Ranking Routes in Semiconductor Wafer Fabs

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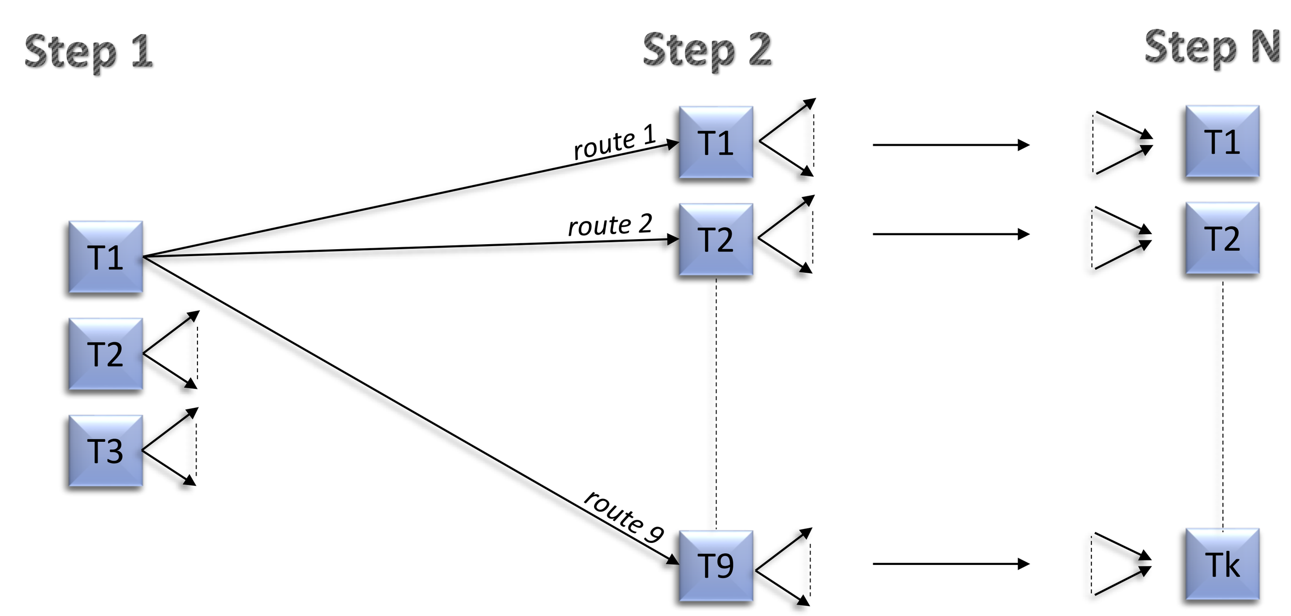
INTRODUCTION

- Routes are comprised of a series of tools inside the fab.



- Defect data represents the number of defects of each type for the various routes

Step 1	Step 2	...	Step N	Route	Def 1	Def 2	Def 3	Def 4	Total
					Counts / Positive Numbers / Positive Integers				
$T_{1,1}$	$T_{2,1}$	...	$T_{N,3}$	route 1	2	0	0	2	4
$T_{1,2}$	$T_{2,4}$	...	$T_{N,3}$	route 2	0	0	0	0	0
$T_{1,3}$	$T_{2,1}$		$T_{N,7}$	route 3	0	4	53	2	59
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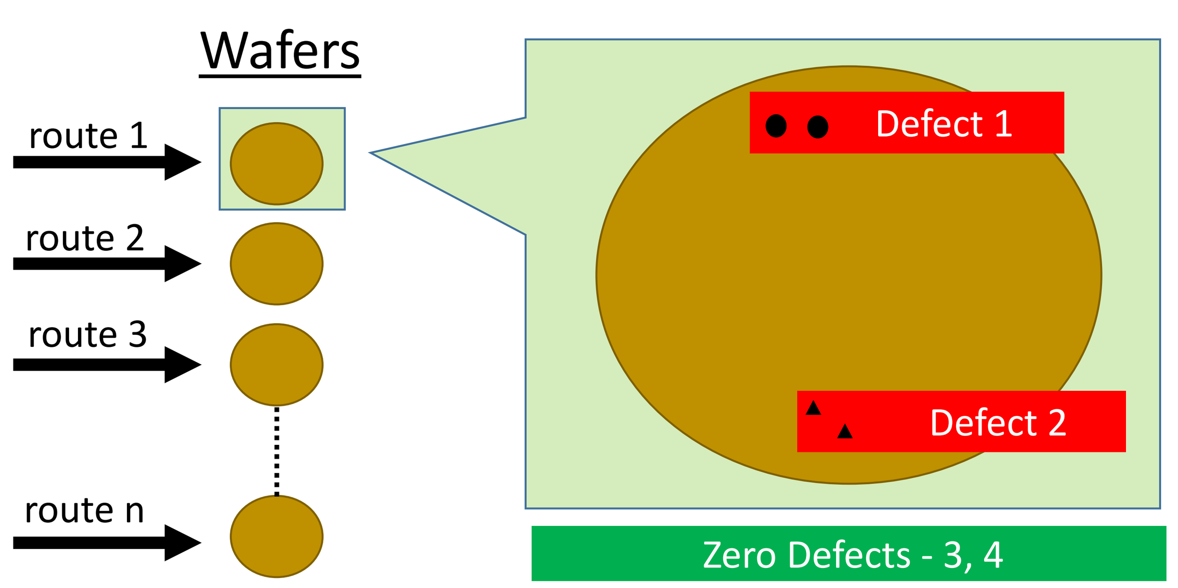


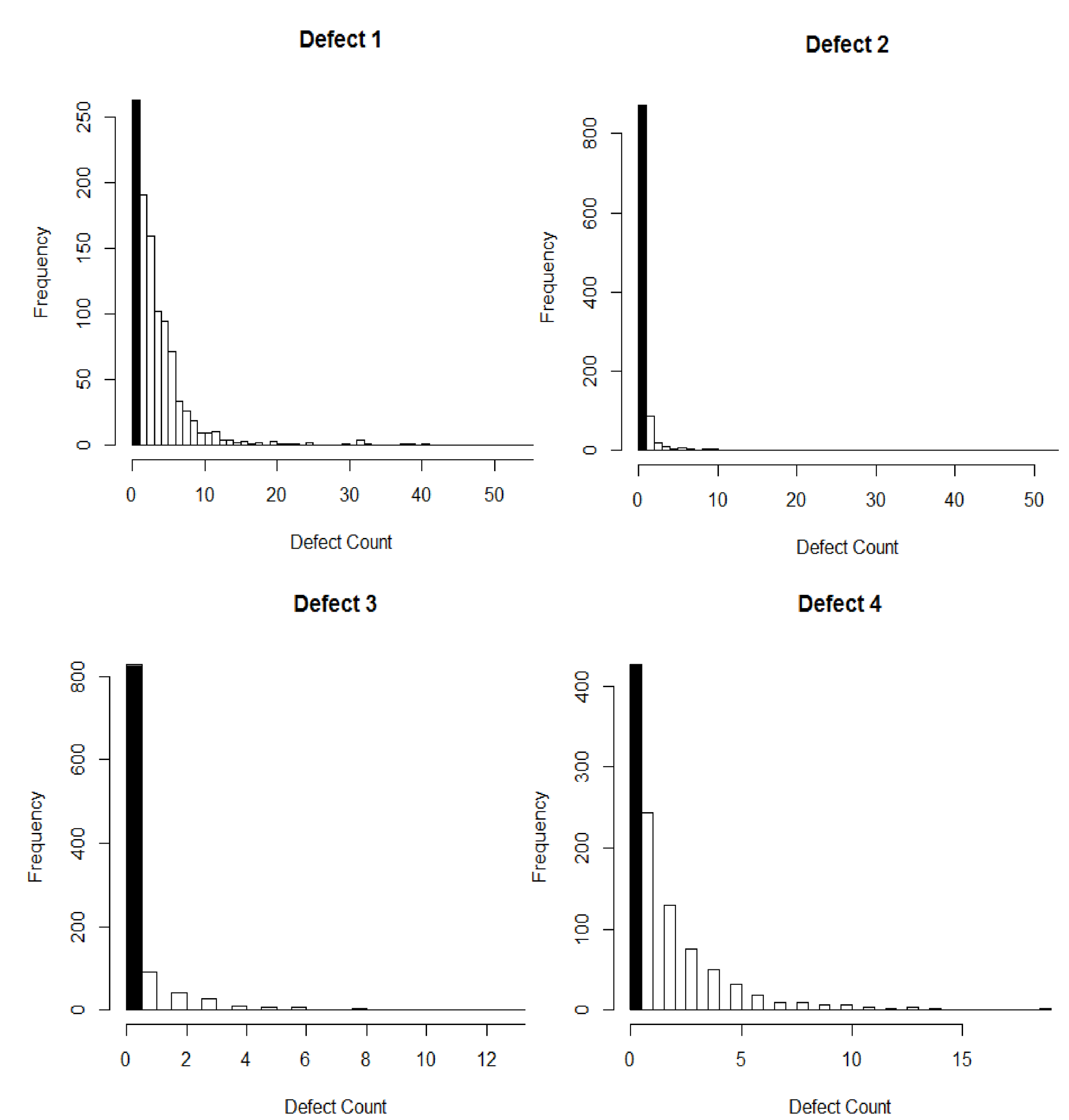
APPLICATIONS

- Exploratory adjustments on the best route (new recipes, or parameters, are tested on the best routes)
- Potential use in scheduling

CHALLENGES

Data Summary

- 2 months of data
- 4 defect types
- 11 steps
- 5 to 15 tools within each step
- 14 billion possible routes
- 652 routes represented
- 85-97% zero defect counts



OBJECTIVES

Build a statistically based heuristic that can:

i. Efficiently ranks 14 billion routes using only 652 sample routes.
ii. Model count data sets that are highly overdispersed due to excess zeros.

METHODOLOGY

COUNT REGRESSION

- n - number of tools
- X_{jl} - dummy variable for l^{th} tool of j^{th} step:

$$X_{jl} = \begin{cases} 1, & \text{Tool } l \text{ of } j^{th} \text{ step} \\ 0, & \text{otherwise} \end{cases}$$

- μ_{ij} - Poisson rate of incurring the i^{th} defect due to the j^{th} step
- Count Regression equation:

$$\ln(\mu_{ij}) = \beta_{ij1} + \sum_{l=2}^{n} \beta_{ijl} X_{jl}$$

- β_{ij1} - effect of l^{th} tool of j^{th} step on i^{th} defect
- Y_{ijl} - average number of the i^{th} defect incurred due to the l^{th} tool of the j^{th} step:

$$Y_{ijl} = \begin{cases} e^{\beta_{ij1}}, & \text{Tool } l = 1 \\ e^{\beta_{ij1}+\beta_{ijl}}, & \text{Tool } i \neq 1 \end{cases}$$

- p_{ij} - probability of incurring the i^{th} defect by the j^{th} step
- Count Regression Equation:

$$\ln\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{ij1} + \sum_{l=2}^{n} \beta_{ijl} X_{jl}$$

- p_{ijl} - probability of incurring the i^{th} defect by the l^{th} tool j^{th} step:

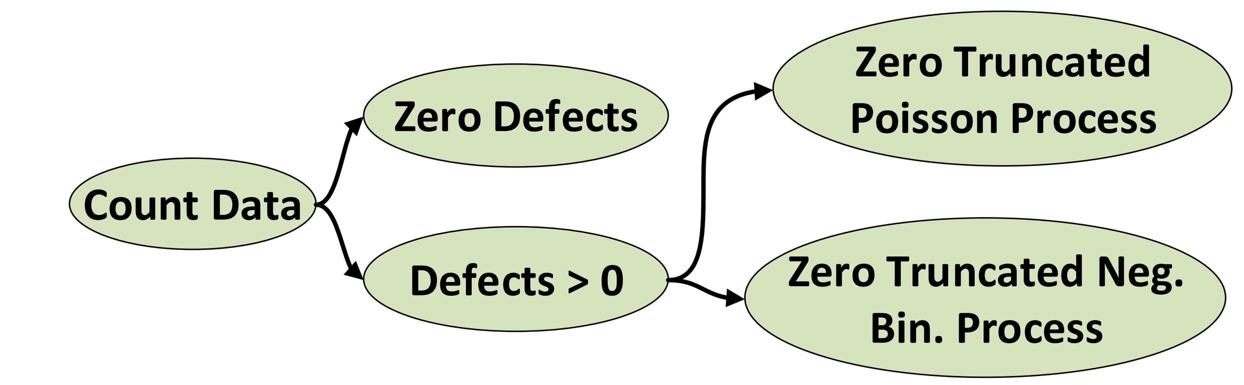
$$p_{ijl} = \begin{cases} \dfrac{e^{\beta_{ij1}}}{1+e^{\beta_{ij1}}}, & \text{Tool } l = 1 \\ \dfrac{e^{\beta_{ij1}+\beta_{ijl}}}{1+e^{\beta_{ij1}+\beta_{ijl}}}, & \text{Tool } l \neq 1 \end{cases}$$

- Expected number of defects by the hurdle model:

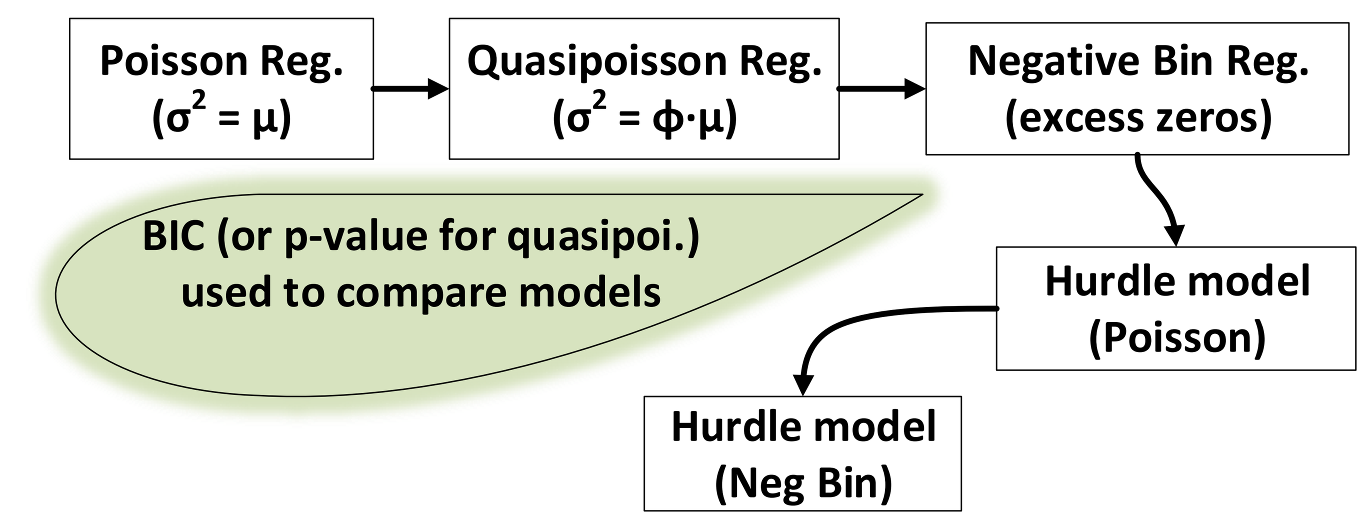
$$E(Y_{ijl}) = \begin{cases} p_{ijl} \cdot e^{\beta_{ij1}}, & \text{Tool } l = 1 \\ p_{ijl} \cdot e^{\beta_{ij1}+\beta_{ijl}}, & \text{Tool } l \neq 1 \end{cases}$$

ALGORITHM

HURDLE MODEL



RANKING ROUTES



Defect	Step	Regression Type	P-value	Dispersion	BIC	Best Fit
def2	Step3	poisson	0.00	2.52	3487.78	no
def2	Step3	quasipoi.	0.00	2.52	NA	no
def2	Step3	negative bin.	1	0.77	2466.20	no
def2	Step3	hurdle- bin, poi	NA in R	NA	3040.51	no
def2	Step3	hurdle- bin, neg bin	NA in R	NA	2439.69	yes

- Highest Tool Rank 1 for the tool generating the smallest number of a specific defect.
- Local Route Ranks are produced by ranking the sum of tool ranks for every defect

Tool RankDefect-3					
Step 1	Tool Rank	Step 11	Tool Rank	Local Route Score	Local Route Rank
EQP_31	5	EQP_57	6	11	2
EQP_32	1	EQP_58	1	2	1
EQP_35	6	EQP_59	7	13	3
EQP_36	4	EQP_60	9	13	3

- Global Route Ranks are obtained by ranking the weighted sum of local route ranks.

Route			Local Route Rank				Weighted Global Score	Global Rank
Step1	Step2	Step3	Def 1 (w1 = 1)	Def 2 (w2 = 1)	Def 3 (w3 = 1)	Def 4 (w4 =1)		
EQP_35	EQP_16	EQP_49	8	5	24	18	55	4
EQP_38	EQP_16	EQP_48	6	10	19	17	52	2
EQP_32	EQP_10	EQP_48	14	7	8	13	42	1
EQP_31	EQP_16	EQP_49	12	6	21	15	54	3