

Ownership Networks and Economic Power in the Italian Energy Sector

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Who is really behind a foreign investment?

Direct ownership may not reveal effective control



What policymakers observe

- ▶ Direct shareholder
- ▶ Nominal ownership stake

What policymakers need to know

- ▶ Ultimate controller
- ▶ Indirect ownership paths
- ▶ Intermediaries transmitting control

From a policy question to a network measurement problem

An ownership structure can be represented as a **directed weighted network**:

- ▶ **Nodes:** firms, investors, funds, governments, holding companies
- ▶ **Edges:** ownership relations
- ▶ **Weights:** equity shares or voting rights

This representation is useful because it allows us to identify not only direct ownership, but also indirect ownership through several layers.

Once we represent ownership as a network, the next question is: **what exactly do we want to measure?**

We will use network power as the general concept. But network power can take different dimensions.

A taxonomy of network-based measures of power and control

Centrality-based

Power = position

Who occupies a structurally advantageous position?

Flow-based

Power = propagation

How does influence travel through network paths?

Game-theoretic

Power = pivotality

Who is decisive in forming a controlling coalition?

Optimization-based

Power = strategic control

What is the least-cost structure needed to obtain control?

Concentration-based

Power = accumulation

How concentrated is control among a few actors?

Hybrid approaches

Power = pivotality + propagation

Combining decisional power with network transmission.

Network Power Index (NPI): the basic idea

The Network Power Index (NPI), introduced by Mizuno, Doi & Kurizaki (2020), measures the probability that an investor ultimately controls a firm once both direct and indirect ownership relations are taken into account.

Consider an ownership network

$$G = (N, X),$$

where

$$x_{ij} \in [0, 1]$$

denotes the ownership share of investor i in firm j , and q_j is the control threshold of firm j .

The NPI combines two mechanisms:

- 1 **Game-theoretic pivotality:** identify which shareholder is decisive in forming a controlling coalition;
- 2 **Network propagation:** transmit that control through indirect ownership relations.

NPI – Step 1: identifying the pivotal controller

For each firm k , consider its shareholders and their ownership shares

$$x_{1k}, \dots, x_{nk},$$

together with the control threshold q_j .

In each simulation, the shareholders are placed in a **random order**.

Their ownership shares are then added sequentially:

$$x_{1k} + x_{2k} + \dots$$

until the cumulative ownership reaches the control threshold q_k .

The shareholder that makes the cumulative share cross the threshold is identified as the **pivotal shareholder**.

The pivotal shareholder is the actor whose entry turns a non-controlling coalition into a controlling one.

NPI – Step 2: propagating control through the network

Suppose investor i is identified as the pivotal shareholder of firm k .

Then firm k is treated as being controlled by investor i :

$$L_k = i.$$

Now suppose firm k owns shares in another firm j :

$$i \longrightarrow k \longrightarrow j.$$

Because i controls k , the ownership stake held by k in j is attributed to investor i .

If investor i controls several firms that own shares in j , these shares are added together:

$$\tilde{x}_{ij} = \sum_{k: L_k=i} x_{kj}.$$

The updated ownership shares are then used to identify the pivotal shareholder of the next firm.

Identify control → transfer ownership rights → update the network → continue downstream.

NPI – Step 3: repeated simulations

Each simulation generates one possible **control structure for the entire ownership network**.

For each simulation $t = 1, \dots, T$:

- 1 shareholders are randomly ordered within each firm;
- 2 the pivotal shareholder is identified;
- 3 control is assigned;
- 4 control is propagated through the full ownership network.

Repeating this procedure many times allows us to recover the **distribution of ultimate control across the ownership network**.

Network Power Flow (NPF): The basic idea

The NPF, introduced by Mizuno et al. (2023), builds on the same **pivotality mechanism** used by the NPI.

NPI

Who ultimately controls a target firm?

Focuses on the **ultimate controller**.

NPF

Who is important in transmitting control through the ownership network?

Also captures the role of **intermediate shareholders**.

Consider a control path:

$$i \longrightarrow k_1 \longrightarrow k_2 \longrightarrow j$$

Under the NPI, i is identified as the ultimate controller of j .

Under the NPF, we also measure the role of k_1 and k_2 , because control passes through them.

How to interpret the NPF

The NPF is a **network-level measure**.

It evaluates how important each shareholder is in transmitting corporate control through the ownership network.

A shareholder has a high NPF when it:

- ▶ frequently plays a pivotal role in control paths;
- ▶ lies on important ownership chains;
- ▶ mediates control over many firms in the network.

Therefore, a shareholder can have a high NPF even if it is **not the ultimate controller** of many firms.

NPI tells us who controls.

NPF tells us who is important in transmitting control.

From global network power to target-specific control

The original NPI and NPF provide a **global** view of power in the ownership network.

For FDI analysis, however, the relevant question is often:

Who controls a specific target firm?

In our recent paper Pannone et al. (2026), we therefore introduce target-based extensions:

$$T-NPI_{i \rightarrow f} \quad \text{and} \quad T-NPF_{i \rightarrow f}.$$

- ▶ $T-NPI_{i \rightarrow f}$: probability that investor i ultimately controls target firm f ;
- ▶ $T-NPF_{i \rightarrow f}$: intensity with which control is transmitted toward f through investor or intermediary i .

The perspective shifts from “who is powerful in the network?”
to “who controls this particular firm, and through which path?”

From target-specific to aggregate network power

For sector-level analysis, we consider a set of firms

$$V = \{1, \dots, |V|\}.$$

Because firms differ in economic relevance, we assign each firm a weight

$$w_j = \frac{v_j}{\sum_{k \in V} v_k}, \quad \sum_{j \in V} w_j = 1.$$

We then define:

$$A-NPI_i^w(V) = \sum_{j \in V} w_j T-NPI_{i \rightarrow j},$$
$$A-NPF_i^w(V) = \sum_{j \in V} w_j T-NPF_{i \rightarrow j}.$$

- ▶ **A-NPI:** Captures the overall level of ultimate control exercised by a node (i) across sector firms.
- ▶ **A-NPF:** Captures the overall role of a node (i) in transmitting control through the sector's ownership network.

Empirical application: the Italian energy sector

We first identify the main firms belonging to the Italian energy sector.

The selection is based on:

- ▶ sector classification, mainly NACE 35 and 49.50;
- ▶ additional discretionary criteria to include strategically relevant firms.

Starting from these firms, we use ownership data from **LSEG Workspace** to trace their shareholders and ownership links.

This allows us to reconstruct the **ownership network** surrounding the main firms operating in the Italian energy sector.

Ownership data and network reconstruction

The reconstructed network includes:

- ▶ domestic and foreign shareholders;
- ▶ institutional investors and asset managers;
- ▶ public entities and municipalities;
- ▶ holding companies and financial intermediaries.

Historical context

- ▶ The Italian energy sector has historically been characterized by a **strong public presence**.
- ▶ Major operators such as **Eni, Enel, Terna, and Snam** originated as state-controlled enterprises and still play key roles in the national energy system.
- ▶ Liberalization and privatization progressively opened the sector to **private capital and financial markets**, while public actors continued to retain important ownership stakes.
- ▶ The sector remains highly interconnected through electricity grids, gas transportation, storage, and distribution infrastructures.

Aggregate Network Power and the Governance Paradox

Aggregate network power by ownership category:

Category	A-NPI (%)	A-NPF (%)
Public actors	28.48	8.04
Municipal actors	5.85	1.79
Institutional investors	65.41	52.28
Industrial shareholders	0.13	37.80
Families and foundations	0.13	0.09

The **Italian State** remains important, especially in terms of ultimate control.

At the same time, a large share of sector-wide influence is associated with **private institutional investors**, particularly **Vanguard and BlackRock**, which are present across several major energy firms.

Governance Paradox: the State retains important ownership stakes in strategic firms, but sector-wide influence is increasingly associated with institutional investors that are present across multiple companies.

Conclusions and policy implications

① Looking only at direct shareholders can hide important information.

Control and influence may also emerge through indirect ownership chains, intermediary entities, and repeated ownership positions across several firms.

② A network perspective reveals the broader ownership structure.

A-NPI identifies ultimate control, while A-NPF captures how influence is transmitted through the ownership network.

③ This reveals a Governance Paradox in the Italian energy sector.

The State still retains important ownership positions in strategic firms, but liberalization and privatization have progressively opened the sector to private and international capital.

④ Institutional investors can become important at the sector level without holding large stakes in a single firm.

Investors such as BlackRock and Vanguard hold relatively small positions across several strategically relevant companies, generating significant network-wide influence.