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EUROPEAN CENTRAL BANK

EUROSYSTEM

**Francis Gross**

Senior Advisor
DG Statistics

House of Finance - Workshop

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# measuring finance and the economy in the digital age

# – vision, architecture, infrastructure

a look where to go beyond immediate feasibility

## Chapters

1. A systems vision of the economy and finance suited to measurement and analysis in the digital age

2. A conceptual architecture of the measurement system and its necessary infrastructures, including LEI and ACTUS

3. An attempt at generalising ACTUS to all types of contracts, beyond finance

## Chapter

1. A systems vision of the economy and finance suited to measurement and analysis in the digital age

## Preliminary ramblings

Perception,

Representation,

Language,

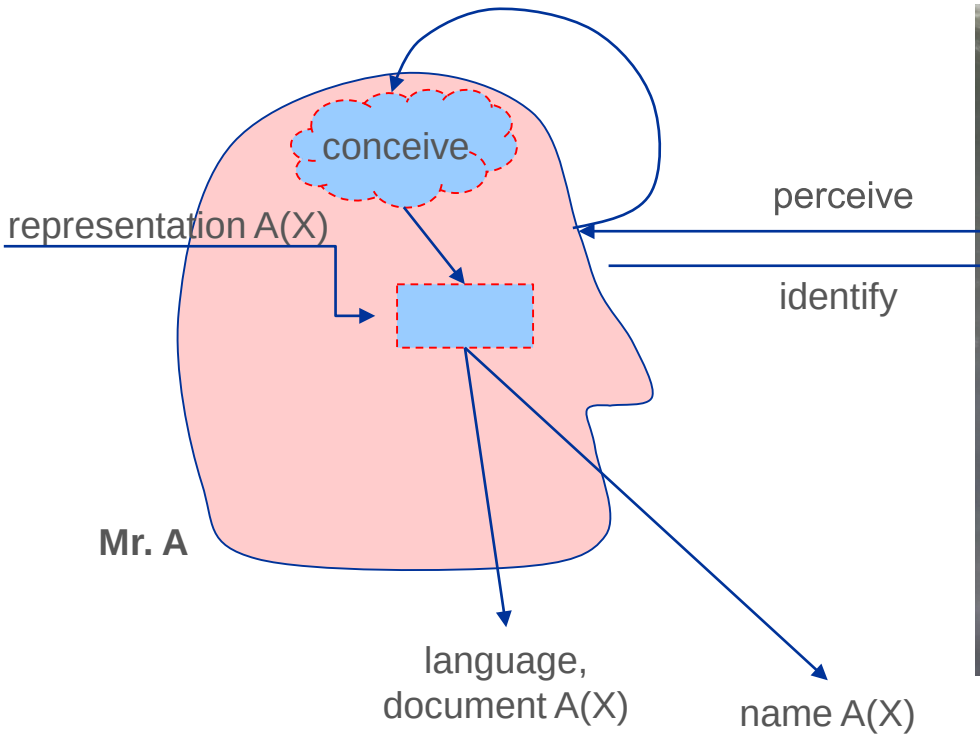
Data,

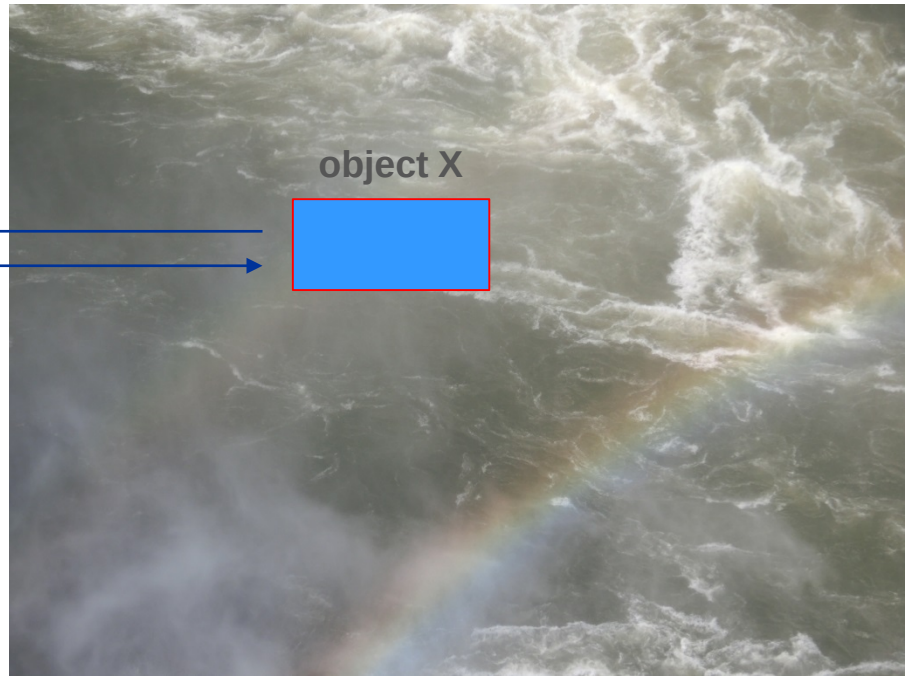
Vision,

Systems,

Measurement,

# Object recognition and identification in a complex environment



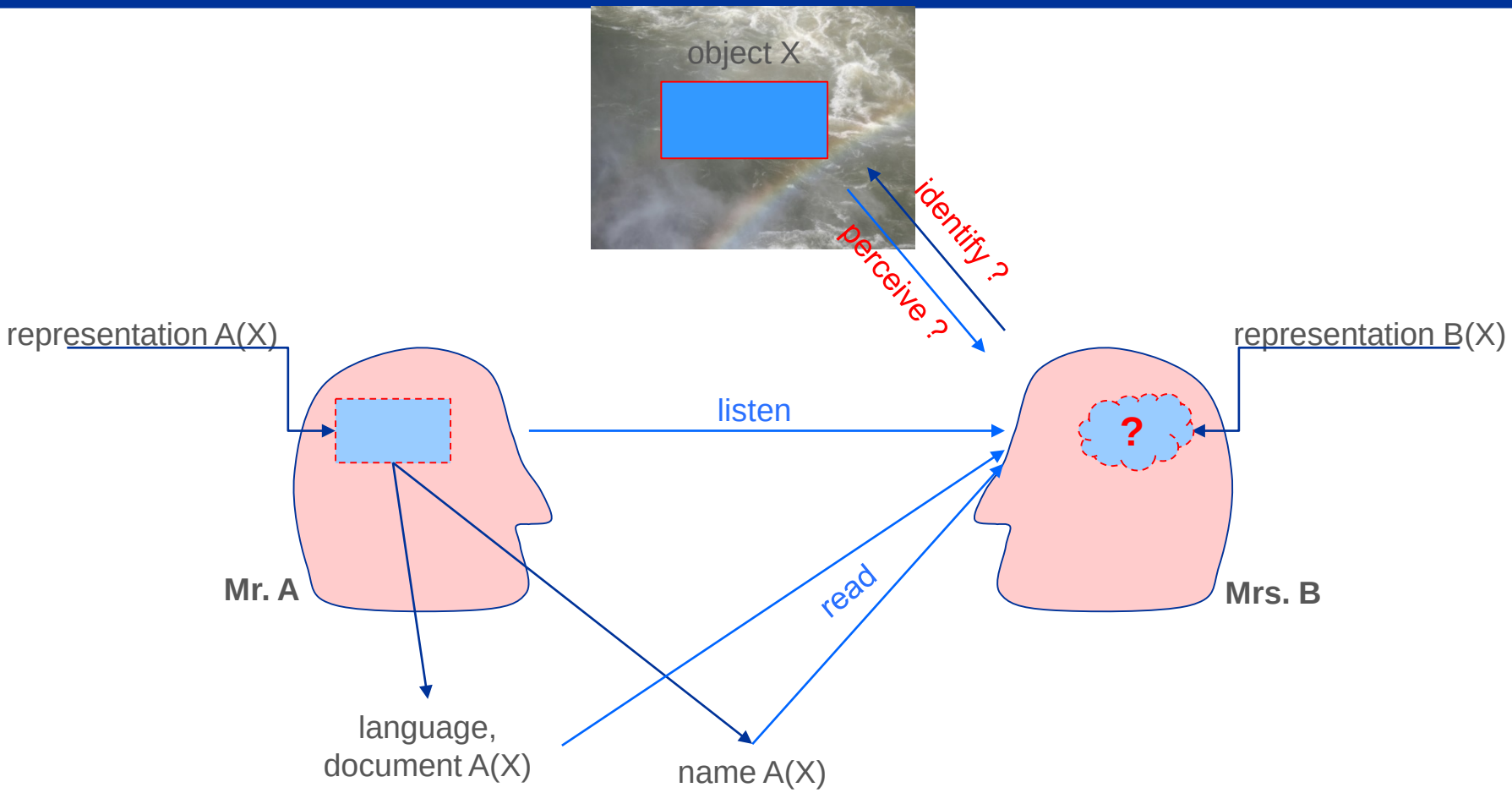




perceive

identify

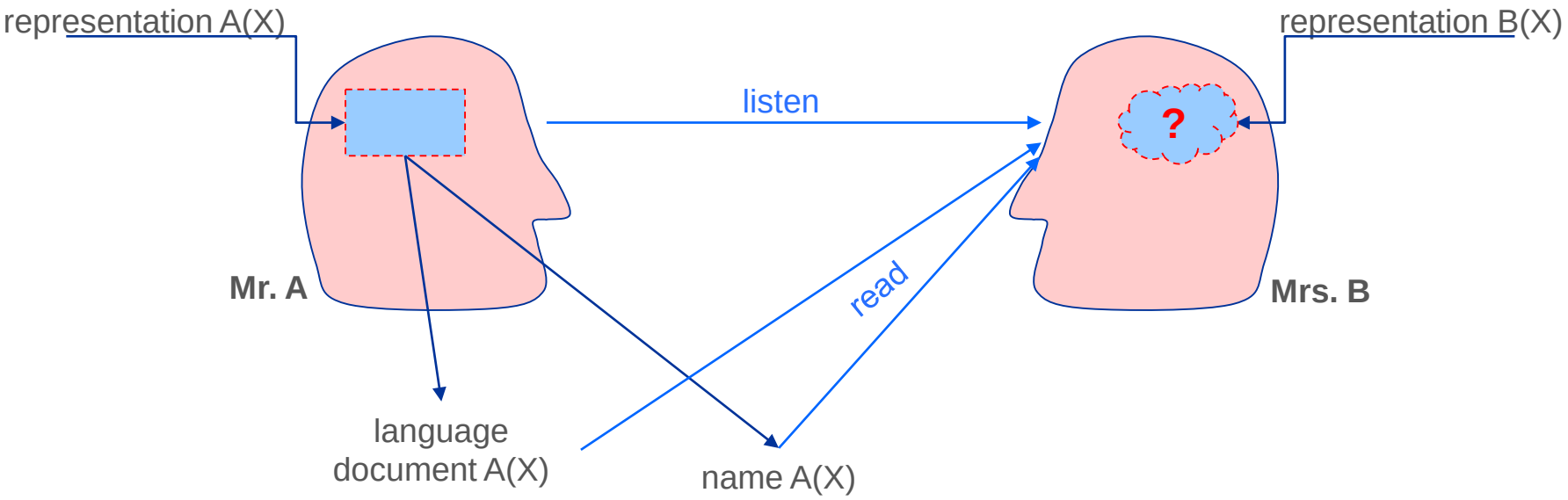
- **Mr. A's brain receives perception from his complex "real world" environment**
- **Whatever "exists" in the "real world", Mr. A chooses to create object X in his brain**
- **Whatever the representation of object X in Mr. A's brain, he can create a name and documents that will be associated with the perception**
- **When Mr. A perceives object X again, he can identify it by associating it with the name and the document created earlier and stored in his brain.**

# Object recognition and identification from language; material objects




- **What if Mrs. B learns about object X only from listening to Mr. A or from the Name and Documents Mr. A created?**
- **Will Mrs. B identify Object X "the same way" as Mr. A?**
- **Observing Mrs. B's action can give an indication. Will Mrs. B act in the same way as Mr. A who has seen object X? ("language game", Wittgenstein)?**

# Object recognition and identification: immaterial, abstract objects



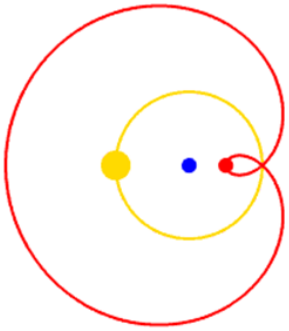

- **What if object X is immaterial, abstract, cannot be perceived through senses?**
- **Mrs. B can only listen to Mr. A or read Name and Document related to object X**
- **Mrs. B can play a language game with Mr. A to refine Representation B(X)**
- **What if Mrs. B has no access to Mr. A?**
- **What if Mr. A cannot observe Mrs. B's action and give feedback?**
- **What with many names and documents from many sources, without feedback?**

# Abstract objects, documents, names, language and data - trust

- **What when many names and documents, from many sources, representing abstract objects, are stored by many people, independently, in many computers, condensed into data that is separated from documents and authors, and travels alone to other computers, via other people or directly?**
- **When data is processed into new data in many places in the network?**
- **When data generated through computing travels further on?**
- **When some data is used to generate human-readable statements?**
- **When data volumes are too high, paths too long and hard-to-know for the reader to validate her understanding of the statement?**
- **What when some of that data is used to steer machines?**
- **How could we responsibly trust the outcome and use it further?**

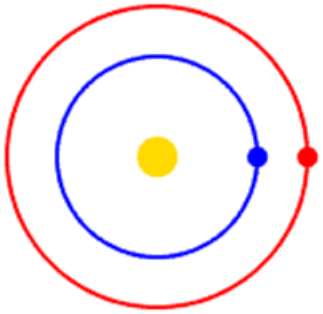
# Vision: technical tool, not flight of fancy

- **A way we choose to see the world**
- **A representation we associate with our perception**



**The solar system**
heliocentric (right)
vs.
Geocentric (left)

In red: orbit of Mars



- **“All models are wrong; some models are useful” George E.P. Box, statistician**
- **“It is the theory that decides what we can observe” Albert Einstein**





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# System

- **A whole made of elements that interact. Interaction among elements determines the behaviour of the whole.**
- **Elements belonging to the system are identified. There is a boundary.**
- **Elements of a system can interact with elements outside the system. Outside influence is possible.**
- **A system evolves over time. At each moment it is in a state, knowable or not.**

# System is representation and vision, not reality

- **We define a system and its elements as a representation built from representations of objects we perceive.**
- **We can define many systems to represent aspects of a same reality, for instance a human body: skeletal system, muscular system, nervous system, digestive system, cardio-vascular system, skin and pilous system, microbiome**
- **Systems representing aspects of a same reality can overlap. They can also combine to map reality without overlap.**
- **We can define systems representing different degrees of detail and precision of the same aspect of a given reality, for instance the human cardio-vascular system as just the main veins and arteries or down the the smallest vessels.**

# The system is not (necessarily) the model

- **A model can be built by combining systems needed for the analytical purpose, each one represented at a suitable and feasible degree of detail.**
- **For instance, analysing human movement doesn't require considering the digestive system, the cardio-vascular system or the microbiome, or they might be represented just as a notional mass that needs to be moved along.**
- **The systems that compose a model interact**

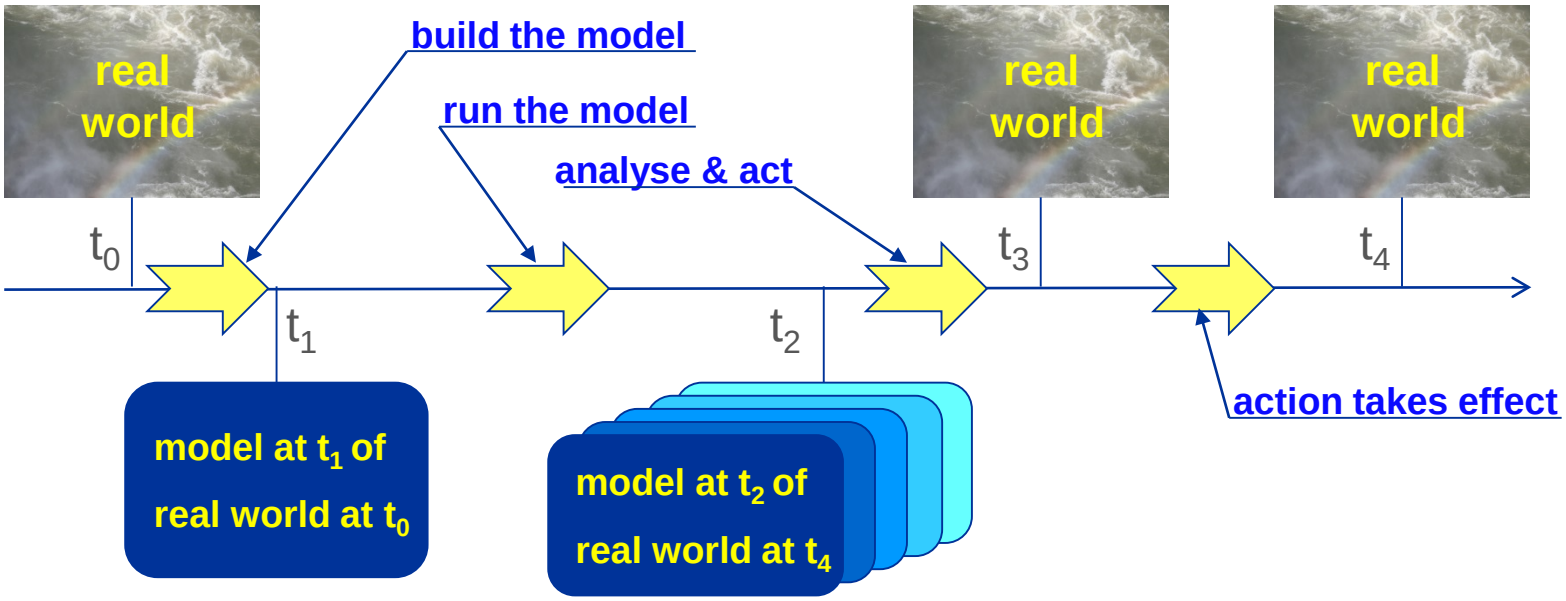
# Model

- **A model (single system or combination of several systems) can be too complex for a brain to represent or for a brain to figure out the evolution of the model over time.**
- **Computers can be used to represent very large systems and models and to calculate their states over time.**
- **Humans can study, observe, query and test models and systems that unfold their behaviour in a computer**
- **If the computer is faster than reality, prediction is possible**

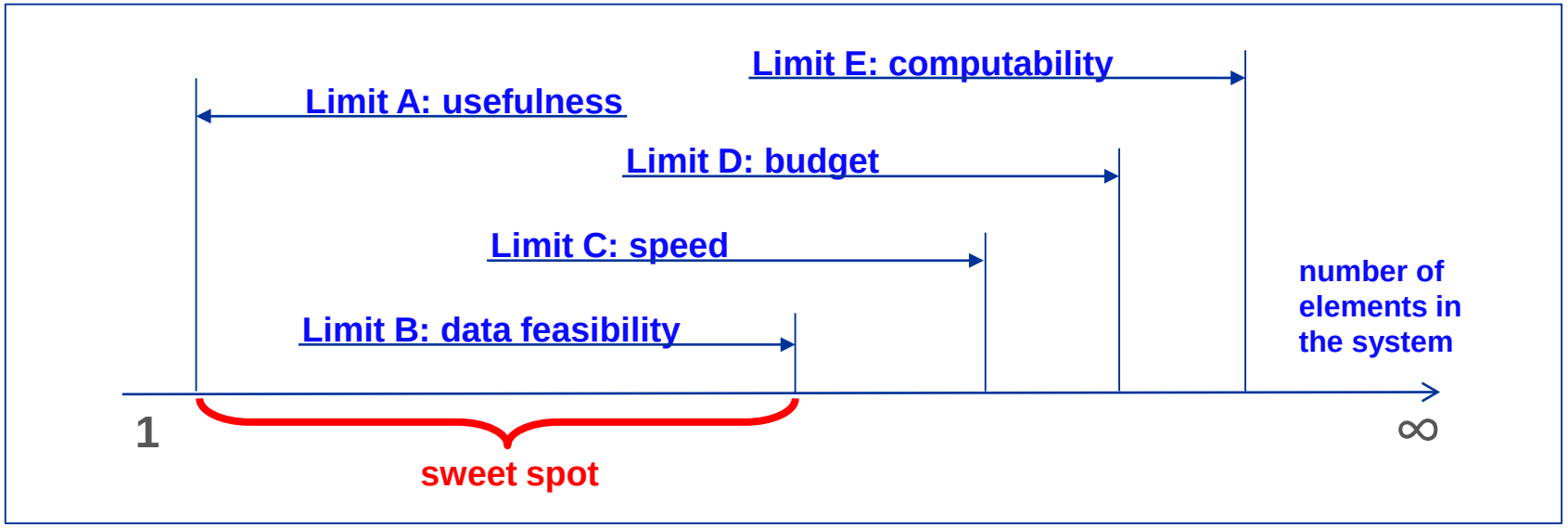
# Model and simulation

- **Many variants or configurations of a model can be used to generate scenarios of how the model evolves and to represent future states of the model.**
- **Humans can compare scenarios and states generated in the model by simulation conducted running that model with perceptions of reality.**

- **If simulation is fast enough, prediction is possible.**



- **Design of a system / model selects detail / granularity that best serves the use**
- **There are limits to design re. number of elements in the system /model**




- **A system / model in the sweet spot can satisfy demand**
- **The sweet spot can be void if feasible size is lower than usefulness demands**

# The model is not reality

New slide

- **The model is built from a number of systems that reflect aspects of reality**
- **Each system is introduced at a granularity adequate to the model, limited by data and computing power available as well as by the complexity that can be mastered in a model**
- **Reality is always far more complex than any model hence**
- **The predictive power of a model is limited. At best, it goes as far as the influence / effects of factors not covered in the model remain small. F.i.: predictive power in finance stops where panic of large human groups begins.**
- **It is safe to assume that simulation can allow us to query in a consistent and possibly precise way many aspects of the current configuration and trajectory of reality as modeled, which can be very useful input for further analysis.**

New slide

# The simulation is not the analysis

New slide

- **Analysis draws in more information than the outcome of a simulation can give**
- **Analysis also includes all aspects of reality not covered by models used**
- **Analysis can raise questions and issues that can be tested through tailored simulations, to better understand consistency with the model, to gauge system behaviour in the case studied, or for testing analysts' assumptions.**
- **Simulation can enrich analysis by revealing effects, behaviours and correlations a human mind wouldn't generate**
- **Just as classical statistics, model-based simulation supports analysis, but in a more responsive way.**
- **Yet simulation is not analysis.**

New slide

# Analysis is not decision

New slide

- **Analysis doesn’t make decisions; it helps identify and evaluate options.**
- **Decision remains purely human, the “irrational” choice made once rational analysis is exhausted.**
- **Model-based simulation feeds and informs analysis, possibly through a dialogue between analysts and modelers, though modelers are only one of the analysts’ partners.**
- **Simulation seen as a form of measurement allows a richer understanding and analysis, especially of a complex reality, than could still statistics.**

New slide

**Some system design parametres:**

- **Number of elements**
- **Granularity / size of elements**
- **Coverage of system / model (area covered, sample or census)**
- **Precision of element description**
- **Detail of element description**

**Sophisticated enough**

- **To be fit for purpose**
- **For sufficient time horizon**
- **For flexibility / versatility**
- **For reliability**
- **For detail of output**

**VS.**

**Simple enough**

- **To be feasible**
- **To be computable**
- **To be affordable**
- **To be fast enough**
- **To be understandable**
- **To be trustworthy**
- **For data timely availability**

**The San hunter shoots his arrow, kills the prey.**

**His senses are sufficient.**

**He doesn't need measurement.**

**The pilot of a night flight sees airport lights,**

**Yet he needs measurement of altitude, speed, etc. to land safely.**

**His senses need to be augmented through measurement.**

**Our senses don't perceive finance at all,**

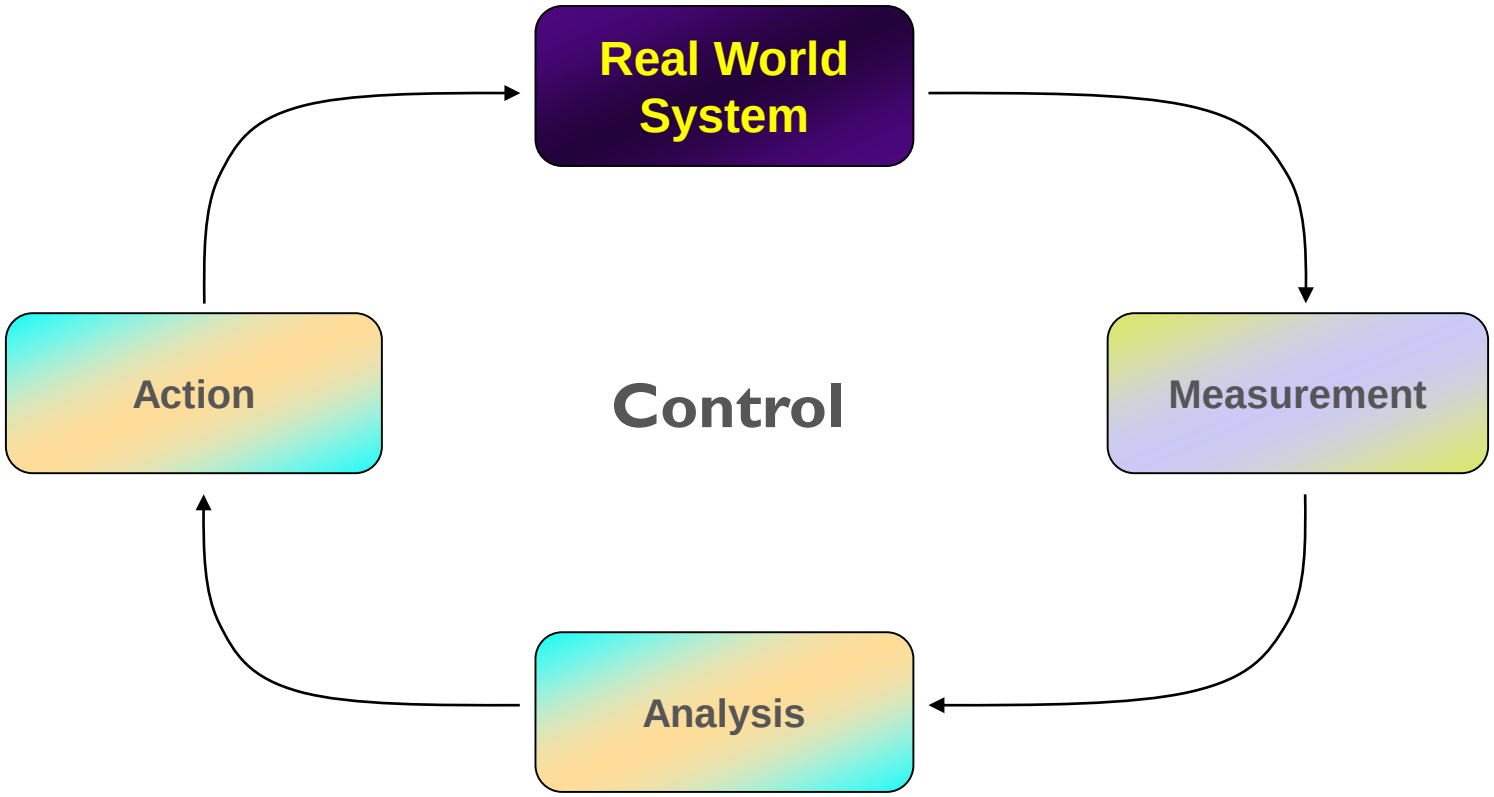
**We need artificial senses.**

**We need measurement, i.e. statistics, and more.**

# Measurement as augmentation of our senses

- **Measurement augments our senses where they don’t suffice for the purpose**
- **Measurement is the production of information that augments our senses**
- **Simulation through a system / model is measurement of a more complex type**

# What do we measure for?




- **Measurement is a necessary condition for control**
- **Effective measurement must be at a scale relevant to the system measured**
- **For modern finance, the relevant scale is global, relevant speed is real time.**

**What systems**

**to**

**represent finance and the economy**

**for**

**measurement and analysis**

**?**

# Design challenge for the architecture of a measurement system

**Real-world**

**Heterogeneity**

**in**

**Languages**

**Data practices**

**Technical systems**

**Legal systems**

**Cultures**

**VS.**

**Technology-driven**

**Need for Homogeneity**

**in**

**Language**

**Data practices**

**Technical systems**

# What vision of finance and the economy on which to design a measurement system?

**Vision 1**

A set of

**Closed Systems**

(national economies)

**with**

**Perturbations**

(international trade and investment)

**VS.**

**Vision 2**

**A Global Network**

of

**Contracts**

among a

**Global Population**

of

**Agents**

# Vision 1: Closed systems with perturbations

**A set of closed systems (national economies) perturbed by international trade and investment, baked into current law and statistical systems (SNA, BPM6, BD4)**

- **Diverse local statistical practices and data practices**
- **Aggregation in successive stages**
- **Global groups & supply chains are broken down and aggregated up again**
- **Slow**
- **Inflexible**
- **Poor analytics (e.g. drill down, views on global groups, markets, processes)**
- **Decays as perturbations grow, i.e. with globalisation & digitisation**

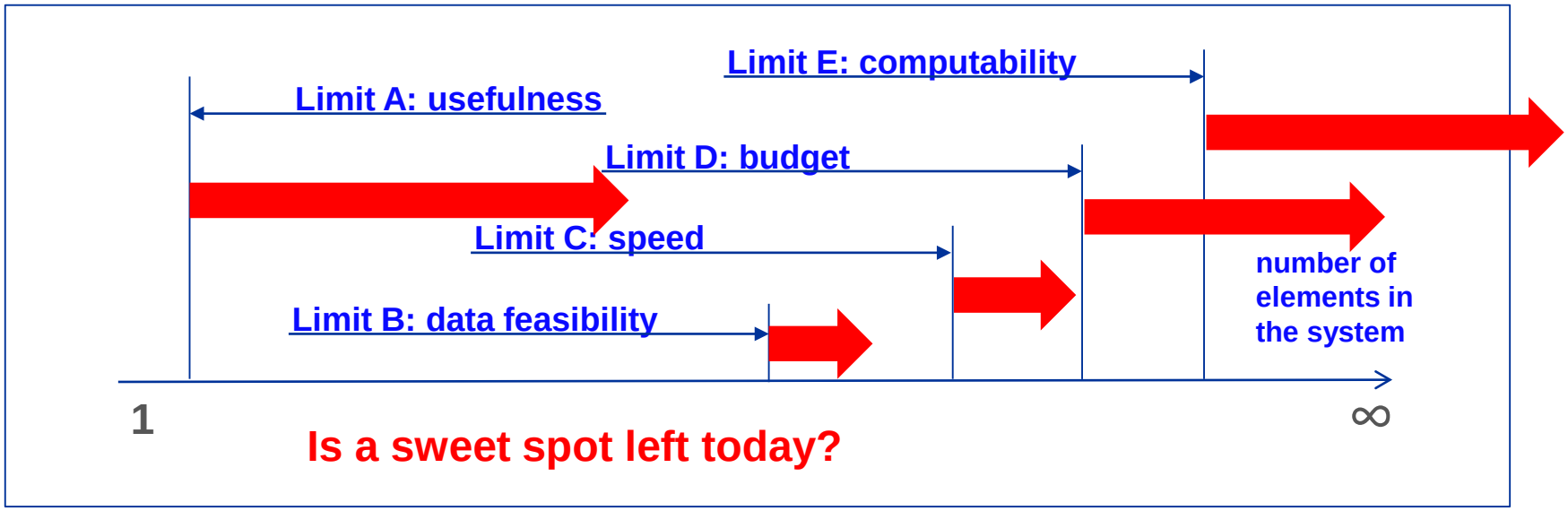
**Heterogeneity of the real world is reflected, integrated measurement suffers**

# Vision 2: A global network of contracts among a global population of agents

- **A global population of parties**
- **A global population of contracts as relationships among those agents**
- **Can in principle cover the whole formal economy**
- **Requires standardised ID of parties and contracts, globally**
- **Allows multiple aggregations: national, corporates, markets, contract types, etc.**
- **Promises fast flexible drill-down and analysis, and timely reaction to surprises**
- **Requires re-thinking and adjusting some of the legal environment**
- **Suited for a global, digital environment**
- **Could start from easy core and grow in depth and coverage**

**Fast, integrated measurement; yet culture change and technical learning are needed**

# Limits to system / model design changed through globalisation & digital explosion




**A: Much larger systems / models are needed to compute much larger amounts of more granular data to simulate more turbulent, large-scale situations**

**E: Computing power has increased tremendously**

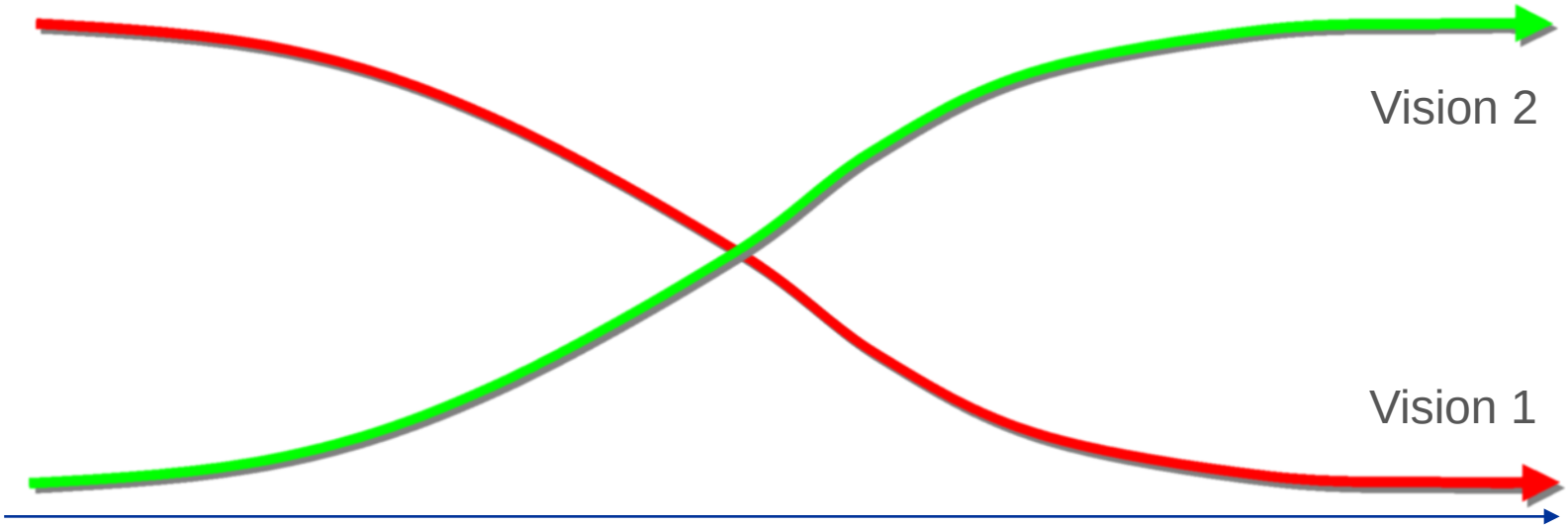
**D: Cost of computing power is much lower: budgets can go much further**

**C: Data collection has accelerated, but much less than technology and the real-world markets**

**B: Data feasibility (availability, quality) has progressed little while needs exploded and sources multiplied, leading f.i. to "mapping hell"**

# Gradual shift from Vision 1 to Vision 2

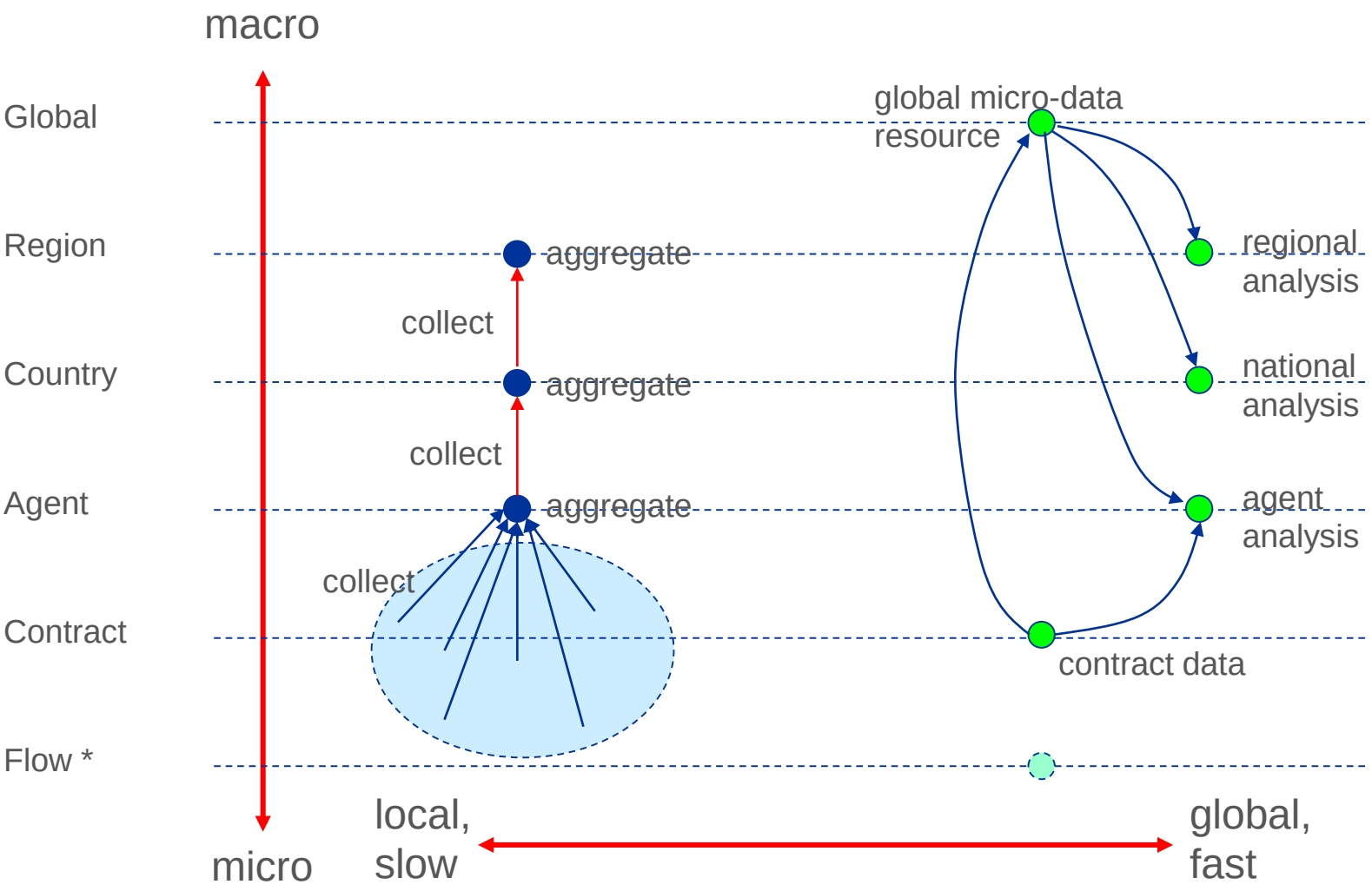
- **Spread awareness of the two approaches, of benefits and risks**
- **Design implementation solutions with specific populations of agents and types of contracts, in the private and the public sector**
- **Ensure learning from initial steps to build subsequent ones**
- **Need to build political will and stakeholder consensus to get started, if needed with backing by regulation, f.i. “digital infrastructure” legislation.**



## Chapter

2. A conceptual architecture of the measurement system and its necessary infrastructures, including LEI and ACTUS

# Micro has become relevant for understanding macro




- **Ideally, global micro-data resource built from standardised operational data**
- **All macro data derived from same global micro-data resource gives consistency**

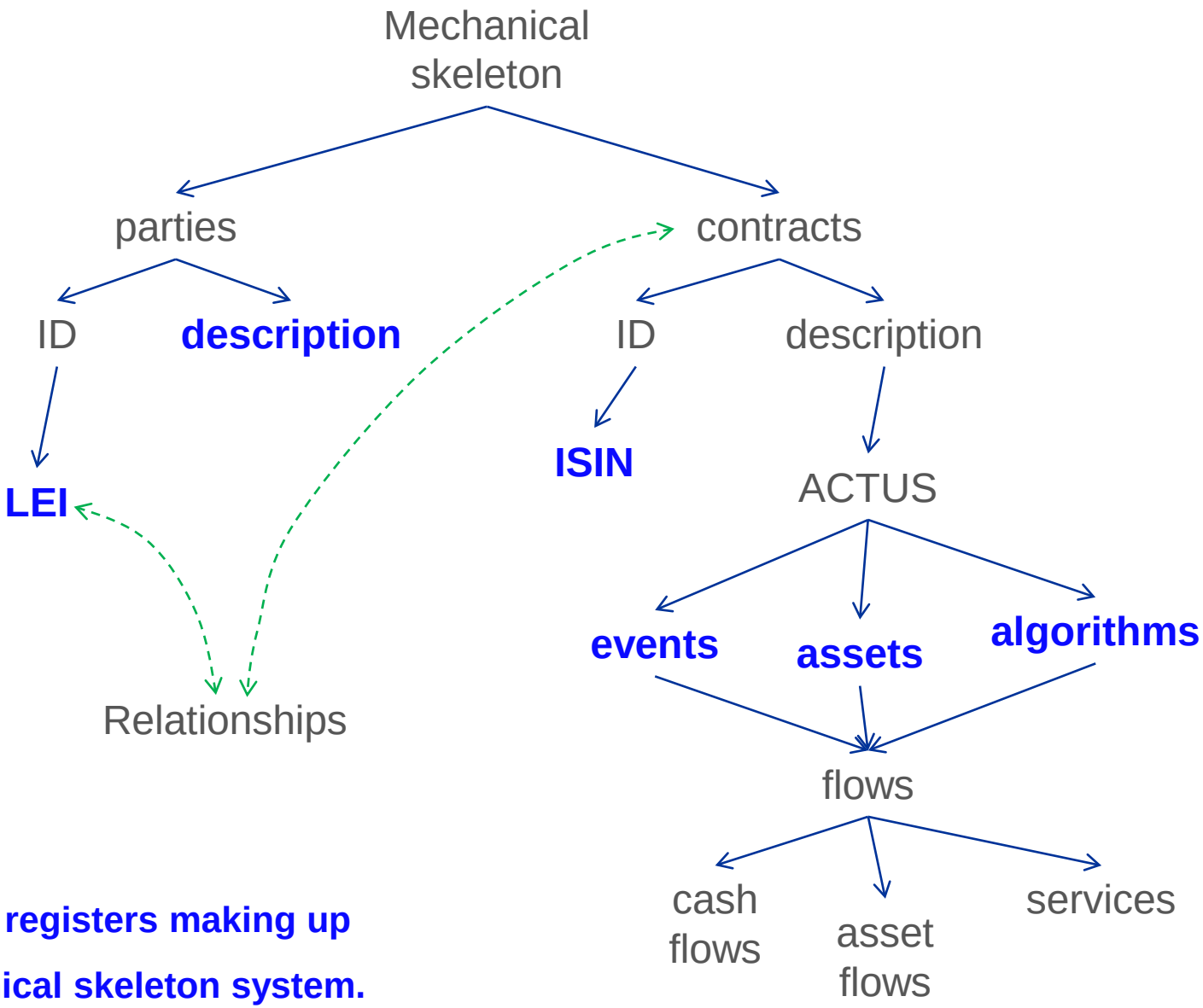
* cash, goods, services

# Systems needed for models of finance and the economy, examples

- **Network of agents and contracts: the mechanical skeleton**
- **Accounting system**
- **Markets, exchanges, transactions**
- **Corporates, industries, sectors**
- **Currencies**
- **Governments, legal systems, fiscal systems**
- **Physical geography, etc.**

- **The skeleton made of agents and contracts seems central to or underlying many of the models that will be used to measure finance and the economy.**
- **Its components are easier to identify in a unique, consensual way as they are anchored in the laws that govern their creation and existence.**
- **It can be used at lower granularity, but must be available at highest granularity**

# Core system: the mechanical skeleton



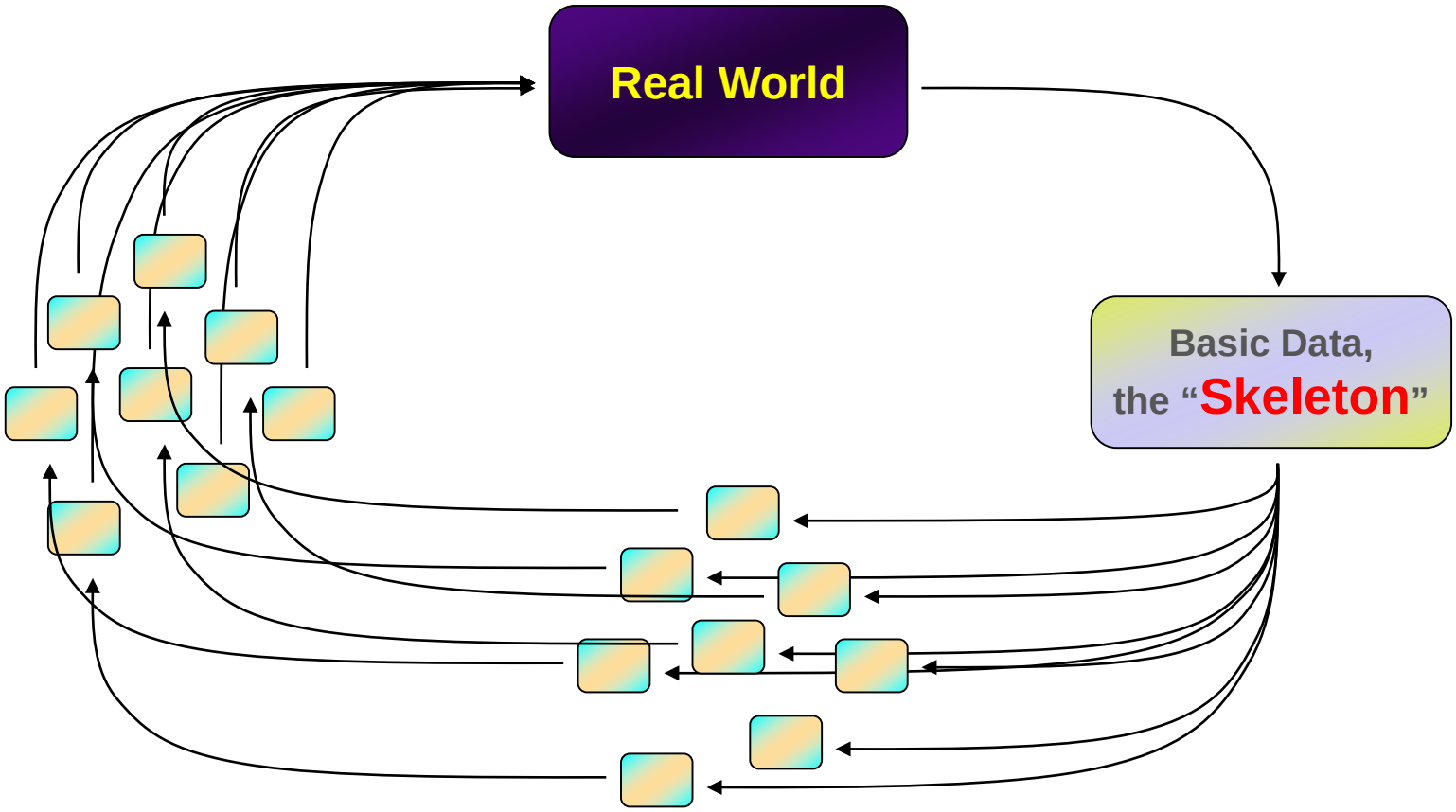

**In blue: registers making up mechanical skeleton system.**

# The substance we measure has changed, so must measurement and operations

**Conceptually, technology could allow all to run operations and administration, and to build national, local, sectoral or corporate measurement from a single "micro-level data world at skeleton level"**

**if it is well organised.**

## All control cycles share the same real world
## They should share the same basic object-level data




**Goal should be that the same basic "skeleton" of object-level data is used by all, be it in operations, administration or measurement.**

# The “mechanical skeleton” of finance

- **All market participants registered**
- **All contracts registered**

- **Unique, standardised identifier**
- **Basic reference data**

- **All data current and accurate**

- **Public good in a global infrastructure**

**Further steps:**

- **Each contract represented as an algorithm**
- **Extension to non-financial contracts**

# First successful, concrete steps have been taken

- **LEI**
  - **The Global Legal Entity Identifier System is a reality**
  - **Nearly 450.000 entities registered worldwide**
  - **Registers entities and relationships among them**

- **ACTUS**
  - **Algorithmic Contract Types Unified Standard**
  - **Describes financial contracts in a rigorous language**
  - **Computes contract cash flows, driven by event scenarios**

- **Where next? “Every contract is a relationship among parties”**
  - **LEI has potential to picture the “mechanical skeleton”**
  - **ACTUS has potential to extend it a level deeper: to flows**

# LEI and ACTUS are a good start for more

- **Could be the data infrastructure of the Mechanical Skeleton of Finance**
- **Need regulatory push to reach critical mass**
- **On the way to global, universal coverage.**
- **It could enable a cascade of further, market-driven change.**
- **Just as bar code changed supply chains > industries > economies**
- **This impulse could trigger the system to reconfigure with its own energy**

**LEI and ACTUS**

**could unfold**

# TRANSFORMATIONAL POWER

# A possible strategy for measurement (1)

**Improve measurement by:**

- **Moving data reduction closer to the measurement output**
- **Using micro-data in much larger volumes and**
- **Using large-scale IT and increasing automation**

# A possible strategy for measurement (2)

**As immediate enabling steps, move upstream to better basic data by:**

- **Forging alliances across stakeholder groups to**
- **Create standards for reference and other basic data and to**
- **Build a globally shared data infrastructure**
- **Backed by a public sector infrastructure strategy**
- **Including legislation for a digital infrastructure**

## A new positioning for measurement?

- From “HUNTER-GATHERERS” of data
- To interdisciplinary “DATA FARMERS”

Measure the world better by making it easier to measure and at the same time help it to work better!

**Is it ethically acceptable to influence the system we measure to make it more measurable?**

Classical wisdom says:

- Measurement should not influence the phenomenon measured.

But in reality it always does:

- ‘Observer effect’ in physical systems.
- Measurement guides key decisions, shapes our world. For good or bad!

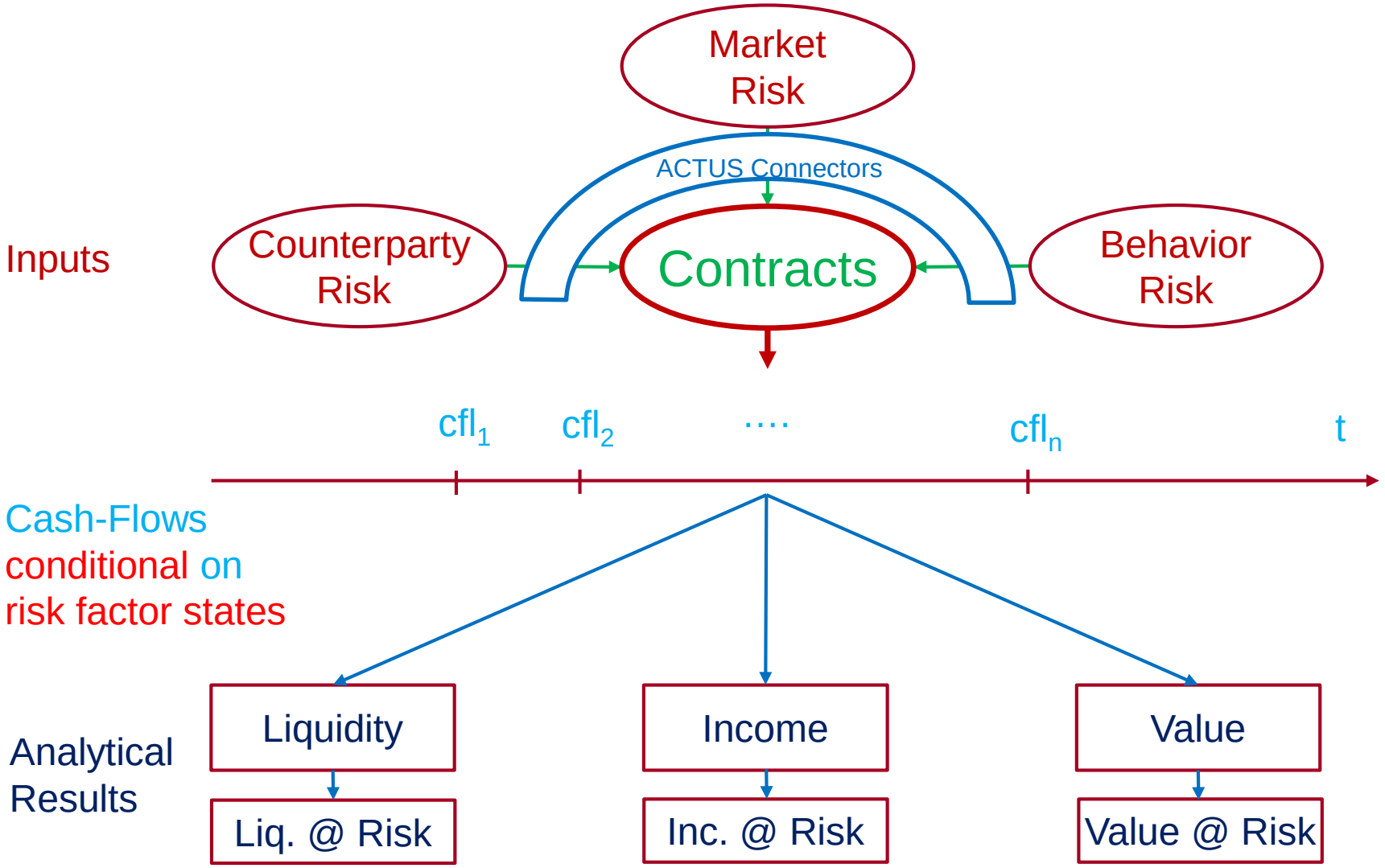
**It seems perfectly legitimate to consider strategies that influence the system measured to make it more measurable.**

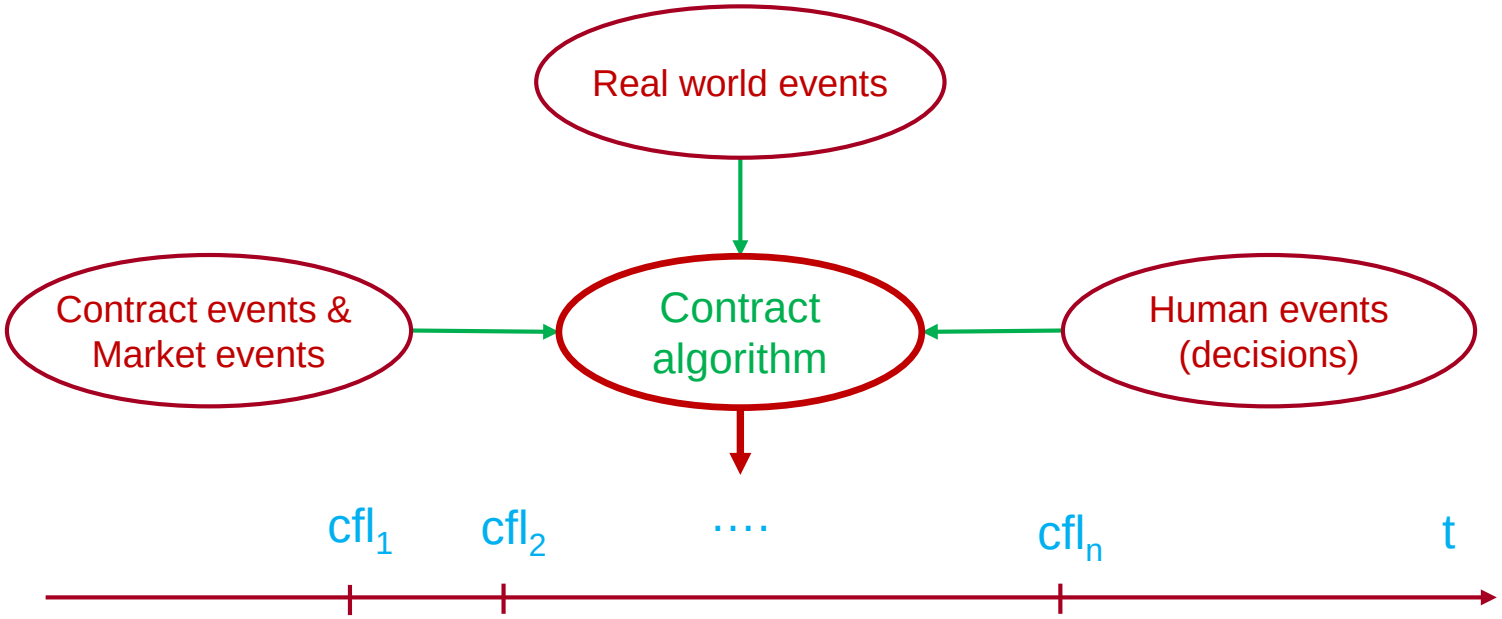
## Chapters

3. An attempt at generalising ACTUS to all types of contracts, beyond finance

# ACTUS Concept: Modeling Logic

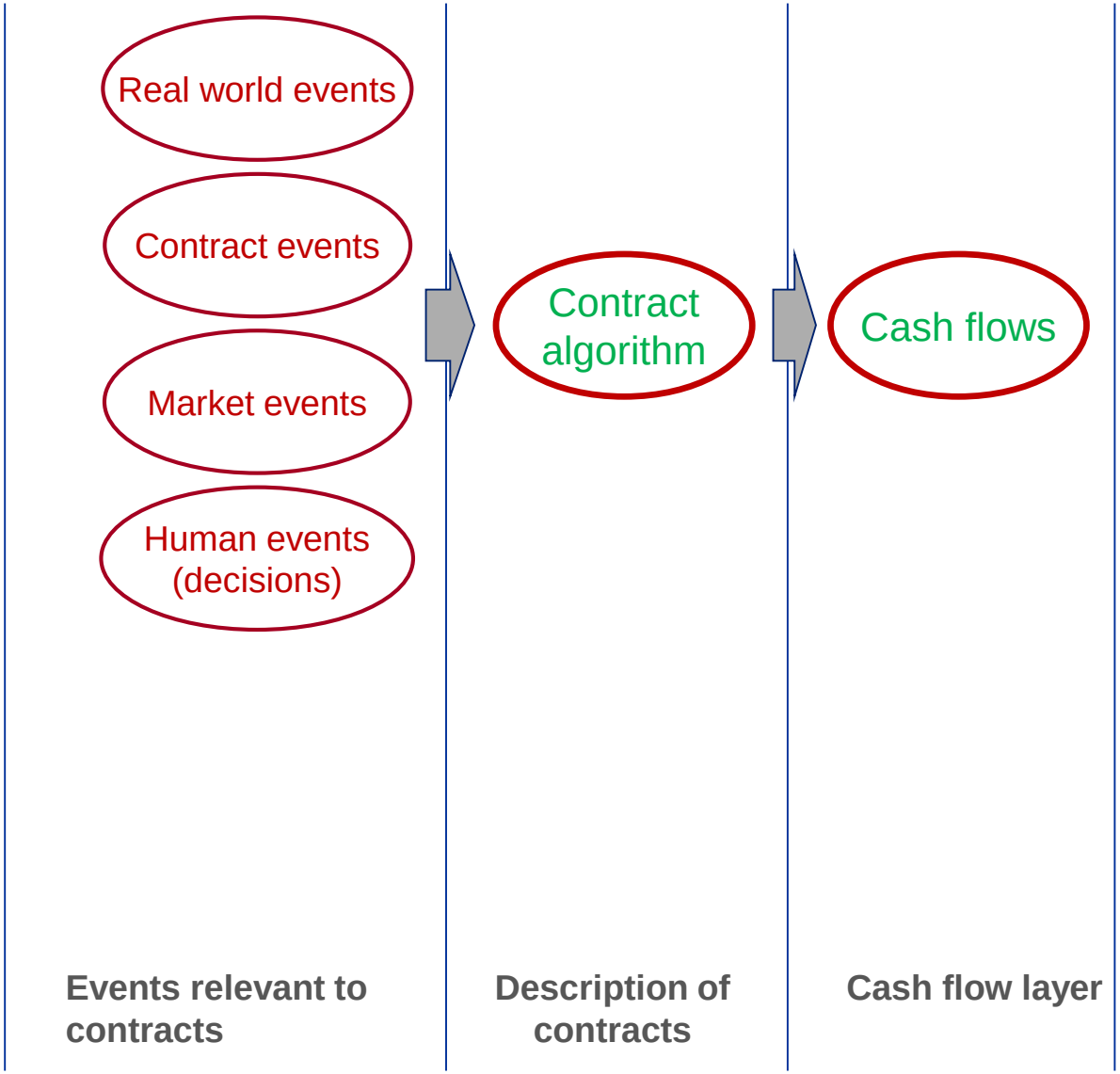
Brammertz, Akkizidis, Breymann, Entin, Rustmann, *Unified Financial Analysis*. Wiley, Chichester, 2009.

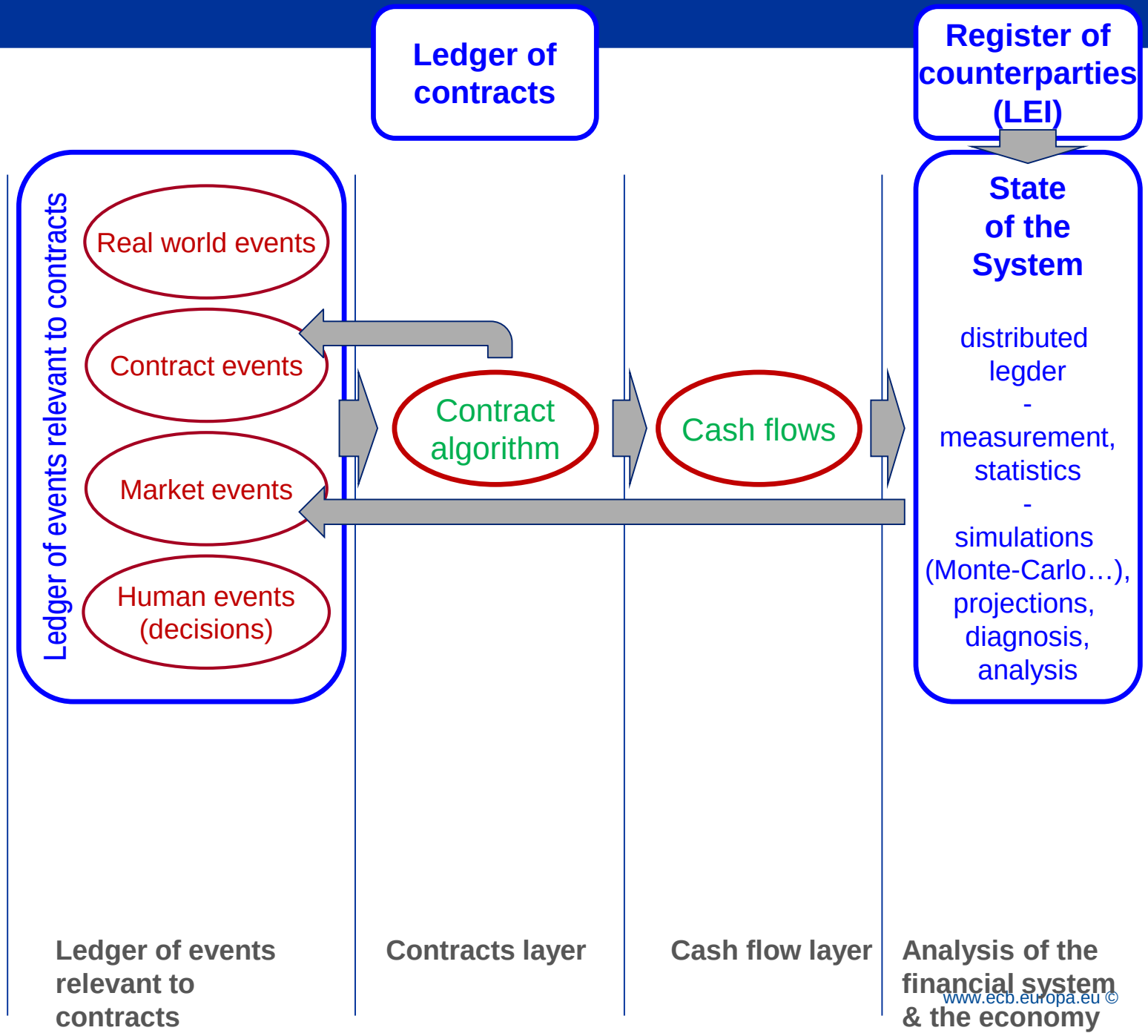


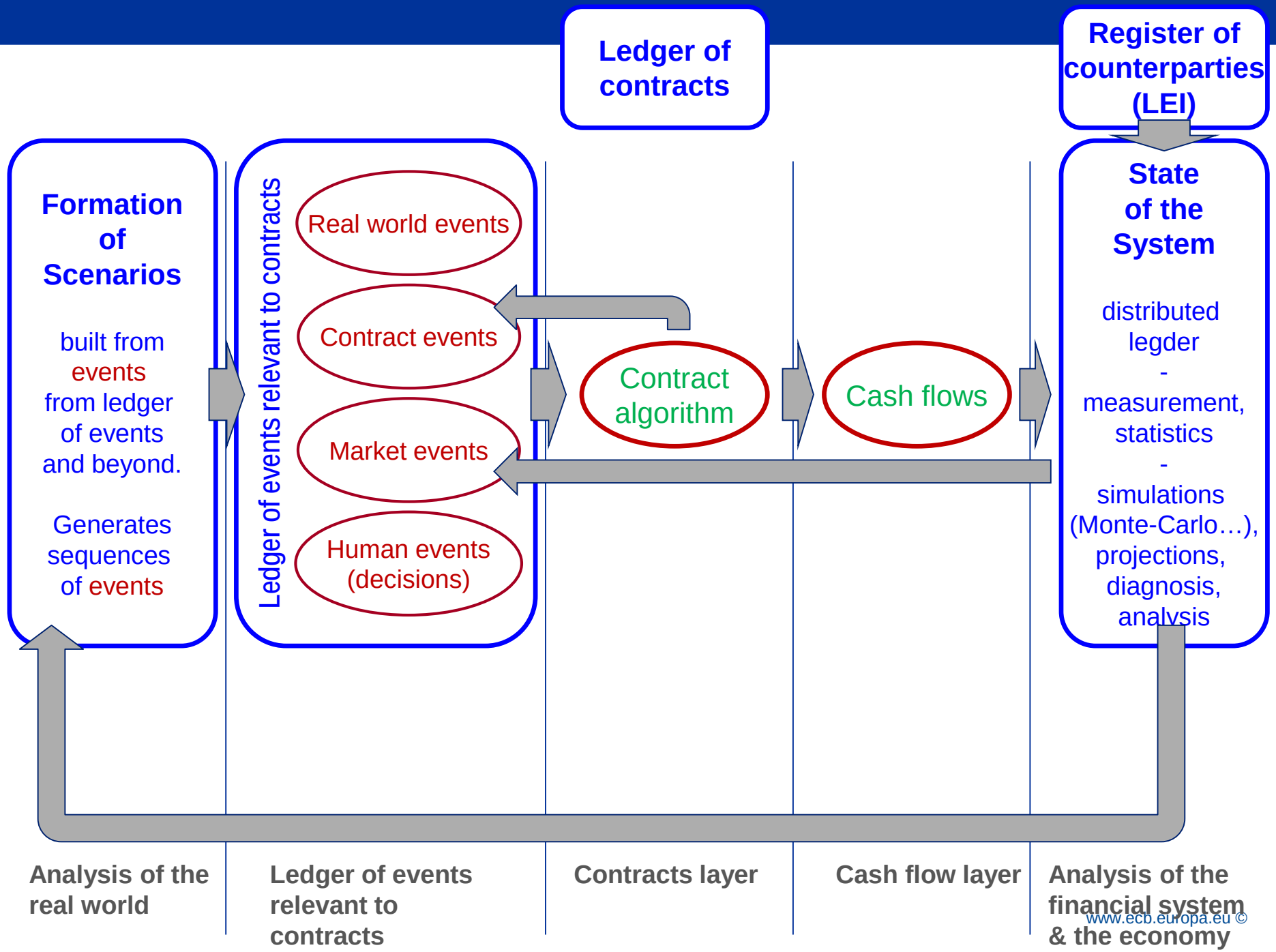



The contract algorithm is executed as a string of cash-flows, conditional on events

Inspired from: Brammertz, Akkizidis, Breymann, Entin, Rustmann, *Unified Financial Analysis*. Wiley, Chichester, 2009.






Ledger of contracts
Register of counterparties (LEI)
Formation of Scenarios
built from events from ledger of events and beyond.
Generates sequences of events
Ledger of events relevant to contracts
Real world events
Contract events
Market events
Human events (decisions)
Contract algorithm
Cash flows
State of the System
distributed legder
-
measurement, statistics
-
simulations (Monte-Carlo…), projections, diagnosis, analysis
Analysis of the real world
Ledger of events relevant to contracts
Contracts layer
Cash flow layer
Analysis of the financial system & the economy
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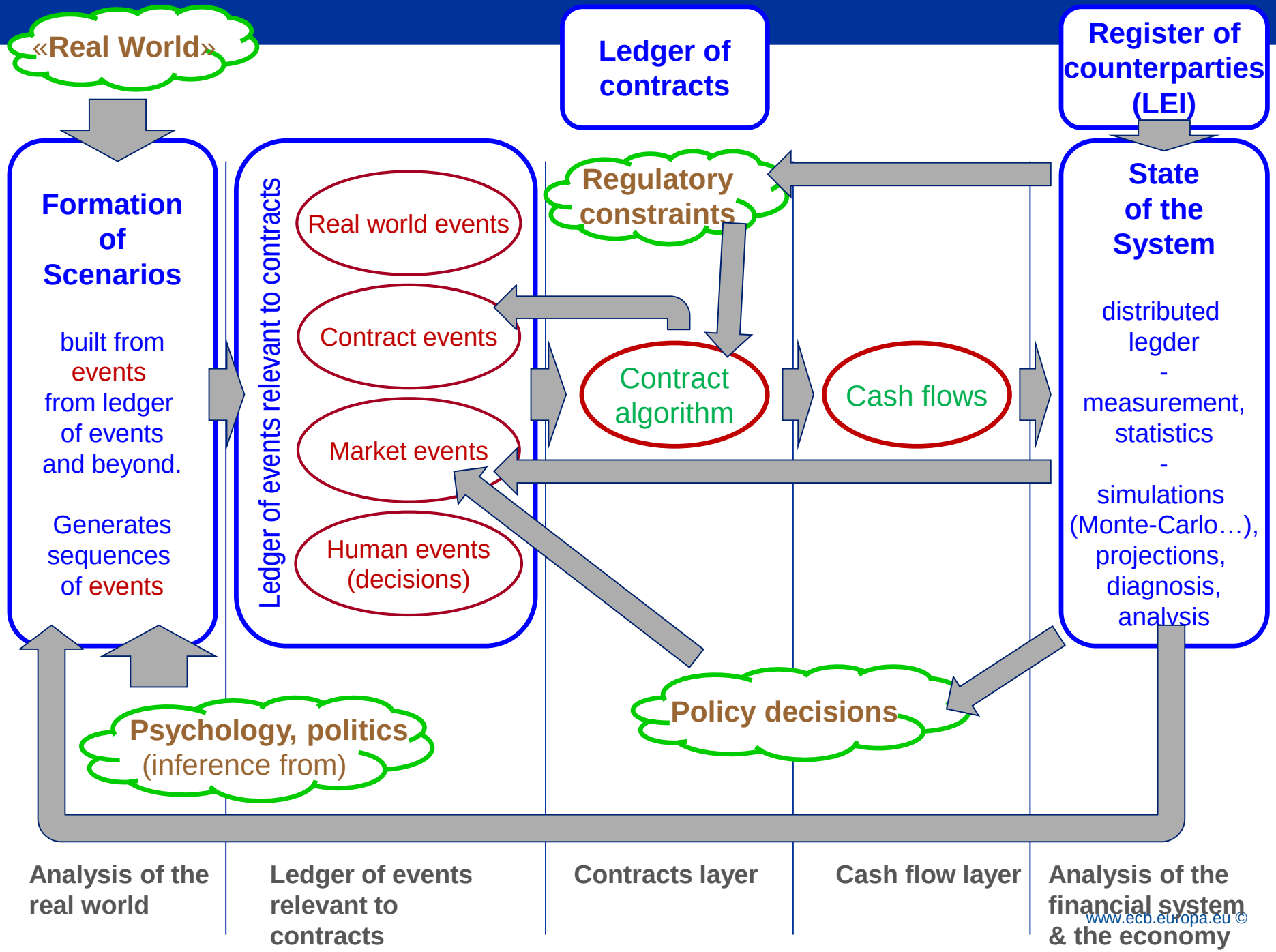

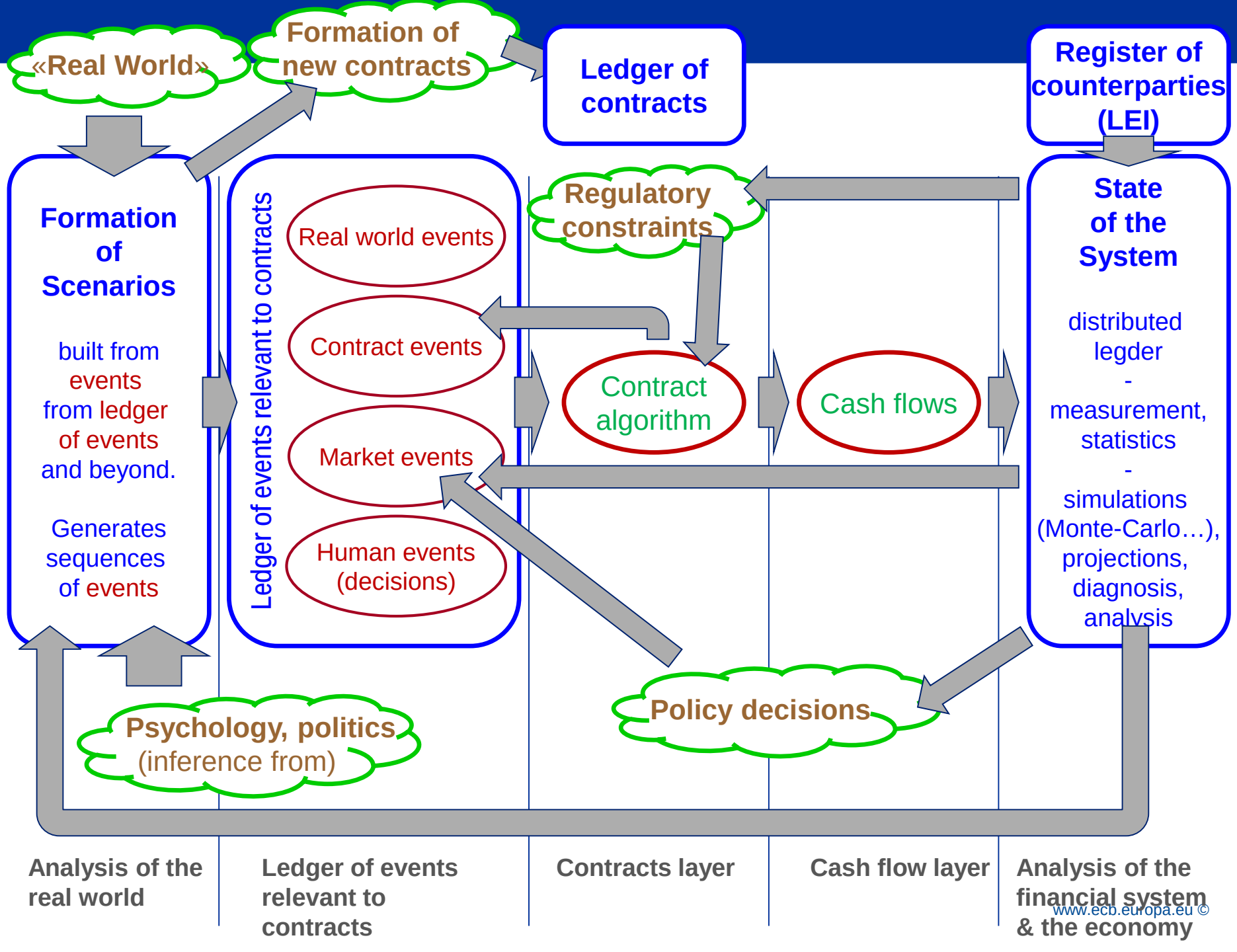
«Real World»
Formation of new contracts
Ledger of contracts
Register of counterparties (LEI)
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simulations (Monte-Carlo…), projections, diagnosis, analysis
Psychology, politics (inference from)
Policy decisions
Analysis of the real world
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Contracts layer
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Analysis of the financial system & the economy
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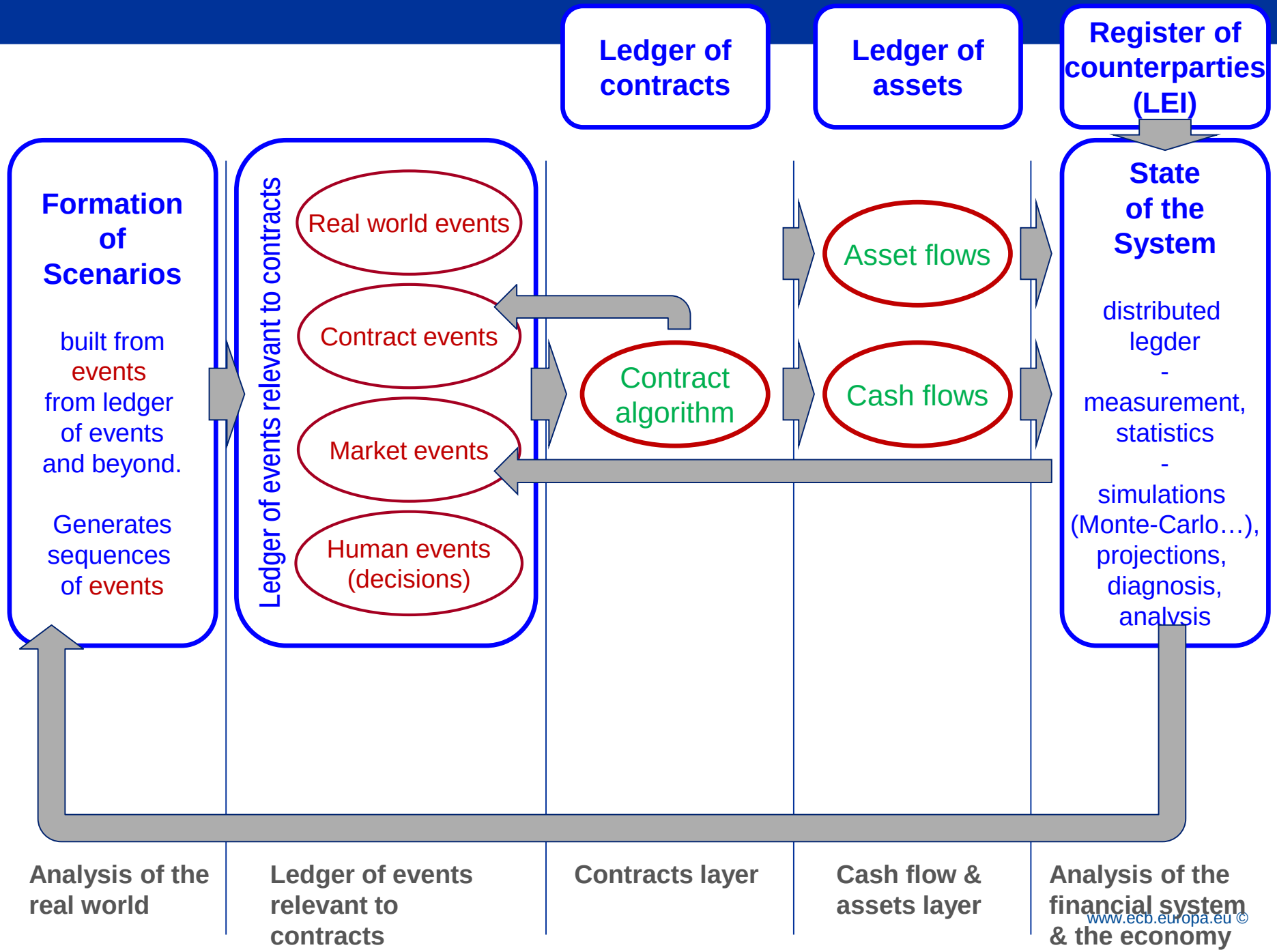

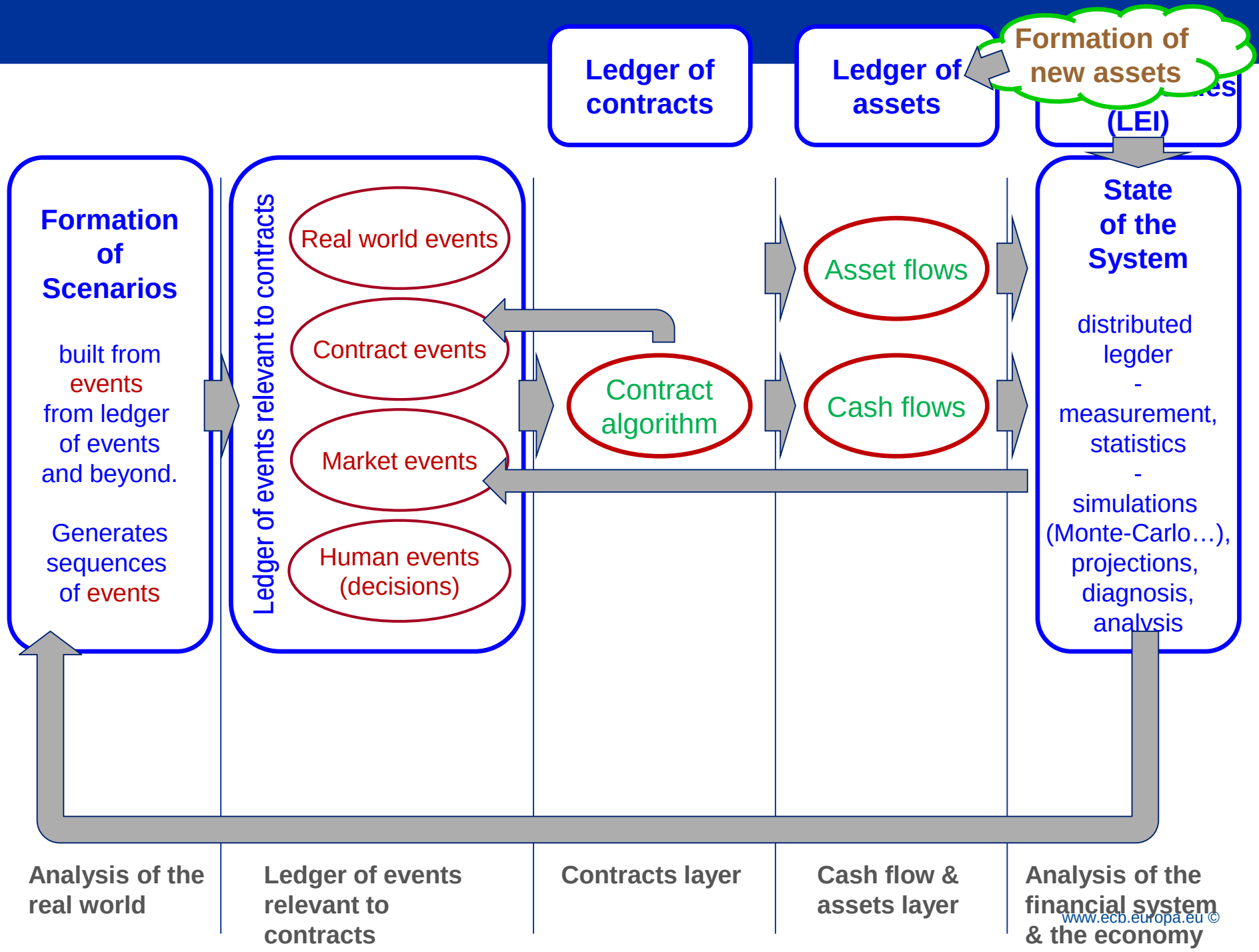

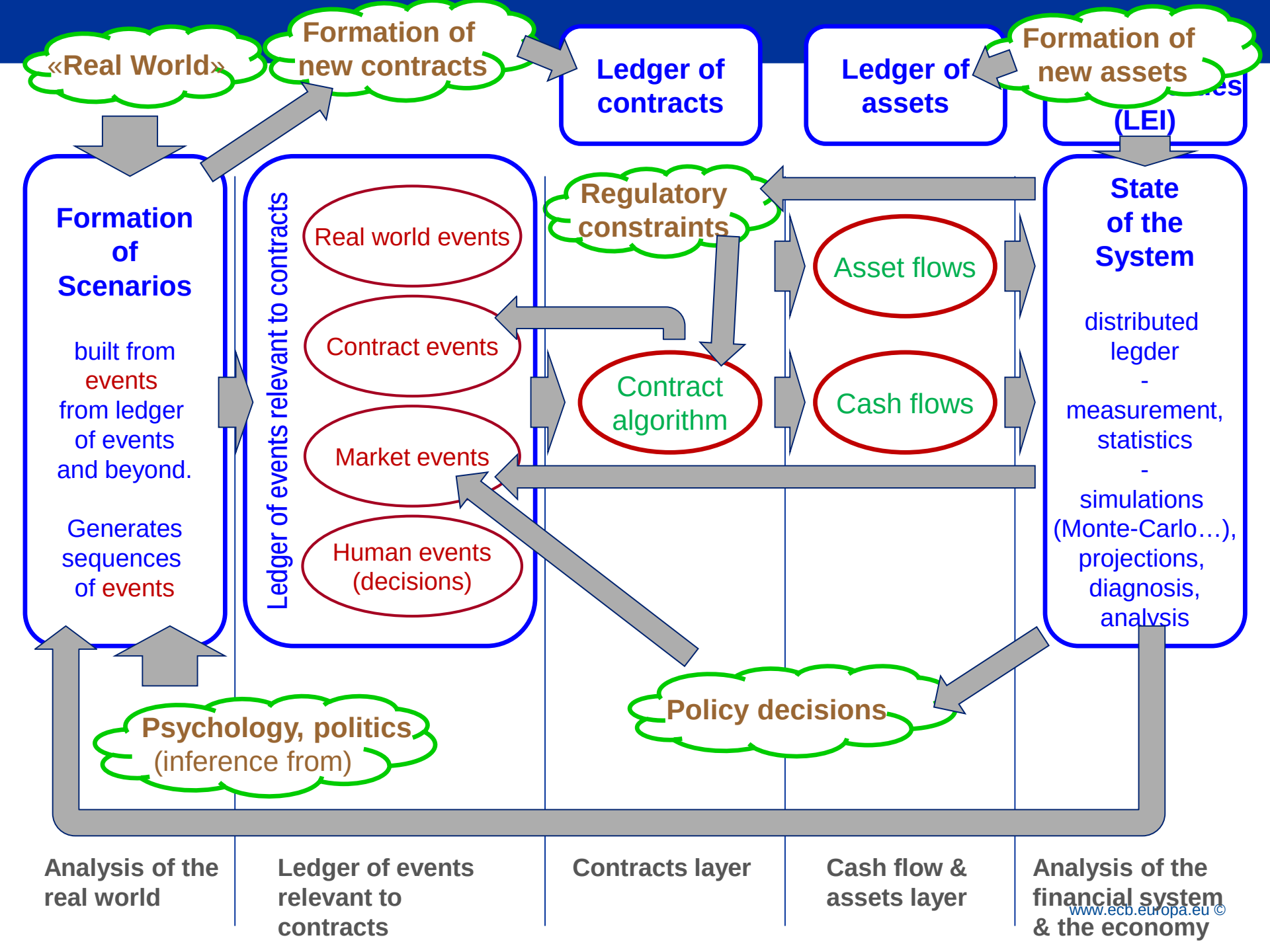

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*Francis Gross*

*Senior Adviser*
*Directorate General Statistics*
*European Central Bank*
*Sonnemannstrasse 22, D-60314 Frankfurt am Main*
*off: +49 69 1344 7513*
*mob: +49 160 746 84 82*
*fax: +49 69 1344 7056*
*email: francis.gross@ecb.int*