The Impact of Narrow Lane on Safety of the Arterial Roads

Hyeonsup Lim

THE UNIVERSITY OF TENNESSEE KNOXVILLE

What do we know about Narrow Lane?

- ***AASHTO Green book,***

  *lane widths may vary from **10 to 12 feet** for rural and urban arterials.*

- ***NCHRP 330** **(Effective Utilization of Street Width on Urban Arterials)***

  *"**Narrower lane widths (less than 11ft) can be used** effectively in urban arteri al street improvement projects where the additional space can be used to relieve traffic congestion or **address specific accident patterns**"…*

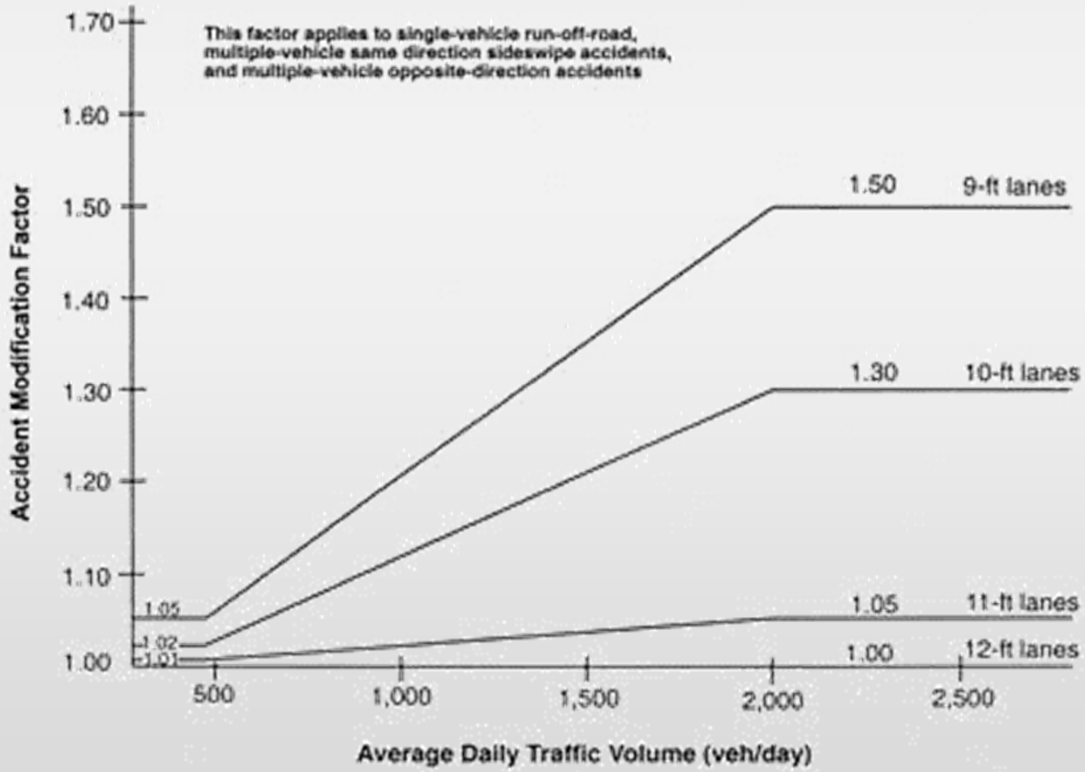
- ***Ingred B. Potts, et al., 2007***

  *"A safety evaluation of lane widths for arterial roadway segments found **no indic ation**, except in limited cases, that **the use of narrower lanes increases crash f requencies**"*

What do we know about Narrow Lane?

- ***Highway Safety Manual***

  "Widening lanes on rural two-lane roads reduces a specific set of related crash types, namely s ingle-vehicle run-off-the-road crashes and multiple-vehicle head-on, opposite-direction sidesw ipe, and same-direction sideswipe collisions."



Negative Binomial

Let x_1 be VMT and y number of crashes

$$log(y) = \alpha + \beta_1 x_1 + \beta_2 x_2$$

If $x_1 = 0$, then

$$\begin{aligned} log(y) &= \alpha + \beta_1 \cdot 0 + \beta_2 x_2 \\ &= \alpha + \beta_2 x_2 \end{aligned}$$

indicates that $y > 0$, unless $\alpha + \beta_2 x_2 = -\infty$

Negative Binomial

What if we use y/x_1 (rate) instead of y (count), where x_1 denotes e xposure?

$$log(y/x_1) = \alpha^* + \beta_2^* x_2$$

This restricts $x_1>0$, which also can be shown below

$$log(y) - log(x_1) = \alpha^* + \beta_2^* x_2$$

$$y = x_1 exp(\alpha^* + \beta_2^* x_2)$$

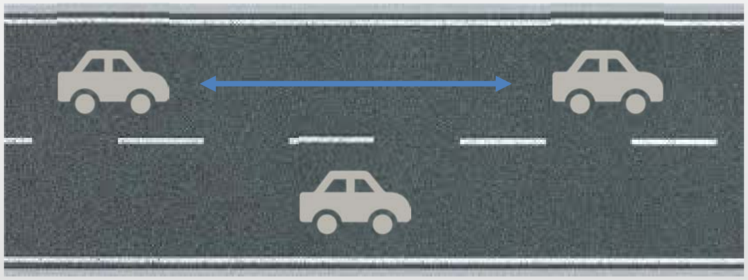
However, the term $-log(x_1)$, which is called an offset, means that y is proportional to x_1 with constant proportionality depending on t he value of the explanatory variable

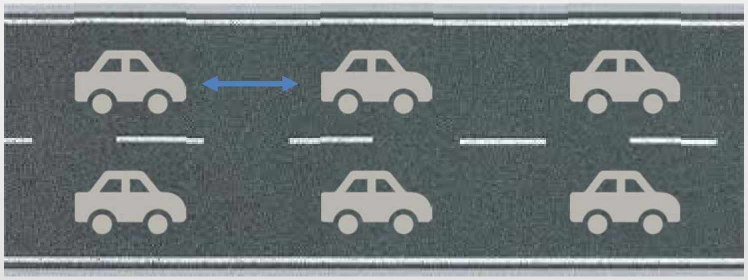
Negative Binomial

To alleviate this issue, use x_1 (or similar variables) both in left and right side.

$$\log(y/x_1) = \alpha^* + (\beta_1^* x_1^*) + \beta_2^* x_2 + \cdots$$

What is this telling us? (expectation)





Descriptive Statistic

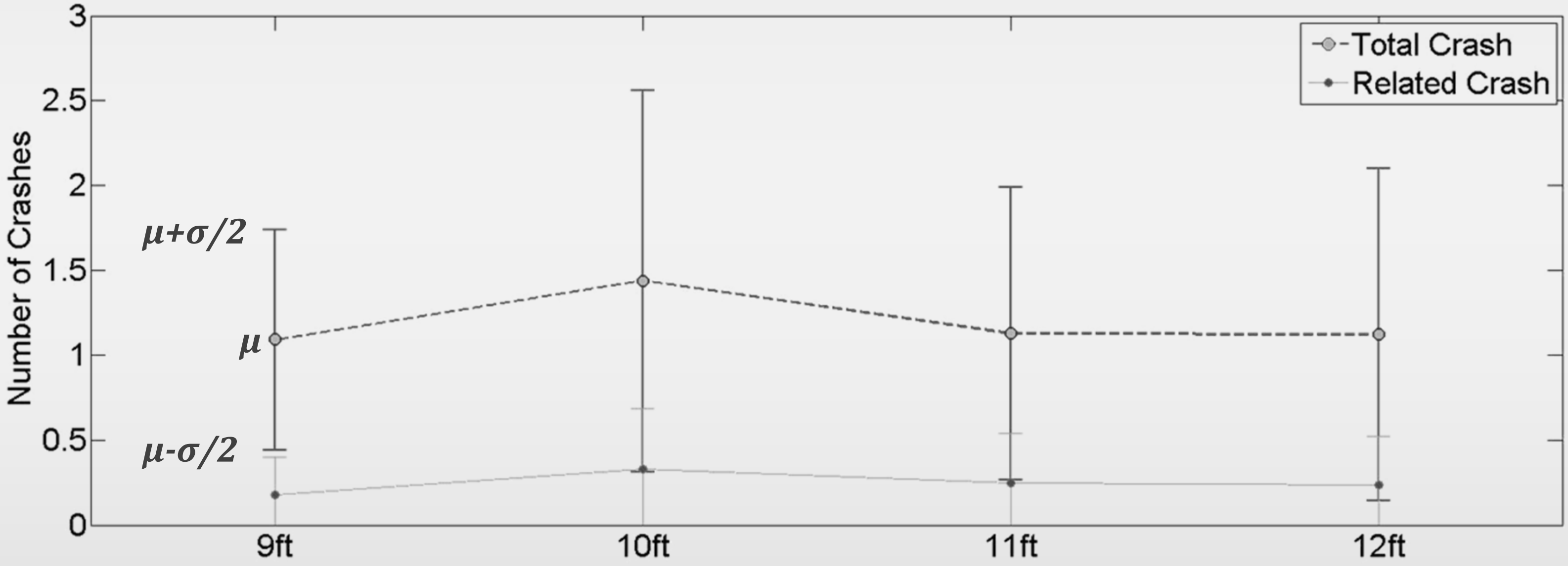
- 4 cities (Grand Island, Lincoln, Omaha, and South Sioux) of Nebraska.
- 1,956 segments for year 2003 to 2012, and total length is 773.4 miles

Variable		N	Mean	Std Dev	Minimum	Maximum
Year		18,227	2007.5	2.9	2003	2012
Total Crash		18,227	1.2	1.9	0	44
Related Crash		18,227	0.3	0.6	0.0	10.0
Lane Width (ft)		18,227	11.3	0.8	9.0	12.0
Speed Limit (mph)		18,227	38.3	6.4	20	60
Number of Lanes		18,227	1.9	0.6	1	6
AADT (veh/lane)		18,227	5348.1	2460.1	100.0	19480.4
Segment Length (miles)		18,227	0.39	0.33	0.02	3.88
Road Classification* (categorical)		18,227	15.5	0.9	14	17
Binary Variable (1=Yes/ 0=No)	One Way	18,227	0.0	0.2	0	1
	Shoulder	18,227	0.3	0.4	0	1
	Median	18,227	0.7	0.4	0	1
	On-Street Parking	18,227	0.1	0.2	0	1
	CBD	18,227	0.1	0.3	0	1

Variable Selection

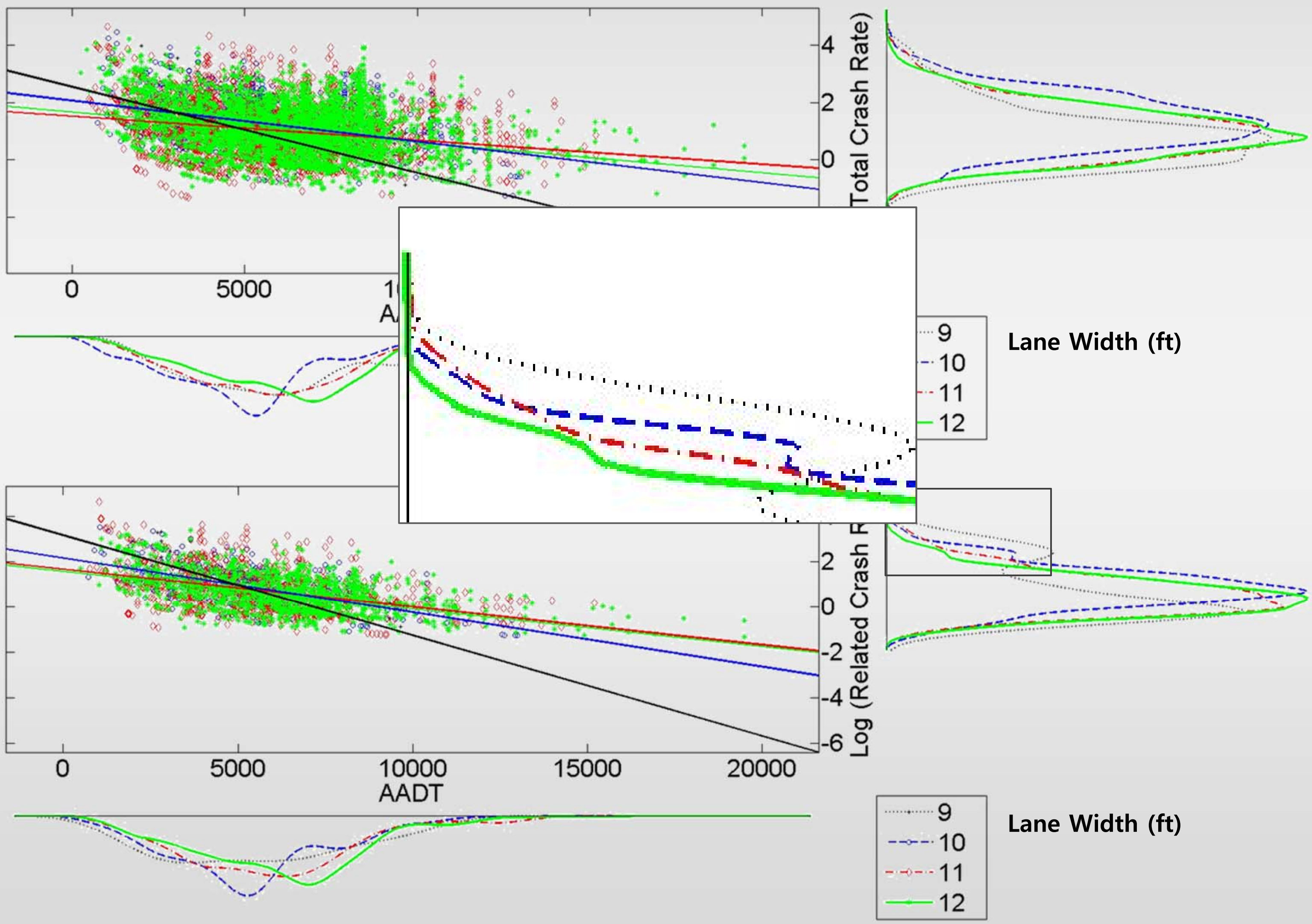
What should be y, x1, x2, …?

For y, Total Crashes vs Crashes with Specific Types



❖ *Related crash type includes head-on and sideswipe collisions (both same and opposite direction)*

Variable Selection



Model Selection

- *Akaike Information Criterion*

		Included Variables													
Model	Number of Parmeters	Year	Speed Limit	Lane Width	No. of Lanes	AADT	Should er	Media n	OnStre etPark ing	CBD	Segme nt Len gth	Road Classif ication	One Way	logL	AIC
1	**10**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**			**-11100.8**	**22,221.5**
2	11	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	-11100	22,222.1
3	11	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		-11100.5	22,222.9
4	12	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-11099.9	22,223.7
5	9	Y	Y	Y	Y	Y	Y	Y	Y		Y			-11104	22,225.9
6	10	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y		-11103.7	22,227.4
7	10	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y		-11103.8	22,227.5
8	9	Y	Y	Y	Y		Y	Y	Y	Y	Y			-11104.8	22,227.6
9	10	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	-11104	22,227.9

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Summary Result 1

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	69.5055	13.8003	42.4575	96.5535	25.37	<.0001
Year	1	-0.0335	0.0069	-0.0469	-0.0200	23.70	<.0001
SpeedLimit	1	-0.0509	0.0045	-0.0597	-0.0421	129.62	<.0001
LaneWidth	1	-0.1363	0.0252	-0.1857	-0.0870	29.31	<.0001
NumberOfLanes	1	0.3437	0.0354	0.2743	0.4132	94.03	<.0001
AADTK	1	-0.0287	0.0091	-0.0464	-0.0109	10.03	0.0015
Shoulder	1	-0.2237	0.0530	-0.3277	-0.1198	17.80	<.0001
Median	1	-0.3624	0.0499	-0.4603	-0.2646	52.71	<.0001
OnStreetParking	1	0.2885	0.0849	0.1221	0.4549	11.55	0.0007
CBD	1	-0.1932	0.0827	-0.3553	-0.0312	5.46	0.0194
SegmentLength	1	-1.3713	0.0974	-1.5621	-1.1805	198.38	<.0001
Dispersion	1	2.8804	0.0987	2.6933	3.0805		

Summary Result 2

Analysis Of Maximum Likelihood Parameter Estimates								
Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept		1	68.0451	13.7994	40.9988	95.0915	24.31	<.0001
Year		1	-0.0335	0.0069	-0.0470	-0.0201	23.82	<.0001
SpeedLimit		1	-0.0508	0.0045	-0.0596	-0.0420	128.05	<.0001
LaneWidth	9	1	0.2833				5.07	0.0243
LaneWidth	10	1	0.2990				26.22	<.0001
LaneWidth	11	1	0.1617				12.67	0.0004
LaneWidth	12	0	0.0000				.	.
NumberOfLanes		1	0.3378	0.0358	0.2677	0.4079	89.18	<.0001
AADTK		1	-0.0284	0.0091	-0.0461	-0.0106	9.84	0.0017
Shoulder		1	-0.2184	0.0532	-0.3228	-0.1141	16.84	<.0001
Median		1	-0.3569	0.0502	-0.4553	-0.2586	50.62	<.0001
OnStreetParking		1	0.2938	0.0853	0.1266	0.4609	11.86	0.0006
CBD		1	-0.1823	0.0837	-0.3464	-0.0182	4.74	0.0294
SegmentLength		1	-1.3721	0.0974	-1.5629	-1.1813	198.63	<.0001
Dispersion		1	2.8820	0.0987	2.6949	3.0821		

Compared to 12ft lane…

CMF_{9ft} = exp(0.2833) = 1.33
CMF_{10ft} = exp(0.2990) = 1.35
CMF_{11ft} = exp(0.1617) = 1.18

Final Model

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	0.8851	0.1552	0.5809	1.1893	32.53	<.0001
Year_2003	1	-0.0339	0.0069	-0.0473	-0.0204	24.3	<.0001
SpeedLimit	1	-0.0481	0.0043	-0.0566	-0.0397	124.83	<.0001
NumberOfLanes	1	0.3192	0.0347	0.2512	0.3873	84.58	<.0001
AADTK*LaneWidth (11 or 12 ft)	1	-0.0372					
AADTK*LaneWidth (9 or 10 ft)	1	0.0263					
Shoulder*LaneWidth (11 or 12 ft)	1	-0.1686					
Shoulder*LaneWidth (9 or 10 ft)	1	-0.5252					
Median	1	-0.3849	0.0499	-0.4827	-0.2871	59.5	<.0001
OnStreetP*LaneWidth (11 or 12 ft)	1	0.2131					
OnStreetP*LaneWidth (9 or 10ft)	1	0.2989					
SegmentLength	1	-1.3371	0.0964	-1.526	-1.1483	192.54	<.0001
Dispersion	1	2.8866	0.0987	2.6995	3.0867		

As AADT increases, so does the impact of Lane Width. As AADT increases, the narrow lane increases the rela ted crash rate while the wide lane reduces it

-40% by shoulder where the lane width is 9 or 10 ft, while -16% where the lane width is 11 or 12 ft.

+35% by on-streetP where the lane width is 9 or 10 ft, while +24% where the lane width is 11 or 12 ft.

Conclusion & Limitation

- *The narrow lane does not necessarily always increase(or decrease) crashes*
- *Carefully consider the implementation of narrowing lanes depending on AADT, and presence of shoulder and on-street parking*
  (e.g., we might consider the narrow lane primarily on the roadway where AADT is not too high, and there is shoulder, but on-street parking)
- *Difficult to provide a general conclusion*
- *Model is sensitive to variable selection*
- *Finding inherent impact of narrowing lane might be very important*

A Property of Harmonic Mean:

A Property of SMS that You Should Consider

Hyeonsup Lim

THE UNIVERSITY OF
TENNESSEE
KNOXVILLE

Quiz

- *Suppose that we have a data set…*

  1, 2, 3, … 18, 19, 20

- *(A) Calculate the harmonic mean of population*
- *(B) Now, you pick three of them, calculate again*
- *Choose the best answer from the followings:*

  1) E(A) >E(B), 2) E(A)<E(B), 3) E(A)=E(B)

Hint

- *Example of (A) and (B)*

$$(\boldsymbol{A}) = \frac{\mathbf{20}}{\frac{\mathbf{1}}{\mathbf{1}}+\frac{\mathbf{1}}{\mathbf{2}}+\frac{\mathbf{1}}{\mathbf{3}}+\cdots+\frac{\mathbf{1}}{\mathbf{19}}+\frac{\mathbf{1}}{\mathbf{20}}} = \mathbf{5.56}$$

$$(\boldsymbol{B}) = \frac{\mathbf{3}}{\frac{\mathbf{1}}{\mathbf{1}}+\frac{\mathbf{1}}{\mathbf{11}}+\frac{\mathbf{1}}{\mathbf{20}}} = \mathbf{2.63}$$

- *There are* $_{20}C_3$=***1,140*** *cases of (B).*

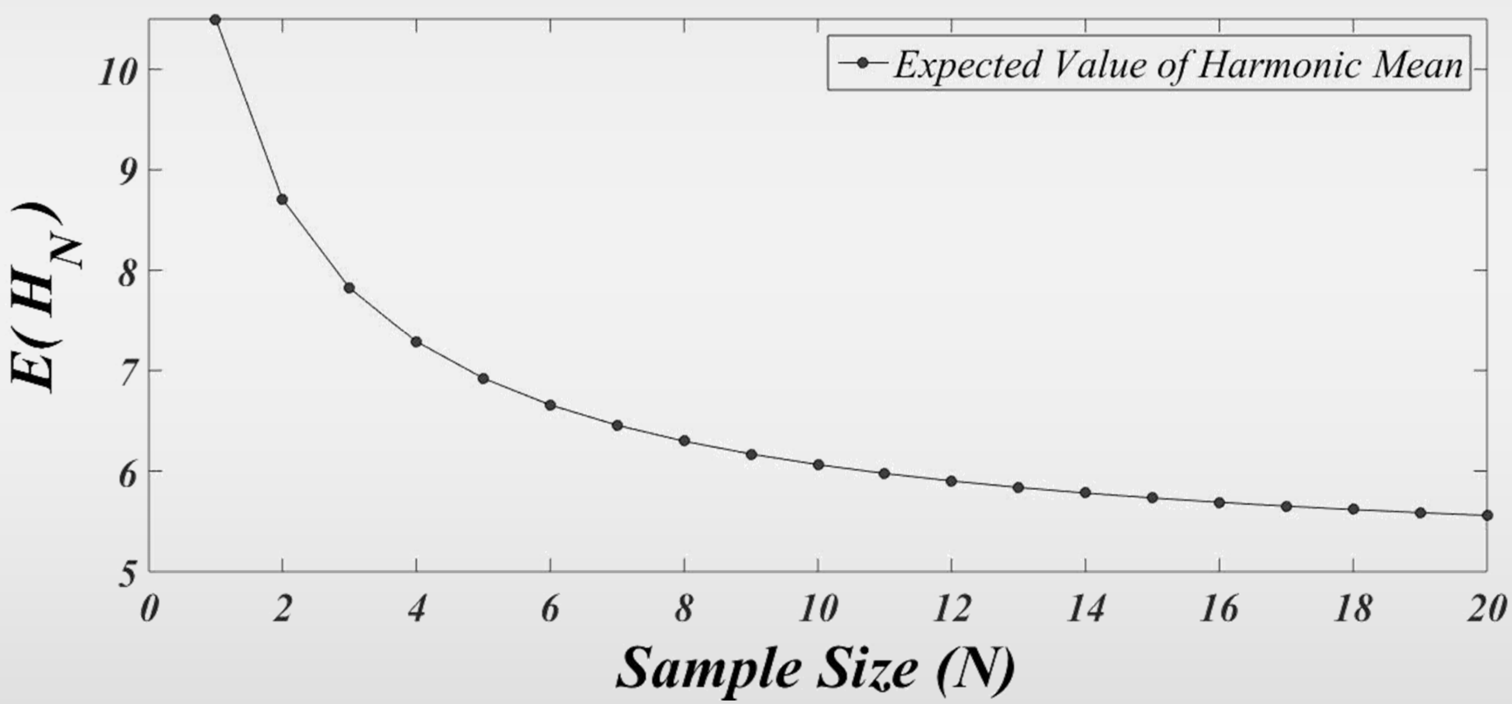
Answer

- $E(A) = 5.56$

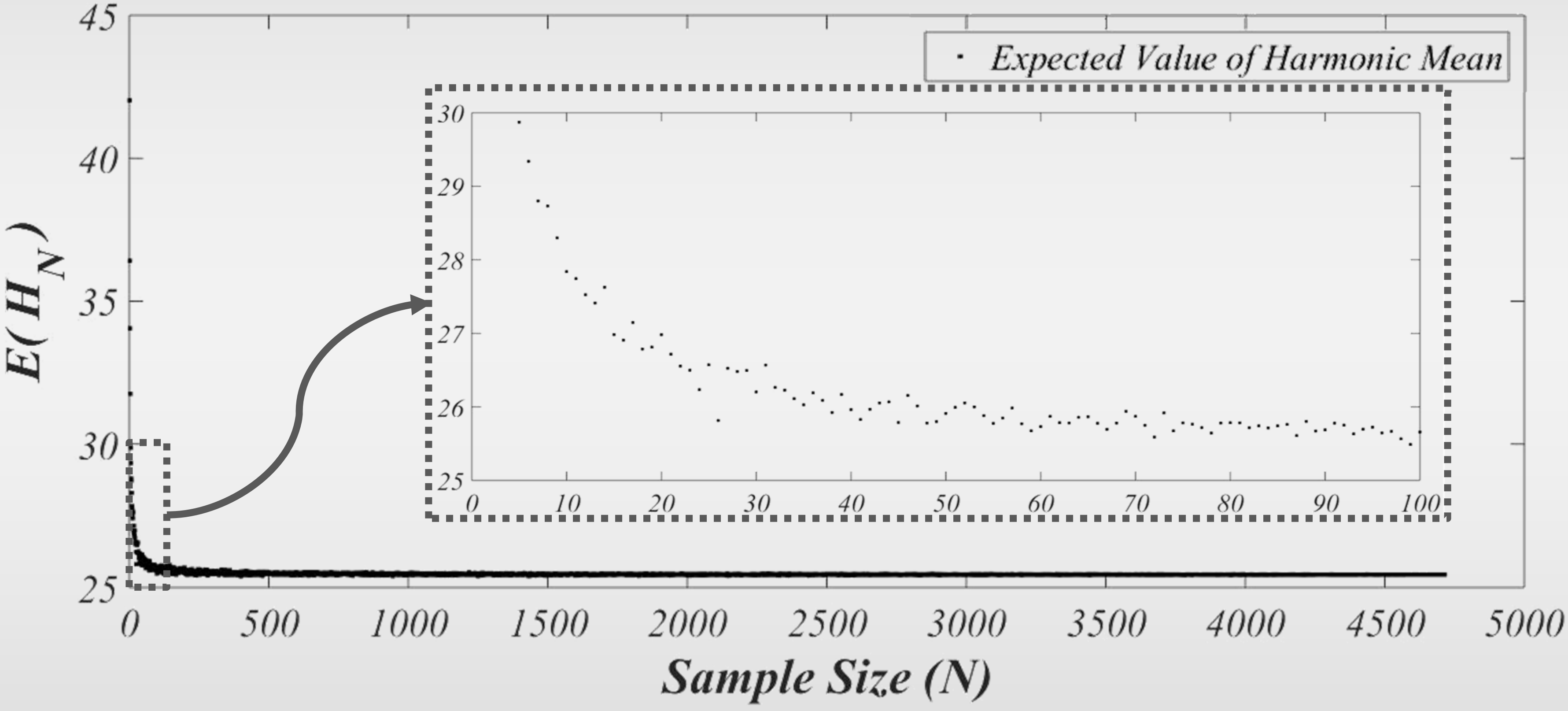
- $E(B) = \frac{\frac{3}{\frac{1}{1}+\frac{1}{2}+\frac{1}{3}}+\frac{3}{\frac{1}{1}+\frac{1}{2}+\frac{1}{4}}+\cdots+\frac{3}{\frac{1}{18}+\frac{1}{19}+\frac{1}{20}}}{1{,}140} = 7.82$

- 1) $E(A) > E(B)$, **2) $E(A) < E(B)$**, 3) $E(A) = E(B)$

Here are more



Simulation using a field data



Why?

$x_1 \quad x_2 \quad x_3 \quad x_4 \quad x_5 \quad x_6 \quad x_7 \quad x_8$ $\cdots E(H_1)$

$H_{2a} \leq A_{\{x_1,x_2\}} \quad H_{2b} \leq A_{\{x_3,x_4\}} \quad H_{2c} \leq A_{\{x_5,x_6\}} \quad H_{2d} \leq A_{\{x_7,x_8\}}$ $\cdots E(H_2) \leq E(H_1)$

$H_{4a} \leq A_{\{H_{2a},H_{2b}\}} \quad H_{4b} \leq A_{\{H_{2c},H_{2d}\}}$ $\cdots E(H_4) \leq E(H_2)$

$H_{8a} \leq A_{\{H_{4a},H_{4b}\}}$ $\cdots E(H_8) \leq E(H_4)$

$\cdots\cdots$ $E(H_m) \leq E(H_n), if\ m \geq n$

$$H_{2a} = \frac{2}{\frac{1}{x_1} + \frac{1}{x_2}}, \qquad H_{2b} = \frac{2}{\frac{1}{x_3} + \frac{1}{x_4}}$$

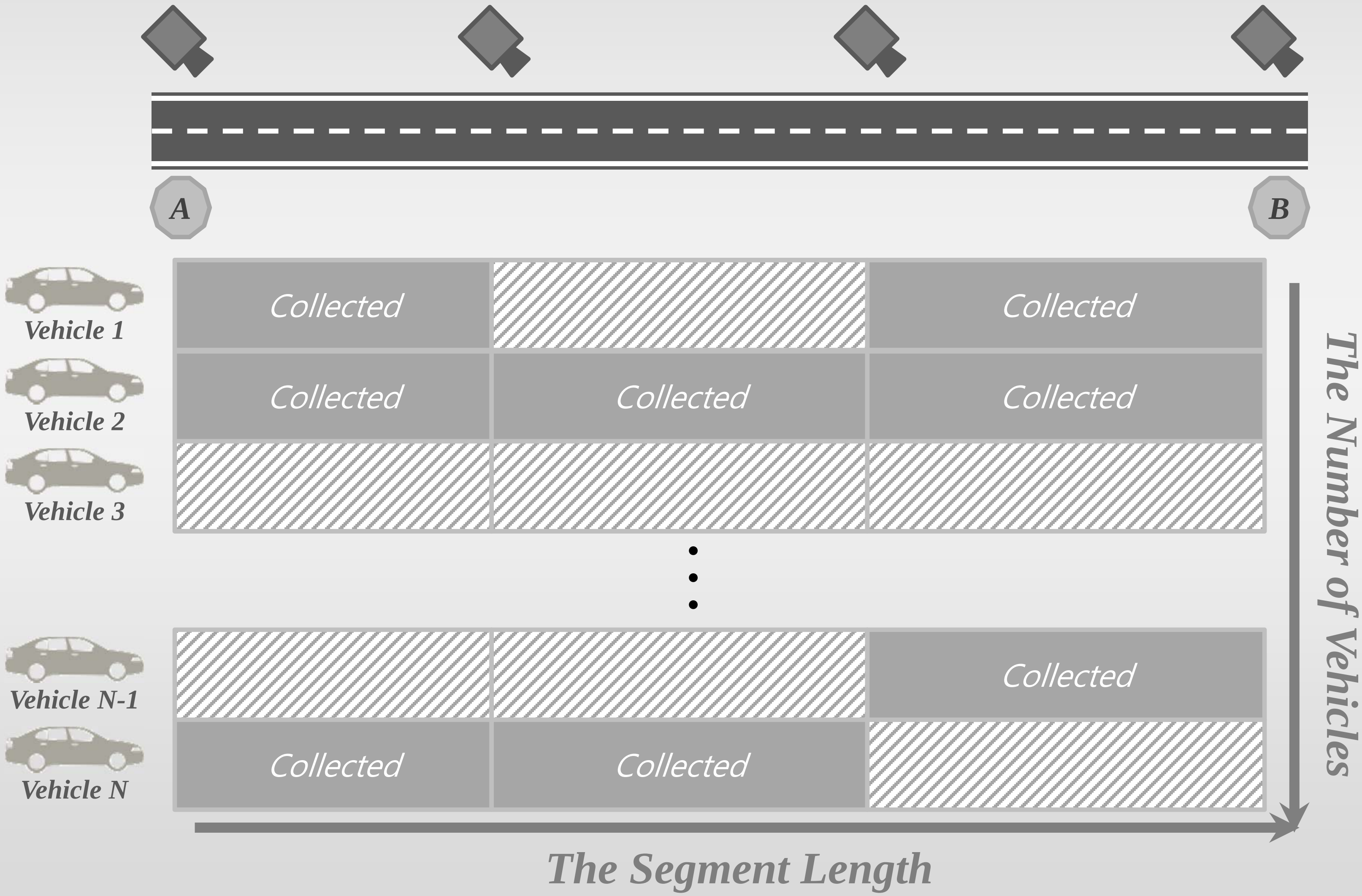
$$H_{4a} = \frac{4}{\frac{1}{x_1} + \frac{1}{x_2} + \frac{1}{x_3} + \frac{1}{x_4}} = \frac{2}{\frac{1}{H_{2a}} + \frac{1}{H_{2b}}}$$

What does it mean?

- *It means that we overestimate SMS of population, when we have a data set which of sample size is smaller than the entire population.*

$$\boldsymbol{E(H_m) \geq E(H_n), if\ m \leq n}$$

Why is it so important?



What do we need to do?

- *This study **only identifies** that the expected valu e of SMS is related to sample size.*
- *It remains the following questions:*
  - ✓ *How much different?*
  - ✓ *Relationship with a variation of data?*
  - ✓ *If so, can we estimate SMS for any sample size?*

Thank you

hlim4@vols.utk.edu

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