

## Assessing economic sustainability



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## Take home message:

Economic sustainability is assessed on a per actor basis by:

- Counting the number of value transfers
- Assigning economic value to value objects obtained and provided
- Calculating a net value flow by multiplying the number of value transfers times the value objects they transfer
- Summing up these value flows in a net value flow sheet
- Discounting net value flows sheets, to account properly for the value of time
- Analyzing the value flows for sensitivities

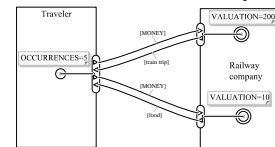
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## Net value flows

- A net value flow for an actor equals:
  - The economic value for all ingoing value objects minus the economic value for all outgoing value objects
- Assumption: for a sustainable constellation, all actors in the constellation should have a positive net value on the long term
- A discounted net value flow takes a long period into consideration, and accounts for the value of time

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## A first example A Traveler and a Railway company



Value Interface	Value Port	Value Transfer	Occurrences	Valuation	Economic Value	Total
train trip, food	MONEY, MONEY		5	0	-1050	
	in: train trip	(all transfers)	5	0	0	
	in: food	(all transfers)	5	0	0	
	out: MONEY	MONEY	5	10	-50	
	out: MONEY	MONEY	5	200	-1050	
INVESTMENT					0	
EXPENSES					0	
total for actor						-1050

Value Interface	Value Port	Value Transfer	Occurrences	Valuation	Economic Value	Total
(MONEY, food)			5		50	
	in: MONEY	MONEY	5	10	50	
	out: food	(all transfers)	5	0	0	
(MONEY, train trip)			5		1000	
	in: MONEY	MONEY	5	200	1000	
	out: train trip	(all transfers)	5	0	0	
INVESTMENT					0	
EXPENSES					0	
total for actor						1050

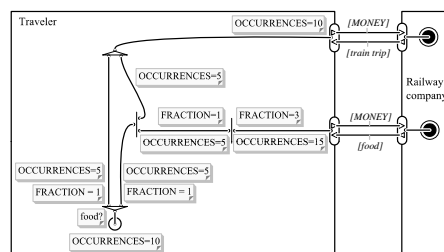
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## Steps to calculate a net value sheet

1. Count the number of times value transfers that take place, by considering the dependencies (e.g. the consumer need) and value transfers;
2. Assign economic value to value objects obtained and delivered by each actor;
3. Calculate the net value flow sheet by subtracting the value of all outgoing value objects from the value of all incoming value objects, per actor.

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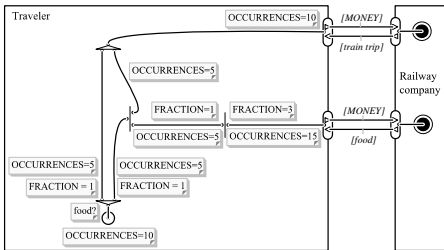
## Counting value transfers Another example



- Find traces using needs
  - Follow trace
  - ... until a boundary element
  - Propagate need occurrences
- All needs should consider the same timeframe; know this timeframe (day, month, year)

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### Counting value transfers cont'd OR fork

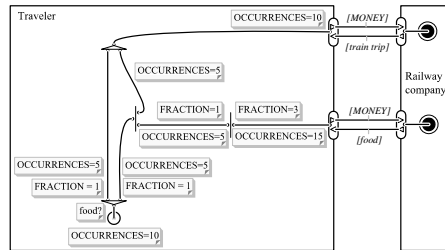


An OR fork splits occurrences depending on the stated fractions

$$Occurrences_{port_{out}i} = \frac{Fraction(port_i)}{\sum_{j=1}^n Fraction(port_j)} \times Occurrences_{port_{in}}$$

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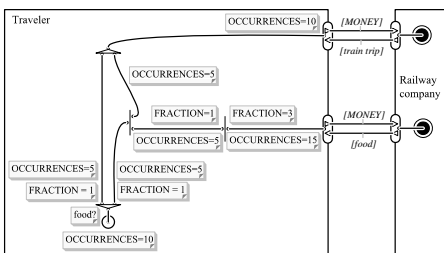
### Counting value transfers cont'd AND fork



An AND fork duplicates occurrences of the in-port of the fork

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### Counting value transfers cont'd OR join

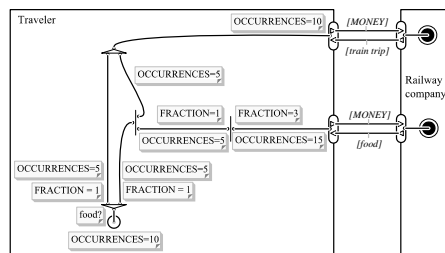


An OR join sums up the occurrences of the in-ports of the fork

$$Occurrences_{port_{out}} = \sum_{i=1}^n Occurrences_{port_{in}i}$$

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### Counting value transfers cont'd Explosion/Implosion element

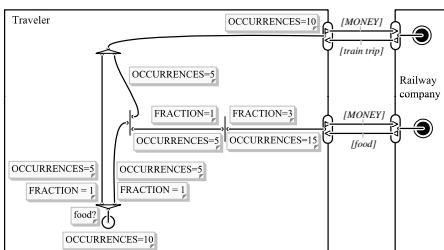


An explosion / implosion element multiplies / divides the occurrences of the in-port of the element

$$Occurrences_{port_{out}} = \frac{Fraction(port_{out})}{Fraction(port_{in})} \times Occurrences_{port_{in}}$$

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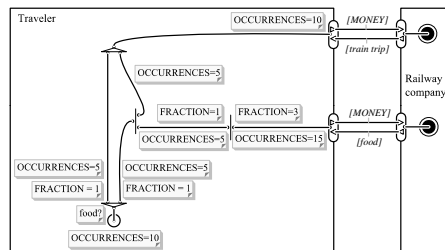
### Counting value transfers cont'd Value interface



A value interface inherits the occurrences of incoming dependency element

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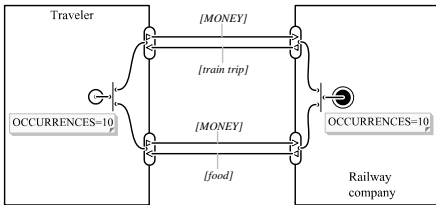
### Counting value transfers cont'd Boundary element



A boundary element signals that trace traversing ends

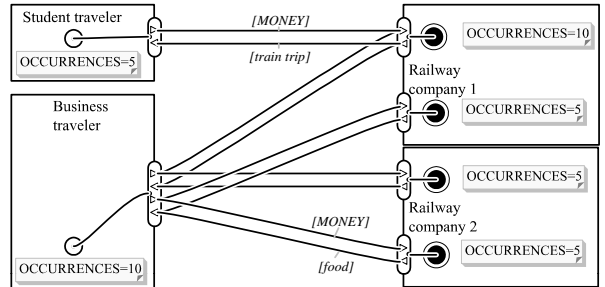
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### Counting value transfers cont'd AND join



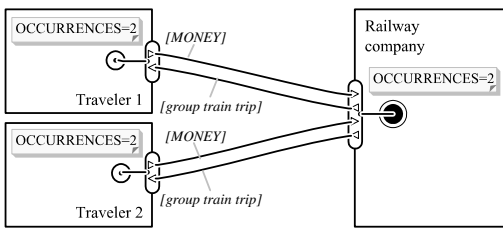
An AND join enforces that the occurrences on the incoming ports should be equal

### Counting value transfers cont'd Value interfaces / transactions as ORs



How many occurrences are there on the interfaces of railway company 1 and 2, given that all fractions on the transaction are all 1?  
(hint: decide first about the value transactions themselves)

### Counting value transfers cont'd Value interfaces / transactions as ANDs



- How many occurrences are there on the interfaces of the railway company?
- Is this model correct?

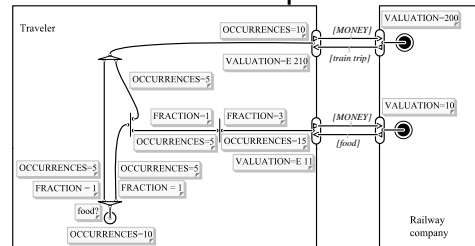
### Assigning economic value to value objects Money versus everything else

- Value objects come into two flavors:
  - Value objects representing money
    - The amount of money transferred from one actor to another actor can objectively be stated
      - Note: actors may disagree about this amount ex-ante the transfer, but do not disagree ex-post the transfer
    - Value in transfer
  - Everything else
    - Actors assign economic value to the object obtained or provides, but do so subjectively
    - Value in use

### Assigning economic value to value objects Valuation formula

- A valuation formula calculates for a port, which transfers value objects, the economic value of the value object that leaves or enters the actor via that value port, in terms of monetary units
- A valuation formula consists of a name (always VALUATION) and an expression
- Example:
  - VALUATION = 10

### Assigning economic value to money objects An example



Railway company

Value Interface	Value Port	Value Transfer	Occurrences	Valuation	Economic Value	Total
(MONEY food)						
	in: MONEY	MONEY	5	10	50	50
	out: food	(all transfers)	5	0	0	0
(MONEY train trip)						
	in: MONEY	MONEY	5	200	1000	1000
	out: train trip	(all transfers)	5	0	0	0
INVESTMENT EXPENSES					0	0
total for actor						1050

## Assigning economic value to money objects

### A valuation formula is a property of ...

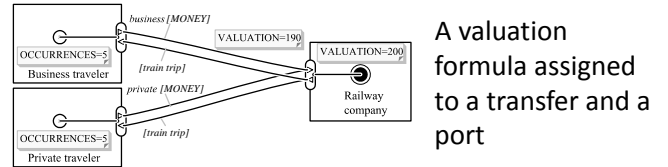
Depending on who determines the valuation formula (here: the pricing formula):

- In case both actors who are transferring a value object determine the price: Assign the formula to the transfer (often: the outcome of a negotiation process)
- In case the providing actor determines the price: Assign the formula to the providing port of that actor
- In case the requesting actor determines the price: Assign the formula to the requesting port of that actor (this situation is quite unusual)

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## Assigning economic value to money objects

### An example



A valuation formula assigned to a transfer and a port

How to find for a port the appropriate valuation formula in general?

For each value transfer connected to a port under consideration:

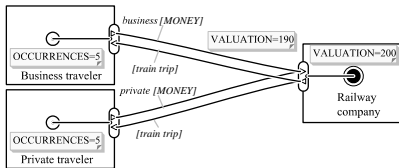
1. If a valuation formula is found at the value transfer it is used for the considered transfer of the port; otherwise
2. If a valuation formula is found at the port itself it is used for that considered transfer of the port; otherwise
3. If a valuation formula is found at the peer port, it is used for that considered transfer of the port; otherwise
4. No valuation is found, which is considered as an error.

Note: a port can use multiple valuation formulas, one per transfer

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## Assigning economic value to money objects

### An example



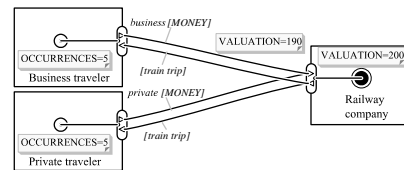
Railway company

Value Interface	Value Port	Value Transfer	Occurrences	Valuation	Economic Value	Total
(MONEY train trip)			10			1950
	in: MONEY	MONEY	5	200	1000	
	in: MONEY	MONEY	5	190	950	
	out: train trip	(all transfers)	10	0	0	
INVESTMENT						0
EXPENSES						0
total for actor						1950

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## Assigning economic value to money objects

### Referring to the valuation formula of a port



The normalized valuation formula averages all valuation formulas for a port, using the number of occurrences for those formulas

$$NORM_{VALUE} = \frac{\sum_{i=1}^n OCCURRENCES_{transfer_i} \times VALUATION_{transfer_i}}{\sum_{j=1}^m OCCURRENCES_{transfer_j}}$$

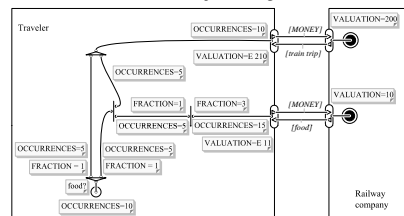
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## Assigning economic value to non-money objects

- Remember: non-money objects are valued differently by different actors
- A bottle beer is usually assigned a different value by different persons, e.g. depending on the context
- Only final consumers value non-money objects (value in use)
- For enterprises we assume:
  - Every value object flowing in, is also flowing out
  - Therefore, enterprises have no valuation formulas for non-money objects, thereby neglecting value of stock

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## Assigning economic value to non-money objects: An example



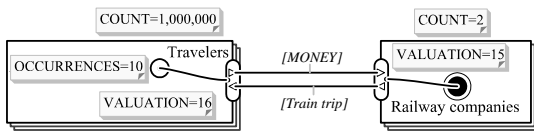
Valuation formulas for non-money objects can only be meaningfully assigned to ports of the valuing actor (value in use)

Value Interface	Value Port	Value Transfer	Occurrences	Valuation	Economic Value	Total
(MONEY food)			15			-150
	out: MONEY	MONEY	15	10	-150	
	in: food	(all transfers)	15	11	165	
(MONEY train trip)			10		-100	
	out: MONEY	MONEY	10	200	-2000	
	in: train trip	(all transfers)	10	210	2100	
INVESTMENT						0
EXPENSES						0
total for actor						115

Traveler

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## How about market segments?

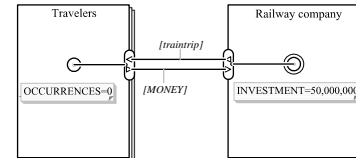


Value Interface	Value Port	Value Transfer	Occurrences	Valuation	Economic Value	Total
MONEY: Train trip						
	in: MONEY	MONEY	5000000	15	75000000	
	out: Train trip	(all transfers)	5000000	0	0	
COUNT	2					
INVESTMENT						0
EXPENSES						0
total for actor						75000000

Observe the number of occurrences

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## Adding upfront investments



Value Interface	Value Port	Value Transfer	Occurrences	Valuation	Economic Value	Total
traintrip: MONEY						
	out: traintrip	(all transfers)	0	0	0	
	in: MONEY	MONEY	0	200	0	
INVESTMENT						50000000
EXPENSES						0
total for actor						-50000000

Observe:

- The INVESTMENT formula is a property of the Railway company
- Why is the number of occurrences=0?

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## Calculating the net value flow sheet

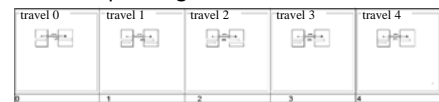
For each actor:

- For each in-going value port: list the number of value transfers as well as the valuation of the object transferred, and multiply the number of transfers with the valuation of the object in these transfers;
- For each out-going value port: list the number of value transfers as well as the valuation of the object transferred, and multiply the number of transfers with the valuation of the object in these transfers;
- Subtract the total value of all out-going value transfers and investments from the total value of all in-going transfers.

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## Discounted net present value flow sheets

- So far, a value web model and the belonging value sheets cover one period (e.g. a year)
- For investment decisions, multiple sequential periods have to be considered.
- Therefore, a time series consists of a number of sequential time periods of value web diagrams
  - Each time period can be considered as 'snapshot'
  - Each time period gives a net value flow



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## Discounted net present value flow calculation: Summing up the net value flows of all periods

- Suppose the following value flows (in years). How do we calculate the total net value flow over these years?

Period	Revenues	Expenses	Investments	Total
0			1,000	-1,000
1	500	100		400
2	500	100		400
3	500	100		400
Total				200

- A naïve approach for calculating the value over these years would be:

$$NetCashFlow = \sum_{period=0}^m (Revenues - Expenses - Investments)_{period}$$

## Discounted net present value flow calculation: Why is the naïve way actually wrong?

- Suppose we have 1,000 euros right now to invest
- We can invest in risk-free state bonds with an interest rate of 5% (or we can invest in the value web)
- After one year, the 1,000 euros are worth:  $1,000 \times 1.05 = 1,050$  euros

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## Discounted net present value flow calculation: Why is the naïve way actually wrong cont'd?

- Now suppose that we invest 952.38 euros in risk free state bonds. After one year these are worth 1,000 euros
- If we invest 907.03 euros now, the result is also 1,000 euros, but after two years
- In general, an amount of money X we will have in a few years, is worth Y right now, and  $Y < X$
- So, if we sum up amounts of money we have in different years, we have to discount these amounts to a same year (usually the first year)

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## Discounted net present value flow calculation: Why is the naïve way actually wrong cont'd?

- Discounting money uses the following formula:

$$\text{NetPresentDiscountedCashFlow} = \sum_{\text{period}=0}^m \frac{(\text{Revenues} - \text{Expenses} - \text{Investment})_{\text{period}}}{(1 + \text{interest})^{\text{period}}}$$

- Discounting the naïve table

Period	Revenues	Expenses	Investments	Total
0			1,000	-1,000
1	500	100		400
2	500	100		400
3	500	100		400
Total				200

Period	Revenues	Expenses	Investments	DNPC
0			1,000	-1,000
1	500	100		380.85
2	500	100		362.81
3	500	100		345.54
Total				89.30

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## Discounted net present value flow calculation: What interest rate to use?

- Usually, investments in value webs are not risk-free
- Factors determining the appropriate interest rate
  - A risk fee = uncertainty about future cash-flows
  - Cost of capital (typically investments require loan)
  - Usually, interest rates are high (20 to 60%)

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## Sensitivity analysis using scenarios

- All calculations are based on best-effort estimates of future profits, market size, etc.
- It is therefore important to understand sensitivities in these estimates
- Evolutionary scenarios are used to represent future events that may influence the estimates
  - Scenarios are small stories that explain the future event
  - Scenarios are also used in strategic decision taking

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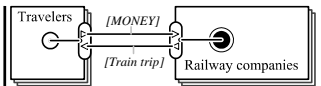
## Sensitivity analysis using scenarios cont'd

- Tricks to elicit scenarios: Look for
  - Changes in consumer needs, and the size of market segments
  - Changes in the way value is calculated (e.g. pricing)
  - Changes in the structure of the web (e.g. actors leaving the web or new participants entering the web)
  - Changes in the assignment of activities to different actors
- Changes are subject to a risk that they indeed occur:
  - A known risk is a foreseen event for which the chance on occurrence can be predicated to a certain extent (e.g. by using historical data);
  - A structural uncertainty is an event that can be thought of, but for which it is difficult to estimate the chance on occurrence;
  - An unknowable is an event, which can not reasonably be foreseen on beforehand

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## Sensitivity analysis using scenarios cont'd

Sensitivity Analysis	Scenarios and risks SA-1
SCENARIO TITLE	State only the future event.
SCENARIO DESCRIPTION	Makes short description of the future event that impacts the value web.
IMPACT ON VALUE WEB	Indicate in a concise manner the changes in value web if the foreseen event really happens. Possible changes are: 1. Increasing or decreasing consumer needs. 2. Increasing or decreasing market segment size. 3. Different valuation formulas. 4. Actors/ Market segments entering or leaving the web, changes in value transfers. 5. The performing actor of value activities changes.
CHANCE	In case the event imposes a risk, estimate the likelihood of occurrence. If the event is a structural uncertainty, the estimate is unknown.
PERIOD	1. Indicate the time periods, the event is expected to occur.



Sensitivity Analysis	Scenarios and risks SA-1
SCENARIO TITLE	Disturbances in the infrastructure.
SCENARIO DESCRIPTION	Because of insufficient maintenance, many disturbances in the railway infrastructure occur.
IMPACT ON VALUE WEB	1. Consumer needs decrease with 2, as compared to the previous period (people take the train less). 2. 'Traveler' market segment size decreases with 15%, as compared to the previous period (less people take the train).
CHANCE	Given the current state of maintenance, the chance is about 30 %.
PERIOD	The event can happen in all considered periods, if maintenance is not improved.

Scenario	Chance	'Railway Company'	'Traveler'
Null-scenario	n.a.	381,167,241.65	-7,497.65
Disturbances in the infrastructure	30 %	249,792,462.70	-6,127.50

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Next lecture:  
Advanced topics in economic  
sustainability assessment

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## Key points

- The number of value transfers in a value web are counted by starting at the consumer needs (one-by-one), by traversing through the model by following a trace, and by ending the traverse as soon as a boundary element is encountered. Meanwhile, a variable 'occurrences' is maintained.
- Objects have an economic value. In case value objects are money, this value is objective (actors can not disagree). In all other cases, the value is subjective (actors assign different values to a same object).
- Actors, value activities, and market segments may have investments, which represent one-time and often upfront expenses.
- A series of value models can be combined into a time series. Each model represents a specific time period. Using Discount Net Present Value calculation, the value flows can be summed up.
- Financial numbers are just estimates; therefore a sensitivity analysis must be done.

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