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FOREIGN TRADE, TECHNOLOGICAL CHANGE AND ECONOMIC GROWTH IN THE U.S.: 1820-1913

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ABSTRACT

Master's Thesis

Foreign Trade, Technological Change and Economic Growth in the U.S.: 1820-1913

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United States experienced an impressive economic growth between 1820 and 1913. Over this period United States had been transformed from a raw material supplier to a manufacturing economy. Roles of various factors were stressed in order to explain the 19th century economic performance of the United States by numerous scholars.

In neoclassical development studies on the other hand, positive role of foreign trade on technological change and economic performance has been asserted frequently. Some economists however, argue the converse and stress that core countries did not benefit from free international trade during their development process. In line with these discussions, causal relationships between technological change, foreign trade and economic growth of the American economy are investigated in this thesis for the periods of 1820-1860 and 1866-1913. In this study, foreign trade is measured by trade openness ratio; annual number of patented inventions per capita is used as the proxy of technological change and economic growth is represented with GDP per capita series. Granger non-causality test with Toda-Yamamoto approach is applied to these series. Results of this test suggest merely unidirectional causality from GDP per capita to trade openness ratio and from GDP per capita to the number of patented inventions per 1000 capita for the post-Civil War period. No causality relationship is found for the pre-Civil War period.

Keywords: United States, American Economic History, Patent, Trade Openness, Protectionism.

ÖZET

Yüksek Lisans Tezi

Amerika Birleşik Devletleri'nde Dış Ticaret, Teknolojik Değişme ve Ekonomik Büyüme: 1820-1913

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Dokuz Eylül Üniversitesi

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İngilizce İktisat Anabilim Dalı

İngilizce İktisat Programı

Amerika Birleşik Devletleri (ABD) 1820-1913 yılları arasında etkileyici bir ekonomik büyüme performansı sergiledi. Bu süreçte ABD hammadde sağlayıcısı olmaktan çıkıp üreten bir ekonomi haline geldi. ABD'nin 19. yüzyıldaki ekonomik performansını açıklayabilmek adına birçok akademisyen çeşitli faktörlerin rolleri üzerinde duran çalışmalar yaptı.

Neo-klasik kalkınma çalışmalarında ise bugüne kadar sıklıkla dış ticaretin, teknolojik değişme ve ekonomik performans üzerindeki olumlu rolü vurgulandı. Bu iddianın aksine bazı iktisatçılar ise merkez ülkelerin kalkınma süreçlerinde serbest uluslararası ticaretten faydalanmadıklarını savunur. Söz konusu tartışmaların ışığında, bu tezde ABD'nin 1820-1860 ve 1866-1913 yılları arasındaki teknolojik değişmesi, dış ticareti ve ekonomik büyümesi arasındaki nedensellik ilişkisi araştırılmıştır. Bu tezde dış ticaret, ticarete açıklık oranı ile, teknolojik değişme 1000 kişi başına düşen patent almış icat sayısı ile, ekonomik büyüme ise kişi başına gayri safi yurtiçi hasıla (GSYİH) ile temsil edilmektedir. Bu serilere Toda-Yamamoto yaklaşımına göre Granger nedensellik testi uygulanmıştır. Bu testin sonuçları Amerikan İç Savaşı sonrası dönem için kişi başına GSYİH'den ticaret açıklığına ve kişi başına GSYİH'den kişi başına düşen patent sayısına doğru tek yönlü 2 adet nedensellik ilişkisi ortaya koymuştur. Amerikan İç Savaşı öncesi dönem için ise seriler arasında herhangi bir nedensellik ilişkisi bulunamamıştır.

Anahtar Kelimeler: Amerika Birleşik Devletleri, Amerikan İktisat Tarihi, Patent, Ticaret Açıklığı, Korumacılık.

FOREIGN TRADE, TECHNOLOGICAL CHANGE AND ECONOMIC GROWTH IN THE U.S.: 1820-1913

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ABBREVIATIONS

ADF	Augmented Dickey-Fuller
GDP	Gross Domestic Product
I(0)	Integrated of order zero
I(1)	Integrated of order one
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
p. c.	Per capita
PP	Phillips-Perron
R&D	Research and Development
SEUM	Society for Establishing Useful Manufactures
UK	United Kingdom
US	United States
WWII	World War 2

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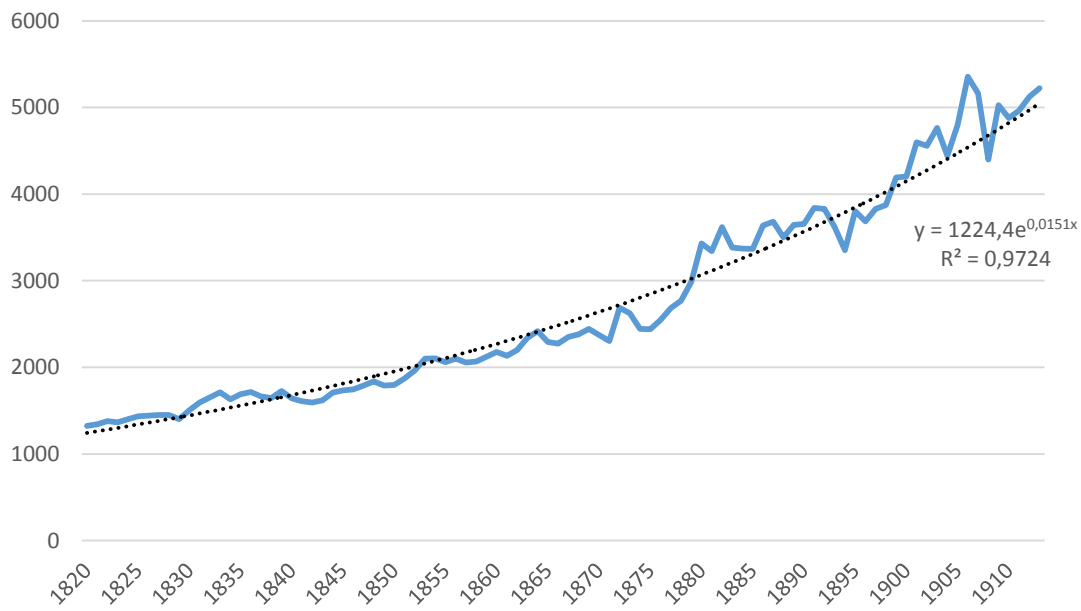
INTRODUCTION

In the aftermath of WWII, development policies for less-developed and developing countries became an important research area in economics. Since then, unequal international competition, dependency of periphery countries and capitalism, with reference to global power structure have been discussed intensively. Historical development patterns of core countries can be a good guide for periphery countries. However, due to dominance of neoclassical approach in economics since the 1970s, development issue has been discussed predominantly with reference to short-run macroeconomic variables such as government budget balance, inflation rates, and current account balance. Investment, industrialization, state intervention and planning have lost the pivotal positions that they occupied in the 1960s. Regardless of their industrial capability, periphery countries were advised by international economic authorities, to lower public spending and to abolish international trade barriers. Free international trade has opened the doors of periphery country markets to the firms of core countries. International competition is supposed to reduce inefficiency and make the developing countries better off. Firms from core countries nevertheless hold the knowledge monopoly, i.e. patents and capital. Moreover, they have colossal organizations with low operational costs. Since local private and public enterprises could not compete with and survive against these firms, critical sectors have been unable to improve in many cases. Thereupon contributions of global economic freedom to long-run economic condition of periphery countries have become somewhat questionable.

This puzzle has been the main motivation of this study. Following questions await answers: What had happened in the economic history of developed countries? What kind of a trade policy had been pursued? Can the significance of recent neoclassical recommendations concerning trade openness-technological change-economic growth relationship be tested for a developed country in the historical context? Had United States, as one of the most remarkable example of a core country, benefited from international trade in its industrialization and development process? If they had, had trade-induced-growth occurred through international spillover of knowledge and technological advancement, or via another channel?

Progress and rapid economic growth of the United States have been studied by many scholars. Various factors, such as population growth, land abundance, institutions, resource abundance, infrastructure investments (canals and railroads), technological change, trade, slavery, an effective banking system, universal education system and infant industry protection were used to explain the impressive 19th century economic performance of the United States. Due to unique conditions of the country, whether American development was an exceptional process in the economic history has been a source of debate among scholars. Indeed, United States as a group of former crown colonies of the UK, had caught up Britain during the 1870s in GDP and in the first decade of the 20th century in GDP per capita. In spite of increasing population, GDP per capita grew exponentially over the course of the 19th century (Figure 1). Subsequently, United States became the undoubted superpower of the 20th century.

Figure 1: U.S. - Real GDP per capita in 1996 dollars (1820-1913)



Source: Sutch, 2006: Table Ca9-19

Since the time of the first settlement of the English colonists in Virginia, lands of North America have always been hosting agricultural production. After the

Independence War and the political liberation of the American colonies from the British hegemony in the late 18th century, 19th century turned into a second liberation era for the young nation from dependency and economic imperialism. In the 19th century, industrial production began in the United States. As artisans lost their economic role, hand and water powered manufacturing was replaced with steam powered manufactures. Industrialization altered the character of former American colonies and carried out a transformation from a raw material supplier to a machinery producer economy. Over the same period, the number of patents issued in the US also increased substantially.

Besides, means of transportation had developed rapidly during the same period. In 1830, first miles of the American railroads were constructed. These first miles were just an initial part of a huge national railroad network, which was built over the course of the 19th century. Railroad network enabled Americans to move westwards and to reach new lands, on which they can settle and produce. The number of steam powered merchant ships also increased dramatically, from 22 registered ships in 1820 to more than 5000 vessels in 1911 (Palgrave Macmillan Ltd., 2013: F4 North America). These developments changed the structure of internal and external trade of the United States profoundly.

In order to investigate the above mentioned questions about development and structural changes in the American economy, this master thesis focuses on the causality relationship between foreign trade, technological change and economic growth series of the United States between 1820-1860 and 1866-1913. In our study, foreign trade is subject to trade openness ratio; annual number of patented inventions is used as the proxy of technological change and economic growth is represented with GDP per capita series. Following the introduction, firstly, theory, history and literature are discussed. However, our aim is not to discuss the recent theory emerged in the 1990s on trade, technology and growth in depth. The literature on the American economic history is covered more comprehensively. Secondly, data and methodology will be explained. Econometric tests for 3 series will be performed and findings will be presented. In time series analysis, Augmented Dickey Fuller (ADF), Philipps Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests were applied in order to detect the maximum order of integration. Toda-Yamamoto

procedure have been used for Granger non-causality test. In addition, serial correlations and dynamic stability of Vector Autoregressive Model (VAR) were checked. To the best knowledge of the author of this thesis, an econometric analysis, which investigates the relationship between growth, technological change and foreign trade for the United States covering the 1820-1860 and 1866-1913 periods was not performed so far. Hence, this research can make a contribution to the body of knowledge in American Economic History.

CHAPTER ONE
THEORY, HISTORY AND LITERATURE

Several scholars, among them such as Grossman and Helpman (1990, 1994), Acemoglu (2008: 789-796), Rivera and Romer (1990) have discussed the theory of relationship between economic growth, international trade and technology. Two models, based on simple assumptions, were presented: "learning by doing" and "learning by exporting".

In "learning by exporting" model, it is argued that markets and profit opportunities expand due to free international trade. Reaching global markets and various profit opportunities encourage inventing activity and induce technical change emerged from technological spillover. Diffusion of technical change within and among sectors triggers long-run economic growth. In this schema optimism rules and both parties of international trade win. Nevertheless, comparative advantage and specialization in low-tech industrial and/or agriculture sectors may deteriorate this optimism. A country, specialized merely or predominantly in labor intensive sectors due to her comparative advantage, would not have the skilled human capital and required physical capital to take the advantage of any international technological spillover. Patents and monopoly rights accumulate in the countries, which are specialized in capital intensive manufacturing. Hence, "learning by doing" emerges as a counterpart model. In order to avoid wrong specialization, and accordingly a probable poor long-run economic growth, foreign trade is restricted, national industries are created and supported by the state. Thereupon, in the closed economy of a less-developed country, products of national infant industries with lower quality and higher operational costs can have the playground to compete, improve, subsequently develop own patented inventions and step into international competition in the long run.

1.1 FOREIGN TRADE POLICY AND TRADE OPENNESS

Debate on foreign trade policies (protecting the local private and/or public enterprises or allowing the international trade) had been crucial over the course of the 19th century both in Europe and the United States. Consequences of trade policy preferences, the effects of tariff rates, or generally effect of protectionism (including state interventions in terms of various incentives for domestic manufactures) on the growth pattern of a country have been discussed by numerous scholars. In spite of the ongoing controversies over the role of tariff rates and foreign trade in economic growth, mainstream economics tends to agree on positive role of foreign trade. Welfare state of post-WWII era have been increasingly replaced by the minimal state, deregulation and free international trade since the end of the 1970s. Correspondingly many economists such as Feyrer (2009), Sachs and Warner (1995), Frankel and Romer (1999), Williamson (2002) have emphasized the role of foreign trade and its benefits in economic performance. Over the course of time, free international trade argument have been considered as a universal remedy in international political and bureaucratic circles regardless of other conditions. However, some economists such as Hudson (2004), Rodrik (2006: 973), Stiglitz (2002), Chang (2002) have criticized the "stabilize, privatize, liberalize" motto. Particularly Chang (2002) analyzes the historical roles of foreign trade and protection in the long-run development experiences of each developed country and assigns the highest value to protectionist tariff rates and state intervention as a common feature during the industrialization era of western economies.

Outcome of foreign trade policies depends very much on the output composition of an economy, on the proportions of capital-intensive and labor-intensive products in a country's total output. Hence, efforts of claiming a trade policy law, i.e. a universal recipe for all economies –regardless of technological superiorities, capital stocks, demography, geography and other causal links– may be quite misleading. Moreover, since development is a dynamic process, specific cultural features, and political and socioeconomic events have also unique roles to play in each country's historical performance. Interests and dominance of economic

classes vary in each country due to her specific conditions. For instance, British landholders as a protectionist interest group in Britain were opposing repeal of Corn Laws in the first half of the 19th century. On the other side, capital abundant British manufacturers had been lobbying for free trade. Simultaneously however, American farmers -free trade supporters of the United States- had been enjoying cheap and abundant land, and seeking for more opportunity to trade with Europe, while American industry was struggling in internal market and trying to grow mature in order to become internationally competitive (O'Rourke and Williamson, 2001: 77, 114).

Friedrich List (1789-1846) and Alexander Hamilton (1755-1804) had been the most prominent protagonists of protectionist school of thought, though it should be noted that Hamilton became Friedrich List's influence, during List's exile in the United States (1825-1830). As such, Friedrich List converted dramatically from international trade advocacy to protectionism and became the prominent national economist of Europe (Chang, 2002: 25).

1.1.1 American Protectionism and Alexander Hamilton

Debates between the first Secretary of the Treasury Alexander Hamilton and the first Secretary of the State (and subsequently the third President) Thomas Jefferson shaped the future of long term American economic vision. Jeffersonian projection was an agrarian economy, based on the free market principles with many small producers. State-business cooperation and large scale manufacturing was condemned by Jefferson since those were perceived as too British for the recently liberated United States (Irwin, 2004: 815; Lind, 2012: 25,26). On the other side, Alexander Hamilton was the winner of this struggle and became the distinguished character of the American economic history. Hamilton's influences were British and French state-backed economic modernization experiences (Lind, 2012: 50-52). Despite numerous extraordinary events in American social and economic life, philosophy of "Report on Manufactures" (Hamilton, 1892) kept its relevance for a very long time. Hamilton's views were sustained by important political characters of

the American history such as Henry Clay and Abraham Lincoln. In contrast with the Jefferson's support for free trade and dominance of agricultural production, Hamilton proposed to the U.S. Congress to take action for industrialization by approving various incentives and tariff rates (Irwin; 2004; 802,803). Alexander Hamilton's report (1892; 51-56) consisted of articles such as imposing "high tariff rates for foreign rival manufactures", "prohibiting the exportation of the materials of manufacture and exempting the materials of manufactures from duty", aiming at protecting American infant industries from unequal international competition, or in other words from British industrial superiority.[1] Even though the report was not considered as a whole, proposals on tariff rates were subsequently approved by the Congress (Irwin; 2004; 801). After a while, Jefferson's administration also issued similar reports to Hamilton's, in spite of President Jefferson's former opposite views.

In addition to preparing comprehensive reports, Alexander Hamilton also tried to improve artisan production with industrial projects. In 1791, the same year with the presentation of "Report on Manufactures", Hamilton founded the Society for Establishing Useful Manufactures (SEUM) in order to create the first planned industrial city of the United States in Paterson, New Jersey, which would benefit from the water power of the Great Falls of Passaic. SEUM in Paterson had been the first real life practices of Hamilton's American developmentalism. Moreover, Hamilton imported human capital from the British textile sector. Textile refugees were hosted and subsidized by the Secretary of the Treasury (Chernow, 2004: 374). Particularly in the 19th century, Hamilton's Paterson hosted leading industries and triggered the industrial change in the United States nationwide. Lind (2012: 6-10) argues that Paterson, as "a dynamic center of enterprise and innovation", was an earlier version of Detroit and Silicon Valley. Besides, SEUM site was also granted with an extra tax exemption (Chernow, 2004: 373)

[1] "In 1721, British commercial law was reformed to promote manufacturing by raising tariffs on foreign manufactured goods, eliminating export duties on most British manufactured goods, lowering or eliminating tariffs on raw materials used by British manufacturers, and providing subsidies to British export industries", which is very similar to Hamilton's Report on Manufactures (1791) (Lind, 2012: 22)

1.1.2 Tariff Rates and Trade Openness

Trade openness is widely used in economic research in order to evaluate the outcome of free and restrictive foreign trade policies. However, tariff rates or ratio of custom duties to total imports are preferred in economic history papers rather than trade openness ratio. Obviously, availability of the tariff data is a primary advantage for economic history research. On the other hand, the role of tariff rates in the 19th century was more crucial than their current role. 19th century governments' budget limiting narrow tax base was disrupting public investments. Absence of today's central banks and correspondingly lack of a broad monetary policy (until the beginning of 20th century both in the United States and many other countries) made it impossible to distribute credits with lower interest rates (in terms of directed credit programs) to critical industrial sectors efficiently. Under these circumstances, tariff protection as the most useful policy tool, was enabling the governments to protect and develop particular industrial sectors (Chang, 2002; 16, 17). Since the production costs of national infant industries were expected to be higher than the production costs of similar products from industrialized countries (such as Britain), governments attempted to keep their infant industries relatively more competitive in the internal market. In order to keep the infant industry competitive, market price of national infant industry products had to be lower than the total of foreign manufactures' market price plus the tariff tax of related product (Taussig, 2010: 161, 162). Hence, tariff rate's function was vital for the national industries of developing countries and thus, it has an explanatory power in economic history research.

Nonetheless, since tariff rates do not exhibit the effect of protection in terms of the volume of imported goods and services, *ratio of duties calculated to imports* is used as a weighted protection index in economic research. Whereas, taking *ratio of duties calculated to total imports* into consideration as protection index comprises some defects. Firstly, if the tariff rate on a particular good is raised, the particular good's weight in protection index falls. Correspondingly a prohibitive tariff would reduce the weight of a particular good to zero in the overall tariff index, which makes the quantitative effect of prohibitive tariff invisible. Additionally, and more

importantly, tariff revenues have also public financing role. Thus, beside manufactures, agricultural products and raw materials are also dutiable and they are counted in the tariff index (O'Rourke 2000; 462). These factors affect the explanatory power of tariff index on infant industry protection dramatically, but not the sectoral protection efficiency of high tariff rates. It would make sense using export, import or trade openness ratio in economic history research as well. High transport costs and risks arising from remoteness, geography and political instability, have considerable effects on producer's and/or merchant's decision making and trade preferences. Thus, in contrast to tariff index, trade openness ratio may serve as a more comprehensive index for the 19th century United States, which exhibits the total outcome of above mentioned variables on foreign trade's role in economic growth.

1.1.3 Literature on the Impact of Tariff Rates and Foreign Trade in the 19th century

This brief literature review begins with the studies focused on the impact of tariff rates in the 19th century economic growth. Following the review of the literature about tariff rates' impact on a group of western economies, researches specifically on the tariff rates of the United States are presented and discussed in the historical context of American economy. Finally, studies on the role of foreign trade will be introduced and discussed.

Recent debates on the 19th century protectionism emerged from the works of Bairoch (1972, 1993). Bairoch (1993; 16) underscores the importance of protectionism for industrializing western economies in the late 19th century, criticizes the neoliberal approach "Free trade is the rule, protection is the exception" and emphasizes completely the opposite. Additionally, Bairoch (1993; 32,33,52) argues that United States as "mother country and bastion of modern protectionism" have demonstrated better performance over the course of protectionist periods. Indeed, United States began to promote her domestic production through high tariff regime during and aftermath of extra ordinary periods, such as Embargo Act of 1807 ("infinite tariffs"), War of 1812 and the Civil War. For instance, protective measures of antebellum era – between 1816-1832– had incited textile sector (Lipsey, 2000:

725-727; O'Brien, 1988: 62). Nevertheless, there is not a consensus on the overall impact of tariffs on the long run and short run economic growth, because import tariffs had not been implemented merely for infant industries, but also for public finances of warfare and infrastructure.

Subsequent to Bairoch's works, O'Rourke (2000; 473) tests Bairoch's hypothesis for the late 19th century and confirms the correlation between tariff and growth. In this research several European (Denmark, France, Germany, Italy, Norway, Sweden, United Kingdom) and New World (United States, Australia, Canada) countries were analyzed.

Irwin (2002; 2) reconsiders the tariff-growth relationship with 17 core countries and finds a positive relationship as well. Nonetheless, Irwin argues that labor-scarce, land-abundant New World economies -United States, Canada and Argentina- are the outliers of this correlation. According to Irwin (2002; 7), these outliers cause a dramatic increase in the correlation from 0.08 to 0.68. It is also stressed that "import duties were primarily designed to raise fiscal revenue for the government", not for import substitution. On the other hand, Junguito (2009) investigates the same relationship for the 1870's industrial tariffs by taking regional asymmetries of core and periphery countries into consideration. He concludes that, tariff rates had a limited positive impact on growth of core countries (including United States), while they had been protecting the unskilled-inefficient sectors in poor countries (Junguito, 2009; 29-30).

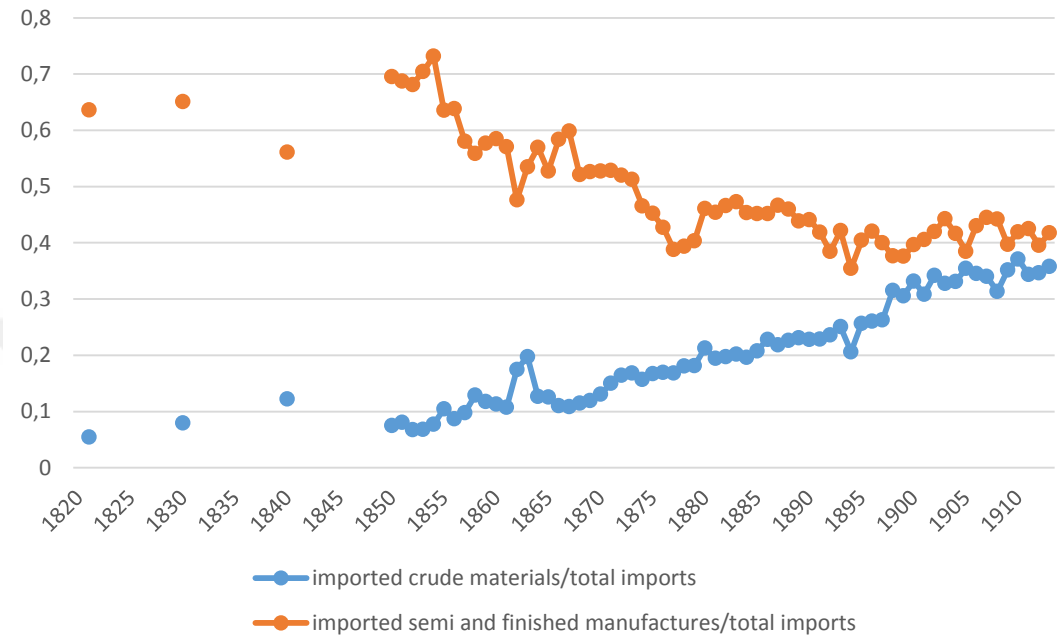
In another study, Irwin (2000b) attempts to analyze merely United States' tariff-growth relationship and stresses the difference among correlation and causation with respect to this relationship. Irwin (2000b: 11) asserts that the key determinants of the late 19th century (1870-1913) American economic performance were labor force expansion and capital accumulation. While labor force expansion was occurring together with immigrant inflows, births and increase in life expectancy (Higgs, 2011: 54-58), capital accumulation was driven by savings. According to Irwin (2000b: 3) rather than having a positive effect on growth, "import tariffs probably raised the price of imported capital goods" and hindered capital

accumulation. However, for the same period (1870-1913), Collins and Williamson (2001: 76-77) argues the opposite. According to Collins and Williamson (2001: 84), "United States was favored by relatively cheap capital goods, and thus, compared with their competitors, could achieve the same accumulation performance with lower savings rate".

From the pre-Civil War to the beginning of the 20th century, output composition of the American industry had changed dramatically. In 1860, manufacture of agricultural material-based cotton goods was the leading industry in the United States (6,7% of total value added and 7,8% of total employment in all manufacturing), but capital and knowledge intensive machinery sector became the leading sector in 1910 with an increased proportion of value added (from 4% to 8.1%) and employment (from 2.8% to 8%) among all manufacturing sectors (Engerman and Sokoloff, 2000: 376). Agricultural raw material-based industries, such as cotton goods, boots and shoes, leather and woolen goods, had relatively lost their dominance in the industrial total output composition from 1860 to 1910. Sectoral and general foreign trade data of the United States also reflect the structural change of the American economy very well. American capital intensive sectors were becoming internationally more competitive. Sectoral export-output ratio of the U.S. machinery production increases from 3.2 to 7.7 percent between 1869-1909. Within the same period there are more dramatic increases in sectoral export-output ratios of nonferrous metal products (from 1.7 to 9.3 %), iron and steel products (from 1.7 to 4.2 %) and transportation equipment (from 0.8 to 3.2 %) (Lipsey, 2000: 710). Additionally, proportion of crude material in all merchandise imports increases from 5.5% in 1821 to 37.1% in 1910, while finished and semi manufacture imports (excluding manufactured food) are decreasing from 65.1% (1830) to under 40% at the end of the 19th century (Figure 2). The opposite occurs in merchandise export composition. At the beginning of the 19th century, United States had been exporting predominantly crude materials. Finished and semi manufactures was a very little proportion of total merchandise exports. Yet in 1913, export proportion of semi and finished manufactures have reached 48.8% in parallel with the industrialization of the American economy. It's noteworthy to mention that sharp increase in export

proportion of semi and finished manufactures begins in the last decade of the 19th century (Figure 3).

Figure 2: Composition of Merchandise Imports (1821-1913) [2]



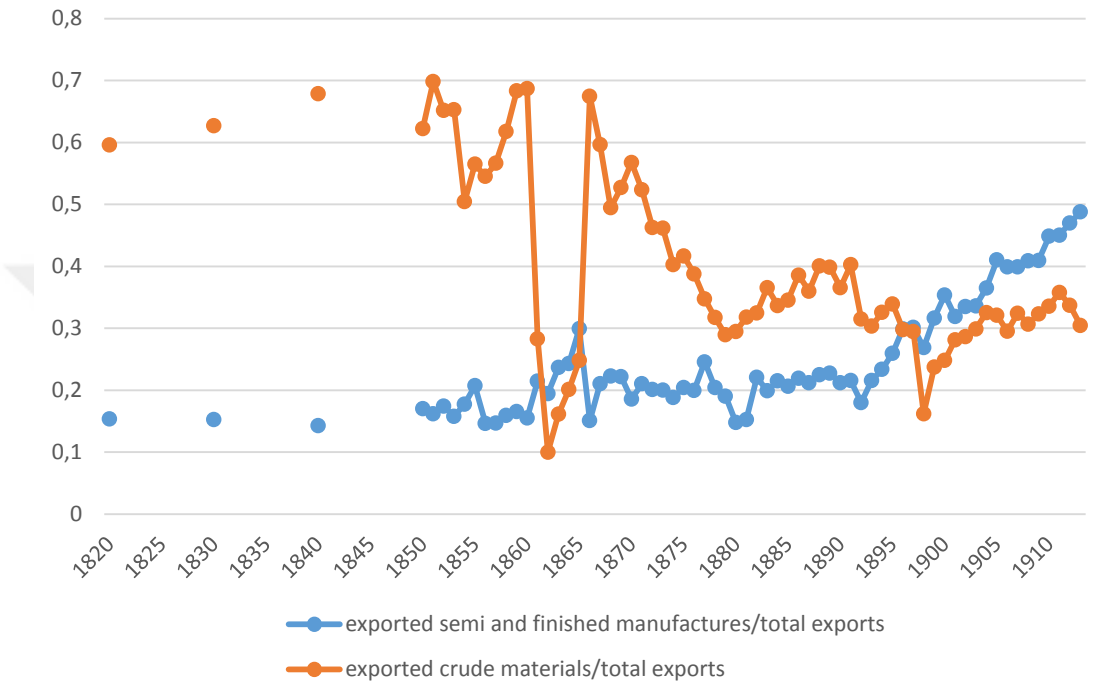
Source: U.S. Bureau of the Census, 1975: 889, 890.

While the great gap among proportions of imported crude materials and imported manufactures was constantly narrowing (Figure 2), export of semi and finished manufactures had already outperformed the crude material exports on the eve of the 20th century (Figure 3). Huge fall in the proportion of exported crude materials is also remarkable during the American Civil War (Figure 3). Simultaneously, a surprising upward change occurs in the proportion of exported semi and finished manufactures (Figure 3). Nevertheless, according to data of the U.S. Bureau of the Census (1975: 889-890), the proportion of exported semi and

[2] In historical export and import statistics of the United States, traded goods are classified as the following: crude materials, crude food, manufactured food, semi-manufactures and finished-manufactures. Figure 2 and 3 exhibit merely the change over time in crude material, semi-manufactures and finished-manufactures, in order to reflect the industrial transformation of American economy. For detailed information on categories see Appendix Table 1.

finished manufactures increases during the Civil War primarily due to declining value of total merchandise exports, not because of a quantitative increase in exported semi and finished manufactures.

Figure 3: Composition of Merchandise Exports (1820-1913)[3]



Source: U.S. Bureau of the Census, 1975: 889, 890.

Following the antebellum high tariffs era (1816-1832), free trade tendency emerged in the U.S. between 1832-1861. Nonetheless, after the Civil War, protectionism became remarkably dominant again. Irwin (2000b: 11) argues that American tariffs of the late 19th century tended to protect labor-intensive (cotton textiles and leather) sectors rather than capital intensive iron-steel and machinery sectors. In contrast with Irwin (2000b), Lipsey (2000: 725-727) stresses that high tariffs supported import substitution of manufactured goods between 1869-1909. Particularly import of capital intensive iron-steel manufactures fell sharply from 12% to 1.5% and iron-steel import was substituted by domestic production.

Besides, in spite of famous "abundant land and natural resources" argument

[3] See footnote 2

about the US development, Allen (2013: 5-6) argues that American raw materials and energy resources had not been cheaper than the British materials and resources until the last decade of the 19th century. Advantage of abundant natural resources such as coal and iron ore were canceled out by their remoteness over the wide geographical area of the United States. In contrast to this, Britain's natural resources were cheap, since they were located close to cities. High tariff rates however kept British imports away from the American internal market and allowed the efficient industrial sectors become competitive at the end of the century (Allen, 2013: 11). Nonetheless, Lipsey (2000: 727) mentions that import substitution's positive effect on specific sectors does not necessarily indicate an increased growth for the whole economy.

Apart from the recent debates, back in 1888, Frank William Taussig (2010) argued that high import tariff rates had not been crucial for sectoral developments in American industries such as cotton, woolens and iron. On the other hand, Irwin (2000a) stresses that protective tariff rates had shifted the development of American tinplate industry approximately one decade earlier. Similar sector-based studies (David, 1970; Williamson, 1972; Ishikawa, 1973) are done for cotton textile industry. Additionally, Hawke (1975) attempts to calculate the effective rate of protection for some sectors of the United States. In order to find the sectoral effective protection rate, he considers the tariff rates for output and inputs with respect to each sector. Due to high tariff rates to industrial inputs, Hawke (1975: 98) concludes that between 1879-1904, protection for the American industrial sectors had been less than it has been perceived.

Table 1: Average Tariff Rates

	1820* **	**1875**	**1913**
Average tariff rates on manufactured goods (weighted average; in percentages of value) *	≈ 40 %	≈ 45 %	44 %
Average tariff rates on consumption goods (weighted average; in percentages of value)**	43.21 %	29.36 %	17.69 %

Sources:

* Bairoch, 1993: 40

** U.S. Bureau of the Census, 1975: 888

*** "Average tariff rates on consumption goods" data for 1820 is originally from 1821

**** Since the tariff estimates range between two numbers, the average (≈) is taken into consideration as approximate rate. 1820 data ranges between 35% – 45% and 1875 data ranges between 40% – 50%.

The purpose of high American tariff rates has been subject to debate: The main question is whether they are designed for fiscal revenue purposes or import substitution. Comparing the average import tariff rates on manufactured products and all consumption goods can be a simple but helpful method to observe the actual purpose of high import tariff rate regime. Indeed, average tariff rates of 1820 show that fiscal purposes outweigh import substitution since there were high duties for all consumption goods (43.21%), rather than a tariff discrimination merely on behalf of manufactured goods. High tariff revenues of 1820s were channeled into finance of internal improvements such as construction of canals and roads which were essential for the existence of a national market on such a broad geography (Irwin, 2006). On the other hand, unambiguously higher rate of duties to import for manufactures, compared to the average tariff rates for all consumption goods, may imply that the import substitution (i.e. infant industry protection) was the primary purpose of high tariff rates in 1875 (45% > 29.36%) and 1913 (44% > 17.69%); (Table 1).

Custom revenues had such an excessive dominance in the annual public budgets of the Antebellum U.S. that contribution of internal revenues compared to customs was almost negligible. Besides it should be noted that even under post-Civil War's import substitution regime, proportion of customs revenue had been substantially higher than the internal revenue's proportion in the state budget until the beginning of the 20th century. [4] Nevertheless, as analyzed above, primary purpose of high tariff rates was industry protection rather than fiscal revenue in the post-Civil War era. There had been some attempts to reform the post-Civil War's high tariff regime, such as the tariff reduction in 1872. A horizontal 10% reduction of Civil War's extraordinarily high tariff rates was a source of debate in 1872. This proposal

[4] See Appendix Table 2 for proportion of customs in public revenues

was accepted by protectionist manufacturing lobby in return for much more striking tariff reductions in raw materials. While hides, paper, tea and coffee were becoming completely exempt of duty, duties on coal, salt and tobacco were heavily reduced. This tariff reduction was perceived as a modest success by both protectionist and free trade circles. However, in 1875, even this little free trade victory of 1872 was repealed due to financial concerns (Taussig, 2010: 158-163). As Taussig (2010: 163) emphasized, "step by step, in the various tariff acts passed since the war, all the non-protective duties have been swept away", but protective duties remained in force for a long time.

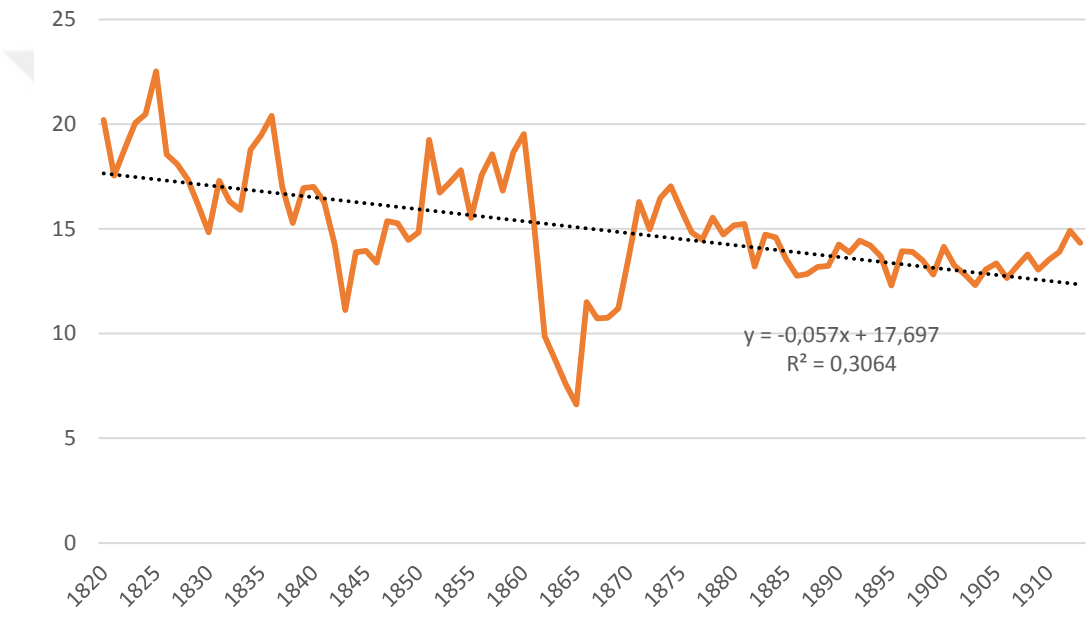
Related to the role of foreign trade on growth, Douglas C. North asserts that export was "the most important proximate cause" of antebellum growth between 1815 and 1843 (Kravis, 1972). According to North, high and continuous external demand for cotton increased the prices and created a secular growth particularly in 1815-1818 and 1831-1839 periods. Indeed, proportion of exported crude materials increases between 1820-1840 from 59.6% to 67.9% (Figure 2). However, it is questionable whether this 145% increase in exported crude materials from 1820 (31 mil. of dollars) to 1840 (76 mil. of dollars) can explain a secular growth.[5] In contrast to North, Kravis (1972: 395,396) views the effect of external cotton demand as cyclical, rather than secular. Kravis assesses the role of trade in the 19th century American growth only as supplementary. Similarly, Lipsey (2000: 727) also stresses the poor role of foreign trade in American economic growth over the course of the 19th century.

Haute finance and its "peace interest" had been dominant between 1815-1914. As Polanyi (2001) emphasizes originally in 1944, over the course of the 19th century, world peace had been preserved thanks to international trade and finance. Indeed, foreign trade (export + import) to GDP ratio had increased dramatically in the 19th century Europe. Europe's average trade openness had increased from 8% in 1820 to 37% in 1913. Simultaneously United Kingdom's international trade to GDP ratio had been rising from 21% to 51%, Netherlands' from 33% to 180% and Denmark's from 8% to 62% (Ospina and Roser, 2016). In contrast to overall trend in

[5] U.S. Bureau of the Census, 888

the rest of the world however, United States' foreign trade to GDP ratio exhibits a slight downwards trend from 1820 to 1913. Moreover, average trade openness ratio is merely around 15%. During the same period, foreign trade of the American economy had experienced its peak in 1825 with 22.5%. The Civil War's contractionary effect on foreign trade, represents probably the most remarkable part of this series (Figure 4).

Figure 4: U.S. - Trade Openness (%; 1820-1913)[6]



Joseph E. Stiglitz (2016) emphasizes that "under the assumption of perfect markets, free trade equalizes the wages of unskilled workers around the world. Trade in goods is a substitute for the movement of people." Apparently universal and local conditions had managed to operate this assumption in the opposite direction for the United States. Because, after the Civil War, high tariff rates were preserved generally as the prize of victorious Northerners, which relatively restricted the goods trade in spite of internationally falling transport costs. On the other side, movement of people

[6] Trade openness data of the United States is calculated by the author of this thesis. Calculation details are given in "Data and Descriptive Statistics".

toward the USA was intense. Population had been growing strikingly between 1820 and 1913 due to increasing birth rates and immigrant influx, including many experts and inventors from various countries.

1.2 PATENTS, TECHNOLOGICAL CHANGE AND TECHNICAL CHANGE

In spite of frequent daily and scientific usage of terms such as technology, technique, innovation, invention, research and development etc., these terms are often perceived carelessly as substitutes to each other. As an important issue to address, in order to discuss the determinants of a long-run process properly, differences among these terms ought to be emphasized.

Jacob Schmookler's (1966: 1-7) following emphasis and effort to distinguish the above mentioned terms is enlightening. *Technology* is the total industrial knowledge of engineering knowledge, applied science, invention and sub-invention. Invention defines an attested new and novel whole process or product. Sub-invention, on the other hand, is any eventual improvement and/or limited alteration on an already existing process, good or service without official attestation. In this regard, *technological change* or *progress* is a one-time event in the history as a new contribution to international industrial knowledge pool through research, development and inventive activity. *Technical change* is the production of a new good/service, or the implementation of a new production method or input, which is a more economic term as a real life practice of technological knowledge. The first application of a technical change is called *innovation*, and the subsequent applications of that innovation are *imitation* in Schmookler's terms. Of course, a more palatable term for imitation would be *diffusion of innovation* or *diffusion of technical change*.

Technological and technical change and increasing productivity have been important features of growth in American economic history. Organizational and technological improvements enhanced United States' labor productivity in major sectors over the course of the 19th century (Broadberry and Irwin, 2006: 261). Engerman and Sokoloff (2000: 375-377) divide 19th century American manufacturing into two parts with respect to drivers of productivity growth. In the Antebellum U.S., productivity had increased predominantly through organizational transformation in production from artisan shops to manufactories and division of

labor, rather than technological change and capital deepening.[7] Sokoloff (1992: 360, 361) notes that, total factor productivity growth had been the main driver of increasing labor productivity over the Antebellum period. Labor force started to move in the 1850s from water and hand powered establishments to large scale steam powered manufactories (Atack and Bateman and Margo 2008: 191).[8] Increases in labor productivity, particularly in less-mechanized (3.9 %) and labor-intensive (4.5%) industries are quite remarkable during this period. From 1850s on, impact of capital deepening had started to become dominant on increasing labor productivity (Sokoloff, 1992: 360, 361).

Engerman and Sokoloff (2000: 384,385) emphasize that total factor productivity did not make the major contribution to growth of American manufacturing between 1869 and 1919. Instead, increases in factor inputs such as labor, capital and raw materials were crucial during this period. Average annual growth rate of total factor production had been 1% between 1869-1919, which falls behind the average annual growth rates of manufacturing output (4,4%), capital input (6.3%) and labor input (2.9%). Contribution of total factor productivity remains limited in this period. Nevertheless, remarkable increase in capital input indicates diffusion of technical change. Average annual growth rates of total factor production (2 %) and capital input (8.8 %) had reached their peak however, during the decade of 1879-1889.

Integrating machinery into any production process is the main part of the increase in capital input. Machinery production however, have always been a complex work, which requires ingenuity, creativity and skilled labor force. Rise of

[7] Cotton and wool manufactures of the Antebellum era were exceptional due to their mechanized and large scale processes. (Sokoloff, 1992: 358)

[8] Median manufacturing establishment's number of workers have increased dramatically from 15 to 44 between 1850-1870 (Atack, Margo and Rhode, 2015: 29).

Thanks to steam power, manufacturing sector overcame the geographical and seasonal limitations and earned the ability to function far from waterfalls and therefore their seasonal imbalances such as drought and ice. Midwest benefited very much from the geographical expansion of industry due to her coal fields. In the late 19th century leading role of the Northeast as manufacturing region was overtaken by Midwest (Engerman and Sokoloff, 2000: 374,394).

the American System of Manufacturing eased the assembly process and increased the productivity in industry. American System of Manufacturing relies on the standardization and interchangeability of parts. This method was attested by the U.S. Patent Office in 1798 for its inventor as a contribution to knowledge. Nevertheless, it was used and diffused by Eli Whitney in arms production, not by its inventor. American system of manufacturing had been the step towards mass production universally (Hounshell, 1985:31-32). While technical change of interchangeability was diffusing in the US and in Europe subsequently, concept of interchangeability went beyond the production of parts. American system was extended to labor factor in the name of Frederick W. Taylor's "scientific management". Taylorism have divided the production into simple tasks and made unskilled labor easily employable and interchangeable in manufacturing (Zinn, 2009: 878).

Over the course of the 19th century, the number of inventive activities had increased in the United States. Since inventions have been patented by the U.S. Patent Office since 1790, total number of historical inventive activities can be tracked from patent records. Despite huge numbers of immigrant inflows and decrease in mortality, annual growth rates of issued patents was generally higher than the striking annual growth rates of American population, which increased the patented inventions/population ratio over the course of the 19th century.

From the 1820s to mid 1830s there is a slight increase in patenting rate. However, in 1850s and particularly after the American Civil War number of patented inventions have started a leap. Moreover, the number of issued patents increased from 0.09 per 1000 capita in 1861 to 0.325 per 1000 capita in 1867. Apart from patenting rate, Acemoglu and Robinson (2013: 31, 32) emphasize the remarkable difference between length of Mexico's (1824-1867) and United States' (1860-1865) political instability periods. They argue that long-lasting political instability worsens economic outlook, expectations, weakens property rights, institutions and disrupts inventive activities, development and industrialization process, just like in Mexican case. In contrast to Mexico, United States apparently overcame the political instability of the Civil War in a relatively short time and have continued with increasing number of issued patents and capital deepening in manufacturing sector. Even after first year of the Civil War, patenting activity had started to increase.

Overall, number of patented inventions per capita exhibits a strong upward trend over the course of century (Figure 5).

Figure 5: U.S. - Patented inventions per 1000 capita (1820-1913)

Source: Patent data from the U.S. Bureau of the Census, 1975: 958, 959
Population data from Maddison (2010)

Association on patents, patent system, technical change, technological change, i.e. progress and productivity is widely discussed by scholars (Lamoreaux and Sokoloff, 2007; Kuznets, 1962; Engerman and Sokoloff, 2000; Griliches, 1998; Beggs, 1984; Schmookler, 1966). Naturally, it's not expected to see a negative relationship between patents, i.e. technological progress and technical change. Moreover, technological change has a strong potential to increase productivity. It is not clear nevertheless, how many patents will gain an economic value in the future, i.e. what proportion of the technological change will be subject to capitalist marketization, increase productivity and diffuse among sectors. As Keller (2004, 757) puts it, since "a small number of patents accounts for the most of the value of all patents … simple patent counts may not measure technology output well".

However, Beggs (1984, 156) asserts that "patents are one of the few immediately applicable statistical indicators of technological change". Schmookler (1966) and Griliches (1998) interpret patents as an input factor, rather than being an output factor such as productivity change. Griliches (1998) finds a strong relationship between patents and research and development expenditures, which is a technological input statistic. This implies that, it is expected to observe a considerable impact of patents on productivity growth, nevertheless solely the number of patents may not be enough to explain productivity growth and technical change. However, Griliches (1998, 336) also notes that "in spite of all the difficulties, patent statistics remain a unique resource for the analysis of the process of technical change. Nothing else even comes close in the quantity of available data, accessibility, and the potential industrial, organizational, and technological detail."[9] Schmookler (1966: 44-46) argues that almost 85% of variations in patent data occur due to variations of research and development (R&D) expenditures. Although the studies of Griliches and Schmookler are made with 20th century data, above placed emphasis on the input role of patents is still inspirational.[10] Moreover, data for R&D expenditures is not available for pre-1950s. Thus, patent data has even a more important role in the 19th century research due to lack of any other input data such as R&D expenditures, R&D workers, etc. Additionally, since the historical productivity estimations are far from being accurate and not useful for time series analysis, number of annually issued patents can be considered as a decent measure of technological change and can be put into analysis. At least official patent data from the Census Bureau can provide accuracy criteria, which is not based on a limited sample.

[9] It should be noted that 56.5 % of patented inventions were used commercially in 1938, 1948 and 1952 (Schmookler, 1966: 49). Besides, Griliches (1998: 335-6) also warns that overinterpretation of "small and even sizable differences in patent numbers" would be misleading.

[10] The most debated point of Schmookler (1966) was "demand-induced inventions" argument. As put by Godin and Lane (2013: 19), this argument has become the alternative of Schumpeter's "knowledge-induced" argument. Subsequently Schmookler's argument was studied by various scholars such as Rosenberg (1974), Scherer (1982), Kleinknecht and Verspagen (1990).

Patents are "artificial barriers" (Davis and North, 153: 1971) to competition and fortress of monopolists, which can create a substantial increase in capital accumulation through increasing producer surplus. In 1623 British parliament took a step toward a patenting system and have limited King's right of granting monopolies (Acemoglu and Robinson, 2013: 32). Already in 1810, United States had succeeded to have much more number of patents per capita than Britain (Lamoreaux and Sokoloff, 2007: 5). In spite of early steps of Britain in the 17th century, the United States had designed the first modern patent institution of the world in order to stimulate economic growth, with 1790 and 1793 laws (Engerman and Sokoloff, 2000: 395). U.S. patent system enabled the independent inventor to become an entrepreneur and gave him the opportunity to produce and/or sell at tempting prices in his monopoly fortress. In accordance with "inclusive institution" notion of Acemoglu and Robinson (2013: 429, 430), U.S. Patent Office was an open attestation authority for all inventors. Following a meritocratic evaluation procedure, intellectual property rights were secured for all inventors regardless of their income, education, ethnicity and religion (Khan and Sokoloff, 2004). Additional incentives were also provided by the US government, such as very low patent application fees – "less than 5 percent of the level in Britain"– and making the patent information public (Lamoreaux and Sokoloff, 2007: 4, 5). Since patent information was made public and legally protected at the same time, patentees were able to find the investors easily. Thus, many inventors were able to pursue a career as an independent patentee with contracts rather than long-term attachments to firms. At the beginning of the 19th century's last decade almost 36 percent of all patentees had at least 10 licensed inventions in their lifetime. While patentees had been signing contracts with different assignees from various parts of the country, institutional inventorship became crucial for geographic expansion of technological change. (Lamoreaux and Sokoloff, 2007: 9, 10)

Three remarkable reforms in American patenting system between 1820 and 1913 are:

1) 1836 reform on the patent applications with respect to "novelty and conformity" integrated technical experts' views to the examination process.

This reform was crucial for determining the validity and market value of patents. (Sokoloff and Lamoreaux, 2007: 4)

2) "For 1800-1836, only aliens who had resided in the United States for 2 years and who had declared their intention of becoming citizens could apply for U.S. patents. For 1836-1861, aliens paid higher fees than citizens on a theory of reciprocity. Discrimination based on nationality was eliminated in 1861." (Census part 2, 1975: 955)
3) Approval of designs as patents started in 1842. Nevertheless, design patents shouldn't be considered as technological contribution since they merely "relate to the appearance, not to the structure or use, of articles of manufacture" (Census part 2, 1975: 955).

Lomoreaux and Sokoloff (2007: 3) state that the United States surprised Europeans in 1851 at the Crystal Palace exhibition with her creativity in technology and led them to reform their patent institutions according to American standards. Moreover, Hobsbawm (2003: 59) asserts, Europeans were concerned about American technological superiority in mass production during the 1860s.

Apart from awareness and perception of Europeans, comparative rates of the United States to the United Kingdom in labor productivity, capital per worker and total factor productivity exhibit the American catch-up pattern quantitatively. Over the course of the 19th century comparative labor productivity US/UK have reached from 89.9 to 124.7 and comparative capital per worker US/UK from 97 to 157.6. However, comparative total factor productivity had remained more or less the same. This implies that historical catch-up process and comparative labor productivity dominance of the US have occurred due to increasing capital intensity. Additionally, progress in some industries and service sectors such as manufacture, mining, transport and utilities had been crucial for the historical catch-up path of the United States. From 1839/41 to 1909/11, United States' comparative labor productivity had been increasing in relation to the United Kingdom's mining, transport and utilities sectors. Surprisingly however, already in 1839/41, labor productivity of the United States in manufacturing was much higher than the labor productivity of the United

Kingdom. United States have preserved her superiority in labor productivity of manufacturing sector during the century, in spite of a subsequent fall and slight rise (Table 2).

Table 2: US/UK comparative productivity

(UK=100)	**Mining**	**Manufacturing**	**Transport and utilities**
1839/1841	63.5	239.3	
1849/1851	68.3	224.9	
1859/1861	60.5	190.5	
1869/1871	102.5	182.6	88.2
1879/1881	98.8	169.9	113.4
1889/1891	108.5	193.6	146.5
1899/1901	146.5	195.7	198.3
1909/1911	161.3	201.9	191.3

Source: Broadberry and Irwin, 2006: 265, 267

Habakkuk (1962: 11-17) attempts to explain the increased American capital deepening and comparative productivity, based on labor dearness and land abundance of the United States. According to Habakkuk, while low land prices were magnetizing Americans to agricultural production, wage payments in the American industry had to be at least as high as the average income of an American farmer family in order to keep the labor force in industrial sectors. Thereupon high wages led the American industry to invent and use labor saving machinery during the 19th century. In contrast with the United States, lands of Britain were dear and not affordable for the British working class. A blue-collar job was the mere option for the vast majority of the British people. Therefore, British industry was relying on cheap labor compared to the US industry and correspondingly, British capitalists had relatively less incentives for labor saving machinery, i.e. technological change.

However, Peter Temin (1971) asserts that land abundance-labor scarcity argument alone is superficial and not significant for an explanation of the 19th century labor saving inventions in American manufacturing. More importantly, Temin stresses that in the absence of protective measures, land abundance would merely lead to a specialization in agriculture, rather than industrialization and labor saving inventions.

CHAPTER TWO
DATA, METHODOLOGY AND EMPIRICAL FINDINGS

2.1 DATA AND DESCRIPTIVE STATISTICS

In this study, real GDP per capita in 1996 dollars were obtained directly from the website of the Historical Statistics of the United States Millennial Edition Online (Sutch, 2006: Table Ca9-19). Trade openness ratio ($\frac{Real\ Export+Real\ Import}{Real\ GDP}$) is considered as the measure of foreign trade. In order to calculate the trade openness ratio, Real GDP in 1996 million dollars and Price Deflator (1996=100) were similarly obtained from the website of Historical Statistics of the United States Millennial Edition Online (Sutch, 2006: Table Ca9-19). On the other hand, nominal export and import numbers from Historical Statistics of the United States, Colonial Times to 1970: Bicentennial Edition (U.S. Bureau of the Census, 1975: 864, 865), were converted to real terms of 1996 by means of Price Deflator series. Finally, trade openness ratio of the United States is calculated by the author of this thesis.

Technological change is statistically represented with the series of annually patented inventions per 1000 capita as yearly contributions to scientific knowledge pool, which have the potential to gain an economic value in the market, trigger the technical change and diffuse within and across the sectors. In the absence of any other reliable historical data, annual patent data of the U.S. Patent Office seems to be the best possible indicator for technological change. Further discussions on explanatory function of the patent data were presented in literature review.

Additionally, since GDP and patented inventions series are taken into account as per capita variables, an eventual impact of the United States' striking population increase over the century was eliminated. Moreover, with respect to all our three series, unusual breaks emerging from the Civil War conditions would deteriorate our research's outcome. Thus, the Civil War (1861-1865) is not covered in our econometric analysis. Our econometric analysis is divided into pre-Civil War (1820-1860) and post-Civil War (1866-1913) periods.

Descriptive statistics are presented below. In tables, number of observations, mean, standard deviation, minimum and maximum values of the series are given. Besides,

divided series are also presented graphically. Discussions on growth, technology and trade series are already presented in the introduction, literature review and history parts of this thesis. In order not to repeat the same statements, discussions on the data are kept brief.

Besides all our 3 series are converted into natural logarithmic form for time series analysis. Logarithmic form of the series can be found in Appendix 3.

Table 3: Descriptive Statistics (1820-1860)

Series (1820-1860)	**Number of Observations**	**Mean**	**Standard Deviation**	**Minimum value**	**Maximum value**
RGDP p. c.	41	1707,122	246,7949	1322	2177
Trade Openness(%)	41	17,06	2,3	11,12	22,51
Number of issued patents p. 1000 c.	41	0,041504	0,0298	0,01553	0,1368

Table 4: Descriptive Statistics (1866-1913)

Series (1866-1913)	**Number of Observations**	**Mean**	**Standard Deviation**	**Minimum value**	**Maximum value**
RGDP p. c.	48	3655,33	923,2	2275	5357
Trade Openness(%)	48	13,786	1,358	10,722	17,04
Number of issued patents p. 1000 c.	48	0,3286	0,04497	0,2404	0,4106

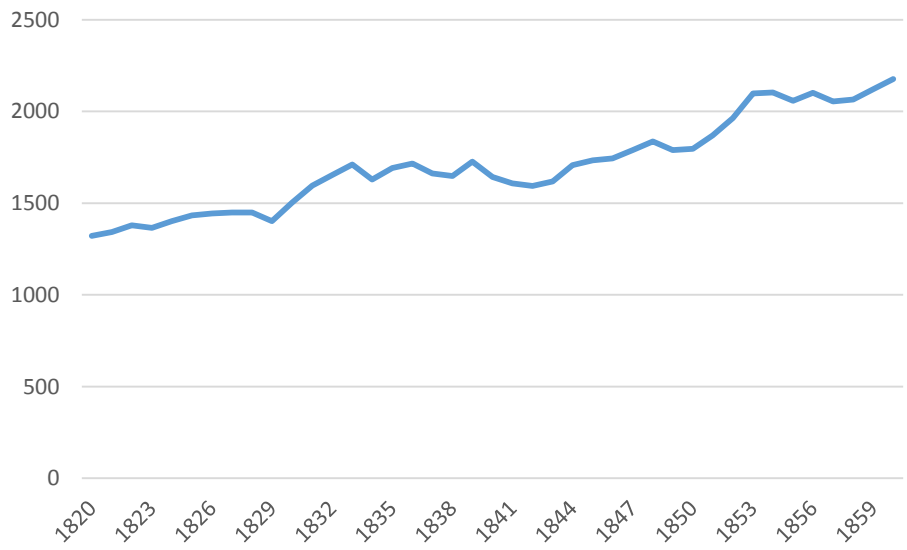
In the Antebellum, Real GDP per capita has an upward trend and ranges from 1322 to 2177 in terms of 1996 dollars (Figure 6). In the aftermath of the Civil War

era, real GDP p. c. ranges from the minimum value of 2275 to maximum value of 5357 in terms of 1996 dollars until 1913 (Figure 7). Since 1820-1860 Real GDP p. c. series is more variable than the 1866-1913 Real GDP p. c. series, standard deviation of the post-Civil War real GDP p. c. (932.2 in 1996 dollars) is relatively higher than the standard deviation of 1820-1860 real GDP p. c. series (246.8 in 1996 dollars).

Annual numbers of patented inventions per 1000 capita between 1820-1860 range from the minimum number of 0,01553 to maximum number of 0,1368. Particularly in the 1850s, there is a remarkable secular growth in patented inventions per capita (Figure 8). In 1866-1913 period minimum number of patented inventions p. 1000 c. was even higher than the maximum number of patented inventions p. 1000 c. between 1820-1860. Moreover, in 1907 the annual number of patented inventions reached the maximum value of 0.4106 per 1000 capita in the United States.

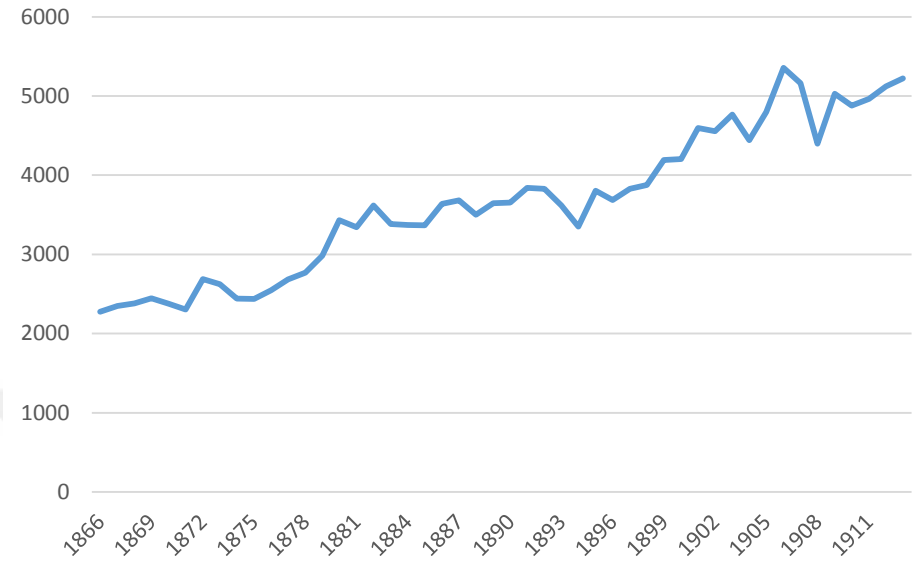
Average share of the foreign trade in the real gross domestic product is around 17% between 1820-1860 and merely 13.8% between 1866-1913. Additionally, standard deviation of trade openness is also higher between 1820-1860. Maximum openness to trade had been 22.51% between 1820-1860 and 17.04% within 1866-1913 period. Minimum trade openness ratio (10.72%) occurred in the aftermath of the Civil War, in 1867 (Figures 10 and 11).

Figure 6: U.S. - Real GDP per capita in 1996 dollars (1820-1860)



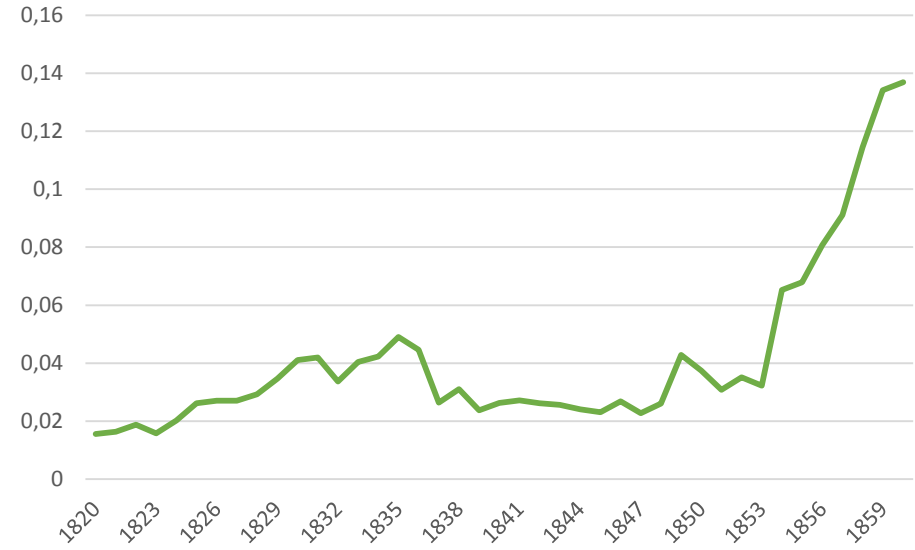
Source: Sutch, 2006: Table Ca9-19

Figure 7: U.S. - Real GDP per capita in 1996 dollars (1866-1913)



Source: Sutch, 2006: Table Ca9-19

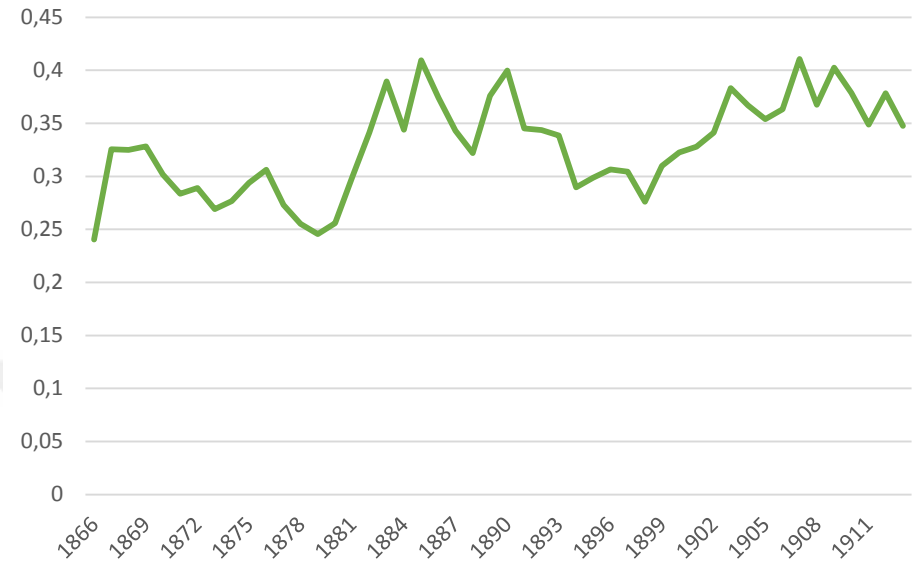
Figure 8: Patented inventions per 1000 capita (1820-1860)



Sources: Patent data from U.S. Bureau of the Census, 1975: 958, 959

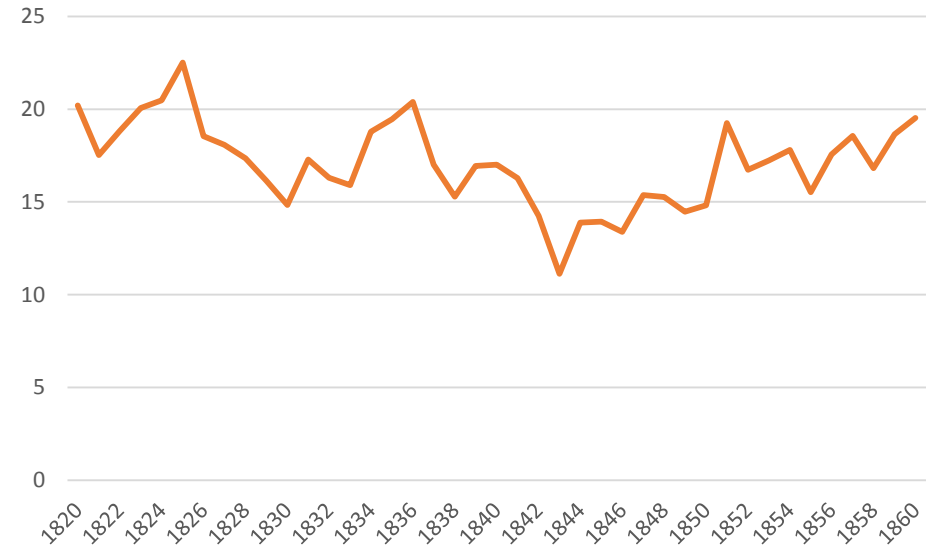
Population data from Maddison, 2010

Figure 9: Patented inventions per 1000 capita (1866-1913)



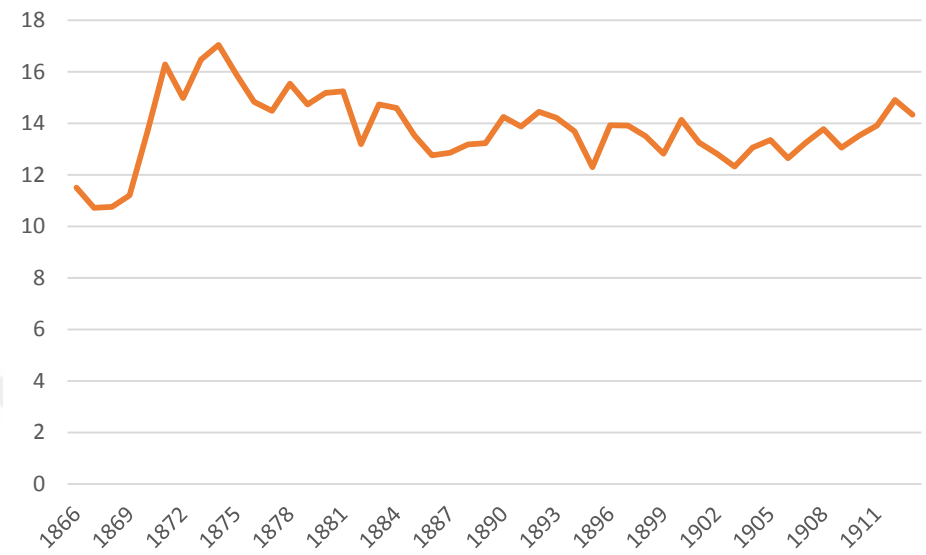
Sources: Patent data from U.S. Bureau of the Census, 1975: 958, 959
Population data from Maddison, 2010

Figure 10: U.S. - Trade Openness (%; 1820-1860)[11]



[11] See footnote 6

Figure 11: U.S. - Trade Openness (%; 1866-1913)[12]



[12] See footnote 6

2.2 METHODOLOGY

In this study, Toda-Yamamoto approach to Granger (1969) non-causality test is applied in order to investigate the causal relationship between foreign trade, technological change and growth per capita. Toda Yamamoto approach can be applied to Granger non-causality, regardless of VAR's order of integration or cointegration.

Firstly, unit root of the series ought to be checked. With respect to unit root check following tests are performed: Dickey-Fuller (1979), Philipps-Perron (1988) and Kwiatkowski-Phillips-Schmidt-Shin (1992). ADF and PP tests are designed primarily for the detection of unit root, i.e. non-stationarity. Their alternative hypothesis is the absence of unit root, i.e. stationarity of the series. In contrast with ADF and PP, KPSS is a stationarity test. Presence of unit root, i.e. non-stationarity is the alternative hypothesis of the KPSS test. The outcome of unit root testing will be the detection of the maximum order of integration (d_{max}) for Toda-Yamamoto approach.

1820-1860

Variables	ADF (constant)	ADF (constant and trend)	PP (constant)	PP (constant and trend)	KPSS (constant)	KPSS (constant and trend)
			Levels			
GDP p. c.	-0.592497	-2.339208	-0.565362	-2.339208	0.753524[a]	0.087278
Trade Openness	-2.855195[c]	-2.691744	-2.839140[c]	-2.684609	0.272563	0.155456[b]
Number of issued patents p. 1000 c.	-0.319111	-1.101705	-0.319111	-1.044384	0.468432[b]	0.127609[c]
			First Differences			
GDP p. c.	-5.704029[a]	-5.626152[a]	-5.692410[a]	-5.600574[a]	0.057851	0.056917
Trade Openness	-6.078510[a]	-6.132392[a]	-7.895330[a]	-7.946331[a]	0.153373	0.048835
Number of issued patents p. 1000 c.	-6.875757[a]	-6.906386[a]	-6.875757[a]	-6.906386[a]	0.185464	0.145997[c]

1866-1913

Variables	ADF (constant)	ADF (constant and trend)	PP (constant)	PP (constant and trend)	KPSS (constant)	KPSS (constant and trend)
			Levels			
GDP p. c.	-1.047370	-3.540526[b]	-0.830900	-3.540526[b]	0.870898[a]	0.093834
Trade Openness	-2.916940[c]	-2.955649	-2.921964[b]	-2.843532	0.112271	0.093088
Number of issued patents p. 1000 c.	-3.07932[b]	-3.315624[c]	-3.173211[a]	-3.502954[c]	0.462899[c]	0.058922
			First Differences			
GDP p. c.	-8.639216[a]	-8.547806[a]	-10.72112[a]	-10.73658[a]	0.295176	0.281210
Trade Openness	-7.253963[a]	-5.635612[a]	-7.253963[a]	-7.253335[a]	0.110425	0.085920
Number of issued patents p. 1000 c.	-8.070180[a]	-7.957957[a]	-8.180775[a]	-8.066001[a]	0.087751	0.052010

Note: “a”, “b” and “c” represent the significance levels of 1%, 5% and 10%.

Grey colored numbers indicate stationarity levels of the series with respect to 5 percent significance values. In accordance with ADF and PP non-stationarity tests for 1820-60 period, null hypothesis of unit root for all 3 variables cannot be rejected at level, but can be rejected at the first difference. However, results of KPSS stationarity test for the same period contradict with the outcome of non-stationarity tests partially and exhibit stationarity at level with or without trend for each series.

On the other hand, contradiction on the stationarity of the series is greater in the period of 1866-1913. With respect to ADF, KPSS and PP unit root tests, GDP p.c. without trend is I(1), but GDP p.c. with trend is I(0). KPSS test results accept the null hypothesis and exhibit stationarity without trend and with trend for trade openness and patents per 1000 capita at levels. Nevertheless, results of KPSS for these two series become questionable due to I(1) results from PP and ADF non-

stationarity tests in trend and intercept. Due to different stationarity results of the unit root tests at various levels, Toda-Yamamoto approach to Granger non-causality test seems to be the appropriate method to test the causality relationship between our series. Apparently, for both periods 1820-60 and 1866-1913, maximum order of integration is one ($d_{max}=1$).

Following the unit root tests, optimal lag length of the VAR for both periods must be selected in accordance with LR (Likelihood Ratio), FPE (Final Prediction Error), Akaike (AIC), Schwarz (SC) and Hannan Quinn (HQ) information criteria. True lag length (k) is one (1) for all VARs both in 1820-1860 and 1866-1913 periods. Serial correlations in the residuals and dynamic stability of the model ought to be checked as well. If any serial correlations are detected in Portmanteau and LM autocorrelation tests, lag must be increased until there is no more serial correlation. In this analysis, except GDP p.c. – Trade Openness VAR for 1866-1913, no serial correlations are found. Serial correlation problem in GDP p.c. – Trade Openness VAR for 1866-1913 is resolved at the 4^{th} lag. Besides, all VAR models are found dynamically stable. Further details on lag selection, serial correlation and dynamic stability can be found in appendices 4, 5, 6 and 7.

In Toda-Yamamoto approach, VAR's lag length must be greater than or equal to maximum order of integration ($k \geq d_{max}$). Since our highest integration order is I(1), there is no restriction to the applicability of Toda-Yamamoto (1995: 245) approach for our series. Toda-Yamamoto (1995) approach to Granger non-causality test proposes to add extra lag or lags to ($k+d_{max}$) to the Vector Autoregressive (VAR) model's exogenous variables with respect to maximum order of integration.

In this study, causality relationship between GDP p.c.-Trade Openness, GDP p.c.-Patented Inventions p. 1000 c. and Trade Openness-Patented Inventions p. 1000 c. are tested with respect to bivariate approach. The equations of causality relationships are given below.

GDP p.c. (Y) – Trade Openness (TO)

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2j} Y_{t-j} + \sum_{i=1}^{k} \beta_{1i} TO_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2j} TO_{t-j} + \varepsilon_{1t} \quad (1)$$

$$TO_t = b_0 + \sum_{i=1}^{k} b_{1i} TO_{t-i} + \sum_{j=k+1}^{d_{max}} b_{2j} TO_{t-j} + \sum_{i=1}^{k} \gamma_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \gamma_{2j} Y_{t-j} + \varepsilon_{2t} \quad (2)$$

GDP p.c. (Y) – Patented inventions p. 1000 c. (PI)

$$Y_t = \delta_0 + \sum_{i=1}^{k} \delta_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2j} Y_{t-j} + \sum_{i=1}^{k} \theta_{1i} PI_{t-i} + \sum_{j=k+1}^{d_{max}} \theta_{2j} PI_{t-j} + \varepsilon_{3t} \quad (3)$$

$$PI_t = \vartheta_0 + \sum_{i=1}^{k} \vartheta_{1i} PI_{t-i} + \sum_{j=k+1}^{d_{max}} \vartheta_{2j} PI_{t-j} + \sum_{i=1}^{k} \sigma_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \sigma_{2j} Y_{t-j} + \varepsilon_{4t} \quad (4)$$

Trade Openness (TO) – Patented inventions p. 1000 c. (PI)

$$TO_t = \varphi_0 + \sum_{i=1}^{k} \varphi_{1i} TO_{t-i} + \sum_{j=k+1}^{d_{max}} \varphi_{2j} TO_{t-j} + \sum_{i=1}^{k} \tau_{1i} PI_{t-i} + \sum_{j=k+1}^{d_{max}} \tau_{2j} PI_{t-j} + \varepsilon_{5t} \quad (5)$$

$$PI_t = \mu_0 + \sum_{i=1}^{k} \mu_{1i} PI_{t-i} + \sum_{j=k+1}^{d_{max}} \mu_{2j} PI_{t-j} + \sum_{i=1}^{k} \omega_{1i} TO_{t-i} + \sum_{j=k+1}^{d_{max}} \omega_{2j} TO_{t-j} + \varepsilon_{6t} \quad (6)$$

If $\beta_{1i} \neq 0 \forall_i$ in equation 1, unidirectional causation runs from trade openness to GDP p. c.. On the other hand, GDP p.c. causes trade openness in case of $\gamma_{1i} \neq 0 \forall_i$ (equation 2). The presence of both coefficients ($\beta_{1i} \neq 0 ; \gamma_{1i} \neq 0$) would imply bidirectional causality relationship between GDP p.c. and trade openness. Similarly, unidirectional and/or bidirectional causation relationships between GDP p. c. and patented inventions per 1000 capita as well as trade openness and patented inventions per 1000 capita require the following conditions: $\theta_{1i} \neq 0 \forall_i$ in eq. 3 , $\sigma_{1i} \neq 0 \forall_i$ in eq. 4 , $\tau_{1i} \neq 0 \forall_i$ in eq. 5 and $\omega_{1i} \neq 0 \forall_i$in eq. 6.

2.3 EMPIRICAL FINDINGS

Results of Toda-Yamamoto approach to Granger non-causality test for 1820-1860 and 1866-1913 periods are as following:

Causality Direction (1820-1860)	Chi-squared	Probability
Trade Openness → GDP p. c.	1.67	0.1964
GDP p. c. → Trade Openness	1.91	0.1673
Patented inventions p. 1000 c. → GDP p.c.	0.008	0.9271
GDP p.c. → Patented inventions p. 1000 c.	0.16	0.6915
Trade Openness → Patented inventions p. 1000 c.	0.15	0.6948
Patented inventions p. 1000 c. → Trade Openness	0.41	0.5216

It is not possible to reject null hypothesis of non-causality for any relationship between 1820-1860. Hence, no significant causality relationship is found among GDP p. c., trade openness and patenting p.c. series for the pre-Civil War period of the United States at any significance level.

Causality Direction (1866-1913)	Chi-squared	Probability
Trade Openness → GDP p. c.	4.19	0.2413
GDP p. c. → Trade Openness	7.56	0.056
Patented inventions p. 1000 c. → GDP p.c.	0.008	0.93
GDP p.c. → Patented inventions p. 1000 c.	3.945	0.047
Trade Openness → Patented inventions p. 1000 c.	0.66	0.415
Patented inventions p. 1000 c. → Trade Openness	1.64	0.2

Granger non-causality null hypotheses cannot be rejected for Trade Openness → GDP p. c., Patented inventions p. 1000 c. → GDP p.c., Trade Openness → Patented inventions p. 1000 c. and, Patented inventions p. 1000 c. → Trade Openness causality directions. On the other hand, 1866-1913 period of the United States is still relatively more generous than the antebellum period with respect to causality relationships. Our findings for the post-Civil War period demonstrate a

causality running from GDP p. c. to trade openness at the 10% and virtually also at the 5% significance levels. Additionally, our results also suggest a causality running from GDP per capita to the patented inventions per 1000 capita at the 5% significance level in the post-Civil War period.

CONCLUSION

Starting point of this study is the neoclassical development policy proposals on the foreign trade-technological change-economic growth relationship and the validity of these recommendations in the economic history of the United States (1820-1913). Causality results of this thesis for both pre and post-Civil War periods do not support neoclassical free trade and learning by exporting assertions. In line with Lipsey's (2000) argument on the poor role of foreign trade in economic growth, no significant causality relationship is found running from foreign trade to economic growth directly or via technological change in terms of patenting. Moreover, an inverse causality running from economic growth to trade openness, i.e. foreign trade is found for 1866-1913 era. It implies that in the post-Civil War era, foreign trade had been an output of the economic growth.

Apart from the absence of any foreign trade causation, there is also no causality running from patented inventions, i.e. technological change to GDP per capita in both periods of the American economic history. Our result however, does not automatically imply that patented inventions are unimportant for the 19th century American industry, but probably, as Keller (2004, 757) argued, majority of the patented inventions do not have a significant, groundbreaking effect on productivity and economic growth. Regardless of its market value, technological knowledge accumulates through inventions, sub-inventions and becomes a worth for the society. However, accumulating body of technological knowledge does not transform into monetary value constantly, rather marketization of technological change occurs by leaps at certain points in time and diffuse over the following period within the industry. Therefore, causal effect of particular patented inventions in economic growth cannot be observed in time series analysis.

On the other hand, not in the pre-Civil War period, but between 1866-1913, causality runs from GDP p. c. to patented inventions per 1000 capita. This implies that in the post-Civil War era, economic growth had been a positive causal factor in increasing patented inventions p. c. rate. Schmookler (1966) and Griliches (1998) had argued a strong relationship between R&D expenditures and patent numbers in the 20th century. This argument seems to be enlightening also for our post-Civil War

finding. As the real GDP p. c. increases, the amount of money channeled into research and development increases as well, and rise in R&D expenditures affects number of patented inventions directly.

Causality results of this thesis enable us to speculate further on the American historical development in the light of existing literature. Particularly, absence of a causality relationship running from foreign trade to economic growth shifts the focus of debate. Apparently some internal features of the U.S. economy were the drivers of the economic growth over the 19th century. Crucial internal factors might be geographical expansion, increasing population, protectionism (tariff barriers and incentives as a combination) and investments in transportation. These factors were the keys of growing internal market in the United States over the 19th century.

In the late 18th century, United States was founded on a large piece of land. In addition to that, 19th century had been the century of geographical expansion for the United States: Louisiana Purchase (1803), Florida Purchase (1819), Annexation of Texas (1845), Oregon Treaty (1846), Mexican Cession (1848), Gadsden Purchase (1853), Alaska Purchase (1867) and Annexation of Hawaii (1898). Moreover, during the 1840s, geographical expansion reached almost 70% of the former land area of the United States (Higgs, 2011: 64-65).[13] Over the course of the post-Civil War era these sparsely populated or uninhabited areas became the host for transportation investments and increasing population. In addition, since the late 18th century, share of immigrants in overall population increase had been quite crucial for geographically expanding and labor scarce country. Most importantly, there were numerous skilled workers, inventors and entrepreneurs coming from Europe to United States and contributing to American technological and technical progress as well as increasing productivity.

Probably, as argued by Habakkuk (1962), land abundance and labor scarcity had played an important role in search for labor-saving technology. However, as stressed by Temin (1971), land abundance without protective measures would merely lead to specialization in agriculture. It should be noted that 19th century was a global colonialization and dependency era for the agriculture-based economies.

[13] Louisiana Purchase (1803) had doubled the size of the United States.

Tariff barriers were crucial for infant industrial sectors, and these sectors had strategic importance for the development in the long-run. On the other hand, geographical remoteness of the United States from Europe had also been another important protection factor until the period of falling transportation costs over the late 19th century.

REFERENCES

Acemoglu, D. (2008). *Introduction to Modern Economic Growth*. Princeton, NJ: Princeton University Press.

Acemoglu, D. and James, A. R. (2012), *Why Nations Fail: The Origins of Power, Prosperity and Poverty*. London: Profile Books.

Allen, R. C. (2013). American Exceptionalism as a Problem in Global History. *Oxford Economics Discussion Paper 689*. 2013(December)

Atack, J. and Bateman, F. and Margo, R. A. (2008). Steam power, establishment size, and labor productivity growth in nineteenth century American manufacturing. *Explorations in Economic History*. 45: 185–198.

Atack, J. and Margo, R. A. and Rhode P. W. (2015). The Division of Labor and Economies of Scale in Late Nineteenth Century American Manufacturing: New Evidence. 2015(January) https://ipl.econ.duke.edu/seminars/system/files/seminars/1437.pdf

Bairoch, P. (1972). Free Trade and European Economic Development in the 19th century. *European Economic Review*. 3(3): 211-245.

Bairoch, P. (1993). *Economic and World History: Myths and Paradoxes*. Chicago: The University of Chicago Press.

Beggs, J. J. (1984). Long-Run Trends in Patenting. *R & D, Patents, and Productivity* (p. 155 - 174). Editor Zvi Griliches. Chicago: University of Chicago Press.

Broadberry, S. N. and Irwin D.A. (2006). Labor productivity in the United States and the United Kingdom during the nineteenth century. *Explorations in Economic History*. 43: 257–279.

Chang, H.J. (2002). *Kicking Away the Ladder: Development Strategy in Historical Perspective*. London: Anthem Press.

Chernow, R. (2004). *Alexander Hamilton.* New York, NY: Penguin Books.

Collins, W. J. and Williamson, J. G. (2001). Capital-Goods Prices and Investment, 1870-1950. *The Journal of Economic History*. 61(1): 59-94.

David, P.A. (1970). Learning By Doing and Tariff Protection: A Reconsideration of the Case of the Ante-Bellum United States Cotton Textile Industry. *The Journal of Economic History*. 30(3): 521-601.

Davis, L. E. and North, D. C. (1971). *Institutional Change and American Economic Growth*. Cambridge: Cambridge University Press.

Engerman, S. L. and Sokoloff, K. L. (2000). Technology and Industrialization, 1790-1914. *The Cambridge Economic History of the United States Vol. II, the Long Nineteenth Century* (pp. 367-401). Editors Engerman, Stanley L. and Robert E. Gallman. Cambridge: Cambridge University Press.

Feyrer, J. (2009). Trade and Income – Exploiting Time Series In Geography. *NBER, Working Paper 14910*. 2009(April)

Frankel, J.A. and Romer, D. (1999). Does Trade Cause Growth? *The American Economic Review*. 1999(June): 379-399.

Godin, B. and Lane, J. P. (2013). "Pushes and Pulls": The Hi(story) of the Demand Pull Model of Innovation. *Project on the Intellectual History of Innovation Working Paper No. 13*. 2013

Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica.* 37(3): 424-438

Griliches, Z. (1998). Patent Statistics as Economic Indicators: A Survey. *R & D, Patents, and Productivity* (p. 287 - 343). Editor Zvi Griliches. Chicago: University of Chicago Press.

Grossman, G.M. and Helpman, E. (1990). Trade, Knowledge Spillovers, And Growth. *NBER Working Paper No. 3485*. 1990(October).

Grossman, G.M. and Helpman, E. (1994). Technology and Trade. *NBER Working Paper No. 4926*. 1994(November).

Habakkuk, H. J. (1962). *American and British Technology in the Nineteenth Century: The Search for Labour-Saving Inventions*. Cambridge: Cambridge University Press.

Hamilton, A. (1892). *Alexander Hamilton's Famous Report on Manufactures Made to Congress December 5, 1791, In His Capacity as Secretary of the Treasury*. Boston: Potter Publishing Co.

Hawke, G.R. (1975). The United States Tariff and Industrial Protection in the Late Nineteenth Century. The Economic History Review. 28(1): 84-99.

Higgs, R. (2011). *The Transformation of the American Economy, 1865-1914*. Auburn, AL: Ludwig von Mises Institute.

Hobsbawm, E. J. (2003). *Sermaye Çağı (The Age of Capital)*. Ankara: Dost Kitabevi.

Hounshell, D. A. (1985). *From American System to Mass Production, 1800-1932*. Baltimore, MD: The Johns Hopkins University Press

Hudson, M. (2004). Technical progress and obsolescence of capital and skills: theoretical foundations of nineteenth-century US industrial and trade policy. *Globalization, Economic Development and Inequality: An alternative Perspective* (pp. 100-111). Editor Reinert, E. S.. Cheltenham: Edward Elgar Publishing.

Irwin, D. A. (2000a). Did Late-Nineteenth-Century U.S. Tariffs Promote Infant Industries? Evidence from the Tinplate Industry. *The Journal of Economic History*. 60(2): 335-360.

Irwin, D. A. (2000b). Tariffs and Growth in Late Nineteenth Century America. http://www.dartmouth.edu/~dirwin/docs/Growth.pdf

Irwin, D. A. (2002). Interpreting the Tariff-Growth Correlation of the Late Nineteenth Century. *NBER Working Paper No. 8739*. 2002(January)

Irwin, D. A. (2004). The Aftermath of Hamilton's "Report on Manufatures". *The Journal of Economic History*. 2004(September): 800-821

Irwin, D. A. (2006). Antebellum Tariff Politics: Coalition Formation and Shifting Regional Interests. *NBER Working Paper 12161*. 2006(April)

Ishikawa, T. (1973). Conceptualization of Learning by Doing: A Note on Paul David's Learning by Doing and the Ante-Bellum United States Cotton Textile Industry. *The Journal of Economic History*. 33(4): 851-861.

Junguito, T. A. (2009). Bairoch Revisited. Tariff Structure and Growth in the Late 19th Century. *Working Papers No. 121/09.* 2009(June)

Keller, W. (2004). International Technology Diffusion. *Journal of Economic Literature*. XLII(September): 752-782

Khan, Z. B. and Sokoloff, K. L. (2004). Institutions and Democratic Invention in 19th-Century America: Evidence from "Great Inventors," 1790-1930. *The American Economic Review*. 94(2): 395-401

Kravis, I. B. (1972). The Role of Exports in Nineteenth-Century United States Growth. *Economic Development and Cultural Change*. 20(3): 387-405

Kuznets, S. (1962). Inventive Activity: Problems of Definition and Measurement. *The Rate and Direction of Inventive Activity: Economic and Social Factors* (19-52). Editors Universities-National Bureau Committee for Economic Research, Committee

on Economic Growth of the Social Science Research Council. Princeton University Press.

Kwiatkowski, D., Phillips, P. C. B., Schmidt P. and Shin Y. (1992), Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economic time series have a unit Root? *Journal of Econometrics*, 54(1-3): 159-178.

Lamoreaux, N. R. and Sokoloff, K. L. (2007). *Financing innovation in the United States, 1870 to the present*. Cambridge, MA: The MIT Press.

Lind, M. (2012). *Land of Promise: An Economic History of the United States*. New York, NY: HarperCollins.

Lipsey, R. E. (2000). U.S. Foreign Trade and the Balance of Payments, 1800-1913. *The Cambridge Economic History of the United States Vol. II, the Long Nineteenth Century* (pp. 685-732). Editors Engerman, S. L. and Robert E. G.. Cambridge: Cambridge University Press.

Maddison, A. (2010). *Historical Statistics of the World Economy: 1-2008 AD.* www.ggdc.net/maddison/

O'Brien, P. (1988). *The Economic Effects of the American Civil War*. London: Macmillan Education Ltd.

O'Rourke, K. H. (2000). Tariffs and Growth in the Late 19th Century. *The Economic Journal*. 110 (April): 456-483.

O'Rourke, K. H. and Williamson, J. G. (2001). *Globalization and History: The Evolution of a Nineteenth-Century Atlantic Economy.* The MIT Press.

Ospina, E. O. and Roser, M. (2016). International Trade. *Published online at OurWorldInData.org.* Retrieved from: https://ourworldindata.org/international-trade [Online Resource]

Özgür, E. and Vergil, Ö. (unpublished manuscript). Foreign Trade and Nineteenth Century American Growth.

Palgrave Macmillan Ltd. (2013). *International Historical Statistics*. Palgrave Macmillan UK.

Polanyi, K. (2001). The great transformation: the political and economic origins of our time. Boston, MA: Beacon Press.

Rivera, L. A. and Romer, P. M. (1990). Economic Integration and Endogenous Growth. *NBER Working Paper No. 3528*. 1990(December)

Rodrik, D. (2006). Goodbye Washington Consensus, Hello Washington Confusion? A Review of the World Bank's Economic Growth in the 1990's: Learning from a Decade of Reform. *Journal of Economic Literature*. 2006(December): 973-987

Sachs, J. D. and Warner, A. (1995). Economic Reform and the Process of Global Integration. *Brookings Papers on Economic Activity.* 1995(1): 1-118.

Schmookler, J (1966). *Invention and Economic Growth*. Cambridge, MA: Harvard University Press.

Sokoloff, K.L. (1992). Invention, Innovation, and Manufacturing Productivity Growth in the Antebellum Northeast. *American Economic Growth and Standards of Living before the Civil War* (pp. 345-378). Editors Robert E. Gallman and John Joseph Wallis. Chicago: The University of Chicago Press.

Stiglitz (2016), J. E., Globalization and Its New Discontents, 05.08.2016, https://www.project-syndicate.org/commentary/globalization-new-discontents-by-joseph-e--stiglitz-2016-08, (07.05.2017)

Stiglitz, J. E. (2002). *Globalization and Its Discontents.* New York, NY: W.W.

Norton & Company, Inc.

Sutch, R. (2006). Gross domestic product: 1790–2002 [Continuous annual series] Table Ca9-19 in *Historical Statistics of the United States, Earliest Times to the Present: Millennial Edition*, edited by Susan B. Carter, Scott Sigmund Gartner, Michael R. Haines, Alan L. Olmstead, Richard Sutch, and Gavin Wright. New York: Cambridge University Press, 2006. http://dx.doi.org/10.1017/ISBN-9780511132971.Ca1-2610.1017/ISBN-9780511132971.Ca1-26

Taussig, F. W. (2010). *The Tariff History of the United States*. Auburn, AL: Ludwig von Mises Institute.

Temin, P. (1975). *Causal Factors in American Economic Growth in the Nineteenth Century*. London: The Macmillan Press Ltd.

U.S. Bureau of the Census (1975). *Historical Statistics of the United States, Colonial Times to 1970: Bicentennial Edition, Part 2*: Washington D.C.

Wallerstein, I. (2006). *World-System Analysis: An Introduction*. Durham and London: Duke University Press.

Williamson, J. (2002). What Washington Means by Policy Reform. *Peterson Institute for International Economics*. (https://www.wcl.american.edu/hracademy/documents/Williamson1990WhatWashingtonMeansbyPolicyReform.pdf)

Williamson, J.G. (1972). Embodiment, Disembodiment, Learning by Doing, and Returns to Scale in Nineteenth- Century Cotton Textiles. *The Journal of Economic History*. 32(3): 691-705.

Zinn, H. (2009). *A People's History of the United States: 1492-Present*. New York, NY: HarperCollins e-books.

APPENDICES

APPENDIX 1: Types of Exported and Imported Goods

Appendix Table 1: Types of Exported and Imported Goods

Class (1820-1970)	**Exports**	**Imports**
Crude materials	Crude petroleum	Crude rubber
	Coal	Raw silk
	Raw cotton	Hides and skins
Semi-manufactures	Iron and steel plates	Wood pulp
	Lumber	Copper in bars, etc.
	Refined copper	Tin in bars, etc.
Finished manufactures	Aircraft	Wool manufactures
	Cigarettes	Newsprint
	Radios and television sets	Automobiles and parts

Source: U.S. Bureau of the Census, 1975: 879

Note: U.S. Census Bureau had selected this sample of exports and imports for the time period of 1820-1970. Therefore, some of the export and import manufactures on the list such as aircraft, radios and television, automobiles remain irrelevant with respect to scope of this thesis (1820-1913).

APPENDIX 2: Proportion of custom revenues to total revenues

Appendix Table 2: Proportion of custom revenues to total revenues

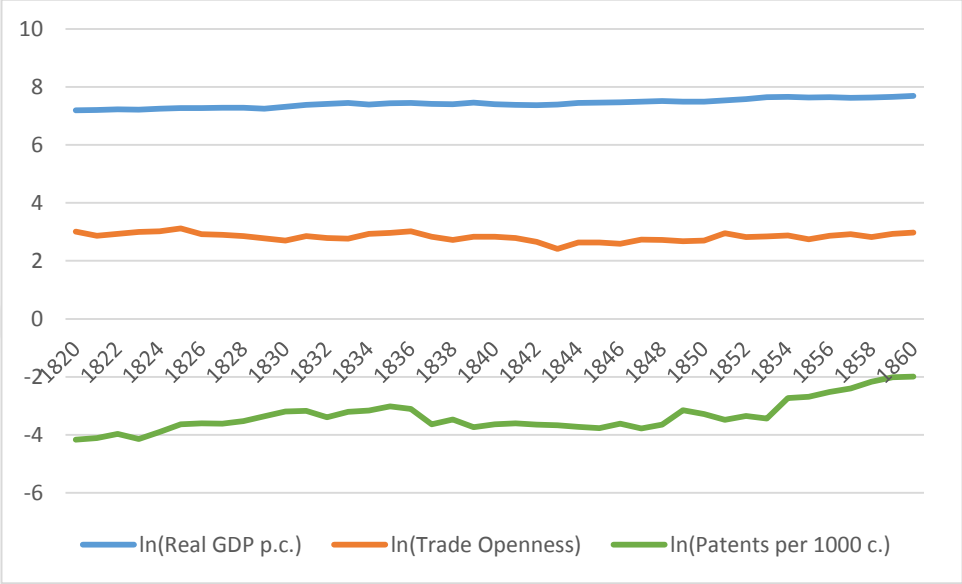
Years	**custom revenues/ total revenues (%)**
1820-29	90.1
1830-39	70.3
1840-49	87.2
1850-59	90.4
1860-69	56.7
1870-79	52.1
1880-89	56.3
1890-99	48
1900-09	47.2
1910-13	45.9

Source: U.S. Bureau of the Census, 1975: 1106

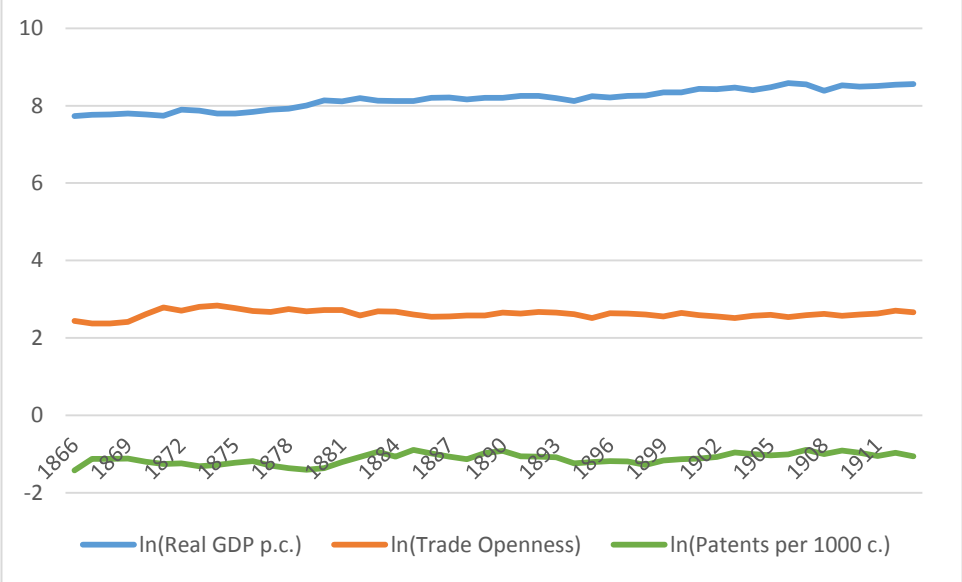
Note: Sharp fall in the proportion of customs in 1860s is due to increased internal revenues during the Civil War.

APPENDIX 3: Series in natural logarithmic form

Appendix Figure 1: Series in natural logarithmic form (1820-1860)



Appendix Figure 2: Series in natural logarithmic form (1866-1913)



APPENDIX 4: Lag Length Selection (1820-1860)

(* indicates lag order selected by the criterion)

ln (RGDP p.c.) – ln (Patented inventions p. 1000 c.)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	9.249862	NA	0.002209	-0.439386	-0.348688	-0.408869
1	73.34933	116.5445*	5.79e-05*	-4.081778*	-3.809685*	-3.990227*
2	73.87759	0.896442	7.17e-05	-3.871369	-3.417882	-3.718784
3	74.43115	0.872277	8.92e-05	-3.662494	-3.027612	-3.448875
4	75.78322	1.966653	0.000106	-3.502014	-2.685737	-3.227361
5	78.03757	3.005794	0.000121	-3.396216	-2.398545	-3.060530
6	82.70330	5.655431	0.000121	-3.436564	-2.257497	-3.039844
7	88.54105	6.368451	0.000114	-3.547942	-2.187481	-3.090188
8	92.46870	3.808631	0.000123	-3.543557	-2.001701	-3.024770

ln (RGDP p.c.) – ln (Trade Openness)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	47.52563	NA	0.000217	-2.759129	-2.668432	-2.728612
1	98.09091	91.93688*	1.29e-05*	-5.581267*	-5.309175*	-5.489717*
2	98.80879	1.218221	1.58e-05	-5.382351	-4.928864	-5.229766
3	101.0968	3.605280	1.77e-05	-5.278591	-4.643709	-5.064973
4	104.9675	5.630109	1.81e-05	-5.270755	-4.454478	-4.996103
5	106.3074	1.786554	2.18e-05	-5.109538	-4.111866	-4.773852
6	108.9079	3.152174	2.47e-05	-5.024722	-3.845656	-4.628002
7	109.9544	1.141635	3.11e-05	-4.845722	-3.485261	-4.387968
8	110.9888	1.003038	4.01e-05	-4.665988	-3.124132	-4.147200

ln (Patented inventions p. 1000 c.) – ln (Trade Openness)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1.798639	NA	0.003470	0.012204	0.102901	0.042721
1	35.71520	61.66648*	0.000567*	-1.800921*	-1.528829*	-1.709370*
2	36.28050	0.959303	0.000700	-1.592758	-1.139271	-1.440173
3	36.92282	1.012141	0.000866	-1.389262	-0.754380	-1.175644
4	37.81903	1.303578	0.001061	-1.201154	-0.384877	-0.926501
5	38.31971	0.667573	0.001344	-0.989074	0.008598	-0.653387
6	42.97026	5.637024	0.001341	-1.028501	0.150566	-0.631781
7	48.70979	6.261311	0.001273	-1.133927	0.226535	-0.676173
8	51.03686	2.256548	0.001519	-1.032537	0.509319	-0.513749

APPENDIX 5: Lag Length Selection (1866-1913)

(* indicates lag order selected by the criterion)

ln (RGDP p.c.) – ln (Patented inventions p. 1000 c.)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	38.07752	NA	0.000564	-1.803876	-1.719432	-1.773344
1	99.23929	113.1493	3.24e-05	-4.661965	-4.408633*	-4.570368*
2	101.4427	3.856009	3.55e-05	-4.572136	-4.149917	-4.419475
3	104.1799	4.516358	3.80e-05	-4.508996	-3.917888	-4.295270
4	108.7888	7.143768	3.72e-05	-4.539440	-3.779444	-4.264649
5	112.0950	4.793974	3.90e-05	-4.504749	-3.575866	-4.168894
6	114.8262	3.687194	4.24e-05	-4.441312	-3.343540	-4.044392
7	127.3360	15.63720*	2.85e-05	-4.866800	-3.600140	-4.408816
8	133.1668	6.705445	2.70e-05*	-4.958341*	-3.522794	-4.439292

ln (RGDP p.c.) – ln (Trade Openness)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	64.13114	NA	0.000153	-3.106557	-3.022113	-3.076025
1	121.7058	106.5130*	1.05e-05	-5.785288	-5.531956*	-5.693691*
2	126.1067	7.701684	1.04e-05*	-5.805336*	-5.383116	-5.652675
3	127.8839	2.932318	1.16e-05	-5.694194	-5.103087	-5.480468
4	130.0330	3.331058	1.29e-05	-5.601648	-4.841652	-5.326857
5	134.9833	7.178049	1.24e-05	-5.649167	-4.720283	-5.313312
6	137.4589	3.342036	1.37e-05	-5.572946	-4.475174	-5.176026
7	138.4320	1.216353	1.64e-05	-5.421600	-4.154940	-4.963616
8	142.7891	5.010647	1.67e-05	-5.439454	-4.003907	-4.920406

ln (Patented inventions p. 1000 c.) – ln (Trade Openness)

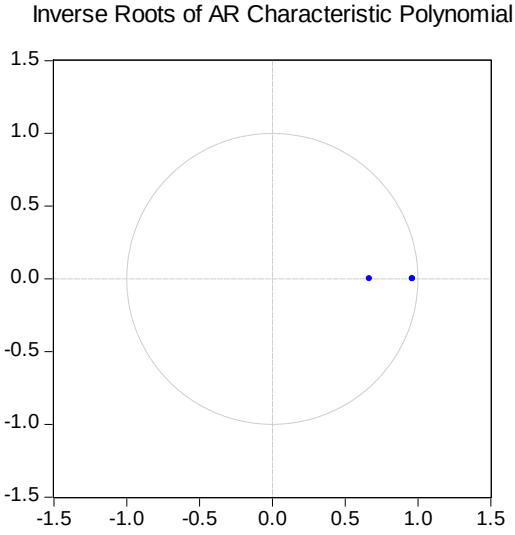
Lag	LogL	LR	FPE	AIC	SC	HQ
0	77.28552	NA	7.95e-05	-3.764276	-3.679832	-3.733743
1	104.9624	51.20223*	2.43e-05*	-4.948120*	-4.694788*	-4.856523*
2	105.5770	1.075534	2.89e-05	-4.778849	-4.356630	-4.626188
3	109.2483	6.057589	2.95e-05	-4.762413	-4.171305	-4.548687
4	110.8366	2.461989	3.36e-05	-4.641832	-3.881836	-4.367041
5	114.6996	5.601359	3.43e-05	-4.634982	-3.706098	-4.299127
6	115.6303	1.256344	4.07e-05	-4.481513	-3.383742	-4.084594
7	120.8473	6.521236	3.94e-05	-4.542363	-3.275703	-4.084379
8	126.9141	6.976889	3.69e-05	-4.645706	-3.210158	-4.126657

APPENDIX 6: Serial Correlation and Dynamic Stability (1820-1860)

ln (RGDP p.c.) – ln (Trade Openness)

Lags	LM-Stat	Prob
1	1.896360	0.7548
2	2.837330	0.5854
3	6.764692	0.1489
4	3.269804	0.5137
5	0.118894	0.9983
6	2.790936	0.5934

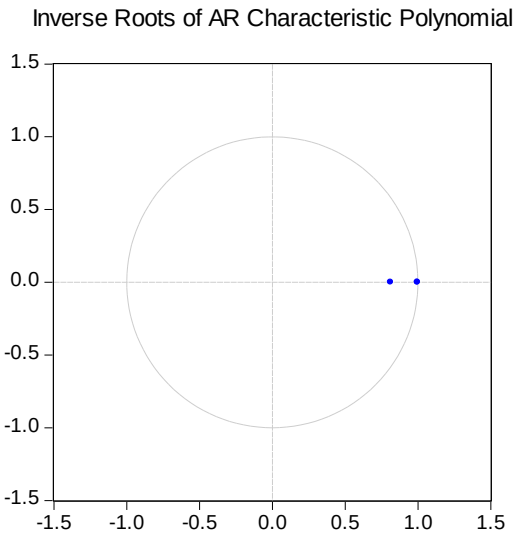
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	2.026658	NA*	2.078624	NA*	NA*
2	4.762499	0.3125	4.958456	0.2916	4
3	11.43124	0.1784	12.16791	0.1439	8
4	14.63037	0.2623	15.72249	0.2043	12
5	14.75089	0.5430	15.86023	0.4628	16
6	17.54459	0.6174	19.14694	0.5123	20



ln (RGDP p.c.) – ln (Patented inventions p. 1000 c.)

Lags	LM-Stat	Prob
1	0.686699	0.9530
2	1.482473	0.8297
3	2.626703	0.6221
4	2.100684	0.7172
5	7.040753	0.1338
6	0.503079	0.9732

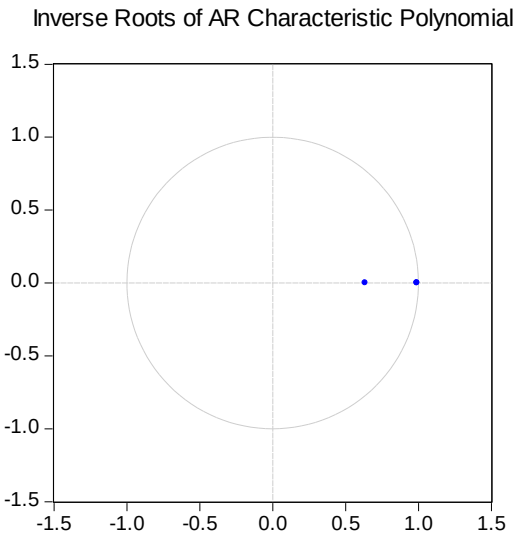
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.526867	NA*	0.540376	NA*	NA*
2	1.987923	0.7380	2.078330	0.7214	4
3	4.828170	0.7758	5.148868	0.7416	8
4	6.980116	0.8589	7.539918	0.8200	12
5	13.59184	0.6291	15.09617	0.5176	16
6	14.03904	0.8285	15.62230	0.7398	20



ln (Patented inventions p. 1000 c.) – ln (Trade Openness)

Lags	LM-Stat	Prob
1	0.611316	0.9618
2	1.079318	0.8975
3	1.864684	0.7606
4	1.134235	0.8888
5	7.710744	0.1028
6	4.786609	0.3099

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.559589	NA*	0.573937	NA*	NA*
2	1.596820	0.8094	1.665760	0.7969	4
3	3.498172	0.8993	3.721275	0.8814	8
4	4.629682	0.9692	4.978509	0.9587	12
5	11.99311	0.7445	13.39385	0.6438	16
6	16.35023	0.6947	18.51987	0.5532	20

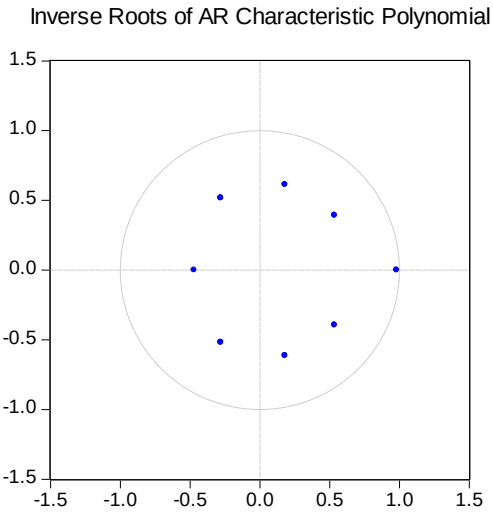


APPENDIX 7: Serial Correlation and Dynamic Stability (1866-1913)

ln (RGDP p.c.) – ln (Trade Openness)

Lags	LM-Stat	Prob
1	0.938036	0.9190
2	3.223349	0.5212
3	2.075200	0.7219
4	3.361967	0.4992
5	3.306983	0.5078
6	2.346498	0.6723
7	6.970945	0.1374
8	2.348403	0.6720

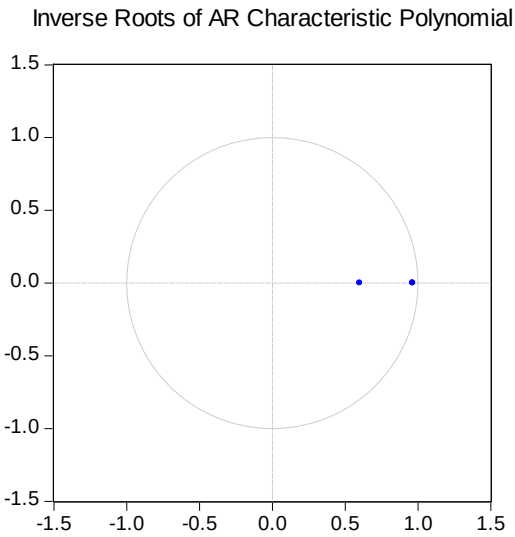
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.130014	NA*	0.133038	NA*	NA*
2	0.989065	NA*	1.032995	NA*	NA*
3	1.419715	NA*	1.495156	NA*	NA*
4	3.775458	NA*	4.086474	NA*	NA*
5	7.303035	0.1207	8.066305	0.0892	4
6	9.343786	0.3141	10.42928	0.2362	8
7	15.22124	0.2296	17.41868	0.1345	12
8	16.94448	0.3892	19.52487	0.2424	16
9	21.57851	0.3638	25.35051	0.1883	20
10	27.67458	0.2740	33.23954	0.0991	24



ln (RGDP p.c.) – ln (Patented inventions p. 1000 c.)

Lags	LM-Stat	Prob
1	6.733571	0.1507
2	3.264951	0.5145
3	4.155654	0.3854
4	3.470312	0.4824
5	2.814777	0.5893
6	2.363260	0.6693

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	5.358083	NA*	5.474564	NA*	NA*
2	8.149250	0.0863	8.389782	0.0783	4
3	12.49792	0.1303	13.03495	0.1107	8
4	16.13110	0.1853	17.00610	0.1494	12
5	18.93632	0.2720	20.14528	0.2137	16
6	21.12745	0.3897	22.65706	0.3059	20



ln (Patented inventions p. 1000 c.) – ln (Trade Openness)

Lags	LM-Stat	Prob
1	1.305022	0.8605
2	5.004158	0.2869
3	0.059290	0.9996
4	1.014325	0.9076
5	2.479813	0.6483
6	4.332821	0.3628

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.892535	NA*	0.911938	NA*	NA*
2	5.193588	0.2680	5.404149	0.2483	4
3	5.247303	0.7308	5.461526	0.7073	8
4	6.295957	0.9004	6.607729	0.8824	12
5	8.701089	0.9252	9.299186	0.9006	16
6	12.96182	0.8790	14.18343	0.8211	20