

The Impact of Bunker Price on VLCC Spot Rates

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Abstract

Over the last ten years, VLCC spot rates have been extremely volatile with full-on booms in 2004 and 2007/2008. The strengthening of the market in 2002 through 2004 leading to the 2004 boom can be explained simply by ton-mile demand growing faster than available ton-mile supply. But this is not the case for the 2007/2008 boom. The paper argues that these rates spikes were caused by increases in bunker prices changing the shape of the VLCC supply curve. At least in the short run, high bunker prices are an owner's best friend.

Keywords

VLCC; Spot Rates; Bunker price; Slow steaming

1 The Question

Figure 1 summarizes the VLCC market over the last decade. In early 2002, rates were at near-lay-up levels. Persian Gulf (PG) liftings, the all-important source of VLCC demand, were at about 18 MM BPD. The VLCC fleet afloat was about 125 tons. The VLCC orderbook was nearly non-existent.

Over the next two years, PG liftings rose nearly 5 MM BPD, the VLCC fleet grew only by about 5 million tons, and rates climbed to a full-scale boom in late 2004. This induced a tremendous amount of ordering.

Between late 2004 and late 2007, PG liftings fell by about 1 MM BPD. The VLCC fleet grew by about 18 million tons. Yet in late 2007, the VLCC spot rate skyrocketed to over WS300, rates we had not seen since 1973.

The obvious question is: **how can ton-mile demand go down by 5%, ton-mile supply go up by 14%, and rates go through the roof?**

2 A Closer Look at the last three years

Figure 2 is a better view of VLCC spot rates since 2007. This figure also shows bunker prices over this period. There is quite a bit of **positive** correlation between rates and the price of bunker fuel oil (BFO). At the beginning of 2007, BFO prices were around \$250 per ton. Through 2007, they climbed to over \$500 per ton. In 2007, the growth in PG liftings — roughly 5% — was approximately matched by growth in VLCC tonnage, yet spot rates expressed Term Charter Equivalent (TCE) rates went from \$30,000 per day to \$300,000 per day.

In 2008, there was a lull in VLCC deliveries, and a slight further increase in PG liftings; but the overall demand-supply picture was far less favorable than in 2005, yet in July rates again spiked to over \$200,000 per day. At the same time, BFO prices went to an unheard of \$750 per ton plus.

The demand side fell apart in late 2008. Between August 2008 and February 2009, PG liftings fell over 3 MM BPD (about 15%). And bunker prices fell to below \$200 per ton. The VLCC spot rate plummeted, briefly touching lay-up levels in early 2009. At the same time, fleet growth resumed. VLCC tonnage afloat grew 15 million tons despite about 7 mm tons of VLCC to VLOC conversions. This should have put the VLCC market in a classic slump with rates at lay-up levels or below. Yet the spot rates have remained well-above layup level, fluctuating between \$10,000 and \$25,000 per day, with a strong blip into the 40's in April. At the same time, BFO prices have jumped from \$200 per ton to over \$400 per ton. Most of that increase took place in the spring. As we shall see, this is not a coincidence.

3 VLCC Slow-steaming Curves

Figure 3 displays four slow steaming curves for a late 1990's double hull VLCC. A slow-steaming curve shows the optimal steaming speed at a function of spot rate for a given BFO price. If rates are low enough, the owner should be laid-up and the opti-

mal steaming speed is zero. As rates improve, eventually they will reach *lay-up level*, the level at which the owner is indifferent between being laid up and operating. If he is operating at this level, it will be at a very reduced speed. In the case of a conventional long-stroke diesel, it is technically difficult to operate below about 50% power —about 12.5 to 13 knots average loaded/ballasted — for any length of time.¹ For such engines this will be the operating speed when the spot market is at layup levels. As rates further improve, it will pay the owner to speed up as he balances the additional fuel cost against the additional revenue.

However, the amount of this speed up is critically dependent on bunker prices. As Figure 3 shows, if BFO prices are at \$100 per ton, the owner comes out of layup at a Worldscale rate of about 15, and it only takes another 7 to 10 WS points, before he is at full speed. This was the standard situation for motor VLCC's prior to the big jump in crude prices in 2002.

As bunker prices rise, not only does the horizontal portion of the curve rise, but the curve becomes less J-shaped for owners will speed up less rapidly with a given increase in spot rate. At \$200 per ton BFO, the bottom of the recent range, the owner comes out of lay up in the mid-30's WS, and will be at full speed at about WS60. At \$400 per ton BFO, the owners needs another 20 WS points before coming out of layup, and he will not go to full speed until rates hit WS100. At \$800 BFO, the owner needs over WS200 to justify going to full speed.

If thinking in terms of slow steaming curves is not your thing, then please see Appendix A for a concrete example of how this works.

At first glance, one might think this argument applies only to ships that are actually in the spot market, and not to term chartered or oil company tankers. In fact, all ships will speed up/slow down in response to the spot rate in exactly the same way as the players attempt to maximize their profits or minimize their costs. Doubters please see Appendix B.

4 VLCC Short-run supply

A little reflection will reveal that, in the short-run, the VLCC ton-mile supply curve is simply all the fleet's slow steaming curves for the prevailing BFO price added up horizontally.² In fact, if we assume that all VLCC's have the same slow-steaming curve — very roughly true — then the short-run VLCC supply curve is just the VLCC slow-steaming curve with the horizontal axis relabeled to ton-miles, as shown in Figure 4. The vertical portion on the right

¹ In about 2003, owners began switching to main engines with electronically controlled fuel injection valves for their new-buildings. This technology extends the range of the engine downward considerably. As these new technology engines become more predominant the supply curve will become less J-shaped below 12/13 knots.

² Short-run in this context is a period short enough so that the overall VLCC fleet afloat can be assumed to be fixed.

³ It takes a period of below layup level rates to induce owners to layup.

at 15.75 knots is 100% of available ton-miles. Each knot decrease in average steaming speed represents a reduction in ton-miles supplied by about 6%.

From this perspective, a change in BFO price changes the shape of the short-run ton-mile supply curve. At \$100 BFO or less, the supply curve is almost completely J-shaped. Supply is extremely elastic up until the point at which the entire fleet is at full speed, at which point supply becomes totally inelastic. This in an on-off market; rates are either at or near lay-up levels or they are in boom.

As bunker prices rise, the situation becomes more interesting. In the short-run VLCC ton-mile demand is almost independent of VLCC spot rates. Thus, ton-mile demand is a nearly vertical line in Figure 4. Suppose ton-mile demand is at 90% of available ton-miles afloat, as shown in Figure 4. Table 1 shows the resulting supply-demand intersections as a function of BFO price.

The interesting column is on the right. Not only does the equilibrium Worldscale rate rise as bunker prices increase; ***but the revenue increase is far more than the increase in bunker outlays, and the owner's earnings per day increase as well.*** In fact, the revenue increase pretty much overwhelms the bunker price increase in terms of the bottom line. In short, the ***positive*** correlation between bunker prices and owners' earnings in Figure 2 in 2007 and 2008 is anything but a coincidence.

2009 is slightly different. The fall in PG liftings and the simultaneous cratering of bunker prices in late 2008 was a double whammy. Ton-mile demand shifted to the left about 13%, and the shape of the supply curve moved from the green line to the blue line. Rates fell to near lay-up levels. New tonnage continued to flow out of the yards, shifting the vertical portion of the supply curve to the right. If this had been all that had happened, rates would now be mired at layup levels or below.³ But at the same time, bunker prices recovered sharply, moving us from the blue curve to the red curve or higher. As a result we had a nice rate blip in April and average rates remained well above layup.

5 Commercial Conclusions

The conclusion is obvious. In analysing the tanker market, it is misleading — in fact, nearly meaningless — to merely compare ton-mile demand with total available (full speed) ton-mile supply. The shape of the supply-curve is as important as these other two factors. And the key factor that controls the shape of the supply curve is bunker prices. Any model of the tanker market that does not recognize this fact will go hopelessly astray in today's BFO price envi-

ronment.

A possibly surprising corollary is that, unless the market is so strong that all tankers are steaming at full speed, owners should welcome an increase in bunker prices, and fear a decrease, at least in the short run.⁴ In particular, they should embrace restrictions on fuel sulfur content, and a carbon content based bunkers tax.

6 Regulatory Implications

Conversely, understanding slow-steaming is essential to efficient regulation of the bulk carrier markets. Consider CO₂ emissions. We assume the goal is to reduce CO₂ emissions *efficiently*, that is, whatever level of emissions reduction is achieved, we want to do it in the least costly manner possible. In the short run with the fleet fixed, slow-steaming is essentially the only means of reducing CO₂ emissions from ships. The issue is: what is the efficient level of slow-steaming?

The answer is: it depends on the market. In boom, when ships are scarce the value of a marginal ton-mile to society is an order of magnitude or more higher than in slumps when ships are in surplus, and this is reflected in the spot rate.⁵ To reduce overall CO₂ emissions at a minimum cost to society, ship owners should reduce speed far more in a slump than in a boom.

Any regulatory scheme which does not recognize this fact will end up being horribly inefficient and ineffective. Imposition of an EEDI (Energy Efficiency Design Index) is such a scheme. EEDI at its core is a mandatory reduction in installed power. EEDI not only does nothing to incentivize slow-steaming, but will actually increase CO₂ emissions in non-booms by forcing owners to push their engines harder moving away from the most fuel efficient operating point which is about 70% of installed power.⁶

The obvious way of inducing more slow-steaming than would otherwise occur is to increase bunker price. By imposing a tax on bunkers based on the fuel's carbon content, we effectively impose a price on carbon emissions. In the short run, this will result in

the efficient amount of slow steaming including this cost. In the long run, the fleet will operate at a lower **average** speed due to the increased bunkers costs, which means a larger fleet overall than without the tax.

A A Concrete Example

To illustrate what is behind the shape of the supply curve, let's run some numbers from the point of view of an individual owner. Let's assume we are the owner of a VLCC who has a voyage east, and are trying to decide how fast we should go. Figure 5 shows the basic input we will use for this exercise.⁷ The key numbers are the loaded and ballast fuel consumption curves and the bunker price.

With this input, it is a straight forward matter to compute our fuel bill and voyage length, for a range of speeds. This has been done in the first three columns in Table 2 under the assumption that we have decided that whatever our loaded speed is, our ballast speed will be 1.5 knots faster. Starting out at the low speed end, we see that by speeding up a half-knot, we can save 1.66 days at a cost of \$67,000. This is a good idea if and only if the market rate is such that we can net \$40,400 or better with the extra days. For this route and BFO price, this \$/day rate turns out to be equivalent to Worldscale 52.⁸

Once we get to 12.5/14 kts, we note that by speeding up another half knot, we can save 1.53 days at a cost of \$63,000.⁹ This is a good idea if and only if we can earn \$44,000 per day (about WS53) or better with the days saved. Continuing in this fashion, we see that, in this situation with this bunker price, we need to expect to earn \$103,000 per day or better with the time saved to induce us to go full speed. The rightmost column in Table 2 tells us this is equivalent to about WS 93.¹⁰

All tanker owners have one thing in common: they want to make as much money as possible. All VLCC owners are operating ships that are not that much different from our example ship. Thus, all VLCC owners will react more or less the same way, trying to match their steaming speeds to the mar-

⁴ High bunker prices result from high crude prices. In the long-run, very high crude prices will depress demand for oil, and hence ton-mile demand.

⁵ The same thing is true, a bit less dramatically, in the other shipping sectors such as container ships. In late 2008/early 2009, the spot box rate, Asia to Europe, dropped from around \$2000/TEU to near zero. Containership owners scrambled to install slow-steaming enhancements. If anything slow-steaming is more important for box ships than it is for bulk carriers given the much higher design speeds.

⁶ EEDI also has serious, negative safety implications. See Efficient, Safe Reduction of CO₂ Emissions from Shipping.

⁷ This is essentially the same data we used in computing the speed-up and supply curves in Figures 3 and 4.

⁸ In normal market parlance, this is reversed. Market players take the Worldscale rate as given and compute the equivalent net earnings per day which is usually called the Term Charter Equivalent or TCE. Either way we are ignoring all owner expenses that are fixed with respect to the speed up decision, including not only capital costs, but crew, insurance, etc.

⁹ The increase in engine efficiency (lower SFC) is responsible for the slight drop in marginal cost.

¹⁰ As I write this, the VLCC market east is about WS50. For this ship, the optimal speeds at WS50 and a \$500 BFO price are 13.0 knots loaded and 13.5 knots in ballast which generates a TCE of just over \$37,000 per day. If you mistakenly compute the TCE at full speed as some brokers do in converting Worldscale to TCE in this situation, you will arrive at a TCE of just over \$31,000 per day, seriously understating the owners' earnings.

¹¹ ***It is not the rate at which the current voyage was fixed, but the rate the owner expects to get on the next voyage which should be used in his calculations.*** Strictly speaking, the current rate is irrelevant. However, owners tend to use the last done rate in their speed calculations, implicitly assuming the market will not change much in a single voyage. This of course

ket.¹¹

If the market is weak and bunker prices are high, they will all slow down. If the market is strong and bunker prices are low, they will all speed up. In so doing, possibly without even knowing it, they are changing the shape of the supply curve.

B What about Oil Company and Term Chartered Ships?

It doesn't matter if the ship is "in" the spot market, on a one year term charter, a ten year bareboat charter, or oil company owned. All tanker "owners" will respond to the spot rate in their speed decisions in essentially the same way. The only difference is for ships that are on term charter, the effective "owner" is the term charterer. A term charterer can either be long or short tonnage. It doesn't matter. Same thing is true of an oil company's own ships.

If a term charterer finds himself in a boom, he is going to go just as fast as he can, just like the real owner would if he were in control. He does this either to free up tonnage he can relet at boom rates, or to minimize the amount of tonnage he has to charter in from the spot market.

If he finds himself in a slump, he is going to go just as slow as an owner of a non-TCed ship. If he went faster than this, he would find that by slowing down his fuel savings would be larger than the cost of chartering in the additional tonnage required by the slow down (or the lost relet revenue). If he went slower than this, he would find that by speeding up, the increase in fuel costs would be smaller than the savings in sport tonnage required (or, if he's long, the value of reletting the tonnage freed up by the speed up.)

Perhaps a little math will help. Let's start out with an over-simplified route that has no port time or port charges and no differences between loaded and ballast legs. For an owner in the spot market, his job is to pick the speed that maximizes his earnings per day:

$$\max_v \left\{ \frac{sC}{24v} - pF(v) - E \right\} \quad (1)$$

where s is the spot rate in say \$/ton, C is the cargo in tons which for present purposes we can assume is not a function of speed, D is the route round-

trip distance, v is the steaming speed, p is the bunker price, $F(v)$ is the daily fuel consumption at speed v , and E is his operating expense or OPEX (crew, insurance, etc) in \$/day.

But E does not depend on speed, so we can toss that out of the speed optimization and end up with

$$\max_v \left\{ \frac{sC24v}{D} - pF(v) \right\} \quad (2)$$

The important point to notice is $\frac{D}{24v}$ is the trip time in days and $\frac{C24v}{D}$ is the tons delivered per day.

Now suppose the same ship is term chartered by an oil company which needs to move R tons per day on this route. The oil company's job is to pick the speed that minimizes its costs per day. Its costs are made up of the costs of the chartered in ship and the money it must spend in the spot market to transport the tonnage not handled by that ship, or:

$$\min_v \left\{ s \left(R - \frac{C24v}{D} \right) + T + pF(v) \right\} \quad (3)$$

where T is the term charter rate in \$/day. The first term is the cost of chartering in tonnage on the spot market. But sR doesn't depend on v , so for the purposes of choosing v , we can throw that away. Ditto T . What's left is the negative of the spot owner's problem, Expression (2). But minimizing $-x$ is the same thing as maximizing x ; so the two problems are the same. Notice it doesn't matter if R is smaller than $\frac{C24v}{D}$, in which case the term charterer is long tonnage. The expression being minimized becomes the negative of the earnings he can get by reletting his surplus tonnage.

Notice also that the rate at which the ship was term-chartered is totally irrelevant to these calculations. From the point of view of the speed decision, the TC rate is a fixed or sunk cost, just like OPEX is for the real owner.

If we now go back and put in port time and port charges, loaded/ballast differences, deadweight lost to bunkers, etc, etc both expressions become much more complicated, but they still end up being essentially the same optimization problem.¹²

All tankers are effectively in the spot market because any owner: oil company, disponent owner, or real owner (of a non-TCed ship) has the opportunity to buy from and sell to the spot market.

is not necessarily true and the resulting errors can lead to extra market volatility.

¹² There are some very minor differences. For example, a ship in the spot market will normally have brokerage expenses that a term chartered ship avoids.

Table 1: Market clearing rate for 90% ton-miles as a function of BFO price

BFO PRICE	WORLDSCALE	TCE(\$/day)
100	23.5	15,194
200	36.5	22,855
400	74	51,343
800	145	103,794

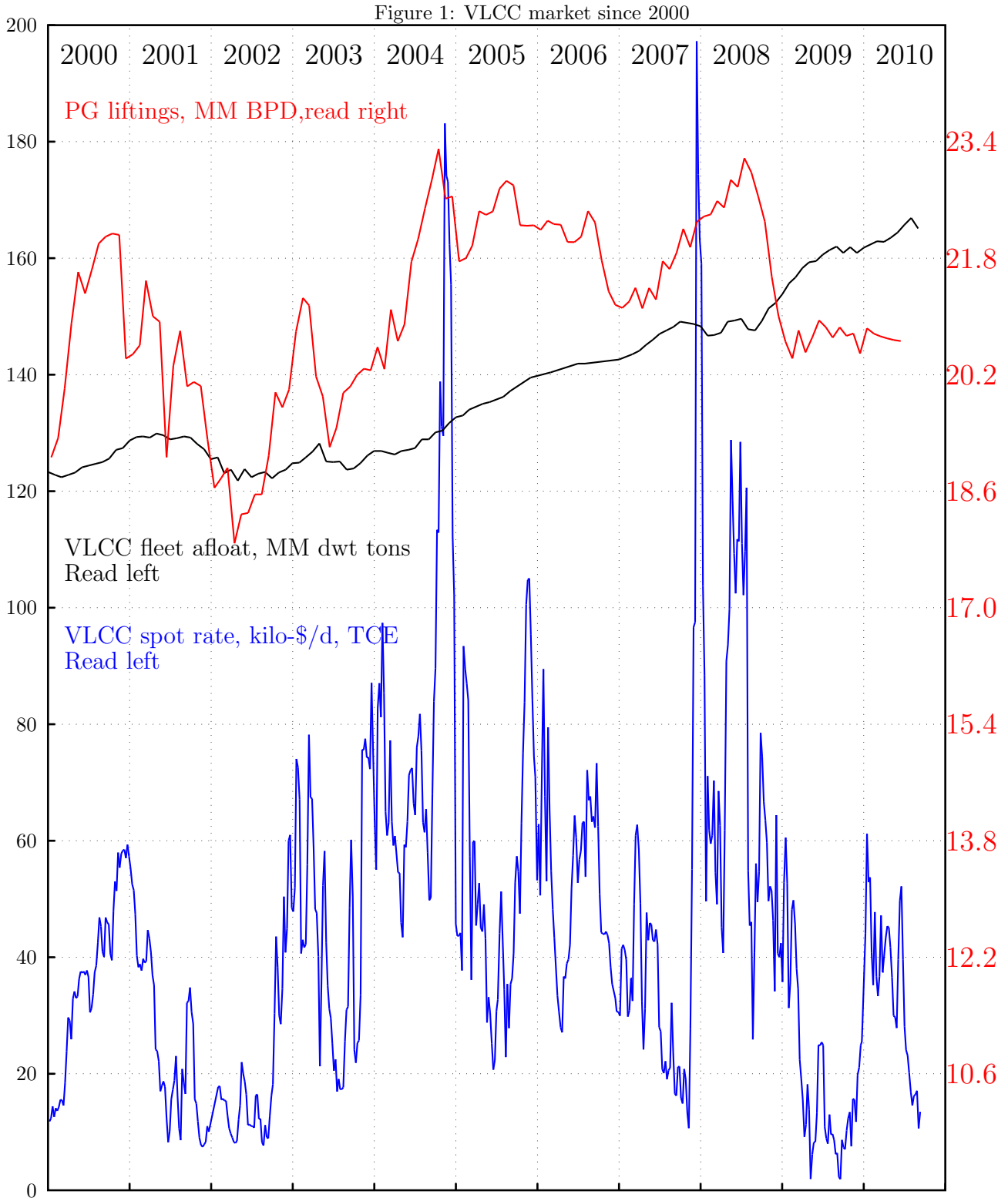
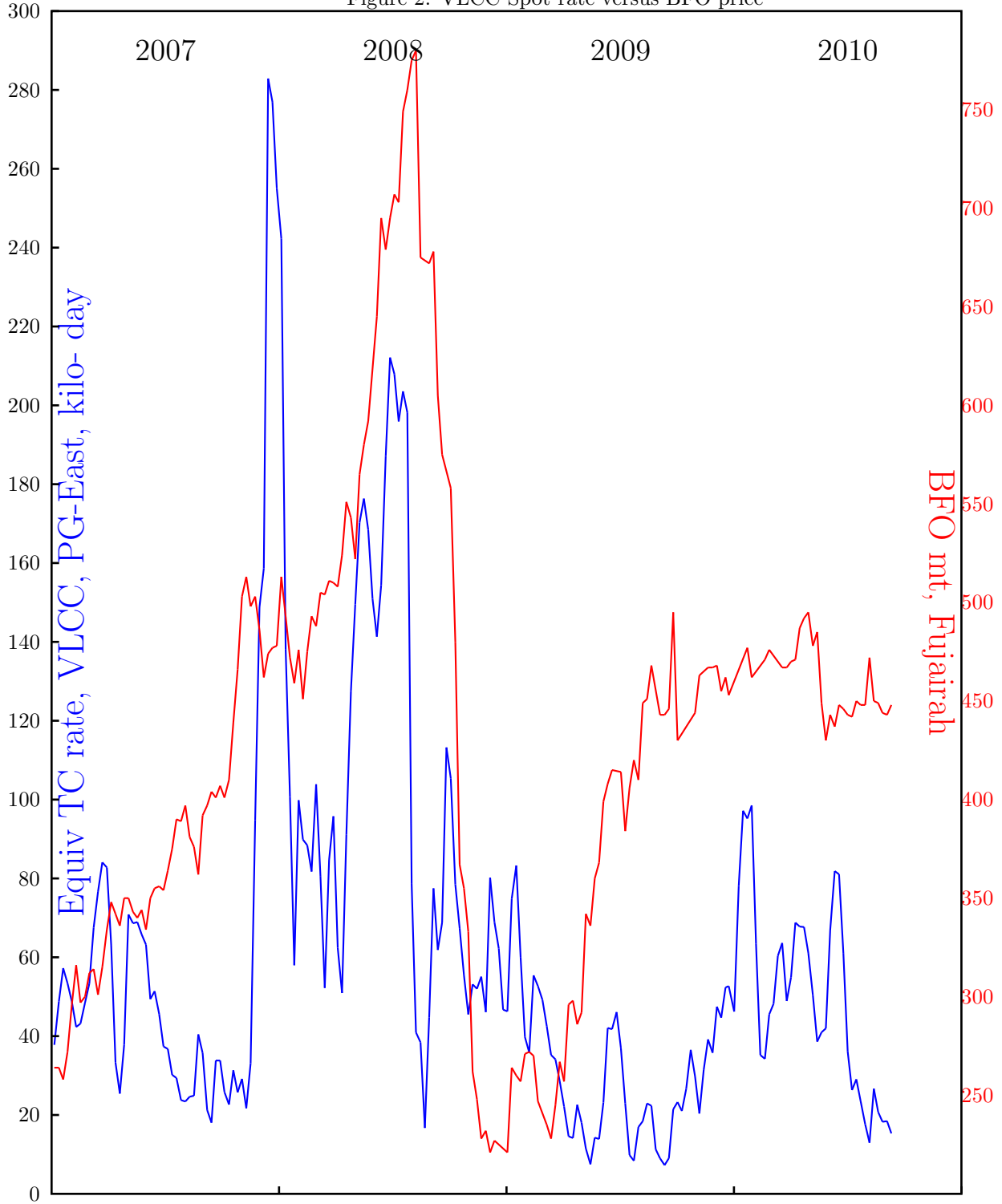
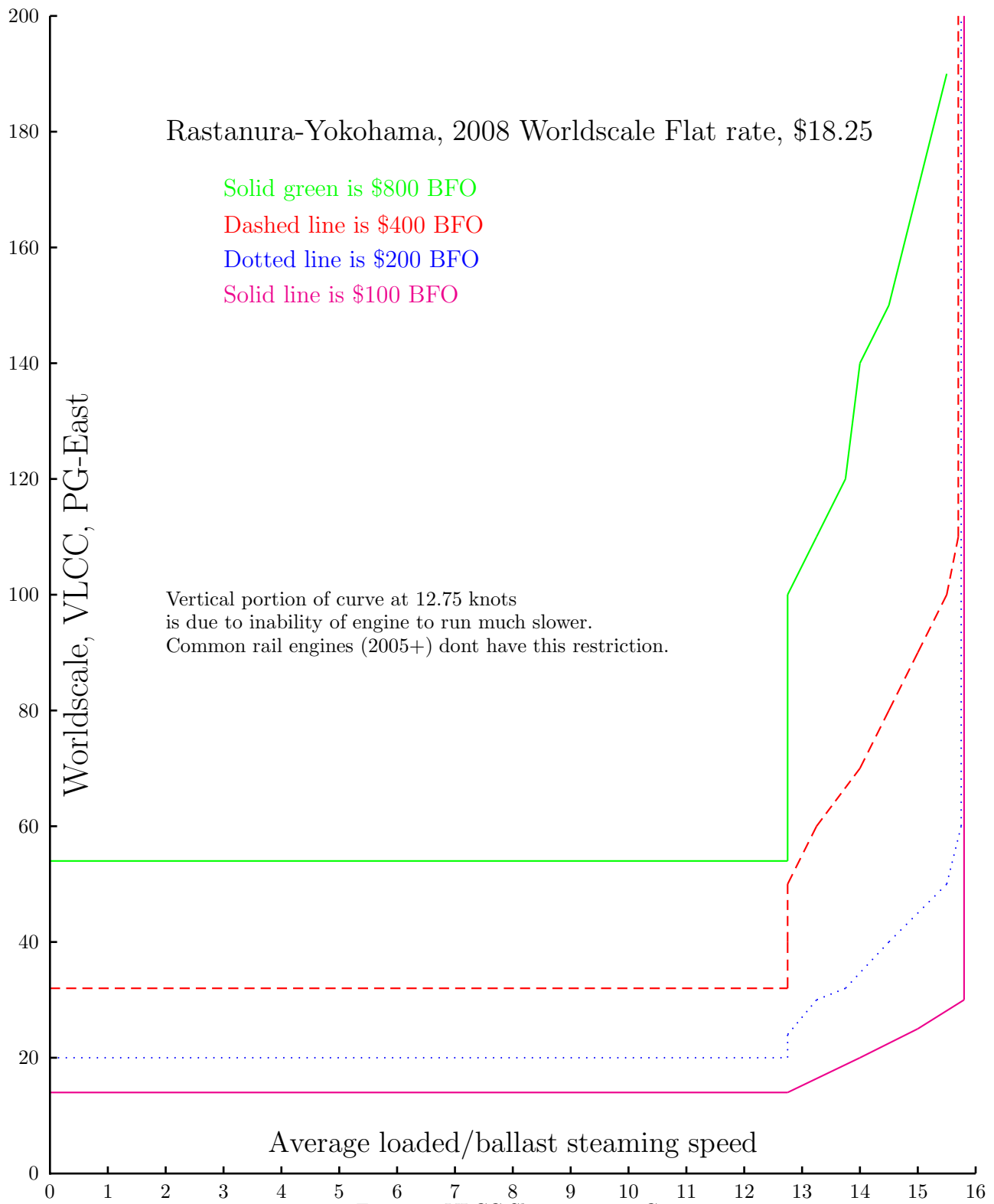


Figure 2: VLCC Spot rate versus BFO price



SPEED LD/BL	VOYAGE DAYS	BFO/LO COST	DAYS SAVED	EXTRA COST	B/E \$/D	Equivalent Worldscale
12.0/13.5	47.65	1,386,000				
12.5/14.0	45.99	1,453,000	1.66	67,000	40,400	52
13.0/14.5	44.46	1,516,000	1.53	63,000	41,200	53
13.5/15.0	43.03	1,595,000	1.43	79,000	55,200	62
14.0/15.5	41.70	1,690,000	1.33	95,000	71,400	73
14.5/16.0	40.46	1,798,000	1.24	108,000	87,100	83
15.0/16.5	39.30	1,918,000	1.16	120,000	103,400	93

Table 2: VLCC Speed up calculations, PG-East, BFO \$500/ton



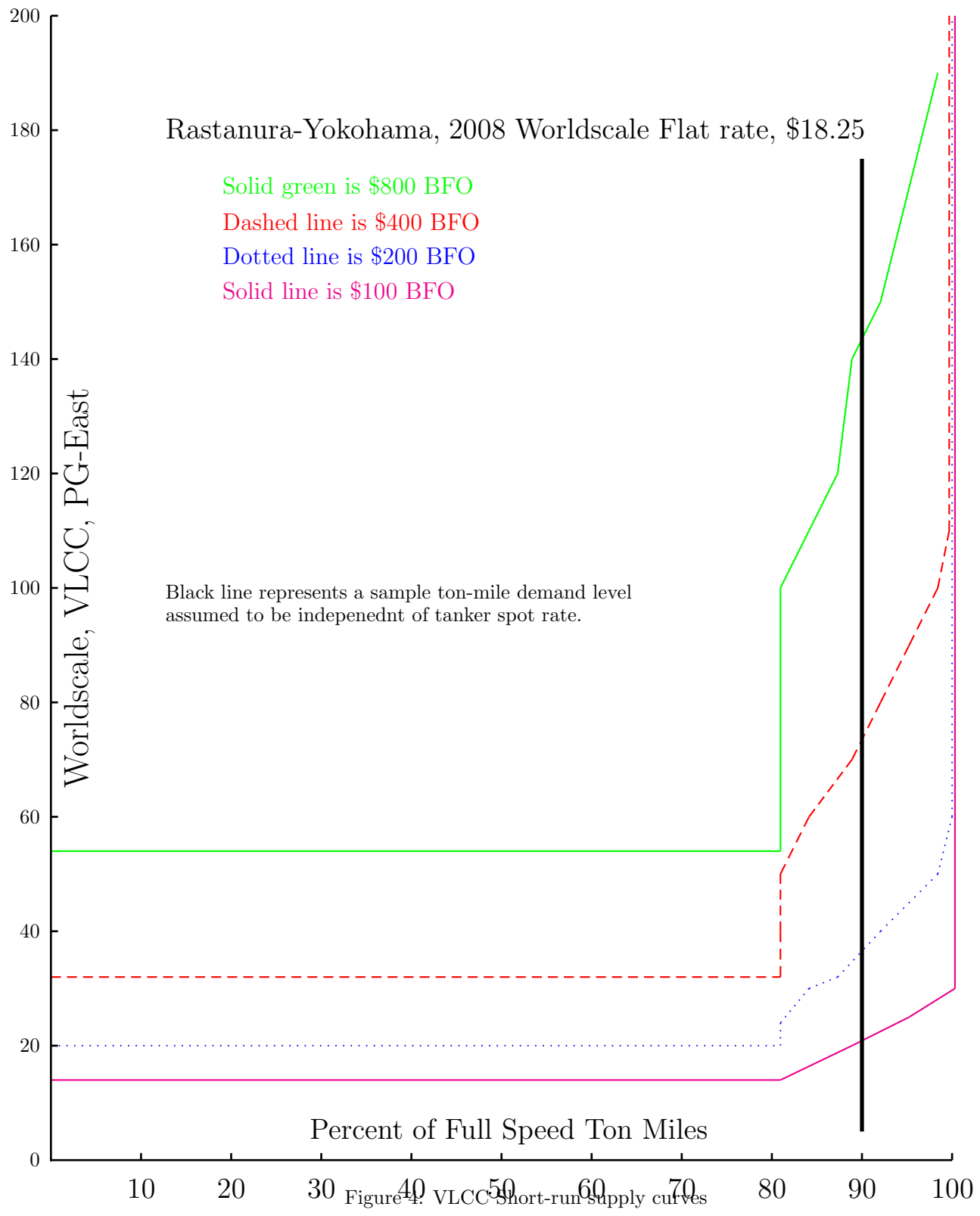


Figure 4. VLCC short-run supply curves

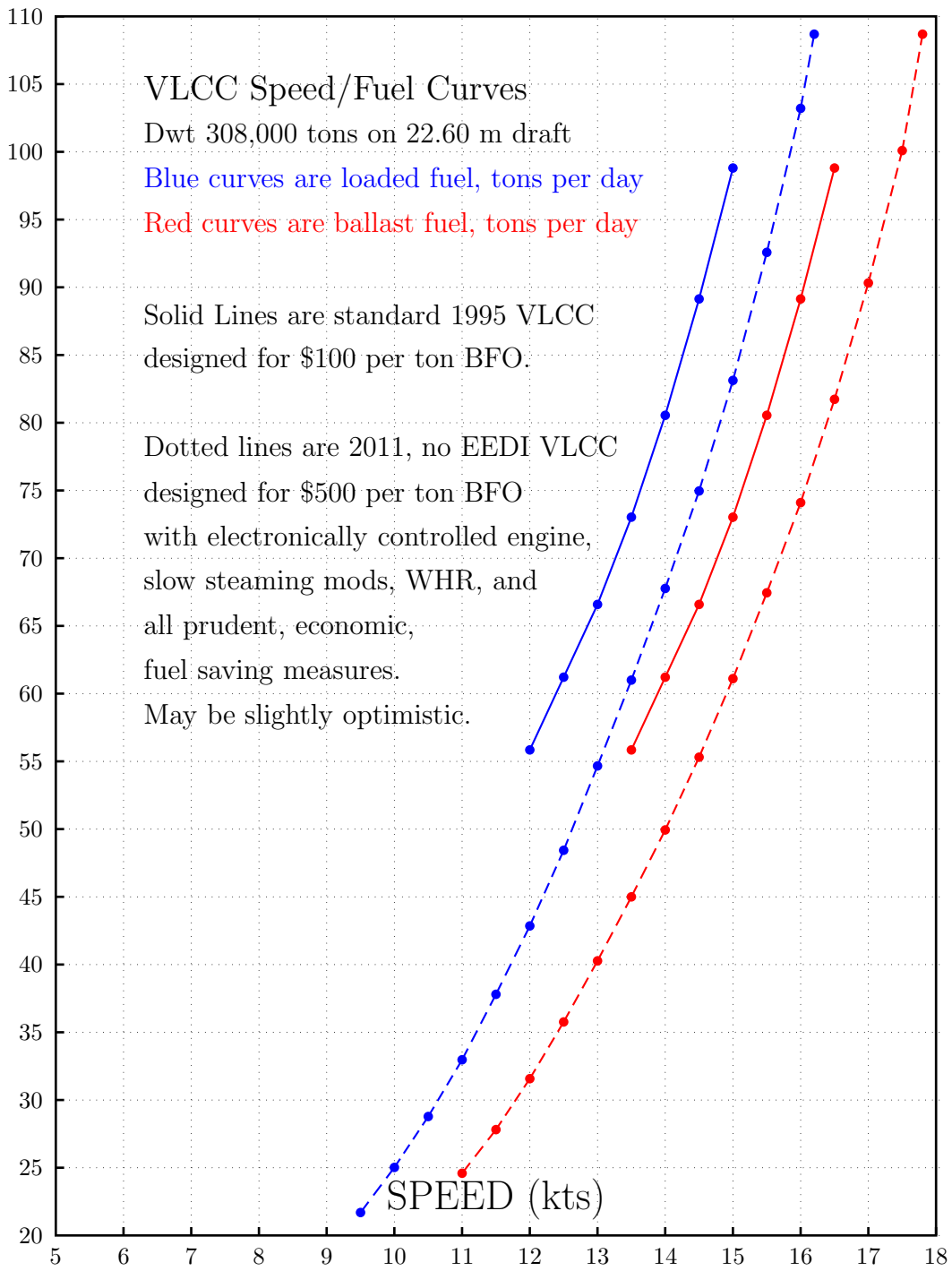


Figure 5: VLCC Fuel Consumption Curves