematics. The newer technologies required full-time professional formation and a curriculum which related scientific principles with practical applications. Schumpeter (1942) recognized the importance of basic science to technological capabilities in the large German electrical concerns of the 1890s: AEG and Siemens. In the eve of the I World War they employed already more than 50 thousand workers. Similarly, in the US, General Electric and Westinghouse dominated the sector. The "in-house" laboratories, pioneered by the German chemical industry, enabled the large chemical and electrical firms to generate a stream of new products and processes. The German innovation system comprised university laboratories (with Liebig initiative in chemical departments and the introduction of the PhD research degree), the "in-house" industry laboratories in leading industrial sectors and quality control and testing facilities in other industries, national standards institutes and national research institutes and libraries, a network of national scientific and technical societies and publications, all supported by a growing supply of qualified technical people from the educational system and the famous vocational training system for a variety of craft and technical skills.

Although the USA did not have such a strong innovation system it benefited from the steady and increasing inflow of European qualified immigrants and of a very rapid growth of general and technical education, as well as the Institutes of Technology in the higher education system. Private contract laboratories headed by outstanding inventors and scientists, such as Edison and Tesla played an important role in the last decade of the 19th and beginning of the 20th century.

It was not just the entrepreneurial spirit but a set of institutions that furthered technological progress, and countries like Sweden and Switzerland, that imitated the German system were also quick in the catching-up process.

[28] A. Lewis (1977).

4.2. Technological diffusion and globalization

Technological diffusion is intimately connected with globalization. First tech diffusion influences the spread of economic activity. In fact, neoclassical theory assumes that there is only one technology across countries. Second, the intensification in trade, capital and labor flows facilitates the process of technology transfer and consequently tech diffusion. In manufacturing the most important innovations were: (i) steel and iron (date of invention and lags in diffusion, but be careful – what is relevant is within Europe and WO), (ii) organic chemicals and dyestuffs (iii) textiles, (iv) electricity, lightning and electrical motors, (vi) pharmaceuticals, (viii) office technology and printing, (ix) agriculture and food processing.

Figure 7

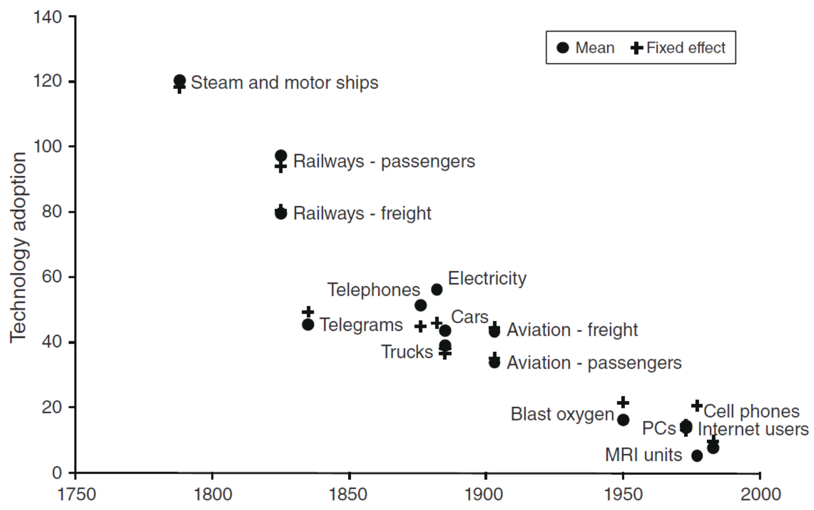


FIGURE 5. TECHNOLOGY ADOPTION LAGS DECREASE FOR LATER INVENTIONS

Innovation is a complex process that converts inventions and a myriad of technical changes into economic goods or improvements in techniques. It results from R&D at different levels from pure to applied, in universities, industries and public research institutions, from ideas that come from the shop floor to management proposals or market research, from learning-by-doing to technical training.

Once an innovation is introduced by a firm or individual somewhere at a given time it spreads at a given rate and within a given geographical radius, the process of technological diffusion is taking hold (Figure 7). This process may be localized or spread through borders and globalize.

Technological change and progress is the result of the process of innovation and the related technological diffusion.

Technological diffusion takes place through a number of channels:

- Local R&D or network R&D that may take place in different universities, industries and other research institutions, or among several individuals. R&D may spill to other firms and countries.
- Once patented, the invention may be bought by firms in the same country or by different countries. Similar use may be made of licenses and copyrights.
- Technical change is also embodied in capital goods traded among countries, namely imports of goods incorporating technical advances and enhancing efficiency of physical or human capital in the importing country.
- Technical change is also embodied in intermediate goods by importing goods that incorporate a higher level of technology or a technical change that improves the efficiency in the production process.
- Foreign Direct Investment by making investments in greenfield or acquiring control in a foreign firm, transferring equipment or designs from the country of origin or other more developed country, transferring management techniques or organizational structures.
- Information flows through the multinational corporation
- Technical advice resulting from technical assistance at government or firm level is also an important source of technical change that may be used by different agents in the same country or in different countries.
- Sending students abroad to study in universities that are more advanced than the originating country
- Exchange of research personnel
- Sending personnel for training or internships in technological more advanced firms domestically or abroad.
- Other forms of spreading technical or management knowledge are also important, like trade fairs, trade association gatherings, and informal contacts, among other diffused relationships.
- Emigration or immigration (reversed brain drain) of workers, professionals and managers.

Table 7 compares the importance of each channel of technology diffusion in the first and second age of globalization (in a scale of 1 to 5). In the first wave immigration to the Western Offshoots and trade in capital and intermediate goods were the dominant form of technology transfer. In the second wave all types of technology transfer were relevant with a lower role for immigration and still an undeveloped process of exchange of researchers and training/internships abroad as well as exchange of managers.

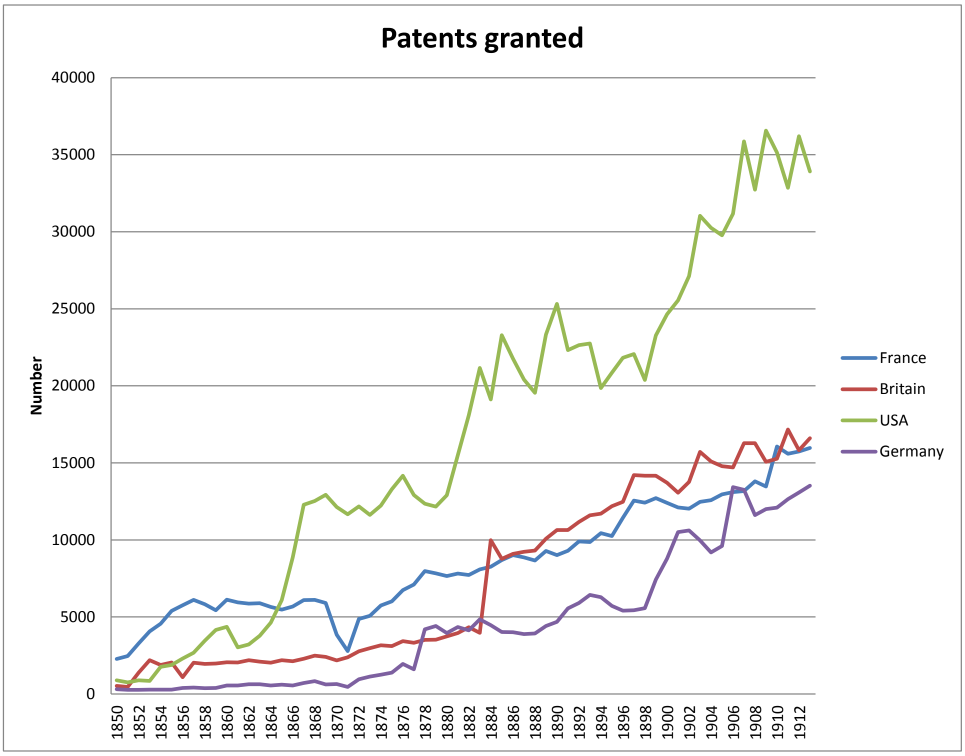
Table 7: Channels of Innovation

	First Global Wave	Second Global Wave	Authors
Local R&D or network R&D	0	5	Eaton and Kortum (1999), Griffith, Redding and Van Reneen (2000)

Lease and other utilization of patents	1	5	Rivera-Batiz and Romer (1991)
Trade in capital goods incorporating superior technologies	5	5	Xu and Wang (1999)
Trade in intermediate goods incorporating superior technologies	3	5	Eaton and Kortum (2002)
Foreign Direct Investment	2	5	Griffith, Redding, and Simpson (2003)
Multinational corporation	0	5	Keller and Yaple (2003)
Technical advice and assistance	0	5	
Students in foreign universities	0	5	
Exchange of researchers	0	3	
Training and internships abroad	0	3	
Trade fairs and trade associations	2	4	
Emigration/immigration of professionals and managers	5	2	

We start with a narrow definition of innovation and technology measured by patents granted (Figure 8). The USA jumped ahead after the civil war with acceleration after 1880s. France, Britain and Germany follow, with Britain taking second place after 1885, largely due to the reform in patent registration. Another important fact is the closing of the gap by Germany in the first decade of the 20th century.

Figure 8

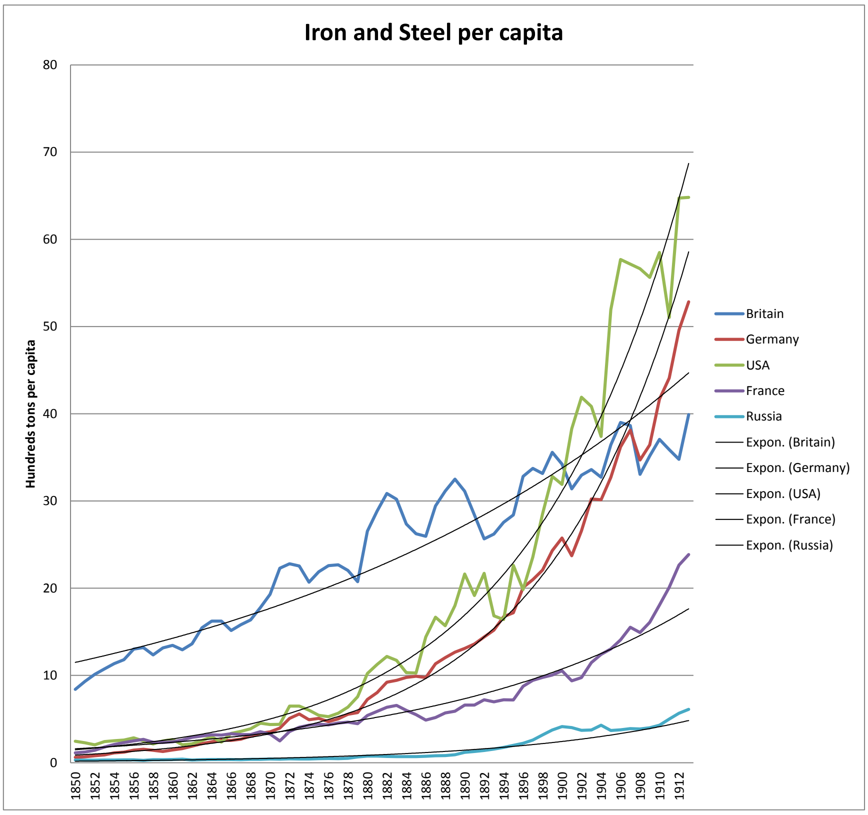


Source: http://eh.net/encyclopedia/article/khan.patents

Among the above technologies, the ones of relevance for the study of the first wave should (i) be strategic important in terms of the its technological relations (input-out matrix) or as an infrastructure, (ii) cover the pre-globalization as well as the globalization phase. There are two that satisfy both criteria: iron and steel production and railways.[29]

Figure 9 gives the production of pig iron and all types of steel for the period 1850 to 1913. This was an undisputed strategic product in the first wave of globalization. It was used for the construction of basic transport infrastructure (railways and steamships) and all types of machinery and in the last period of the wave in vehicles. Moreover, international trade was still limited by high transport costs due to weight, so countries with good access to iron ore and coal had a clear comparative advantage. The evolution of the series shows that Britain had a large advantage in the 1850s, a country that initiated the first industrial revolution. Using the measure of Comin of technological lags, the US had a lag of about 30 years,[30] Germany 36 years and France about 50 years. The gap for Russia was way above any 80 to 100 years.

Figure 9



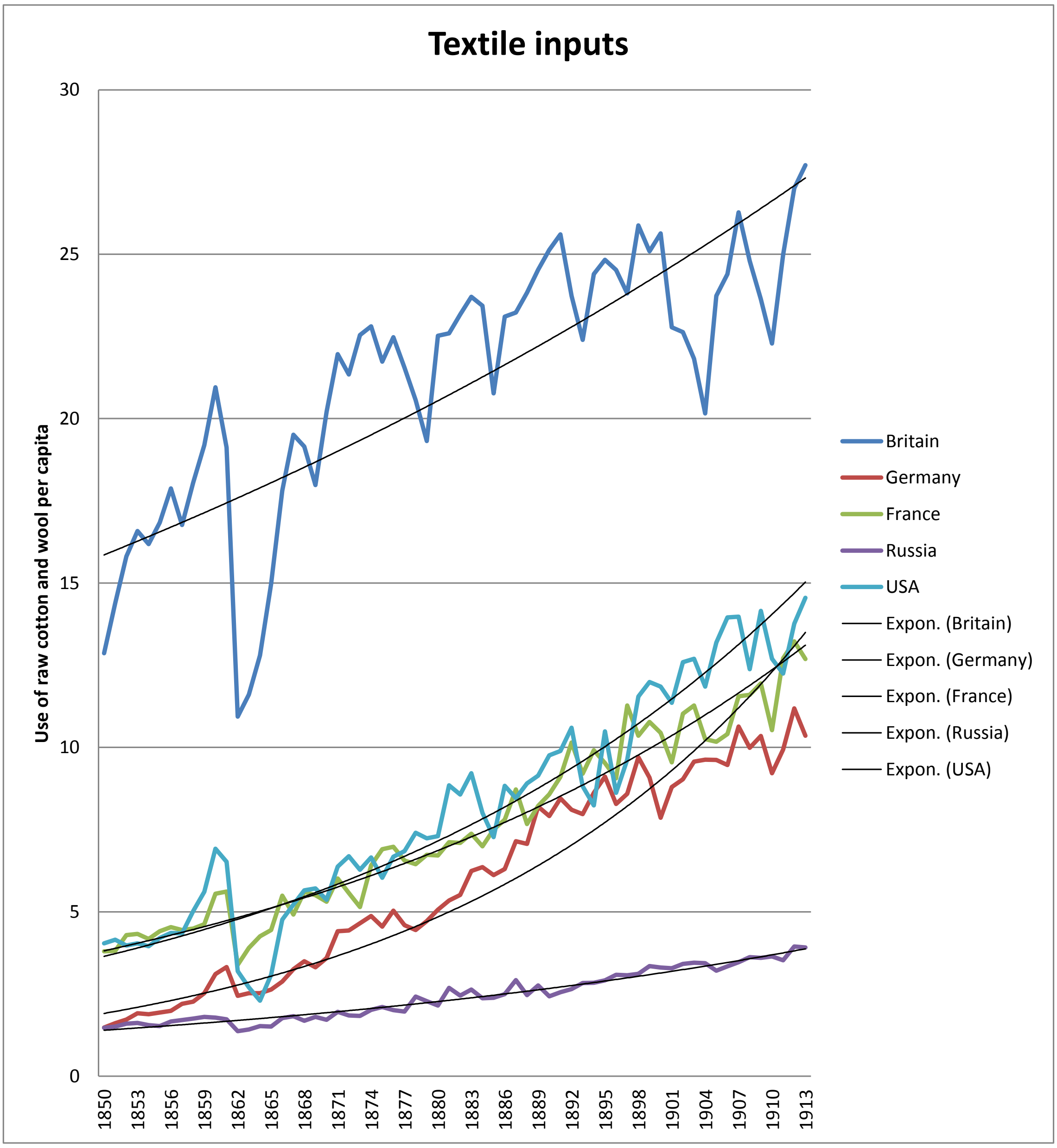
Source: Mitchell (2007)

[29] One of the problems with Comin and CHAT database is that the technologies used only cover infrastructure for most of duration of the first wave (railways and steamships).
[30] Horizontal difference between the trend lines.

The graph shows the rapid catch-up of the USA and Germany. The USA had overtaken Britain by 1900 and Germany about 4 years later. The Benelux countries had also overtaken Britain at the end of the century. For all these countries the fast catch-up phase took place after 1880.

Another production that is considered at the core of the take-off by historians (Rostow and others) is textiles. Figure 10 shows production of the textile industry measured by the consumption of raw cotton and raw wool. What is striking is the leading role of Britain (since the first industrial revolution) that was never put in risk in the period covered. The closest country is the USA with a lag of about 60 years. Within the remaining countries, USA takes the second position early in 1865 from France, and Germany overtakes France after 1910. Confirming other indicators, despite the progress made, Russia remains a distant fifth.

Figure 10

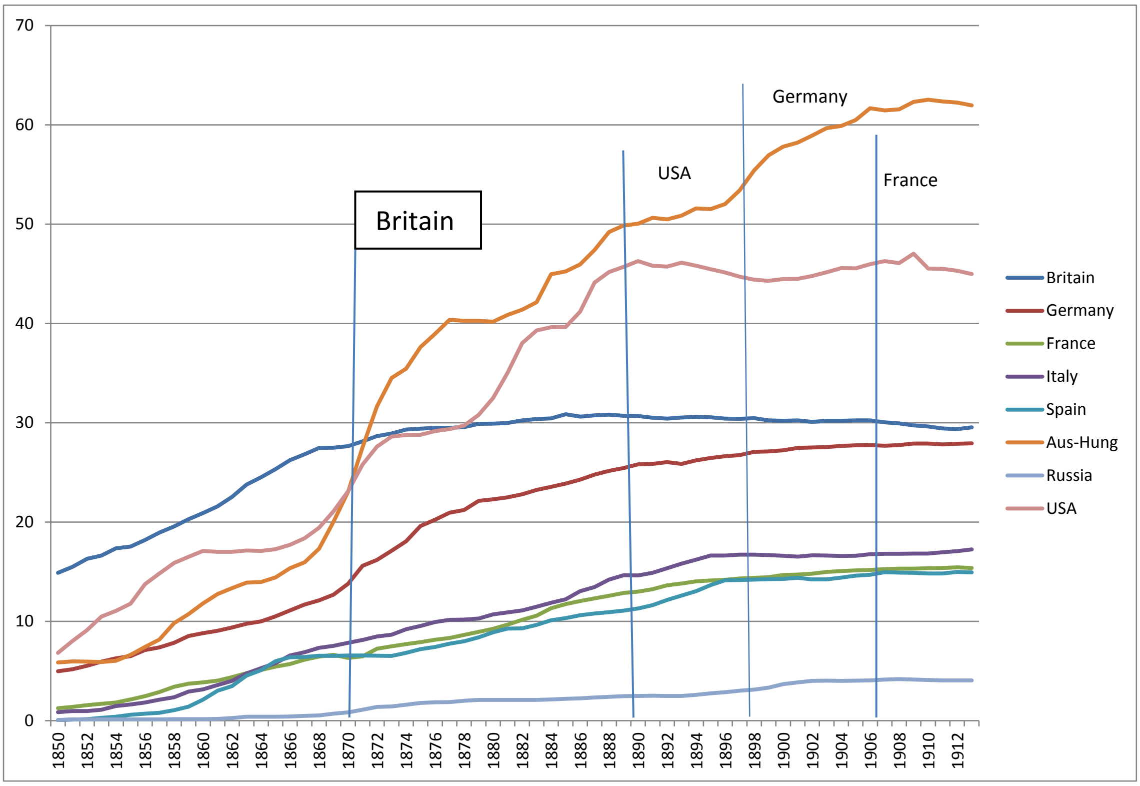


Source: Mitchell (2007) and author´s calculations

In the case of railways we use a different methodology of Comin. Instead of concentrating on the dating of the adoption which is more difficult to compute, we study the maturity of the technology in each country. Figure 11 gives the length of the railway system per capita[31]

The figure shows maturity of the system when its curvature becomes horizontal and the freight levels decelerate significantly for a substantial period. Britain is the first country to reach maturity in 1870 followed by the USA in 1890, Germany in 1898 and France and Austria-Hungary around 1907. These lags confirm the conclusions of the iron and steel data that the US had closed the technological gap in the 1890s with Britain (and overtaken it). Among continental countries, Germany had also closed the gap before the end of the century and France only in the first decade of the new century, followed by Austria-Hungary with some distance.

Figure 11: Length of the railway system per capita



Source: Mitchell (2007) and author´s calculations.

Despite the progress made by Russia in the 1870-1913 period, it was clearly lagging any of these countries. Italy and Spain were also substantially behind in technological terms, by more than 70-80 years vis-à-vis Britain/USA.

[31] Because of the difference in areas of the countries and concentration of populations we normalize the length by the freight rates in 1900.

4.3. Technological knowledge: managerial and organizational revolution – the rise of the modern corporation and institutionalized R&D

During the second stage of Chandler's model (1840-1880), exposed in the *The Visible Hand*, the balance between the Smithian market and the Chandlerian firm was decisively transformed by a triad of epochal technological advances: the railroad, the telegraph, and the widespread utilization of anthracite coal with the integration of local and regional markets into a large national market. The stage was set for reaping economies of scale and specialization of production through the appearance of the large corporation. The most transformative stage of Chandler's model of American economic development began around 1880, with the integration of mass production and mass distribution in the modern industrial enterprise. Firms such as American Tobacco, Armour, McCormick Reaper, and Singer Sewing Machine integrated vertically, hastening organizational innovation in middle management. Other firms, including Standard Oil, General Electric, United States Rubber, and Du Pont integrated horizontally, encouraging organizational innovation in top management. Many firms went through a similar metamorphosis, which began with horizontal combination and legal centralization and ended with vertical integration and administrative coordination. The consolidation process culminated with the great merger movement of the late 1890s and early 1900s that led to the creation of industrial giants such as U.S. Steel which the antitrust movement could not stop. The rise of the modern business enterprise, Chandler explained, was an organizational response to fundamental technological advances in mass production and mass distribution made possible by the utilization of new sources of energy such as electricity and the increasing application to industrial technology of scientific knowledge grounded in recent advances in chemistry and physics.

Chandler asserted that technological change had made it possible by the late nineteenth century for firms in some sectors of the economy to reap substantial economies of scale by building large factories to achieve these lower unit costs and setting-up the managerial structures to organize and operate large organizations. Firms were also bringing in supply and distribution activities under their direct control by integrating backward into raw-material production and forward into marketing.

Chandler claimed that firms that took these steps improved on the workings of the market, captured the resulting gains in efficiency, and reaped enormous competitive advantages. Because relatively few firms could raise the enormous amounts of capital required, these industries led to oligopolistic structures. Moreover, because large firms could exploit economies of scope as well as of scale by diversifying their operations into other industries, as time went on they wielded their managerial authority over an increasing share of the economy.

It was the "three-pronged" investment by creative entrepreneurs in production, distribution, and management, Chandler posited, that constituted the "central dynamic" of modern industrial capitalism.[32] The thesis of *The Visible Hand* is that administrative structure and

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[32] Chandler traced the beginnings of big business to the railroad, rather than to the sedentary merchants who, in the pre-railroad era, dominated overseas trade. To buttress his point, Chandler rejected George Rogers Taylor's

managerial coordination, “the visible hand”, replaced Adam Smith's "invisible hand" (market forces) as the core developmental and structuring impetus of modern business.

In the US Ford and GM dominated the automobile sector, Vanderbilt railways, Rockefeller oil extraction and refining, J.P. Morgan banking, Carnegie steel. Big corporations also dominated the German economy in the early 20th century like Krupp on steel, Bayer and Basf on chemicals, AEG and Siemens on electrical machinery.

Modern theories of the firm by Coase (1937), Williamson (1967), Hart (1995) and others have laid the theoretical foundations of this evolution. The firm is a nexus of contracts between stockholders, managers, workers, creditors, debtors, suppliers and clients. The firm reduces market transaction costs arising from imperfect and asymmetric information by hierarchical relationships and contracts, but on the other hand there are monitoring costs of those contracts. Due to uncertainty it is also impossible to predict all probable and possible situations, so immediate discretionary action may be required which is exercised by management within the firm. But eliciting the best effort from managers and workers is also a limitation of the firm in the agent-principal problem.

Coordination mechanisms can be made more effective by combining them with devices from other parts. Under certain circumstances, problems of asymmetric information in markets can be reduced with a limited infusion of hierarchy (for example, by creating a regulatory authority to oversee exchanges), and problems in hierarchies can be mitigated by adding a component of market competition (as, for example, when plant managers are evaluated according to their relative ability to reduce unit costs). The threat of competition can be used in long-term relationships to keep costs under control. Similarly, the hierarchical ordering that occurs when one party is more powerful than another can make it easier to alter the terms of such a relationship in response to economic needs.

The extent to which particular coordination mechanisms (or combinations of them) effectively solve problems of asymmetric information also depends on the institutional environment, which (following Douglass North (1989)) can be defined to include not only formal rules (such as laws) but also moral and ethical norms. Thus markets, and also long-term relationships, may work better in situations where buyers and sellers are members of the same cultural background. Similarly, subordinates in hierarchies may be more likely to respond positively to instructions if their superior's authority is legitimated by broader cultural values, whether meritocratic or ascriptive. In addition, the extent to which the legal system efficiently punishes violations of contract can affect the utility of markets relative to long-term relationships and hierarchies, both of which can serve as substitutes for effective contract enforcement. Outsourcing may be a particularly valuable strategy where there is a great deal of uncertainty about the direction of technological change and both parties can benefit from the pooling of information and resources that trust makes

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thesis that the transportation revolution began with the canal boom in the years immediately following the War of 1812, several decades prior to the coming of the steam railroad. In addition, he challenged Robert G. Albion's claim that the communication revolution began with various improvements in the late eighteenth century, more than half a century before the commercialization of the electric telegraph. Chandler´s view contrasted with the prevailing view of industrialists as robber-barons.

possible. On the other hand, long-term relationships are by their nature somewhat isolated from pressures to reduce costs and improve efficiency. Moreover, it can be difficult to renegotiate the terms of a relationship in response to evolving economic conditions.

By emphasizing the interplay between historical circumstances and the advantages and disadvantages of the different mechanisms used to coordinate economic activity, we can recapture the sense of contingency that the actors themselves experienced.

How the big corporation appeared in the US? In the first decades of the 19th century most of the population was spread thinly in the countryside and coordination mechanisms were based by the hierarchical structures of the family. Economic activity within shops and stores was an extension of that within families. Interactions between these various economic units typically were mediated by more equal long-term relationships. When farmers did business with local storekeepers and craftsmen, they transacted with kinsmen or neighbors with whom they had close multidimensional relationships. The need to deal with each other repeatedly in a number of different contexts discouraged one party from taking advantage of another. In addition, a variety of customary practices governed these local transactions. Long-distance exchange generally operated through networks built up by merchants in port cities—networks that incorporated both storekeepers in the countryside and merchants in other ports throughout the trading world. Because trade over long distances posed difficult principal-agent problems when transportation and communication costs were high, the earliest links among merchants in different locations were mainly familial. Some firms in the textile sector started to experiment putting-out systems by distributing thread for farm households to weave cloth (case of Almy and Brown), based on trading relationships, but the coordination problems led to expansion of the factory and integration of both activities. Other entrepreneurs detected an opportunity in hiring peddlers that canvassed the countryside to sell durable goods: the motive for mass production was born. Connecticut merchants Levi and Edward Porter attempted to capitalize on this lesson by contracting in 1807 with Eli Terry for the production of 4,000 inexpensive, wooden-movement clocks—more than a clockmaker using traditional techniques could make in an entire lifetime. Terry fulfilled the contract in the stipulated three years by figuring out how to simplify the clock's mechanisms and by developing special-purpose machinery that allowed him to produce the component parts in quantity.

The dramatic fall in transportation and communication costs associated with the canals, railways, steamboats and telegraph expanded and connected regional markets. By the 1850s merchants had begun to take the wheat out of sacks and pour it into grain elevators and railroad cars. As wheat from one farm became intermixed with, and therefore indistinguishable from, wheat from other farms, consumers could no longer use the reputation of a farmer as an assurance of quality. The Chicago Board of Trade solved the problem by standardizing weight and quality and monitoring the system.[33] For non-commodities large wholesalers were set-up that stocked and distributed a large number of goods. First Montgomery Ward, and then Sears, Roebuck & Company, took advantage of the new national railroad network to create a distribution system based on mail-order catalogues. In the big

[33] See Lamoreaux et al. (2003).

cities large department stores assumed the role of “fashion intermediaries”. These trade networks soon posed pressure on manufacturing to also integrate and mass-produce. The example of Singer Company and sewing machines is paradigmatic. Consumers were reluctant to buy expensive items like sewing machines unless they had instruction in how to use them and also assurance that broken devices would be speedily and inexpensively repaired. Wholesalers had no incentives to solve those problems. Hence Singer had to integrate vertically into distribution and take on these tasks itself. Beginning in the late 1850s, the company built a national system of sales offices, each staffed at minimum by a manager, a female demonstrator, a mechanic, and a salesman. Singer redesigned both its product and its production process along American-system lines, using special-purpose machine tools to turn out standardized parts that could be assembled with predominantly unskilled labor

Before the publication of The Visible Hand, most business historians had traced the origins of the industrial revolution in the United States to the establishment in New England during the 1800s and 1810s of large-scale, water-powered textile mills filled with machinery made mostly of wood and leather. These historians, in turn, were reacting against the social historian Charles Beard, who in the 1920s had linked the triumph of industrialism with the Union victory in the Civil War. According to Chandler, its origins dated to the 1830s and 1840s, following the opening of the anthracite coal fields of eastern Pennsylvania. Anthracite coal was the first fossil fuel to be widely used in the United States and it greatly facilitated the manufacture of iron, metal machinery, and metal products of all kinds, since the mass production of these goods depended on easy access to a reliable, cheap, and high-intensity energy source. From Chandler's standpoint, coal, iron, and steam power were necessary but not sufficient preconditions for the managerial revolution that was his major concern. In Great Britain, after all, an industrial revolution had taken place, beginning in the late eighteenth century, without hastening a managerial revolution that was in any way comparable to the managerial revolution that occurred in the mid-nineteenth-century United States. This is where economies of scale and scope in a large market start to play a role, as we saw above and will see below in the Crafts and Venables model.

Schumpeter theory of creative destruction applies perfectly to the first wave of globalization. Scherer and Ross (1984, ch. 2) trace the genesis of the modern corporate R&D lab in the United States to 1876, when Thomas Edison opened his R&D lab in Menlo Park and Alexander Graham Bell established a similar facility in Boston. Mowery and Rosenberg (1989, pp. 38–39) report that the first Bessemer steel, made in the United States in Wyandotte, Michigan, in 1864, and anticipating problems associated with chemical variations in inputs, a chemical lab was established in Wyandotte in 1863. This was the first chemical lab established in the metallurgical sector in the United States and one of the first attached to an industrial firm. Railroad companies, like the Burlington Railroad in 1876 and the Pennsylvania Railroad in 1874, established testing labs to make sure that the steel met appropriate specifications. Similar stories can be told about many other manufacturing sectors in the United States and in European countries (see Mowery and Rosenberg, 1989, chs. 3–4, and the references cited therein). According to Baumol (1993, ch. 6), the most important characteristic of corporate R&D is that it is systematic, incremental, and cumulative.

Peretto (1998) builds a model explaining the transition from individuals carrying out R&D – entrepreneurial innovation created by independent firms, to corporate research that is the hallmark of R&D nowadays. Most of the historians place that transition at the end of the 19th century with the labs of Thomas Edison and Graham Bell. The model explains that transition by the interaction of market structure and technological change. This change occurs due to rivalry, dispersion and scale effects. According to the model, when a critical number of firms have entered the market, established firms start to invest in R&D based on the marginal value of knowledge to increase productivity and maintain profitability. Entry is costly, only when there are a sufficiently large number of firms the rivalry effect is dominant. Then, the economy converges to a steady-state where R&D is only carried out in-house.

4.4. Institutional building in the New World was immediate because of the transfer of European institutions: democracy, legal systems, culture.

Table 8 essays to establish a scoring of an institutional indicator for the US using political and regulatory indicators. It shows a clear upward trend, first with the end of the civil war and with the regulatory measure taken after the last decade of the 19th into the 20th century, as US entered the Progressive Era.

Table 8

			INSTITUTIONAL INDICATORS						
	1850	1860	1870	1880	1890	1900	1910	1913	
US Political and Regulatory					1	1	1		Sherman Act enacted in 1890
							1		Breakup of Standard Oil (1911), Clayton Act (1913)
							1		Sixth Amendment ratified
						1	1		Primary elections introduced at state level (1906)
							1		First regulation of medicines and food
			1	1	1	1	1		Trade Union movement (since 1870)
				1	1	1	1		Democratic party reelected and call for political reform
	-2	-5							Civil war
	-2	-5	1	2	3	4	7		Total
Patents US				136,351	224,356	362,656	432,504	587,450	
Patents UK			30,487	35,079	47,062	147,839	261,137	290,427	
Literacy rates 1/				65	68	73	77	81	

1/ Europe and US literacy rates

A cross correlation among institutional factors above shows a strong correlation among all of them, in particular between patents and literacy rates.

	INST_INDIC	LITERACY	PATENTS_UK	PATENTS_US	
INST_INDIC	1.000	0.953	0.829	0.921	
LITERACY	0.953	1.000	0.950	0.987	
PATENTS_UK	0.829	0.950	1.000	0.963	
PATENTS_US	0.921	0.987	0.963	1.000	

The Gilded Age and the first years of the twentieth century were a time of great social change and economic growth in the United States. Roughly spanning the years between Reconstruction and the dawn of the new century, the Gilded Age saw rapid industrialization, urbanization, the construction of great transcontinental railroads, innovations in science and technology, and the rise of big business. Afterward, the first years of the new century that followed were dominated by progressivism, a forward-looking political movement that attempted to redress some of the ills that had arisen during the Gilded Age. Progressives passed legislation to rein in big business, combat corruption, free the government from special interests, and protect the rights of consumers, workers, immigrants, and the poor.
Driven by the North, which emerged from the Civil War an industrial powerhouse, the United States experienced a flurry of unprecedented growth and industrialization during the Gilded Age, with a continent full of seemingly unlimited natural resources and driven by millions of immigrants ready to work. In fact, some historians have referred to this era as America's second Industrial Revolution, because it completely changed American society, politics, and the economy. Mechanization and marketing were the keys to success in this age: companies that could mass-produce products and convince people to buy them accumulated enormous amounts of wealth.
Railroads were the linchpin in the new industrialized economy. The railroad industry enabled raw materials, finished products, food, and people to travel cross-country in a matter of days, as opposed to the months or years that it took just prior to the Civil War. By the end of the war, the United States boasted some 35,000 miles of track, mostly in the industrialized North.

The first wave the organization of production was characterized by the rise of the large corporations and trusts at the national level. Powerful capitalists formed giant trusts to monopolize the production of goods that were in high demand. Andrew Carnegie built a giant steel empire using vertical integration. He eventually sold his company to Wall Street financier J. P. Morgan, who used it to form the U.S. Steel Corporation trust in 1901. Conversely, John D. Rockefeller's Standard Oil Company used horizontal integration, by putting competitors out of business using tactics to lower the value of their businesses and then acquire them, effectively creating a monopoly.

By 1900, American railroad capitalists like Cornelius Vanderbilt had laid hundreds of thousands of miles of track across the country, transporting both tradable goods and passengers. The industry was hugely profitable for its leaders but riddled with corrupt practices, such as those associated with the Crédit Mobilier scandal of 1871. When the Supreme Court ruled in favor of corrupt railroads in the Wabash case, Congress passed the Interstate Commerce Act in 18 87 to protect farmers and other consumers from unfair business practices.

The first large-scale union, the National Labor Union, was formed just after the end of Civil War, in 1866. The most notable strikes of this era were the Great Railroad Strike, the Homestead Strike, and the Pullman Strike, all of which ended violently. The more exclusive American Federation of Labor, or AFL, emerged as the most powerful union in the late 1880s.

A growing middle class enlarged substantially the market for mass produced industrial goods. It spurred a late-nineteenth-century reform movement to reduce poverty and improve society. Reformer Jane Addams, for example, founded Hull House in Chicago to help poor immigrant families adjust to life in America. The success of Hull House prompted other reformers to build similar settlement houses in the immigrant-clogged cities of the eastern United States. Plagued by steep railroad fares, high taxes under the McKinley Tariff, and soaring debt, thousands of small farmers banded together to form the Populist Party in the late 1880s. The Populists called for a national income tax, cheaper money (what Populists called “free silver”), shorter workdays, single-term limits for presidents, immigration restrictions, and government control of railroads.

The Progressive movement, which formed as a response to the rapid social and economic growth and change that was taking place, helped spawn a new era of social reform. Muckrakers—journalists who wrote about political and industrial corruption as well as social hardships—had significant influence on Roosevelt, who outlined a package of domestic reforms called the Square Deal, which were meant to protect consumers, tame big business, support the labor movement, and conserve the nation’s natural resources.

Congress, meanwhile, passed the Elkins Act and Hepburn Act to regulate the railroads and the Pure Food and Drug Act and Meat Inspection Act to regulate food inspection and sanitation. Congress passed the acts, in part, after the popularity of Upton Sinclair’s novel The Jungle , which exposed unsanitary meatpacking practices. Roosevelt also supported strikers in the Anthracite Strike, prosecuted several trusts under the Sherman Anti-Trust Act, and signed the 1902 Newlands Act, selling lands in the West to fund irrigation projects. In 1914, the tougher Clayton Anti-Trust Act replaced the Sherman Act, eliminating many of the older act’s loopholes.

5. Globalization and Engines of Growth in the USA

We assembled a data basis using the most recent statistical data available. The GDP data used a combination of sources: (i) Kendrick estimates for the period 1870-1913,[34] (ii) Gallman data for the 1840-69 period, corrected by Rhode,[35] and (iii) GDP computed by Turner et al. based on Easterlin. The stock of capital is estimated based on Gallman (estimate for the national capital stock in 1840 and then applying the equality of gross investment less amortization, with the time series estimated for the rate of investment by Gallman. Giving the uncertainty about the impact of the civil war, we use the growth rates estimate for the decade of 1860-70 by that

[34] Downloaded from the Groninger Development Center: www.ggdc.net.
[35] The data of Maddison for the period 1870-1900 has serious flaws, since it shows the same growth rate per decade.

author. The population series is given by the BEA historical data. Data on labor, schooling and experience indicator is obtained from the recent estimates of Turner et al. (2006) for the American states and aggregated for the all country.

The growth rates per decade of these variables are presented in Table 9. The GDP average growth rate was about 4.4%, with physical capital stock growing at 5.1 percent per year. Population growth averaged 2.4%, the labor force with a higher rate of 2.7% and the schooling indicator at 2.6%.

In contrast with the post-II WW estimates of Solow (1956?) and others that give a dominant role to TFP, we found a large contribution for labor and physical capital to the US GDP growth in the 19th century: physical capital (53%), and labor (28%), with TPF growing at about 1.54% per year and contributing only 16% for the overall growth.[36] For 1870-1911 the contribution of physical capital is even higher (74%) and TFP contributed only 6%. Estimates by Crafts (2002) show a contribution of capital of 56% and labor of 37%, with the remaining 7% for TFP, which are no substantially different from ours.

Table 9

	Average Growth Rates per Decade						
	GDP	POP	LABOR	CAPITAL	SCHOOL	EXPER	TFP
1840-50	6.01	3.11	3.56	3.97	3.76	3.56	3.14
1850-60	4.41	3.08	3.26	5.68	4.22	1.85	1.13
1860-70	1.88	2.17	0.97	2.05	0.26	0.00	0.78
1870-80	7.41	2.33	3.10	6.84	3.96	0.96	3.83
1880-90	3.69	2.29	3.11	6.28	2.30	0.43	0.28
1890-1900	3.23	1.90	2.13	5.88	2.29	1.06	0.39
1900-10	4.19	1.96	2.76	5.32	1.45	-0.10	1.24
Averages	4.40	2.41	2.70	5.14	2.60	1.11	1.54

Source: See text.

We start by studying the correlations among GDP and the growth factors (Table 10). It shows that GDP is closely correlated with all growth factors, but it also reveals that the schooling variable is more correlated with population and labor than with GDP. A similar relation exists between the experience variable and labor and school variable. This poses a problem of multi-co-linearity: how to disentangle the effect of an expansion of labor from human capital and experience? All these variables have unit roots so a regression among these variables could be spurious. However, since they have a common trend, we estimate a co-integrating regression.

Table 10: Cross-correlations between GDP and factors of production

[36] These estimates use the factor elasticities used in most of the growth accounting exercises.

	GDPNR	POP	LABOR	SCHOOL	EXPER	CAPITALN
GDPNR	1.000000	0.976862	0.991266	0.976925	0.907033	0.986649
POP	0.976862	1.000000	0.994986	0.996539	0.968412	0.941828
LABOR	0.991266	0.994986	1.000000	0.993725	0.944910	0.968038
SCHOOL	0.976925	0.996539	0.993725	1.000000	0.970396	0.939009
EXPER	0.907033	0.968412	0.944910	0.970396	1.000000	0.844042
CAPITALN	0.986649	0.941828	0.968038	0.939009	0.844042	1.000000

Estimating a co-integration of GDP with labor and physical capital we obtain the results below. They show that both variables are highly significant. Labor has an output elasticity of .839 and physical capital .332. However, the sum of both elasticities is higher than 1, which may reveal economies of scale or technological change.

Dependent Variable: GDPNR
Method: Fully Modified Least Squares (FMOLS)
Date: 11/09/13 Time: 09:38
Sample (adjusted): 1841 1913
Included observations: 65 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LABOR	0.545451	0.051558	10.57933	0.0000
CAPITALN	0.085304	0.010752	7.933643	0.0000
C	-2169.742	523.4778	-4.144860	0.0001

R-squared	0.994124	Mean dependent var	12693.58
Adjusted R-squared	0.993934	S.D. dependent var	9646.291
S.E. of regression	751.3006	Sum squared resid	34996057
Durbin-Watson stat	1.145140	Long-run variance	1086875.

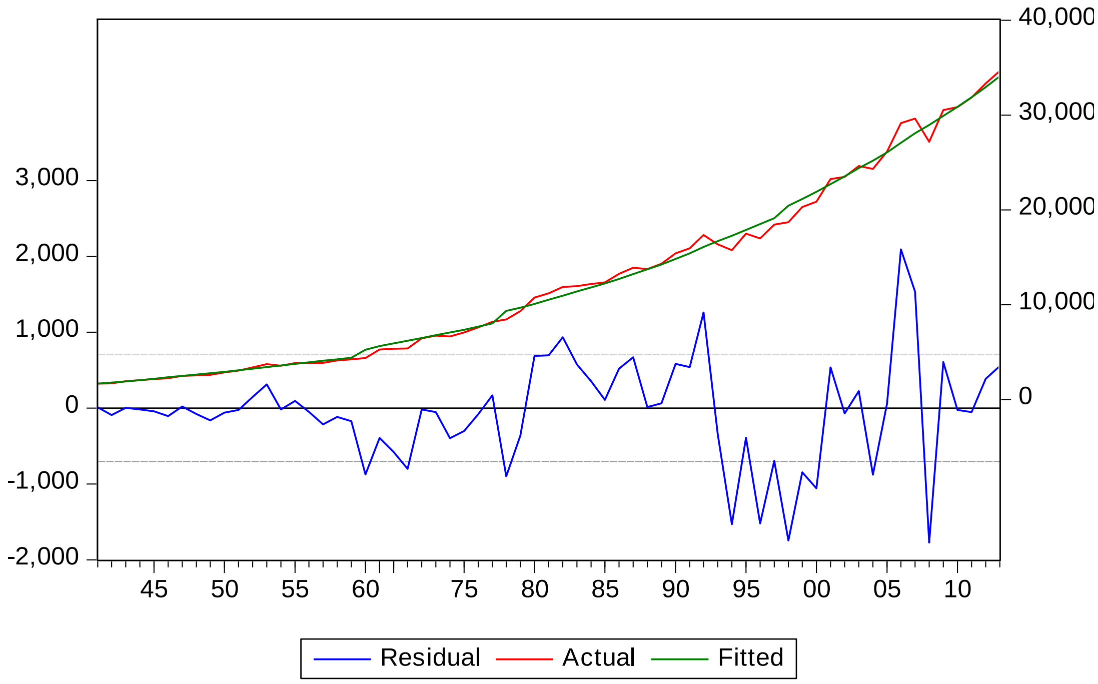
We also estimated a co-integration between GDP with human[37] and physical capital variables. The significance of variables increases. Now the output elasticities are .672 and .441, respectively.

[37] Measured by the average of schooling of workers. See Turner et al. (2007) for methodology.

Dependent Variable: GDPNR
Method: Fully Modified Least Squares (FMOLS)
Date: 11/09/13 Time: 09:44
Sample (adjusted): 1841 1913
Included observations: 65 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SCHOOL	63.80282	4.901976	13.01573	0.0000
CAPITALN	0.113332	0.006583	17.21665	0.0000
C	-1378.789	381.5163	-3.613972	0.0006

R-squared	0.994835	Mean dependent var	12693.58
Adjusted R-squared	0.994669	S.D. dependent var	9646.291
S.E. of regression	704.3195	Sum squared resid	30756087
Durbin-Watson stat	1.371363	Long-run variance	774556.5



Running a co-integration between GDP and population and physical capital we obtain an output elasticity for population of .699 and for physical capital of .451.

Dependent Variable: GDPN				
Method: Fully Modified Least Squares (FMOLS)				
Date: 11/02/13 Time: 19:22				
Sample (adjusted): 1841 1913				
Included observations: 65 after adjustments				
Cointegrating equation deterministics: C				
Regressor equations estimated using differences				
Additional regressor deterministics: SCHOOL EXPER				
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth				
= 4.0000)				
Variable	Coefficier	Std. Error	t-Statistic	Prob.
CAPITALN	0.117572	0.005556	21.16039	0
POP	9.86E-05	1.16E-05	8.536524	0
C	-365.845	352.7625	-1.03709	0.3037
R-squared	0.995755	Mean dependent v	11031.64	
Adjusted R	0.995618	S.D. dependent va	8207.459	
S.E. of reg	543.2814	Sum squared resid	18299589	
Durbin-W	1.434407	Long-run variance	460632.3	

Dependent Variable: GDPNR
Method: Fully Modified Least Squares (FMOLS)
Date: 11/09/13 Time: 09:47
Sample (adjusted): 1841 1913
Included observations: 65 after adjustments
Cointegrating equation deterministics: C
Regressor equations estimated using differences
Additional regressor deterministics: SCHOOL EXPER
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
POP	0.000168	1.79E-05	9.378802	0.0000
CAPITALN	0.115916	0.008851	13.09573	0.0000
C	-1857.222	570.9735	-3.252729	0.0019

R-squared	0.993369	Mean dependent var	12693.58
Adjusted R-squared	0.993155	S.D. dependent var	9646.291
S.E. of regression	798.0908	Sum squared resid	39490832
Durbin-Watson stat	1.012601	Long-run variance	1329842.

Due to the co-linearity between labor and human capital variables we used a combined variable multiplying the two. Including physical capital the results show that the human capital overwhelms the model, taking all the significance and leading to a negative coefficient for physical capital.

The main conclusion of these estimations is that both human and physical capital are able to explain the dominant part of growth in the US economy of the second part of the 19th century, and that if forced, the model shows that human capital is the crucial variable.

6. Globalization and Convergence of the Rest of Europe and Western Offshoots

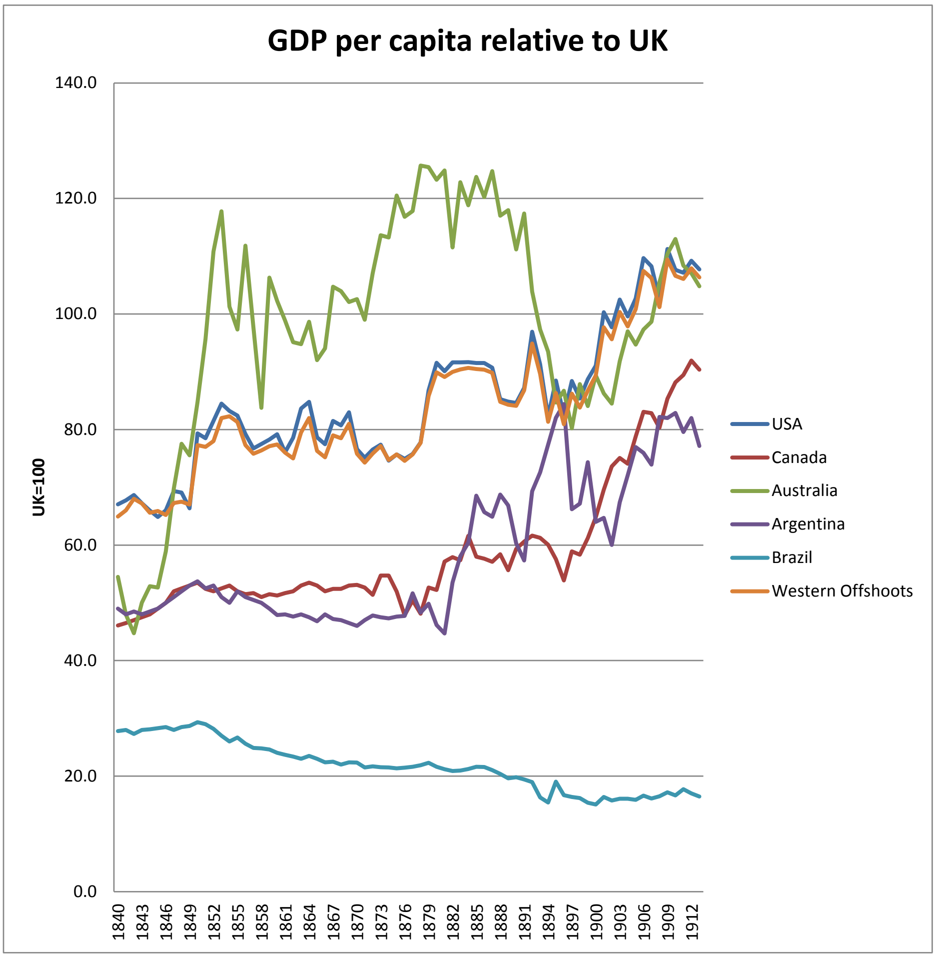
In the first wave there were two concurrent processes: the spread of the "industrial revolution" to the European continent, in special to France, Germany, Netherlands, Denmark, Sweden, Switzerland and Austria-Hungary; and the second the transplant of the new industrialized economy to the Western Offshoots, in special US, Australia, New Zealand and to a less extent some Latin American countries like Argentina.

The rate of convergence in the first wave was 2.85 percentage points per decade.[38] Evidence that in the first wave Western Offshoots were mainly transplant economies is given by Figure 11 by the case of Australia: it reduced a whopping 66 points the gap in its GDP level vis-à-vis the UK in just one decade (1840s) - the discovery and exploitation of gold mines was the immediate factor.

Within the Western-Offshoots, the most successful was Australia, which decreased its gap of GDP per capita vis-a-vis the UK by 50 pp between 1840 and 1913, followed by Canada (44 pp) and the US (40.7 pp). In Latin America, the most successful country was Argentina (28 pp), but there were cases of divergence like Brazil, where the GDP gap increased by 11 pp.

Figure 11

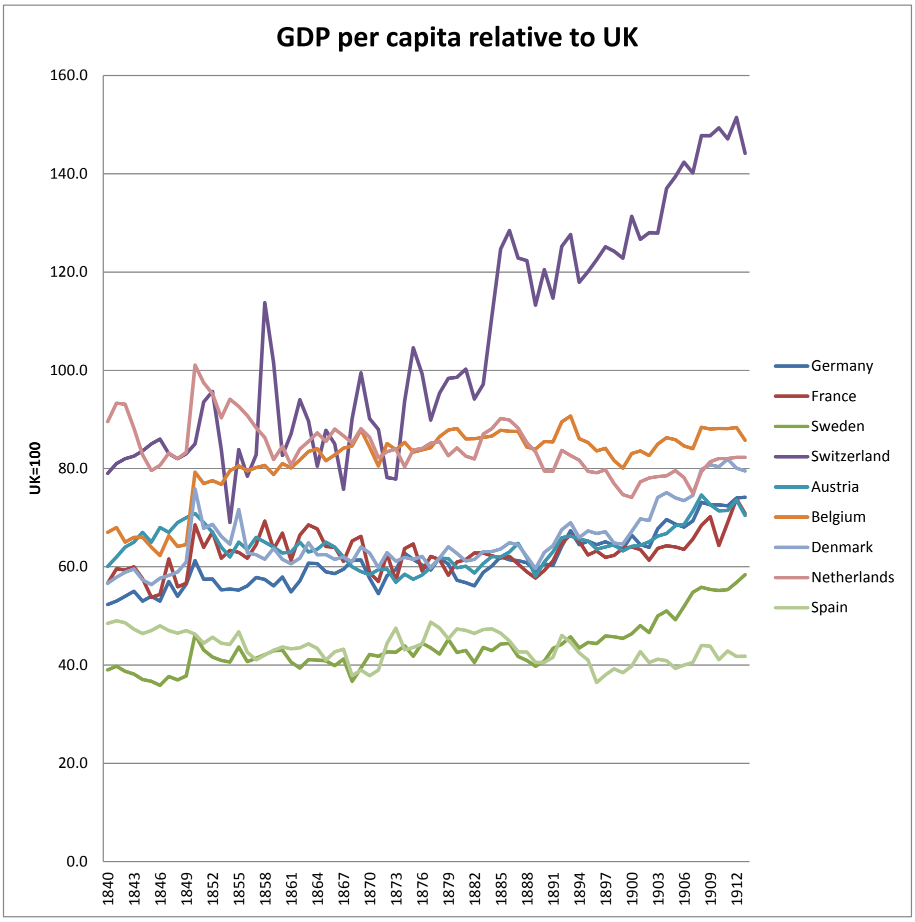
[38] We use the latest data from the Maddison Project in PPP USD, first update of Bolt and Zanden (2013).



Source: Bolt and Zanden (2013)

In Europe, the convergence process was mixed, with a group of countries catching-up and mainly South and Eastern Europe falling behind (Figure 12). The most successful country was Switzerland (gaining 65 pp) even surpassing largely the UK. There was a group of countries where the GDP gap at the end of the period was less than 30 pp: Belgium (gained 18.8 pp), Denmark (22.9 pp), Germany (21.8 pp), France (14 pp) and Austria (10.4 pp). Sweden made a remarkable catch-up (19.4 pp) but was still at 58% of the level of the UK in 1913. Netherlands was and odd case, with 82% of the UK GDP per capita, but fell behind about 7 pp. Among the diverging countries with low GDP per capita was Spain, Portugal and Greece that fell 6.7, 14.6 and 19 pp behind, respectively, and had a GDP per capita level relative to the UK of 42, 25 and 24 pp.

Figure 12

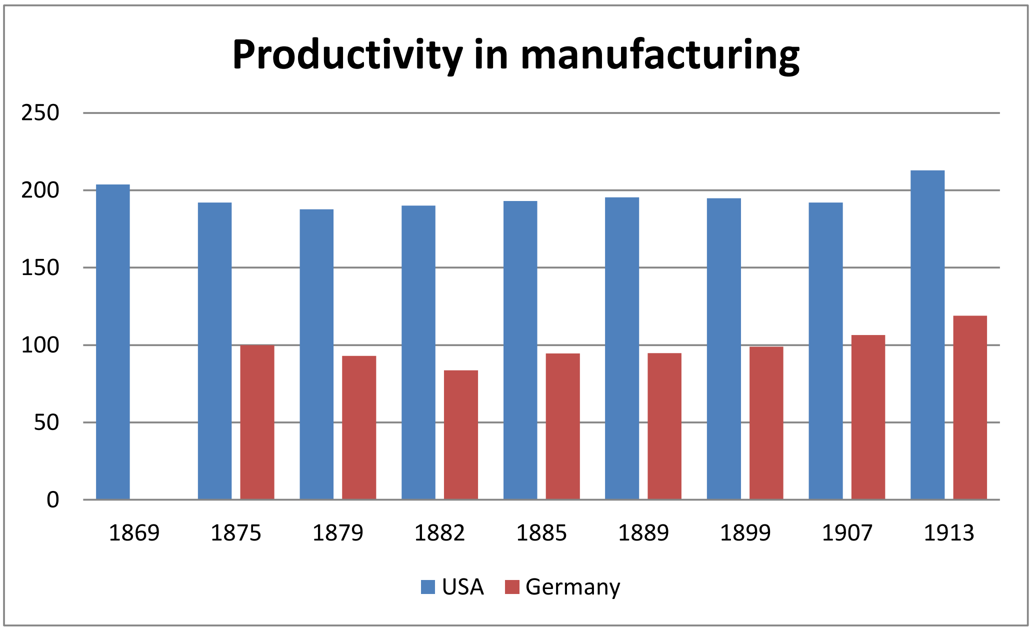


However, the picture is quite different if we consider only the manufacturing sector. According to data assembled by Broadberry (1993, 1998), the US had already in 1869 the double of labor and total productivity in manufacturing when compared with Britain. Although productivity in the US was lower in agriculture and in services, by 1910 all sectors, except finance had completely caught-up or maintained its large lead like manufacturing and transport. It is also interesting that while capital per worker was lower in the US in the 1870s, by the end of the 19th century was already 50% above the capital intensity in Britain. So, the difference in productivity was due to both higher capital intensity and technological factors (standardization and mass production are among the ones cited by the author).

Germany had in 1882 about 83% of Britain productivity in manufacturing, and started to catch-up rapidly at the end of the century to overtake Britain in the first decade of the 20th century. After the turn of the century productivity in Germany was rising rapidly (Figure 13). By 1913 it had already a much higher productivity than Britain (about 120%). Germany had particularly high productivity in chemicals and metals and engineering products.

The GDP and manufacturing time series are reconcilable. GDP catch-up occurred due to the shift of labor out of agriculture (e.g. more than 20 pp in the US from 1870 to 1910, 15 pp in Germany, against 10 pp in the UK), which had lower labor productivity in the US and Germany, and improving the productivity in services, according to the evidence provided by Broadberry (1993, 1998).

Figure 13



Source: Broadberry (1993)

7. Transportation and communication costs

Consider a product that moves from location A in country X and location D in country Y, using an export port B in country X and an import port C in country Y.[39] There are three distinct components in the trade cost: two intra-national costs and one international trade costs. First, there are marginal intra-national trade costs in country X as the product moves from the location of production (or origin), that may involve an export intermediary, and the port of export:

$$P_{Ex} - P_0 = \tau_X(X_d^X) + \mu_X$$

Which states that the price gap between the location of origin and port of export, $P_{Ex} - P_0$, is the sum of the marginal intra-national trade costs ($\tau_X(X_d^X)$, that includes transportation and communication costs, which is a function of distance and other locational factors) and a mark-up (μ_X) charged by traders. Second, there are international trade costs associated with moving the good from the export to the import port, usually measured by the difference

[39] There might be cases of entrepots that the product has to transpose or other intermediate ports or countries. This is the case of landlocked countries.

between the cif and fob price of the good, plus the tariff or other border costs associated with quantitative restrictions at the border level:

$$P_{Im} - P_{Ex} = \tau_{XY}\left(X_d^{XY}\right) + \mu_{XY}$$

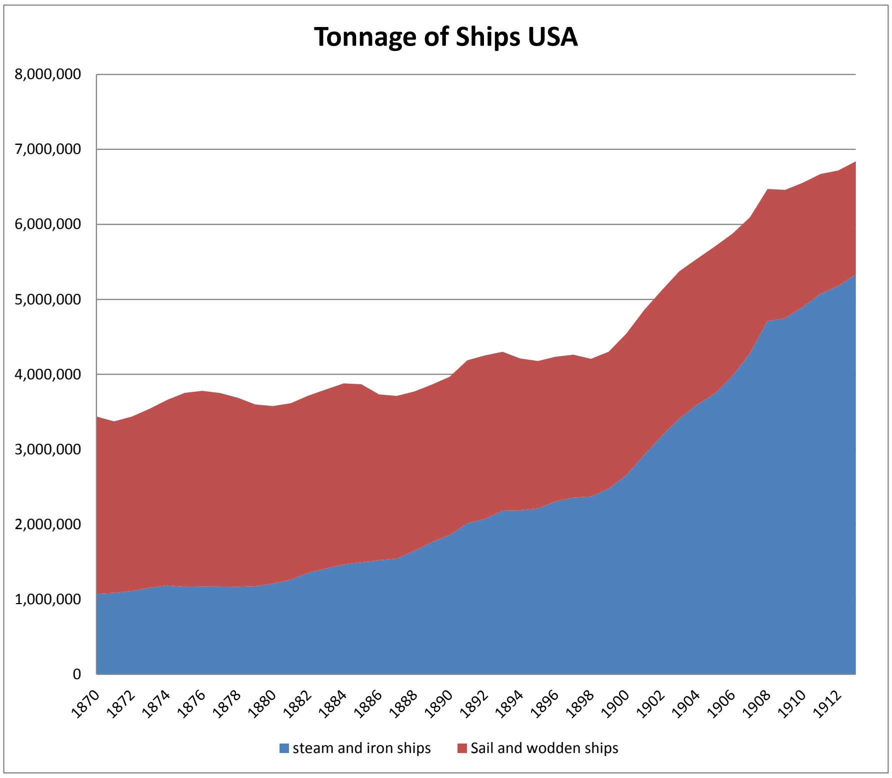
which states similarly that the difference between the import price in country Y and export price in country X is a function of trade costs and intermediation charges of the export-import business. Trade costs involve transportation and communication costs which are a function of distance, in general, and also other border costs, as stated, and the intermediation mark-up. Third, there are marginal intra-national trade costs in country Y as the product moves from the location of importation that may involve an import wholesale or other type of intermediary, and the local of use of the good:

$$P_f - P_{Im} = \tau_Y\left(X_d^Y\right) + \mu_Y$$

Which states that the price gap between the final price at the location of use and port of import, $P_f - P_{Im}$, is the sum of the marginal intra-national trade costs ($\tau_Y\left(X_d^Y\right)$, that includes transportation and communication costs, which is a function of distance and other locational factors) and a mark-up (μ_X) charged by traders.

<u>Reduction in Transcontinental Transportation Costs</u>. According to the British Index of transcontinental transport computed by Harley, the freight costs by ship were cut by 65% between 1850 and 1913. Although this represents already a substantial decrease in trade costs, it sub estimates the true transportation costs. In fact, after 1850, and particularly after 1870, there was a significant substitution of steel ships powered by steam engines for wooden ships with sails. Figure 14 illustrates the evolution of both modes of transportation by US ships.

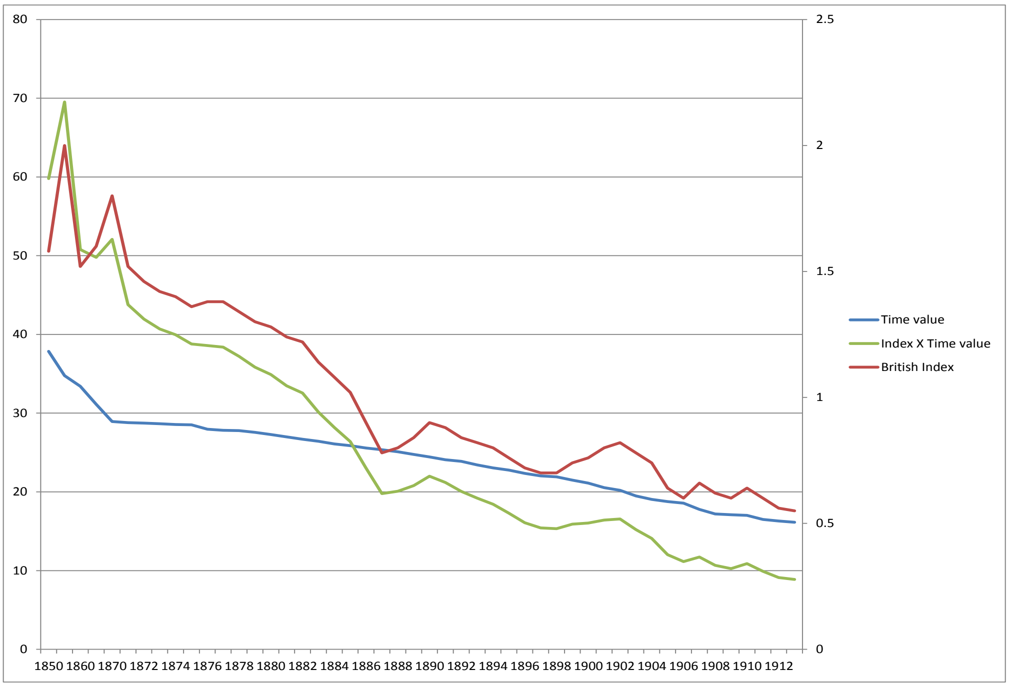
Figure 14



Source: BoC, 1947.

While the first type represented only 25% of total tonnage, at the beginning of the period, in 1913 they represented 68% of the total. Transportation by steel and steam ships was not only more reliable in terms of time of arrival but also more secure. However, there is another important source of sub estimation related to the value of time. In a transatlantic route, the duration of a voyage was about 35 days in 1850, and had been reduced to about 8 days in 1913 in the steamship steel boats. Matching shipments that are equal in all respects except mode of transport, Hummels (2001) estimates the value of time saved at 0.5% of the value of goods, per day. We do not have enough data to replicate this estimation for the 19th century. Assuming a similar value, we multiplied the Harley index by a factor representing the economic value of saved time (Figure 15). The result is a reduction in transportation costs equivalent to 85%.

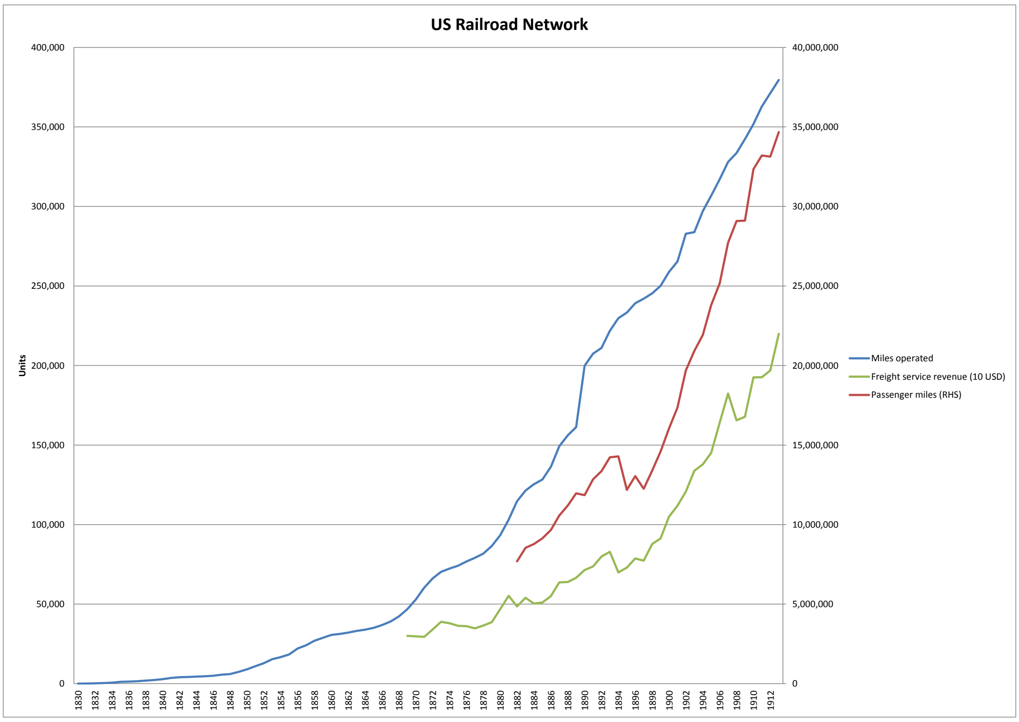
Figure 15



Source: Author´s estimation. From Factors Globalization I, (3)

<u>Reduction in Domestic Transportation Costs</u>. The construction of the railroad network first in Britain and continental Europe, in the US as well as in several colonies had a large economic impact, by reducing transportation (and distribution) costs and enlarging the market access. In the case of the US, seminal work done by Rostow and other historians placed the railroads at the core of the American industrialization (and take-off) process. The large expansion of the rail network in the US is illustrated in Figure 16. However, Fogel contested its impact, considering the opportunity costs of building a water canal network. Starting with Fishlow and other authors, the estimates of the economic impact of railroads, usually measured in terms of the value of agricultural land, has been shown to underestimate its impact, not least because the alternative scenario from which the economic opportunity cost is estimated, but also considering the impact of railroads in cutting monopoly rents due to market fragmentation. Recent work by Donaldson and Hornbeck (2012) confirms the important economic role of railroads. Using a reduced form estimation based on general trade theory equilibrium, and optimizing county-to-county network, they estimate that railroads had contributed in 1890 for 73% of land value and 6.3% of GDP. This impact includes not only the direct impact on increasing the market by connecting a given destination with a lower cost source of supply, particularly when this connection has large trade costs and the market population is large, but also the spillover effects that such reduction has on other suppliers that see their market increase.

Figure 16



Source: BEA, Historical Statistics

Another important factor considered by Hummels et al. (2007) is the opportunity cost of time in transport. Assuming the same cost, if we compare two dates with a reduction in time of travel, there is obviously a reduction in transportation cost due to technological improvement. If there are two matched shipments in terms of commodities and route but one shipper prefers one mode of transport to another must be because he values time of shipment. Moreover there may be different quality of service in terms of reliability and security. Using US import data the authors estimate that avoiding one day of delay is worth 2% of the value of shipment for road vehicles and .2% for footwear. Hummels (2001) computes an average of .5% per value per day. We use these estimates for improving the index of transport costs.

Reduction in Communication Costs. Equally important for long-distance trades were communication costs. Before the invention of the telegraph the speed of communication was closely linked to the speed of transportation.[40] There were two major innovations invented during the period under study: telegraph and telephone that delinked communication and transport technologies. Cooke and Wheatstone had their first commercial success with a telegraph installed on the Great Western Railway over the 13 miles (21 km) from Paddington station to West Drayton in 1838. An electrical telegraph was independently developed and patented in the United States in 1837 by Samuel Morse. His assistant, Alfred Vail, developed the Morse code signaling alphabet with Morse. The first telegram in the United States was sent

[40] "In the beginning of the nineteenth century letter-writers in England could expect to wait up to two years for an answer to a letter to Calcutta. Ships often had to wait for weeks to sail the 80 miles up the Hooghly river from the Bay of Bengal to the city, and the monsoon winds precluded fast return journeys. By the 1840s the time of a one-way journey from London to Calcutta had fallen to six weeks, and by 1914 the voyage could be made in two weeks ." (Mokyr, 1990, p. 129). This is a fall from 100 in 1800 to 10.7 in 1840 and then to 3.56.

by Morse on 11 January 1838, across two miles (3 km) of wire at Speedwell Ironworks near Morristown, New Jersey. The Morse/Vail telegraph was quickly deployed in the following two decades; the overland telegraph connected the west coast of the continent to the east coast by 24 October 1861, bringing an end to the Pony Express. At intercontinental level, the Atlantic Telegraph Company was formed in London in 1866 to undertake to construct a commercial telegraph cable across the Atlantic Ocean. It was successfully completed on 18 July 1866. The telegraph lines from Britain to India were connected in 1870. Australia was first linked to the rest of the world in October 1872. The telegraph across the Pacific was completed in 1902, finally encircling the world. For telephony, it is crucial the network of wires and the number of telephones connected. Taking data from the USA the number of telephones available per person increased 16.9 times just from 1876 to 1880, and by 3.9 in the next decade.

We computed a quasi-hedonic index based on the two time series and represented in Figure Z. In 1913 communication costs were only about 5% of the costs in 1850. The largest drop took place from 1850 to 1880 when communication costs were only 28% of the level at the beginning of the period.

Trade Policies: tariffs and commercial policies. Table 10 summarizes tariffs on manufactured products from the sources available. If weighted by the values of external trade in the different countries, we arrive at a world average of 20%[41] in 1850, 7% in 1870, which represents a decrease of about 65%, reflecting the wave of liberalization across the world. By 1870 the world more protectionist country was the United States of America followed by Latin America. The fall in protectionism was due to Continental Europe and mainly the open up of Asia.

Table 10

[41] The average for Asia in 1850 reflects the prohibition of trade in Japan, the difficulties of trade in China and several other Asian countries, and as such is a notional figure.

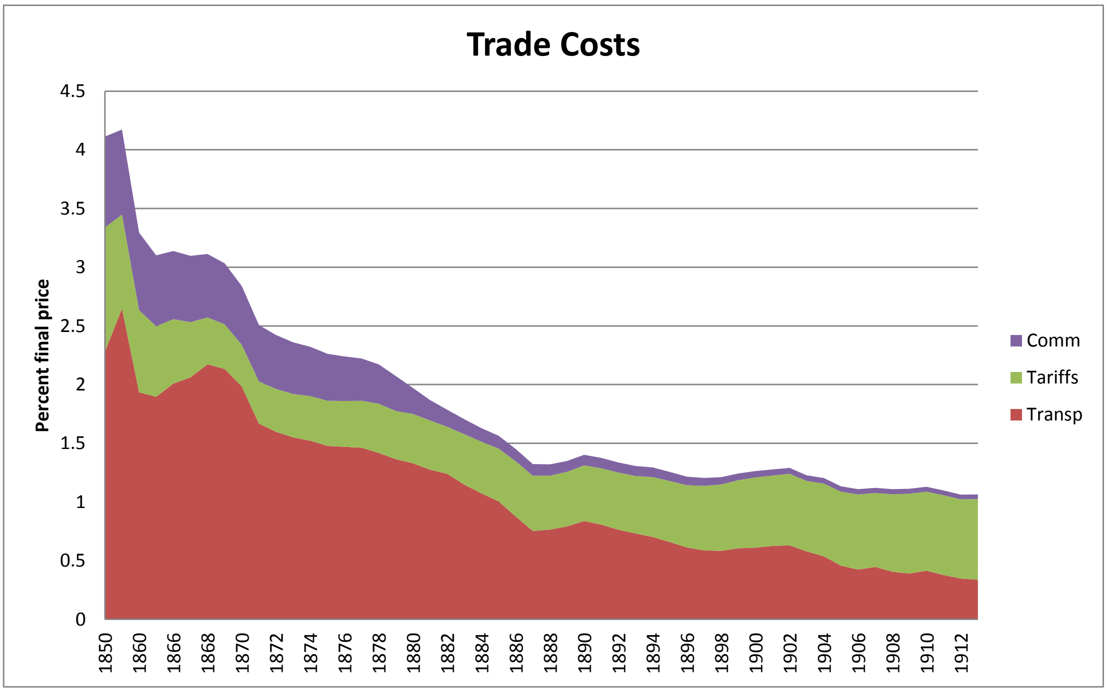
		World Average Industrial Tariffs				
			1850	1870	1890	1910
UK			0	0	0	0
Germany, France			16	9	12	16
Other developed Europe			18	10	13	17
Rest Western Europe			30	18	23	27
Total Western Europe						
Western Offshoots						
USA			25	35	40	44
Canada			0	0	22	26
Australia			0	5	5	16
Total						
Russia and Eastern Europe			30	20	30	40
Latin America			30	25	35	45
Asia			90	10	0	10
Africa			0	0	0	0
Average world tariff			20.11	7.16	9.54	13.53

Source: See Annex

From 1870 to 1890 the average tariff rate increased from 7 to 9.5%, an increase of about 33%. The increase affected almost all the world except for Britain and the British Empire. The increase in protectionism further increased to an average of 13.5%, equivalent to a rate of increase of 42%. Even so, the global average tariff was still 67% of the average of 1850. The highest levels of protection were in Latin America, the United States of America and Russia and Eastern Europe.

<u>Aggregating Trade Costs</u>. There is a simple way to aggregate all trade costs, including transportation, insurance and handling costs plus communication costs and tariffs. All these costs affect trade. It seems that we are the first to make this aggregation. We convert all costs to an average price of goods, so each one can be added ad valorem. Figure 17 presents that estimation using our estimates above for transportation costs corrected by value of time, communication costs and average world tariffs. Our estimates show a reduction of 74% in trade costs from 1850 to 1913, reaching 106% of the unit value of a good at the end of the period. The largest fall incurred from 1850 to 1870 (30%), and then up to 1887 (53% fall). After that date, the fall in transportation costs was in part compensated by an increase in tariffs. Even so, trade costs fell by an additional 20%.

Figure 17

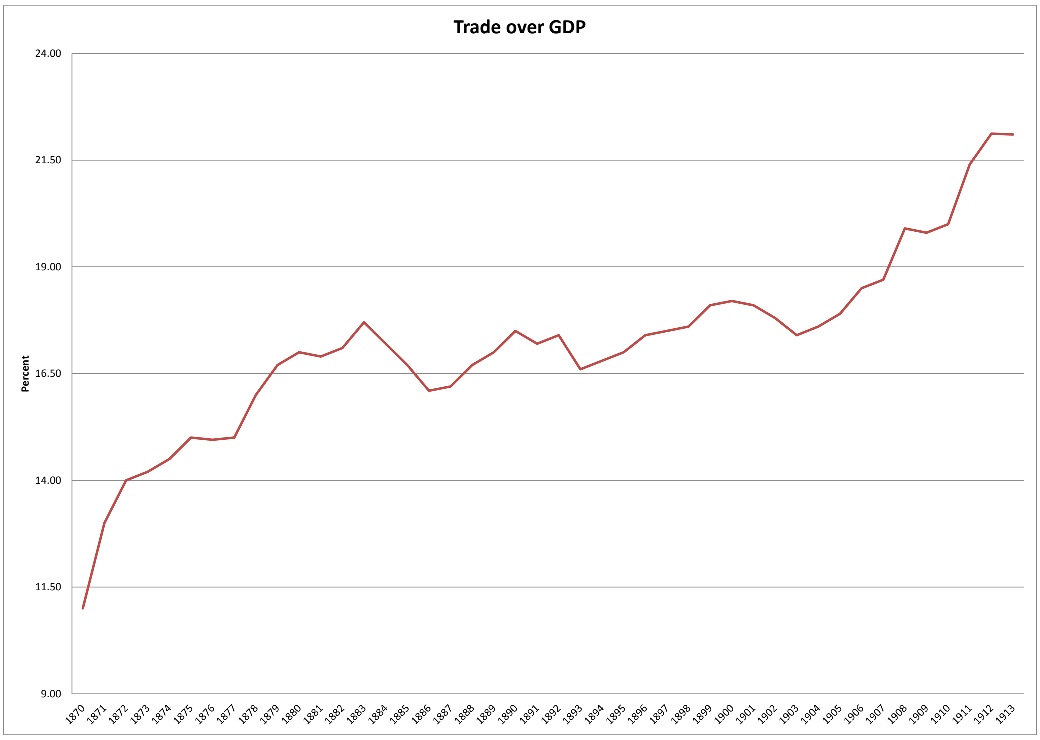


Source: Author´s calculations.

8. Explaining globalization

One of the most used measures of the intensity of globalization is the ratio of exports of goods or goods and services over GDP or the sum of exports and imports over GDP. In Figure 18 we present the ratio of exports over GDP using two recent data sets: one assembled by Taylor and associates, largely based on trade data by Mitchell (2007) and using Maddison (2001) data on GDP. The data by Taylor gives a larger increase (11.1 percentage points) of the ratio from 1870 to 1913. We can distinguish clearly three phases in the globalization process: the first from 1870 to around 1882 with very rapid increase, reflecting still the recovery of the US civil war but also of the very strong technological improvements and reduction in trade costs that had occurred in the two previous decades. The second phase, from 1883 to 1992, reflects the increase in barriers to trade and the strong process of import substitution taking place in the Western Offshoots.

Figure 18



Source: Estevadeordal et al. (2002)

The third phase takes place from 1902 to 1913, in the eve of the I World War, with a strong expansion as trade costs decrease substantially again and the interconnection between the Western offshoots and Europe intensify. The first wave of globalization ends with a ratio of exports of goods over GDP of about 21-22%, a ratio that would not be achieved again before the 1990s.[42]

The strong correlation between trade costs and the intensity of globalization in the first phase is quite obvious if we compare Figures 17 and 18: in fact, trade costs[43] fell faster in the 1870 to 1891 than at any period under study: at a rate of 18% per decade. In the period of 1850 to 1870 trade costs were already dropping at a rate of 11.9% per decade, the second highest rate in our study. In the second phase the rate of decrease was reduced to 9.1% and in the third phase to 6.2%. It remains to explain why despite the deceleration in the reduction in trade costs in the early 20th century globalization intensified. We believe that this was due to inertia carried on from previous periods and the intensification of network links between the systems of production in Europe and the Western Offshoots, mainly in terms of raw materials.

Let us exploit now the econometric evidence of the factors associated with the first wave of globalization. We first estimated a regression of the trade ratio on transport and communication costs and tariffs (Eq 1 of Table 11). All coefficients are of the expected sign, lowering transport and communication costs leads to an increase in the globalization index.

[42] Obviously with a much higher denominator, i.e., with a multiple of world GDP (see below).
[43] Trade costs include transportation and communication costs and tariffs. See the Statistical Annex for methods of estimation.

Moreover, we obtain a negative relation between tariffs and the globalization index, as expected, since increasing protection around the world should decrease the level of trade.[44] However, the estimates have a low rate of significance. The regression using Taylor series fares much better than the Flandreau series. Trade costs explain 74% of the variance in the Export GDP ratio in the first case and only 40% in the second case.

But behind these aggregate numbers there are profound structural changes: technology, human capital, institutional and resource allocation. Let us take the example of the US. For most of the century, the United States had a strong comparative advantage in agricultural goods and exported mainly raw cotton, grains, and meat products in exchange for imports of manufactured goods. But in the mid-1890s, America's exports of manufactures began to surge. Manufactured goods jumped from 20 percent of U.S. exports in 1890 to 35 percent by 1900 and nearly 50 percent by 1913. In about two decades, the United States reversed a century-old trade pattern and became a large net exporter of manufactured goods. Research by Irwin (2006) suggests that natural resource abundance fueled a dramatic expansion of iron and steel exports, in part by enabling a sharp reduction in the price of U.S. exports relative to other competitors. The non-tradability of American ore resulted in its distinctive impact on the pattern of U.S. trade; whereas raw cotton was tradable, and hence the domestic cotton textile industry did not reap an advantage from having local production of cotton.

Regressing the value of exports by Europe on GDP of Europe (Eq 2) on the GDP of Western Offshoots and trade costs increases the rate of adherence, with the right signs and GDP of Western Offshoots and trade costs being significant at 5% level. The estimation is done in logs and using least squares. The elasticity of exports to the new region is about .44.

Table 11: Regressions explaining Global Exports

[44] The "tariff paradox" of Williamson (2003) and others establishes a positive relation between tariffs and economic growth. Since growth in GDP is associated with growth in exports the same relation would appear between tariffs and exports. However, we think that the correlation between tariffs and GDP growth does not lead to direct causation. First, the relationship has not been tested within a full specification of a growth model. Second, the fragility of the statistical data does not allow for any sophisticated econometric analysis. Third, as we will demonstrate, the tariff effect may be associated with omitted variables like institutional and technological development. Fourth, microeconomic studies do not support such conclusion like the impact of tariffs on iron and steel and tin plates in the case of the US (Irwin 2000). The abundant iron ore deposits around Lake Superior, the rich coal veins of Pennsylvania and the easy access to cheap water transportation routes on the Great Lakes, the Midwest became the center of American heavy industry. In the years after the Civil War, the American steel industry grew rapidly as the economy expanded to become the largest in the world. Between 1880 and the turn of the century, steel production increased from 1.25 million tons to more than 10 million tons. By 1910 America was producing more than 24 million tons, by far the greatest of any country. Irwin (2006) conducted extensive research on the relationship between protection, productivity and GDP growth questioning the conclusions of some authors justifying the need for protectionism for industrialization (e.g. Chang (2002)).

	Eq 0	Eq 1	Eq 1.1	Eq 1.2	Eq 2	Eq 3	Eq 4	Eq 5	Eq 6
Dependent variable	Exp over GDP 1/	Exp over GDP 2/	Exp over GDP 2/	Exp over GDP 2/	Log ExpEU	Log EXpWO	Log ExpEU+WO	ExpEU+WO	ExpEU+WO
Constant	26.478 (.862)	30.601 (10.752)	28.489 (6.107)	21.997 (4.672)	4.056 (2.599)	8.408 (8.113)	.705 (1.203)	1.362 (4.272)	-.628 (4.458)
Log GDP EU					.154 (.381)	-.003 (.647)			
Log GDP WO					.443 (.212)				
Log GDP EU + GDP WO							.822 (.076)	.779 (.331)	1.074 (.390)
Transport and communication									
Transport costs		-6.988 (6.276)	-4.708 (6.107)	-1.962 (2.589)		-.235 (.634)		-.394 (.385)	-.393 (.381)
Communication costs		-1.428 (4.772)	-2.021 (4.579)			-.491 (.467)		-.248 (.279)	-.347 (.284)
Tariffs		-11.972 (11.226)	-18.163 (11.142)	-10.431 (6.039)		3.085 (1.629)		-.494 (.989)	-.935 (1.028)
Trade costs	-5.897 (.536)				-.382 (.134)		-.405 (.129)		
Inst and Political			.845 (.398)	.785 (.586)					-.169 (.121)
R-squared	0.743	0.399	0.464		0.957	0.94	0.962	0.964	0.965
F-statistic	121.15	8.664	8.208	8.208	296.06	148.18	519.9	251.9	206.8
DW	0.266	0.309	0.321	0.281	0.579	0.715	0.541	0.454	0.518
	LR	LR	LR	Co-integrat	LR	LR	LR	LR	LR
1/ Taylor data									
2/ Mitchell-Flandreau data									

A similar regression (Eq 3) for the exports of the Western Offshoots gives the right sign for transport and communication costs, but with a low level of significance. However, the GDP of Europe is without any explanatory power and tariff rates are now positive and significant at 10% level.

Estimating a linear regression model for the total value of European and Western Offshoots exports (Eq 4) produces an elasticity of .82 for GDP of the aggregated regions and the right and significant coefficient for trade costs with an elasticity close to .4.

A decomposition of trade costs by each component does not improve the precision of the regression (Eq 5). However, all the components of trade costs have the right signal.

We suspect that the inclusion of tariffs in our regressions picks up the effects of some omitted variables. It is clear that there was significant technological progress and institutional development during the 1870-1913 period. The level of technological progress may be captured by the number of patent applications (Eq 6). We have only statistics for the US and UK. This variable (patents of the US) is included in Eq 1.1. and 1.2 to explain the ratio of Exports over GDP and it comes out with the right sign and is mildly significant. A 1% increase in patent applications would lead to an increase of about .2 percentage points in the ratio of exports over GDP.

The level of institutional development is closely related with the level of literacy of the populations.[45] The matrix of partial correlations confirms the suspicion that tariffs are highly correlated with the institutional factors,[46] as Table 12 below demonstrates.

Table 12

Correlations among factors of globalization

	TRGDPFLEAUU	TRANSP	TARIF	COMM	LIT	PATUS	PATUK
TRGDPFLE	1	-0.5775901	0.49489609	-0.61712	0.498451	0.579604	0.366778
TRANSP	-0.577590104	1	-0.96783167	0.909049	-0.98405	-0.93904	-0.93234
TARIF	0.49489609	-0.96783167	1	-0.79856	0.98543	0.947716	0.906566
COMM	-0.617121167	0.909049161	-0.79856067	1	-0.86126	-0.79879	-0.87346
LIT	0.498451344	-0.98404893	0.985430226	-0.86126	1	0.955179	0.95343
PATUS	0.579604021	-0.93903924	0.947716457	-0.79879	0.955179	1	0.883311
PATUK	0.366778371	-0.93233594	0.906566284	-0.87346	0.95343	0.883311	1

	EXPEU	EXPWO	GDPEU	GDPWO	TRANSP	TARIF	COMM	PATUK	PATUS
EXPEU	1	0.964630594	0.977168359	0.977518	-0.94452	0.958406	-0.79038	0.835731	0.965848
EXPWO	0.964630594	1	0.974836381	0.973025	-0.92967	0.970371	-0.74348	0.827424	0.919066
GDPEU	0.977168359	0.974836381	1	0.993497	-0.95346	0.989764	-0.7685	0.886691	0.96329
GDPWO	0.977518332	0.973025164	0.993496764	1	-0.94192	0.982266	-0.7477	0.864277	0.96813
TRANSP	-0.94451943	-0.92966729	-0.95346143	-0.94192	1	-0.96783	0.909049	-0.93234	-0.93904
TARIF	0.958405871	0.970370922	0.989763909	0.982266	-0.96783	1	-0.79856	0.906566	0.947716
COMM	-0.79038049	-0.74347571	-0.7685027	-0.7477	0.909049	-0.79856	1	-0.87346	-0.79879
PATUK	0.835731119	0.827423583	0.886691045	0.864277	-0.93234	0.906566	-0.87346	1	0.883311
PATUS	0.965847767	0.919066146	0.963289905	0.96813	-0.93904	0.947716	-0.79879	0.883311	1

The correlations between tariffs and patents are fairly high, and the negative correlation with transport costs will cause also multi-colinearity problems in estimation. Notice that the correlation between tariffs and either the ratio of exports or the level of exports is again evidence of the "tariff paradox". There is also a high level of positive partial correlation between tariffs and the literacy rate.

9. Conclusions and further research

This paper presents a reinterpretation of the first wave of globalization. First, we emphasize the interaction of growth and trade: globalization would not have occurred without the spurt of growth associated with the second industrial revolution, and the substantial acceleration of growth (more than trebled) would not have achieved such high rate without the intensification in cross-border transactions. However, reviewing the literature we find that theoretical foundations for that interaction are still in its infancy even after the contributions of the new and new-new trade theory and endogenous growth. Second, while the works of O´Rourke and Williamson and Pomeranz have focused on several of the same factors, we recast the factors

[45] See Mateus, A. (2013) for econometric evidence.
[46] And to complicate, highly negatively correlated with transport costs.

of globalization by emphasizing a natural experiment: the massive transfer of human capital (only for the US this transfer is estimated at 1.6 trillion USD) and the transplant of Western European institutions from Western Europe to the Western Offshoots are the two main factors behind the globalization-cum-growth. This is in line with most of the recent literature on growth that emphasizes the role of human capital and institutions.

Third, the acceleration of technological progress, carried in tandem in both sides of the Atlantic: US, Britain and Germany and later also France and other NW European economies, created the conditions for rapid economic growth and also the intensification of cross-border trade and investment. Business networks as well as financial networks started to play a major role in globalization and economic growth of the Western Offshoots.

Forth, the globalization led to a massive expansion in the world production possibility set (more than a third of the previous existing resources) due to the incorporation in the world economic system of the natural resources of the New World and the incorporation of the resources associated with Asia. Fifth, demographic transition, economic and political integration in Europe and the incorporation of the Asian countries in the world economic system also led to an expansion of the global market, which created the possibility of exploring resource structure differentials, economies of scale and agglomeration economies.

Sixth, convergence of the Western Offshoots was quite rapid. Already from the 1860s on, there is evidence that the US had the double of Britain labor productivity in manufacturing and the US became the leading developed country by the turn of the century as a result of factor reallocation away from agriculture. The factors that explain that convergence are again human capital accumulation and physical capital accumulation. Total factor productivity plays a much lower role than in the 20th century, which is in line with recent estimates across countries that show that this factor has a lower relevance in the first stages of development.

Seventh, convergence of several countries in Continental Europe and especially Germany to the British levels was also rapid after the 1870s, with this country overtaking Britain at the beginning of the 20th century. Technological progress in technical universities and corporate R&D also plays a major role in the case of US and Germany vis-à-vis Britain.

Finally, we also document the importance of the extraordinary reduction in overall trade costs. Building a composite index of trade costs we demonstrate the strong fall in these costs, even taking into consideration the increase in protectionism in the last decades of the 19th century.

What was behind the increase in world trade? We confirm evidence that the decrease in transportation and communication costs closely linked to technological changes was one of the most important factors, besides the increase in GDP on both side of the Atlantic. However, we should not forget that what enabled all these effects to deepen trade-cum-growth were the fact that the Western Offshoots were transplant economies: common institutions and culture. We pick up some evidence by including institutional and political factors in the previous regression.

In the rest of the World, namely vast regions of Asia, Africa and Latin America, standards of living did not increase appreciably, and they had to wait until the second millennia of the 20th

century to experience either a take-off or acceleration in their growth rates. Some enclaves of development appeared in these countries associated with the exploitation of natural resources or for colonial dominance.

Our analysis shows how deceptive is to extract lessons from this epoch to the present problems of developing countries. How can we compare any present African country with the 19th century US and take inferences, e.g. on trade policies? We hope our contribution can bridge the research of most historians with present research on the economics of development and trade.

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