Evaluating the Impact of Speed Limit Reductions on Greek Motorways: A Cost-Benefit and Acceptance Analysis

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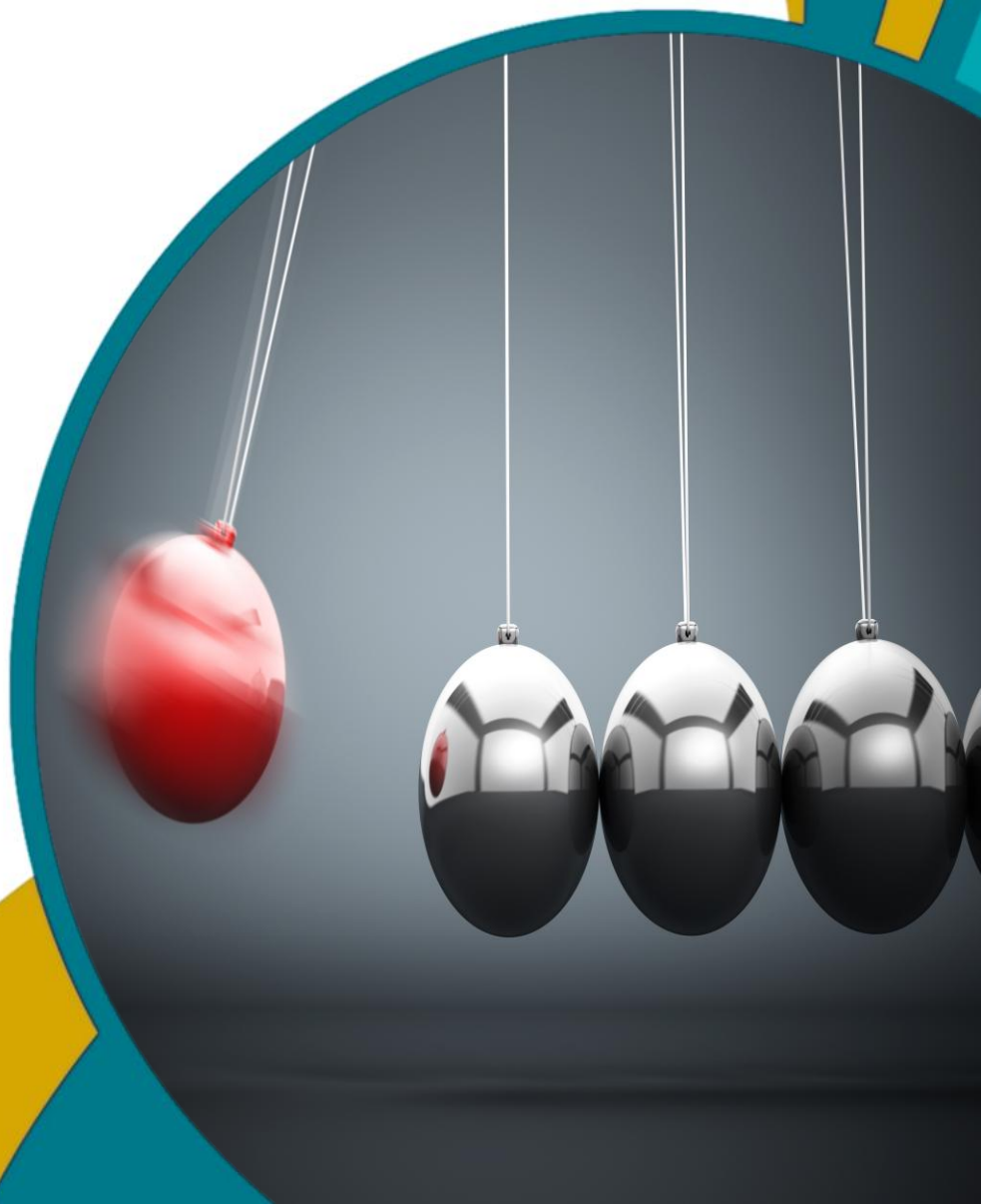
Introduction

- Motorways are considered the safest type of road, yet speed remains a key risk factor in crashes.
- Excessive speed contributes to 28% of fatal crashes in the US and 40.8% in Italy.
- In Greece:
  - Motorway fatalities rose from 6.1% in 2021 to 13.5% in 2022 (post-COVID traffic rebound).
  - 76.9% of drivers respect speed limits, but V_{85} speed = 117.8 km/h.
- Reducing speed is proven to improve road safety, fuel efficiency, and environmental sustainability.
- EU Vision Zero has set the goal to halve fatalities by 2030.

Objectives

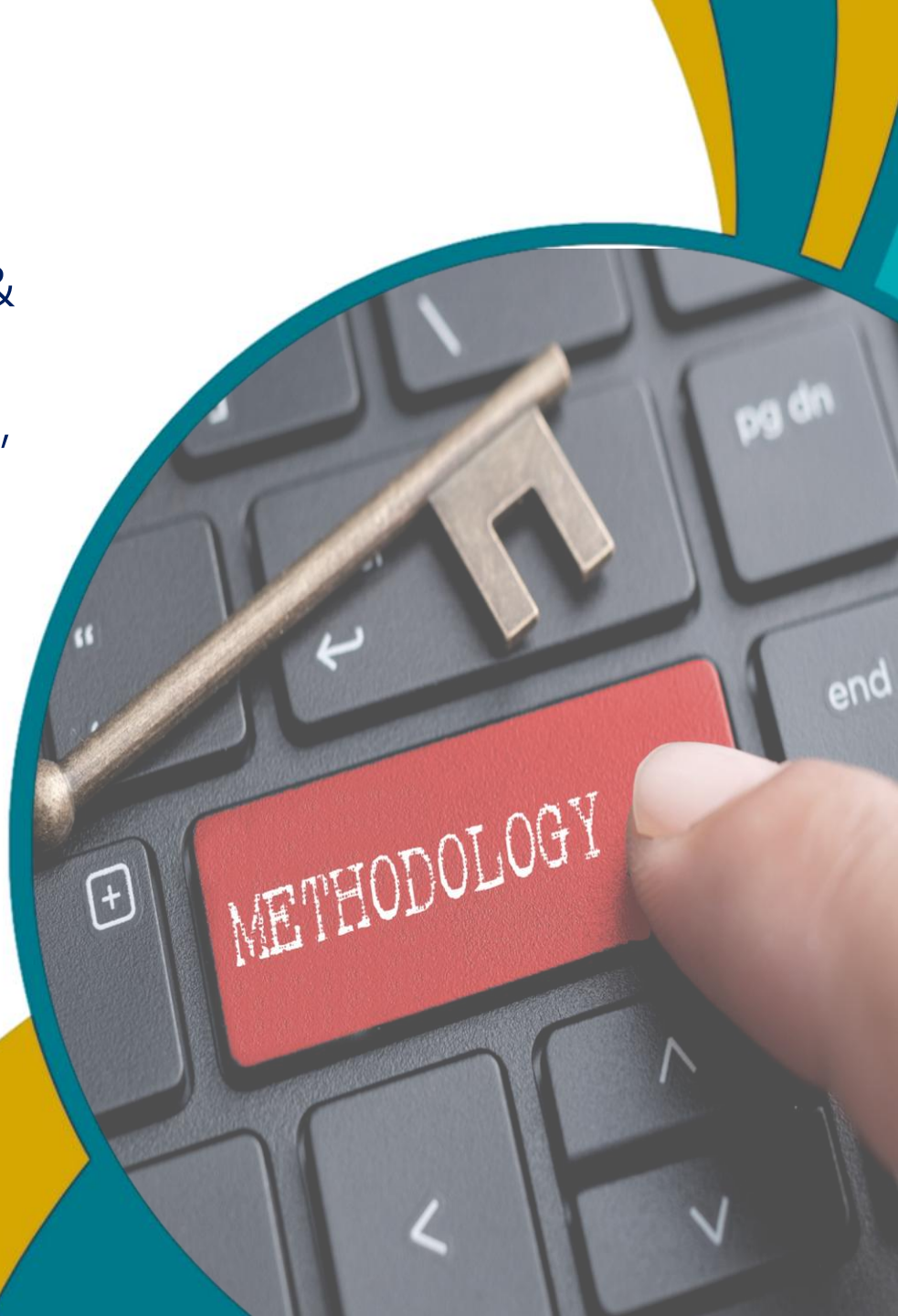
- Examine public acceptance of lowering motorway speed limits in Greece.
- Quantify the socioeconomic impacts of a reduction to 110 km/h using cost-benefit analysis.
- Provide evidence-based recommendations to align with:
  - National Road Safety Strategic Plan.
  - EU climate and safety targets.
  - Vision Zero 2030 goal.



Methodology

- **Statistical Models:**
  - ✓ Binary Logistic Regression: Acceptance of 110 km/h & 120 km/h.
  - ✓ Multinomial Logistic Regression: Choice between 110, 120, 130.
- **Cost-Benefit Analysis (CBA):**

  Based on EU guidelines.
  - ✓ **Benefits:** Road safety, fuel savings, emissions reduction.
  - ✓ **Costs:** Travel time increases, implementation, and operation.
- **Key indicators:**
  - ✓ Economic Net Present Value (ENPV).
  - ✓ Benefit-Cost Ratio (B/C).
  - ✓ Economic Rate of Return (ERR).



Survey Acceptance Results

- Public preferences:
  - 22% support reduction to 110 km/h.
  - 49% support reduction to 120 km/h.
  - 29% prefer no change (130 km/h).

- Key Influences:
  - Positive: Prior injury crashes, high risk perception, higher education, and medium income.
  - Negative: Long driving experience, property-damage-only crash history, women, unmarried drivers.

- A speed of 120 km/h is considered a "reasonable" compromise.
- Where 110 km/h is perceived as an "excessive" sacrifice of travel time.

Figure 1: *Respondents' opinion of the speed's importance*

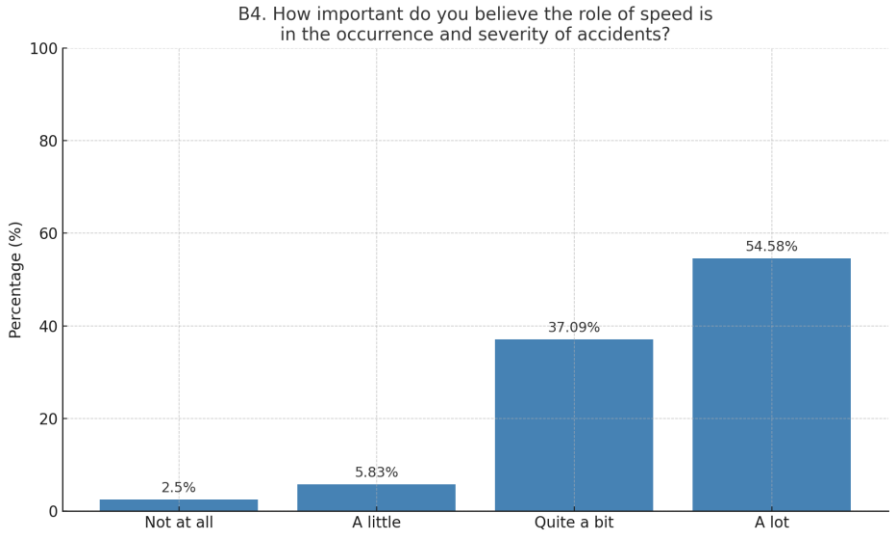
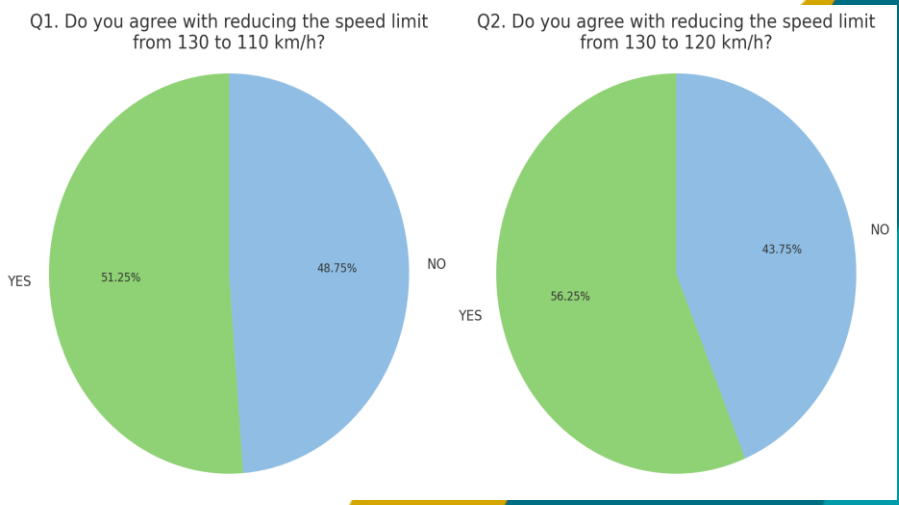


Figure 2: *Respondent's agreement on speed limit reduction at 110 km/h (a) and 120 km/h (b)*



Multinomial Logistic Regression Model

- Multinomial Model:
  - Travel time ↑ → supports 110 & 120 km/h.
  - Crash risk ↓ → increases acceptance of 120, reduces acceptance of 110.

- U_{choice_1}= 0.8922 + 2.9952*Time - 5.2611*Crash
- U_{choice_2} =-0.430 + 0.329*Time + 1.603*Crash

$$Pchoice1 = \frac{e^{U(Choice\ 1)}}{1 + e^{U(Choice\ 1)} + e^{U(Choice2)}}$$

$$Pchoice2 = \frac{e^{U(Choice\ 2)}}{1 + e^{U(Choice\ 1)} + e^{U(Choice2)}}$$

Table 1: *Multinomial Logistic Regression Results*

MNLogit Regression Results						
Dep. Variable:			No. Observations:			2400
Model:	MNLogit		Df Residuals:			2394
Method:	MLE		Df Model:			4
			Pseudo R squ:			0.3895
			Log-Likelihood:			-1531
			LL-Null:			-2507
			LLR p-value:			0
Choice = 1	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
const	0.8922	0.252	3.535	0	0.398	1.387
Time_norm	2.9952	0.303	9.875	0	2.402	3.588
Crash_norm	-5.2611	0.334	-15.736	0	-5.916	-4.606
Choice = 2	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
const	-0.430	0.265	-1.619	0.105	-0.950	0.091
Time_norm	0.329	0.272	1.210	0.226	-0.204	0.863
Crash_norm	1.603	0.272	5.893	0.000	1.070	2.136

Binomial Logistic Regression Model

- Binary Models:
  - 110 km/h → supported by risk-aware drivers, frequent users, injury crash survivors.
  - 120 km/h → supported by balanced profiles (experience 5-9 years, urban drivers).
- Model accuracy:
  - ROC curves show AUC = 0.88-0.91, indicating excellent predictive power.

Table 3: *Binomial logistic regression for speed limit reduction to 110 km/h results*

Reducing speed limit from 130 km/h to 120 km/h			
Logit Regression Results			
Dep. Variable:	C2	No. Observations:	2400
Model:	Logit	Residuals:	
Method:	MLE	Model:	
		Pseudo R squ:	0.3711
		Log-Likelihood:	-1034.4
		LL-Null:	-1644.8
		LLR p-value:	1.91E-231

Table 4: *Binomial logistic regression for speed limit reduction to 110 km/h results*

Reducing speed limit from 130 km/h to 110 km/h			
Logit Regression Results			
Dep. Variable:	C1	No. Observations:	2400
Model:	Logit	Residuals:	2361
Method:	MLE	Model:	38
		Pseudo R squ:	0.4617
		Log-Likelihood:	-895.15
		LL-Null:	-1662.8
		LLR p-value:	5.60E-298

Cost-Benefit Analysis

Table 1: *Investment and operational costs of CBA*

Costs (-)	Benefits (+)
C1. Initial Investment Cost	B1. Traffic related Benefits
C1.1 Procurement and installation of camera systems	B1.1 Travel Time savings
C1.2 Upgrade of horizontal and vertical signage	B2. Fuel Consumption Reduction
C1.3 Cost of Traffic Control Center camera system	
C1.4 Procurement and installation of Variable Message Signs (VMS)	
C1.5 Study and design cost	
C2. Operational Costs	B2. Externalities
C2.1 Operation and maintenance of the Traffic Control Center	B2.1 Road Crashes
C2.1 Operation and maintenance of the Traffic Control Center	B2.2 Environmental Pollutants
C2.3 Operation and maintenance of mechanical equipment	B2.2.1 - CO2 Emissions
C2.4 Employment of additional personnel	B2.2.2 – NOX Emissions
C2.5 Biennial evaluation of the measure's effectiveness	B2.2.3 – PM Emissions

- Reducing to 110 km/h is expected to:
  - Reduce fatalities by 32.5%.
  - Reduce serious injuries by 29.3%.
  - Reduce minor injuries by 24.5%.

Cost-Benefit Analysis Results (1)

- **Fuel savings**:
  - 37 million liters saved → €30M benefit
- **Environmental gains**:
  - CO_2 ↓ 77,803 tons (€17.3M benefit).
  - NOx ↓ 479 tons (€0.1M).
  - PM ↓ 3 tons.
- **Investment & Operation Costs**:
  - Initial: €1.39M.
  - Operating (10 yrs): €7.02M.
- **Indicators**:
  - ENPV: €10.94M.
  - B/C ratio: 2.30.
  - ERR: 55.8%.

Table 5: *Benefits in Road Safety*

KPIs	Slight Injuries/Year				Serious Injuries/Year				Fatalities/Year				Property Damage			
Year	S0	S1	S1-S0	Benefit(€)	S0	S1	S1-S0	Benefit(€)	S0	S1	S1-S0	Benefit(€)	S0	S1	S1-S0	Benefit(€)
2023	28	26	-2	102.746	3	3	0	0	6	6	0	0	781	714	67	265.320
2024	28	25	-2	154.119	3	3	0	0	6	6	0	0	762	675	87	344.520
2025	28	24	-3	205.492	3	3	0	0	6	5	1	2.148.034	743	634	109	431.640
2026	28	23	-4	256.865	3	3	0	0	6	5	1	2.148.034	725	583	142	562.320
2027	28	22	-6	308.238	3	3	0	0	6	5	1	2.148.034	707	534	173	685.080
2028	28	22	-6	308.238	3	3	0	0	6	5	1	2.148.034	690	521	169	669.240
2029	28	22	-6	308.238	3	3	0	0	6	5	1	2.148.034	673	508	165	748.240
2030	28	22	-6	308.238	3	3	0	0	6	5	1	2.148.034	657	496	161	637.560
2031	28	22	-6	308.238	3	3	0	0	6	5	1	2.148.034	641	484	157	621.720
2032	28	22	-6	308.238	3	3	0	0	6	5	1	2.148.034	625	472	153	605.880
SUM	252	214	-44	2.568.650	27	27	0	0 €	54	42	-8	17.184.272	6.379	5.149	1.230	5.571.720
Total Benefits													25.324.642 €			

Table 6: *Costs in Travel Time and Benefits of Fuel Consumption & Environmental Impact*

Year	Travel Time Costs	Fuel Consumtion Benefits	CO_2	NOx	$PM_{2,5}$
2023-2024	-1.947.146 €	2.123.644 €	450.112 €	1.534 €	21 €
2024-2025	-2.107.006 €	2.236.649 €	682.886 €	2.327 €	33 €
2025-2026	-2.870.818 €	2.205.264 €	971.906 €	3.311 €	45 €
2026-2027	-4.085.365 €	2.174.558 €	1.401.543 €	10.011 €	66 €
2027-2028	-5.450.387 €	2.144.447 €	1.902.543 €	13.334 €	86 €
2028-2029	-5.817.198 €	2.669.820 €	2.051.673 €	14.104 €	89 €
2029-2030	-6.208.696 €	3.550.186 €	2.183.441 €	14.825 €	91 €
2030-2031	-6.626.541 €	4.375.006 €	2.326.811 €	15.491 €	92 €
2031-2032	-7.072.507 €	4.311.602 €	2.569.691 €	16.768 €	97 €
2032-2033	-7.548.487 €	4.247.590 €	2.809.002 €	17.956 €	130 €
Total Sum	-49.761.150 €	30.068.766 €	17.349.959 €	109.661 €	749 €

Cost-Benefit Analysis Results (2)

- Monetary value: €25.3 million saved in safety benefits (2023–2032).
- 14.91% increase in travel time = €49.8M socioeconomic cost.
- Strong contribution to the Vision Zero target of zero motorway fatalities by 2030.

			2024	2025	2026	2027	2028	2029	2030	2031	2032
Benefits & Costs	NPV 3.0%	Implementation	Operation								
C1. Investment Costs (€)	-1.388.709	-1.430.370	0	0	0	0	0	0	0	0	0
C1.1 Traffic Detection Units	-349.515	-360.000	0	0	0	0	0	0	0	0	0
C1.2 Road Signs	-12.816	-13.200	0	0	0	0	0	0	0	0	0
C1.3 Study/Planning Costs	-333.175	-343.170	0	0	0	0	0	0	0	0	0
C1.4 Cameras & Software	-576.699	-594.000	0	0	0	0	0	0	0	0	0
C1.5 Bluetooth Readers	-116.505	-120.000	0	0	0	0	0	0	0	0	0
C2. Operating Costs (€)	-7.018.003	-2.152.000	-652.000	-652.000	-652.000	-652.000	-652.000	-652.000	-652.000	-652.000	-652.000
C2.1 Operation & Supervision Costs	-2.132.551	-250.000	-250.000	-250.000	-250.000	-250.000	-250.000	-250.000	-250.000	-250.000	-250.000
C2.2 Annual Maintenance of C1.4 & C1.5	-17.060	-2.000	-2.000	-2.000	-2.000	-2.000	-2.000	-2.000	-2.000	-2.000	-2.000
C2.3 Contingencies	-1.456.311	-1.500.000	0	0	0	0	0	0	0	0	0
C2.4 Media Campaigns	-1.706.041	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000
C2.5 Biennial Effectiveness Assessment of the Measure	-1.706.041	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000	-200.000
Total Investment and Operating Costs	-8.406.712	-3.582.370	-652.000	-652.000	-652.000	-652.000	-652.000	-652.000	-652.000	-652.000	-652.000
Economic Impacts – Benefits (€)											
User surplus_(-)	16.013.121	+149.498	+129.644	665.554	1.910.807	3.305.940	3.117.378	2.658.510	2.251.535	2.760.905	3.300.897
B1. Travel Time (-)	41.049.625	1.974.146	2.107.006	2.870.818	4.085.365	5.450.387	5.817.198	6.208.696	6.626.541	7.072.507	7.548.487
B2. Fuel Consumption	25.036.504	2.123.644	2.236.649	2.205.264	2.174.558	2.144.447	2.699.820	3.550.186	4.375.006	4.311.602	4.247.590
External Impact Benefits	35.362.281	819.740	1.183.885	3.760.428	4.378.839	5.057.657	5.191.378	5.403.068	5.436.226	5.664.548	5.889.240
B3. Road Safety	21.025.420	368.066	498.639	2.785.166	2.967.219	3.141.352	3.125.512	3.204.712	3.093.832	3.077.992	3.062.152
B4. Environment	14.336.862	451.674	685.246	975.262	1.411.620	1.916.305	2.065.866	2.198.356	2.342.394	2.586.556	2.827.088
B4.1 CO_2 Emissions	14.246.829	450.120	682.886	971.906	1.401.543	1.902.885	2.051.673	2.183.441	2.326.811	2.569.691	2.809.002
B4.2 NO_x Emissions	89.416	1.534	2.327	3.311	10.011	13.334	14.104	14.825	15.941	16.768	17.956
B4.3 PM Emissions	617	21	33	45	66	86	89	91	92	97	130
Total Benefits	19.349.161	969.239	1.313.529	3.094.875	2.468.032	1.751.717	2.074.000	2.744.559	3.184.691	2.903.643	2.588.343
ENPV/Net Benefits	10.942.449	-2.613.131	661.529	2.442.875	1.816.032	1.099.717	1.422.000	2.092.559	2.532.691	2.251.643	1.936.343
ERR>	55.8%										
B/C Ratio	2.30										

Discussion

- Drivers perceive time cost as the main drawback of stricter reductions.
- But the benefits are:
  - Safety & sustainability outweigh losses.
  - Net effect still positive & viable.
- Phased implementation recommended:
  - Step 1: Reduction to 120 km/h (higher acceptance).
  - Step 2: Transition to 110 km/h supported by campaigns.
- Public awareness campaigns are crucial:
  - Highlight safety benefits.
  - Show environmental & economic savings.
  - Target groups with low acceptance
- European alignment:
  - Sweden & Finland max = 120 km/h.
  - Greece can follow best practice.

Conclusions

- Reducing speed limits:
  - Improves safety, fuel economy, environment.
  - Economically viable (ENPV > €10M, B/C = 2.30).
- 120 km/h = compromise with broad acceptance.
- 110 km/h = stronger benefits but low acceptance.
- Policy should combine legal changes with awareness campaigns.
- Aligns with Vision Zero 2030 and EU climate goals.

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