Measurement, computation, simulation, etc: is there still a difference in the "big data" age?

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https://scm.etu.ru/2021/en

My profile

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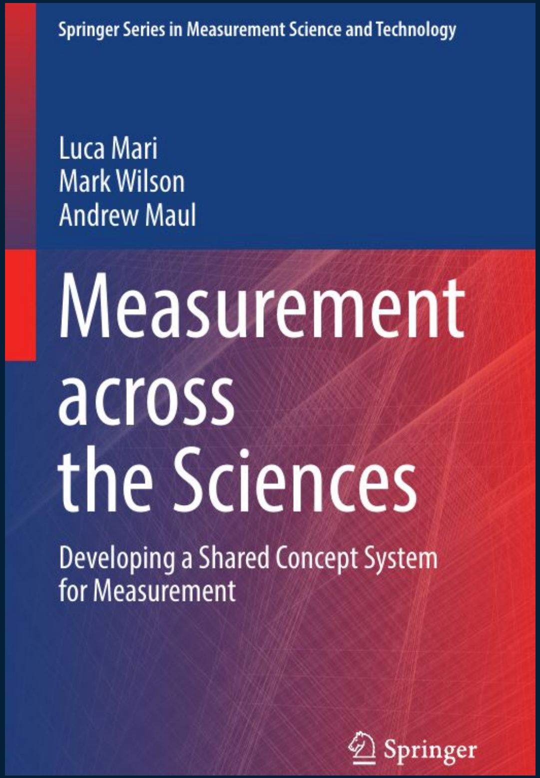
Justification

(why maintaining a distinction between measurement
and other, related processes (computation, simulation, etc)
is important today)

"Measurement is an integral part of modern science
as well as of engineering, commerce, and daily life.
Measurement is often considered a hallmark of the scientific enterprise
and **a privileged source of knowledge**" (Tal, 2020)

But "**what [is] the source of [this] special efficacy**" of measurement?
(Kuhn, 1961)

Drawing from...



<measur*> in four easy steps

1. At the origin: the Greek concept of measure
2. A critical enabler of the experimental method
3. Exploring measurement as a way of representation
4. … and today?

1. At the origin: the Greek concept of measure

“A magnitude is a part of a(nother) magnitude, the less of the greater, when **it measures** the greater” (Euclid, 300 BC)

This seems to justify the claim that the Elements are “the earliest contribution to the philosophy of measurement available in the historical record” (Michell, 2005)

Yes, but...

“A number is part of a(nother) number, the lesser of the greater, when **it measures** the greater” (Euclid, 300 BC)

and indeed, “**a measure** of a number is any number that divides it, without leaving a reminder. So, 2 is a measure of 4, of 8, etc” (Hutton, 1795)

“The term ‘**measure**’ is used [by Euclid] conversely to ‘multiple’; hence [if] A and B have a common measure [they] are said to be commensurable” (De Morgan, 1836)

To settle the issue:

“in the geometrical constructions employed in the Elements [...] **empirical proofs by means of measurement are strictly forbidden**”
(Fitzpatrick, 2008; in his introductory notes to his translation of Euclid’s Elements)

This is about <measure> as <ratio>, not <measurement>:
(out of scope)

the source of the special efficacy of measurement
cannot be the Euclidean concept of measure

2. A critical enabler of the experimental method

Before Galileo, “no one had the idea of counting, of weighing and of measuring; or, more exactly, no one ever sought to get beyond the practical uses of number, weight, measure in the imprecision of everyday life” (Koyré, 1948)

The experimental method was grounded on empirical processes, but about measurement maintained a geometric focus:

> MEASURING, the same as MENSURATION.

> MENSURATION, the act, or art, of measuring figured extension and bodies; or of finding the dimensions and contents of bodies, both superficial and solid.

(Hutton, 1795)

And indeed, what about, e.g., temperature?
(Hutton uses the term “observation” for its evaluation...)

Plausibly, this focus was based on the assumption that **extensivity is necessary for measurement**, thus justifying – in reference to the outcomes of the Ferguson committee (1940) – that "the main point against the measurability of the intensity of a sensation was the impossibility of satisfactorily defining **an addition operation** for it" (Rossi, 2007)

This is about <measurement> of a specific class of quantities only:
(too specific)

the source of the special efficacy of measurement
cannot be this kind of physicalism

3. Exploring measurement as a way of representation

From the seminal claim that “measurement is the process of assigning numbers **to represent** qualities” (Campbell, 1920) ...

... the idea of measurement as a “well-behaved” representation arose...

... up to the position that a representation theorem
“makes the theory of finite weak orderings a theory of measurement, because of its numerical representation” (Suppes, 2002)

With the mindset that “the theory of measurement is difficult enough without bringing in the theory of making measurements” (Kyburg, 1984) RTM **is too abstract** for being a theory of an empirical process

This is <measurement> as consistent representation:
(too generic)

the source of the special efficacy of measurement
cannot be consistency in representation

4. … and today?

Summary of the open issues deriving from these clashing standpoints

The source of the special efficacy of measurement **is not**

- the Euclidean concept of measure
- a specific kind of physicalism
- consistency in representation

And then?

One option: change paradigm

Renounce to consider measurement as a process with a special efficacy, and characterize it as an **evaluation whose quality is documented**

NIST

PROJECTS/PROGRAMS

Virtual Measurements

Summary

Compared with conventional, physical measurements, the cost of computational modeling continues to drop. This has driven many industries to incorporate computational predictions in their R&D processes. However, to replace a physical measurement, the quantitative reliability of a computational prediction must be known.

NIST Technical Note 1900

Simple Guide for Evaluating and Expressing the Uncertainty of NIST Measurement Results

Antonio Possolo

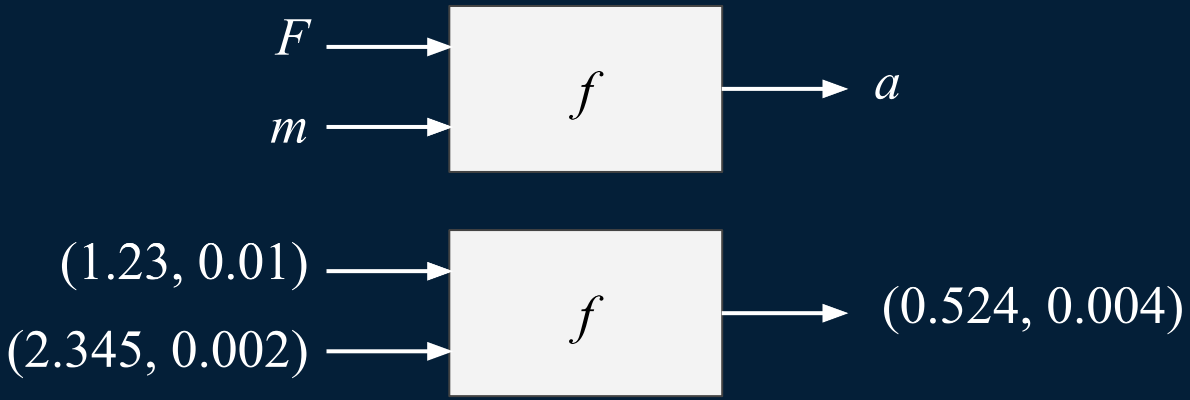
Measurement is an experimental or computational process that, by comparison with a standard, produces an estimate of the true value of a property of a material or virtual object or collection of objects, or of a process, event, or series of events, together with an evaluation of the uncertainty associated with that estimate, and intended for use in support of decision-making.

According to this position,
computations and simulations of documented quality are measurements

Documenting quality is not only a (possibly) necessary condition
for a property evaluation to be a measurement, but **is also sufficient**

An example:

What acceleration does a force of 1.23(1) N produce on a body of mass 2.345(2) kg?



We have **computed** a value of acceleration and a related standard uncertainty:
have we performed a measurement?

Lately f (where then $f(F, m) = F/m$) has been called
a **measurement model**

(a “mathematical relation among all quantities known to be involved in a measurement”, according to the International Vocabulary of Metrology (VIM))

Since “even the simplest model will be incomplete if corrections to the indications of the instruments used in direct measurements are not taken into account …
no measurement can strictly be considered to be ‘direct’.” (Lira, 2002)

The argument is apparently:

P1. any measurement requires corrections
P2. corrections are taken into account through a model
C1. any measurement is based on a model

P3. a measurement that is based on a model is indirect
C2. any measurement is indirect

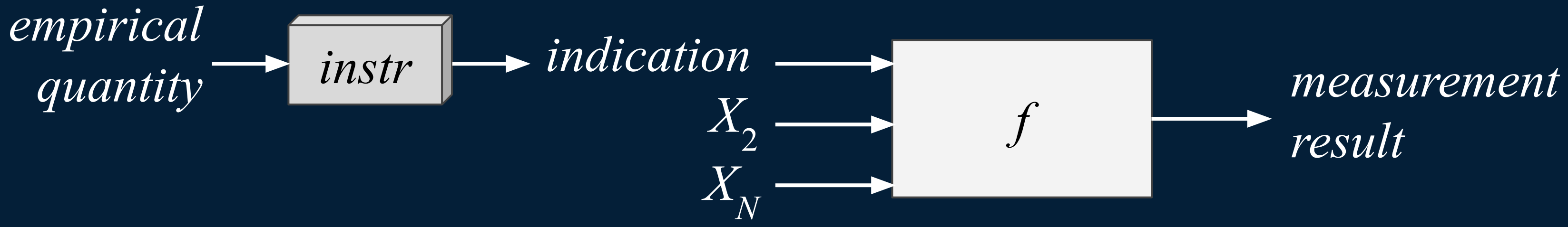
Any measurement is based on a (explicit or implicit) model: **yes, of course!**

A measurement that is based on a model is indirect (and therefore measurement can be a purely computational process): **… really?**

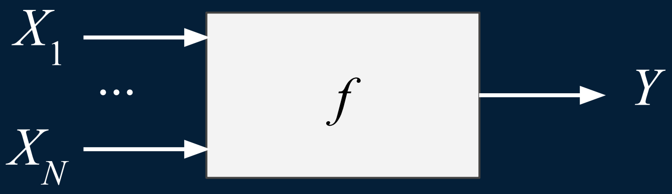
Can there be another option?

Another option: maintain and strengthen the paradigm

Let us recover the key distinction:

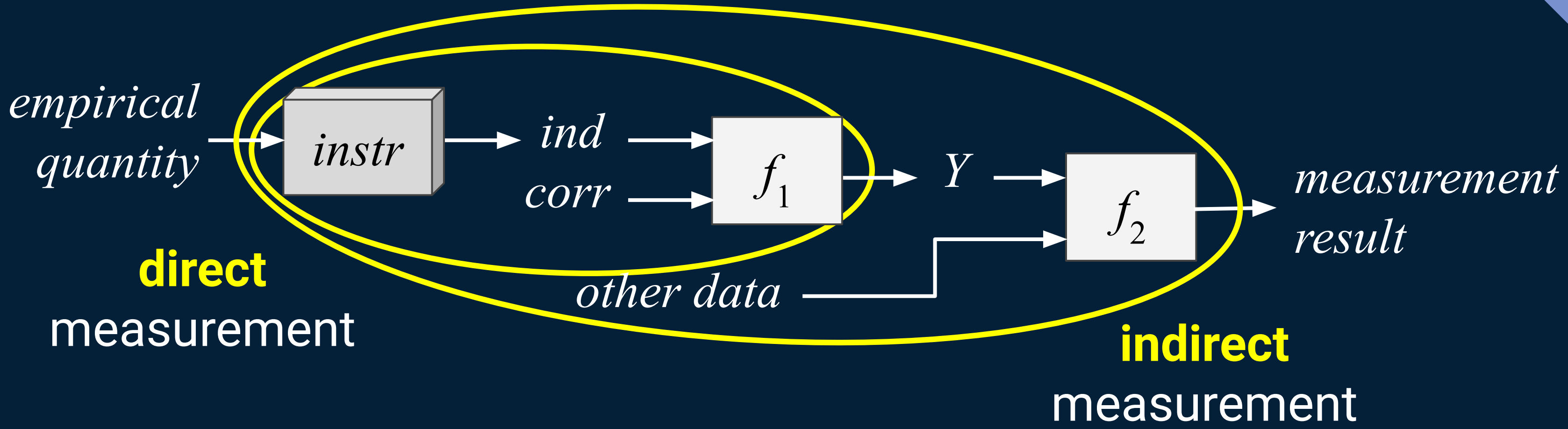


This is measurement



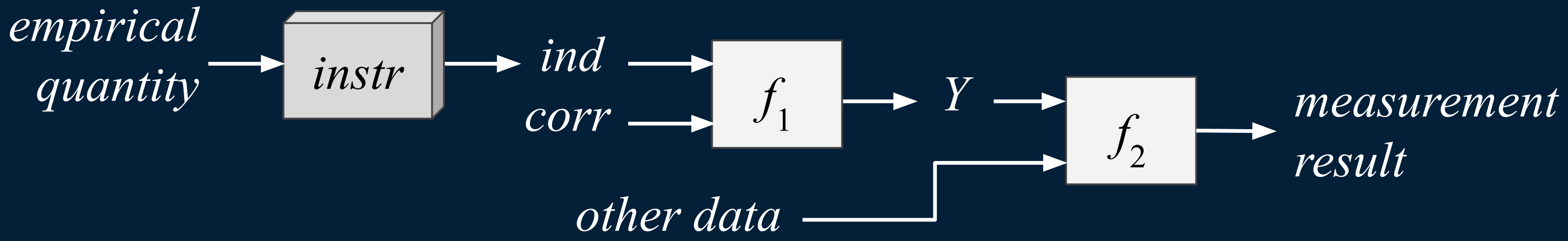
This is not measurement

A more complete picture:



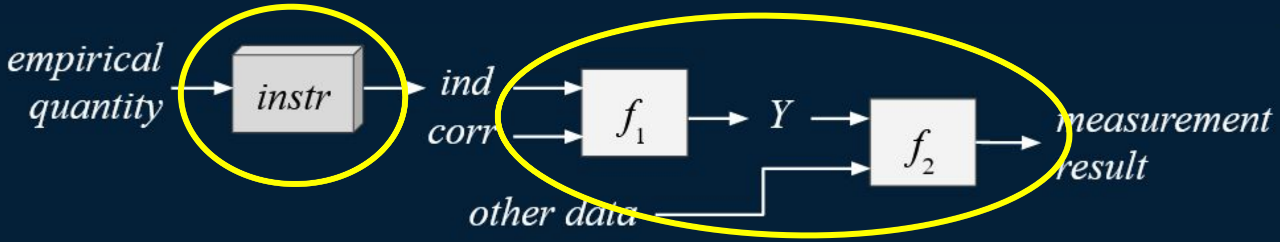
Indirect measurements include at least one direct measurement

A more complete picture:



Indirect measurements include at least one direct measurement

Our question was:
"**what is the source of the efficacy of measurement as a privileged source of knowledge?**"



Measurement is effective...
because it is effective...

in **acquiring information from the empirical world**

and in **interpreting it by means of models**

This standpoint promotes a **model-dependent, critical realism**

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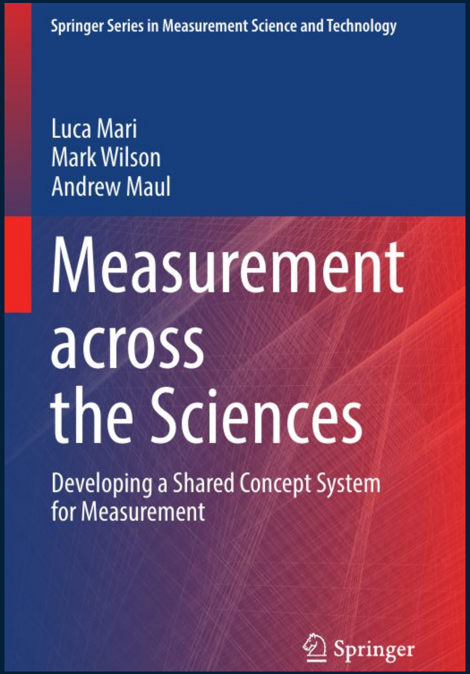
Thank you for your kind attention

(to be possibly continued here  …)

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