Rail Freight Operators' Association

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04 September 2013

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Dear Cathryn

SCHEDULE 8 NETWORK RAIL PAYMENT RATE – EVIDENCE

The Rail Freight Operators' Association has not collectively responded to the draft determination as each freight operator has done this individually.

However we would like to draw your attention to the work that we have commissioned as RFOA to obtain further evidence regarding the value of the Network Rail payment rate in Schedule 8. This follows the publication of the ORR's draft determination in June this year. The draft determination stated that there is uncertainty surrounding the proportion of freight user costs passed through to freight operators in the form of reduced revenues and asks for further evidence from freight operators.

The RFOA has commissioned work in 2 parts:

- LEK have undertaken some analysis to consider the constituent elements of the current NR payment rate and how those are affected by an increase in train value, as expressed by the increase in net train weight (tonnes per train)

- leading and authoritative economist, David Myatt, Professor of Economics at London Business School has provided his views on the percentage of cost pass-back from freight users to freight operators

These 2 pieces of work are appended to this letter. We would very much welcome the opportunity to discuss this new work further with the ORR over the next few weeks.

Using the CP4 NR payment rate of £17.47 (2009/10) as the start point, the conclusion from the LEK work on train value are:

1. Over CP4 the average rate has been undervalued by £1.28 per minute; and

2. Applying the proposed RPI only adjustment to CP5, the average rate will be undervalued by £5.61 per minute.

The key conclusions from the Professor David P. Myatt paper on the pass-through rates of freight user costs, i.e. how much is borne by the FOC, are:

1. In a scenario in which there are no switching opportunities to other transport modes, but it is easy for freight to switch between different rail freight operators 87.5% of the value is pushed back to freight operators;

2. In a scenario in which it is also easy for freight users to switch to other transport modes, such as road freight - 98.75% of the value is pushed back to freight operators;

3. In a setting in which users find it easy to switch to other transport modes, but where the delay-induced cost is incurred by the users of all rail freight operators - 95% of the value is pushed back to freight operators

On the basis of this work, taking a low end estimate of 90% and applying it to the difference between £3 (0% freight user cost, i.e. operator cost only) and £25 (operator cost plus 100% freight user cost) results in a 2012/13 price for operator and freight user cost of £22.80 (£3 + 0.9*(£25-£3)), or £3.67 more than the 2013/14 priced £19.13.

We therefore propose a rebasing the NR payment rate for CP5.

It seems logical to apply Professor Myatt's adjustment first followed by the train value impact. This changes the CP4 exit rate from £19.74 to £23.53 (having applied the RPI increase (3.1%) on Professor Myatt's 2012/13 equivalent value of £22.80). Applying an estimated RPI increase alone for 2014/15 would result in a CP5 entry value of £24.24.

Consequently we suggest an annual adjustment (two way), in addition to RPI, to reflect freight train value as per LEK's rationale (net tonnes per train being a proxy for train value). This would result in an exit CP4 value of £24.30 and a forecast CP5 entry value of £25.86. The table overleaf details these movements, noting the operator costs are only 80% variable to changes in train value whereas the user costs are 100%.

	CP4		CP5
	2012/13	2013/14	2014/15
RPI		3.2%	3.0%
Operator Cost (£ per min)		3.21	3.30
User Cost (£ per min)		16.53	17.04
Payment Rate (£ pr min)		**19.74**	**20.34**

Myatt (90% @ 12/13 prices)	22.80		
RPI		3.2%	3.0%
Operator Cost (£ per min)	*3.00*	3.10	3.19
User Cost (£ per min)	*19.80*	20.43	21.05
Payment Rate (£ pr min)	**22.80**	**23.53**	**24.24**

Growth in train load		3.4%	3.4%
Operator cost		3.18	3.36
User costs		21.12	22.50
Payment Rate (£ pr min)		**24.30**	**25.86**

Difference in payment rates		4.56	5.52

We feel it is important that there is an as accurate valuation of freight as possible in light of the diverging delta between passenger and freight rates that, if determined, we believe will incentivise a negative NR behaviour towards freight, i.e. we believe there is a risk that NR will default delay / disruption onto freight as the cost to NR of delaying freight is substantially below that of delaying passenger operations.

We recognise that there is not much time before the final determination but we thought that it was important that this gap in evidence was filled before the ORR made its final determination. We request that this evidence is utilised to make a decision on the level of the CP5 Network Rail payment rate.

Yours sincerely,

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Chair, Rail Freight Operators' Association

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Train load impacts on the Network Rail Payment Rate

4 September 2013

STRICTLY CONFIDENTIAL

Network Rail Payment Rate – Train Load

1. Following the review of the Network Rail Payment Rate (the "payment rate") conducted during PR08, the payment rate was set at £17.47 per train minute of delay. The rate of £17.47 applied for the year 2009/10 and has since been uplifted annually for inflation. In the draft determination for PR13, the ORR propose to follow the same approach of annual uplifts for inflation such that the payment rate was £19.13 in 2012/13, is £19.74 in 2013/14 and would be uplifted for inflation in each year of CP5.

2. However, inflation is not the only factor that affects the per train minute cost of delay. Train load - i.e. the amount/volume of goods moved - is also an important factor. As train loads increase, each train minute of delay affects more goods and inflicts greater costs on both freight operators and freight users.

3. The table below shows the elements of freight operator costs (sourced from ORR research), their relative sizes and how they respond to changes in train load:[1]

Freight operator costs	Effects of increased loads per train on delay costs	Approx. % of freight operator costs	Changes proportionally with train load?
Loco lease & maintenance	Same number of locomotives required to move load	7%	×
Wagon lease and maintenance	More wagons required to move larger load	6%	✓
Driver costs	Same number of drivers required to move load	12%	×
Fuel	Fuel consumption higher with heavier load	55%	✓
Handling	Greater staff numbers/machinery required to load/unload	13%	✓
Repositioning	Greater logistical problems in repositioning more wagons	6%	✓
	Total	100%	80%

4. The table above shows that for an increase in train load, 80% of the freight operator costs of delay would also increase proportionally.

5. The table below shows the elements of freight user costs (sourced from the AECOM/ITS report) and how they respond to changes in train load:[2]

Freight user costs	Effects of increased loads per train on delay costs	Changes proportionally with train load?
Handling	Greater terminal handling costs per load	✓
Labour	Overtime payment is greater if train load increases	✓
Short-loading	Risk of not being able to fully load wagons due to delay increases as number of wagons increases	✓
Management Time	More phone calls and administrative time spent in contingency	✓
Road Substitution	With a longer delay, more lorries would be needed to move the load	✓
Penalties	Penalties determined by size of load	✓
Collection & delivery	More drivers/vehicles waiting for train to arrive	✓
Stock out	Greater likelihood as loads increase	✓
Equipment	Extra machinery needed to unload if wagon numbers increase and turnaround time is reduced by delay	✓

[1] ORR Research reported in Annex C of Review of Access Policy Consultation (2010)
[2] Rail Freight User Values of Time & Reliability (2010)

6. The table above shows that for an increase in train load, all freight user costs of delay would also increase proportionally.

7. In excluding changes in train loads from its calculations, the ORR is failing to compensate FOCs for increases in the consequences of delay. Since the entire premise of the payment rate is that it should compensate FOCs for the costs of delay and train loads are an important factor affecting those costs of delay, the payment rate should be adjusted to account for changes in train load.

8. We therefore suggest that the proposed payment rate should be adjusted for changes in train load since the beginning of CP4 and that, going forward, the payment rate should be adjusted annually to account for both inflation and changes in train load. In particular, the tables above demonstrate that freight user costs should change proportionally with average train load and that freight operator costs should change at 80% of the rate of the average train load.

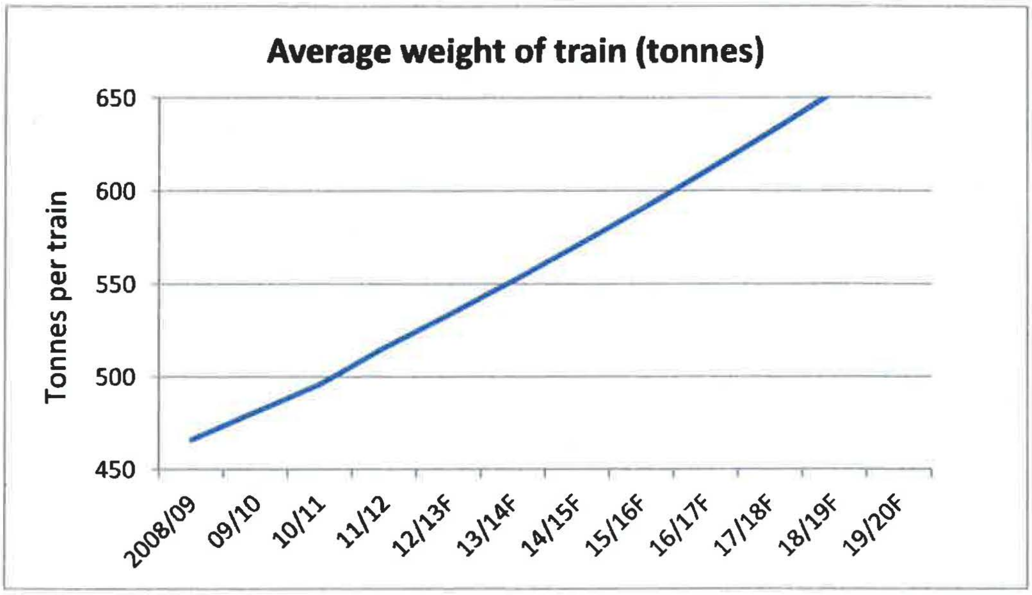
9. Network Rail does not publish figures for the amount/volume of goods transported on the railway network; however, it does publish figures for the weight of goods transported. Although it is the amount/volume of goods that directly affects costs of delay, the weight of goods acts as a reasonable proxy for the amount/volume of goods. One proviso to this is that the different commodity types have different densities and so using industry-level figures for changes in average train weight will not accurately represent changes in the amount/volume of goods moved.

10. Network Rail figures show that average train loads, as measured by tonnes of cargo (i.e. net of the weight of the rolling stock itself) per train, have increased at an average rate of 3.4% per annum between 2009/10 (the beginning of CP4) and 2011/12.[3] Given the slight commodity shift towards intermodal during CP4, we believe that the average rate of 3.4% in fact masks a stronger increase in the amount/volume of goods moved per train. Consequently, the true increase in annual volume of goods per train would be higher than 3.4% p.a. However, since there has only been a slight shift in commodity mix during CP4, we use the figure of 3.4% as a proxy for the increase in amount of goods transported but note that it is lower than the true rate for the increase in amount of goods transported for these years.

11. Official figures for average tonnes per train are not available for the years after 2011/12, but the trend of increasing average tonnes per train is forecast by Network Rail to continue throughout CP5. Since Network Rail's forecast for freight traffic in total tonne kilometres is not based upon average weight per train, dividing Network Rail forecast tonne kilometres by forecast train kilometres would be misleading due to significant forecast changes in commodity mix.

12. Both track access charges and increasing network congestion incentivise freight operating companies to increase train loads rather than the number of train movements. Furthermore, the Network Rail forecast appears to assume unconstrained demand growth; this would suggest Network Rail under-estimates the growth in average train load as freight operating companies face very real constraints on their ability to add extra train movements. For these reasons, we have used the historical growth rate of 3.4% in our following indicative analysis.[4]

[3] Network Rail Long Term Planning Process (April 2013)
[4] NR forecasts set out in Network Rail Long Term Planning Process - Freight Market Study Draft for Consultation, April 2013



13. The table below sets out our proposed methodology for recalculating the payment rate from the beginning of CP4 and throughout CP5. First, we separate the payment rate of £17.47 at the beginning of CP4 into a freight operator cost component and a freight user cost component (taking the freight operator cost figures from ORR Research)[5]. Secondly, we uplift the freight operator cost component for (i) inflation and (ii) 80% of the change in average train load. Thirdly, we uplift the freight user cost component for (i) inflation and (ii) the change in average train load. We then repeat each step on an annual basis.

[5] ORR Review of Access Policy 2010, Annex C

	CP4					CP5				
	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Payment rates uplifted only for inflation as proposed by ORR										
Inflation - RPI (Previous year to December)[6] (%)	n/a	(0.5)	4.6	5.2	3.2	3.1	2.7	2.7	2.6	3.4
Operator costs (uplifted for inflation) (£)	2.68	2.67	2.79	2.93	3.03	3.12	3.21	3.29	3.38	3.49
User costs (uplifted for inflation) (£)	14.79	14.71	15.39	16.19	16.71	17.22	17.69	18.17	18.65	19.28
Payment rate (£)	**17.47**	**17.38**	**18.18**	**19.13**	**19.74**	**20.34**	**20.90**	**21.46**	**22.03**	**22.77**
Average for control periods (£)	**18.38**					**21.50**				
Payment rates uplifted for both inflation and changes in train load										
Growth in train load (Previous year) (%)	n/a	3.2	3.1	4.0	3.4	3.4	3.4	3.4	3.4	3.4
Operator costs (uplifted for inflation and partially for train load) (£)	n/a	2.73	2.93	3.18	3.37	3.57	3.77	3.98	4.20	4.46
User costs (uplifted for inflation and train load) (£)	n/a	15.19	16.38	17.92	19.12	20.38	21.66	23.00	24.42	26.11
Payment rate uplifted for train load (£)	**n/a**	**17.92**	**19.31**	**21.10**	**22.49**	**23.95**	**25.43**	**26.98**	**28.61**	**30.57**
Average for control periods (£)	**19.66**					**27.11**				
Differences between payment rates uplifted only for inflation and payment rates uplifted for both inflation and changes in train load										
Difference between payment rates (£)	**n/a**	**0.54**	**1.13**	**1.97**	**2.76**	**3.61**	**4.53**	**5.52**	**6.59**	**7.79**
Difference in average payment rates for control periods (£)	**1.28**					**5.61**				

14. Using this methodology to correct the Network Rail payment rate for changes in train load gives an indicative payment rate in 2013/14 of £22.49 rather than £19.74 as currently in place. By the end of CP5, further increases in train load produce an indicative payment rate of £30.57 as opposed to £22.77 and an average increase in payment rate during CP5 of £5.61. The difference in payment rates reflects the significant extra costs of delay incurred due to increases in train loads which should be factored into the payment rate.

15. We note that the table above uses industry-wide (i.e. not corrected for differences in density of commodities) figures for average train weight growth for the years 2009/10 to 2012/13 and an estimate of industry-wide average train weight growth of 3.4% to calculate the payment rate for the years after and including 2013/14. When using actual figures rather than forecast figures to set future payment rates, the ORR should beware that, due to forecast changes in commodity mix, growth in tonnes per train is likely to under-estimate growth in the true driver of user costs which is the amount of goods being carried per train.

16. In conclusion, the ORR proposes in the Draft Determination that the current payment rate, as set at the beginning of CP4 and subsequently uplifted for inflation, continue to be uplifted for

[6] ONS (RPI reference CHAW); Oxford Economics (ONS, Haver Analytics)

inflation during CP5. However, since the beginning of CP4 train loads have increased at an average rate of 3.4% and are projected to continue increasing throughout CP5. As shown in the tables in paragraphs 3-5, train load is an important factor affecting the costs of delay per train minute because almost all cost consequences of delay are linked to the amount/volume of goods that are delayed. If the payment rate is to compensate freight operators for the costs of delay, it should therefore be uplifted to account for the increase in train load.

On the Pass-through Impact of Freight User Costs

Opinion

by **Professor David P. Myatt**

September 2013

1. Context and Scope

1.1. **Context.** The Office of Rail Regulation (henceforth the ORR) has published proposed aspects of Network Rail's regulatory environment. One feature is the payment rate which compensates rail freight operators for delays caused by Network Rail.

The ORR's research uses, at least implicitly, the economic analysis of the extent to which freight user costs (that is, costs incurred by freight users as a consequence of the aforementioned delays) are passed back to freight operators. At the moment, the ORR's position is (or at least appears to be) that an appropriate pass-through rate is 50%. That is, for a delay cost incurred by a freight user, and following the adjustment of price, 50% of that cost falls on the user, whereas 50% is carried by the operator.

The relevant source material here is Section 3.7 of "Freight Schedule 8 Performance Regime: Updating the Network Rail Payment Rate and Cancellation Payments." In particular, items 3.7.2 and 3.7.5–3.7.7 are most directly relevant.

1.2. **Scope.** I have been asked to consider the impact on different market participants of freight user costs. Specifically, I have analysed the consequences of a delay-induced cost that is incurred by the user of a particular freight operator. This is within the context of two different (but related) scenarios: (i) firstly, a scenario in which there are no switching opportunities to other transport modes, but it is easy for freight to switch between different rail freight operators; and (ii) secondly, a scenario in which it is also easy for freight users to switch to other transport modes, such as road freight.

Although not specifically requested, I have considered also a third scenario: (iii) a setting in which users find it easy to switch to other transport modes, but where the delay-induced cost is incurred by the users of all rail freight operators.

2. Opinion

2.1. **Summary.** *In all three of the scenarios, described above, the pass-through rate of the delay-induced cost to the relevant operator (or operators) substantially exceeds 50%.*

I have considered the three scenarios described in the scope of this report for the relatively cautious case when the elasticity of supply is equal to the elasticity of demand.

I have assumed that the freight operators act as competitive price-takers and that there are four similarly sized competing operators.

For these cases, the pass-through rates are as follows:

	Cost Type	*Relevant Market Scope*	*Rate*
(i)	Supplier	Rail Freight	87.50%
(ii)	Supplier	Rail and Road Freight	98.75%
(iii)	Sector	Rail and Road Freight	95.00%

For the avoidance of doubt, scenarios (i) and (ii) concern situations in which the relevant delay-induced cost affects only a single operator, whereas scenario (iii) is a situation in which all rail freight operators are affected by the same cost. For scenario (i), buyers are able to switch easily between rail freight operators, but are unable to switch elsewhere, whereas in scenarios (ii) and (iii) freight users are also able to switch to road freight.

For completeness, let me interpret the 87.5% pass-through rate reported in the first line of this table. This says that if a delay affects the users of a single rail freight operator, then 87.5% of the associated delay cost will be passed through (in the form of a lower price) to that operator. The users will carry 12.5% of that delay cost. Furthermore, the price received by other operators will rise by 12.5%. These pass-through rates also measure the profit impact on the relevant operator. That is,

$$\text{Profit Impact} = \text{Pass-Through Rate} \times \text{Per-Unit Delay Cost} \times \text{Operator's Output}.$$

Note again that these calculations use a conservative specification in which the elasticity of supply for each operator is equal to the elasticity of demand. The pass-through rates rise if supply is less elastic. My calculations below report pass-through rates for a range of elasticities. A key feature is that those rates all significantly exceed 50%.

In Section 2.2 I mention briefly some issues that arise in oligopolistic markets, before returning in Section 2.3 to discuss the key factors that influence pass-through rates in a competitive (price-taking) market. Sections 2.4 and 2.5 are more technical: they report explicit formulae for those rates. Section 2.6 provides a more detailed table for pass-through rate effects for various scenarios of interest; this extends the table reported above.

2.2. **Oligopoly.** The calculations reported above assume that rail freight operators act as price takers. That is, this is a competitive market in the sense that each operator does not expect to exert a significant influence over the market price.

A further specification to consider is one in which rail freight operators recognise that they exert some market power. An appropriate model here is one in which operators are thought of as “Cournot” oligopolists. This is when they compete by non-cooperatively choosing their outputs, but where they recognise the price implications of output changes.

Although the details are not reported here (they are available upon request) the relevant pass-through rates are also large (typically larger) in the oligopolistic case. For example, in the simplest case when freight is supplied by a monopolist the appropriate compensation rate for delay costs is 100%. Furthermore, if a single operator in an oligopoly is hit by a delay cost then the operator’s loss typically exceeds 100% of the direct delay cost. This is because of the strategic disadvantage that an operator suffers; the consequent output expansion by competitors raises the impact on the cost-hit operator to above 100%. Finally, in an oligopoly environment the total impact (on all market participants; that is, all users and all operators) of a delay is greater than direct cost of that delay. That is,

$$\text{Overall Impact of a Delay} > \text{Per-Unit Delay Cost} \times \text{Affected Operators' Output}.$$

The right-hand side of this inequality is the direct cost of a delay. In a competitive scenario (when operators are price-takers) this is also the total impact. However, in an oligopoly the delay cost induces an overall contraction of industry output. In an oligopoly the marginal units of output involve a price (representing the marginal benefit of output) that strictly exceeds the marginal cost of production. Hence, the induced contraction of industry output is costly. In contrast, when suppliers are “perfectly competitive” (that is, they are price-takers) price is equal to marginal cost and so any industry contraction (following the presence of delays) involves a negligible additional cost above the direct impact.

2.3. Pass-Through in Competitive Markets. The determination of pass-through rates is closely related to the economic incidence of taxes and other costs. The economic incidence of a cost is the extent to which a market participant is affected by it; this differs from (and is independent of) the identity of the participant who directly bears the cost.

In a perfectly competitive market (in which no one player substantially influences prices) the imposition of a cost on all buyers (on the demand side) has the direct effect of harming those buyers. However, the consequent reduction in demand pushes down the equilibrium price. This price reduction partially offsets the cost carried by buyers; hence part of the impact is passed through to the suppliers in the form of a lower price.

In a classic "textbook" environment the relative impact on the two sides of the market is determined by the relative size of the elasticities of supply and demand. For example, if those elasticities are equal then the overall impact of the cost is balanced across the two sides of the market: 50% is borne by the buyers, and 50% by the sellers. Precisely the same analysis applies when a cost is imposed on all suppliers in a market.

Crucially, however, this logic applies only if the cost is imposed on all buyers, or upon all suppliers, in a market. If the cost is borne by only some suppliers (or, equivalently, by buyers when they purchase from those suppliers) then the incidence effects change in important ways: the fraction of the cost borne by the affected suppliers grows substantially; the impact on buyers is lessened substantially; and suppliers who are not directly affected by the relevant cost enjoy a benefit (rather than suffer a harm) from the cost change.

For the purposes of discussion, suppose that the users of a single rail freight operator are affected by a delay cost. There are three steps that determine the final impact:

(1) In the very short run, before the freight user is able to adjust behaviour, any delay cost affecting freight users will be directly paid by those users.
(2) In the medium run, the relevant operator must set a price that is lower than the price of others' products. This price reduction exactly equals the relevant delay cost, and so at this point 100% of the cost is passed to the operator.
(3) With upward sloping supply, the affected operator contracts output. That output contraction forces prices upward. The price rises push part of the cost increase back onto users; this also raises the profits enjoyed by other competing operators.

The third effect depends upon the size of the operator's output change and the extent to which that influences the market equilibrium. Importantly, this depends upon the market share of the affected operator. If an operator represents a small fraction of the relevant market then only a small fraction of the cost shock is pushed back into the market system. Hence a relatively small operator carries a large percentage of any operator-specific cost.

Sections 2.4 and 2.5 that follow are more technical in nature: they report the mathematical formulae for pass-through effects. Numerical illustrations are provided in Section 2.6.

2.4. **Basic Formula for Cost-Shock Pass-Through Rates.** The fraction of the cost impact which is avoided (that is, passed on to others) by a particular operator (or sector of operators who are hit with the same sector-specific cost shock) is proportional to that operator's market share (or the sector's share, for a sector-specific shock).

For example, if all operators are hit by the same shock, and if the elasticities of supply and demand are the same, then the pass through is 50%. If, however, an operator affected by a cost shock represents only 20% of the relevant market, then only 10% of the cost is passed on to others, and so the affected operator carries 90% of the effect. In general, the pass-through rate (to an operator) of the cost is in this setting is mathematically

$$(\star) \qquad \text{Pass-Through Rate} = 100\% - \frac{\text{Market Share}}{2}.$$

As an illustration, consider scenario (i): a single rail freight operator is hit by an operator-specific cost shock (perhaps paid by the corresponding user), and buyers may freely switch to other rail freight operators, but not to roads. Furthermore, suppose that there are four operators. The market share of the affected operator is 25%, and so the formula ($\star$) gives:

$$\text{Pass-Through Rate} = 100\% - \frac{25\%}{2} = 87.5\%.$$

Other operators gain (and their users lose) from a price rise equal to 12.5% of the cost.

In scenario (iii) all operators are hit with the same delay cost, and users are able to switch to other transport modes. If rail freight represents 10% of the overall freight market, then

$$\text{Pass-Through Rate} = 100\% - \frac{10\%}{2} = 95\%.$$

An associated price rise (5% of the cost) helps the non-rail operators and harms users.

2.5. **The Effect of Elasticities.** The formula ($\star$) applies if the elasticities of supply and demand are equal. Any reduction in the elasticity of supply increases the pass-through rate felt by the relevant operator. In the rail freight environment, it might be expected that supply is relatively inelastic (owing to capacity constraints) compared to both the elasticity of demand and the elasticity of other (e.g. road-based) freight operators. If this is so, then the pass-through rate experienced by rail operators would be higher.

Specifically, if all operators share the same elasticity of supply, but that elasticity differs from the elasticity of demand, then the pass-through-rate formula becomes

$$(\dagger) \qquad \text{Pass-Through Rate} = 100\% - \frac{\text{Market Share} \times \text{Supply Elasticity}}{\text{Demand Elasticity} + \text{Supply Elasticity}}.$$

This rate becomes greater as supply becomes more inelastic (the elasticity of supply is lower) which corresponds to a case where outputs react only sluggishly to price changes. It seems reasonable to think that this may apply in rail freight, which suggest that the pass-through rates are larger than those reported in the previous scenario-based examples.

Nevertheless, it is possible to compute a "worst case" specification for the lowest possible pass-through rate. Even if supply is very elastic the pass-through rate must satisfy

$$\text{Pass-Through Rate} \geq 100\% - \text{Market Share}.$$

For scenario (i) the pass-through rate exceeds 75%, and in scenario (iii) it exceeds 90%.

I have yet to discuss the second scenario. In scenario (ii), an operator-specific shock hits one of four rail freight operators within a 10% slice of the overall freight market. The relevant market share for an individual rail operator is 2.5%, and so the pass-through rate must (according to the formula above) exceed 97.5%. Moreover, if supply is less elastic than demand (as it might be expected to be) then the pass-through rate exceeds 98.25%.

2.6. **Numerical Pass-Through Rates.** It is helpful to compute numerical pass-through rates for different cases. The three scenarios that form the scope of this opinion are:

(i) A single operator is hit with a cost shock. The relevant market is for rail freight. I have been asked to consider the case with four similarly sized operators.

(i) A single operator is hit with a cost shock. The relevant market is for freight generally, where rail represents 10% of this market. There are four similar rail operators.

(ii) Here all four rail freight operators are hit with the same shock. However, they jointly form, as in scenario (ii), 10% of the relevant (larger) freight market.

I also consider here the following four configurations for the elasticity of supply:

- Supply is completely inelastic (symbolically, $\varepsilon_S = 0$).
- Demand is three times as elastic as supply ($\varepsilon_D = 3\varepsilon_S$).
- Supply and demand are equally elastic ($\varepsilon_D = \varepsilon_S$).
- Supply is completely elastic ($\varepsilon_S = \infty$).

Here "ε_S" and "ε_D" indicate the elasticities of supply and demand, respectively.

For the three scenarios and four elasticity configurations, the pass-through rates are these.

	Cost Type	*Relevant Market Scope*	$\varepsilon_S = 0$	$\varepsilon_D = 3\varepsilon_S$	$\varepsilon_D = \varepsilon_S$	$\varepsilon_S = \infty$
(i)	Supplier	Rail Freight	100.000%	93.750%	87.500%	75.000%
(ii)	Supplier	Rail and Road Freight	100.000%	99.375%	98.750%	97.500%
(iii)	Sector	Rail and Road Freight	100.000%	97.500%	95.000%	90.000%

The clear message emerging from all of these numerical exercises is that pass-through rates are high for all of the elasticity configurations documented here.

3. Brief Concluding Remarks

I conclude with some brief additional comments.

Firstly, the analysis here considers competitive markets. A move to consider oligopolistic markets can raise, rather than lower, the pass-through rates that apply to operators.

Secondly, in the settings where the relevant market comprises both road and rail freight, the elasticities of supply may differ. A reasonable guess is that the elasticity of rail freight operators is relatively low; this again serves to increase the pass-through rates.

Thirdly, in an oligopoly setting the total impact of a delay cost actually exceeds the value obtained by multiplying the per-unit delay cost by the volume of affected freight.

DPM. September 3, 2013.

4. Mathematical Appendix

This appendix is designed exclusively for a technical reader. It documents the formal mathematical formulae that lie behind the analysis used in this opinion.

4.1. **Cost Shocks in a Perfectly Competitive Market.**

Consider a market in which all suppliers are price takers. I write p for the market equilibrium price. The demand function is $D(p)$. Supply is drawn from N suppliers, where supplier $i \in \{1, \ldots, n\}$ is potentially affected by a cost shock c_i. The supply function of i is $S_i(p, c_i)$.

My objective here is to investigate the impact of a change in the cost shock c_j on buyers and on the profits of both supplier j and other competing suppliers $i \neq j$. The cost shock c_i is a constant additional marginal cost added to the production cost of supplier i. This is equivalent to a reduction in the price offered for its product. Mathematically,

$$\frac{\partial S_i(p, c_i)}{\partial c_i} = -\frac{\partial S_i(p, c_i)}{\partial p}.$$

An equilibrium is obtained by equating supply to demand, so that $D(p) = \sum_{i=1}^{N} S_i(p, c_i)$. To investigate the effect of a change in the cost parameter c_j on the market price, this equilibrium condition can be totally differentiated with respect to c_j. This yields:

$$\begin{aligned} \frac{\partial D(p)}{\partial p}\frac{dp}{dc_j} &= \frac{\partial S_j(p, c_j)}{\partial c_j} + \frac{dp}{dc_j}\sum_{i=1}^{n} \frac{\partial S_i(p, c_i)}{\partial p} \\ &= -\frac{\partial S_j(p, c_j)}{\partial p} + \frac{dp}{dc_j}\sum_{i=1}^{n} \frac{\partial S_i(p, c_i)}{\partial p} \\ &\Rightarrow \quad \frac{dp}{dc_j} = \frac{\frac{\partial S_j(p, c_j)}{\partial p}}{-\frac{\partial D(p)}{\partial p} + \sum_{i=1}^{n} \frac{\partial S_i(p, c_i)}{\partial p}}. \end{aligned}$$

To move further it is helpful to work in terms of elasticities. I write ε_D for the elasticity of demand and ε_i for the elasticity of supply. Mathematically,

$$\begin{aligned} &\varepsilon_D = -\frac{\partial D(p)}{\partial p}\frac{p}{D(p)} \quad \text{and} \quad \varepsilon_i = \frac{\partial S_i(p, c_i)}{\partial p}\frac{p}{S_i(p, c_i)} \\ &\Rightarrow \quad \frac{\partial D(p)}{\partial p} = -\frac{\varepsilon_D D(p)}{p} \quad \text{and} \quad \frac{\partial S_i(p, c_i)}{\partial p} = \frac{\varepsilon_i S_i(p, c_i)}{p}. \end{aligned}$$

These expressions can be substituted into the the solution for dp/dc_j, so that

$$\frac{dp}{dc_j} = \frac{\varepsilon_j S_j(p, c_i)}{\varepsilon_D D(p) + \sum_{i=1}^{n} \varepsilon_i S_i(p, c_i)} = \frac{\varepsilon_j [S_j(p, c_j)/D(p)]}{\varepsilon_D + \sum_{i=1}^{n} \varepsilon_i [S_i(p, c_i)/D(p)]}.$$

In equilibrium, demand $D(p)$ is equal to the total supply ${}_{i=1}^{n} S_i(p, c_i)$, and so $S_j(p, c_j)/D(p)$ is the market share of supplier j. Writing α_i for the market share of each supplier i,

$$\frac{dp}{dc_j} = \frac{\varepsilon_j \alpha_j}{\varepsilon_D + {}_{i=1}^{n} \varepsilon_i \alpha_i}.$$

In fact, the summation in the denominator is equal the overall elasticity of supply in this market. That is, $\varepsilon_S == {}_{i=1}^{n} \alpha_i \varepsilon_i$. Hence the effect of an increase in the cost shock c_j associated with supplier j on the overall price in the market is

$$\frac{dp}{dc_j} = \frac{\varepsilon_j \alpha_j}{\varepsilon_D + \varepsilon_S}.$$

This represents the degree to which a cost shock affecting j is deflected into the market price. To obtain the profit impact on supplier j, differentiating j's profit readily yields

$$\frac{\partial[\text{Profit of } j]}{\partial c_j} = S_j(p, c_j) \left(1 - \frac{dp}{dc_j}\right) = S_j(p, c_j) \left(1 - \frac{\varepsilon_j \alpha_j}{\varepsilon_D + \varepsilon_S}\right).$$

Summarising, and writing in terms of percentages,

$$\text{Pass through percentage} = 100\% - \frac{\varepsilon_j \times (\text{Market Share of } j)}{\varepsilon_D + \varepsilon_S}.$$

This underpins formula (†) used in my main opinion.

4.2. **Buyer-Paid Costs.** The environment of relevance to this opinion is one in which a buyer incurs an extra cost when purchasing from a particular supplier. This occurs when a freight user suffers a delay cost of c_i when purchasing from operator i.

Given that products are easily substitutable, the direct effect of a shock c_i is to shift downwards the price receive by supplier i by the amount c_i. This is because supplier i must offer a price exactly c_i below the price of products offered by other competitors in order to sell. This means that p can be interpreted as the price for a perfect product, whereas $p_i = p - c_i$ is the price paid to a supplier affected by a delay cost c_i. Hence, the cost carried directly by a buyer is equivalent to a cost paid instead by the supplier. This is in accordance with the general principle that the ultimate incidence of a cost is independent of the identity of the trading partner who directly pays that cost.

5. Biographical Note

David P. Myatt is Professor of Economics at London Business School (LBS). Amongst other positions he is also: an Associate Member of Nuffield College, University of Oxford; an Associate Fellow of the Department of Economics, University of Warwick; and a Research Fellow of the Centre for Economic Policy Research. He was educated at the London School of Economics (LSE), at the Massachusetts Institute of Technology (MIT), and at the University of Oxford. Prior to moving to LBS he held various academic positions within the University of Oxford, including Fellowships of St Catherine's College and Nuffield College.

David's academic research often uses the tools of game theory (the scientific analysis of strategic decision-making) applied to various settings in both economics and political science. In economics his research includes the study of advertising, marketing, and product design strategies; in political science, his work includes theories of leadership, strategic voting, and executive performance. His academic research papers have been published in the very top academic journals in both economics (including the American Economic Review and the Review of Economic Studies) and political science (including the American Political Science Review and the American Journal of Political Science). In an editorial capacity, he previously served the Royal Economic Society as Editor of the Economic Journal. He is currently Co-Editor of the Quarterly Journal of Political Science and Associate Editor of the Journal of Economic Theory, and holds other positions on editorial boards and within leading scientific associations.

At LBS, David's teaching ranges across the full portfolio of programmes, including the MBA, EMBA, MiM, and PhD degrees. Within the core Managerial Economics course, he teaches tools for output choice and pricing in markets where businesses seek to exploit their market power; within the elective Thinking Strategically he uses the tools of game theory to analyse strategic decision-making; and within the Business, Government, and Society course he explores the interaction of businesses with wider societal stakeholders.

David also has experience in both open and custom executive education programmes; he has served private clients in this capacity, and he is a long-standing contributor to the sixty-year-old Oxford University Business Economics Programme. In his consulting activities, David has advised clients on competition policy, auction strategy, business organisation, and various aspects of the regulatory environment.