Interaction and experiments

Networks are back!

Learning outcomes

Understand the different types of **agent interactions**
Distinguish **equilibria**
Run a **sensitivity analysis**

recap

Nature of agents
List of variables describing their state
List of actions the agents can perform
Structure of their interaction with other agents

} **Agent design**

recap

Nature of agents
List of variables describing their state
List of actions the agents can perform
Structure of their interaction with other agents

Agent design

New, exciting things

Interaction

Traditional economic theory overlooks interactions
Mathematical modelling of interactions is complicated
ABMs are perfect for this

Local vs global

Local if agents interact with “neighbourhood”
If **global**, agents take into account all the population

Exogenous vs endogenous

Exogenous if don’t change over time
Endogenous if agents can choose interactions

Deterministic vs stochastic

Deterministic if interactions are between same agents
Stochastic if interaction involves probability

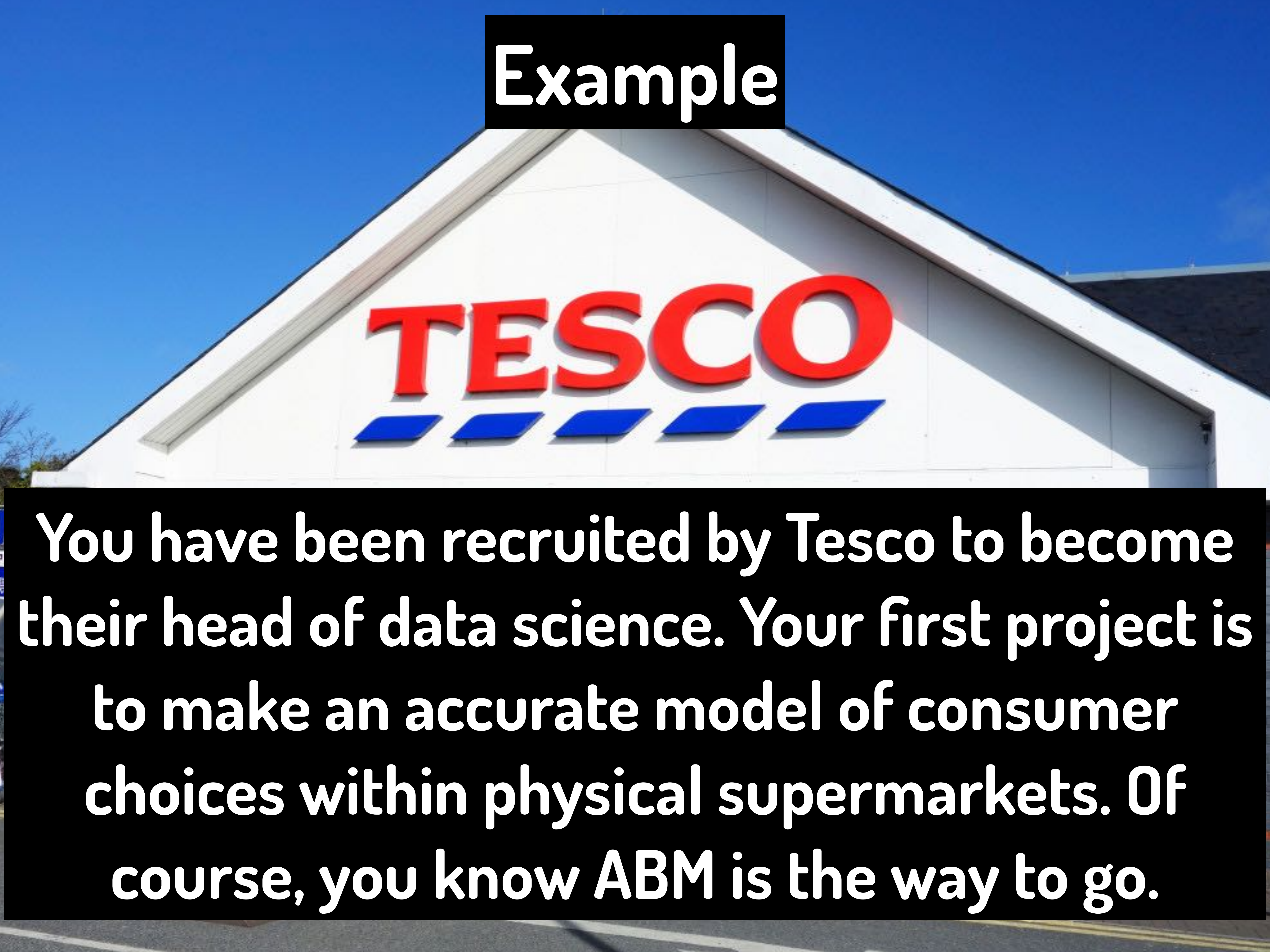
Direct vs indirect

Direct if agents are affected directly by interaction
Indirect if interactions affect model only (but the model affects the agents somehow)

Networks

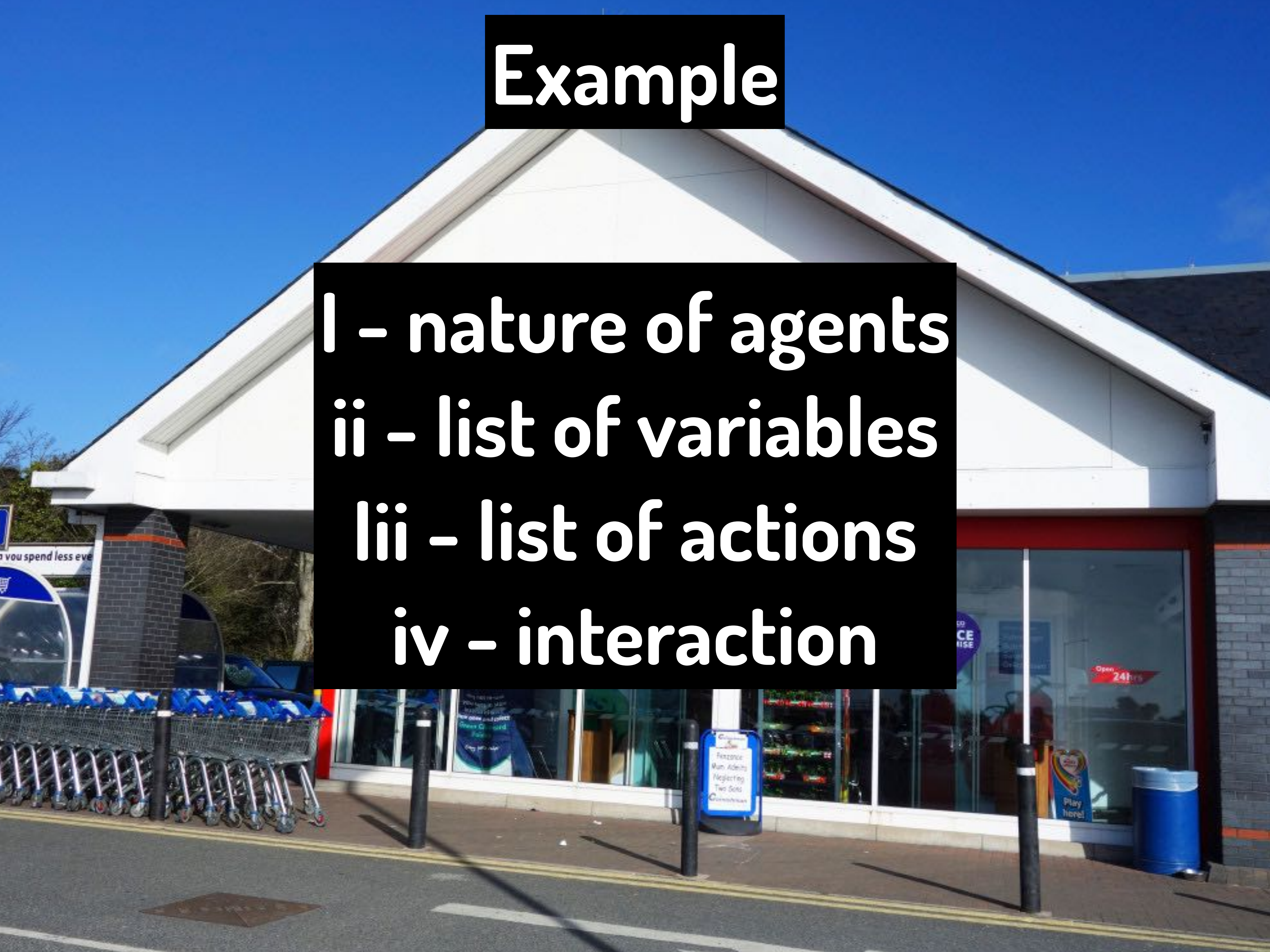
Most direct interactions are modelled by networks

Example



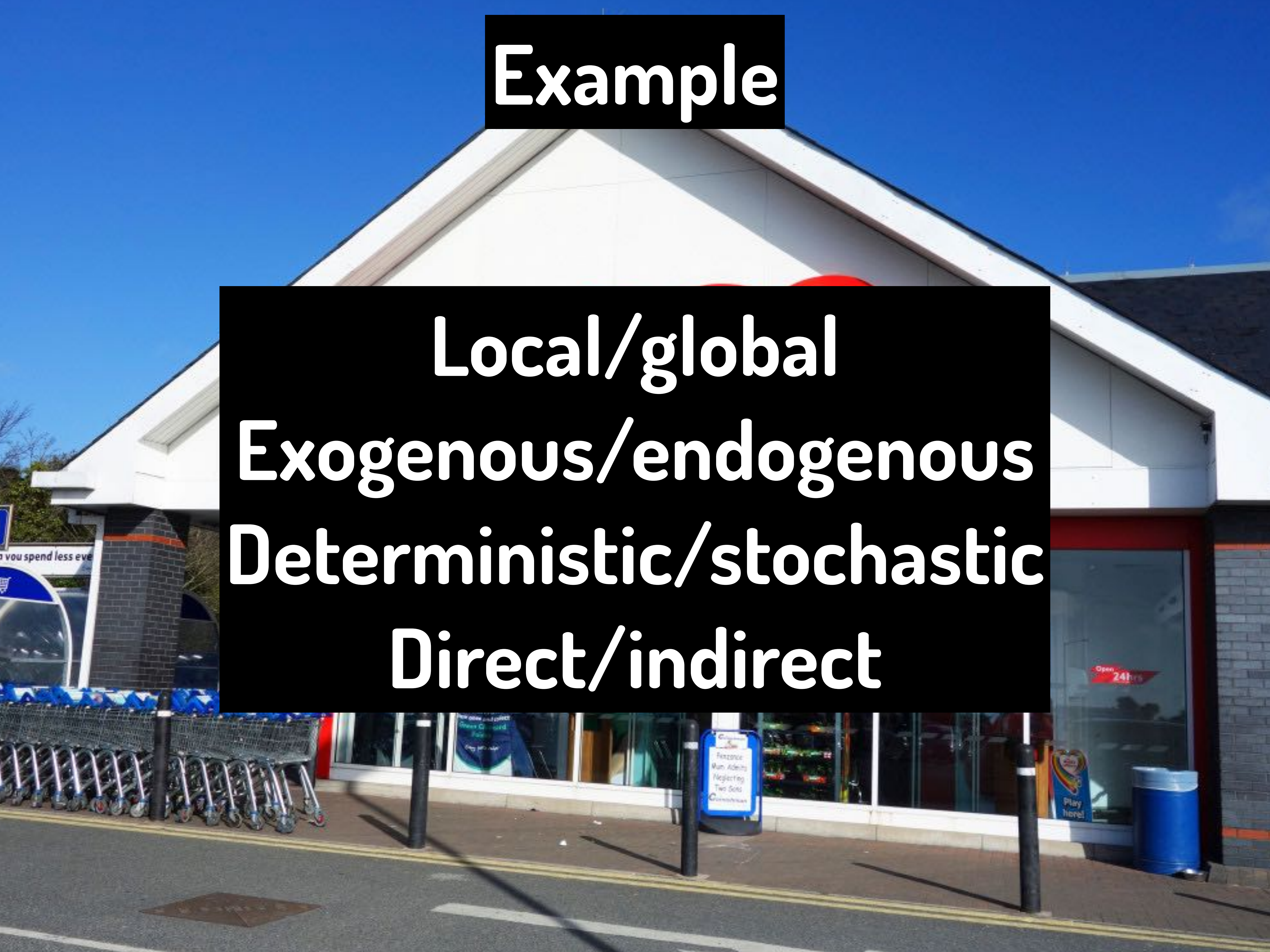
You have been recruited by Tesco to become their head of data science. Your first project is to make an accurate model of consumer choices within physical supermarkets. Of course, you know ABM is the way to go.

Example



I - nature of agents
ii - list of variables
Iii - list of actions
iv - interaction

Example



Local/global
Exogenous/endogenous
Deterministic/stochastic
Direct/indirect

The ABM experiment

Because of their complex nature, often we don't know what to expect from ABMs. We need to study the output of our own model to gain insights into the system.

Equilibrium

Equilibrium in ABMs can only be defined at the **aggregate level**

Equilibrium

Equilibrium in abms can only be defined at the **aggregate level**

Transition equation

$$X_{t+1} = F(X_t, \theta, s)$$

Measurement equation

$$y_t = m(X_t, s)$$

$$\boldsymbol{X}_{t+1} = \boldsymbol{F}(\boldsymbol{X}_t, \boldsymbol{\theta}, \boldsymbol{s})$$

State of agents at time t+1

$$\boldsymbol{y}_t = \boldsymbol{m}(\boldsymbol{X}_t, \boldsymbol{s})$$

Function of agents

$$\boldsymbol{X}_{t+1} = \boldsymbol{F}(\boldsymbol{X}_t, \boldsymbol{\theta}, \boldsymbol{s})$$

State of agents at time t+1

$$\boldsymbol{y}_t = \boldsymbol{m}(\boldsymbol{X}_t, \boldsymbol{s})$$

Function of agents

$$X_{t+1} = F(X_t, \theta, s)$$

State of agents at time **t+1**

State of agents at time **t**

$$y_t = m(X_t, s)$$

Function of agents

Parameters of agents

$$X_{t+1} = F(X_t, \theta, s)$$

State of agents at time **t+1**

State of agents at time **t**

$$y_t = m(X_t, s)$$

Function of agents

Parameters of agents

$$X_{t+1} = F(X_t, \theta, s)$$

State of agents at time t+1

State of agents at time t

$$y_t = m(X_t, s)$$

Aggregate variables at time t

Function of agents

Parameters of agents

$$X_{t+1} = F(X_t, \theta, s)$$

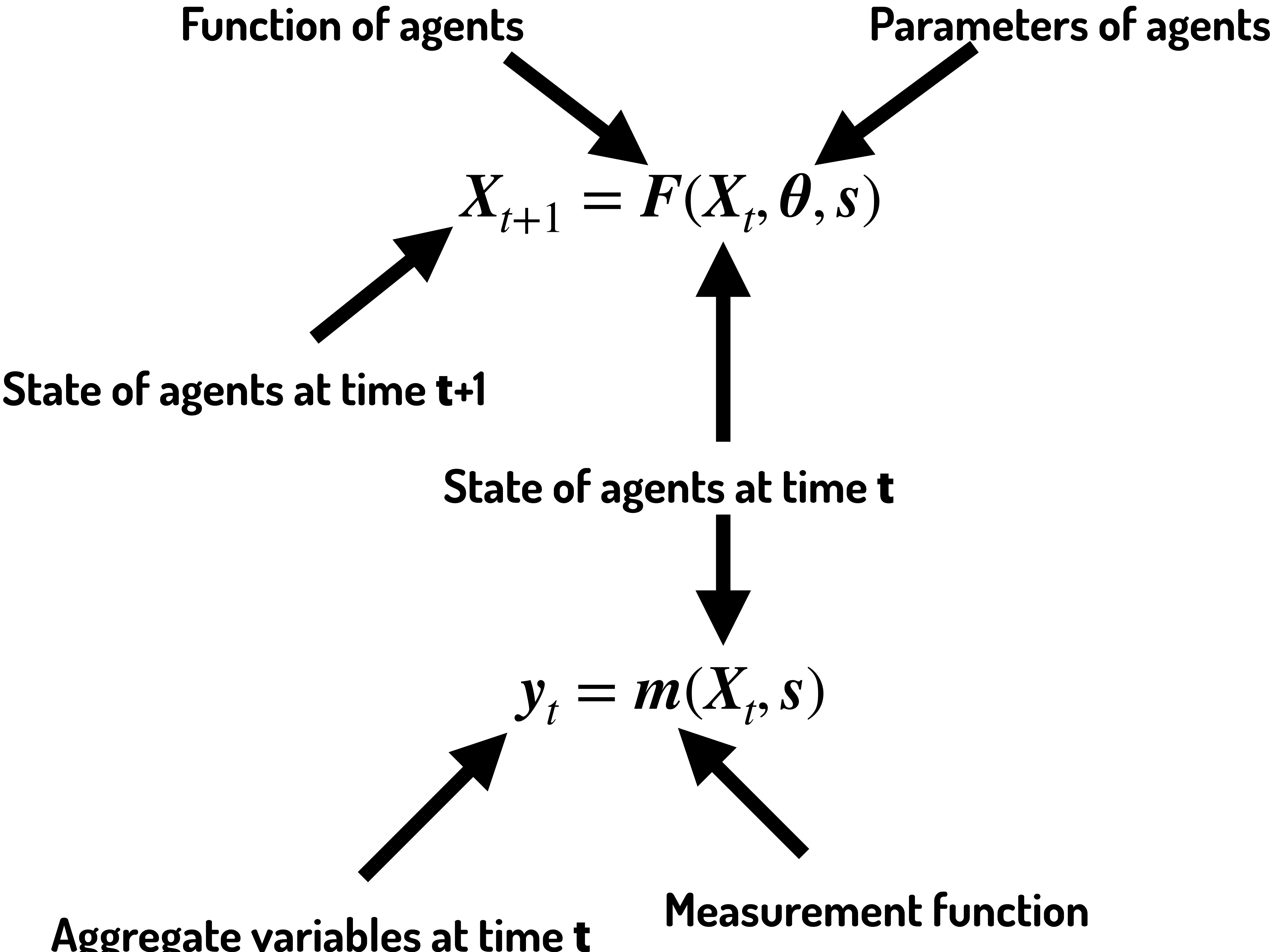
State of agents at time t+1

State of agents at time t

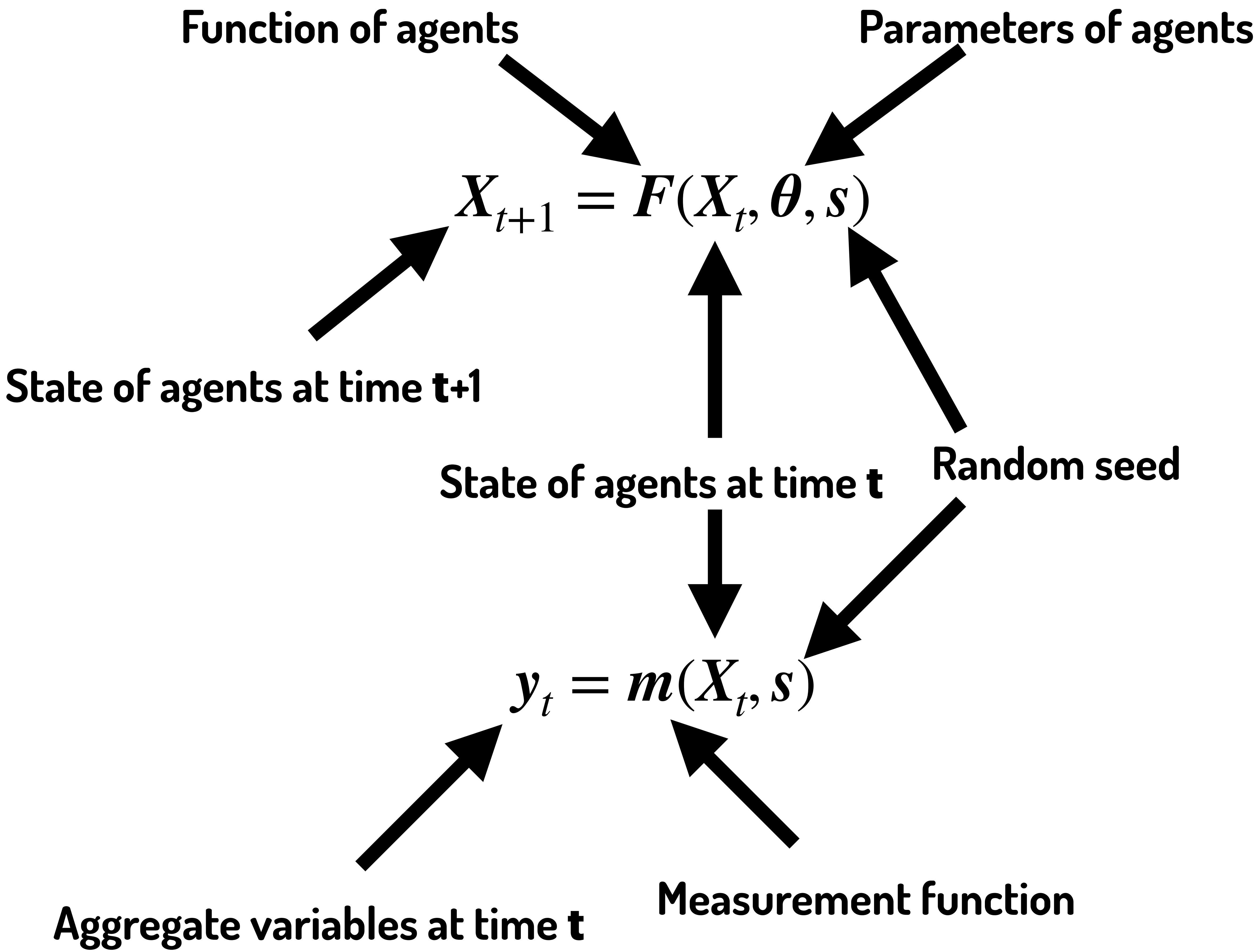
$$y_t = m(X_t, s)$$

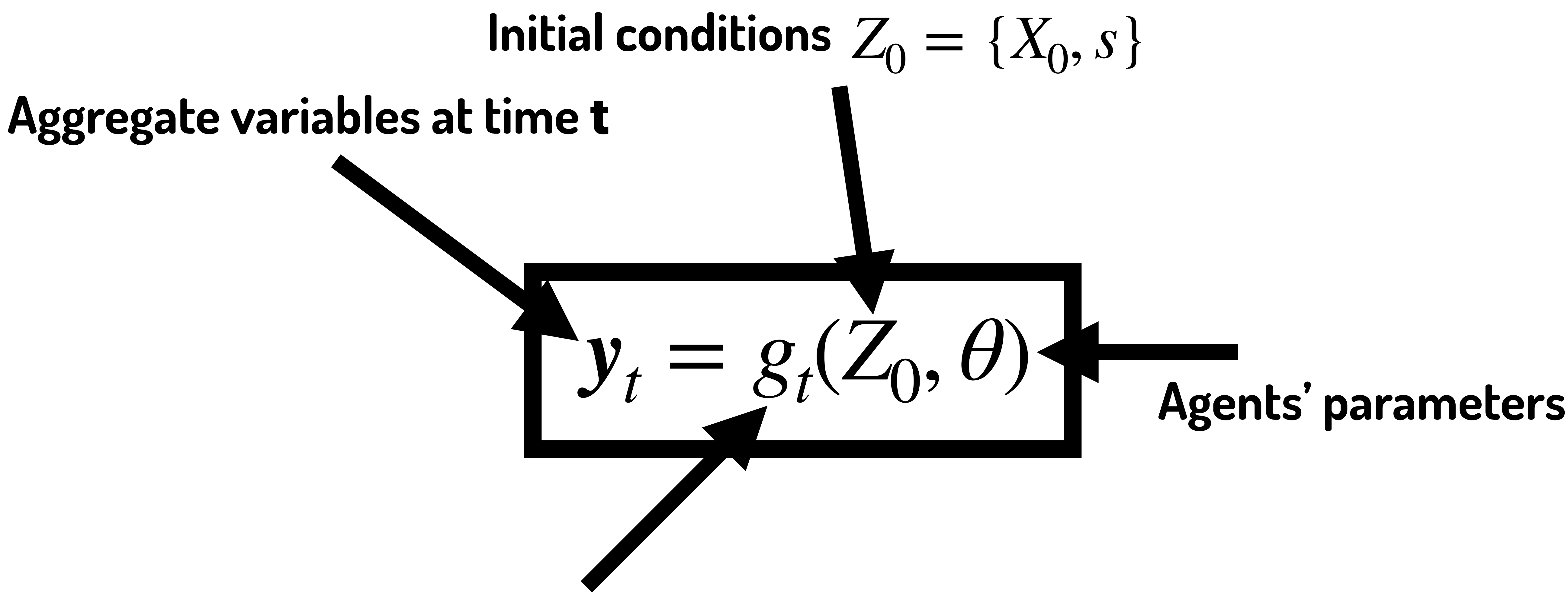
Aggregate variables at time t

Measurement function



Function of agents
Parameters of agents
$X_{t+1} = F(X_t, \theta, s)$
State of agents at time t+1
State of agents at time t
$y_t = m(X_t, s)$
Aggregate variables at time t
Measurement function


Function of agents
Parameters of agents
$X_{t+1} = F(X_t, \theta, s)$
State of agents at time t+1
State of agents at time t
Random seed
$y_t = m(X_t, s)$
Aggregate variables at time t
Measurement function



$$g_t(Z_0, \theta) = m(F(F \ldots (F(Z_0, \theta) \ldots))) = m(F^t(Z_0, \theta))$$

Equilibrium

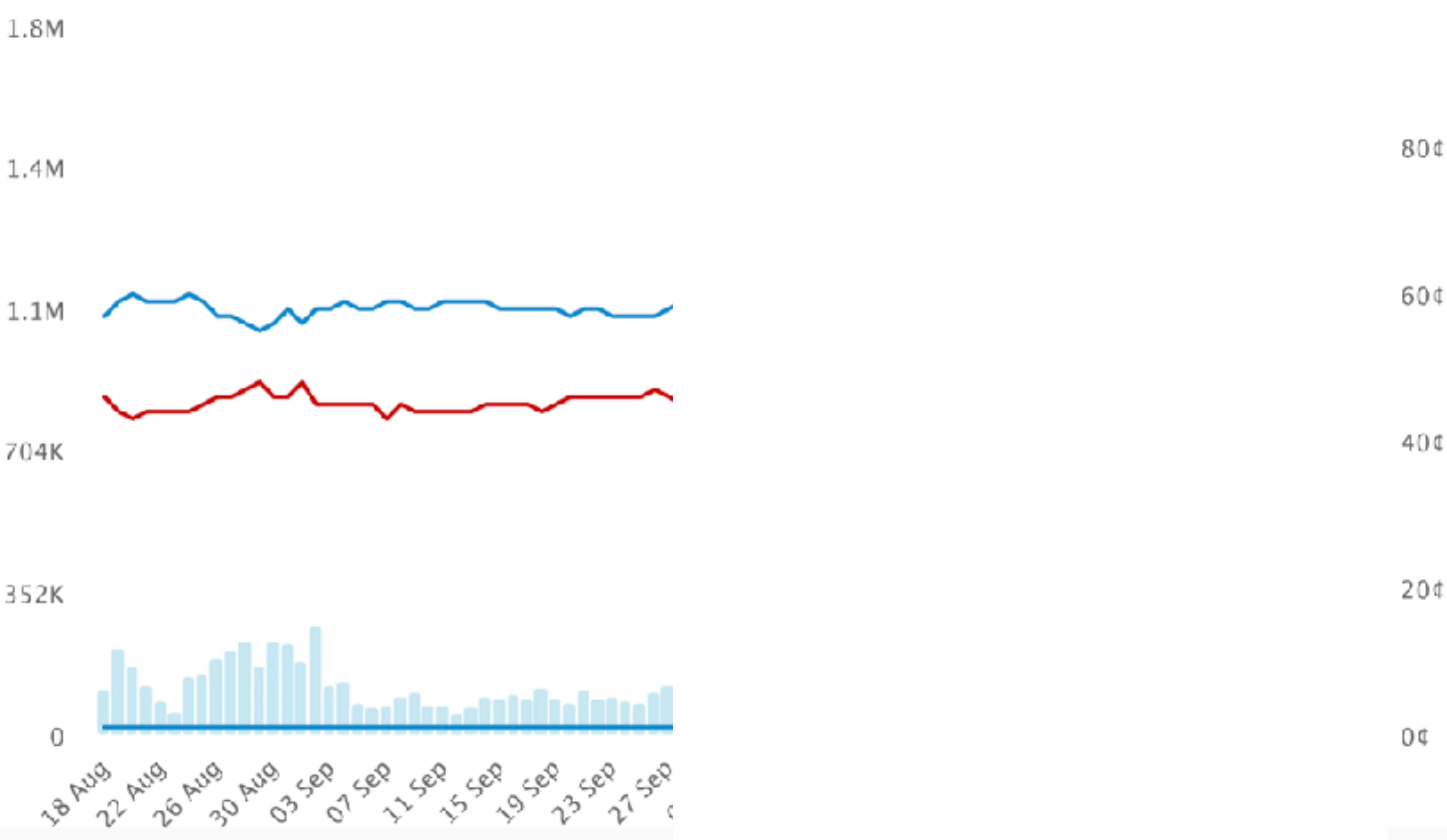
For each **statistics** y_t, if statistical equilibrium is achieved in a given time window $(\underline{T}, \overline{T})$, then y_t is **stationary**

Long-run vs transient Equilibrium

A model is said to have reached **long-run equilibrium** if y_t
Is stationary in $(\underline{T}, \underline{T}+\tau)$, $\tau \to \infty$

An equilibrium is said to be **transient** if y_t
is stationary in $(\underline{T}, \overline{T})$
but no longer in $(\underline{T}, \underline{T}+\tau)$, $\tau \to \infty$

Biden **Trump**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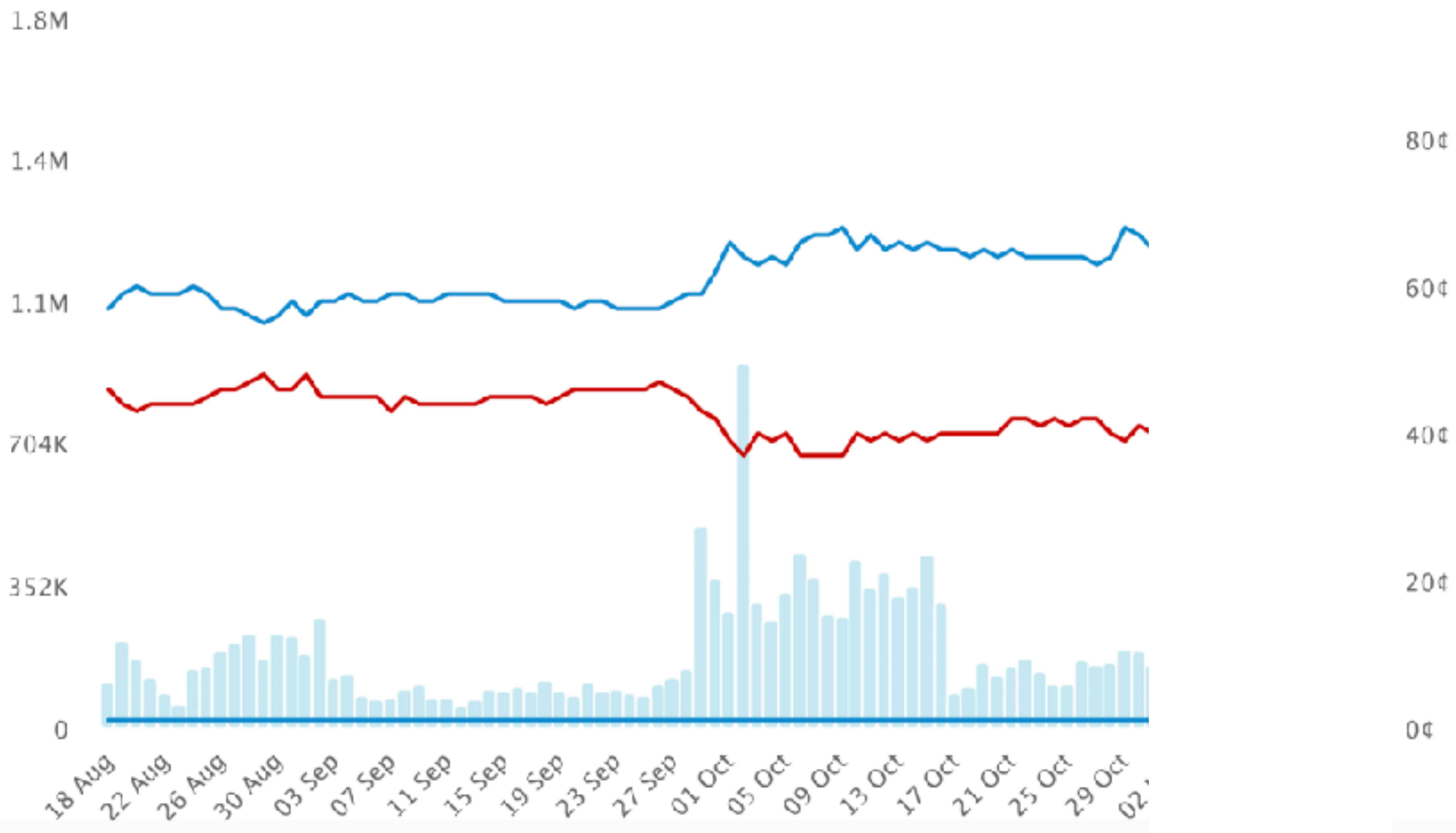
Biden **Trump**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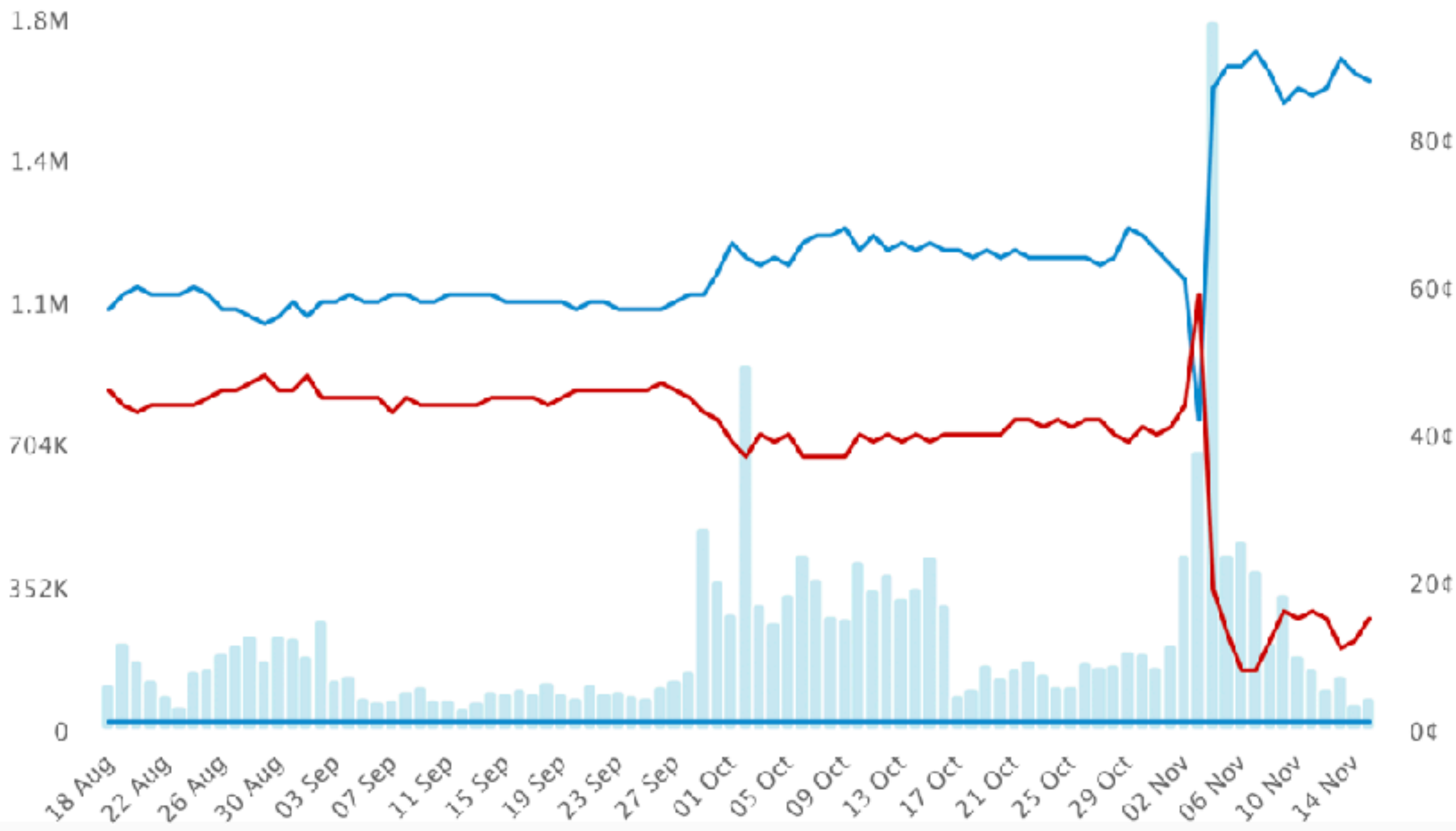
Biden

Trump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02 Nov
06 Nov
10 Nov
14 Nov


OH, LOOK...
I WON...AGAIN!!
Trump
80¢
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10 Nov
14 Nov

Ergodicity

y_t is **ergodic** if the model reaches the **same** equilibria **irrespective of the initial conditions**

Sensitivity analysis

"the study of how **uncertainty** in the **output** of a model can be apportioned to different sources of **uncertainty** in the model **input**"

Sensitivity analysis

To understand which variables are **useful**
To understand the **impact** of each variable on the output

Sensitivity analysis
Settings

Identify the most influential factors

Factor screening

Local sensitivity analysis

Global sensitivity analysis

Sensitivity analysis Settings

Identify the most influential factors

Factor screening

Fine grained search around predetermined values

Local sensitivity analysis

Global sensitivity analysis

Sensitivity analysis Settings

Identify the most influential factors

Factor screening

Fine grained search around predetermined values

Local sensitivity analysis

Global sensitivity analysis

Search around the entire range of values

Sensitivity analysis Strategies

Factor prioritisation

Factor fixing

Factor mapping

Metamodelling

Identifies factor that is responsible for the most variance of the output

Sensitivity analysis
Strategies

Factor prioritisation

Factor fixing → Fixes factors that do not contribute too much to output

Factor mapping

Metamodelling

Sensitivity analysis Strategies

Factor prioritisation

Factor fixing

Factor mapping → Focus on critical areas (thresholds, phase transitions, etc.)

Metamodelling

Sensitivity analysis Strategies

Factor prioritisation

Factor fixing

Factor mapping

Metamodelling

To identify the relation between input and output

recap

Nature of agents
List of variables describing their state
List of actions the agents can perform
Structure of their interaction with other agents

} **Agent design**

Definition of output variables of interest
Appropriate experimental design
Analysis of equilibria
Sensitivity analysis

} **Experiment**