6. MODELING RESULTS

This chapter presents the results of the modeling of carrier operations under the options. The measured impacts of the HOS options on productivity are presented first, followed by a description of the weighting procedure used to combine the individual simulation runs into weighted average estimates of productivity impacts. These productivity changes are then translated into total cost estimates and changes in the number of drivers required. The next section presents and discusses in a parallel fashion the estimated crash risk impacts of the options for each run, the weighted impacts on crashes, and the value of those impacts.

Most of the analysis centers on the effects of the options on LH operations. Effects of the special provisions for smaller trucks in SH/local operations, which affect different entities and are estimated using a different approach, are covered briefly at the end of each section.

6.1 MEASURED PRODUCTIVITY IMPACTS OF OPTIONS ON LH OPERATIONS

Exhibit 6-1 shows the average percentage change in driving hours between Option 1 and the other options. The impacts of Options 2, 3, and 4, relative to Option 1, varied widely across the runs. Some patterns were readily apparent, however. The impacts tended to be greater for drivers assumed to take advantage of split sleeper berths, for both SR and LR drivers. This effect is expected, given that Option 1 allows drivers to enter their sleeper berths if they need to wait several hours before a load can be picked up or delivered. Because under Option 1 the use of the sleeper berth extends the 14-hour driving window, there are circumstances in which the drivers can be more productive, or can accept more advantageous loads. This use of the sleeper berth is more important if there are more waiting periods and less driving, which tends to be characteristic of operations with shorter lengths of haul. Thus, it is not very surprising that the relative impact of not having the split break available is absent for the LH cases (and the positive effect of eliminating the split break for LH drivers can be attributed to random elements in the simulation procedure). Overall, the loss of the split break appeared to be of minor importance for the productivity of solo drivers. This observation is likely due to the fact that, while the opportunity to initiate a split break provides flexibility, the rules for using this feature imparts rigidity to a driver's schedule for subsequent tours of duty. For team drivers, we concluded that there was no necessary reason for a productivity impact from eliminating split break periods because two drivers alternating 10-hour driving periods can drive as much as two drivers alternating 5-hour driving periods (as discussed below, at the end of this section).

The relative productivity loss caused by Option 3 is substantially greater than that for Options 2 and 4 in almost all cases. This pattern comes from the fact that the important difference between these options is the length of the restart period. For the random drivers, the lack of a regularly scheduled off-duty period means that a short restart can be very advantageous, especially for the hard-working drivers that were modeled. The exceptions to this trend can be explained by the reduced value of the restart in particular cases. The regular weekly and daily routes (which generally have a full weekend off), and team drivers (who share duty hours each day) do not need to restart because their cumulative 8-day on-duty totals do not reach 70 hours. Finally, it should be noted that the one case of a negative measured impact of Options 3 and 4 are artifacts of the random elements in the simulation procedure, and would not be expected to persist if these runs were repeated a large number of times.

Exhibit 6-1
Estimated Changes in Long-Haul Productivity by Option and Case

			Option 2 Compared to Option 1	**Option 3 Compared to Option 1**	**Option 4 Compared to Option 1**
Run characteristics			**Relative Reduction in driving hours**		
For-hire, random	Using split sleeper berths	Short Regional	1.1%	24.9%	10.3%
		Long Regional	5.9%	26.2%	19.4%
		Lon Haul	-3.1%	17.9%	9.6%
	No split sleeper berths	Short Regional	0%	24.1%	9.3%
		Long Regional	0%	21.4%	14.2%
		Long Haul	0%	20.4%	12.5%
Regular Routes (Private TL, LTL, regular for-hire)	Full weekend off	Weekly route	0%	16.1%	5%
		Daily route	0%	-2.0%	-1%
	Six-day work week	weekly route	0%	29.2%	19%
		Daily route	0%	8.9%	10%
Team drivers*	Using split sleeper berths		0%	5.0%	5.0%
	No split sleeper berths		0%	5.0%	5.0%

* These impact estimates were based on simplified scenarios rather than model runs.

For Options 3 and 4, the team drivers were expected to lose 5 percent of their productivity as a result of the loss of the 11th hour of driving. This impact could occur despite the fact that teams are not expected to use more than 10 hours per day per driver on average. We found a consensus among industry observers[40] that teams, on average, do not exceed 20 hours a day of driving. The average team driver, therefore, does not exceed an average of ten hours of driving in 24 hours on the clock. It does not, however, follow from this that there is no productivity loss for team operation from eliminating the 11th hour of driving.

The cost stems from the fact that a driver is very unlikely to find a suitable place to stop at the precise moment that his tenth driving hour ends. As long as he can use part of the 11th hour, this is not a problem. A driver can take what he deems as a convenient opportunity to stop, whether before or after the end of the tenth hour. The driver's convenience and the spacing of stopping places would mean some driving tours over ten hours and some under. Team members' driving times, then, would approximate an average of ten hours.

The result is different, however, when the drivers are limited to ten hours each. Since they cannot drive after ten hours, they must stop, effectively, before ten hours. Thus, the average driving time for each team member is necessarily less than ten hours; a few driving tours might end very close

[40] See section 2.1.6

to ten hours, but many would have to be well short of that, possibly anywhere in the range of nine to ten hours.

It is not feasible to offer a precise estimate of when in the nine-to-ten-hour range the average driver would stop. This would depend on the spacing of suitable stopping places on the route along which the team is moving. It also depends on what the team members would regard as suitable. Some gas stations have enough paved area for an 18-wheel tractor-trailer to park quickly. When one of the drivers is approaching the ten-hour limit, however, it is very likely that the vehicle has been moving for four or five hours and both team members would prefer more extensive facilities than a gas station would offer. Truck stops will be considerably less closely spaced along a highway than gas stations. To be conservative, we have assumed that the team will pass only one truck stop in the tenth hour and that could happen at any point in that hour. On this basis, the average driving time for each team member would be 9.5 hours rather than 10, a reduction of 5 percent.

In contrast to the expectation that a reduction in driving hours would reduce the productivity of teams, we concluded that eliminating split breaks would not affect their productivity. It is true that the splitting of breaks is common for teams, with drivers alternating moderately short driving and sleeper berth periods, interspersed with shorter periods in which the truck is stopped. For example, the first team member could drive for five hours, followed by a one-hour rest period for both drivers. The second member could then drive for five hours and stop for one hour, while the first member rested in the sleeper berth. Repeating this pattern, each driver could average 10 hours of driving per 24, which is as much productivity as is expected from teams (as discussed in Section 2.1.6).

We have found, however, that the same productivity can be achieved by a team that does not split, by alternating ten-hour driving and break periods (again, interspersed with short periods in which neither member of the team is driving). This pattern might start with five hours of driving by the first member, followed by a one-hour break, and then a second five-hour driving shift by the same driver. After another one-hour break, the first member of the team would stay off-duty, while the second member would begin a five-hour driving shift. After two driving shifts by the second driver, with a one-hour stop in between and another one-hour stop after the second shift, the entire pattern could be repeated. Thus, in each 24 hours, each team member would be able to drive an average of 10 hours, in two shifts with a short break in between, and each driver would have an uninterrupted off-duty period of 13 hours. This schedule is just as productive as the schedule that involves splitting – a total of 20 hours of driving out of 24. Some team members might find it more onerous to drive for 10 hours following a long break than to alternate shorter driving shifts with shorter breaks, but it is clear that solo drivers are capable of longer periods of driving between extensive off-duty periods. Thus, although many team drivers might prefer the flexibility allowed by split sleeper berth periods, we were unable to attach a productivity gain to this preference.

6.2 WEIGHTING OF THE INDIVIDUAL RUNS

Because the impacts of the options in the individual runs varies so widely, it was important to find the weighted average impacts across the runs, rather than relying on unweighted averages or simply presenting the range. The weighting procedure was based, in the first instance, on estimates of the fraction of total VMT accounted for by each operational pattern. Teams, for example, account for about 9 percent of total LH VMT, and LTL over-the-road operations account for another 5 percent. The remaining VMT is split roughly equally between for-hire and private fleets – 42 and 44 percent respectively. As noted in Chapter 2, we have found that about 60 percent of for-hire VMT can be considered random as opposed to regular. Furthermore, long regional and long haul operations are of greater magnitude than shorter operations, with about 38, 42, and 20 percent of VMT for these operational categories, respectively. We have also found that more than half of for-hire operations, and somewhat less than half of private fleet operations, are intensive enough to press the HOS limits, and should therefore be affected by changes in those limits.

In addition to representing the typical patterns in the industry, however, it was important that the modeling reproduced the usage of the important features of the HOS rules that differ between the options. To ensure that the weighting resulting in an accurate reflection of the use of these features (and therefore that the impacts of the options is realistically measured), the weights were altered to some degree, relying on data such as that shown in Exhibit 6-2, below. To match our estimate of the aggregate degree to which the 11th hour was used across the industry, we increased the assumed percentage of operations that were intensive enough to be affected by changes in the HOS rules beyond the degree indicated by the data. In the case of random TL operations, only a slight decrease (from 65% to 58%) was needed. In the case of regular operations, it was necessary to increase the assumed degree of intensive operations to 45%, compared to the 31% that emerged strictly from our analysis of the data in the FMCSA survey.[41]

To calibrate the results to match the percentage of drivers taking advantage of the split sleeper berth provision, we compared data on the percentage of times that actual drivers appeared to use the provision to the same measure for the simulated drivers in runs that allowed splitting. The degree of use of the split sleeper berth provision appears to vary widely, and is generally difficult to estimate; we approximated its use by assuming that it was used on an average of 13 percent of breaks by random-schedule solo drivers, and half of breaks by team drivers. We did not model solo drivers with regular schedules splitting their break periods, in part because we expected that the ability to plan and set up repeating schedules would reduce the value of the flexibility offered by splitting. In addition, as mentioned in Appendix (I), survey data showed considerably less splitting by drivers with regular schedules than by those with random schedules, and very little splitting overall. Finally, we expected that, even if some splitting occurs within this industry segment, it is likely to be related more to driver convenience than to an effort to enhance productivity. On the whole, there is considerable uncertainty about the actual extent to which splitting occurs, and the modeling procedure and weighting used for this study could have understated it. We have found, however, that because splitting did not show major productivity impacts, the estimate of the costs of the options are not very sensitive to inaccuracies of this kind.

[41] See Exhibit A-4. This increase in the percentage of the regular drivers that work intensively could result in an overstatement of the impacts of the options, particularly Options 3 and 4, if private fleets actually have relatively little intense operation. On the other hand, data used for the previous RIA (see Exhibit C-1, p. C-3 of the appendices) found a relatively small difference in intensity of effort between for-hire and private fleet operations – 44% to 46% and 32% to 37%, respectively – which we expect to track differences between random and regular operations. Thus, it may be that the FMCSA survey data understates the intensity of regular operations to some degree.

6.3 WEIGHTED LH PRODUCTIVITY IMPACTS

The weights used in the modeling are shown in Exhibit 6-3. This table also shows each operational type's contribution to the nationwide weighted impact, which is calculated by multiplying the relative impacts in Exhibit 6-1 by the weights.

The sums of these weighted contributions are also shown at the bottom of the table. Option 2 was found to reduce average driver productivity by only 0.042 percent, while the impacts of Option 3 was many times greater, at 7.1 percent. Option 4 was found to have an impact intermediate between 1 and 3, at 4.6 percent. Multiplying these weighted average productivity impacts by the costs per percent decrease in productivity presented in Chapter 4 – $298 million – yields $13 million per year for the incremental effect of Option 2. Option 3's impact, again relative to Option 1, is estimated to be $2,121 million on an annual basis. Finally, the impact of Option 4 relative to Option 1 is estimated to be $1,374 million per year.

Exhibit 6-2
Use of the 11th Hour by Run

			Percentage of Tours with More than 10 hours of Driving in Option 1
Run Characteristics			
For-hire, random	Using split sleeper berths	Short Regional	0%
		Long Regional	10%
		Long Haul	21%
	No split sleeper berths	Short Regional	0%
		Long Regional	11%
		Long Haul	28%
Regular routes (Private TL, LTL, regular for-hire)	Full weekend off	Weekly route	31%
		Daily route	55%
	Six-day work week	Weekly route	29%
		Daily route	34%
Team drivers*	Using split sleeper berths		50%
	No split sleeper berths		50%

*Estimates for team drivers are based on simplified assumptions rather than modeling.

As presented in Chapter 4, retraining is expected to add an annualized $21 million to the costs of Options 2, 3, and 4. Thus, the total annual incremental costs for Option 2 is $13+$21 = $34 million, for Option 3 is $2,121 + $21 = $2,142 million. These estimates are summarized in Exhibit 6-4.

Exhibit 6-3
Weighted Changes in LH Productivity by Option and Case

			Weight	Option 2 Impact	Option 3 Impact	Option 4 Impact
Run characteristics						
For-hire, random	Using split sleeper berths	Short Regional (SR)	0.5%	0.01%	0.14%	0.06%
		Long Regional (LR)	1.2%	0.07%	0.32%	0.24%
		Long Haul (LH)	1.2%	-0.03%	0.21%	0.11%
	No split sleeper berths	SR	2.4%	0.00%	0.57%	0.22%
		LR	4.9%	0.00%	1.05%	0.70%
		LH	4.4%	0.00%	0.89%	0.55%
Regular routes (Private TL, LTL, regular for-hire)	Full weekend off	Weekly	6.9%	0.00%	1.11%	0.32%
		Daily	7.9%	0.00%	-0.15%	-0.06%
	Six-day work week	Weekly	5.9%	0.00%	1.73%	1.15%
		Daily	8.9%	0.00%	0.79%	0.88%
Team drivers	Using split sleeper berths		4.5%	0.00%	0.23%	0.23%
	No split sleeper berths		4.5%	0.00%	0.23%	0.23%
Unaffected (due to less-intense schedules)			45.1%	0.00%	0.00%	0.00%
Total			100.0%	0.042%	7.12%	4.61%

6.4 COST IMPACTS OF THE OPTIONS ON SH OPERATIONS

The analysis concentrates on the LH segment of the motor carrier industry because the major HOS provisions differentiating the options are expected to have little or no effect on local and SH operations. Drivers who stay within a short radius of their base of operations and return home every evening will have no use for the sleeper berth provisions, and will very rarely be able to drive more than 10 hours in a tour of duty because of the number of stops for waiting, loading and/or unloading that are typical for local and SH operations. Furthermore, because local/SH drivers generally have weekends off and less intense schedules, changes in the restart provisions will make relatively little difference to their productivity.

Exhibit 6-4
Incremental Annual Costs of the Options for LH Operations
Relative to Option 1

	Option 2	Option 3	Option 4
Change in LH Productivity	0.042%	7.12%	4.61%
Change in Annual Costs due to Productivity Impact (millions of 2004$)	$13	$2,121	$1,374
Incremental Annualized Retraining Cost (millions of 2004$)	$21	$21	$21
Total Annual Incremental Cost	$34	$2,142	$1,395

Source: ICF analysis.

Two provisions of Options 2, 3, and 4, however, affect only local/SH drivers: the exemption from keeping log books, and a second 16-hour day in each week. These two provisions apply only for drivers of vehicles between 10,000 and 26,000 lbs. GVW that stay within a 150 air-mile radius of their base of operations, and return to that base at the end of each tour of duty.

We have estimated the cost impacts of these provisions by dividing local/SH vehicles into a limited set of cases, determining the time savings of the log-book exemption for each vehicle in each case, and valuing those savings per vehicle. We then estimated the number of vehicles in each case, multiplied by the savings per vehicle, and summed across the cases.

We estimated the savings from the second 16-hour day per week using a variant of the analysis of the savings from the first 16-hour day per week, which was conducted for the 2003 RIA. Those estimated savings were translated into an annual per-vehicle value, and then scaled appropriately for our estimate of the number of affected vehicles.

A summary of the results of these cost analyses is shown in Exhibit 6-5. Details on the analysis are presented in Appendix (IV).

Increases in Drivers

If the same total ton-miles of freight would be transported by truck under all four options, the reductions in LH productivity could be translated directly into percentage increases in the number of drivers needed by the industry. Thus, Option 2 would require an additional 0.042% *1.5 million or about 600 long-haul drivers, Option 3 would require an additional 7.12% * 1.5 million or 107 thousand, and Option 4 would require 4.61 * 1.5 million or 69 thousand.

As discussed in Chapter 4, however, reduced productivity could be expected to raise the trucking rates slightly, leading to slightly more competition from rail. We estimate that the resulting mode shift would cut the need for additional drivers slightly.

Exhibit 6-5
Summary of Local/SH Analysis
(Annual Savings in Millions of 2004$, rounded to the nearest $10 million)

	Case 1	**Case 2**	**Case 3**	**Total Annual Savings (millions)**
Description	Now operating within 100-mile range and not keeping logs. Duty tours ≤ 12 hours.	Now operating within 100-mile range and keeping logs. Duty tours up to 14 hours.	Now operating in 100-150 mile range. Must keep logs and observe 14-hour limit.	
Log-book effects	No effect; already exempt from log requirement. Benefit: $0	Relieved from log requirement. Benefit: $100.	Relieved from log requirement. Case-3 benefit: $40	$140
14-hour tour with log-book exemption	May use 14-hour tour now, if they keep log. Tour>12 hours is of little value to this group. Benefit: minimal	Already choosing log-book and 14-hour tour. Benefit: zero	Already have 14-hour tour.	$ 0
	Case 1	**Case 2**	**Case 3**	**Total Annual Savings (millions)**
Second 16-hour day	Would not use the 16-hour day because they already choose not to use the 14-hour tour. Savings: $0	Analysis is an extension of analysis of second 16-hour day that was done for the 2003 RIA. This approach did not distinguish between Cases 2 and 3. Productivity Benefit: $140		$140
Total				$280

Source: ICF analysis. See Appendix (IV).

6.5 CRASH RISK RESULTS BY OPERATIONAL CASE

The results of the crash risk modeling are presented in Exhibit 6-6, with and without scaling the results to yield an average fatigue-related value of 7 percent in Option 1. Overall, the impacts are relatively small, as might be expected for options that are making marginal changes in an existing rule. Some patterns are visible: in almost every case, Options 2, 3, and 4 show lower crash risks than Option 1. In most cases, the crash risk reductions were greater for six-day schedules than for five-day schedules.

Options 3 and 4 have generally greater reductions in risks (shown as negative numbers) than Option 2, as is expected due to the greater stringency of those options. Impacts on team drivers, which were modeled as being the same for Options 3 and 4, were greater for drivers who split their rest periods under Option 1 than for those who did not.

There are also some anomalies in the results. In the random schedule cases, the advantages of Options 2, 3, and 4 over Option 1 were not uniformly greater for drivers inclined to split their rest periods: this was the case for short-regional drivers but not for long-regional or long-haul drivers. There was no overall tendency for Option 3 to out-perform Option 4. As discussed in Chapter 5, however, the advantage of Option 3 over Option 4 (which lies in the extra 14 hours of rest over the weekend) are expected to be very small for well-rested drivers, and it is likely that this small expected advantage was masked by the random factors inherent in the modeling. Random factors in the modeling may also have resulted in an apparent disadvantage for Option 2 over Option 1 for long-regional and long-haul operations, while possibly overstating the impacts on short-regional operations. Because of these random factors, the weighted average impact over all three operational types is likely to be more accurate than any of the individual measures. For those operations that split rest periods, the weighted average impact showed a slight reduction in crash risk.

Weighting the crash risk results in the same manner as the productivity results, we found the overall changes in crash risks to be small. Option 2 resulted in a risk reduction of about 0.1 percent, while Options 3 and 4 each provided a risk reduction of about 0.6 percent.

6.6 VALUE OF THE LH CRASH RISK CHANGES

These percentage changes in risk were valued by multiplying them by an estimate of the total annual damage associated with heavy-duty long-haul truck crashes. For consistency with the earlier analysis, we have used the value from the previous analysis of $32.2 billion in year 2000 dollars, or about $34.9 billion in year 2004 dollars. The 2003 RIA also presented an estimate of the percentage of total damages that were caused by the long-haul segment. Applying the same percentage – just over 58 percent – to $34.9 billion yields just over $20 billion. The reduction in risk attributable to Option 2, given this total value, is 0.1% * $20 billion or about $20 million per year. The value of the risk reduction attributable to Options 3 and 4 is higher, at 0.6% * $20 billion or about $120 million per year. These risk reduction changes are much smaller than the cost changes attributable to the options.

We expect the crash risk impacts of the local/SH changes to be negligible. The analysis of the crash risk impacts of a single 16-hour day for SH drivers in the 2003 RIA, which showed a $10 million annual increase in benefits because the productivity improvement it would provide would reduce the need to hire new, less experienced drivers.[42] Because the second 16-hour day is estimated to be used considerably less than the first, we conclude that the risk impacts of the second 16-hour day would be essentially zero.

[42] See p. 9-9 of the 2002 RIA.

Exhibit 6-6
Incremental Crash Risk Estimates

Run characteristics			Option 2 Compared to Option 1	Option 3 Compared to Option 1	Option 4 Compared to Option 1
			Relative Change in Crash Risk		
For-hire, random	Using split sleeper berths**	SR	-7.4%	-6.3%	-2.4%
		LR	1.4%	-5.6%	-7.5%
		LH	2.0%	-7.2%	-7.6%
	No split sleeper berths	SR	0%	1.1%	5.0%
		LR	0%	-6.9%	-8.9%
		LH	0%	-9.3%	-9.6%
Regular routes (Private TL, LTL, regular for-hire)	Full weekend off	Weekly	0%	0.2%	-0.4%
		Daily	0%	-0.7%	-0.3%
	Six-day work week	Weekly	0%	-0.7%	-1.2%
		Daily	0%	-0.9%	-0.5%
Team drivers*	Using split sleeper berths**		-5.7%	-6.4%	-6.4%
	No split sleeper berths		0%	-0.7%	-0.7%
Weighted Average Impacts (raw)			-0.3%	-1.4%	-1.4%
Weighted Average Impacts (scaled)			-0.1%	-0.6%	-0.6%

*Based on ICF analysis of simplified scenarios.

**These scenarios assumed time-on-task effects for split sleeper berth cases are of the same magnitude as in equivalent non-split cases. Reductions in crashes would be smaller if split rest periods eliminate time-on-task effects.

6.7 NET COSTS BY OPTION

Exhibit 6-7 summarizes the annualized costs, benefits, and net costs of each of the options relative to Option 1. Both LH and local/SH effects are shown. The values have been rounded to the nearest $10 million, in line with the values presented for the local/SH impacts.

Exhibit 6-7
Net Incremental Annual Costs of the Options Relative to Option 1
(millions of 2004$, rounded to nearest $10 million)

		Option 2	Option 3	Option 4
Total Annual Incremental Cost	**LH**	$30	$2,140	$1,390
	SH	-$280	-$280	-$280
Total Crash Reduction Benefits	**LH**	$20	$120	$120
	SH	~0	~0	~0
Net Annual Costs		-$270	$1,740	$990

6.8 LIMITATIONS AND SENSITIVITIES

The estimates of costs and benefits of the options relative to one another are based on data, assumptions, and modeling, each of which are subject to uncertainties of various kinds. We have estimated the effects on the cost and benefit calculations if variants of some of the assumptions used in the analysis were used.

6.8.1 Elimination of the 11th Hour of Driving in Option 2

In addition to Options 1, 2, 3, and 4, we also examined a more restrictive variant of Option 2. That option limited driving to 10 hours in a tour of duty, in addition to the restrictions on the splitting of break periods that constitute the difference between Option 2 and Option 1. This more restrictive option was found to provide more benefits than Option 2, but at substantially higher cost. Crash risks were found to be reduced by about 0.4 percent rather than 0.1 percent, providing about $80 million in annual benefits (20+60) compared to the $20 million provided by Option 2. The projected cost impacts, however, rose by $586 million per year.[43] The minimal financial impacts of Option 2 would increase, spreading the possibility of significant adverse impacts over a much larger portion of the industry. To summarize the effects of restricting driving to 10 hours, we will compare the net of costs and benefits of this restrictive variant of Option 2 to the net for the original Option 2.[44] Exhibit 6-7 shows that the benefits of Option 2 exceed its costs, leading to net annual benefits of $270 million. For Option 2 with 10 hours of driving, total costs become +$336 million annually (+30-280+586) and total benefits are $80 million annually, as just mentioned. As a result, under Option 2 with 10 driving hours, the net annual cost is $256 million annually. The analysis concludes that Option 2 is far more cost-beneficial than that option with 10 driving hours: a net benefit of $270 million annually rather than a net cost of $256 million.

Because various factors and assumptions that feed into the analyses of benefits are uncertain, the costs and benefits of the incremental elimination of the 11th hour could be higher or lower than $586 million and $60 annually. To test whether reasonable changes in the most important assumptions could swing the overall cost-benefit analysis to favor 10 hours in Option 2, we have conducted sensitivity analyses that change each of several key assumptions in turn, and another in which they are changed as a group. The first two single-assumption sensitivity analyses make changes that favor eliminating the 11th hour of driving. These two sensitivity analyses test whether or not Option 2 is still cost-beneficial relative to Option 2 with 10 hours of driving. In other words, we "stress test" the cost-benefit analysis of Option 2 by testing whether unfavorable assumptions would reverse the selection of Option 2 in favor of its more-restrictive variant.

Value Per Statistical Life Saved

Crash reduction benefits were estimated based on examinations of the outcomes of crashes (property damage only, injuries and property damage, or fatalities) and detailed assessments of the social costs of those outcomes. Repair costs, costs of medical treatment, lost time due to delays, and productivity losses due to injuries and deaths are all included. In addition, deaths are valued by computing how many “quality adjusted life years” the victims lose. In the study used

[43] Compared to the $60 million increase in benefits, the increase in costs is almost ten times as great.

[44] Net benefits = benefits – costs. Net costs = costs - benefits

as the basis for the benefits analysis in the 2003 RIA, the value per statistical life saved in large truck crashes was very close to $3 million.[45] In 2004, the Office of Management and Budget (OMB) issued updated guidance to Federal agencies with regard to conducting regulatory impact analyses, including information on the monetary value of a statistical life (VSL). In this guidance, OMB indicated that, "A substantial majority of the resulting estimates of VSL vary from roughly $1 million to $10 million per statistical life." [OMB Circular A-4, p.30].

If a higher value were assumed for avoiding each fatality, the total benefits for reducing crashes through the elimination of the 11th hour of driving would rise, and the net benefits of Option 2 with 10 hours would increase. The effect of raising the value per statistical life saved from $3 million to $10 million, the upper limit of the range recommended by OMB, can be calculated using the total annual damages from all truck-related crashes and the total number of fatalities in those crashes. As presented in Chapter 6, the total cost associated with truck crashes is $34.9 billion per year. The portion of this total due to fatalities, assuming $3 million per fatality, is $3 million * 5,346 or just over $16 billion, where 5,346 is the average annual number of fatalities in truck-related crashes (as reported in Exhibit 8-1 of the 2003 RIA). If the value of a statistical life is taken to be $10 million instead of $3 million, the total cost associated with the fatalities rises to about $53.4 billion, an increase of about $37.4 billion. The total damages from all truck related crashes, then, rise to $34.9 + $37.4 billion or $72.3 billion. Using this value of damages in place of the original $34.9 amounts to an increase by a factor of 72.3/34.9, or 2.07.

The larger VSL would thus increase total benefits for Option 2 with 10 hours from $80 million annually to $166 million.[46] Since the annual costs of Option 2 with 10 hours are unchanged at $336 million, the net cost becomes $170 million (336-166). The $170 million net cost with a higher VSL, while better, is still much less cost-beneficial than under Option 2, which increases from $270 million of net benefits to about $311 as a result of the increase in the VSL. Although more than tripling the VSL does lower the net cost, eliminating the 11th hour of driving in Option 2 is still not cost-beneficial.

Increased Relative Risk from the 11th Hour

As explained in Chapter 5, the benefits of eliminating the 11th hour were calculated using an added TOT multiplier for crash risks for long hours of driving. The magnitude of this multiplier was calculated on the basis of TIFA data for over 30,000 fatal crashes. The analysis measured the percentage of fatal crashes considered to be fatigue-related as a function of number of hours behind the wheel since an extended break. The fatigue-related percentage was low for the first six or seven hours, and then generally increased with each additional driving hour. Breaking the data into 13 categories – 1 hour through 12 hours, and then combining those few data points beyond 12 – we found that the fatigue-related percentage could be described well as a cubic function of TOT: the cubic equation explained more than 98 percent of the variability in the

45 "Costs of Large Truck-and –Bus Involved Crashes", Zaloshnja et al (2000) pg. 21 Table 11. This table shows a cost per fatal crash of about $3.4 million in 2000 dollars, almost all of which was due to the loss of quality adjusted life years and lifetime earnings After adjusting to 2004 dollars and dividing by the average number of fatalities per crash, the damage per statistical life is very close to $3 million.

46 $166 million = $80 million x 2.07

grouped data showing the fatigue-related percentage. Using this equation, driving in the 11th hour entails a fatigue-related crash risk that is about 2.5 times as great as the average for the entire 11 hour trip.

Because the regression equation was based on a sample of data and is only an estimate with error, the true relative risks of fatigue involvement in the 11th hour could be higher or lower. To estimate how much higher this relative risk is likely to be, a "bootstrap" analysis of the data set was conducted.[47] In this analysis, the regression equation was re-estimated 500 times, using data sets randomly selected from the thirteen original points, reflecting the grouped data.[48] Across these 500 equations, the upper bound of the 95 percent confidence interval (between the 12th and 13th highest out of 500) was 3.15, which is about 25 percent higher than the original estimate of relative risk, and the upper bound of the 99 percent confidence interval (the 5th highest out of 500) was 3.56, which is about 40 percent higher than the original estimate. Thus, there is only a 1% chance that the additional risk caused by driving in the 11th hour is more than about 1.4 times greater than the estimate used in the cost-benefit analysis of Option 2 that appears in Exhibit 6-7.[49]

If the risk caused by allowing operators to drive for 11 hours is, in fact, 1.4 greater than had been assumed in the cost-benefit analysis of Option 2, then the benefits for Option 2 with only 10 driving hours would rise from $80 million to $104 million annually (i.e., from $20 + $60 to $20 + $60 * 1.4, because the factor of 1.4 would affect only $60 million in benefits related to elimination of the 11th hour.). Increasing the 11th hour driving risk does not change the cost of Option 2 with 10 hours, which remains at $336 million annually. Consequently, under the higher risk of driving the 11th hour, the net cost of Option 2 with 10 hours becomes $232 million per year (or $336 - $104). Thus, while increasing the relative risk of a fatigue-related crash while driving the 11th hour does reduce the net costs, eliminating the 11th hour is still not cost-beneficial. Conversely, with a net benefit of $270 million annually, Option 2 with 11 hours of driving is still the preferred option compared to alternative Option 2 (i.e., with 10 hours driving), even when assuming a heightened relative risk of fatigue crash in the 11th driving hour.

Overall Use of the 11th Driving Hour

The two sensitivity analyses above stress-tested Option 2 by making plausible changes in assumptions that favored eliminating the 11th driving hour. We next made a sensitivity analysis of changing another key parameter--the use of the 11th driving hour. Reducing the use of the 11th

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[47] The bootstrap regression procedure was implemented in Microsoft Excel, using a methodology developed in the statistical software Stata" StataCorp, 2001. Stata Statistical Software: Release 7.0. College Station, TX: Stata Corporation.

[48] A bootstrap analysis samples the original dataset with replacement, which means that it creates a new dataset with the same number of observations as the original dataset. After each data point is randomly selected as part of an individual data set, it could be chosen again in the same dataset. The variation introduced by this method allows for the calculation of confidence intervals for the regression parameter estimates, and therefore a confidence interval for the relative risk of the 11th hour of driving.

[49] We acknowledge that this type of analysis explicitly identifies one major contributor to the uncertainty of the estimate (sampling error) but does not explicitly correct for more general sources of uncertainty, such as whether or not this relative risk estimate is an unbiased estimate of the true risk of the 11th hour of driving for the reasons discussed earlier in the analysis. Implicitly, however, the increase in relative risk identified by this sensitivity analysis could also be due to a downward-biased original estimate, or indeed any other source of uncertainty.

hour would move the cost-benefit analysis toward Option 2 with 10 hours, but we could not plausibly make that assumption: as the 11th hour of driving becomes more incorporated into normal operations in the future, we believe its use much more likely to increase rather than decrease. Increasing that percentage would increase the costs to the same degree as the crash reduction benefits. For example, a doubling of the percentage would lead to estimated costs for Option 2 with 10 hours of about +$922 million (+30-280+1,172, where 1,172=586*2). Benefits for Option 2 with 10 hours would become $140 million annually (+20+120; where 120=60*2). Net costs for Option 2 with 10 hours would rise from $256 million annually to $782 million annually. If the use of the 11th driving hour doubled, Option 2 with 10 hours would become even less cost-beneficial relative to the original Option 2. Also note that even if the use of the 11th hour dropped, because the use of the 11th hour is cost-beneficial regardless of how often it is used, variation of this single assumption could never make the restriction of the 11th hour of driving cost-beneficial. In other words, this assumption is not decision critical with regard to whether or not to restrict the 11th hour of driving.

Baseline Risks of Fatigue-related Crashes

One important reason that the cost-effectiveness of banning the 11th hour is unfavorable, despite the fact that fatigue-related crashes rise to several times their average value as TOT increases, is that fatigue is associated with only a fraction of all crashes. Thus, even if fatigue-related crashes are two to three times as likely in the 11th hour as in the average hour, the overall change of a crash increases only moderately. For the 2003 RIA, fatigue was estimated to cause 8.15 percent of crashes. If in a given hour that risk increases by a factor of 2.5, to about 20.4 percent overall, then overall crash risks in that hour would rise by only about 12 percent. In addition, because the 2003 rule was estimated to reduce fatigue-related crashes considerably, the incremental effect of the 11th hour would be even smaller.

There is, however, uncertainty about the baseline degree of fatigue. In the 2003 RIA, sensitivity analyses were prepared using alternative assumptions of 5 and 15 percent, in addition to 8.15 percent, because most comments relating to the prevalence of fatigue as a cause of accidents posited values within that range. If the 15 percent value were used for the baseline (in the pre-2003 situation), the estimated crashes caused by fatigue would rise by a factor of 15/8.15 or 1.84 (i.e., an increase of 84 percent of the base). This increase would carry through to the impact of both the splitting of rest periods and eliminating the 11th hour, meaning that assuming a higher baseline fatigue percentage would raise the benefits from $80 million to $80 * 1.84, or $147 million. This change would imply net costs of $336 million - $147 million or about $190 million. Though increasing the baseline risk of fatigue-related crashes from 8.15 percent to 15 percent does reduce the annual net cost (from $256 million to $147 million), eliminating the 11th hour of driving in Option 2 is still not cost-beneficial.

Combinations of Changes in Assumptions

None of the sensitivity analyses described above show a balance of costs and benefits that supports Option 2 with driving restricted to 10 hours. These sensitivity analyses were all conducted, however, with only one assumption changing at a time, and it is at least possible that the most realistic answer would be obtained if the three assumptions that moved the cost-benefit results toward eliminating the 11th hour were changed simultaneously. Take the combined sensitivity analysis for: (1) the value of a statistical life assumed to be at the high end of its range ($10 million, instead of $3 million); (2) the risk of the 11th hour assumed to be at the upper bound of the 99 percent confidence interval (about 1.4 times the value used in the basic analysis); and (3) the baseline fatigue percentage assumed to be at the high end of its range (15 percent instead of 8.15 percent). In that case, the total benefits of Option 2 with 10 hours of driving would be about $396 million per year.[50] while total costs would still be $336 million annually, leaving a net benefit of $60 million per year. Even in this extreme and unlikely case, however, the net benefit of Option 2 would be substantially more favorable at $326 million annually.[51] Thus, it appears highly unlikely that banning the 11th hour would lead to a cost-beneficial rule, even with all favorable assumptions.

These points are summarized in Exhibit 6-8, which presents the effects of different safety-related assumptions on the net costs, benefits, and net benefits of two versions of Option 2, relative to Option 1. Each pair of rows compares the Option with and without a 10-hour driving limit; the

Exhibit 6-8
Sensitivity Analyses of Net Benefits, 10-hour Driving Limit
(millions of 2004$)

	Option	Net Costs Relative to Option 1	Safety Benefits Relative to Option 1	Net Benefits Relative to Option 1	Net Benefits of Option 2 Relative to Option 2 w/10 hours
Basic Assumptions	Option 2	-250	20	270	
	Option 2 w/10 hrs	336	80	-256	526
Twice as Much Use of 11th Hour	Option 2	-250	20	270	
	Option 2 w/10 hrs	922	140	-782	1052
Higher Value of Statistical Life (VSL)	Option 2	-250	41	291	
	Option 2 w/10 hrs	336	166	-170	462
Higher TOT Impact	Option 2	-250	20	270	
	Option 2 w/10 hrs	336	104	-232	502
Higher Baseline Fatigue	Option 2	-250	37	287	
	Option 2 w/10 hrs	336	147	-189	476
Higher VSL, TOT Impact, and Baseline Fatigue	Option 2	-250	76	326	
	Option 2 w/10 hrs	336	396	60	266

[50] These more favorable assumptions would increase the part of total benefits associated with eliminating the 11th hour by a factor of about 2.07 * 1.4 * 1.84, or about 5.33, and would increase the rest of the benefits by a factor of about 2.07 * 1.84, or about 3.8. These changes would imply total benefits for Option 2 with 10 driving hours of about +$396 million per year (=60 * 5.33 + 20 * 3.8).

[51] The benefits of Option 2 would rise under these assumptions from $20 million per year to $20 million * 2.07 *1.84, or to $76 million, so net benefits would rise to $280 -30 + $76 million, or $326 million per year. One should also bear in mind that the impact of TOT in the 11th hour could be overstated as well as understated, and the baseline risk of fatigue could be lower than 8.15 as well as higher. These possibilities, which would make the cost-benefit analysis less favorable to dropping the 11th hour, were not considered explicitly in the sensitivity analyses.

column at the right shows the net advantage of Option 2 over the alternate version with the 10-hour limit. The first column of figures is the net cost of the two options relative to Option 1 under different assumptions; because only the change in the assumption about the use of the 11^{th} hour has an effect on costs, very little changes in this column from one assumption to the next. The next column of figures shows the safety benefits of the options relative to Option 1; in general, the version of Option 2 with the 10-hour limit shows a greater increase in benefits in response to changing the safety assumptions, and shows the higher increase in the last row, which combines the preceding three changes in assumptions. The third column of figures is the difference between the previous two – in other words, the net benefits of the options. For each set of assumptions, Option 2 has positive net benefits relative to Option 1. Option 2 with a 10-hour limit shows positive net benefits relative to Option 1 only in the last row, which combines three assumptions that favor the driving restriction. Even in this case, however, the net benefits of Option 2 with the 10-hour limit are far lower than the net benefits of Option 2 without the 10-hour limit. The disadvantage of the 10-hour limit is brought home in the final column, which compares the two versions of Option 2 directly: even under the most favorable set of assumptions, Option 2 without the 10-hour limit has net benefits that are $266 million higher. Thus, even under the most favorable assumptions, eliminating the 11^{th} hours does not appear to be cost-effective.

6.8.2 Impact of Splitting on the Time-on-task Effect

The safety analysis assumed that driving beyond the 8^{th} hour since an 8-hour break leads to higher risks, due to a "time-on-task" (TOT) effect. This effect was assumed to manifest itself even for drivers who split their off-duty breaks: a 5-hour break, followed by 5 hours of driving, followed by another 5 hour break and another 5 hours of driving, was assumed to result in the same TOT effect as a 10-hour break followed by 10-hours of driving. This assumption might not hold, however. Someone who never drives for more than 5 hours without taking 5 hours off might experience only a 5-hour, not a 10-hour, TOT effect. Recalculating the safety benefits under the assumption that the TOT effect does not carry over from one split period to another, we found that the annual safety benefits for Option 2 would be reduced by $12 million per year, or more than half. The benefits for Options 3 and 4 would be reduced by about $17 million per year, or about 14 percent.

6.8.3 Impacts of Greater Splitting of SB Periods

Both the productivity and safety analyses assumed a limited degree of splitting of sleeper berth periods: 13 percent of random-schedule solo driving, 50 percent of team driving; none of the operations with regular schedules were assumed to split break periods for productivity reasons. Because these assumptions might understate the true amount of splitting, we recalculated costs and benefits assuming twice the use of split sleeper berth periods. This change in assumptions raised the annual benefits of all three options by about $20 million – a 100 percent increase for Option 2 and 20 percent for Options 3 and 4. Costs would increase by about $13 million, a reflection of the minor productivity advantages found for splitting for solo operations and the lack of an advantage assumed in our modeling of team operations.

6.8.4 Use of the 11th Hour of Driving by Local/SH Drivers

The analysis of costs and benefits assumed that the 11th hour of driving allowed under Option 1 was not used by local/SH drivers, on the basis of our understanding these operations and data that corroborated this understanding. We assumed, implicitly, that the few cases in which compliant drivers in local operations reported driving more than 10 hours in a tour of duty were erroneous: either regional drivers were classified as local because they returned to home base every night, or because non-driving time (e.g., during deliveries) was classified as driving for the convenience of the driver in keeping the log.

It may be, however, that this implicit assumption is incorrect, and there would be some impact on local/SH drivers from the elimination of the 11th hour. Taking the FMCSA survey data at face value, and assuming that 5 percent of all local/SH tours of duty exceeded 10 hours of driving, we estimate that Options 3 and 4 would reduce local/SH productivity by about 0.35 percent. Estimating the costs of this productivity impact using the same approach as for LH operations resulted in an estimated cost impact of about $90 million per year, which is less than a tenth of a percent of total local/SH revenues. Safety benefits would amount to approximately $5 million.

6.8.5 Uncertainty about Fatigue-related Crashes

Because of the difficulty of identifying the causes of crashes, there is considerable uncertainty about the percentage of crashes that can be attributed directly or indirectly to fatigue. The 2003 RIA included a sensitivity analysis showing the effects on the benefit estimates of substantial changes in baseline estimates of fatigue-related crashes. A similar sensitivity analysis would show benefit estimates for Option 2 as high as $37 million and as low as $12 million, for baseline fatigue risk estimates of 15 and 5 percent, respectively, in place of the 8.15 percent value used for the 2003 RIA. The benefit estimates for the other two options would range from just over $70 million to about $220 million.

Compliance

As noted earlier in this RIA, the baseline for the 2005 RIA analysis is the current operating environment (the 2003 rule), assuming full compliance with existing regulations. The baseline for the 2003 RIA was the operating environment at that time, or the pre-2003 rule, assuming full compliance by motor carriers with those regulations. The 2003 RIA also considered the effects of incomplete compliance in the baseline, relative to the full compliance baseline, but did not attempt to assess the possible degree of non-compliance with the option that was selected (and which has become Option 1, the baseline for this analysis). The supplemental (incomplete compliance) analysis performed as part of the 2003 RIA was performed due to the relatively broad scope and novelty of the three alternative regulatory packages considered as part of that rulemaking. As such, analyzing the economic impacts of the 2003 rule options from an alternative (incomplete compliance) baseline was appropriate. In contrast, the various regulatory options given serious consideration as part of the 2005 HOS rulemaking were much less sweeping in nature. For instance, under Alternative Options 2, 3, and 4 examined in this RIA, the regulatory choices were generally limited to returning to the pre-2003 rule environment (i.e., eliminating the restart provision (equivalent to 58 hours) and/or returning to 10 hours of daily driving) or revising provisions in that general direction (i.e., increasing the required minimum restart period to 44 hours). Given that the range of 2005 rule revisions were much less sweeping, FMCSA concentrated its analytical efforts on conducting a series of sensitivity analyses described above. FMCSA believes this more finely-grained (sensitivity) analysis was more appropriate here, given the relatively limited scope of the changes considered here.