Winter tyres cost benefit analysis

Purpose

The purpose of this paper is to set out the Cost Benefit Analysis (CBA) that was commissioned by Scottish Minister's on the application of winter tyres to heavy goods vehicles (HGVs) in Scotland to avoid 'jack-knifing' incidents occurring during snow and ice conditions.

The paper's intention is to inform winter resilience discussions between the Scottish Government and the haulage industry on the potential costs and benefits to the Scottish transport network, its operators and users, of using winter tyres on HGVs.

Background

Severe winter weather in November and December 2010, including heavy snow and ice, had a considerable impact on the Scottish transport network and its users. Public, private and commercial vehicles have been subject to difficult driving conditions resulting in a significant number of incidents on the network, many leading to restrictions through road and lane closures and extensive delay to, and cancellation of, journeys.

One element of the difficulties faced on the road network was the 'jack-knifing' of articulated HGVs. This resulted in HGVs becoming stranded and unable to move without recovery assistance, blocking parts of the road network and leading to a grid lock for other road users. Best evidence suggests that between 28th November and 12th December 2010, there were 140 recorded HGV incidents; of these 74 involved jack-knifing[1]; and 27 of these resulted in carriage or road closures[2]. Additional evidence of the problems that the weather has caused is seen through a Freight Transport Association (FTA) survey in which 66% of respondents responded that they have vehicles that have been involved in incidents (e.g. loss of drive axle traction, jack-knifing, loss of control of the vehicle (skidding, sliding, loss of grip)), on the public highway due to snow/ice. 22% of respondents also cited that their incidents had led to road or lane closures[3].

The severe snow and ice conditions experienced over that period contributed to the number of HGV incidents occurring and the resulting impact on the road network and other users. As a means of avoiding such situations re-occurring, one of a range of factors to consider is whether the use of winter tyres by HGVs could have reduced the number and/or severity of incidents.

[1] "Jack-knifing" is a specific type of incident involving articulated vehicles, but other types of loss of traction can result in the same problems (e.g. attempting to restart on a slope). Non-articulated vehicles (cars, LGVs or HGVs) can suffer loss of traction and become stranded, but the current analysis focuses on articulated vehicles.

[2] Source: Scottish Government - Police Road Incident Log.

[3] Source: FTA Survey 2011.

Understanding Winter Tyres

Tyres are designed for a wide range of vehicles and, particularly for HGV's, a wide range of purposes. They are also designed to provide a range of performance characteristics such as traction, braking, fuel economy, noise, handling and tyre endurance. There is no one perfect tyre that can offer optimal performance on each characteristic. There is a certain amount of trade off between the different characteristics.

Definition of 'winter tyre'

Across Europe, there is currently no single definition of a winter tyre. Winter tyres are also referred to as snow tyres, cold weather tyres and thermal tyres interchangably. Presently, for legal requirements alone, winter tyres are identified by the branding 'M+S' (Mud and Snow) on the side of the tyre. These tyres are designed to have a higher traction performance than standard tyres when driving in mud or snow, however, they do not need to meet any specific performace standard. "All weather" tyres, often imported, have to an extent eroded the value of M+S tyres for cars/vans.

In a move towards clarifying the status of winter tyres, the tyre industry has adopted a '3-peak mountain with snowflake' pictogram (also known as the 'alpine symbol'). This symbol should sit alongside the M+S brand on the tyre to differentiate winter tyres (M+S and alipne symbol) from all-season tyres (only M+S). Tyres with the 'M+S and alpine symbol' must have the ability to brake at least 7% better on snow than a standard reference tyre. This marking and associated performance standard will be an EU wide industry regulation for winter tyres starting in 2012[4].

As such, for the purposes of this paper, winter tyres are defined as those with the 'M+S and alpine symbol' on them. Studded snow tyres (as used in some European (mainly Scandinavian) countries) are not being considered in this paper.

How 'winter tyres' work

Holding all other variables constant, winter tyres provide approximately twice as much traction in snow as a standard summer tyre[5]. Their ability to do this is down to the different compounds that are used to make the tyre, which avoid hardening when road surface temperature is less than 7 degrees celsius, allowing the tyre to key further into the road surface. Alsongside this, the tread pattern contains far more and deeper grooves and up to ten times more sipes. This design allows for greater friction in snow conditions, and although it does not eliminate skidding on ice or snow, does reduce the risk.

Standard tyres are designed for specific purposes – there are differences for axle types and for (e.g) long distance use, logging, tipper trucks etc. Their performance characteristrics will differ accordingly, and the *relative* performance of winter tyres

[4] Information provided by the British Tyre Manufacturers Association (BTMA).
[5] Source: BTMA.

will also therefore vary. HGVs (especially articulated HGVs) have a greater degree of variability in terms of vehicle set-up. Loading, braking split balancing etc. can all be changed.

Current use of winter tyres

Current take-up of winter tyres in the UK is very low. This could be for a variety of reasons such as price, hauliers not considering them necessary, or a lack of knowledge about the product. The lack of a 'winter tyre' definition is unlikely to have helped take up – there has been a perception in the past that winter tyres were effectively 'studded tyres' and many are unlikely to be aware of both how winter tyre technology and design has developed and the cost of such tyres.

There are some examples of routine usage in the UK[6]. In two recent surveys of hauliers conducted by the Freight Transport Association (FTA) and the Road Haulage Association (RHA) in 2011, only 7% (FTA) - 23% (RHA)[7] of those who responded to the question said they currently used winter tyres[8], although 60% in the FTA survey responded that they would consider fitting winter tyres. There *are* also examples of hauliers employing 'winter policies', which can consist of specifying greater minimum tread-depth for winter months, and using M+S tyres (on drive axles, for example) either for specific periods or all-year round.

Other countries have been successful in increasing penetration of winter tyre usage. Some have introduced legislation (e.g. Germany), and others have taken a more advisory/informational approach (e.g. Holland). The experience of the latter suggests that change is possible, though over a medium-term period. The surveys of hauliers suggest there is willingness to consider the use of such tyres (with priority given to drive axles), particularly for Scottish operations, though it is far from widespread. Any substantial increase in demand would need to be met by supply-side action to increase availability. Most operators (70% FTA and 80% RHA) who responded to the question in the surveys do not believe the benefits to them of fitting such tyres would justify the expense.

Information from tyre manufacturers suggests that it is feasible to use winter tyres all year round, rather than simply in the winter months, with only a negligible increase in wear rate compared to summer/all-weather tyres, and a very small impact on fuel consumption[9]. As noted above, some hauliers already use M+S tyres all-year round.

Scope and Methodology

There are a range of uncertainties in undertaking this CBA – primarily surrounding the practicalities of fitting winter tyres, their ability to avoid HGV incidents, and the availability of data that will enable a robust estimate of the potential costs and

[6] Market penetration for cars and vans is very low (around 1.5% and 3% respectively) but growth over 2009 has been substantial for both markets.
[7] The higher figure (RHA) is based on very small numbers of respondents, so may be artificially high in light of the lower FTA figure.
[8] This covers operators using all types of HGV, not just articulated HGVs
[9] There is some evidence that all-year use of winter tyres is increasingly common in countries with adverse climates.

benefits that could result. Consequently, a range of assumptions has had to be made.

The CBA considers the scenario in which articulated HGVs are fitted with winter tyres to their drive axles all year round, rather than simply in the winter months. As such, the costs focus on the *additional costs* that are incurred in purchasing and using winter tyres on these axles, and the benefits focus on the *potential benefits* of avoiding jack-knifing incidents. The analysis considers vehicles registered in Scotland, and consequently ignores the potential issues of cross-border or international traffic using the Scottish road network. The costs and benefits considered in this CBA and the assumptions used are detailed below.

Costs

As suggested above, the main cost being considered is that to HGV operators of purchasing and using winter tyres. There may be a range of additional costs, over and above the purchase of winter tyres, that users will face. These might include fitting costs, storage costs, or loss of efficiency. Tyre manufacturers and haulage operators differ in their estimation of the scale of such costs. It has not proved straightforward to identify these costs and some key variables remain as ranges or are derived from anecdotal information.

Price of tyre – As with standard tyres, there is a wide range of performance specifications, sizes and prices of winter tyres. Best evidence suggests that the price of a standard HGV tyre is approximately £250 and that winter tyres are between 5% and 15% more expensive[10]. For the purposes of this CBA, the price of winter tyres is assumed to be between £263 and £288 which represents an additional cost of between £13 and £38 per tyre on average.

Tyre fitting – Some HGV fleet owners do this themselves and some pay a service charge to a tyre fitter. Although there may be a cost associated with the fitting of the tyre, it has not been explicitly factored into the CBA. The key reason for this is that the CBA assumes that the fitting of the winter tyres to the drive axles is incorporated into the existing tyre fitting routine of the fleet owner and as such no *additional costs* (over and above current practice) should be incurred[11].

Use of tyre – There is some anecdotal evidence to suggest that using winter tyres could reduce the fuel efficiency of an HGV due to the extra grip that is created on the road surface, thus leading to higher fuel costs. No data is available to suggest whether this is the case or not, and some experiential information gathered suggests it is not a noticeable effect. The understanding of the tyre manufacturers is that the

[10] A definitive average price of a winter tyre is difficult to ascertain due to (a) the wide range of brands and tyre specifications; (b) the wide range of tyres designed for specific uses and performance characteristics; (c) the use of bulk buying and contract discounts by larger hauliers. Best available evidence provided by tyre manufacturers, haulage companies and their relevant associations.

[11] For context, an average price for tyre fitting services across all fleet owners (both those with and without fitting capacity) was unable to be derived from information provided. If it were assumed that winter tyres were only fitted at one point during the year, there may also be some cost via additional off-the-road time. No evidence for the scale of any such impact has been ascertained.

reduced efficiency would be negligible[12]. As such, this cost has not been explicitly factored into the CBA.

Storage of tyre – The storage of tyres by freight/haulage operators can depend on a range of factors such as the size of the business (number of vehicles in fleet), depot facilities, and whether the operator employs a tyre fitter/mechanic.

In general, it is the smaller operators with one or two vehicles that are more unlikely to store tyres on site. For those operators that do store tyres (either on or off site), a cost for doing so is incurred whether standard tyres or winter tyres are being stored. It is important in a CBA to only focus on the *additional costs* of undertaking an action (i.e. those that would not have been incurred anyway). For the purposes of this CBA, no storage costs are factored explicitly into the analysis as it is assumed that use of winter tyres would simply replace a proportion of the standard tyres that are already stored.

Total cost per vehicle per annum – As set out above, the cost being explicitly taken into account in the CBA is the cost of purchasing winter tyres. The total cost per vehicle per annum is dependent also on the number of tyres being purchased and the frequency of replacement. Based on best evidence, it is assumed that winter tyres would only require fitting to the drive axles which on average is assumed to be 4 wheels. In terms of the frequency of replacement, best evidence available suggests that tyres would need replace every 6 months[13]. As such, it is assumed that the total *additional cost* per vehicle per annum would be between £104 and £304.

Benefits

The main purpose of considering the application of winter tyres to HGVs is to assess their potential to reduce the risk of them losing traction, jack-knifing in snow and ice conditions, becoming stranded and ultimately avoiding an incident leading to road or lane closures that can, at the extremes, bring large volumes of traffic to a stand still[14]. Clearly, winter tyre fitment cannot eliminate the potential for jack-knifing incidents to occur – other factors such as road condition, driver behaviour (of both HGV and other road users), load conditions, tyre pressure and condition and vehicle set-up contribute to the likelihood of a loss of traction. As such, the potential benefits of applying winter tyres to the drive axles are essentially the avoided costs of the jack-knifing incidents that they *might* prevent.

[12] Source: BTMA.
[13] Information provided by BTMA, FTA and RHA.
[14] The focus in this analysis is predominantly on a loss of traction leading to jack-knifing incidents. This is the basis on which the duration of delays has been calculated, the number of vehicles likely to be involved, and that artic HGVs only are considered. Jack-knifing incidents tend to lead to more complications as (i) the HGV tends to end up sideways across lanes leading to full road closure; (ii) a jack-knifed HGV is immobile without recovery assistance.

There is a wide range of costs that could be avoided from an HGV incident. These are detailed below.

Value of time – When an HGV jack-knifes and becomes stranded in snow and ice conditions, it can lead to road or lane closures whilst it is being recovered. This leads to travel delays for other road users on that route and its network links in the surrounding area. The value of time of those other road users delayed has been incorporated into the CBA.

Economic – There is a great deal of uncertainty over what the overall economic benefits of avoiding HGV incidents would be. Examples could include lost output from both hauliers and those other road users unable to get to work, spoiled/damaged goods being transported, and lost business transactions as a result of this. On a case by case basis, both short and long delays to work will have a range of implications for the working time of businesses and driver hours. In general however, given that the length of the delays are relatively short on average (a few hours), it is justified to assume that whatever economic output is lost due to the delay, that it is soon recovered over a period of time (e.g. business transactions concluded at a later date). As such, the specifics of this benefit category are assumed to be included in the value of time.

Public sector – During such incidents, there is a cost to the public sector, particularly police time, of recovering vehicles and managing the operation of the road network at HGV incident sites. This has not been explicitly factored into the benefit side of the CBA as a 'cost avoided' as the full extent of the *additional cost* (i.e. the cost over and above that already incurred for public service provision) avoided has been unable to be ascertained.

Total benefits/avoided costs – For the CBA, the total benefits included in the analysis are those that fall within the value of time bracket. This is used as a proxy 'catch all' for those costs that would be incurred if an HGV incident occurred and as such would be a benefit if the incident were prevented.

Analysis of Costs and Benefits

Key Data Inputs

Input	Figure	Source
Number of articulated HGVs in fleet	7,247	2009 DfT road vehicle statistics
Average number of winter tyres required per HGV	4 (based on fitting to drive axles only)	Meeting with BTMA, tyre manufacturers, FTA and RHA.
Price of winter tyres	Low - £263; High - £288	Meeting with BTMA, tyre manufacturers, FTA and RHA.
Frequency of winter tyre change per annum	2	Meeting with BTMA, tyre manufacturers, FTA and RHA.
Average time lost per HGV incident	3 hours	Scottish Government – Police Incident Log
Average number of road users affected per incident	4,787	Scottish Transport Statistics average hourly flow in peak times on HGV important routes[15]
Average value of time of motorised road user	£13 per hour	Scottish Transport Appraisal Guidance.[16]

Results

Given the uncertainties surrounding the number of incidents that winter tyres could avoid, the results of the CBA seek to identify the break-even point. That is where the Net Present Value (NPV), considered over a 5 year period (2011 – 2015), is equal to zero. This essentially asks the question 'based on the assumptions applied, how many HGV incidents would you need to avoid for the costs of using winter tyres to equal the benefits'.

Two scenarios have been modelled to calculate break even points; one for a low end price of a winter tyre and another for a high end price. As detailed above, this ranges from 5% to 15% more expensive than a standard tyre and is an appropriate approach given the uncertainty surrounding the price that exists.

Low end price (£263 per tyre): Between 11 and 12 incidents per annum across all artic HGVs are required to be prevented for the costs to equal the benefits[17].

High end price (£288 per tyre): Between 34 and 35 incidents per annum across all artic HGVs are required to be prevented for the costs to equal the benefits.

Results in Context

[15] HGV important routes defined as those trunk roads whose HGV traffic makes up at least 10% of traffic flow. Figure also assumes an average of 1.6 people per vehicle based on Scottish Household Survey data.

[16] Average figure is derived from all motorised road users, inflated to 2011 prices and takes account of working and non-working time.

[17] To note: All incidents referred to throughout the paper are per annum.

The results demonstrate that the additional cost of purchasing winter tyres has a large effect on the number of incidents that would need to be avoided for the initiative of using winter tyres to break even – between 11 and 35 incidents. During winter 2010/11 there were 74 HGV jack-knifing incidents, 27 of these resulting in carriage or road closures. Based on these figures, it would suggest that there is a strong case for HGVs to apply winter tyres if it is assumed the additional cost is at the low end.

However, it is important to take account of the particularly severe weather conditions that Scotland encountered during that period. Based on Met Office information, between 1971 and 2000 there has been approximately an average of 9 days of lying snow[18] per annum across Scotland over the November to February period.

Another important caveat is that this CBA has to implicitly assume that the cost of buying winter tyres is directly related to the benefits of HGV incidents being avoided. That is to say it is assumed that winter tyres would prevent HGV jack-knifing incidents from occurring. This is an important consideration on two fronts. Firstly, the costs that are being referred to in this CBA would be borne directly by hauliers and freight operators, whereas the potential benefits would accrue to all road users potentially affected by an incident. Secondly, there are a wide range of other factors that could cause HGVs to jack-knife. These include poor driving, poorly loaded and unstable vehicles; poorly balanced braking systems of vehicle, and reacting to the movements of other road users. As such, it is important to bear in mind that there is no guarantee that the use of winter tyres will prevent jack-knifing from occurring. No specific evidence for their effectiveness at preventing jack-knifing has been found, though there are demonstrable performance benefits (e.g. braking) in certain conditions.

Sensitivity Tests

Given the range of uncertainties surrounding the data and the extent of the assumptions having to be made, sensitivity tests can be applied to the scenarios above to assess how they would affect the results derived.

<u>Changing the cost of tyres</u>

In the main scenario above, it has been assumed that the price of winter tyres is between 5% and 15% greater than the price of a standard tyre. As detailed above, this does not take account of the *potential* additional costs associated with fitting, storage and fuel efficiency impacts.

[18] Source: Met Office – based on regional reports for North, West and East Scotland. Average takes account of average number of days of snow lying at 9am between November and February. A snow lying day is recorded if at least 50% of the ground at the monitoring sites is covered by snow. To get an approximation for snow lying at road level (rather than on mountains), the 3 collection sites were at a maximum of 65 metres above mean sea level.

To include these factors as a sensitivity test, it could be assumed that this could add an additional 10% per tyre on to the high end price above.[19] This would take the total cost of a winter tyre to £317.

High end price (£288 per tyre) plus additional 10% costs (total price: £317 per tyre): Between 61 and 62 incidents per annum across all artic HGVs are required to be prevented for the costs to equal the benefits.

By increasing the costs associated with using winter tyres, the number of incidents that you would need to avoid for the costs to equal the benefits rises.

Specific daily cost to hauliers of stranded HGVs

In discussion with the FTA and RHA, it was ascertained that the average daily cost to a haulier of one of its vehicles and drivers being stranded is £618. In the main scenario modelled above, this value was assumed to be contained within the overall value of time benefits. As a sensitivity test, though, it is worth investigating the effect on the analysis if the £618 per day was incorporated additionally.

The methodology used was to assume that HGVs make up 10% of the hourly traffic flow[20] and assess what the average cost would be to all hauliers if that proportion of HGVs were stranded within an HGV related incident.

The sensitivity test found that in one incident of 3 hour delay, an average of 299 HGVs would be affected. The total cost to hauliers of this delay would be approximately £17,953[21]. It could be the case that any substantial delay results in the load (and journey) being "written off" by the haulier or client. That would increase this figure substantially.

In terms of the affect of this on the CBA, due to the additional benefit that would be accrued from winter tyres avoiding these delays to hauliers, the number of incidents needing to be avoided for the costs of using winter tyres to match the benefits would fall to between 26 and 27 (high end price) and between 9 and 10 (low end price) per annum across all artic-HGVs.

Length of incident time

The analysis undertaken for the main scenario assumed an average length of incident time of 3 hours[22]. However, there are a range of factors that could lead to this incident time increasing or decreasing. In addition, in reality, it can take a considerable amount of time for the traffic flow on a major trunk road to return to normal following a lengthy incident. As such, it is worth considering the effect on the analysis if the effective delay was longer than 3 hours.

[19] The 10% is a notional value as there is no credible evidence to suggest what the average additional costs would be.
[20] Source: Based on Scottish Road Transport Statistics Average Daily Traffic Flows, 2009.
[21] Based on a 3 hour delay at a rate of £618 per day, averaged out at £60 per hour for a 10 hour working day. This includes driver wages and standing costs.
[22] Source: Scottish Government - Police Road Incident Log.

Increasing the average length of the delay due to an HGV incident increases the benefits (costs avoided) of using winter tyres. This is because the delay is longer which in turn increases the number of vehicles and people affected by the delay and increases the value of time "saved" by preventing the incident.

If the average length of an incident is increased to 5 hours, the number of incidents required to reach a break even point falls to between 7 and 8 (low end cost) and between 20 and 21 (high end cost) per annum across all artic HGVs.[23]

If the average length of an incident is increased to 10 hours, the number of incidents required to reach a break even point falls even further to between 3 and 4 (low end cost) and between 10 and 11 (high end cost) per annum across all artic HGVs.

Using both standard and winter tyres on the drive axle

The analysis undertaken for the main scenario assumes that 4 winter tyres are applied, on average, to the drive axle on all articulated HGVs all year round[24]. However, in practice, hauliers could choose to use standard tyres on drive axles for half the year and winter tyres on drive axles for the other half.

Incorporating this scenario into the CBA, *reduces the additional cost of using winter tyres* as they are only purchased for half the year instead of for the whole year.[25]

Low end price (£263 per tyre): Between 6 and 7 incidents per annum across all artic HGVs are required to be prevented for the costs to equal the benefits.

High end price (£288 per tyre): Between 19 and 20 incidents per annum across all artic HGVs are required to be prevented for the costs to equal the benefits.

As can be seen, by reducing the additional financial cost of using winter tyres by only fitting them once a year rather than twice, the number of incidents required to be avoided for the benefits to equal the costs fall when compared to the main scenario.

International Evidence

Across Europe there are a variety of laws and regulations surrounding the use of winter tyres for all road vehicles during the winter months of the year. For the countries that do have a winter tyre regulation, there is virtually no evidence to suggest whether the use of winter tyres specifically, has made a difference to avoidance of incidents on snow or ice laden roads.

[23] Note – this does not take into account the additional cost to hauliers considered above. The increased time and number of vehicles though would increase the value of costs of incidents to that sector too though.

[24] Assumption is valid based on information provided by the BTMA and tyre manufacturers.

[25] This assumes that tyre fitting schedules are unaltered, but that winter tyres are only fitted to the drive axle once a year rather than twice a year.

Conclusion

Acquiring the necessary data to conduct a fully evidenced CBA has not proved possible. With further research, some of those data gaps could be filled, but not all. The lack of UK experience of using such tyres, and the lack of regular severe winter weather, means hard-evidence on their cost, effectiveness and availability is not available. The multitude of factors which contribute to the likelihood a vehicle looses traction complicates the analysis, alongside a lack of clearly defined performance standards for winter tyres.

Current take-up of winter tyres is very low and, according to recent industry surveys, willingness to begin using winter tyres among operators is also low. Tyre manufacturers have also indicated that a supply-side response would be needed if the current level of demand was to significantly increase. However, other countries, notably Holland, have made some progress in increasing the penetration rate of winter tyres over medium-term period.

Despite these limitations, by applying a range of informed assumptions, the analysis has shown that the freight industry's investment in fitting winter tyres could begin to pay off for the Scottish economy if an average of 11 (low end costs)/ 34 (high end cost) or more jack-knife incidents (resulting in road/lane closures) could be prevented per year over a 5 year period. Whether this is a likely outcome depends hugely on the actual cost of fitting the tyres. Despite the 2010 experience, the longer-term trend in Scotland is for relatively less severe winters, with an average of 9 days of lying snow, and if that were to be the case over the appraisal period then it may be that the likelihood of sufficient incidents occurring is much reduced.

The analysis shows that the results are very sensitive to changes in some of the informed assumptions that have been made. Factors that push up the number of incidents required to break even include an increase in the average cost of tyres, and decreases in the average duration of incidents or numbers of road users affected. On the other hand, factors that push down the number of incidents required to break even include using winter tyres for only part of the year (reducing the costs), longer delays to road users, and the inclusion of additional haulier costs that may occur directly to them as a result of stranded vehicles.