The Spatial Term Structure of Spot Freight Rates

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Objective

Spot market indices for the freight markets in bulk shipping, such as those produced by the Baltic Exchange, are estimated by brokers based on a fixed lead time (e.g. “Laydays/cancelling 10/20 days from index date"). In reality, ships can be fixed anywhere along a route such that there may also be a spatial component in the spot freight rate for individual fixtures. Consequently, there is not a single spot rate on a given date, but many along the distance (or time-to-loading) dimension. That is, there exists effectively a spatial “term structure of spot freight rates". Such a spatial component may reflect the degree of risk aversion of shipowners and charterers and is therefore expected to be market dependent. For instance, charterers may worry about transportation shortage in a strong market and be willing to fix ships early at relatively higher rates, while owners may accept a discount for early ships in a poor market just to secure employment. The objective of this paper is to investigate the time-varying properties of spot rates jointly in the time and space dimension.

Data/Methodology

We formulate regression models where the spot freight rates observed for individual fixtures depend on the remaining distance to the loading port, fixture characteristics, vessel technical specifications, and market conditions. Specifically, we examine the spatial term structure of the freight rate using the following model:

$$\mathbf{rate}_{it} = \boldsymbol{\alpha} \cdot \boldsymbol{distance}_{it} + \boldsymbol{X'\eta} + \boldsymbol{\xi}_{g;t} + \boldsymbol{\epsilon}_{it}$$

where $rate_{it}$ is the freight rate for fixture i fixed at date t. Variable $distance_{it}$ is the distance from the vessel’s location on the fixture date to the loading port. We include a set X_{it} of fixture- and vessel-specific characteristics as control variables, including laydays, log of cargo quantity, log of fixture-route distance (distance from the loading port to the discharge port), and vessel age. To reduce the endogeneity due to omitted variables, we also include a variety of fixed effects $\xi_{g;t}$. First, market conditions play a significant role in determining the freight rate on average. We control for this by using monthly fixed effects and time trend (day). Second, the freight rate of a specific fixture depends on the bargaining and market power of the charterer and the ship’s owner. We, hence, include charterer fixed effects and owner fixed effects to account for the time-invariant effect of charterer and ship owner identity.

To examine the spatial term structure of the contacted freight rate for individual fixtures, we are interested in coefficient α. This coefficient represents the change in the freight rate if the ship is one unit farther from the loading port. Alternatively, if the remaining sailing distance reduces an additional unit, the change in the fixture freight rate is -α. We also estimate the potential nonlinear effect of the remaining sailing distance by considering a specification with a quadratic function of $distance_{it}$ and a non-parametric estimation of the cubic smoothing spline.

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We further decompose the spatial premium (discount) by market condition status. We first examine the additional change in spatial premium (discount) by including the interaction between $distance_{it}$ and $market\_deviation_t$, where $market\_deviation_t$ is the percent deviation of the route's Baltic Exchange market index from its historical 150-day average. We then explore the spatial premium (discount) by certain categorical deviation of market condition from its historical average.

The dataset is built by matching each fixture report as obtained from Clarkson Research's Shipping Intelligence Network (date of fixture, origin, destination, laycan period (i.e. pick-up window), name of the vessel, name of charterer, etc.) with the AIS-reported geographical position of the vessel at the moment of getting fixed and assigning ship specifications from the Clarkson Research World Fleet Register. We further test that the ship is physically present in the loading area within the laycan period, albeit with an allowance of potential delays by several days, to eliminate fixture reports that were not realized eventually. From the matched dataset, we measure (from AIS data) the remaining distance to sail between the point of fixture and the loading area. We focus geographically on the transport of iron ore in Capesize vessels from West Australia to northeast Asia as this is the most homogeneous and liquid route in the physical Capesize market.

Our final sample consists of 1,356 observations from 2016 to 2019. Table 1 reports summary statistics of variables in the sample. We use the Baltic Exchange Capesize Index (for the route C5, West Australia to China) to refer to the general state of the spot freight market. To represent the average level of the market index, our main analysis uses the 150-day moving average of the spot market index.[2] Further, to classify high and low market conditions, we calculate the deviation between the market index and its 150-day-average level, focusing on the time when the market is 10%, 20%, and 30% higher and lower than the historical average.

Table 1 Descriptive statistics

	count	mean	sd	min	max
freight rate ($/tonne)	1360	7.79	4.09	1.55	29.75
distance (nm)	1365	3679.04	1400.51	.09	15163.23
cargo quantity	1363	168143.8	42813.39	16000	1700000
deadweight tonnage	1365	178805.7	7215.98	108943	262000
cargo/deadweight tonnage	1363	.94	.24	.09	9.56
age	1365	6.91	3.86	0	30
fixture-route distance	1365	7939.33	3537.33	1703.65	18304.78
period-average level	1365	6.61	0	6.61	6.61
BCI 150-day average level	1365	5.93	1.42	3.65	8.26
BCI deviation from its average level	1356	.07	.22	-.44	.69

[2] Our results are also robust for other moving average choices (100-day, 200-day, and 250-day). We also consider the average of our sample period, from 1 January 2016 to 31 December 2019, as the benchmark for classifying market conditions.

Results/Findings

Table 2 reports the spatial term structure of the fixture freight rate. The most comprehensive linear specification (4) including all fixed effects and controls shows the marginal effect of loading distance on freight rate is -$0.15. Put differently, as the remaining sailing distance of the ship reduces by 1000 nautical miles, the spot rate for fixture will be marked up by $0.15. On average, therefore, ships fixing early have to accept a discount versus the market index.

Table 2 The spatial term structure of spot rates

	rate($/tonne)					
	(1)	(2)	(3)	(4)	(5)	(6)
distance (1000nm)	-0.177*	-0.216***	-0.145**	-0.150*	-0.109	-0.281*
	(0.099)	(0.069)	(0.070)	(0.083)	(0.159)	(0.160)
distance^2					-0.004	0.015
					(0.015)	(0.015)
laydays	0.082**	0.122***	0.030	0.036	0.031	0.034
	(0.033)	(0.024)	(0.025)	(0.030)	(0.025)	(0.030)
log(quantity)	-0.768	-1.629*	-0.826	-0.316	-0.826	-0.327
	(1.161)	(0.931)	(0.564)	(0.457)	(0.562)	(0.465)
age	0.127***	0.019	0.020	0.015	0.020	0.015
	(0.024)	(0.017)	(0.015)	(0.019)	(0.015)	(0.019)
log(fixture-route distance)	6.473***	6.658***	6.470***	6.348***	6.476***	6.321***
	(0.369)	(0.268)	(0.420)	(0.446)	(0.428)	(0.449)
time trend		0.007	0.008	0.009	0.008	0.009
		(0.007)	(0.007)	(0.008)	(0.007)	(0.008)
monthly FE	-	Y	Y	Y	Y	Y
time trend (day)	-	Y	Y	Y	Y	Y
charterer FE	-	-	Y	Y	Y	Y
owner FE	-	-	-	Y	-	Y
Clustered SE	vessel	vessel	vessel	vessel	vessel	vessel
Observations	1358	1358	1358	1358	1358	1358
Adjusted R^2	0.369	0.683	0.757	0.776	0.757	0.776

Table 3 shows the change in marginal effect of loading distance when the market condition deviates from its historical 150-day average. If we control for the time trend and fixed effects, the spatial term structure of the fixture freight rate will marginally increase by 8 cents when the market index is 10% higher than its 150-day moving average.

Table 3: Marginal effects of market condition on the spatial term structure of freight rate

	rate($/tonne)			
	(1)	(2)	(3)	(4)
distance (1000nm)	-0.274***	-0.225***	-0.156**	-0.168**
	(0.091)	(0.068)	(0.071)	(0.084)
distance × market deviation	0.012***	0.009***	0.008***	0.008***
	(0.001)	(0.001)	(0.001)	(0.002)
laydays	0.088***	0.123***	0.031	0.033
	(0.032)	(0.024)	(0.024)	(0.029)
log(quantity)	-0.929	-1.682*	-0.885	-0.358
	(1.126)	(0.987)	(0.629)	(0.513)
age	0.130	0.020	0.021	0.010
	(0.025)	(0.017)	(0.015)	(0.018)
log(fixture-route distance)	6.633***	6.606***	6.404***	6.294***
	(0.368)	(0.268)	(0.421)	(0.446)
time trend		0.002	0.004	0.006
		(0.007)	(0.007)	(0.008)
monthly FE	-	Y	Y	Y
time trend (day)	-	Y	Y	Y
charterer FE	-	-	Y	Y
owner FE	-	-	-	Y
Clustered SE	vessel	vessel	vessel	vessel
Observations	1349	1349	1349	1349
Adjusted R^2	0.431	0.691	0.763	0.783

When breaking the deviation of market condition by categorical percentage level, Table 4 shows that in an average market condition, there is an (insignificant) spatial discount in spot freight rates. However, during strong markets, charterers have to pay spatial premia (relative to the spatial term structure in the average market condition) to secure the remaining few ships. Put differently, there is a price penalty for charterers that fix early. Conversely, during poor freight markets, the net effect is strongly negative, indicating that owners are willing accept a discount in order to secure early employment. This aligns very well with a degree of risk aversion for both parties, and the observation that during poor markets there is an oversupply of vessels, while there can be a shortage of transportation capacity during very strong freight markets.

Table 4: Marginal effect of high/low market condition on the spatial term structure of freight rate relative to an average market (within ± 10% of historical average)

	rate($/tonne)			
	(1)	(2)	(3)	(4)
distance (1000nm)	-0.212	-0.208	-0.120	-0.128
	(0.097)	(0.074)	(0.078)	(0.090)
distance×market in high 30%	0.363***	0.264***	0.172***	0.163***
	(0.071)	(0.066)	(0.060)	(0.062)
distance×market in high 20%	0.161**	0.132**	0.092	0.094
	(0.064)	(0.059)	(0.066)	(0.064)
distance×market in high 10%	0.063	0.087*	0.066	0.097**
	(0.065)	(0.051)	(0.048)	(0.049)
distance×market in low 10%	-0.203**	-0.094	-0.147**	-0.221***
	(0.090)	(0.078)	(0.060)	(0.077)
distance×market in low 20%	-0.204**	-0.195**	-0.222***	-0.221**
	(0.103)	(0.077)	(0.085)	(0.098)
distance×market in low 30%	-0.790***	-0.336***	-0.281**	-0.368***
	(0.092)	(0.129)	(0.123)	(0.140)
laydays	0.086***	0.120***	0.029	0.031
	(0.032)	(0.024)	(0.025)	(0.030)
log(quantity)	-0.897	-1.671*	-0.865	-0.314
	(1.082)	(0.975)	(0.613)	(0.505)
age	0.120	0.018	0.020	0.013
	(0.024)	(0.017)	(0.015)	(0.018)
log(fixture-route distance)	6.664***	6.626***	6.409***	6.278***
	(0.367)	(0.268)	(0.420)	(0.444)
time trend		0.003	0.004	0.004
		(0.007)	(0.007)	(0.008)
monthly FE	-	Y	Y	Y
time trend (day)	-	Y	Y	Y
charterer FE	-	-	Y	Y
owner FE	-	-	-	Y
Cluster SE	vessel	vessel	vessel	vessel
Observations	1358	1358	1358	1358
Adjusted R^2	0.434	0.688	0.761	0.781

Figure 1 plots the net marginal effects of loading distance on fixture freight rate by market condition, or the spatial term structure of freight rates as we have called it. We note that the effect is significant only during poor markets, where we can observe a greater spatial discount in the fixture rate for early ships (i.e. vessels that have a long remaining distance to the load port).

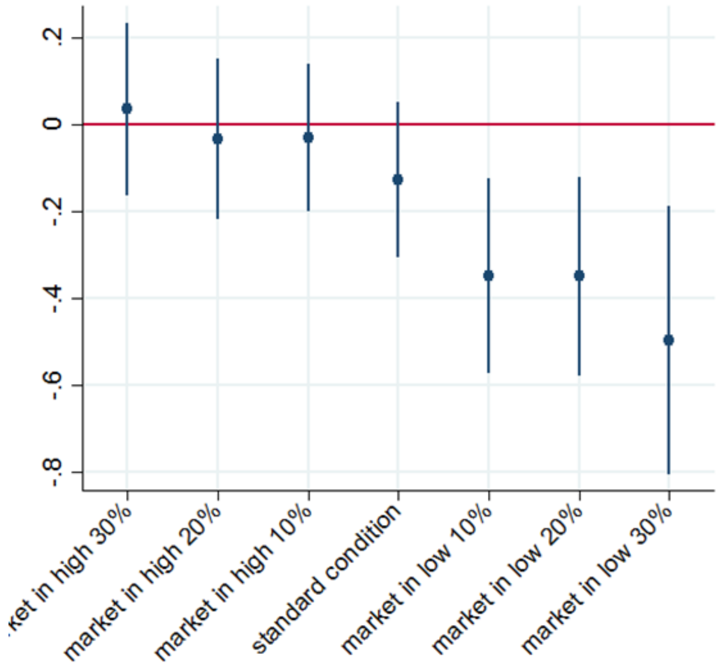

Figure 1: Spatial term structure of freight rates by market condition

Note: This figure shows the marginal effects of loading distance on fixture freight rate by market condition.

Implications for Research/Policy

We have shown, for the first time in the literature, that the spot rate for individual contracts depends not only on the identity of owners/charterers, the overall market condition, and vessel- and contract specifications, but also when the vessel is fixed relative to the loading port. We find evidence of a significant spatial discount during poor freight markets, indicating that owners fixing their vessels early accept a discount to the market index.

Our findings contribute to the under-researched area of freight market behaviour, and have implications for optimal chartering strategies. We also shed light on the impact of risk attitudes, which is an area that deserves more attention in future research.

Keywords: *Term structure, drybulk, spot rates, Capesize, spatial premium*