Most Human Challenges are Systems Challenges

ES 26

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Systems Thinking

- It is a perspective
- Understanding systems alters our outlook
- Learn not only how, but why things work
- Systems have a language – You need learn it and practice it

Systems!

What does it mean?

- Systems thinking does *not* accept looking at the world as isolated components (*not a reductionist approach*)
- Systems roots are found in:
  - Biology
  - Ecology
  - Information

Defining Systems

- Systems consist of components and relationships (interdependent)
- They are adaptive or dynamic – may change through time
- May receive inputs/interactions from the broader environment
- Have a networked structure with some common rules, context, background
- Have some level of autonomy and some level of constraints on each component and their relationship

Characteristics of Systems

- Purpose – a property of the system
- All parts must connect to fulfill the purpose
- All parts must be arranged in a certain order for the system to function
- Stability of the system is created by feedback loops
- Flow of information (Transmit and Receive)

Structure and Architecture

- Structure tells why things are happening.
- Structure can be self-generated with some rules.
- Structure has networks (random, linear, hierarchical, trees,..).
- Architecture: how things are interconnected, assignments of sub-functions.

Complexity

- Caused by relationships, life cycles, hierarchy, layers.
- Feedback Loops give raise to Complexity
- Most systems have non-linear relations
  - Small disturbances can lead to large disruptions - e.g. traffic flow
- Not easy for us to think in a nonlinear models

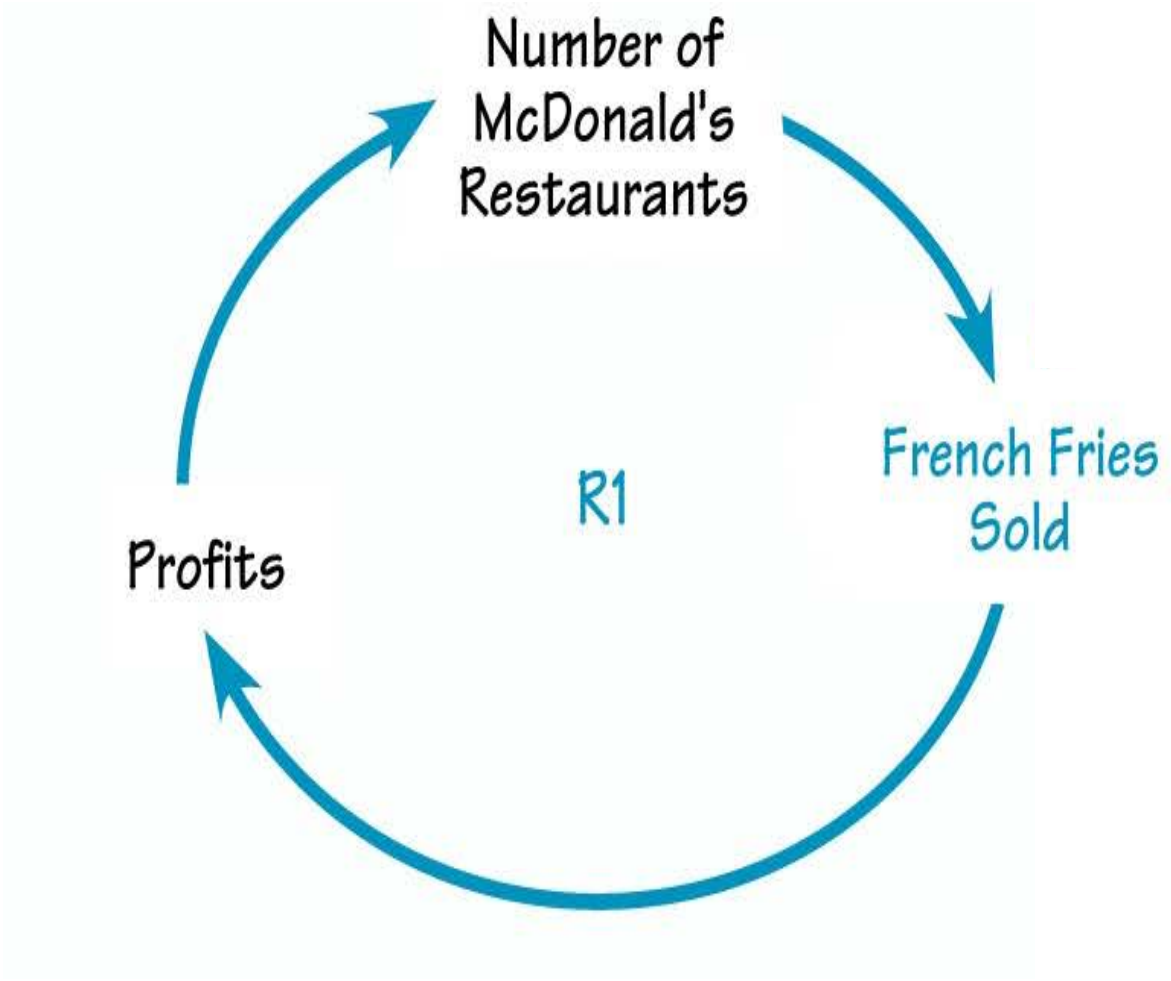
Systemic Behavior

Types of Loops

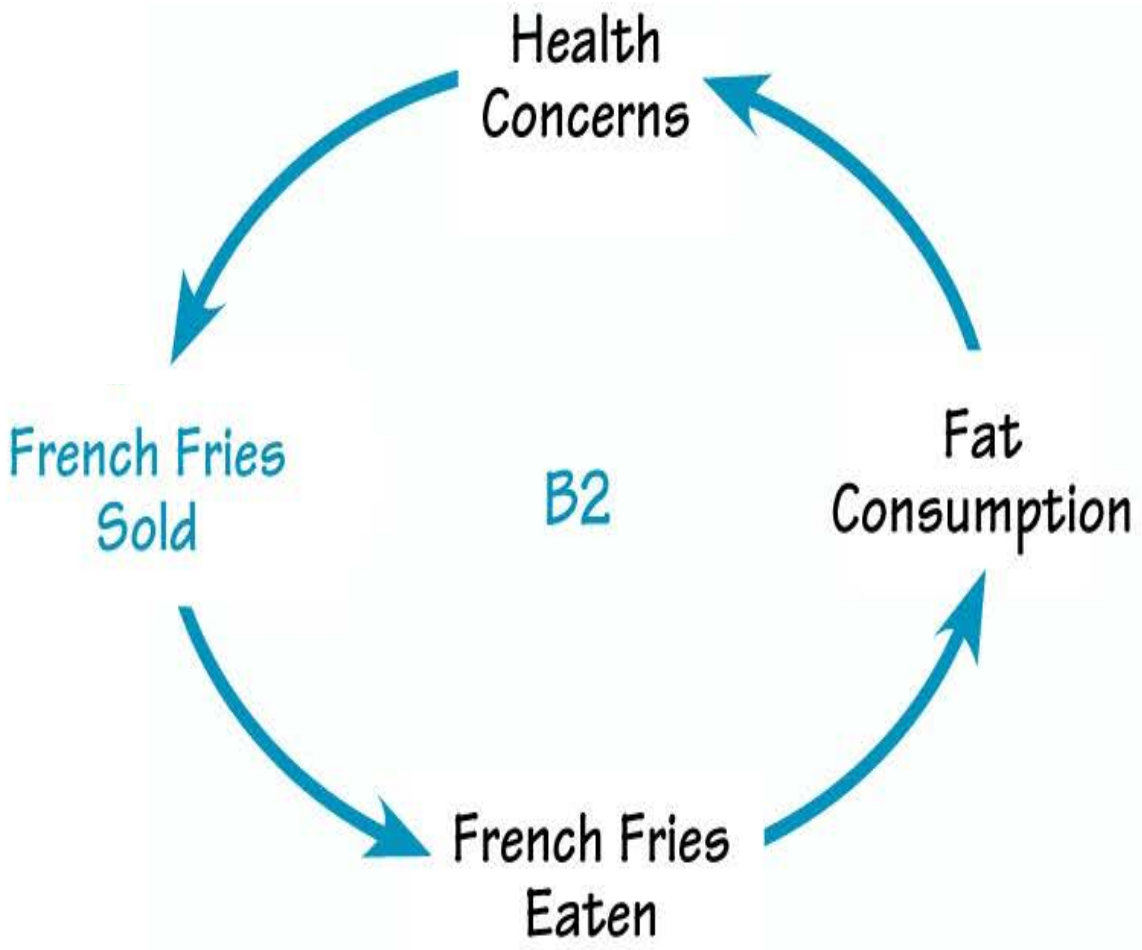
- Reinforcing Loops
  - Create more growth (or collapse!)
  - Successive changes that add up (growth) or (decrease/collapse)
- Balancing Loops

The **System** is more than its **Parts**

Causal Loops



Causal Loops



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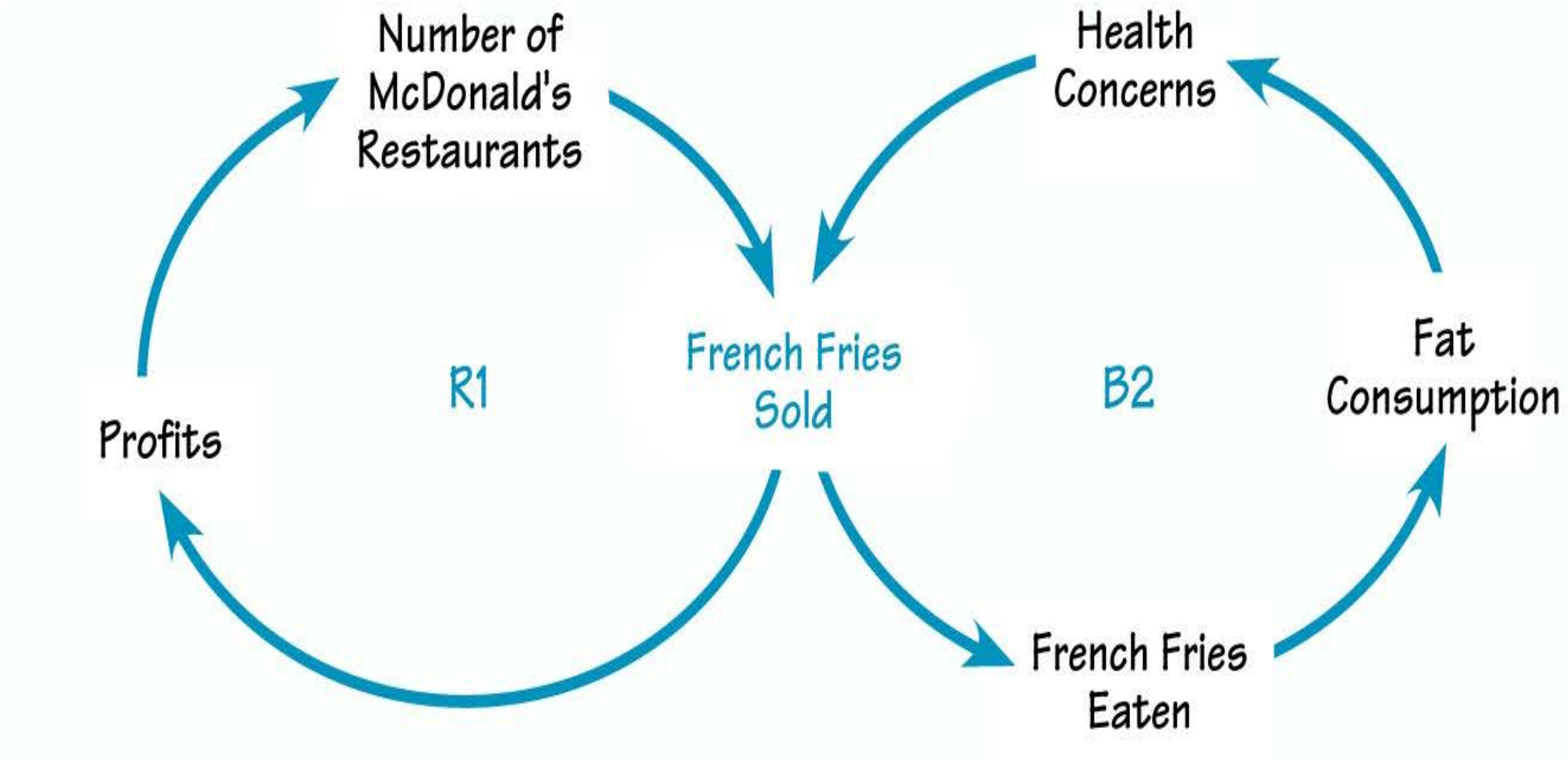

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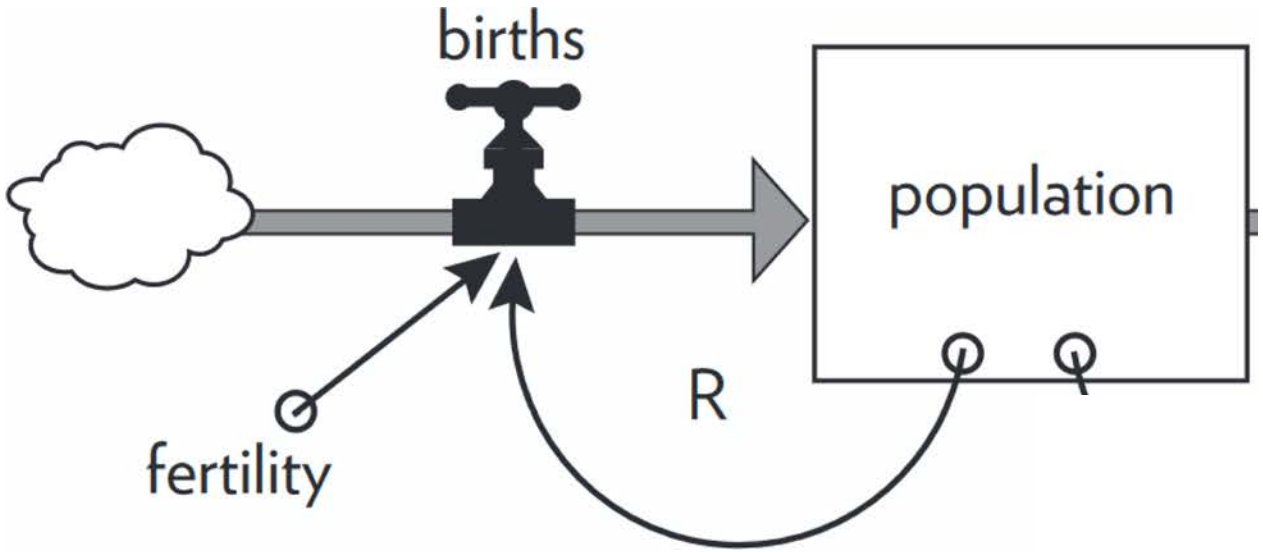
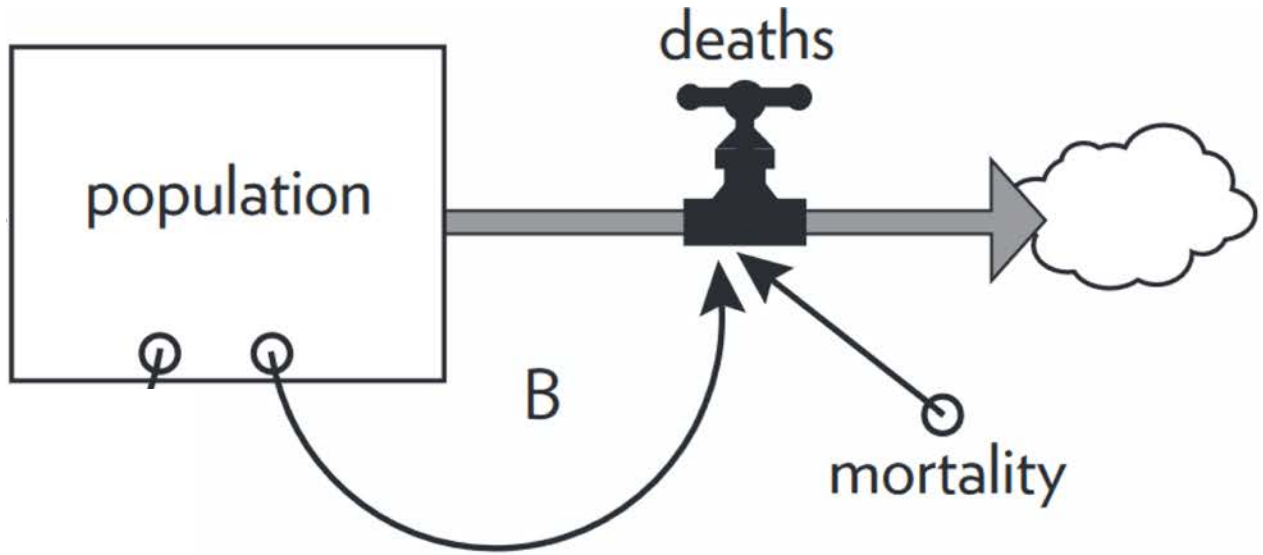


Population governed by a reinforcing loop of births and a balancing loop of deaths.

Causal Loops



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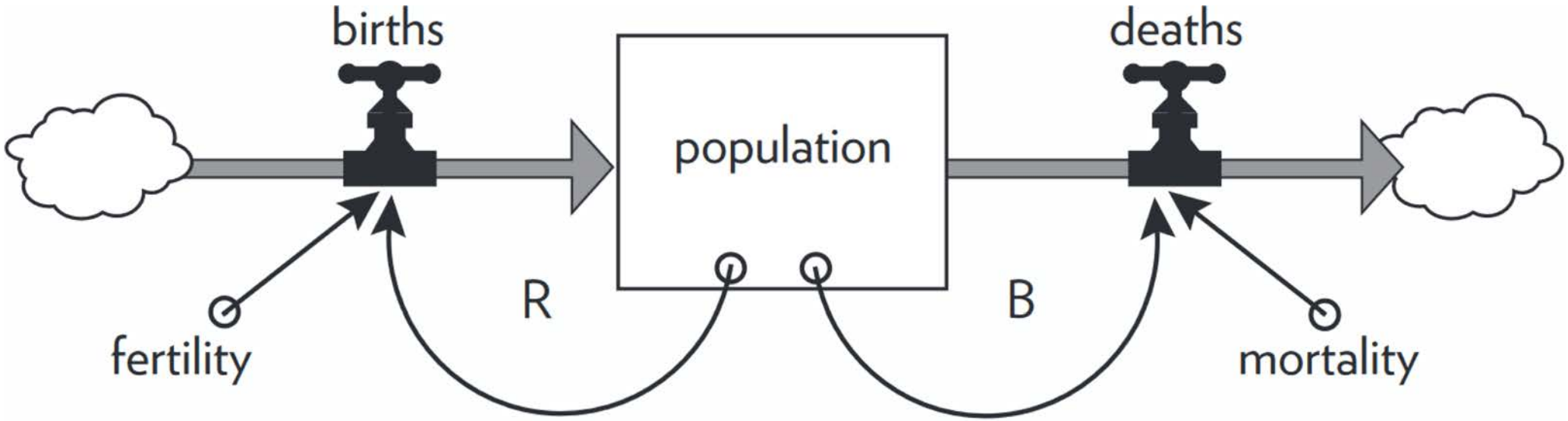

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Dynamics System delays

Hidden troubles!

- Feedback control loops create dynamic processes
- Time delays in feedback loop are often
  - Response takes time: the system may over or under react, causing oscillations (swings) that can be very disruptive
  - Changing the duration of the delay, may make large effects on system behavior
- Physical delays – every transaction can take time to happen!
- Correction may take time to happen due to
  - Information delays
  - Perception delays
- Reactions are NOT instantaneous!!

Systems Archetypes

- Common patterns of behavior in organizations.
- Provide insight into the underlying structures
- Alert to future unintended consequences

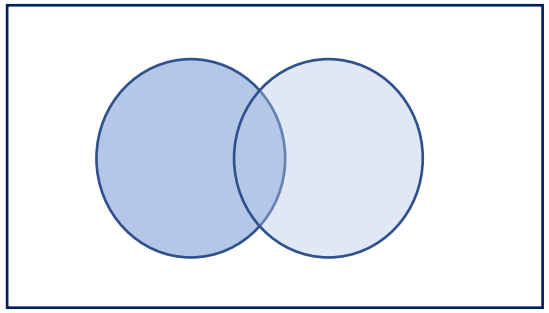
8 Systems Archetypes

- **Fixes that fail**—A solution is rapidly implemented to address the symptoms of an urgent problem.
- **Shifting the burden**— attention shifts to short-term solutions or to the side effects.
- **Limits to success**—positive performance reaches its limit due to constraints that slow down the performance
- **Drifting goals**— when there is a gap between goal and actual performance, a conscious decision is to lower the goal, leading to lower system performance
- **Growth and underinvestment**—Growth approaches a limit potentially avoidable with investments in capacity.
- **Success to the successful**— A successful effort gets disproportionately larger allocation of the resources to the detriment of the others.
- **Escalation**—Parties take mutually threatening actions
- **Tragedy of the commons**—resource is overused and get exhausted resulting in the shutdown of the activities of all parties in the system.

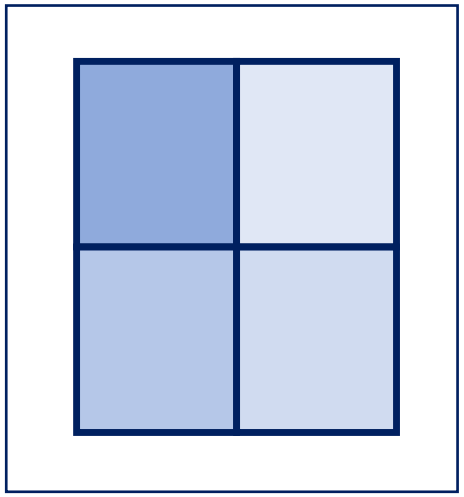
Mapping the System

Frameworks are Visual Representation

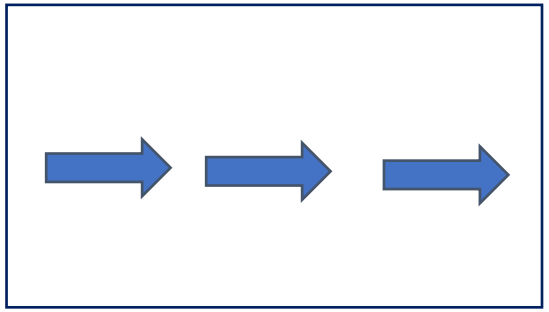
Venn Diagrams help you express a few key themes and the relationships between them. They help you to see the degree of connectedness, overlap and intersection between sets of data.



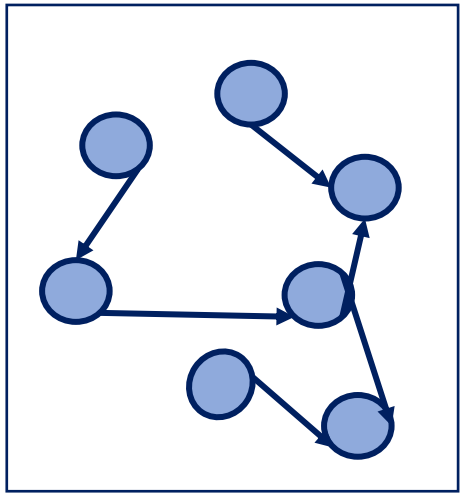
Two-by-Twos help emphasize tensions and categorize modes of behavior. It's a useful tool for categorizing things that can be reduced to two simple (but big) variables.



Journeys are great for looking at an experience over time, from the perspective of the user.



Maps help visually explain key relationships between individuals or systems



An example: System Map for

- Obesity

Obesity

Causes

- Is the problem “people eat too much and move too little”
- Conceptual models
  - An epidemiological model: agents such as food, viruses, and toxins are acting on a host to produce disease
  - A homeostatic model: fat acts on the brain (controller) which in turn feeds back to act on the fat (controlled system)
  - Genetic model: background loads the gun, and the environment pulls the trigger

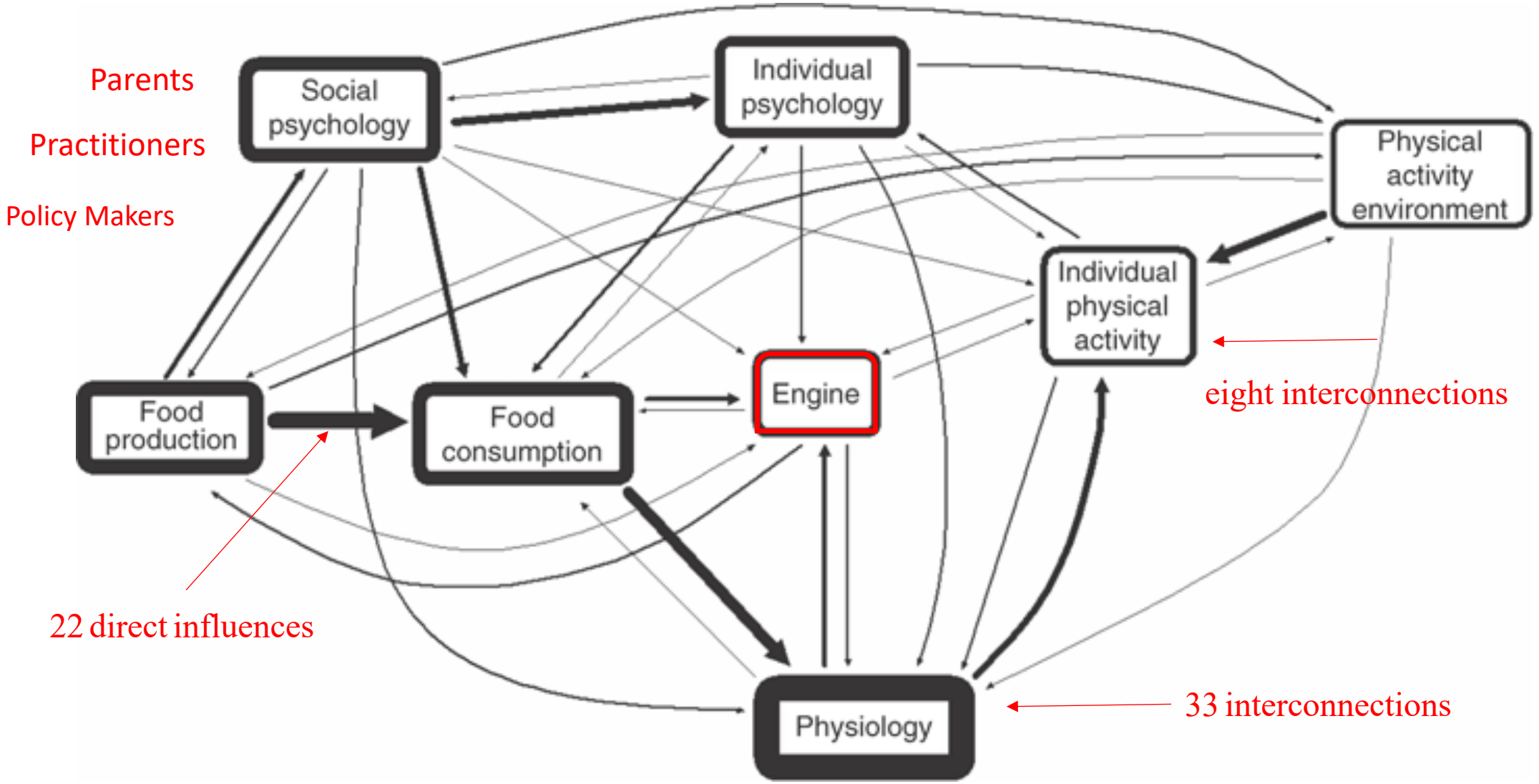
Obesity

the environment

Proximal factors: act on energy expenditure and food intake

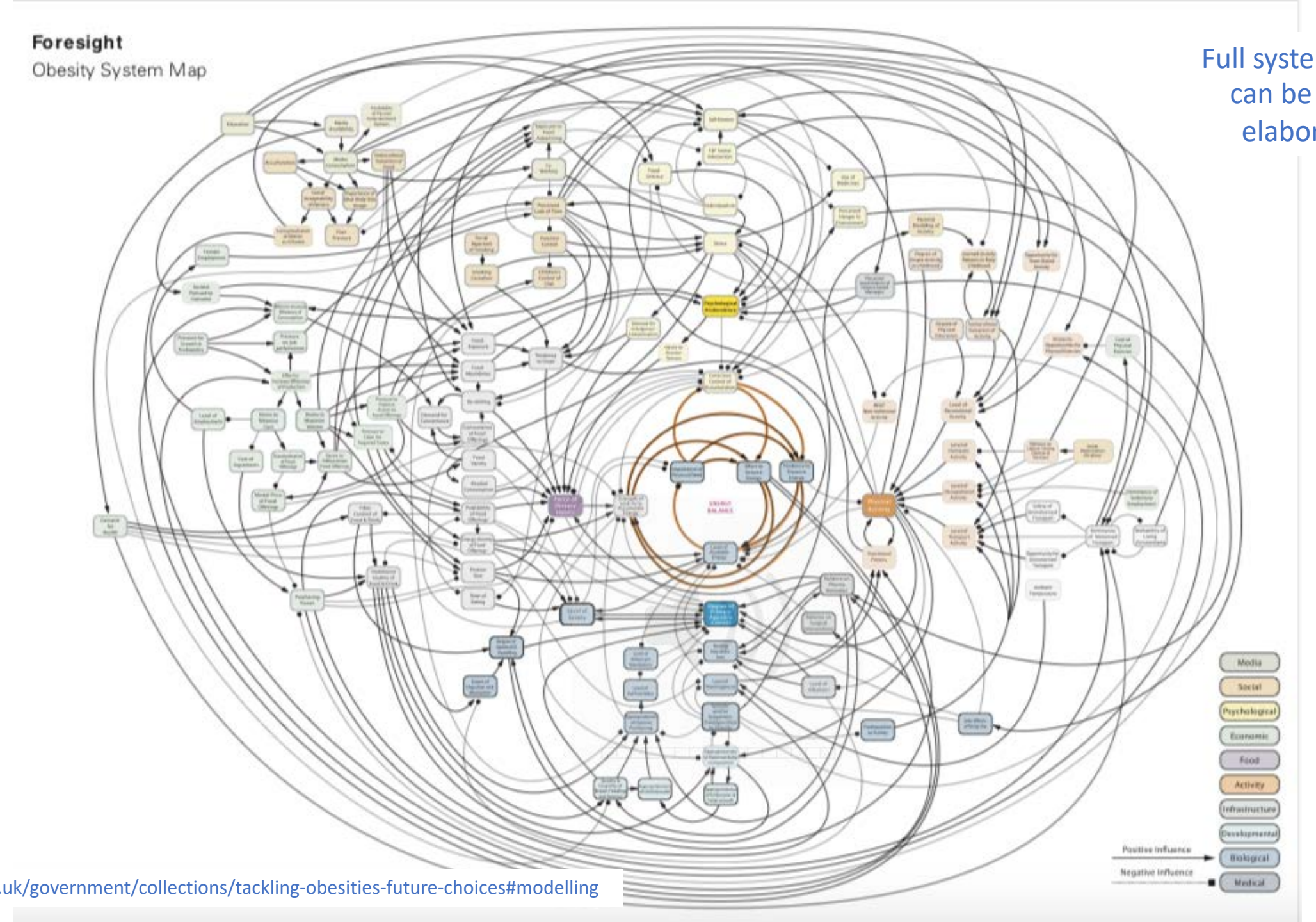
- Work/school/home
- Community/locality,
- National/ regional, and international levels.
- Distal contextual factors
  - globalization of markets,
  - media
  - culture

ENGINE: energy intake - energy expenditure



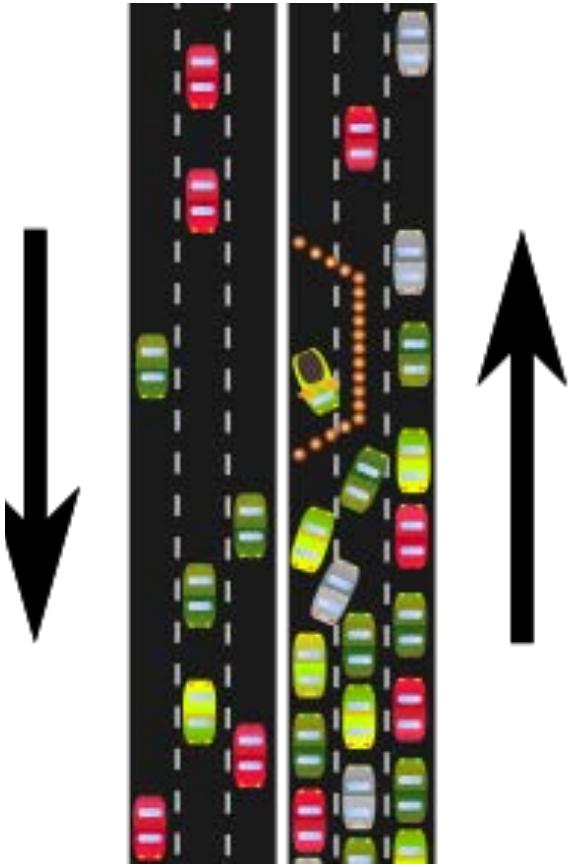
Implications of the Foresight Obesity System Map for Solutions to Childhood Obesity

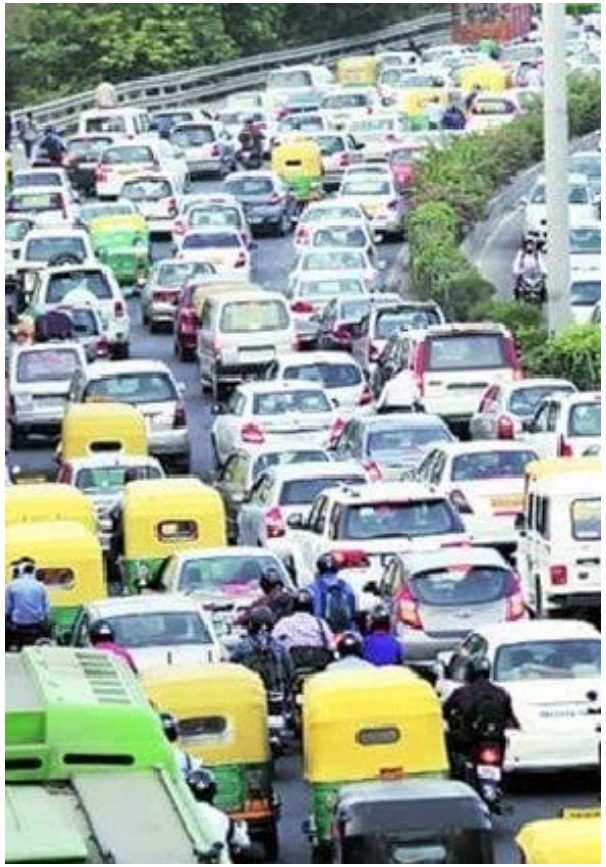
Diane T. Finegood, Thomas D.N. Merth and Harry Rutter -- *Obesity* (2010) **18**, S13–S16. doi:10.1038/oby.2009.426



Full system map can be very elaborate

https://www.gov.uk/government/collections/tackling-obesities-future-choices#modelling





Map this Human Challenge

Map this Human Systems

- Break into groups of 3
- Write down topics and ideas (5 minutes)
- Discuss with each other (5 minutes)
- Use the information/ideas you came-up with to create a systems map (10 minutes)
- Identify: causal loops & balancing loops (5 minutes)
- Can you point out to root causes? (5 minutes)

Causes of Traffic Congestion

- Driving habits [May call for self driving cars!]
  - Tailgating (stop-start)
  - Equal distance
- Construction Zones
- Accidents
- Narrow roads
- Terrain
- Weather
- Road/number of lanes; peak capacity
- Dynamic bottleneck
- Badly timed traffic lights
- Population increase
- City Configuration (center of commerce, hospitals, universities, shopping centers, …)

WORLD ECONOMIC FORUM

Traffic congestion cost the US economy nearly $87 billion in 2018

Effects of Traffic Congestion

- Economy
- Loss of opportunities
- Air quality
- More use of public transportation
- Frustrations
- Social dynamics [unhappy citizens, reduce productivity]
- Accident's
- Pollution
- Gas prices
- Increase of cost of living