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Laboratoire d'Economie des Transports
Unité Mixte de Recherche du CNRS n° 5593
Université Lumière Lyon 2 - ENTPE

Development of Performance-based Pay Adjustment Factors

(in Texas, USA)

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ECTRI
European Conference of Transport Research Institutes

FERSI
Road Safety Research

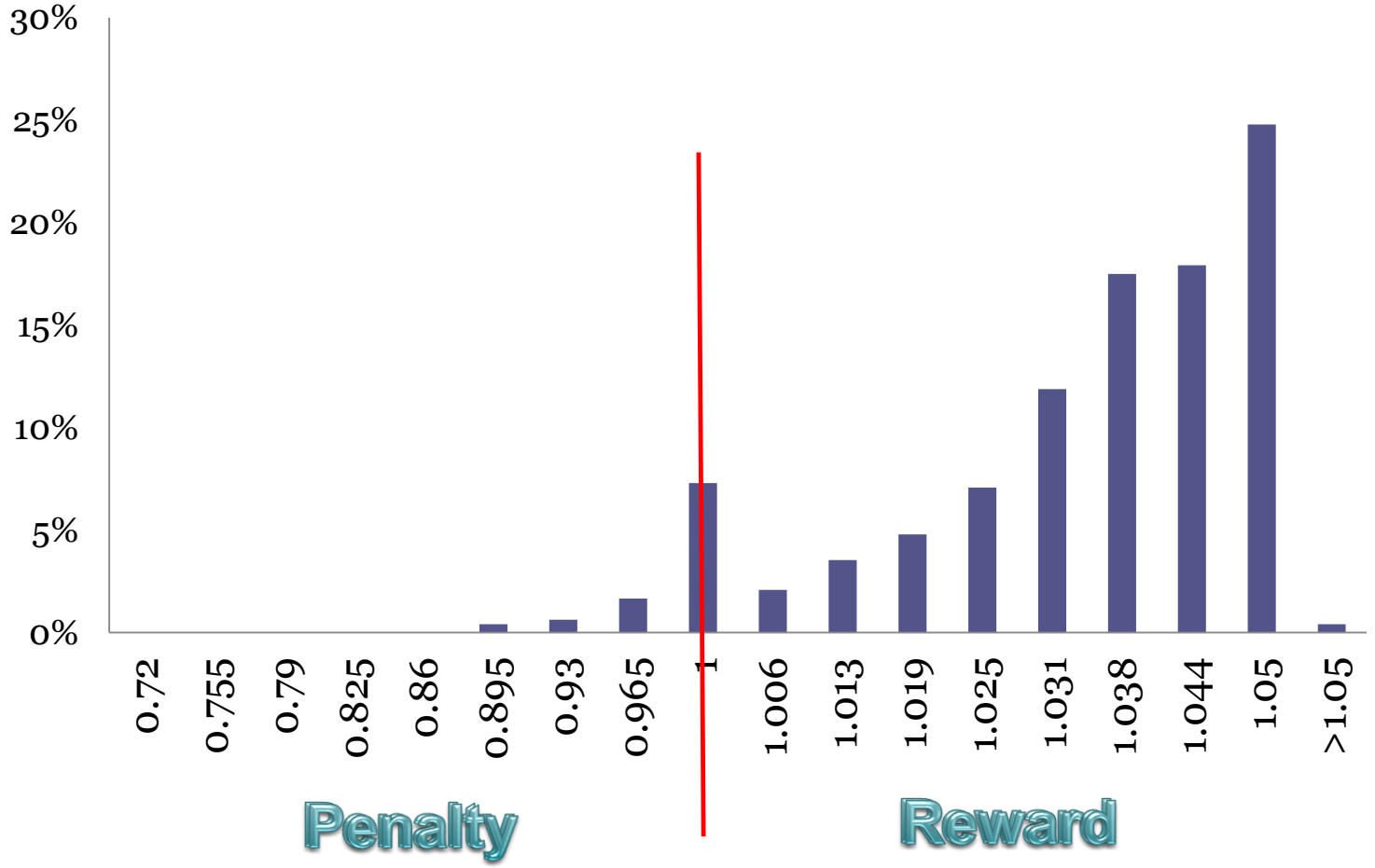
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Introduction

- Texas DOT Pay Adjustment Factor
  - Production (HMA pavements)
  - Placement (HMA Pavements)
  - Ride Quality (HMA and Concrete pavements)
- Developed based on offset to the average contractors' performance
- Improved quality control with the advent of modern equipment
- Skewed PAFs (mostly rewarding)
  - PAF shall be financially justifiable

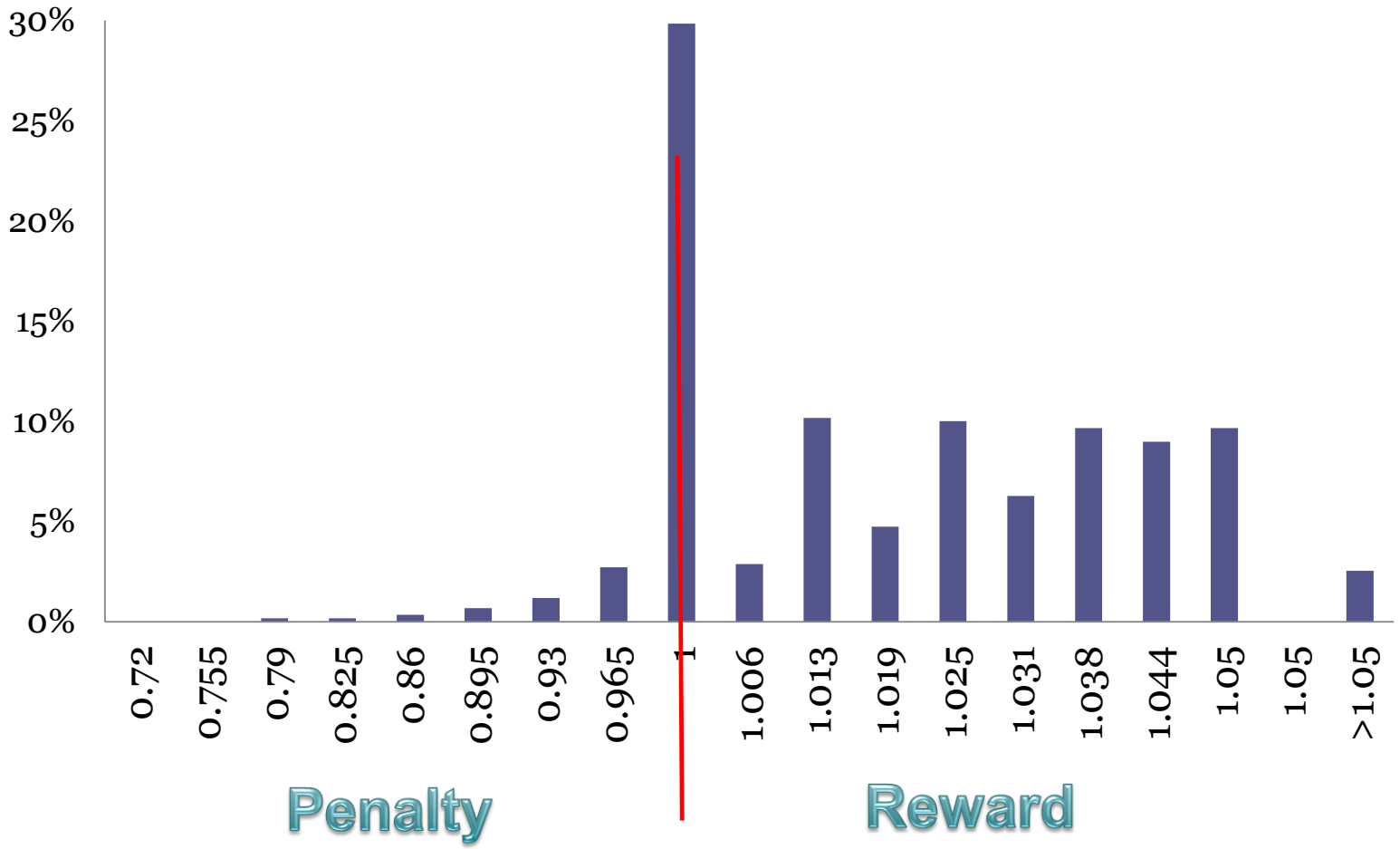
Production


30%
25%
20%
15%
10%
5%
0%
0.72
0.755
0.79
0.825
0.86
0.895
0.93
0.965
1
1.006
1.013
1.019
1.025
1.031
1.038
1.044
1.05
>1.05
Penalty
Reward

Production

Absolute Deviation from Target Laboratory-Molded Density	Production Pay Adjustment Factor
0.0	1.050
0.1	1.050
0.2	1.050
0.3	1.044
0.4	1.038
0.5	1.031
0.6	1.025
0.7	1.019
0.8	1.013
0.9	1.006
1.0	1.000
1.1	0.965
1.2	0.930
1.3	0.895
1.4	0.860
1.5	0.825
1.6	0.790
1.7	0.755
1.8	0.720
> 1.8	Remove and replace

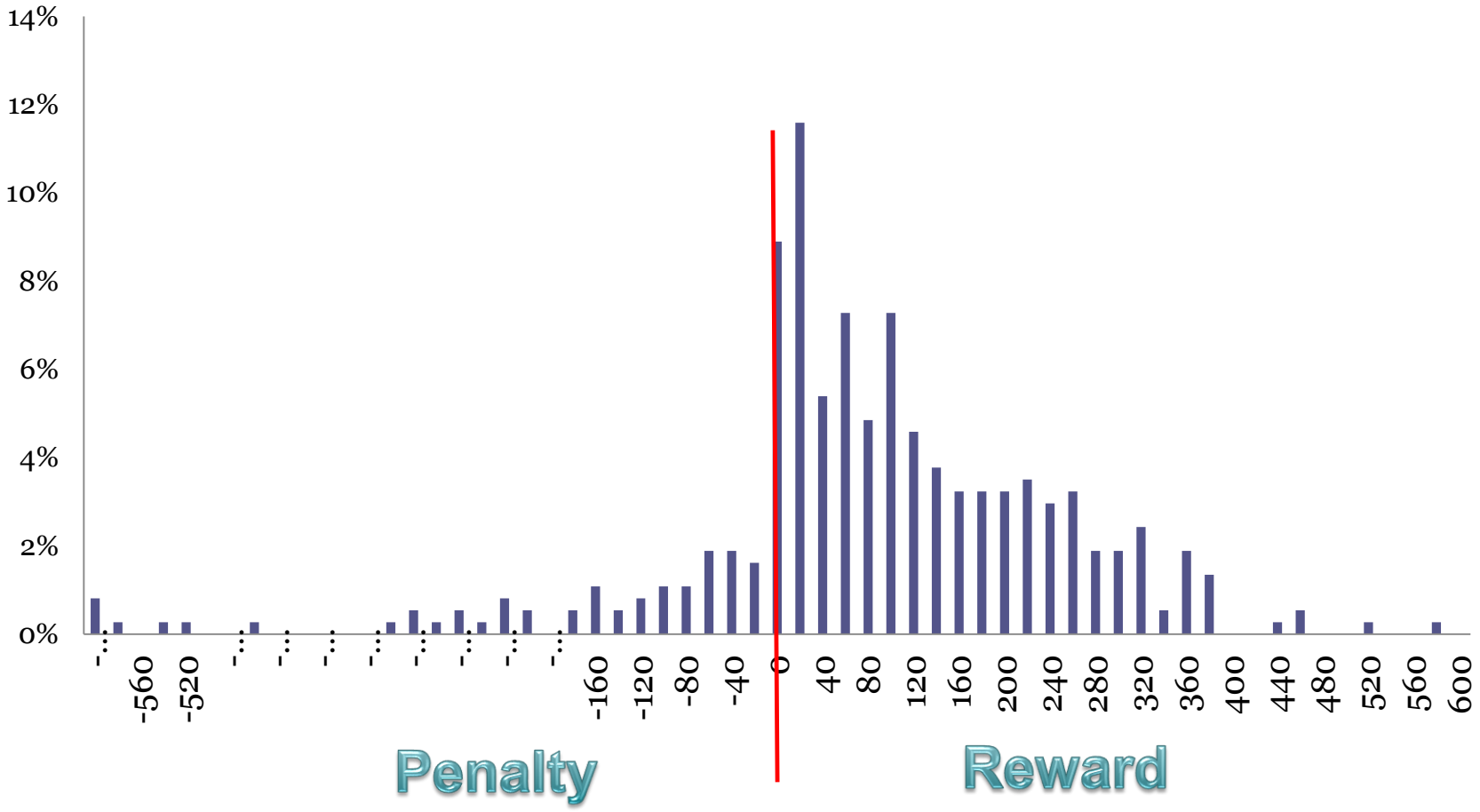
Placement


30%
25%
20%
15%
10%
5%
0%
0.72
0.755
0.79
0.825
0.86
0.895
0.93
0.965
1
1.006
1.013
1.019
1.025
1.031
1.038
1.044
1.05
1.05
>1.05
Penalty
Reward

Placement

In-Place Air Voids	Placement Pay Adjustment Factor	In-Place Air Voids	Placement Pay Adjustment Factor
< 2.7	Remove and Replace	6.4	1.042
2.7	0.705	6.5	1.040
2.8	0.720	6.6	1.038
2.9	0.735	6.7	1.036
3.0	0.750	6.8	1.034
3.1	0.765	6.9	1.032
3.2	0.780	7.0	1.030
3.3	0.795	7.1	1.028
3.4	0.810	7.2	1.026
3.5	0.825	7.3	1.024
3.6	0.840	7.4	1.022
3.7	0.855	7.5	1.020
3.8	0.870	7.6	1.018
3.9	0.885	7.7	1.016
4.0	0.900	7.8	1.014
4.1	0.915	7.9	1.012
4.2	0.930	8.0	1.010
4.3	0.945	8.1	1.008
4.4	0.960	8.2	1.006
4.5	0.975	8.3	1.004
4.6	0.990	8.4	1.002
4.7	1.005	8.5	1.000
4.8	1.020	8.6	0.998
4.9	1.035	8.7	0.996
5.0	1.050	8.8	0.994
5.1	1.050	8.9	0.992
5.2	1.050	9.0	0.990
5.3	1.050	9.1	0.960
5.4	1.050	9.2	0.930
5.5	1.050	9.3	0.900
5.6	1.050	9.4	0.870
5.7	1.050	9.5	0.840
5.8	1.050	9.6	0.810
5.9	1.050	9.7	0.780
6.0	1.050	9.8	0.750
6.1	1.048	9.9	0.720
6.2	1.046	> 9.9	Remove and Replace
6.3	1.044		

Smoothness


14%
12%
10%
8%
6%
4%
2%
0%
-...
-560
-520
-...
-...
-...
-...
-...
-...
-...
-...
-160
-120
-80
-40
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
Penalty
Reward

Smoothness

Average IRI for each 0.10 mi. of Traffic Lane (in. / mi.)	Pay Adjustment $/0.10 mi. of Traffic Lane		
	Schedule 1	Schedule 2	Schedule 3
< 30	600	600	300
30	600	600	300
31	580	580	290
32	560	560	280
33	540	540	270
34	520	520	260
35	500	500	250
36	480	480	240
37	460	460	230
38	440	440	220
39	420	420	210
40	400	400	200
41	380	380	190
63	0	0	0
64	0	0	0
65	0	0	0
66	–20	0	0
67	–40	0	0
68	–60	0	0
69	–80	0	0
70	–100	0	0
71	–120	0	0
72	–140	0	0
73	–160	0	0
74	–180	0	0
75	–200	0	0
76	–220	–20	0
77	–240	–40	0
78	–260	–60	0
79	–280	–80	0

Main Objectives

- Investigating the empirical relationship

  Quality control parameters ⟺ pavement performance

- Identification of performance sensitive measurable QC/QA parameters

Methodology

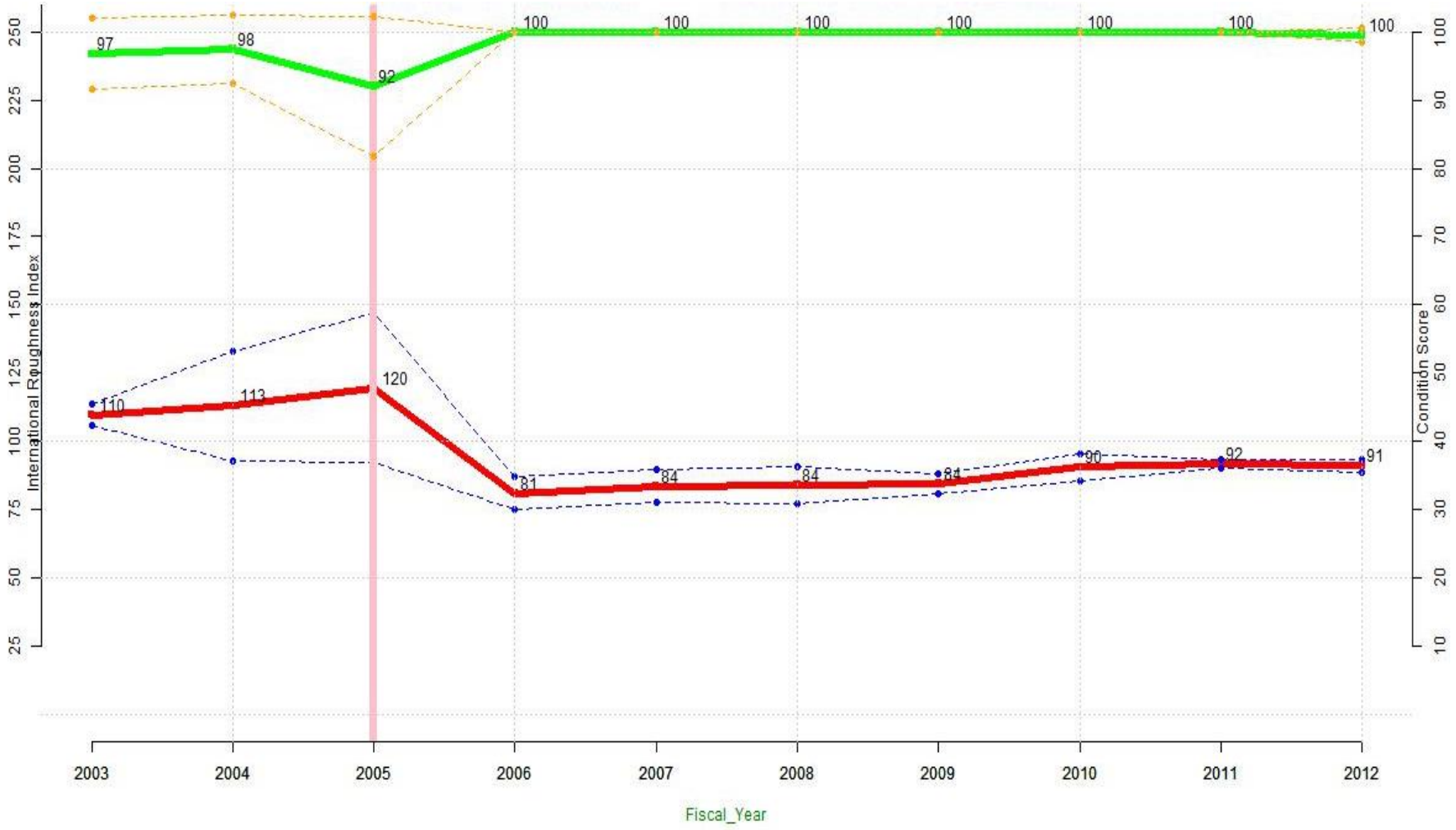
- Gathering data on
  - Pavement performance
  - As-constructed quality

- Three year performance criterion
- Aggregating Quality control data at project level

- Econometric models for building relationships
- Sensitivity analysis

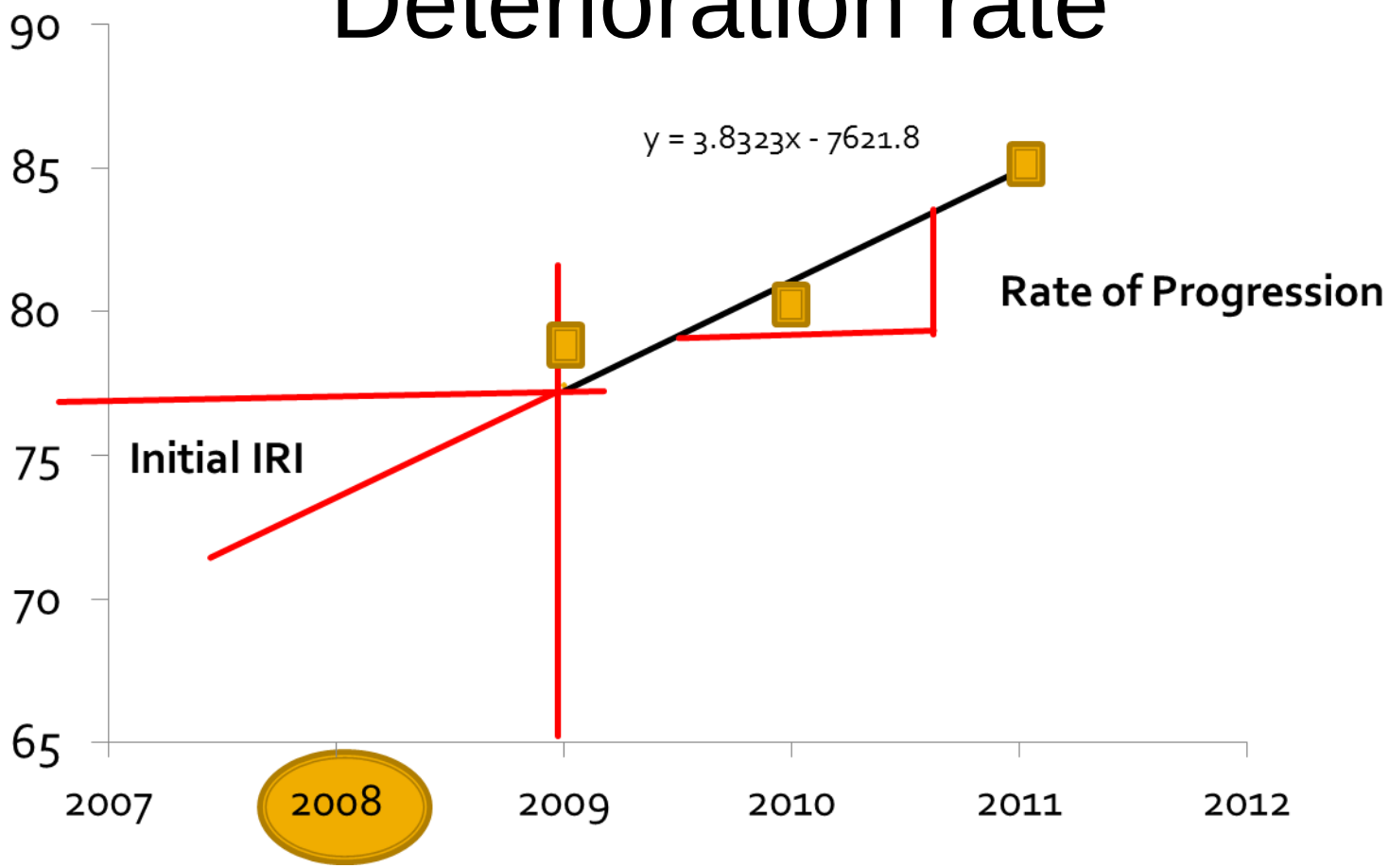
Pavement performance

- Focus on early failures
  - Performance during first three years
  - Attributable to the as-constructed quality
- Not a deterioration model
- Performance measures
  - Deterioration rate (IRI) (Left censored)
  - Rutting (Binary indicator)
  - Cracking (Binary Indicator)



Development of
Performance-based Pay Adjustment Factors

Deterioration rate



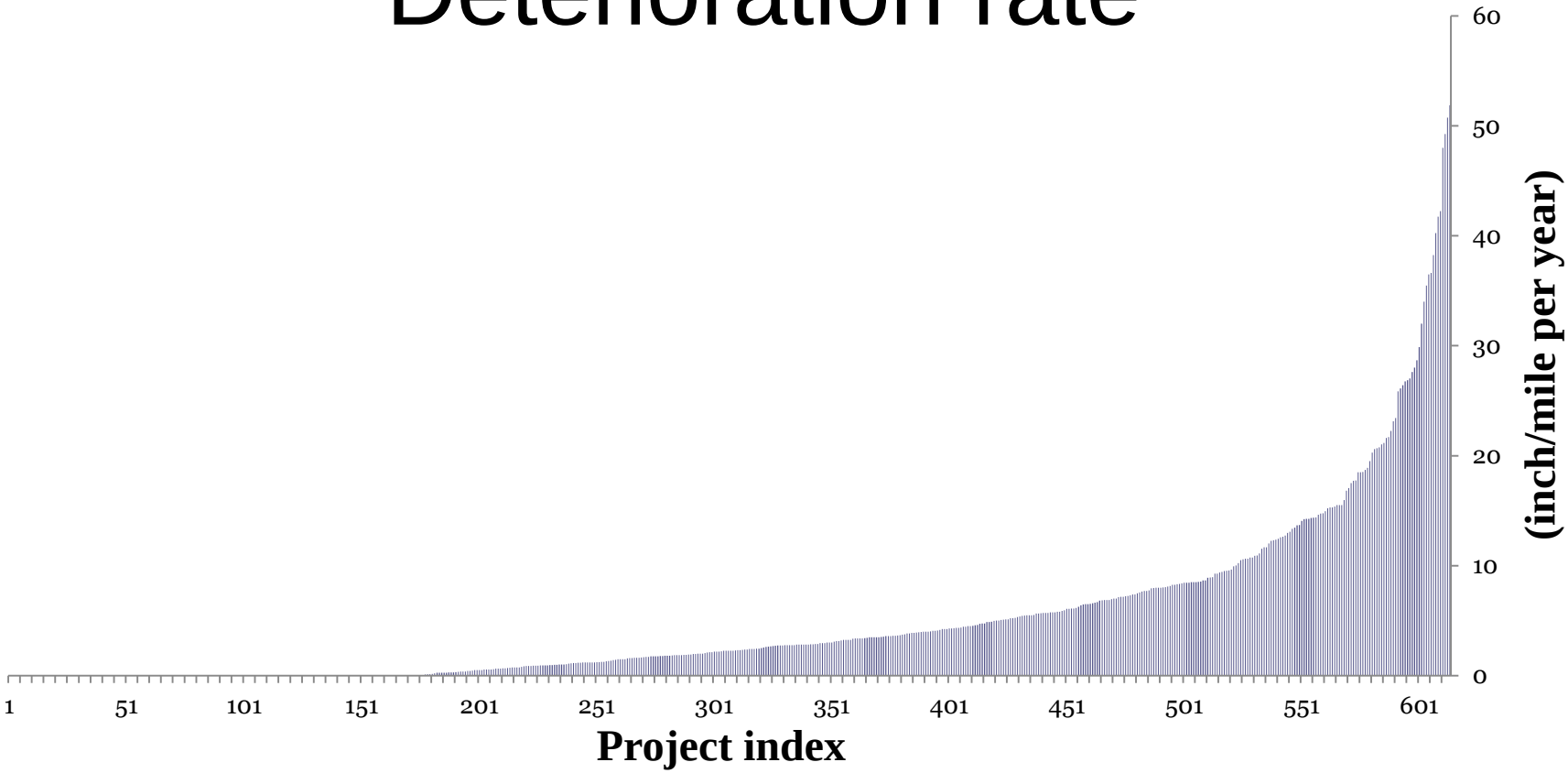
Deterioration rate

- Data quality control
  - Manually filtered “noisy” performance trends

- Estimated the deterioration rate and initial ride quality
  - Linear model assumption (realistic !!)

- Future deterioration rate is irrelevant to the analysis

Deterioration rate



Dependent variables

- Deterioration rate has lot of zeros
  - Categorical (0 or some value)
- Rutting is categorical (0 or 1)
- Cracking is categorical (0 or 1)

Model Structures

- Tobit model (with endogeneity)
  - Deterioration rate (IRI) – (0 or some value)

Deterioration rate

$$y_i = \begin{cases} y_i^* \ \ if \ \ y_i^* > 0 \\ 0 \ \ \ if \ \ y_i^* \leq 0 \end{cases}$$

Initial IRI

$$y_i^* = y_{2i}\alpha_1 + X_{1i}\beta_1 + \varepsilon_i$$

$$y_{2i} = X_{2i}\beta_2 + \delta_i$$

Note: Estimated using STATA (2-stage Least squares)

Model Structures

- Binary probit model (with random coefficients)
  - Rutting (0 or 1)
  - Cracking (0 or 1)

$$y_i = \begin{cases} 1 & if \quad y_i^* > 0 \\ 0 & if \quad y_i^* \leq 0 \end{cases}$$

$$y_i^* = X_i \beta_i + \varepsilon$$

$$\varepsilon \sim N(0,1)$$

$$\beta_{ik} \sim N(\beta_k, \delta_k)$$

Random parameter

Note: Estimated using Maximum Simulated likelihood using Halton draws

Estimation Results

Model : Deterioration rate with endogeneity	Estimate	St.dev	Z-score	P-Value
constant	-16.967	9.001	-1.88	0.059
Indicator variable: IH facility	-5.031	2.316	-2.17	0.030
Right shoulder width	0.454	0.214	2.12	0.034
Ride after construction (IRI in inch/mile)	0.222	0.106	2.10	0.036

Note:
1. Initial_IRI was modeled as endogenous covariate.
2. Plant-mix volumetric parameters are used as instruments.

Estimation Results

Model : Rutting indicator	Estimate	Stdev	Z_score	P_Value
constant	1.057	0.074	14.255	0
Length of the project	0.081	0.022	3.749	0
Current 18-Kip measured average	-0.085	0.033	-2.562	0.011
Indicator Variable: Wet-Warm Weather	-0.713	0.139	-5.125	0
Constructed before 2005	-1.099	0.148	-7.409	0
Speed Limit	0.291	0.086	3.389	0.001
Indicator Variable: Rural	-0.355	0.145	-2.452	0.015
Laboratory VFA: Mean	0.318	0.166	1.917	0.056
Laboratory VFA: St.dev	-0.002	0.16	-0.015	0.988

Estimation Results

Model : Transverse cracking indicator	Estimate	Stdev	Z_score	P_Value
constant	0.103	0.054	1.908	0.057
Length of the project	0.063	0.015	4.077	0
Indicator Variable: Dry-Warm Weather	0.328	0.139	2.368	0.018
Indicator Variable: Wet-Warm Weather	0.36	0.128	2.817	0.005
Indicator Variable: FM facility	-0.647	0.126	-5.15	0
Truck AADT percentage	0.163	0.061	2.654	0.008
Indicator Variable: Rural	-0.351	0.12	-2.936	0.003
Ride after construction (IRI in inch/mile) : Mean	0.064	0.023	2.733	0.006
Ride after construction (IRI in inch/mile) : St.Dev	0	0.022	-0.005	0.996

Conclusions

- Current PAF system does not guarantee performance
- Room for tightening current PAF criteria
  - Vast majority receiving bonus
- Both roughness and cracking models highlight the importance of controlling initial roughness.
- Rutting model indicates that performance related volumetric property to be controlled is Voids Filled with Asphalt (VFA)
  - Need to control two field variables (e.g. VMA and VFA)

Thank you !

THE UNIVERSITY OF TEXAS AT AUSTIN

