Dokuz Eylül Üniversitesi
Denizcilik Fakültesi Dergisi
Cilt:3 Sayı:2 2011

CENTENNIAL DECLINE OF SHIPPING FREIGHT RATES AND LIFE CYCLE EFFECT: THEORY OF LONG TERM CYCLES♣

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ABSTRACT

This paper reviews theories on centennial decline of the shipping freight market in the nineteenth century period and investigates the causes of great downturn. In the history of maritime transportation, the nineteenth century has a particular importance since the cost of shipping service collapsed to a historical depth in the 300 year horizon. Many scholars investigated this phenomenon and proposed theories to clarify possible reasons for the long term decreasing trend in shipping freights. Most of the propositions are based on technological improvements and their secondary influences. However, the twentieth century was a scientific and technological boom in the history of mankind and productivity gains on shipping service have not been deducted, as it is indicated in theories for the previous century. This paper extends the literature by investigating previous works and discusses the long term effects of life cycles.

Keywords: *Freight rates, life expectancy, economic history.*

ÖZET

Bu çalışma dünya deniz ticaretinde navlun fiyatlarının 19. yüzyılda yaşamış olduğu yüzyıllık düşüşün sebeblerini incelemektedir. Son 300 yıl içerisinde deniz ticaretinde en derin ve tarihi bir daralmanın gerçekleşmiş olması nedeniyle, 19.yüzyıl deniz ulaştırma tarihinde hususi bir yere sahiptir. Bir çok araştırmacı bu dönemi incelemiş ve uzun dönem düşüşün muhtemel nedenleri hakkında çeşitli teoriler ortaya atılmıştır. Değerlendirmelerin büyük çoğunluğu teknolojik gelişmeler ve onların ikincil etkileri üzerine yoğunlaşmaktadır. Ancak, 20. yüzyıl insanlık tarihinde teknolojik gelişmeler noktasında 19. yüzyıla nazaran çok daha geniş kapsamlı bir dönem olup, bir önceki yüzyılda deniz ticaretine olan etkileri yönündeki değerlendirmelere karşın, navlun fiyatları tarihi bir çıkış trendi yakalamıştır. Bu çalışma önceki tespitleri incelemekte ve özgün olarak 'yaşam döngüsü' teorisinin bu çerçevedeki uzun dönem etkilerini değerlendirmektedir.

Anahtar kelimeler: *Navlun fiyatları, ortalama yaşam süresi, ekonomi tarihi.*

♣ An earlier version of this paper is presented at IAME 2010 Conference (July 7-9, 2010) held in Lisbon, Portugal.

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INTRODUCTION

The importance of seaborne trade is indicated by several studies (Metaxas, 1971; North, 1958; Jacks, Meissner and Novy, 2009 among others). The value of seaborne trade is calculated by how much cargo is transported in how much distance between two seaports. Productivity of shipment will depend on quantity of cargo and navigating distance. These two main items are affected by various factors including economics, politics, geographical boundaries, warfare, weather conditions etc. Increasing stability on global politics triggers trading activities until the shipping industry steps up to enhance facilities and capacities. On the other hand, seasonal factors may change direction and boost wider navigating durations and distances (i.e. hurricanes, tsunami). However, productivity changes in the long run are based on more extensive elements of world merchandise trade. Such an analysis should be performed by a broader perspective which is enriched by all economic, political, technological and historical domains.

One of the critical instruments of this analysis is proper and quality statistics on seaborne trade. In literature of economic history, statistics for shipping volume and transportation costs are presented and investigated by various studies (Isserlis, 1938; North, 1958; Harley, 1988 among others). By the presentation of proper data, we concluded that shipping played a key role in economic development. The reasons for freight rate fluctuations are discussed in order to understand such economic interactions and results.

Foreign trade balance is generally based on import and export activities. However, there is an unaccounted item, which is the service of overseas transportation (Isserlis, 1938). There is no doubt that shipping is a key indicator in international trade and its cost is a part of retail prices. Fluctuations on shipping freights still influence prices on finished goods as they did previously. The structure and terms of shipping freights are classified into two main divisions, which are voyage domain pricing and time domain pricing. Voyage domain pricing – named voyage charter – includes all fixed and variable costs of shipment such as operation costs, port dues, agency fees, brokerage commissions, financing costs etc. On the other hand, a time domain pricing – named time charter – only consists of fixed costs such as financing costs, daily mandatory expenses (i.e. manning, victualling) and so on. If a trading price of a product is declared as CIF (cost, insurance, freight), it also reflects transport cost factor to some degree.

Various shipping companies, exchanges and governmental institutions keep freight rate records and also several freight indices are published for average of the market and for a specific ship size. History of freight rate is investigated by many scholars and the theories on shipping productivity are indicated according to several hypotheses (Harley, 1988; North, 1958; Mohammed and Williamson, 2004). Particularly on long distance transportation, shipping cost is as crucial as it was in the 18^{th} and 19^{th} century. However, capacity of shipment was highly limited, speed of service tied to proper seasonal winds and cargo traffic single way took longer than both directions do today (i.e. Atlantic trades). Under the conditions of these various factors, shipping service evolved. Freight rates are broadly affected from the particulars of maritime transportation characteristics.

The present research discusses shipping productivity and compares economic thinkers based on their inferences and contributions. Furthermore, the effect of life expectancy on shipping freight rates is discussed.

SEMINAL WORKS AND THEIR CORRESPONDING THEORIES

Preliminary works of Leon Isserlis

In 1938, Leon Isserlis published his outstanding study "Tramp shipping cargoes and freights" and provided one of the noteworthy sources of freight market fluctuations. As an important statistician, he served the Chamber of Shipping, UK and compiled several freight rate data which mainly benefited Angier (1920). His assessments pointed out cycles of warfare in the Franco-German War, the African War and World War I. Although Isserlis supplied freight rate index for a critical turning point of the world, these indices are criticised by many scholars due to the lack of suitable number of fixtures and unnecessarily overweighting of some routes (Mohammed and Williamson, 2004; Veenstra and Dalen, 2008 among others). Gathering this information with previous records and inferring reasons of longer term fluctuations remained for contemporary researchers such as North (1958) and Harley (1988).

Institutional improvement thought of Douglass North

Douglass North (1958) attempted to extend the recent freight market knowledge by superimposing freight rate of British Import and American Export data. According to Douglass North, the decline of freight rates in the nineteenth century was formed by three main factors of shipping productivity: *Increasing efficiency of freight markets*, *Technological innovations* and *Development of external economies*.

The nineteenth century is crucial in terms of communication technology. Increasing availability and speed of telegraphy facilities ensured proper and timely communication between ship-owners, charterers and also masters of ships. Imperfect market condition (Fama, 1970) was mitigated and uniformity in the movement of rates was partly maintained by increasing availability of overseas negotiations.

Another indication is reported with respect to technological improvements. Both steam power usage and metallurgical revolution improved stability for higher carrying capacity ships and rapid service even in the lack of winds for sail propulsion. Resistance for stronger sea conditions is obtained. Hull and engine technologies led to safer navigation and prevented loss of property (i.e. due to piracy attacks).

North (1958) also concluded an important aspect of the post-discovery term for the world, which is the presence of cargoes for returning to homeports named backhaul cargoes. After the industrial revolution, both in North American and Asian destinations, exporting products were supplied and backhaul cargoes could be carried on a highly competitive price as compared with ballast voyages of empty cargo holds. New regions expand in population and income with new export trades and further export products were implemented.

North (1958) extended our knowledge about the long term decline of freight rates in the nineteenth century and the freight rate data stretches until the beginning of the twentieth century. Later these data are judged by Harley (1988) because of the technical particulars of cotton loads.

Technological improvement thought of C. Knick Harley

C. Knick Harley (1988) pointed out that the main source of increasing productivity is metallurgical development, which was broadly improved by industrial revolution. His argument concludes that technological improvements provided stronger hull designs (i.e. metal ships), increasing capacity of ships and service speeds (i.e. steamship technology). Therefore sea transport ensured productivity gains due to technical performance.

Harley (1988) indicates that North’s freight rate data for cotton trades has an important shortcoming since the packaging technique of cotton bags has changed. Compressing cotton into the bags provides additional transport volume and the cost of carriage is lesser per tons of cargo. In this way, capacity decreases from 20-25 pounds per cubic foot to 8-12 pounds per cubic foot. It is almost twice that of previous measures. North’s evidence for the sharp decline at the beginning of the nineteenth century arose mainly by such technical metamorphosis. In spite of a long term moderate decline in the rates, it was not expected to deepen – as indicated for the first half of the 1800s.

Harley (1988) summarises reasons of freight rate decline on six items:

- Innovation of steamships against the sailing ships.
- Opening of Suez Canal and superiority of steamers on Asia-Europe transport. Larger sailing ships are usually not suitable for Red Sea navigation because of lack of proper winds.
- Metallurgical technology provided safer ship design, decreasing number of crew, lessening loss of ships, and increasing capacity of cargo space.
- Increasing productivity on steel industry reinforced the shipbuilding industry for cheaper production and stronger and larger designs.

- Packaging technology ensured increasing use of transport volume.
- Presence of tugs supported manoeuvrings of larger steamers in the port.

Furthermore, there is the unavoidable factor of *warfar*e. The eighteenth century witnessed substantial warfare including the War of the Austrian Succession (1740-1748), the Seven Years War (1756-1763), the War of American Independence (1776-1783), and the Wars of the French Revolution and Napoleon (1793-1815). Compared with the nineteenth century, the eighteenth century had a stronger effect of warfare on international trade. Therefore, it was not safe for navigation, and increments for war risks were incurred on the rates of shipping transport.

Recent contributions

Kaukiainen (2001) reported research about the transmission of information and influences of electric telegraph. After the 1820s, information transfer speed and coverage are broadly developed and communication has been available for intercontinental transmissions as well. Increasing distribution of information ensured efficient use of commercial news, meteorological records and port facilities. Thus, circulation of freight rates and nominated cargoes is easily performed in several locations including both sides of Atlantic and Indian trades. "*Communication technology*" is noted once more as one of the critical reasons for freight rate decline.

O'Rourke and Williamson (2002) examined the "*Globalisation*" issue including a long history of international trade. About the freight market, they pointed out the globalisation effect and increase in international trade. By the establishment of free trade and commercial collaboration between various trading routes, efficiency of markets was increased markets, providing competitiveness in shipping service.

Jacks (2005) investigated international commodity market integration in the Atlantic economy under the global developments of 19th century. He reported issues concerning price fluctuations and trade costs. An important indication is presented about the freight market. Freight rates slackened in the 19th century because of the increasing bilateral trades among the Europe-America and Europe-Asia routes as well as technological developments. During several centuries, trade flows are characterised by the single direction transport and ballast voyages (empty cargo holds) are steered for backing to product sources. The industrial revolution influenced many countries including developing continents such as Americas and Asia. Manufacturing facilities are developed and products are available for exporting. Merchant ships are loaded on both directions and free spaces are utilised well. "*Bilateral utilisation*" provided reduction on cost of shipping.

OVERVIEW OF CONTRIBUTIONS

One of the most cited issue in economic history is the decline of freight rates in the 19th century and its influences on global trade. Although wholesale prices increased in the same period, shipping costs distinctly exposed a long term decline. Many economic philosophers developed theories about the decline of freight rates and they mainly indicated rise of shipping productivity for several reasons. In order to build a wide perspective, I want to summarise and extend these theories.

First of all, the political, economic and structural differences between the 1700s and the 1800s should be defined. Analysis is based on investigation of ‘efficiency of freight markets’ and ’technological capability of shipping service facilities’. Although concentration is on two main issues, one more item should be expressed, which is the opening of Suez Canal.

Efficiency of Freight Markets

Concerning the condition of free trade, Navigation Acts (1660 and 1696) of the British Empire have critical importance. Navigation Acts regulate shipping from and to British states. According to the Acts;

- Only British ships could transport imported and exported goods from the colonies.
- The only people who were allowed to trade with the colonies were British citizens.
- Commodities such as sugar, tobacco, and cotton wool which were produced in the colonies could be exported only to British ports.

These regulations restricted flexibility of the fleet and discriminated other countries’ fleets. Therefore, the available shipping fleet term is different than today. Although probably there is suitable number of tonnages, supply of shipping service is partly regulated. The case of Navigation Acts continues till the end of 1700s. In the second half of 18th century, the British had fallen in several wars and the Navigation Acts are loosened. In spite of the official declaration of free trade in 1849, shipping service gained its freedom by the revolutions.

When passing from 18th century to 19th century, one of the critical discriminations of sea trade is collapsed. The effect of Navigation Acts presumably can not be avoided. Notably, the Napoleonic Wars dissolved the discrimination and both Atlantic and Levant trades gained competitiveness. The downturn of the Ottoman Empire also contributed by releasing Levant trading routes.Another important improvement arose from the ’Bilateral Trading Pattern’. Particularly in the Atlantic case, shipping service is mainly employed on single-way trades from Europe to Americas before the 19th century. However, the Industrial Revolution brought several opportunities for Americas to improve manufacturing activities, while external economies contributed to transportation industry. The technological improvements of the Industrial Revolution (which will be discussed in the next section) ensured the production of some backhaul cargoes from the Americas to Europe and from Indies to European trades. Ships have chosen to be loaded for backing routes at a competitive price. Freight rates would be balanced on both directions day by day. Marginal discounts existed on long distance shipments.

Technological Capability of Shipping Service Facilities

By the Industrial Revolution, shipping industry had gained productivity through three main tracks: the first was the development of steam power on merchant ships, the second was the development of steam power on manufacturing industries, and the third was metallurgical innovations.

Steam power provided an exclusive superiority, and ships were available to navigate more safely, rapidly and with increasing cargo capacity. It was very valuable for both Atlantic and Indian routes. By the steam powered industries on both sides of Atlantic, ships were loaded for both directions. Manufacturing and export products have been raised in Americas and empty spaces of ships could be loaded with reasonable low costs. Metallurgical improvement of hulls provided larger, stronger and higher capacity merchant fleets. These ships were also less costly in the manning. Rather than a highly specialised sail ship operation, metal steam ships are easy to operate and crew size declined. Communication technology is another critical improvement which develops efficiency of freight markets by exchanging commercial information. By the 1800s, port and shipping news were distributed more quickly and intercontinental telegraph communication increased competitiveness of negotiations. Also, both ports and fleet were better utilised.

One of the most fascinating geographical technologies should be the opening of the Suez Canal. In 1869, the Suez Canal had begun service for merchant shipping and the canal provided shorter voyages to Indies. However, in the time of opening and later during the closure issues of the 20th century, effects of Suez canal was not larger than a regular freight rate cycle. Quantitative measures of this issue will be discussed in the next section.

LIFE CYCLE AND INFLUENCES

A recent study of Duru and Yoshida (2010) provided a long term freight rate index (here-after LFI) through combination of unweighted average growths of several freight rate data (See appendix). LFI is based on dry cargo and general cargo (before 1950s); shipping records which are mainly derived from various cited papers. Table 1 presents the source of time series data for establishment of LFI. LFI series has long term data (267 years) starting from 1741 and ending in recent records. Combination of several dataset is performed by using interconnected periods of data. Table 2 shows correlation indices among the various datasets and results indicate that the dataset has a high correlation in most areas. Therefore, it is possible to connect a series by averaging ratio-to-change fluctuations and applying them to an initial value, 100.Such a long term record ensures comparative analysis between several centuries. Fig. 1 indicates the LFI dataset and it is clear that there is a two-century cycle in the 1700s and 1800s. A hundred-year upturn follows the previous cycle. The supercycle of WWI is well noted.

Table 1. Description of data used in LFI.

Term	Description Source	Code
Freight rates & indices		
1741-1872	Tyne - London Coal route freight rate series. Harley (1988)	TLCH
1741-1872	U.S. - British Grain route freight rate series. Harley (1988)	USGH
1790-1815	British Import Freight Rate Index series. North (1958)	BIFRI
1814-1910	American Export Freight Rate Index series. North (1958)	AEFRI
1869-1936	Isserlis Composite Index series. Isserlis (1938)	ISSCI
1869-1913	New UK Index series. Klovland (2002)	NUKFI
1898-1913	Economist’s Freight Index series. Yoshimura (1942)	ECONI
1921-1939	Economist’s Freight Index series. Yoshimura (1942)	ECONI
1920-1969	UK Chamber of Shipping Index series. Isserlis (1938), Hummels (1999	UKCSV
1948-1997	Norwegian Shipping News Voyage Freight Index series. Hummels (1999)	NSNVI
1948-1990	Norwegian Shipping News Time Charter Index series. Hummels (1999)	NSNTI
1952-1989	UK Chamber of Shipping Time Charter Index series. Hummels (1999)	UKCST
1986-2008	Baltic Freight Index / Baltic Dry Index series. Baltic Exchange Co., London; Hummels (1999).	BFI/BDI
1988-1996	German Ministry of Transport Time Charter Index series. Hummels (1999)	GMTTI
1991-2007	Lloyd’s Shipping Economist (LSE) Tramp Index series. LSE Magazine various issues.	LSEFI
Deflator series		
1741-1954	Price of Composite Unit of Consumables. Brown & Hopkins (1956)	PUCON
1954-2008	RPI: Retail Price Index of U.K. Office for national statistics, U.K. (www.statistics.gov.uk).	RPIUK

Table 2. Correlation matrix for consequent freight rates/ indices.

Included observations: 1991-2007, 17 years.

Correlation	LSEFI	BDI
LSEFI	1.00	
BDI	0.99	1.00

Included observations: 1986-1997, 12 years.

Correlation	NSNVI	BDI
NSNVI	1.00	
BDI	0.98	1.00

Included observations: 1952-1989, 38 years.

Correlation	NSNVI	NSNTI	UKCST
NSNVI	1.00		
NSNTI	0.94	1.00	
UKCST	0.88	0.95	1.00

Included observations: 1948-1969, 22 years.

Correlation	NSNVI	NSNTI	UKCSV
NSNVI	1.00		
NSNTI	0.97	1.00	
UKCSV	0.96	0.99	1.00

Included observations: 1921-1936, 16 years.

Correlation	ISSCI	ECONI	UKCSV
ISSCI	1.00		
ECONI	0.98	1.00	
UKCSV	0.98	0.98	1.00

Included observations: 1869-1910, 42 years.

Correlation	ISSCI	AEFRI	NUKFI
ISSCI	1.00		
AEFRI	0.96	1.00	
NUKFI	0.95	0.97	1.00

Included observations: 1814-1872, 59 years.

Correlation	USGH	AEFRI	TLCH
USGH	1.00		
AEFRI	0.77	1.00	
TLCH	0.96	0.76	1.00

Included observations: 1790-1815, 26 years.

Correlation	TLCH	USGH	BIFRI
TLCH	1.00		
USGH	0.89	1.00	
BIFRI	0.70	0.90	1.00

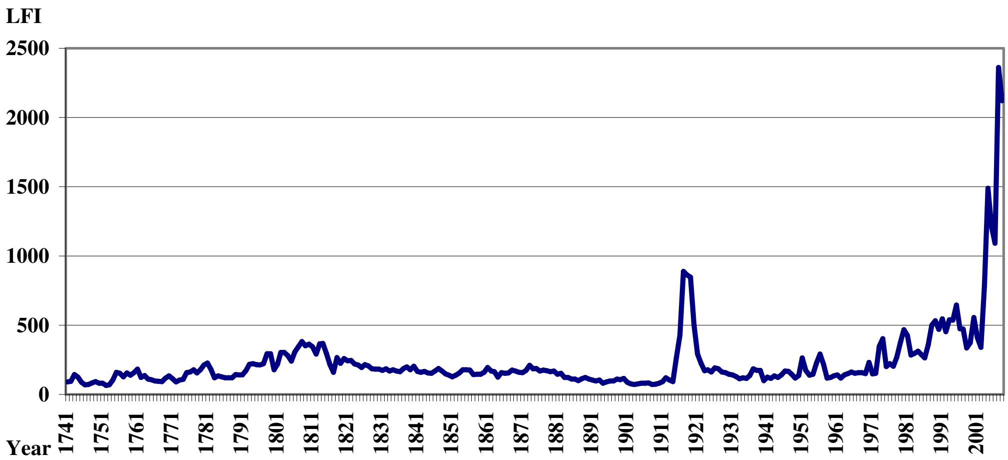


Figure. 1. The LFI series between 1741 and 2008 (Duru and Yoshida, 2010).

The 18th century has a long term increasing trend and higher volatility relative to the 19th century. In the 19th century, a long term decline exists and volatility is broadly dampened. Finally, the 20th century brings a long term upturn with highly volatile rates. The main concentration of comparative analysis will be between the 19th and 20th centuries. We listed several reasons for the decline of freight rates. However, many similar cases exist in the 20th century and their results are the major emphasis. Table 3 point out some important particulars of the two centuries. The 19th century is the long term downturn period and the 20th century is the long term upturn period. The concern is whether conditions are really changed. One of the most noted particulars of the 19th century are the technological improvements. Nevertheless, the 20th century recorded innovations boom such as was never previously seen. Steam power was displaced by diesel engine; both the size and speed of merchant ships are exponentially increased[3].Port technologies have also ensured high speed operations.

Table 3. Comparison of leading factors between centuries.

Factor	1800s	1900s
Trading independence	Free trade policy of England (1849).	Trading is broadly free in worldwide.
Marine technology	Steam power and metal hull	Diesel engines and higher propulsion power, very large carriers, electronic navigation, automatic cargo handling, satellite communication, higher speed, self-manoeuvring by thrusters etc.
Communication technology	Telegraph	Telephone (although it is invented on the last quarter of 1800s, practically and widely used after 1900s), satellite systems, internet, electronic mails, P2P internet phones etc.
Trading routes	Multilateral trading.	Multilateral trading. World wide, unlimited trading.
Transport geography	Suez Canal opening.	Various sea canals were constructed including Panama Canal.

[3] For a detailed information about shipping technology development, please refer to Stopford (2009).

As it is indicated in table 3, the 20th century ensured several technological improvements and also freedom of trade was extended in world wide circumstances. Even these contributions are quite more than in the previous century. However, a possible decline of freight rates was not recorded in the long term. These indications lead us to review the great recession phenomenon with other evidences. The following section points to this issue and introduces life cycle theory and its inferences.

Life cycles and shipping trade

The number of consumers is a key factor in production industry and it influences price of goods and service accordingly. Shipping freights represent a considerable proportion of the price of finished goods, so shipping freights and wholesale prices have a strong relationship in the global economy (Metaxas, 1971).

The effect of population is somewhat complicated since many high population countries can not contribute to developing wealth of nation. The definition of consuming population is crucial. Consuming particulars of population depend on wealth and quality of life among the whole members of community. Increasing life quality is followed by increasing life expectancy on every level of age. Particularly, its impacts are expected to be long term.

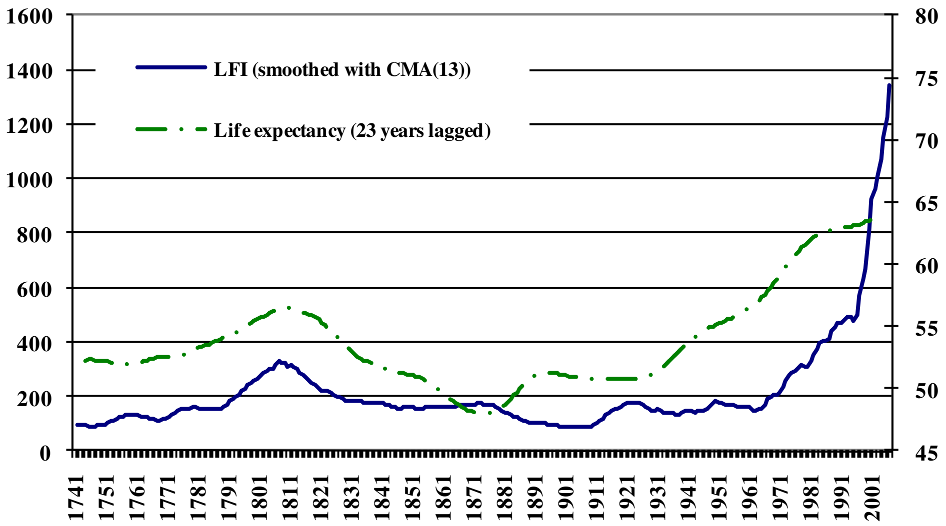
Life expectancy is used for many econometric models and it defines several economic dynamics. Fogel (1994) pointed out effects of decreasing mortality and increasing life expectancy on economic growth. Life expectancy is frequently used for long term modeling and analysis of economic growth (Barro, 1996; Sachs and Warner, 1997; Bloom and Sachs, 1998; Bloom, Canning and Sevilla, 2004 among others). Bloom, Canning and Sevilla (2004) presented a model of economic growth and it is reported that life expectancy is a statistically significant driver of increase in production output among 104 countries.Bloom and Canning (1999) express four main reasons for defining life expectancy as an economic indicator:

> "*Productivity. Healthier populations tend to have higher labor productivity, because their workers are physically more energetic and mentally more robust. They suffer fewer lost workdays due to illness or the need to care for other family members who have fallen ill.Education. Healthier people who live longer have stronger incentives to invest in developing their skills, because they expect to reap the benefits of such investments over longer periods. Increased schooling promotes greater productivity and, in turn, higher income. Good health also promotes school attendance and enhances cognitive function.*
>
> *Investment in physical capital. Improvements in longevity create a greater need for people to save for their retirement. Insofar as increased savings*

lead to increased investment, workers will have access to more capital and their incomes will rise. In addition, a healthy and educated workforce acts as a strong magnet for foreign direct investment.

Demographic dividend. The transition from high to low rates of both mortality and fertility has been dramatic and rapid in many developing countries in recent decades. Mortality declines concentrated among infants and children typically initiate the transition and trigger subsequent declines in fertility. An initial surge in the numbers of young dependents gradually gives way to an increase in the proportion of the population that is of working age. As this happens, income per capita can rise dramatically, provided the broader policy environment permits the new workers to be absorbed into productive employment."

Figure 2 presents life expectancy data and LFI. Life expectancy data is based on U.S. population and at age 10. Since it is available for such long term, U.S. data is preferred. For proper visualisation, LFI data is smoothed and WWI effects are interpolated. Life expectancy data is also smoothed with same particulars, centred on a moving average of 13 years. Finally, life expectancy data lagged 23 years to clarify co-movement. Correlation coefficient between these two series is defined positive at 0.75 levels. Indications of theories and visual results explicitly expose a possible long term co-movement between two indicators.



Source: LFI is a composite index that calculated by Duru and Yoshida (2010). Life expectancy data is by Fogel (1986) and U.N. statistics.

Figure 2. LFI (left scale) and Life expectancy (right scale; 23 years lagged)(at age 10, U.S.) between 1741 and 2008.

Testing for leading effect

For testing the influences of life expectancy data, a classical linear regression model is estimated and coefficient of leading indicator is tested for significance. Table 4 presents descriptive statistics for both dataset. Number of data for life expectation (E10) is more than LFI and it is possible to apply long time lags to E10 for modeling the beginning period of LFI. Although, E10 data is terminated in 2005, the recent data is unnecessary in case of long time lags.

Table 4. Descriptive statistics.

	LFI	E10
Observations	1741-2008	1722-2005
Minimum value	65	47.80
Maximum value	2361	69.60
Standard deviation	246.54	5.25
No. of data	265	284
Mean	228.65	54.88

Tables 5 and 6 indicate Ng-Perron (2001) unit root-stationarity test results. According to assumptions of classical linear regression model, we expect the data has no unit roots. Rather than the conventional unit root tests, Ng-Perron M-tests are developed to improve its power to several conditions. Before testing stationarity, both dataset are smoothed with centred moving average at 13 years length (sLFI and sE10). Ng-Perron test is based on intercept and trend for sE10 and intercept for sLFI. Spectral estimation is performed with autoregressive generalised least squares method. Lag lengths are based on Schwarz information criterion selection (maximum lags:15). Both test results indicate that series have no unit roots (due to higher rates of MZa and MZt) and they are stationary (due to higher rates of MSB and MPT).

Table 5. Ng-Perron (2001) test results for sE10 data.

		MZa	MZt	MSB	MPT
Ng-Perron test statistics		-2.08	-0.75	0.36	30.49
Asymptotic critical values*	1%	-23.80	-3.42	0.14	4.03
	5%	-17.30	-2.91	0.16	5.48
	10%	-14.20	-2.62	0.18	6.67
*Ng-Perron (2001, Table 1)					

Table 6. Ng-Perron (2001) test results for sLFI data.

		MZa	MZt	MSB	MPT
Ng-Perron test statistics		18.44	4.83	0.26	28.03
Asymptotic critical values*	1%	-13.80	-2.58	0.17	1.78
	5%	-8.10	-1.98	0.23	3.17
	10%	-5.70	-1.62	0.27	4.45

*Ng-Perron (2001, Table 1)

Since both dataset are stationary, the leading effect is tested for 23 years. The leading period is selected according to distance between two peaks of data. However, an extended simulation may provide the most significant time lag due to existing period of data. Table 7 presents results of testing equation. Constant and coefficient of life expectancy are quite significant. Durbin-Watson (D.W.) statistics are very low, which indicates that autocorrelation on residuals and additional explanatory terms may improve it. This paper does not deal with modeling LFI and just looks for leading effect. Wald coefficient restriction test shows that the significance of life expectancy is very high. Zero coefficient hypothesis is rejected. According to statistical evidences, life expectancy is recorded as one of the major drivers of long term freight rates in centennial cycles.

Table 7. Testing model for sLFI and sE10.

$$sLFI_t = \beta_0 + \beta_1\, sE10_{t-23} + \varepsilon_t$$

$$\varepsilon_t \sim N(0,\sigma^2)$$

OLS, 1741-2005.

$$sLFI_t = -995.86 + 22.44\, sE10_{t-23} \qquad \text{(eq.1)}$$

(86.774) (1.607)

[-11.476] [13.960]

R-sq: 0.434 S.E.: 102.99 D.W.: 0.06 AIC[1]: 12.115 SIC[2]: 12.142

Wald coefficient restriction test [c(1)=0][3] *F*-statistics 194.90 (*p*: 0.000)
Serial Correlation - Lagrange Multiplier test[4]: *F*-statistics 1.554 (*p*: 0.21)

[1] Akaike Information Criterion (Akaike, 1973).
[2] Schwarz Information Criterion (Schwarz, 1978).
[3] Wald (1943).
[4] Breusch and Pagan (1980).

CONCLUSION

This paper reviews main theoretical ideas on shipping and productivity of sea service. The long term decline of the 19th century is a noteworthy issue, so many scholars investigated the term of decline. Nobel Prize awarded economic historian Douglass North particularly focused on efficiency issue, but several studies also focused towards technology improvements. The 20th century was a unique period of technological improvements. However, these improvements are not priced in freight rates, nor do they have broader influence. Conditions of 19th century and 20th century are quite different. Technology may have had particular importance for the 19th century. However, we should consider that technology is not limited to shipping; it is also one of the drivers of the industrial revolution and increasing trade. Both technological improvements and increasing trade depend on healthy people and their reasonably long life duration. As is indicated in the macroeconomic models, life expectancy is observed as a leading factor for shipping service.

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APPENDIX.

LONG TERM DRY CARGO FREIGHT RATE INDEX

1741-1900

Year	LFI	Year	LFI	Year	LFI	Year	LFI
1741	89.44	1781	226.95	1821	242.72	1861	195.49
1742	95.71	1782	179.59	1822	244.68	1862	169.82
1743	143.76	1783	120.99	1823	220.50	1863	165.22
1744	124.35	1784	134.91	1824	212.90	1864	124.79
1745	88.88	1785	128.44	1825	194.16	1865	156.26
1746	69.73	1786	119.84	1826	216.28	1866	151.96
1747	72.68	1787	120.02	1827	206.85	1867	156.15
1748	83.69	1788	120.71	1828	185.97	1868	175.04
1749	92.18	1789	142.99	1829	182.98	1869	168.08
1750	82.17	1790	141.54	1830	182.68	1870	160.71
1751	80.24	1791	140.78	1831	174.37	1871	157.50
1752	65.52	1792	172.18	1832	185.25	1872	174.05
1753	68.98	1793	218.34	1833	169.36	1873	210.05
1754	105.25	1794	222.47	1834	178.42	1874	185.68
1755	160.68	1795	214.79	1835	169.32	1875	188.07
1756	152.76	1796	213.51	1836	163.23	1876	168.40
1757	127.08	1797	221.60	1837	187.84	1877	175.84
1758	154.80	1798	294.47	1838	199.07	1878	170.51
1759	138.01	1799	295.06	1839	178.40	1879	165.20
1760	158.46	1800	177.91	1840	203.46	1880	168.08
1761	183.96	1801	219.70	1841	167.74	1881	145.87
1762	121.59	1802	302.32	1842	158.64	1882	151.94
1763	137.38	1803	303.04	1843	166.27	1883	123.84
1764	110.39	1804	279.54	1844	154.37	1884	122.36
1765	107.60	1805	240.38	1845	152.87	1885	110.53
1766	98.16	1806	308.73	1846	168.63	1886	111.38
1767	95.63	1807	345.09	1847	187.14	1887	99.47
1768	92.85	1808	383.07	1848	168.23	1888	114.30
1769	118.50	1809	350.87	1849	147.45	1889	121.80
1770	134.25	1810	362.93	1850	138.96	1890	111.93
1771	113.43	1811	344.43	1851	128.44	1891	103.45
1772	89.17	1812	291.81	1852	139.09	1892	96.56
1773	105.06	1813	365.89	1853	155.53	1893	104.12
1774	108.50	1814	369.19	1854	177.66	1894	81.40
1775	158.12	1815	297.23	1855	179.29	1895	89.80
1776	162.98	1816	215.78	1856	175.83	1896	97.62
1777	177.84	1817	159.16	1857	143.15	1897	97.93
1778	155.58	1818	265.53	1858	146.76	1898	110.87
1779	177.87	1819	224.32	1859	145.20	1899	106.99
1780	212.96	1820	260.16	1860	159.72	1900	116.40

1901-2008

Year	LFI	Year	LFI	Year	LFI
1901	87.05	1943	134.48	1989	532.81
1902	77.02	1944	123.25	1990	469.59
1903	72.71	1945	142.23	1991	545.88
1904	75.85	1946	168.97	1992	454.38
1905	80.07	1947	166.50	1993	539.41
1906	80.62	1948	146.92	1994	536.07
1907	82.91	1949	117.47	1995	646.39
1908	71.53	1950	137.36	1996	474.79
1909	73.53	1951	263.86	1997	472.53
1910	82.00	1952	173.26	1998	336.04
1911	93.23	1953	139.62	1999	373.64
1912	120.66	1954	145.61	2000	555.39
1913	104.82	1955	227.99	2001	410.72
1914	92.57	1956	291.82	2002	339.55
1915	267.16	1961	140.93	2003	785.30
1916	428.95	1962	116.97	2004	1488.67
1917	887.86	1963	141.59	2005	1212.41
1918	863.20	1964	149.64	2006	1093.29
1919	847.46	1965	162.91	2007	2360.94
1920	501.34	1966	153.76	2008	2120.39
1921	292.64	1967	156.88		
1922	223.60	1968	157.93		
1923	170.79	1969	150.67		
1924	178.98	1970	231.59		
1925	162.92	1971	148.67		
1926	193.11	1972	153.13		
1927	184.53	1973	347.12		
1928	161.55	1974	403.78		
1929	156.27	1975	201.94		
1930	146.29	1976	222.04		
1931	140.38	1977	204.69		
1932	130.75	1978	271.21		
1933	113.31	1979	374.98		
1934	121.32	1980	466.47		
1935	116.40	1981	425.56		
1936	137.62	1982	285.19		
1937	184.11	1983	296.01		
1938	173.59	1984	312.36		
1939	174.17	1985	289.37		
1940	100.11	1986	263.36		
1941	124.27	1987	359.82		
1942	115.59	1988	500.73		