Dry Bulk Shipping and the Evolution of Maritime Transport Costs, 1850-2020

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This paper evaluates the dynamic effects of fuel price shocks, shipping demand shocks, and shipping supply shocks on real maritime transport costs in the long run. We first analyze a new and large dataset on dry bulk freight rates for the period from 1850 to 2020, finding that they followed a downward but undulating path with a cumulative decline of 79%. Next, we turn to understanding the drivers of booms and busts in the dry bulk shipping industry around this trend, finding that shipping demand shocks strongly dominate all others as drivers of real dry bulk freight rates. Furthermore, while shipping demand shocks have increased in importance over time, shipping supply shocks in particular have become less relevant.

Introduction

Events in the past year have amply demonstrated that volatility in shipping markets not only never went away but also that it is back … big time. Thus, the Baltic Exchange Dry Index nearly quadrupled in value in the short period of time from the end-of-January to the end-of-June 2020 as the aftershocks of COVID-19 first ravaged, then spurred international trade in bulk commodities.

Alongside such considerations of dramatic intra-annual movements in freight rates, professional sentiment has long argued for the existence of alternating booms and busts in the maritime shipping industry which can take years to complete (Metaxas, 1971; Cufley, 1972; Stopford, 2009). What is more, a burgeoning academic literature in behavioral finance and industrial organization has taken these claims to heart, finding that such boom/bust activity goes a long way in understanding the dynamics of ship building, ship earnings, and ship prices in the dry bulk sector.

The key underlying mechanism in these papers is the role of unanticipated positive shipping demand shocks and their propagation over time. In the wake of such shocks, the attendant booms in maritime freight rates generate over-investment in shipping supply either due to time-to-build constraints as in Kalouptsidi (2014) or firms being simultaneously too optimistic in their projections of future freight rates and too pessimistic in their projections of their competitors' responses as in Greenwood and Hansen (2015).

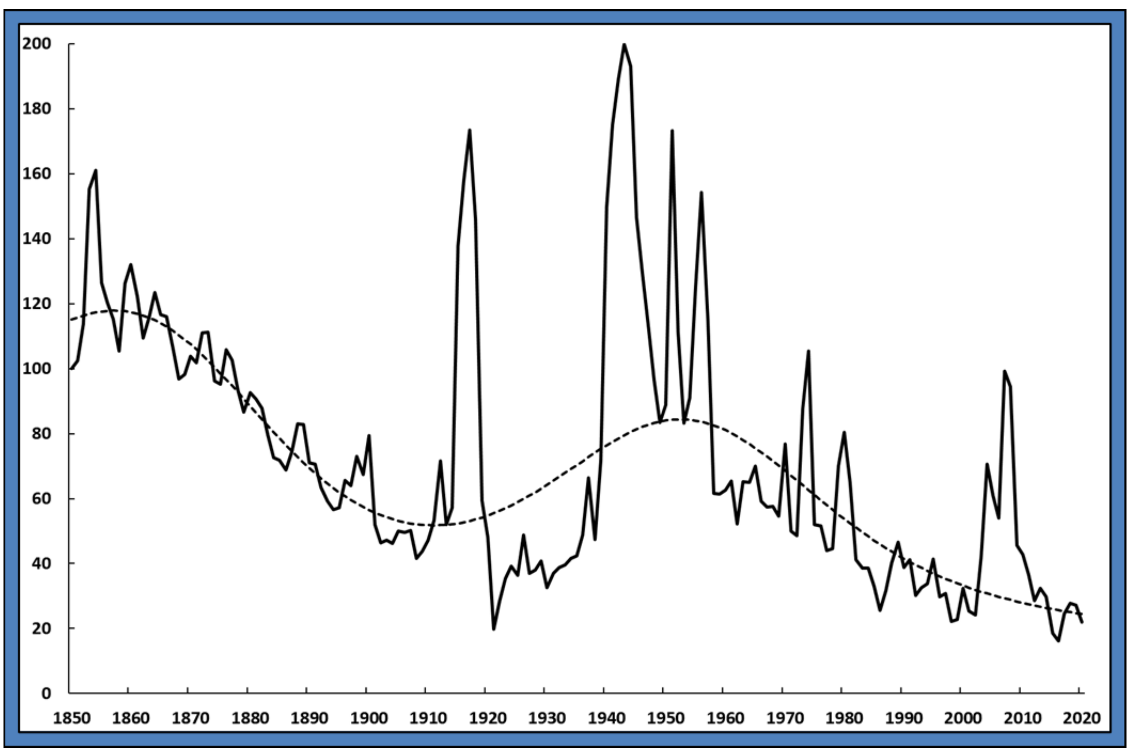
A New Series of Dry Bulk Freight Rates

One of the chief outputs of this paper comes in the form of a new and comprehensive dataset on global dry bulk freight rates from 1850 to 2020. We narrow our attention to activity in the dry bulk sector — that is, commodity cargo like coal, grains, and ore which is shipped in large, unpackaged parcels — for two principal reasons. For one, this sector represents roughly 50% of world trade by volume in the present day (UNCTAD, 2015). Historically, this share would have been even higher, given that the composition of trade by value only began to favor manufactured goods from the late 1950s (Jacks and Tang, 2018). Thus, developments in the dry bulk sector loom large in our understanding of the global economy, shipping markets, and their co-evolution.

For another, dry bulk markets are decentralized spot markets whereby parties must engage in a search process in order to hire a ship for a specific itinerary. Thus, their hire rates — that is, dry bulk freight rates — reflect real-time conditions in the supply of and demand for their services. This is in contrast to other means of maritime transport like containerships or liners which operate in between fixed ports on fixed schedules and which sometimes can be bound to long-term contracts.

All told, there are 10,448 observations on maritime freight rates underlying the real dry bulk index presented below. Our method of aggregating these data into a single real dry bulk index comes in applying the "repeat-sailings" methodology first proposed in Klovland (2009). This procedure has strong intuitive appeal in that it roughly amounts to calculating an unweighted average of changes in real freight rates in any given year. The final series is depicted in Figure 1 below. To our knowledge, this is the longest consistently-measured and continuous series on the costs of shipping goods in the literature.

Figure 1
Real Dry Bulk Index, 1850-2020 (1850=100)



Notes: The solid black line represents the real dry bulk freight rate index, constructed as described in the full paper. The dotted black line is an estimate of the long-run trend derived from the Christiano-Fitzgerald band pass filter which assumes a cyclical component of 70 years duration in the real dry bulk freight rate index.

Figure 1 allows us to document the following important facts:

(1) real dry bulk freight rates are estimated to have followed a downward but undulating path over time: thus, they fell by 55% from 1850 to 1910, rose by 62% from 1910 to 1950, and fell – once again – by 71% from 1950 with a cumulative decline of 79% between 1850 and 2020.

(2) behind these slowly evolving trends, there were also often abrupt movements with real dry bulk freight rates in some instances nearly tripling on a year-to-year basis.

We relate this secular decline to a historical literature which documents significant productivity growth as radical changes in goods handling and storage in ports, naval architecture, and propulsion took place (Harley, 1988; Mohammed and Williamson, 2004; Tenold, 2019). Abstracting away from this long-run trend and its potential productivity-related determinants, we then narrow our focus to understanding the drivers of booms and busts in the dry bulk shipping industry which occur at a higher frequency.

That is, is it possible to rationalize the often extreme inter-annual changes we observe in dry bulk freight rates by considering fundamentals in the sector?

Methodology

We build on a canonical structural vector autoregressive (VAR) model with sign restrictions to set-identify shocks in the dry bulk freight market. Faust (1998), Canova and De Nicolo (2002), and Uhlig (2005) pioneered this model which has become a go-to in empirical macroeconomics. The same methodology makes it possible to set-identify the various shocks that drive dry bulk freight rates at any one moment that might have offsetting impacts. Based on assumptions related to basic supply-and-demand analysis, we specify four orthogonal shocks to real maritime freight rates which we interpret as a shipping demand shock, a shipping supply shock, a fuel price shock, and a residual shock.

In particular, we assume that a positive aggregate demand shock represents an unexpected expansion in global economic activity as in periods of rapid industrialization and urbanization. This, in turn, leads to not only higher global Gross Domestic Product (GDP), but also higher global shipping tonnage, higher real fuel prices, and higher real freight rates. One key mechanism at work here is that an increase in dry bulk freight rates due to an increase in shipping demand triggers not only investment in new shipping capacity but also technological change in the wider industry.

In contrast, a shipping supply shock represents an unexpected inward shift of the shipping supply curve. We associate such shocks with declines in world gross tonnage and assume that they negatively affect global GDP and real fuel prices but positively affect real maritime freight rates. Likewise, we assume that positive fuel price shocks negatively affect global GDP and the supply of shipping services but an increase in real maritime freight rates.

Finally, the residual term captures all remaining uncorrelated shocks, including changes in expectation and potential measurement error. For our purposes, it can also – at least partially – be interpreted as a utilization shock (see Kilian, Nomikos, and Zhou, 2020). For example, the International Maritime

Organization introduced regulation in 2020 imposing a reduction in the sulfur content of fuels used by ships. One means of compliance is through the use of scrubbers for filtration purposes, but this comes with additional monetary and time costs of installation, additional weight for non-shipping purposes, and additional fuel costs as a scrubber-equipped ship consumes roughly 5% more fuel per tonne of cargo (Kerriou, 2020). Here, we assume that residual shocks negatively affect global real GDP, positively affect world gross tonnage, and lead to higher real freight rates. However, we leave the effect of such a residual shock on real fuel prices unrestricted.

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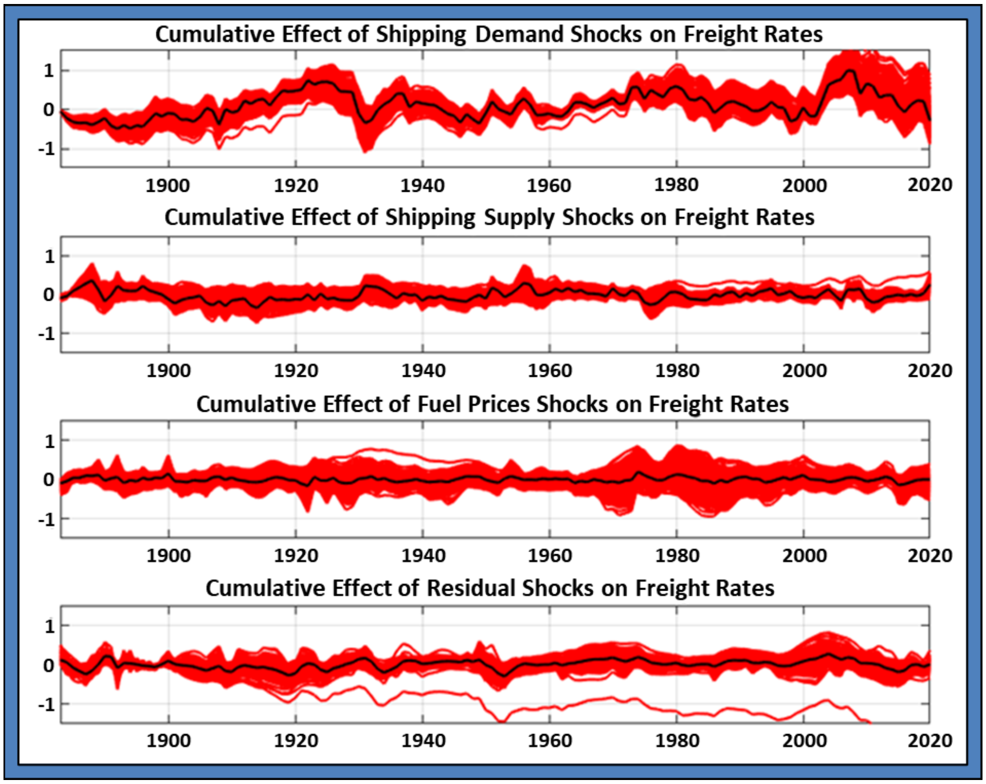
Results

Based on the sign-restricted VAR model, we compute structural impulse response functions and historical decompositions for real dry bulk freight rates. The historical decompositions depicted in Figure 2 on the next page are of particular interest: they show the cumulative contribution at each point in time of each of the four structural shocks in driving booms and busts in real dry bulk freight rates. Thus, they serve to quantify the independent contribution of the four shocks to the deviation of our new series from its base projection after accounting for long-run trends in real dry bulk freight rates.

Figure 2 also allows us to visually discern the historical drivers of booms and busts in the dry bulk shipping industry. The vertical scales are identical across the four sub-panels so that the figures clearly illustrate the relative importance of a given shock. Another way of intuitively thinking about these historical decompositions is that each of the sub-panels represents a counterfactual simulation of what real dry bulk freight rates would have been if it had only been driven by one particular shock.

Figure 2
Historical Decompositions of Real Freight Rates



Notes: The chart shows the historical decompositions from the 68% joint highest posterior density sets obtained from the posterior distribution of the structural models. The cumulative effects implied by the most likely structural model (modal model) are depicted in black. The results shown are based on 5,000 draws from the reduced-form posterior distribution with 20,000 draws of the rotation matrix each, as extensively explained in the full paper.

Table 1 more precisely quantifies these impressions by numerically summarizing the contribution of each shock by period. Our results indicate that shipping demand shocks strongly dominate all others as drivers of real dry bulk freight rates over the long run. For the full period from 1880 to 2020, shipping demand shocks explain 49% of the variation in real dry bulk freight rates while shipping supply shocks explain 22%. These two fundamental shocks which are related to simple supply and demand conditions, thus, explain a significant majority (71%) of the medium- and long-run variation in real dry bulk freight rates. Fuel price shocks and residual shocks respectively explain 11% and 18% of the same.

Table 1
Shares of Shocks in Explaining Booms and Busts in Freight Rates by Period

	Shipping demand shock	Shipping supply shock	Fuel price shock	Residual shock
Full sample: 1880-2020	49%	22%	11%	18%
Pre-World War I: 1880-1913	44%	29%	11%	16%
Interwar: 1919-1939	56%	17%	8%	19%
Post-World War II: 1949-2020	50%	20%	11%	19%

Notes: Table 1 reports the share of variation in the real dry bulk index explained by the four structural shocks for the period from 1880 to 2020 and three sub-periods.

It is also possible to replicate this decomposition for shorter spans of time by using the parameter estimates derived from the full sample in combination with the respective size of shocks for various sub-periods. Table 1 shows that the contribution of shipping demand shocks to variation in real dry bulk freight rates increased substantially in the interwar years and remained elevated in the post-World War II era. Likewise, the contribution of shipping supply shocks decreased substantially in the interwar years and remained suppressed in the post-World War II era. Finally, the contribution of both fuel price shocks and residual shocks remained roughly constant through the three sub-periods.

Tasks for Future Research

What remains as tasks for the future comes in developing disaggregated measures of maritime transport costs across commodity classifications and destination/origin pairings. That is, it would be useful to have a characterization of the respective shares of shocks for particular commodity-destination-origin combinations which could then be matched with known features of commodity and industrial production and their geographical determinants.

An additional way forward would also come in developing a much more refined measure of shipping supply, specifically as it relates to the dry bulk sector. Here, we have had to abstract away from the implications of increasing specialization by ship type, technological change in propulsion, and time-varying utilization rates which may vitally affect any measure of the effective – as opposed to the observed – supply of dry bulk shipping services. Thus, in any final reckoning of the respective role of fundamentals in the dry bulk shipping market, shipping supply may yet reemerge as a more dominant force if our current measure of mercantile gross tonnage diverges too far from actual supply conditions on the ground.

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