



# False, Unknown, and the Scientific Value of Not Knowing

Fabián E. Bustamante  
Northwestern University

# Research $\neq$ Paper

Research is an investigation

A paper is a compression of it

A **lossy** compression

Much of the uncertainty in research disappears in the compression

# What gets compressed?

**True** – Evidence supports the hypothesis

**False** – Evidence refutes the hypothesis

**Unknown** – Insufficient evidence to decide

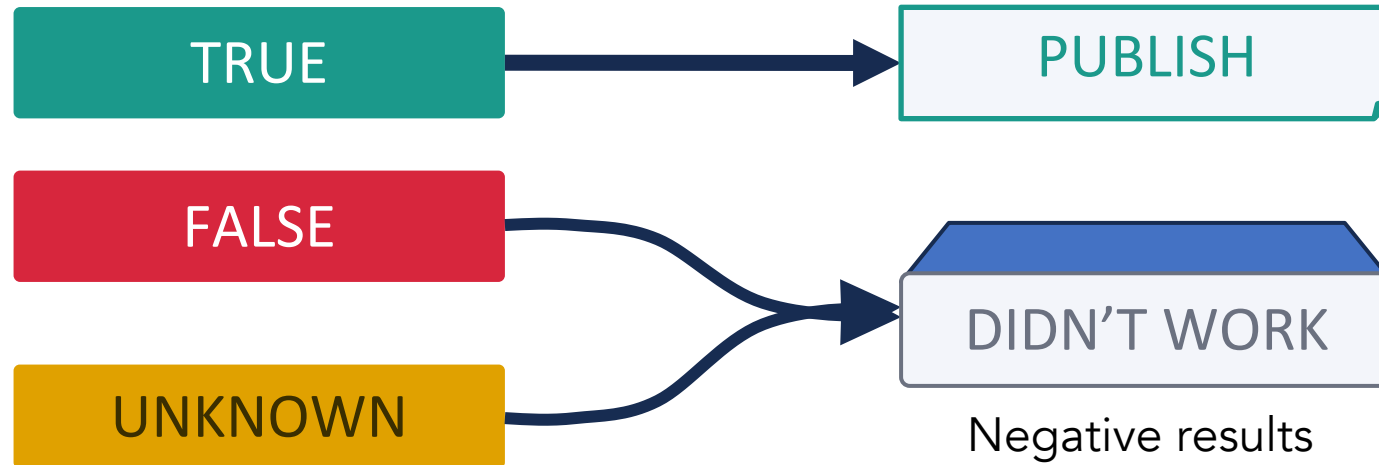
Ping host

- Reply → **TRUE**  
*Reachable and responding*
- No reply → **???**  
*Host down? ICMP filtered?  
Firewall? ...*

**UNKNOWN**  $\neq$  **FALSE**

# The publication mistake

Scientific outcome



Different scientific outcomes, filed together

# FALSE is knowledge

A refutation is a result

Some of our most celebrated contributions establish what cannot be done.



## **CAP theorem**

Consistency or availability under partition – pick one.



## **FLP impossibility**

One faulty process can prevent asynchronous consensus.

Nobody calls these failures. But they are negative results.

# UNKNOWN is knowledge

Not about the hypothesis — about the limits of the experiment

- Underpowered
- Confounded by the testbed
- Measuring an ill-defined quantity
- Not run at enough scale to tell

The experiment cannot distinguish the alternatives

Finding the limit of what we can infer is a result

# The real damage

UNKNOWN  
*dressed as FALSE*

Don't close a question the evidence leaves open

T

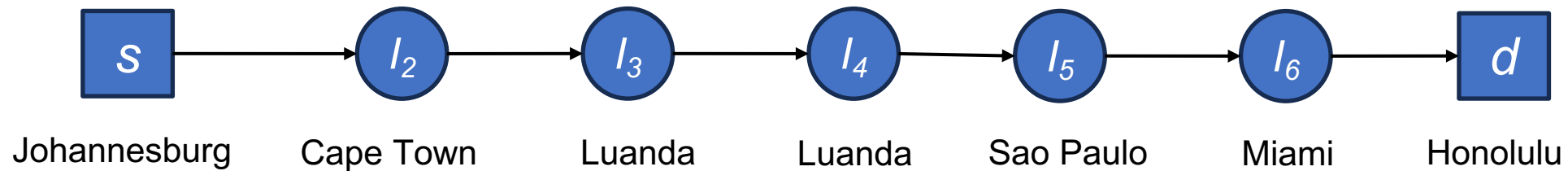
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# Make Unknown explicit, and validation itself gets cheaper.

A worked case: geolocating routers

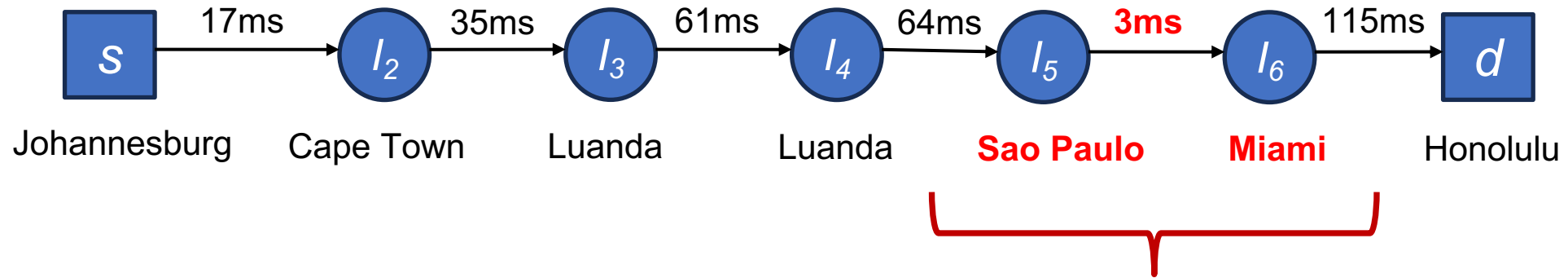
# What physical infrastructure carries a traceroute?



traceroute → router locations → submarine cables

Router locations? GeoDBs, rDNS, Geofeeds

# But does the path make sense?



**FALSE**

Physical minimum  $\approx 60$  ms

We don't need ground truth to know this cannot be right

# Falsification is free

The path itself contains evidence about its proposed locations

candidate locations + observed latencies



*Does the proposed path make sense?*

## Path Consistency Scoring (PCS)

HMM: metadata evidence + latency-constrained transitions

*Score the path, not the points*

# But sometimes the path can't tell

## Latency is informative

*Sao Paulo – 3ms – Miami*  
→ PCS can discriminate

**PCS** How well does the best geographic path explain the evidence?  
metadata + RTT constraints → normalized HMM likelihood

## Latency is not informative

*hidden/asymmetric /noisy path/...*  
→ PCS cannot discriminate

**R** Do the decoded and reference paths tell the same latency–geography story?  
 $R \rightarrow 1$  aligned ·  $R \rightarrow 0$  disagreement

$R \rightarrow 0 \Rightarrow \text{UNKNOWN}$

# The path can now answer True, False, or Unknown

**TRUE**Auckland  $\rightarrow i_2 \rightarrow i_3 \rightarrow \dots$  Nuremberg

✓ Latency-consistent

**FALSE** $\dots \rightarrow$  São Paulo — 3 ms  $\rightarrow$  Miami  $\rightarrow \dots$ ✗ Physical minimum  $\geq 60$  ms**UNKNOWN**Miami  $\rightarrow i_2 \rightarrow \dots$  hidden  $\dots \rightarrow i_n \rightarrow$  Sydney

? Cannot judge

# The system knows when it doesn't know

Don't validate every answer. Validate whether the system knows when to trust its answers.

$$R \geq 0.8$$

**Median error  
 $\approx 4$  km**

latency is informative

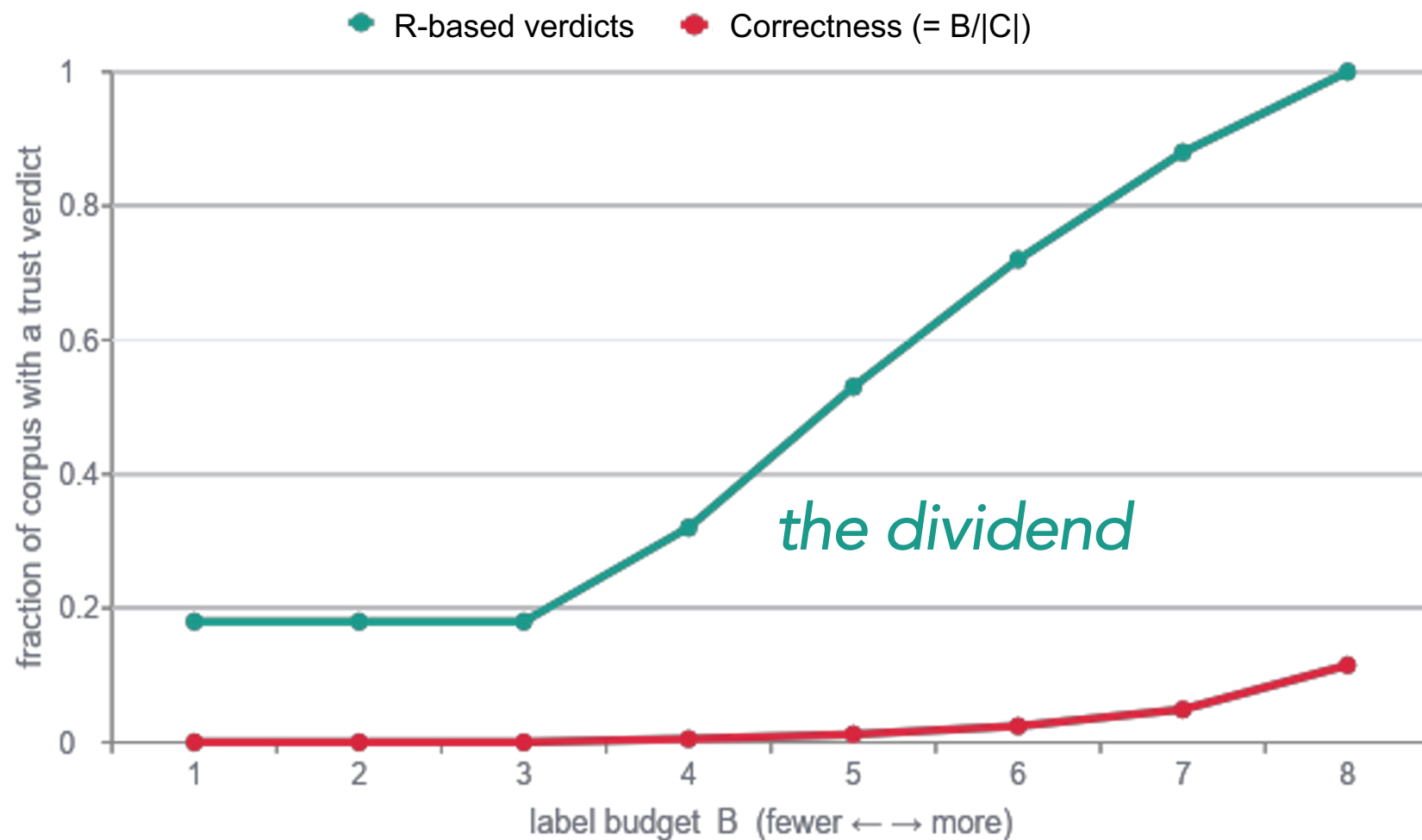
$$R < 0.2$$

**Median error  
 $\approx 245$  km**

latency is not informative

Validate uncertainty, not every inference

# The validation dividend



## CALIBRATION

Few labels → learn the trust rule  
Rule → verdicts across the corpus

## CORRECTNESS

One label → one verified path

Same labels,  
far more verdicts.

# The boundary: coherent error

## Calibrated and wrong at once

Self-validation can detect inconsistency

It cannot detect a coherently wrong inference

*Consistency  $\neq$  correctness*

1999

Traceroute → “the Internet is power-law”

2003–09

Sampling shown to create the effect

Lesson

Valid observations → wrong inference

Coherent error requires independent evidence

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Make Unknown explicit

**False** tells us about the world

**Unknown** tells us about the limits of our observation

Both are scientific results

Don't hide the boundary — make it a result

# THANK YOU

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