# Central Asian Gas in Eurasian Power Game

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# Motivation

Central Asia: Turkmenistan, Kazakhstan, Uzbekistan

- Geopolitical position, surrounded by major powers
- Rich energy sources: 27.8 tcm of proven conventional natural gas reserves (13.3% of the world total)
- Transit dependency on Russia to access consumer markets

Major powers: Russia, China, Iran, Europe & Turkey

- Tap rich gas fields in Central Asia
- Block access of other parties to these fields

Players can act strategically in order to shape the pipeline network to their benefit.

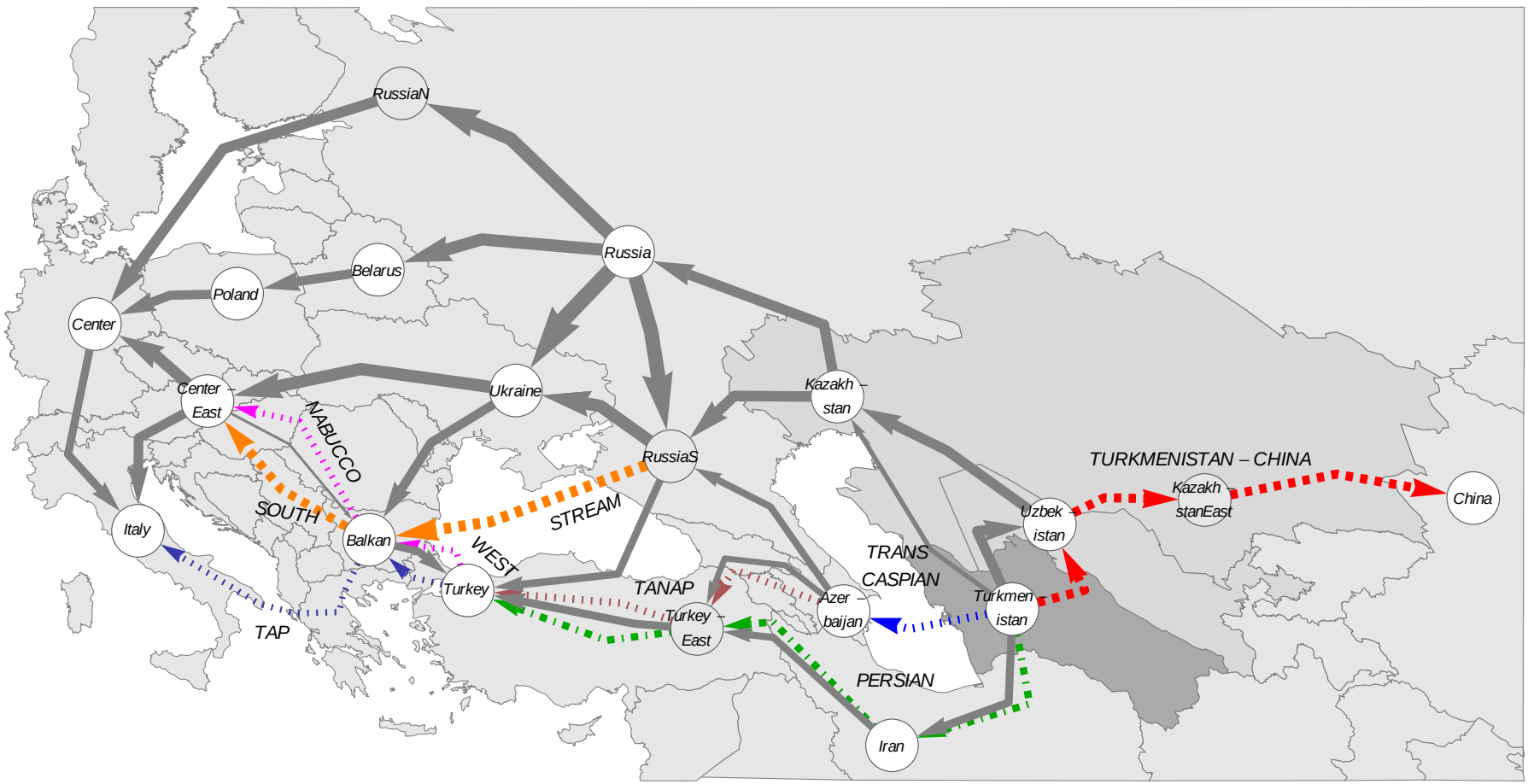
# Motivation

Four pipeline options to diversify transport routes as well as export markets of the Central Asian countries:

- Eastwards
  - the Turkmenistan-China pipeline
- Westwards
  - via Caspian Sea: the Trans-Caspian pipeline & the Southern Corridor
  - via Iran: the Persian pipeline & the Southern Corridor
  - via Russia: the South Stream pipeline

However, the pipelines have to cross multiple countries with different strategic interests!

# Geography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China
TAP
PERSIAN
Iran

# What I show

Pipelines have a strategic role in changing the balance of power in the network.

Using a quantitative model, solved with the Shapley Value I show:

- The Central Asian countries made the right decision by upholding the Turkmenistan-China pipeline instead of the western pipeline options.
- There is no strategic interaction between China and the West.
- For Turkmenistan the route via Caspian Sea is the most beneficial option to reach European markets.
- The leverage accruing to Europe from Central Asian supplies is insufficient for an European investment.

# Literature

**Non-cooperative approach**

Grais & Zheng (1996), Boots et al. (2004), von Hirschhausen et al. (2005) and Holz et al. (2008)

- Computational advantages
- Counterfactual assumptions from standard Cournot and Bertrand set up instead of price-quantity contracts
- Ad hoc assumptions on the nature of strategic interaction at the various stages, the sequencing of actions and the ability to commit

# Literature

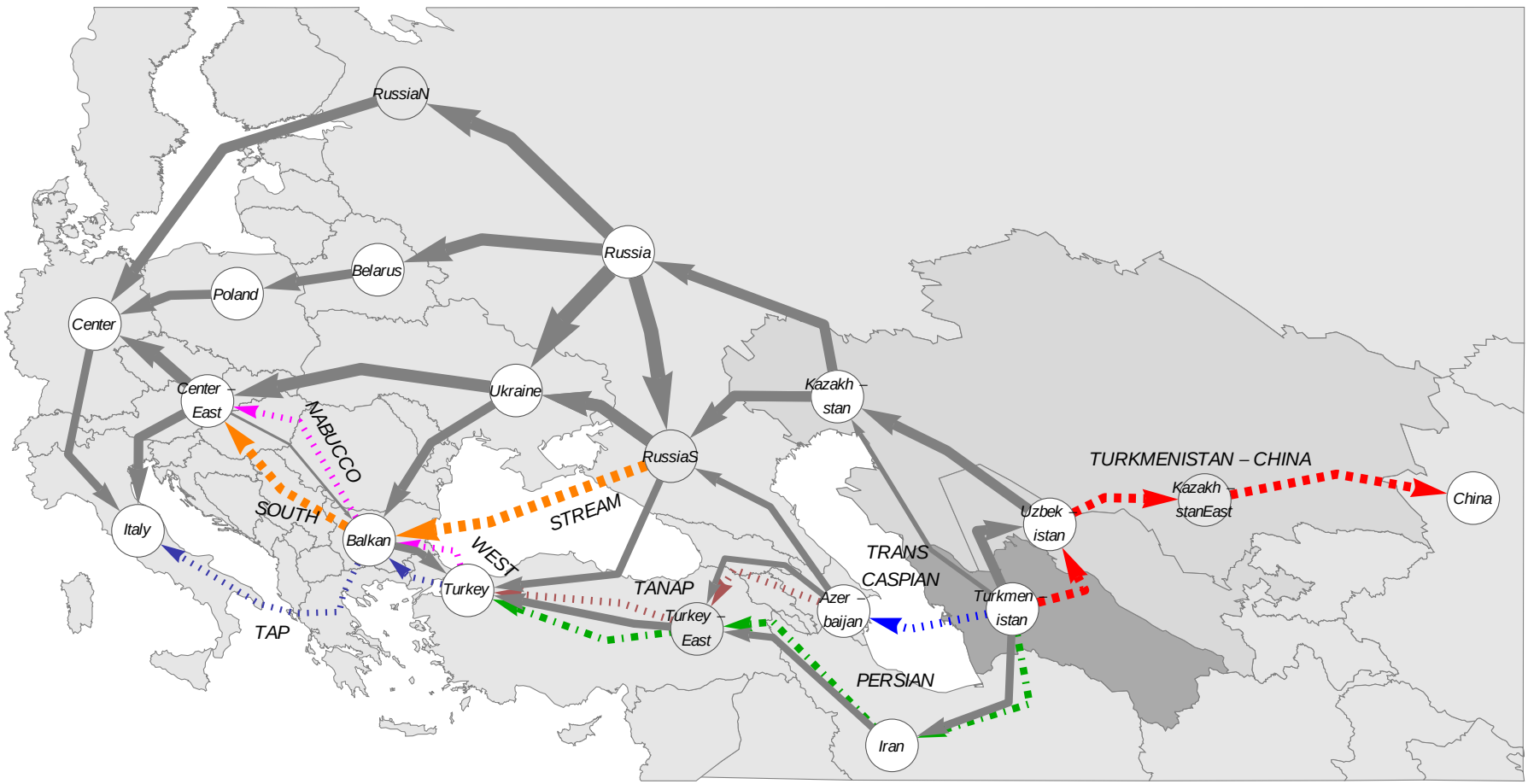
**Cooperative approach**

Hubert & Ikonnikova (2011a)

- Efficient use of the existing network
- Derive power structure endogenously from the actor's role in gas production, transport and consumption
- Narrow regional scope

Hubert & Cobanli (2012)
Pipeline Power

# Geography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# The Network

Set of nodes $R$:

- $R_P$: Production
- $R_T$: Transit connections
- $R_C$: Customer
- $R_{LNG}$: LNG regasification facilities

A link $l = \{i, j\},\ i \neq j \in R$ connects two nodes and has a capacity limit $k_{ij}$ and specific transportation costs $T_{ij}(x)$.

$x_{ij}$ denotes gas flows from $i$ to $j$.

# Value Function

**The value (or characteristic) function** $v : 2^{|N|} \to R_+$ gives the maximal payoff, which a subset of players $S \subseteq N$ can achieve.

The value function captures the essential economics features, such as the geography of the network, different cost of alternative pipelines, demand for gas in the different regions, production cost, ownership and access rights, etc.

For any coalition $S \subseteq N$ we have to determine to which pipelines $L(S) \subseteq L$ the coalition $S$ has access.

# Value Function

$$v(S) = \max_{\{x_{ij} | \{i,j\} \in L(S)\}} \left\{ \sum_{\{i,j\} \in L(S),\, j \in R_C} \int_0^{x_{ij}} p_j(z) dz - \sum_{\{i,j\} \in L(S)} T_{ij}(x_{ij}) \right\} \tag{1}$$

subject to

the node-balancing constraints $\sum_i x_{it} = \sum_j x_{tj},\ \forall\, t \in R_T(S)$

the capacity constraints of the network $|x_{ij}| \leq k_{ij},\ \forall\, \{i,j\} \in L(S)$

and non-negativity constraints
$x_{ij} \geq 0,\ \forall\, i \in R_P$ or $j \in R_C$ or $i \in R_{LNG}$.

# Solution: Shapley Value

**The Shapley value** assigns a share of the surplus from cooperation to each player.

$\phi_i$, $i \in N$, which is player $i$'s weighted contribution to possible coalitions:

$$\phi_i(v) = \sum_{S:i \notin S} P(S)\left[v(S \cup i) - v(S)\right] \tag{2}$$

where $P(S) = |S|!\,(|N| - |S| - 1)!/|N|!$ is the weight of coalition $S$.

$\phi_i(v^1) - \phi_i(v^o)$ : the gross impact of the pipeline on the surplus of player $i$, which is then compared to the investment cost of the pipeline

# Institutional Framework

**Access rights**

- Within the EU: Open third party access (TPA) to the international high pressure transport pipelines
- Outside the EU: Every country has unrestricted control over its pipelines and gas fields.

**Short horizon**

A stationary environment with constant demand, technology, production cost, etc. All pipelines can be made bi-directional, but capacities cannot be increased.

# Calibration

Data for 2009 on production, consumption and LNG imports from IEA(2010a), IEA(2010b) and IEA(2011).

Projection of data from 2009 to 2015 by using forecasts of International Energy Agency (IEA) and Gas Infrastructure Europe (GIE).

Constant production cost up to the production levels achieved in 2015

Linear demand functions with the same intercept for all regions

Slope parameters estimated as to replicate the consumption in 2015, given assumption on production cost

# No Non-strategic Benefits

**The pipeline system as existing in 2015 is sufficient.**

Given the willingness to pay and the cost of producing gas, it is able to deliver the efficient amount of gas into the different consumption nodes.

None of the expensive pipeline projects considered in this paper can be justified in narrow economic terms.

# Critical Assumptions

The main differences between the power of the regions rely on:

- Relation of total consumption to own production and not on demand functions on which information is poor
- Production capacity and pipeline connections to the markets and not on differences in wellhead production cost which are difficult to estimate

# Results - Before Turkmenistan-China pipeline

- The figures confirm the Central Asian countries' decision to gravitate eastwards to China instead of westwards to Europe and Turkey.
- However, the gains are heterogeneously distributed within the Central Asian countries due to their different roles in eastern gas trade.
- For Turkmenistan western options via Caspian Sea and via Iran are more beneficial than the Turkmenistan-China pipeline.
- There is no strategic interaction between China and the West since Turkmenistan has large spare supply capacities.

# Results - Before Turkmenistan-China pipeline

| Players | Bench-mark | Impact of pipelines | | | | |
|---|---|---|---|---|---|---|
| | | *to the East* | *to the West* | | | |
| | | | via Russia | via Caspian Sea | | |
| | | Turkmenistan -China | South Stream | TC[a]+TANAP[b] | TC+TANAP +NabW | TC+TANAP +TAP[c] |
| Azerbaijan | 1.2 | 0. | −0.2 | 0.9 | 0.7 | 0.7 |
| Kazakhstan | 0.1 | 0.5 | 0. | 0. | 0. | 0. |
| Turkmenistan | 0.1 | 0.1 | 0. | 0.5 | 0.5 | 0.5 |
| Uzbekistan | 0. | 0.5 | 0. | 0. | 0. | 0. |
| Balkan | 1.3 | 0. | 0.3 | 0.1 | 0.3 | 0.3 |
| Cont.Eur. | 30.6 | 0. | 1.2 | 0.2 | 0.1 | 0.1 |
| UK | 12.1 | 0. | 0.3 | 0. | 0.1 | 0.1 |
| Turkey | 14.2 | 0. | 0.2 | 0.9 | 1.6 | 1.6 |
| Russia | 28.9 | 0. | 1.8 | −1.7 | −1.7 | −1.7 |
| Ukraine | 14.5 | 0. | −1.8 | −0.2 | −0.9 | −0.9 |
| Belarus | 10.5 | 0. | −0.4 | 0. | 0. | 0. |
| Iran | 1.7 | 0. | −0.3 | −0.2 | −0.4 | −0.4 |
| Norway | 18.7 | 0. | −1.2 | −0.3 | −0.1 | −0.1 |
| China | 0. | 0.5 | 0. | 0. | 0. | 0. |
| project cost[e] | | 0.7 | 1.8 | 1.2 | 2.0 | 1.6 |

# Results - After Turkmenistan-China pipeline

- Given the capacity of the Turkmenistan-China pipeline shipments to China does not affect the western options.
- In Central Asia only Turkmenistan gains from the western pipeline options while power of Kazakhstan and Uzbekistan remains unchanged.
- The route via Caspian Sea (the Trans-Caspian pipeline & the Southern Corridor) benefits Turkmenistan at most.

# Results - After Turkmenistan-China pipeline

| Players | Bench-mark | Impact of pipelines | | | |
|---|---|---|---|---|---|
| | | | *to the West* via Caspian Sea | | |
| | | via Russia South Stream | TC+TANAP | TC+TANAP +NabW | TC+TANAP +TAP |
| Azerbaijan | 1.2 | –0.2 | 0.9 | 0.7 | 0.7 |
| Kazakhstan | 0.5 | 0. | 0. | 0. | 0. |
| Turkmenistan | 0.2 | 0. | 0.5 | 0.5 | 0.5 |
| Uzbekistan | 0.5 | 0. | 0. | 0. | 0. |
| Balkan | 1.3 | 0.3 | 0.1 | 0.3 | 0.3 |
| Cont.Eur. | 30.6 | 1.2 | 0.2 | 0.1 | 0.1 |
| UK | 12.1 | 0.3 | 0. | 0.1 | 0.1 |
| Turkey | 14.2 | 0.2 | 0.9 | 1.6 | 1.6 |
| Russia | 28.9 | 1.8 | –1.7 | –1.7 | –1.7 |
| Ukraine | 14.5 | –1.8 | –0.2 | –0.9 | –0.9 |
| Belarus | 10.5 | –0.4 | 0. | 0. | 0. |
| Iran | 1.7 | –0.3 | –0.2 | –0.4 | –0.4 |
| Norway | 18.8 | –1.2 | –0.3 | –0.1 | –0.1 |
| China | 0.5 | 0. | 0. | 0. | 0. |
| project cost[a] | | 1.8 | 1.2 | 2.0 | 1.6 |

# Results - After Turkmenistan-China pipeline

**The route via Russia:** the South Stream pipeline

- The status quo is maintained for the Central Asian countries since their dependence on Russia prevails.
- Bypassing of the transit countries (Ukraine & Belarus) returns European consumers large benefits.
- The South Stream pipeline fails to forestall investment in the Southern Corridor since the projects benefits Europe and Turkey through different effects: transport and supply competition, respectively.

# Results - Can the South Stream preempt the Southern Corridor?

| Players | Impact of pipelines[a] | | | | | |
|---|---|---|---|---|---|---|
| | w/o SS | | | with SS | | |
| | Bench-mark | TC+TANAP +NabW | TC+TANAP +TAPex[b] | Bench-mark | TC+TANAP +NabW | TC+TANAP +TAPex |
| Azerbaijan | 1.2 | 0.7 | 1. | 1. | 0.7 | 0.9 |
| Kazakhstan | 0.5 | 0. | 0. | 0.6 | 0. | 0. |
| Turkmenistan | 0.2 | 0.5 | 0.5 | 0.2 | 0.5 | 0.5 |
| Uzbekistan | 0.5 | 0. | 0. | 0.5 | 0. | 0. |
| Balkan | 1.3 | 0.3 | 0.1 | 1.6 | 0.1 | 0. |
| Cont.Eur. | 30.6 | 0.1 | 0.3 | 31.8 | 0.3 | 0.3 |
| UK | 12.1 | 0.1 | 0.1 | 12.4 | 0.1 | 0.1 |
| Turkey | 14.2 | 1.6 | 1. | 14.4 | 1.4 | 0.9 |
| Russia | 28.9 | −1.7 | −1.7 | 30.6 | −2. | −1.8 |
| Ukraine | 14.5 | −0.9 | −0.4 | 12.7 | −0.5 | −0.1 |
| Belarus | 10.5 | 0. | 0. | 10.1 | 0. | 0. |
| Iran | 1.7 | −0.4 | −0.2 | 1.4 | −0.2 | −0.1 |
| Norway | 18.8 | −0.1 | −0.5 | 17.6 | −0.1 | −0.4 |
| China | 0.5 | 0. | 0. | 0.5 | 0. | 0. |
| project cost[c] | | 2.0 | 1.6 | | 2.0 | 1.6 |

# Results - After Turkmenistan-China pipeline

**The route via Caspian Sea:** the Trans-Caspian pipeline & the Southern Corridor

- Extension of the Southern Corridor from the Turkey-EU border to Central Europe does not bring in benefits to Europen consumers as well as Turkmenistan.
- Most of the gains accrue to the transit country Turkey.
- Exemption of the TAP from the Third Energy Package alters the power distribution in favor of the EU and Azerbaijan.
- I expect that the EU will exempt the TAP from the Third Energy Package, and the Shah Deniz field's consortium will select the TAP as the final route.

# Results - Exemption in the Southern Corridor

| | Bench-mark | Impact of pipelines[a] (difference to column 1) TC+TANAP | TC+TANAP +TAP | TC+TANAP +TAPex[b] |
|---|---|---|---|---|
| Azerbaijan | 1.2 | 0.9 | 0.7 | 1. |
| Kazakhstan | 0.5 | 0. | 0. | 0. |
| Turkmenistan | 0.2 | 0.5 | 0.5 | 0.5 |
| Uzbekistan | 0.5 | 0. | 0. | 0. |
| Balkan | 1.3 | 0.1 | 0.3 | 0.1 |
| Cont.Eur. | 30.6 | 0.2 | 0.1 | 0.3 |
| UK | 12.1 | 0. | 0.1 | 0.1 |
| Turkey | 14.2 | 0.9 | 1.6 | 1. |
| Russia | 28.9 | −1.7 | −1.7 | −1.7 |
| Ukraine | 14.5 | −0.2 | −0.9 | −0.4 |
| Belarus | 10.5 | 0. | 0. | 0. |
| Iran | 1.7 | −0.2 | −0.4 | −0.2 |
| Norway | 18.8 | −0.3 | −0.1 | −0.5 |
| China | 0.5 | 0. | 0. | 0. |
| project cost[c] | | 1.2 | 1.6 | 1.6 |

# Robustness

The relation of demand intercept and production cost determines the overall surplus from the gas trade.

With respect to an aggregate increase of demand in relation to production cost:

- the relative shares of different players tend to be rather robust
- the absolute values of their shares will increase, and as a result more pipeline projects will become strategically viable for given investment cost

Thank you for your attention!

Questions?

# Shapley Value - Example 1

$N = \{a, b, c\}$

$v(a) = 0; v(b) = 0; v(c) = 0$

$v(a, b) = 0; v(a, c) = 0; v(b, c) = 0$

$v(a, b, c) = 1$

Then, $\phi_a(v) = \phi_b(v) = \phi_c(v) = 1/3$

# Shapley Value - Example 2

$N = \{a, b, c\}$

$v(a) = 0; v(b) = 0; v(c) = 0$

$v(a, b) = 1; v(a, c) = 0; v(b, c) = 0$

$v(a, b, c) = 1$

Then, $\phi_a(v) = \phi_b(v) = 1/2; \phi_c(v) = 0$