# Cleaning Economics

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# *Presentation Outline*

## Introduction

- Why Clean?
- Performance Metrics
- Cost Factors
- Economic Principles
- Cleaning Technology
- Cleaning Mechanism

## The Null Hypothesis

## Rules-of-Thumb

- Functions of Cleaning Frequency

## Break-Even Charts

- Yield-Pull / Profit-Push / Cost-Push
- Economy of Cleaning

## Conclusion

# *Introduction*

## Why Clean?

- Fear of low yield
- Establish process, e.g., after every cassette
- Don't understand the process
- Wear the cards out (abrasive cleaning)

## Performance Metrics

- Cumulative yield
- Contact resistance $C_{RES}$
- Required overtravel
- Consistent scrub marks
- Balanced contact force
- Planarity and alignment
- Cost of ownership (COO)
  - Mean-time to operator intervention (labor costs)
  - Probe card life
  - Process throughput

# *Introduction* *(continued)*

## Direct Cost Factors

- Cost and availability of probe cards
- Lost yield
- Probe wear
- Probe materials (GoreMate)
- Cleaning materials
- Cleaning frequency (throughput)
- Off-line cleaning and conditioning
- Service life

## *Ceteris Paribus*

- “Other things constant”
- The assumption of everything else being equal, of nothing else changing

## Association Is Not Causation

- Incorrect identification of causation is a potential source of error
- Statistical association does not establish causation

## The Fallacy of Composition

- What is true for the sub-component may not be true for the whole

# *Cleaning Technology*

## No Cleaning

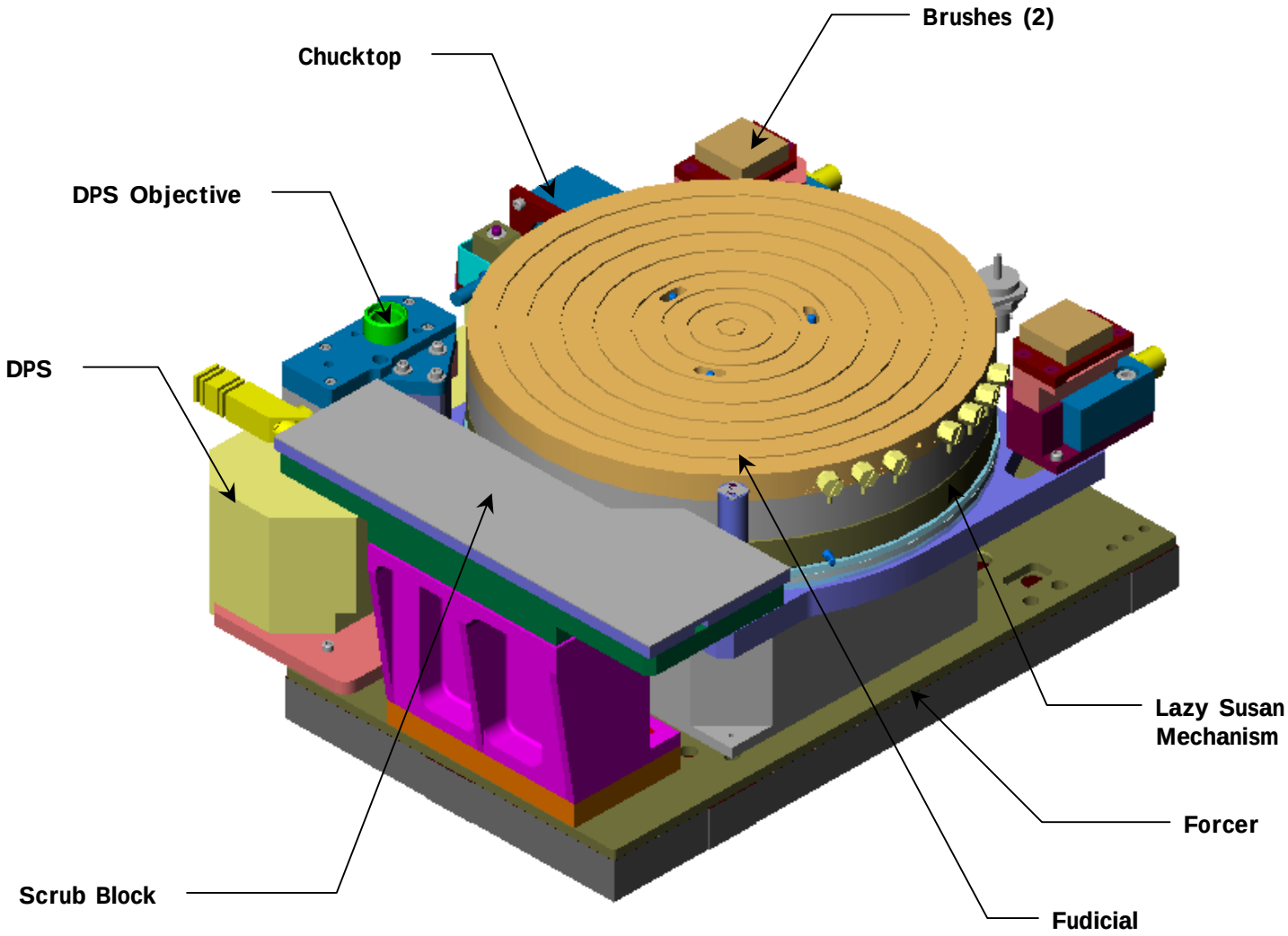
## Non-Conditioning

- Non-Contact
  - Air/Liquid
  - Electrostatic
- Contact
  - Brush
  - Conforming
  - Adhesive

## Conditioning

- Shape-Preserving
  - Abrasive-in-suspension
  - Re-Forming (Off-Line)
- Shaping
  - Abrasive
  - Repair/Replace

# EG 4|200 Cleaning Mechanism



# *The Null Hypothesis*

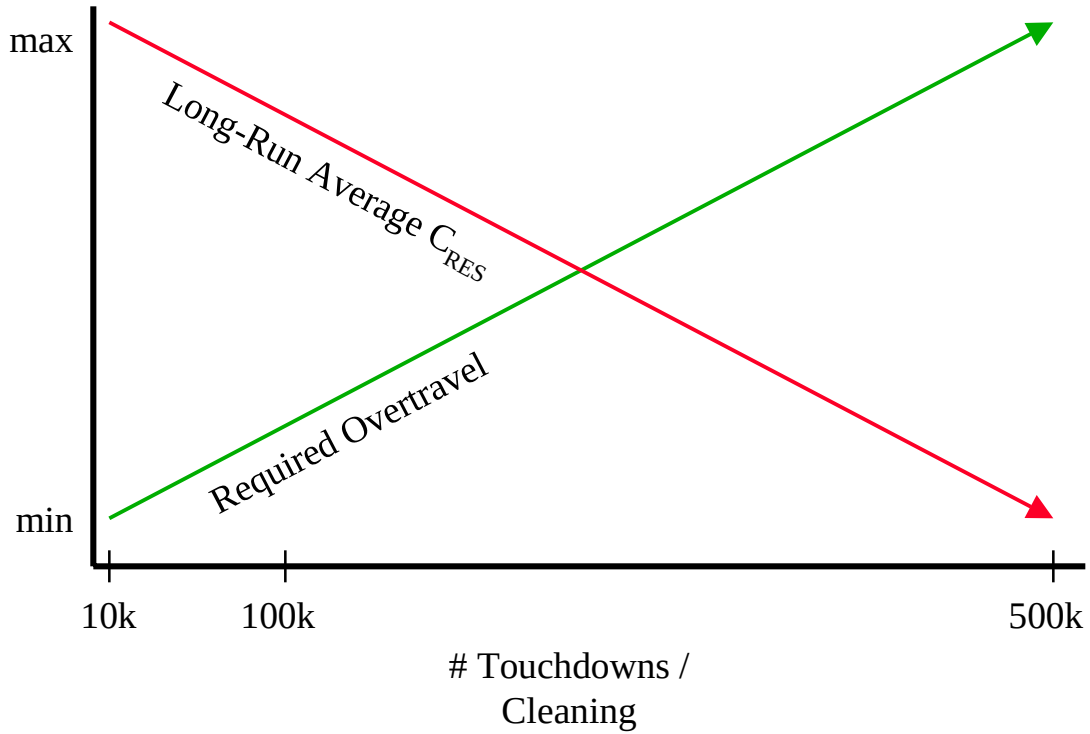
*There exists an optimum probe card cleaning rate that maximizes yield and minimizes production costs.*

**Definitions:**

- **Cleaning rate** is defined as # touchdowns between cleaning.
- **Yield** is defined as the cost of falsely classifying a die as bad when it is good and the associated downtime to determine the failure mechanism, i.e., dirty probe card**.**
- **Production cost** is defined as the long-run average cost of capital, labor, and inventory (throughput).

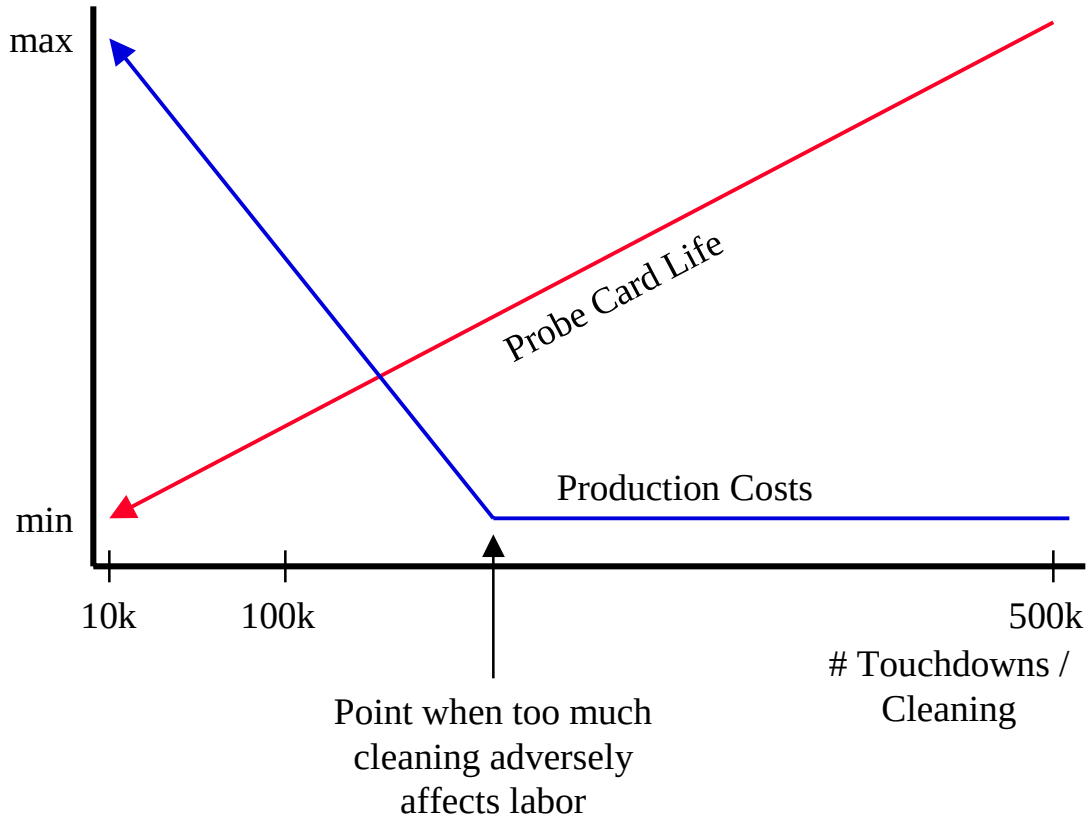
# Rules-of-Thumb

The relationship between required overtravel and long-run average contact resistance as a function of cleaning frequency



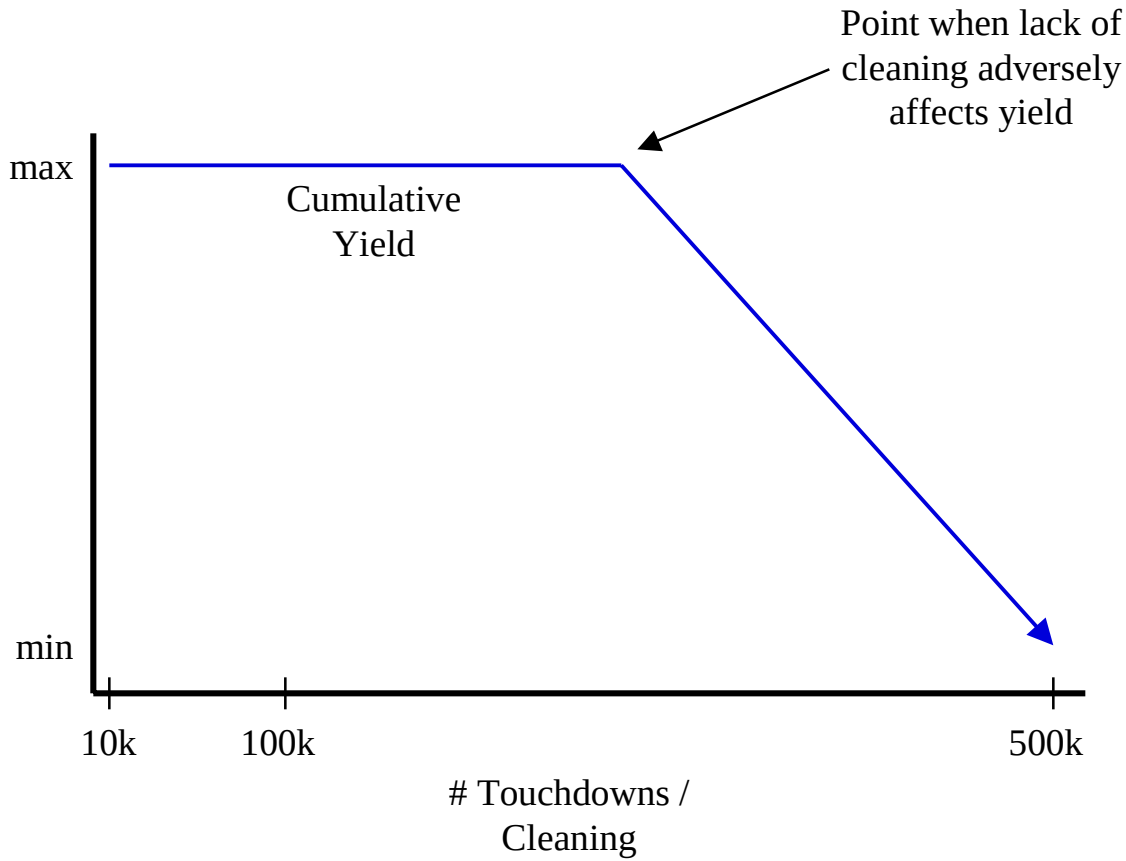
# *Rules-of-Thumb* *(continued)*

The relationship between the probe card life (abrasive cleaning) and production cost (labor & throughput)



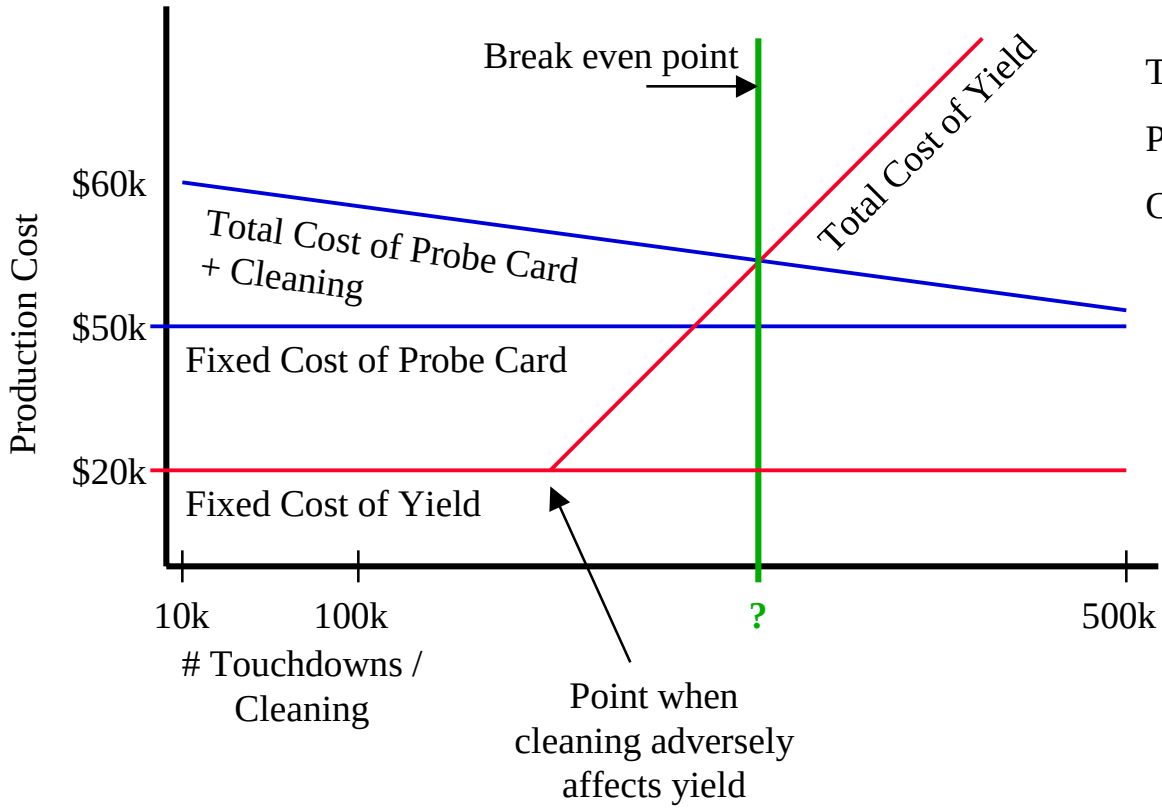
# *Rules-of-Thumb* *(continued)*

Cumulative yield as a function of cleaning frequency



# Break-Even Charts

Determining break-even point of probe card cleaning



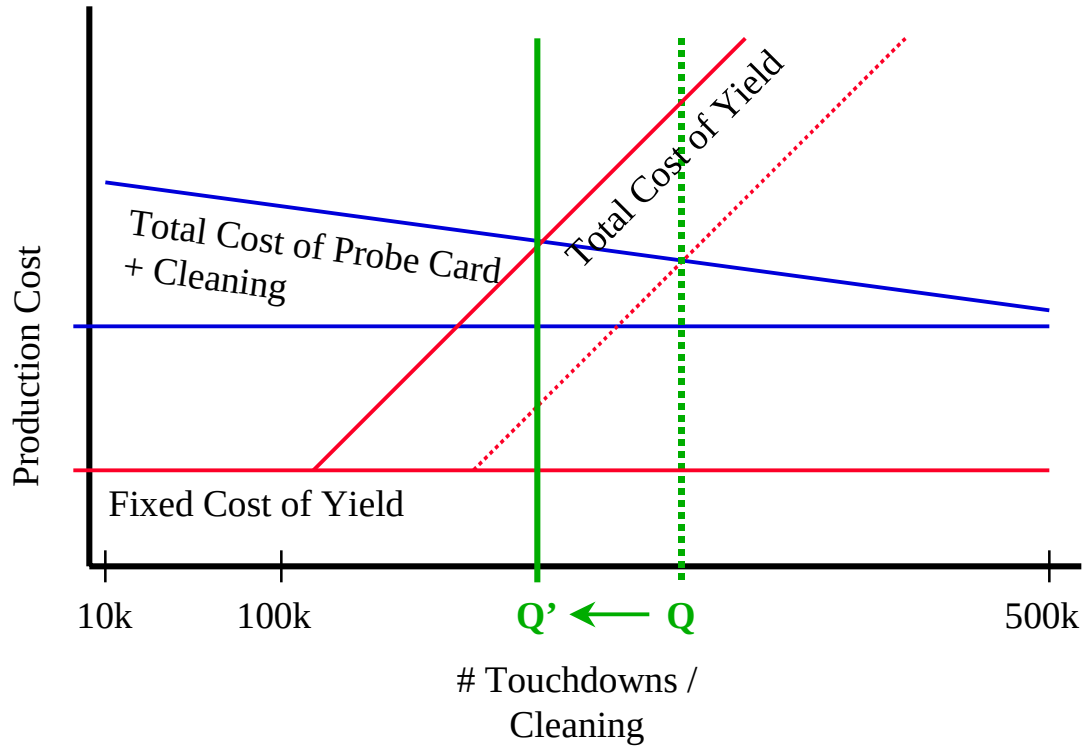

Total Life = 5M touchdowns

Probe Card = $50,000

Cleaning = $10 ea.

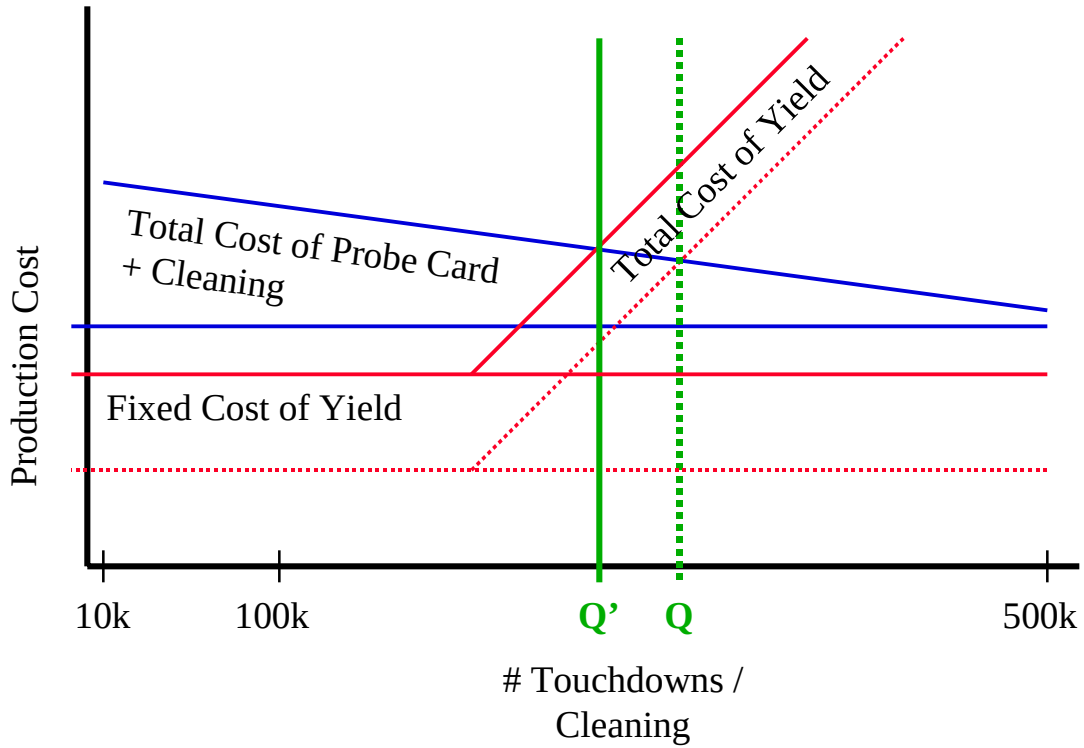
# *Yield-Pull "Inflation"*

An increase in cleaning frequency initiated by a demand for increased yield, *ceteris paribus*.



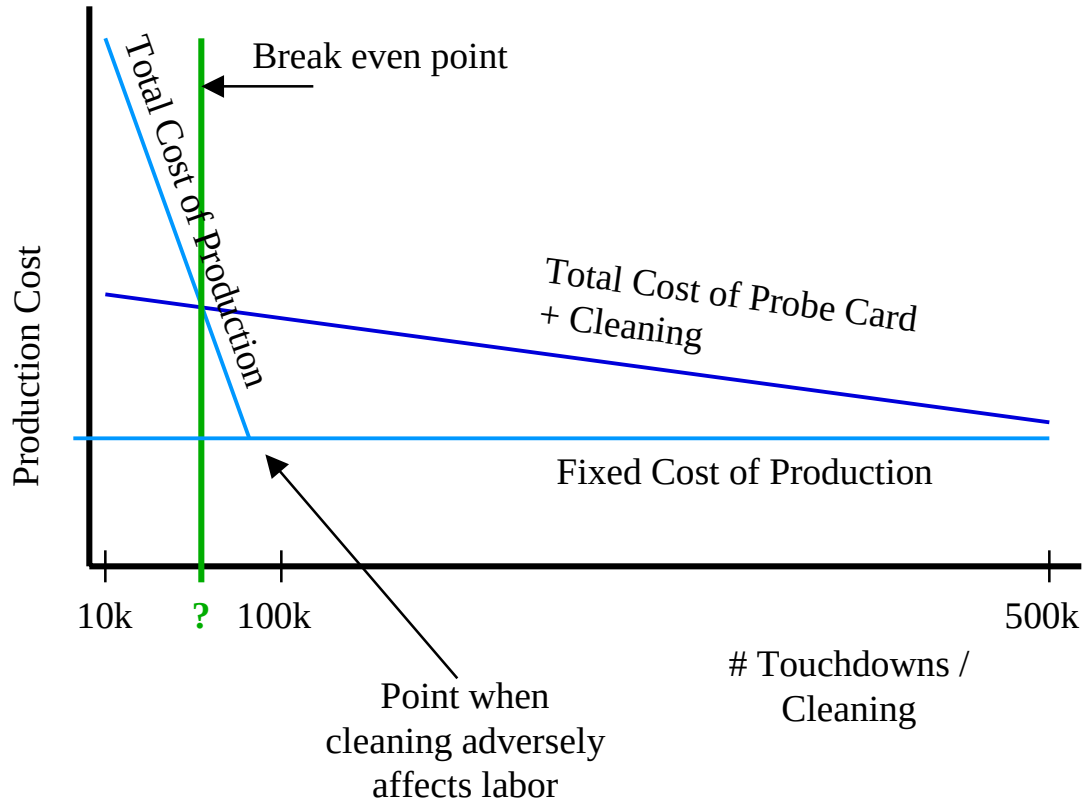
# *Profit-Push "Inflation"*

An increase in cleaning frequency initiated by attempts of producers to raise profit margin, *ceteris paribus*.



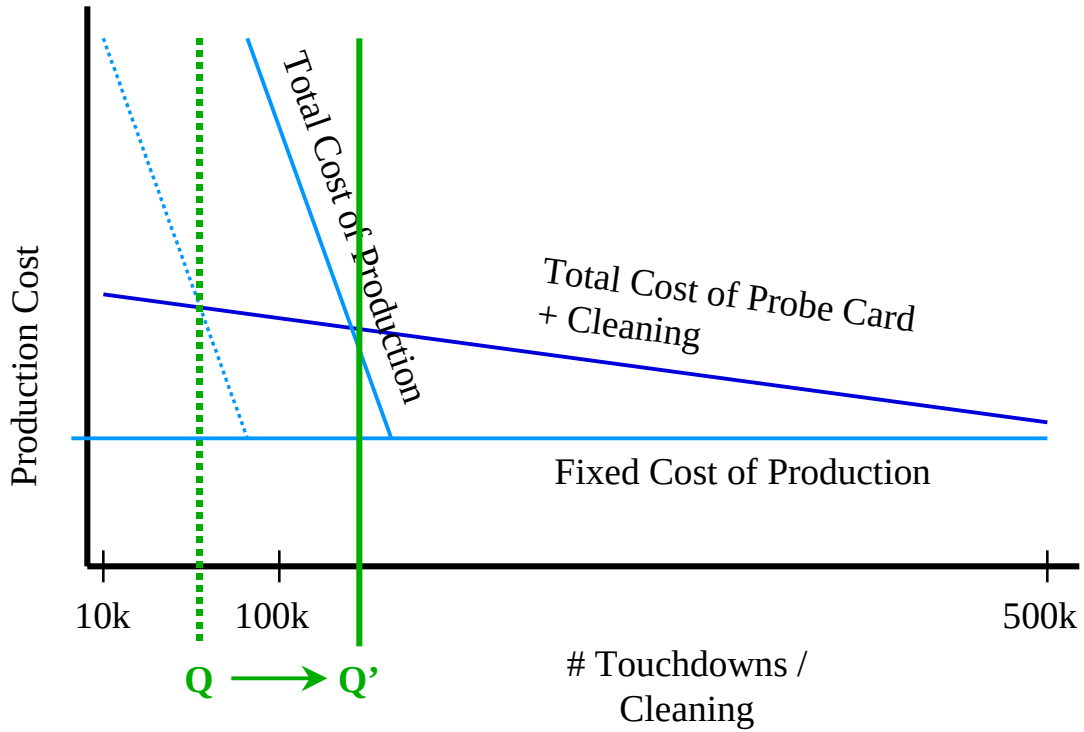
# *Cost of Production*

Clean often to maximize yield, *ceteris paribus*



# *Cost-Push "Deflation"*

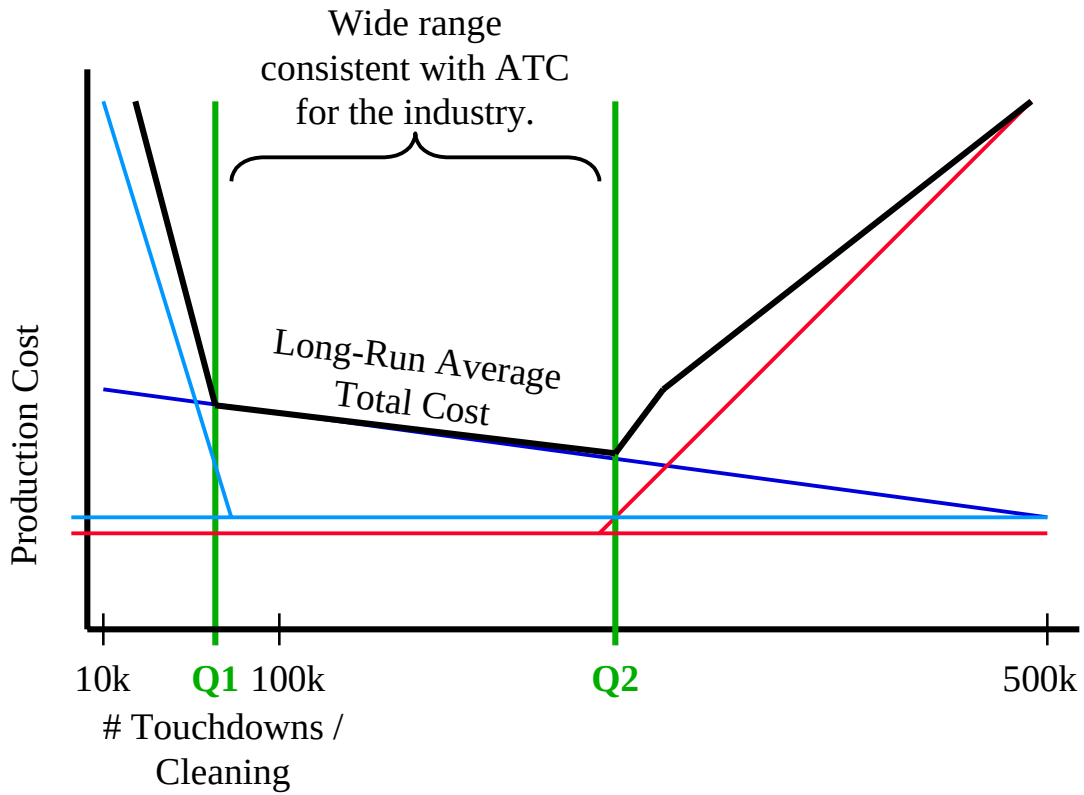
A decrease in the cleaning frequency initiated by an increase in the cost of production, *ceteris paribus*



# *Economy of Cleaning*

For cleaning frequencies greater than Q1, labor/throughput costs dominate.

For cleaning frequencies less than Q2, lost yield costs dominate.



# Conclusion

**Structure Imposes Behavior —** *Both yield and production costs are inelastic constraints compared to long-run average probe card cleaning costs. Aggregate cleaning rates are anchored at "natural" cycles determined by process factors. The plant is described by a Laffer or bathtub curve with wide range of acceptable cleaning rates.*

## Too Little Cleaning

- **Adversely affects yield**

## Too Much Cleaning

- **Adversley affects throughput**
- **Increases production costs**
- **Reduces life of probe card (abrasive)**