Journée Aéronautique UT2J

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Systemic approach to the transition of air travel

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Key features of the aviation sector

A complex, highly structured multi-stakeholder system **on a global scale**.
It is a highly capital-, HR-, IP- and energy-intensive sector, and nowadays it is also culturally and emotionally sensitive (freedom of movement).

Its success (growth) is based on **safety and decreasing airfare**
A provider of **fast** medium- and long-range (intercontinental) **mobility** (added value)
Welfare through **time savings** (value of time saving increases consumer surplus)

A key element of globalized markets (industry, trade, employment, tourism)
A global issue (ICAO) but with regional or diplomatic blocs, OECD vs. BRICS
A global value chain, **multi-scale supply chain** branching from local to global

Manufacturing : Europe is leading the competition (A-B duopoly + E + C)
A high-tech industrial sector, an asset for skilled **employment and exports (trade balance)**

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Decision-making for transitioning to sustainability

Designing and implementing transition policies is **difficult**

Long-term horizons (new aircraft program 1 decade - aircraft lifetime 2-3 decades).

High levels of uncertainty relating to energy, climate and geopolitics.

Interlocking feedback loops and a complex network of (non-linear) interactions.

Delays of a decade or more between actions and their consequences (time lag in the learning curve)

Learning through experimentation is costly (impossible at the scale of the system)

Approach the complexity of the sector with systems science and provide a modeling framework to perform what-if experiences

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Interaction graphs (or CLD)

A graphical language for representing causal chains

Each arrow indicates a **cause-and-effect relationship** (orientation/direction of the relationship), which may be immediate or delayed, large or small, positive or negative.

Mapping interactions

1. A good remedy for formulating overly hasty opinions or simplistic solutions
2. Quantifying complexity (metrics derived from graph theory)
3. Identification of free nodes or parameters, at the discretion of decision-makers
4. Tool to assist in the prescription of research projects
5. Preliminary to modeling (conceptual modeling)
6. Coding the dynamics of complex systems over time (endogenous feedback structures, delays, and nonlinear relationships)
7. Simulations to test policies and scenarios

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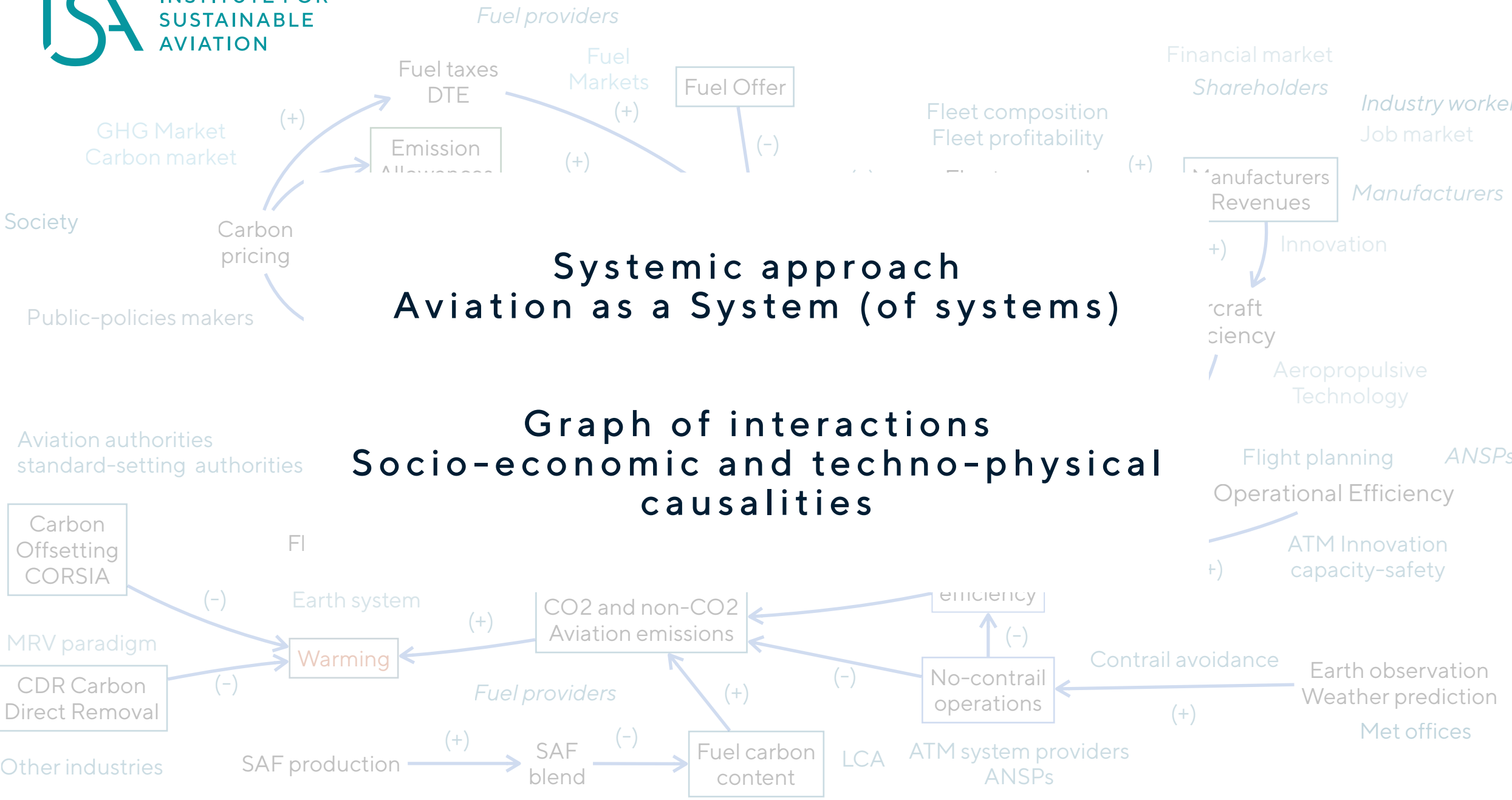
Systemic approach
Aviation as a System (of systems)

Graph of interactions
Socio-economic and techno-physical causalities



Stakeholders

Society

Public-policy makers

Shareholders

Finance Banks & Lessors

Aviation authorities standard-setting authorities

Industry workers

Manufacturers

SAF & Fossil Fuel providers

Passengers

Airlines and service providers

Airports and infrastructure

Global distribution system

ATM system providers ANSPs

Met offices IPCC

Other industries

Economic fluxes

Physical fluxes

Fluxes and Interactions

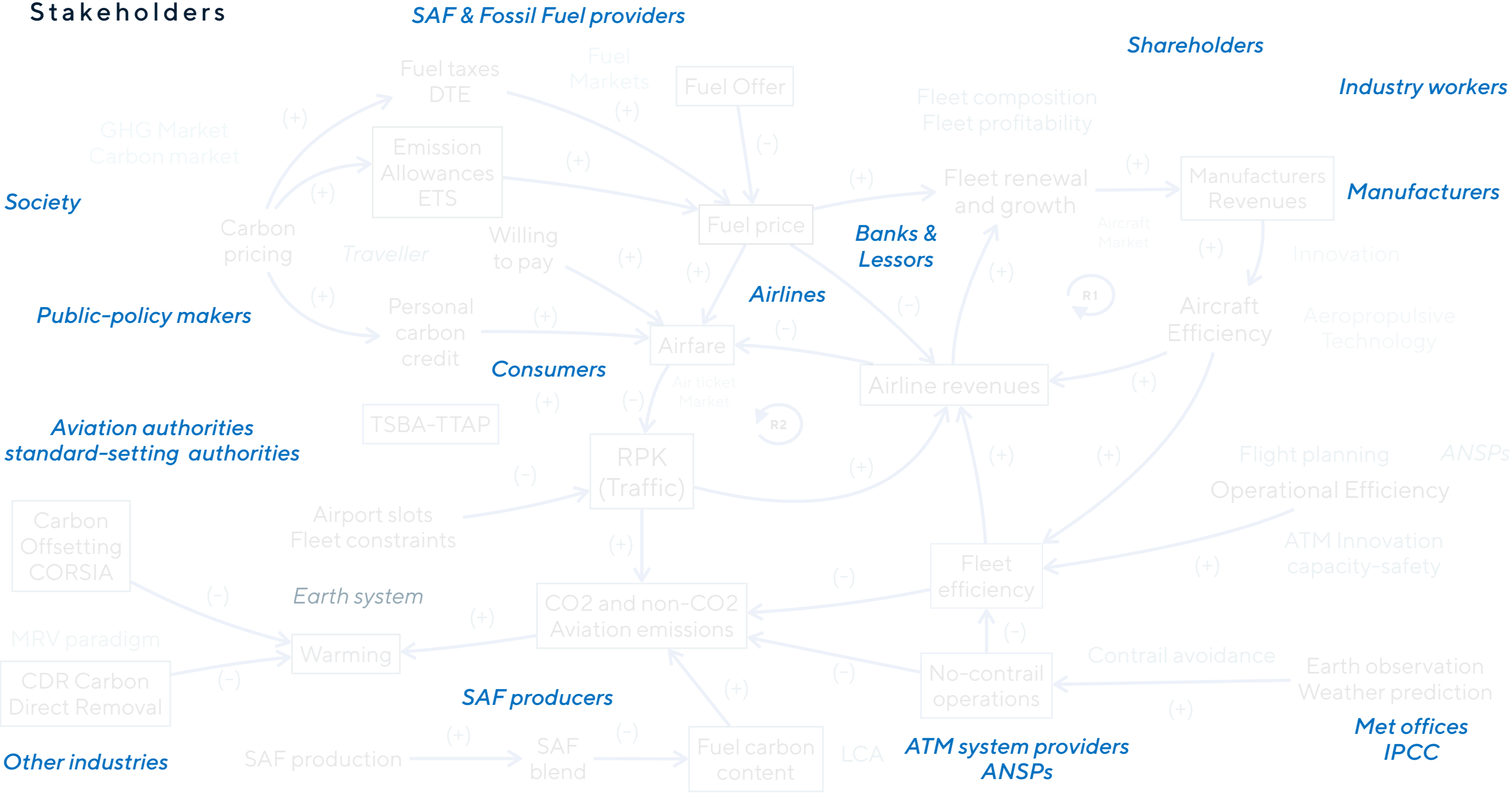
Informational fluxes

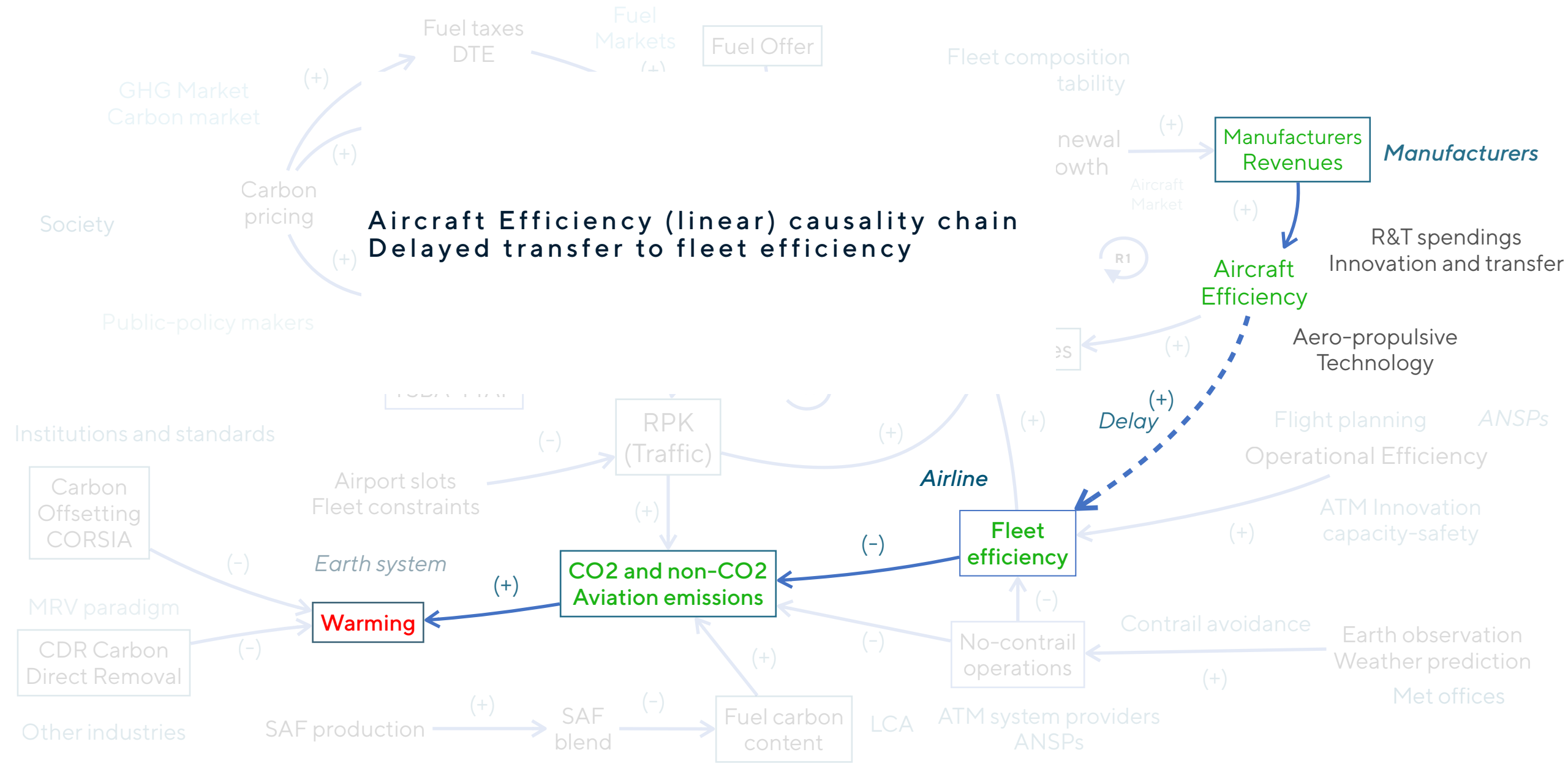
Regulatory and normative fluxes

Mechanisms

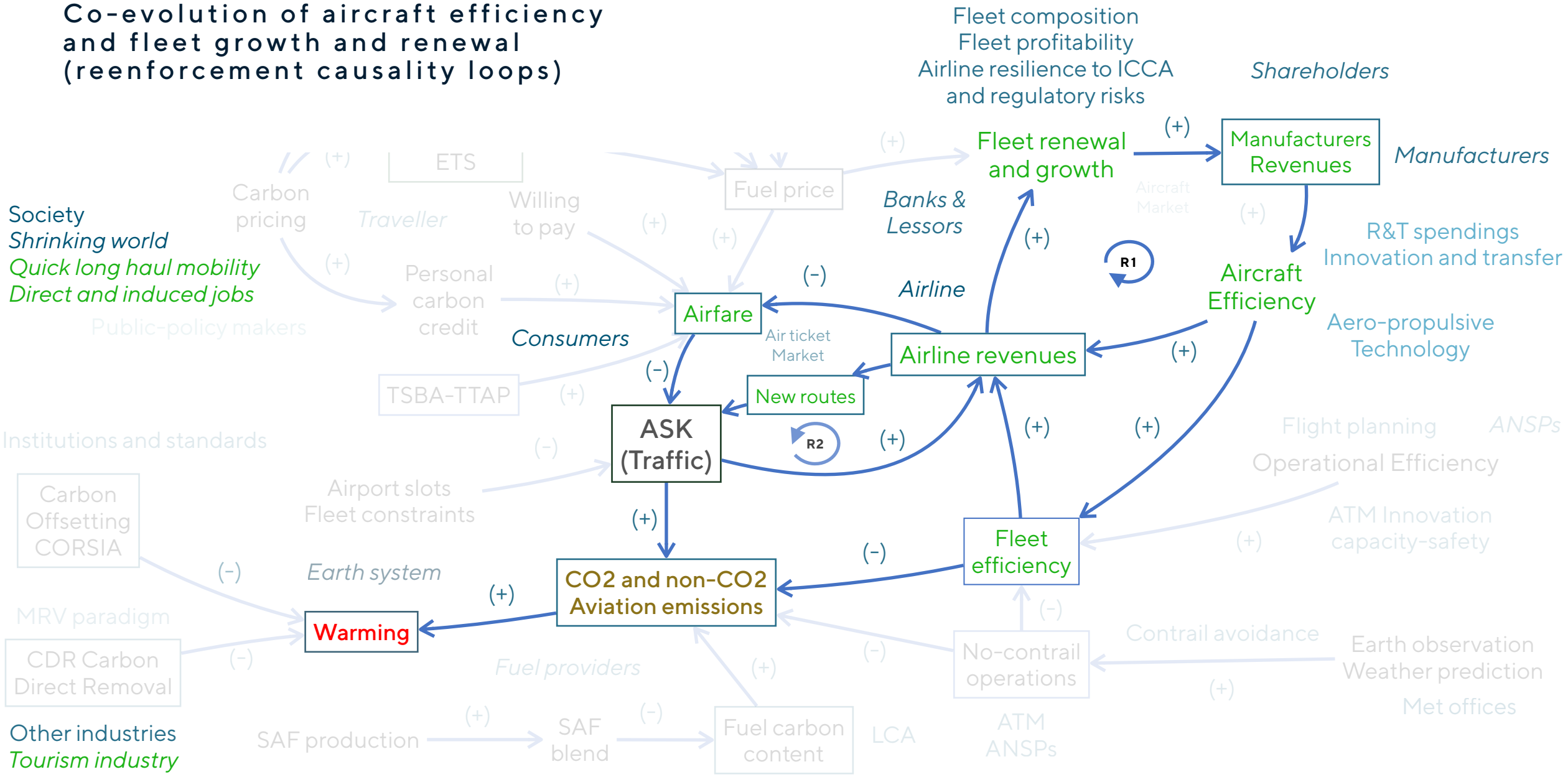
Levers

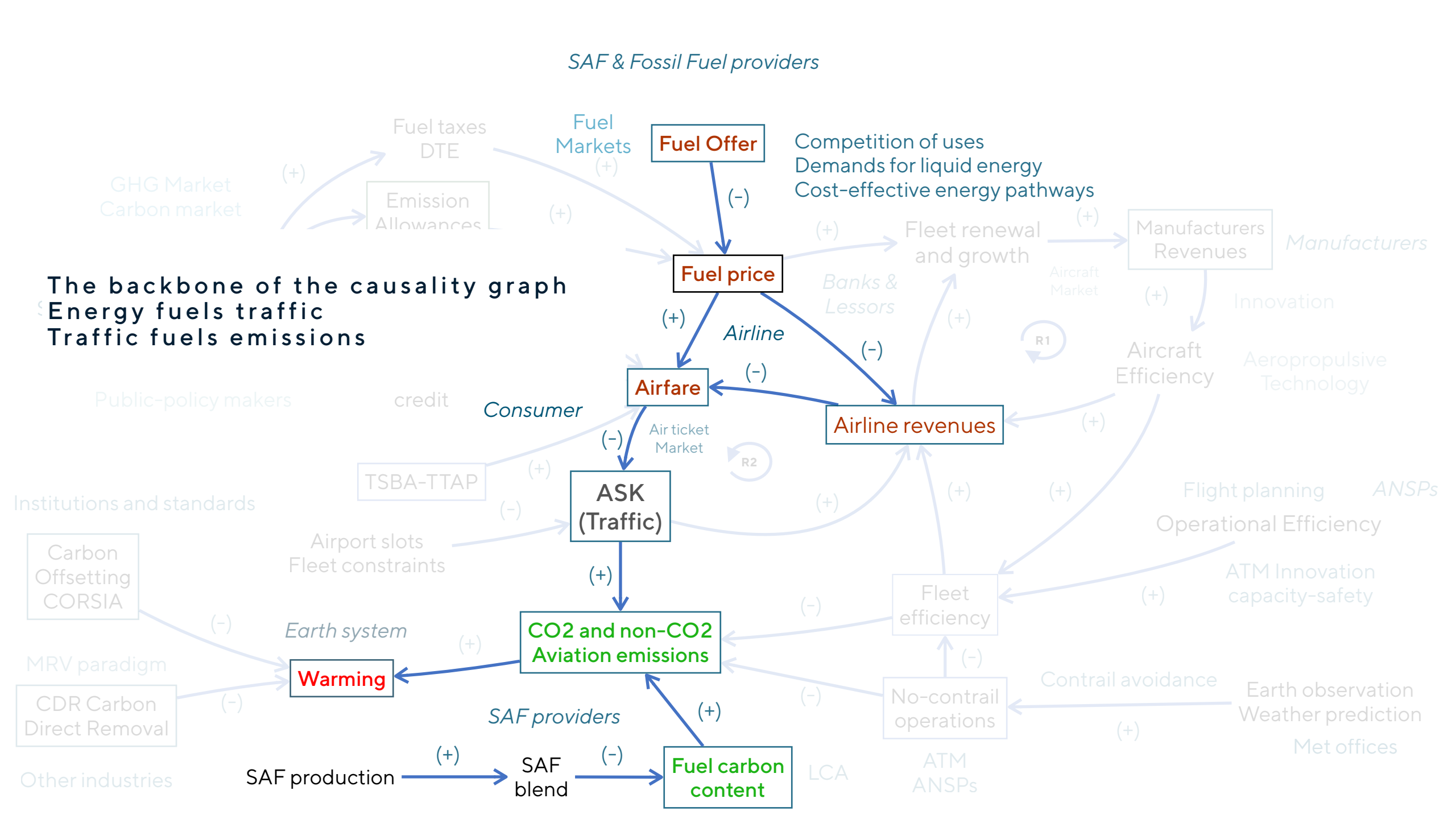
Stakeholders




Aircraft Efficiency (linear) causality chain
Delayed transfer to fleet efficiency
Fuel taxes
DTE
Fuel
Markets
Fuel Offer
GHG Market
Carbon market
Carbon
pricing
Society
Public-policy makers
Fleet composition
tability
newal
owth
Aircraft
Market
Manufacturers
Revenues
Manufacturers
R1
Aircraft
Efficiency
R&T spendings
Innovation and transfer
Aero-propulsive
Technology
Delay
Airline
Institutions and standards
Carbon
Offsetting
CORSIA
RPK
(Traffic)
Airport slots
Fleet constraints
Flight planning
ANSPs
Operational Efficiency
ATM Innovation
capacity-safety
Fleet
efficiency
Earth system
CO2 and non-CO2
Aviation emissions
Warming
MRV paradigm
CDR Carbon
Direct Removal
Other industries
No-contrail
operations
Contrail avoidance
Earth observation
Weather prediction
Met offices
SAF production
SAF
blend
Fuel carbon
content
LCA
ATM system providers
ANSPs

Co-evolution of aircraft efficiency and fleet growth and renewal (reenforcement causality loops)




SAF & Fossil Fuel providers
Fuel taxes DTE
Fuel Markets
Fuel Offer
Competition of uses
Demands for liquid energy
Cost-effective energy pathways
GHG Market
Carbon market
Emission Allowances
Fleet renewal and growth
Manufacturers Revenues
Manufacturers
Fuel price
Banks & Lessors
Aircraft Market
Innovation
The backbone of the causality graph
Energy fuels traffic
Traffic fuels emissions
Airline
R1
Aircraft Efficiency
Aeropropulsive Technology
Public-policy makers
credit
Consumer
Airfare
Airline revenues
Air ticket Market
R2
TSBA-TTAP
Institutions and standards
ASK (Traffic)
Flight planning
ANSPs
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Airport slots
Fleet constraints
Carbon Offsetting CORSIA
ATM Innovation capacity-safety
Fleet efficiency
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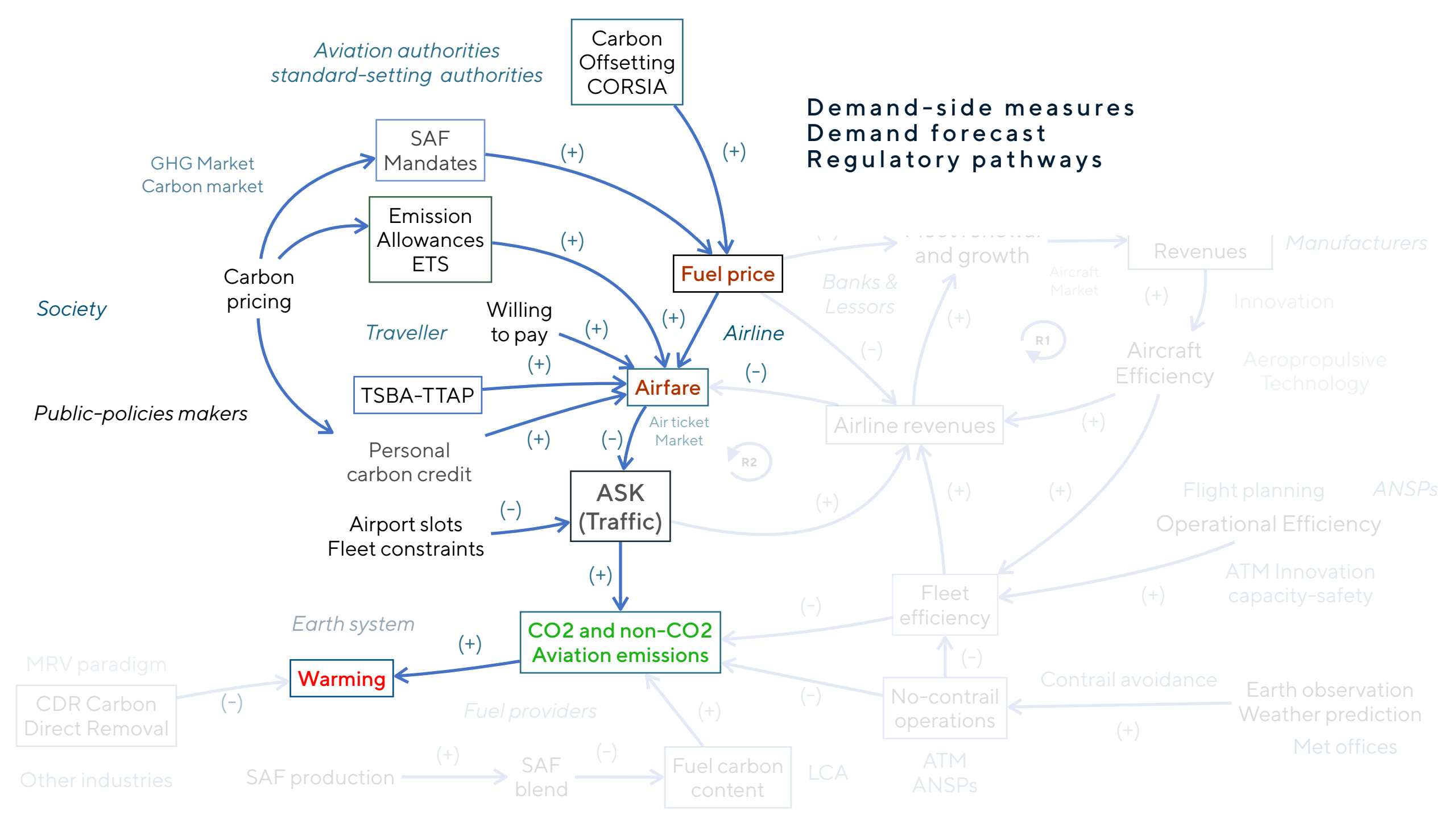
Aviation authorities
standard-setting authorities
Carbon Offsetting CORSIA
Demand-side measures
Demand forecast
Regulatory pathways
SAF Mandates
GHG Market
Carbon market
Emission Allowances ETS
Carbon pricing
Society
Public-policies makers
Traveller
Willing to pay
Airline
TSBA-TTAP
Airfare
Air ticket Market
Personal carbon credit
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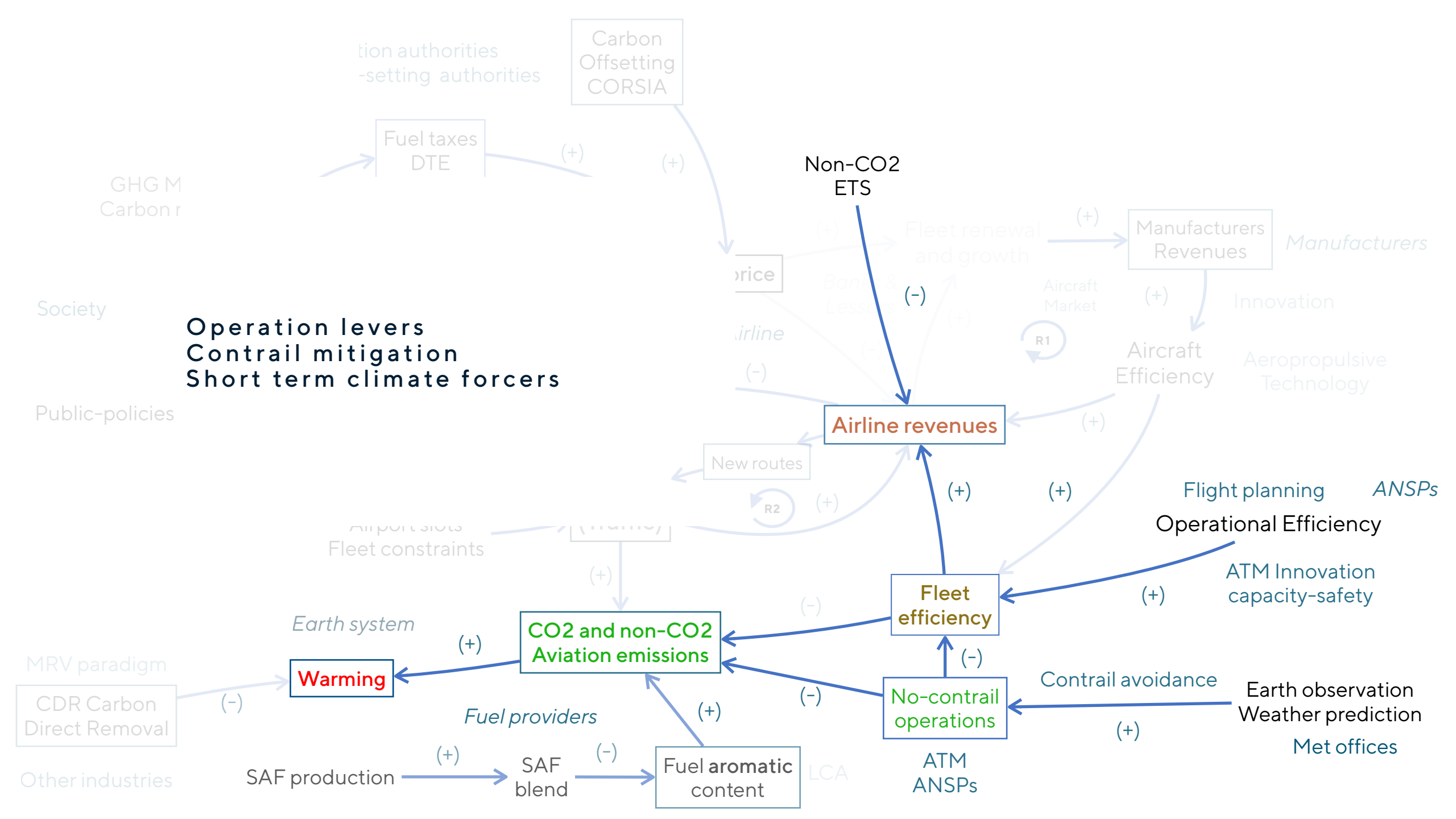
Operation levers
Contrail mitigation
Short term climate forcers
Carbon Offsetting CORSIA
Fuel taxes DTE
Non-CO2 ETS
Manufacturers Revenues
Manufacturers
Innovation
Aircraft Efficiency
Aeropropulsive Technology
Airline revenues
New routes
Flight planning
ANSPs
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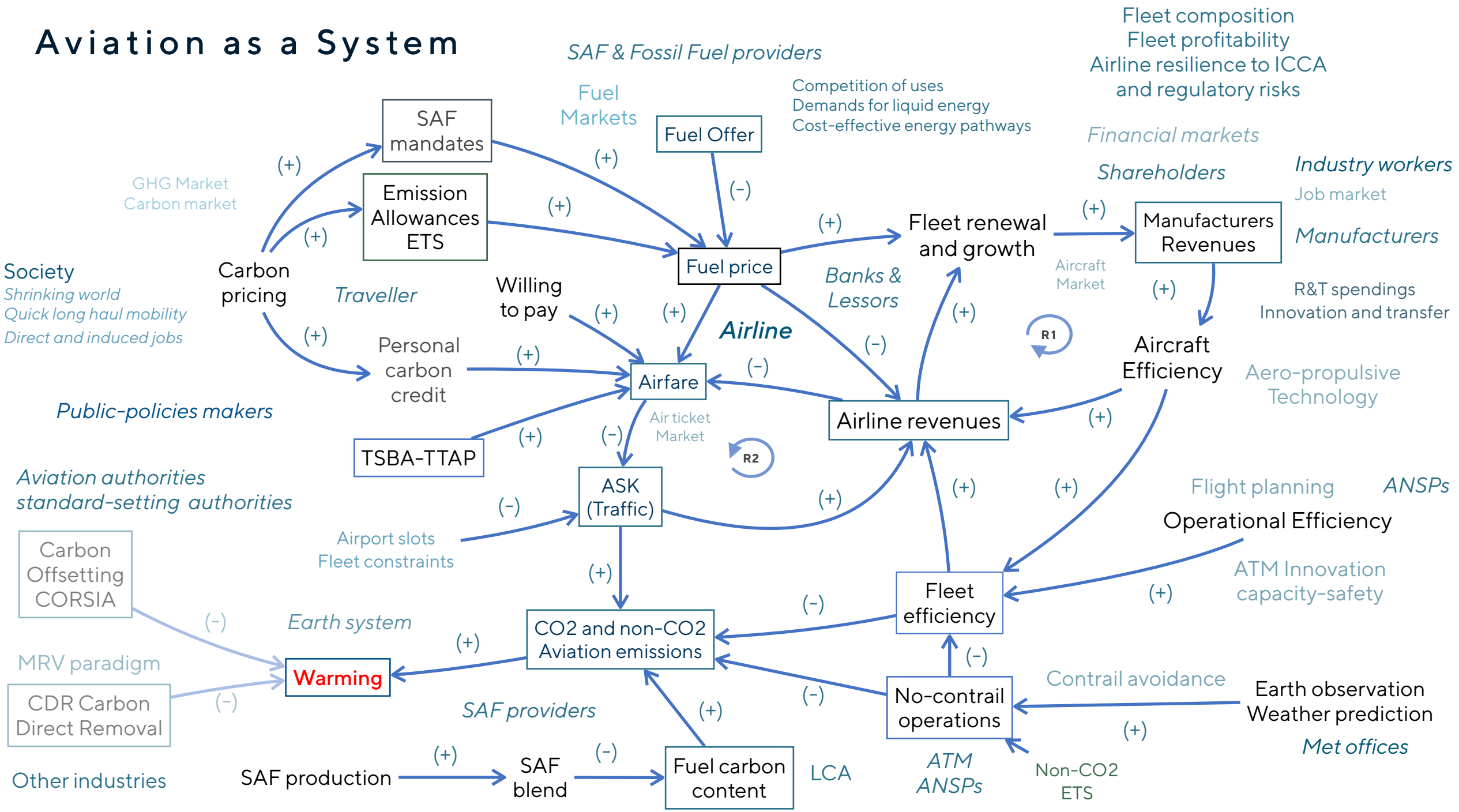
Other industries
Public-policies
Society
Aircraft Market
Fleet constraints
R1
R2
(+)
(-)

Aviation as a System



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Stakeholders

Design CC mitigation and adaptation strategies

Implement but decisions in the hands of many and willingness to take action is not evenly shared

Averse to short-term business penalties

Seek resilience on the long-term

Policy and regulation design

Researchers

Inform decision-strategy makers with systems science

Provide a modeling framework to perform what-if experiments

Diagnose risk-management strategies

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Open research challenges

Methodological ruptures (uncertainty quantification)

Bridging quali with quanti

Demand forecast

Shock capturing

Solve the hardest variables: social legitimacy, behavioral inertia, symbolic value of flying,...

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AeroMAPS

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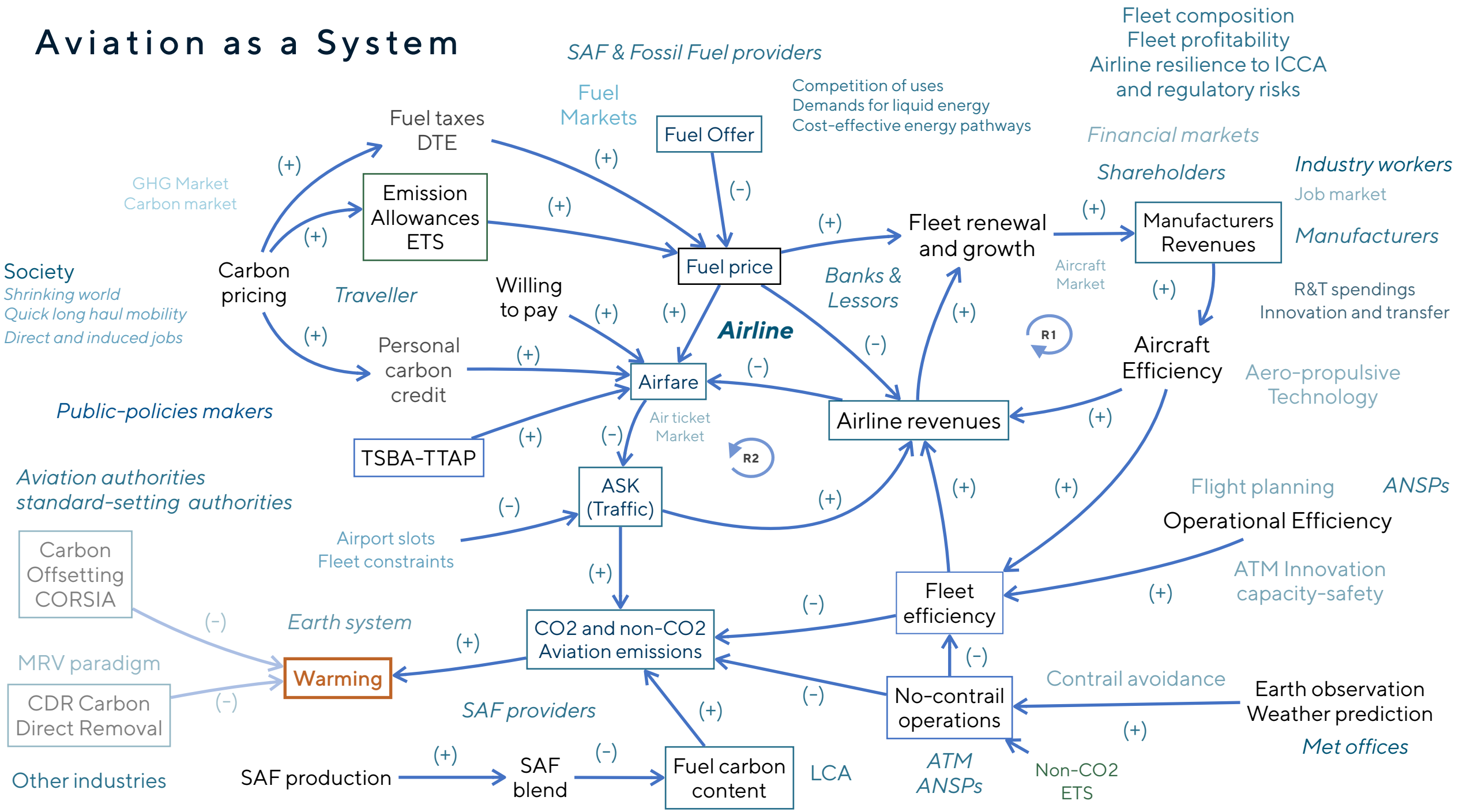
Thanks

Aviation as a System



Aviation as a System