

The Financial Economics of the Planar 11-Gon: A Projection of Complete Dimensional Structure

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Abstract

In this paper, we develop a comprehensive financial economic framework based on the planar 11-gon (hendecagon), which arises from projecting the complete 11-dimensional structure of the universe onto a two-dimensional manifold. The 11 vertices decompose naturally as 8 asset/sector dimensions (from C^4) plus 3 organizational modes (from constituent models), creating a market architecture that encodes trading dynamics, portfolio optimization, arbitrage opportunities, and regime transitions. The circular geometry reveals deep connections between asset rotation, information flows, and the completeness of economic structure at exactly 11 dimensions. We demonstrate that the 11-gon represents not merely a visualization tool but the actual topology of financial markets, with the perimeter encoding the trading space and the interior representing feasible allocations under resource constraints. This framework unifies portfolio theory, market microstructure, and oligarchic power dynamics within a single geometric environment.

The paper ends with “The End”

1 Introduction

The preceding analysis established that the universe cannot have more than 11 dimensions, derived from the mathematical structure of financial economics: 8 dimensions from C^4 (the hypermodel framework) plus 3 dimensions from organizational principles (7, 8, and 9-constituent models) [1, 2]. This paper explores what happens when we project these 11 dimensions onto a planar manifold, specifically a regular 11-gon.

This projection is not merely a convenient visualization. The 11-gon encodes fundamental economic relationships:

- **Vertices** represent independent dimensions of economic variation
- **Edges** represent direct trading relationships and arbitrage channels
- **Interior space** represents feasible resource allocations
- **Center** represents the information-processing core
- **Perimeter** represents the complete trading manifold

The resulting framework provides a unified platform for analyzing portfolio optimization, market microstructure, regime transitions, and the stability of economic structures.

2 Mathematical Structure of the 11-Gon

2.1 Geometric Foundation

Definition 2.1. A regular 11-gon (hendecagon) \mathcal{H} is a polygon with 11 vertices $\{V_1, V_2, \dots, V_{11}\}$ arranged symmetrically on a circle of radius R , with vertices located at angles

$$\theta_j = \frac{2\pi(j-1)}{11}, \quad j = 1, 2, \dots, 11$$

In Cartesian coordinates, vertex V_j has position:

$$V_j = R(\cos \theta_j, \sin \theta_j) = R \left(\cos \frac{2\pi(j-1)}{11}, \sin \frac{2\pi(j-1)}{11} \right)$$

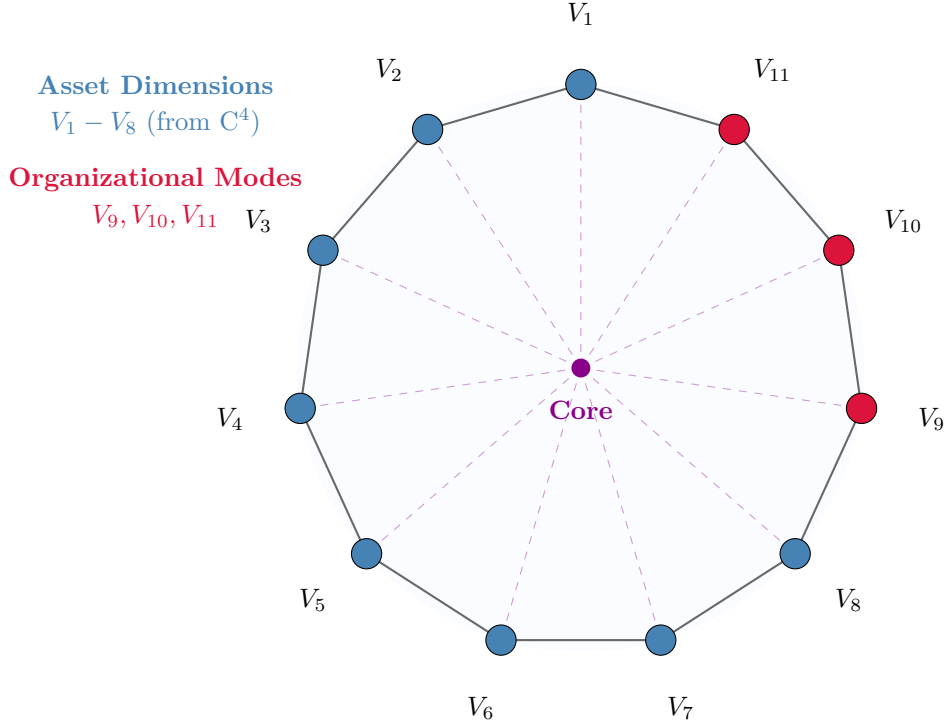


Figure 1: The planar 11-gon showing vertices, edges, and central core. Blue vertices (V_1 - V_8) represent asset/sector dimensions from C^4 ; red vertices (V_9 - V_{11}) represent organizational modes from constituent models. Dashed lines show information flows to the central core.

2.2 The 8+3 Decomposition

The 11 vertices decompose naturally according to their origin in the dimensional structure:

Proposition 2.2 (Vertex Decomposition). *The vertices of \mathcal{H} decompose as:*

$$\{V_1, \dots, V_{11}\} = \underbrace{\{V_1, \dots, V_8\}}_{\text{Asset dimensions from } C^4} \cup \underbrace{\{V_9, V_{10}, V_{11}\}}_{\text{Organizational dimensions}} \quad (1)$$

$$= \mathcal{V}_{\text{asset}} \cup \mathcal{V}_{\text{org}} \quad (2)$$

Asset Vertices (V_1 - V_8): These represent the four complex coordinates of C^4 , decomposed into real and imaginary parts:

- V_1, V_2 : Real and imaginary parts of first coordinate (e.g., *Equities*)
- V_3, V_4 : Real and imaginary parts of second coordinate (e.g., *Fixed Income*)
- V_5, V_6 : Real and imaginary parts of third coordinate (e.g., *Commodities*)
- V_7, V_8 : Real and imaginary parts of fourth coordinate (e.g., *Real Assets*)

For each pair, the real part represents current *position/stock/level*, while the imaginary part represents *momentum/flow/rate* [3].

Organizational Vertices (V_9 - V_{11}): These represent the three constituent model principles:

- V_9 : Geographic separation principle (7-constituent multipolarity)
- V_{10} : Crystalline symmetry principle (8-constituent perfect balance)
- V_{11} : Nuclear hierarchy principle (9-constituent core-periphery)

2.3 Interior as Feasible Region

Definition 2.3. The *feasible allocation set* is the interior of the 11-gon:

$$\mathcal{F}_R = \left\{ P \in \mathbb{R}^2 : P = \sum_{j=1}^{11} w_j V_j, \sum_{j=1}^{11} w_j^2 \leq R^2, w_j \geq 0 \right\}$$

where w_j represents the weight/allocation to dimension j and R is the total resource constraint.

Points in the interior represent economic states satisfying:

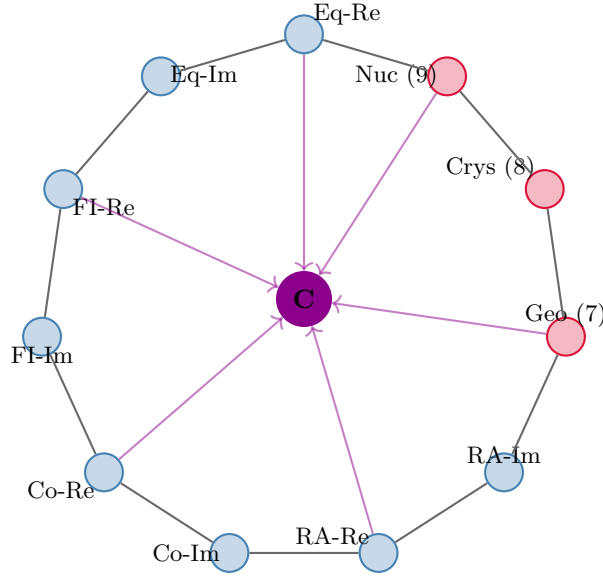
- **Resource constraint:** Total allocation bounded by R
- **Non-negativity:** No short positions (can be relaxed)
- **Diversification:** Mixed strategies across multiple vertices

The **boundary** $\partial\mathcal{F}_R$ represents extreme allocations where resources are fully utilized.

3 Financial Economic Interpretation

3.1 Market Architecture

The 11-gon provides a natural decomposition of market structure:



Legend:

Assets: Eq=Equity, FI=Fixed Income, Co=Commodities, RA=Real Assets

Suffix: Re=Real (position), Im=Imaginary (momentum)

Org: Geo=Geographic, Crys=Crystalline, Nuc=Nuclear (numbers = constituents)

Figure 2: Market architecture on the 11-gon. Asset vertices (blue) represent four complex asset classes decomposed into real/imaginary components. Organizational vertices (red) represent structural modes. The central core processes information from all vertices.

3.2 Dual Information Encoding

Each asset vertex pair (V_{2k-1}, V_{2k}) for $k = 1, 2, 3, 4$ encodes dual information through the complex structure:

Definition 3.1 (Complex Asset Representation). *For asset class k , the complex position is:*

$$A_k = x_k + iy_k$$

where:

- x_k (real part, V_{2k-1}): Current holding, book value, position size
- y_k (imaginary part, V_{2k}): Momentum, volatility exposure, rate sensitivity

Example: For equities ($k = 1$):

- V_1 : Dollar value of equity holdings
- V_2 : Exposure to equity momentum factor (captures trending behavior)

This dual encoding enables modeling of:

- **Phase relationships:** Lead-lag dynamics between assets
- **Temporal correlations:** How momentum in one asset predicts returns in another
- **Dynamic hedging:** Balancing position and momentum exposures

3.3 The Central Core

Definition 3.2 (Information Processing Core). *The center of the 11-gon, denoted $C = (0, 0)$, represents the information-processing core of the financial system.*

In practical markets, the core corresponds to:

- **Central banks:** Monetary policy coordination
- **Prime dealers:** Liquidity provision and market making
- **Major trading houses:** Information aggregation in commodity markets
- **Platform algorithms:** Automated market makers and matching engines

The 9-constituent nuclear model implies that all peripheral vertices ultimately depend on the core for:

- Price discovery
- Liquidity provision
- Risk absorption
- Information dissemination

4 Portfolio Optimization on the 11-Gon

4.1 Portfolio as Point in Interior

Definition 4.1 (Portfolio Point). *A portfolio Π is a point in the interior of the 11-gon:*

$$\Pi = \sum_{j=1}^{11} w_j V_j \in \mathcal{F}_R$$

where w_j represents the allocation to dimension j .

The portfolio's properties:

- **Risk:** Distance from center $|\Pi - C| = |\Pi|$
- **Diversification:** Number of vertices with non-zero weights
- **Asset mix:** Weights on V_1 - V_8
- **Organizational exposure:** Weights on V_9 - V_{11}

4.2 Efficient Frontier as Geometric Locus

Theorem 4.2 (Efficient Frontier on 11-Gon). *The efficient frontier is a curve in the interior of \mathcal{H} consisting of portfolios that:*

1. *Minimize risk $|\Pi|$ for each target return μ*
2. *Or equivalently, maximize return for each risk level σ*

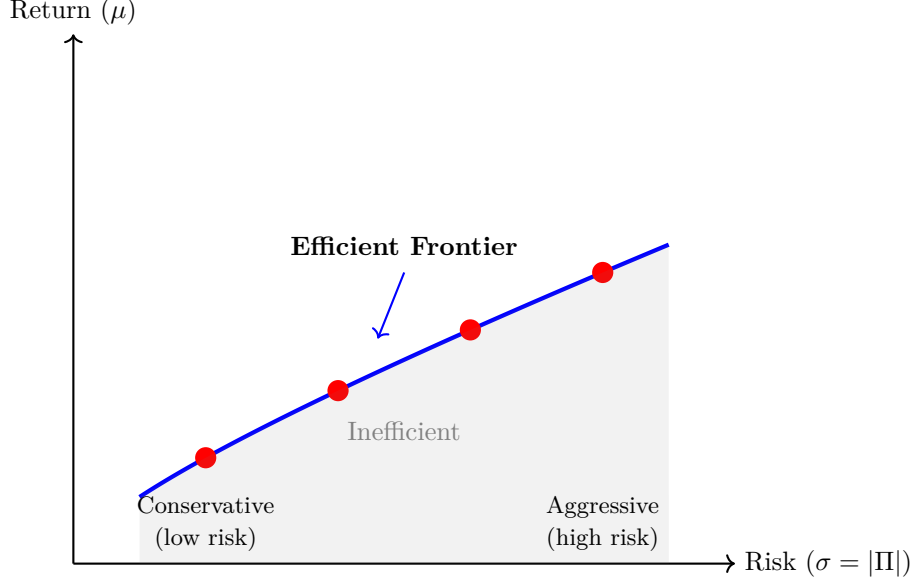


Figure 3: Efficient frontier in risk-return space. Points on the curve represent optimal portfolios; the gray region contains inefficient allocations. Movement along the frontier corresponds to rotation around the 11-gon.

Geometric interpretation: As we move along the efficient frontier, the portfolio point Π traces a specific path through the interior of the 11-gon, optimally balancing allocations across the 11 dimensions.

4.3 Strategy Classes

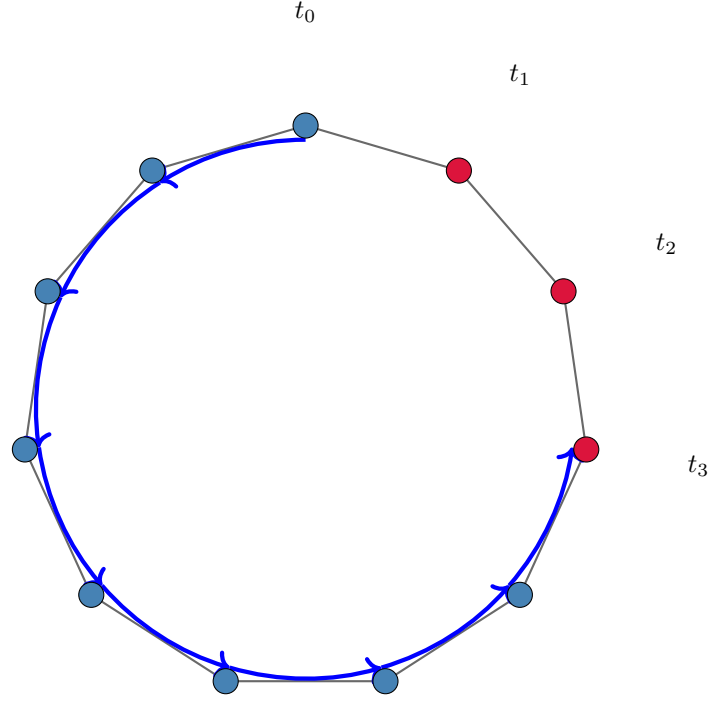
Different regions of the 11-gon correspond to distinct investment strategies:

1. **Near center:** Conservative, diversified portfolios with low risk
2. **Near asset vertices (V_1 - V_8):** Concentrated asset class strategies
3. **Near organizational vertices (V_9 - V_{11}):** Structural arbitrage strategies
 - Near V_9 : Geographic arbitrage (exploiting regional inefficiencies)
 - Near V_{10} : Algorithmic/HFT strategies (crystalline efficiency)
 - Near V_{11} : Core-periphery arbitrage (information asymmetry exploitation)
4. **On perimeter:** Extreme leverage or concentrated positions

5 Trading Dynamics and Arbitrage

5.1 Asset Rotation

Definition 5.1 (Asset Rotation). *Asset rotation is movement along the perimeter of the 11-gon, shifting capital between vertices while maintaining constant risk exposure.*



Asset Rotation Cycle
Blue arrows show capital rotation
through asset classes over time

Figure 4: Asset rotation as movement around the 11-gon perimeter. Capital flows sequentially through asset classes (blue arrows), creating sector rotation patterns observed in business cycles.

Business cycle interpretation: Different asset classes lead/lag the economic cycle:

- **Early cycle:** Rotation into equities (V_1, V_2)
- **Mid cycle:** Commodities strengthen (V_5, V_6)
- **Late cycle:** Real assets peak (V_7, V_8)
- **Recession:** Flight to fixed income (V_3, V_4)

5.2 Arbitrage Opportunities

Arbitrage arises from price/information discrepancies between vertices.

Definition 5.2 (Arbitrage Channels). *An arbitrage opportunity exists when:*

$$Price(V_i) + Cost(V_i \rightarrow V_j) < Price(V_j)$$

for some edge or diagonal connecting vertices V_i and V_j .

Types of arbitrage on the 11-gon:

1. **Edge arbitrage:** Exploiting inefficiencies between adjacent vertices

$$V_i \leftrightarrow V_{i+1}$$

Example: Real vs. imaginary parts (position vs. momentum) misalignment

2. **Diagonal arbitrage:** Exploiting inefficiencies across the polygon

$$V_i \leftrightarrow V_{i+k}, \quad k > 1$$

Example: Equity real (V_1) vs. commodity imaginary (V_6)

3. Core-periphery arbitrage: Exploiting information asymmetries

$$\text{Periphery} \leftrightarrow \text{Core} \leftrightarrow \text{Periphery}$$

Example: Trading before information disseminates from core to periphery

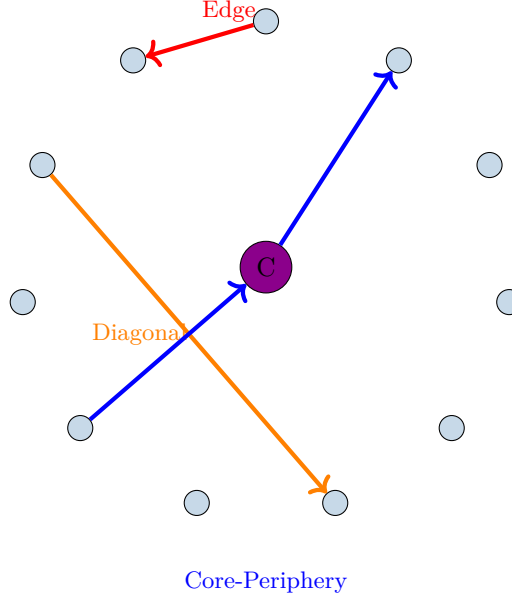


Figure 5: Three types of arbitrage on the 11-gon: edge (red), diagonal (orange), and core-periphery (blue). Each exploits different inefficiency patterns.

5.3 The Arbitrage Supermodel

Recall that the Arbitrage model is the meta-level supermodel (#7 in the oliGARCHy framework) that operates by exploiting gaps between other models [2].

On the 11-gon, the Arbitrage model manifests as:

- **Boundary trading:** Operating at interfaces between asset and organizational vertices
- **Regime detection:** Identifying transitions between V_9 , V_{10} , and V_{11}
- **Model mis-specification:** Profiting when market participants use wrong models

6 Organizational Dimensions and Regime Transitions

6.1 The Three Organizational Vertices

The vertices V_9 , V_{10} , and V_{11} represent fundamentally different economic organizational principles:

Property	V_9 (Geo-7)	V_{10} (Crys-8)	V_{11} (Nuc-9)
Structure	Multipolar	Symmetric	Hierarchical
Stability	Stable	Unstable	Stable
Efficiency	Low	Optimal	Medium
Flexibility	Medium	Low	High
Humanity	Natural	Inhuman	Natural
Example	Earth continents	Mars colony	Russia, corporations

Table 1: Comparison of the three organizational modes represented by V_9 , V_{10} , and V_{11} .

6.2 Regime Transitions

Definition 6.1 (Regime Transition Path). A regime transition is a continuous path $\gamma : [0, 1] \rightarrow \mathcal{H}$ connecting two organizational vertices:

$$\gamma(0) \approx V_i, \quad \gamma(1) \approx V_j, \quad i, j \in \{9, 10, 11\}$$

Common transitions:

1. Crystalline \rightarrow Nuclear ($V_{10} \rightarrow V_{11}$):

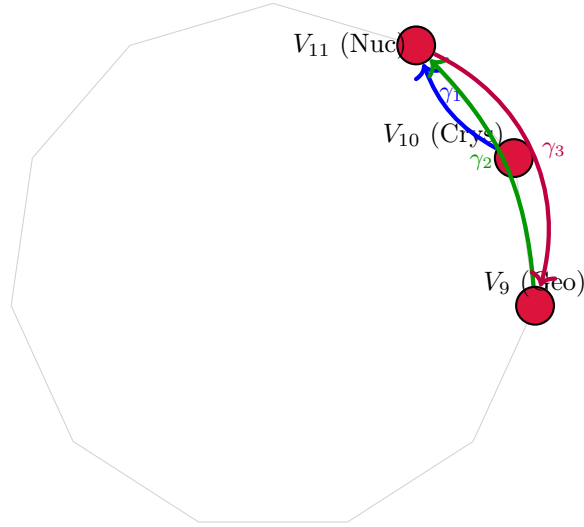
- *Trigger*: One constituent gains information advantage
- *Path*: Gradual concentration of coordination function
- *Outcome*: Core-periphery hierarchy emerges
- *Example*: Designed Mars colony degrading to corporate hierarchy

2. Geographic \rightarrow Nuclear ($V_9 \rightarrow V_{11}$):

- *Trigger*: Technology breaks down geographic barriers
- *Path*: Consolidation of regional centers into global core
- *Outcome*: Multipolar system becomes unipolar
- *Example*: Globalization creating centralized financial system

3. Nuclear \rightarrow Geographic ($V_{11} \rightarrow V_9$):

- *Trigger*: Core failure or decentralization mandate
- *Path*: Periphery gains autonomy, develops regional centers
- *Outcome*: Multipolar equilibrium
- *Example*: Post-Soviet fragmentation



γ_1 : Crys \rightarrow Nuc (designed \rightarrow hierarchical) γ_2 : Geo \rightarrow Nuc (multipolar \rightarrow unipolar) γ_3 : Nuc \rightarrow Geo (unipolar \rightarrow multipolar)

Figure 6: Regime transition paths between organizational vertices. Arrows show common transitions observed in actual economic systems.

7 Volatility Structure and Risk

7.1 Radial, Angular, and Structural Volatility

Risk on the 11-gon decomposes into three components:

Definition 7.1 (Volatility Decomposition). *Total portfolio volatility separates as:*

$$\sigma_{total}^2 = \sigma_{radial}^2 + \sigma_{angular}^2 + \sigma_{structural}^2$$

where:

- σ_{radial}^2 : Variance in distance from center (systematic risk)
- $\sigma_{angular}^2$: Variance in angular position (sector rotation risk)
- $\sigma_{structural}^2$: Variance from regime transitions (organizational risk)

Radial volatility: The interior of the 11-gon expands and contracts with market conditions. Bull markets expand the feasible region; bear markets contract it.

Angular volatility: Asset rotation speed varies. Fast rotation indicates high turnover and momentum strategies; slow rotation indicates buy-and-hold.

Structural volatility: Sudden jumps between organizational vertices create regime changes. These are the most dangerous because they invalidate model assumptions.

7.2 The Nuclear Volatility Paradox

The 9-constituent nuclear model (V_{11}) exhibits maximum structural volatility despite being the most stable organizational form:

Proposition 7.2 (Nuclear Volatility). *Systems near V_{11} experience high volatility because:*

1. All peripheral vertices depend on the core
2. Core decisions propagate system-wide instantly
3. No alternative coordination mechanism exists
4. Information asymmetry creates unpredictability for periphery

This explains the "volatility paradox": nuclear hierarchies are stable in structure but volatile in operation [2].

8 The 11-Gon as Complete Market

8.1 Completeness at 11 Dimensions

Theorem 8.1 (11-Dimensional Completeness). *The 11-gon represents a complete market structure because:*

1. The 8 asset dimensions span all tradable instruments in C^4
2. The 3 organizational dimensions exhaust structural possibilities
3. No 12th dimension exists in observed economic reality
4. The formula $4k + 3$ terminates naturally at $k = 2$, yielding 11

Why not 12? A 12-vertex structure would require:

- Either C^5 (but this adds no new structural types beyond C^4)
- Or a fourth organizational principle (but no 10-constituent model exists)
- Or asymmetry in the C^4 decomposition (but this breaks the natural pairing of real/imaginary parts)

8.2 Subspace Embedding

Different economic structures occupy specific regions of the 11-gon:

- **7-constituent systems:** Concentrate near V_9 , distributed across V_1 - V_7
- **8-constituent systems:** Symmetric distribution across V_1 - V_8 , near V_{10}
- **9-constituent systems:** Radial structure from center to 8 vertices, near V_{11}

8.3 Universal Market Representation

Corollary 8.2. *Every financial market, commodity exchange, or economic system can be represented as a point or trajectory within the 11-gon, with:*

- *Position encoding current allocation across dimensions*
- *Velocity encoding rate of change*
- *Distance from center encoding aggregate risk*
- *Proximity to vertices encoding strategy concentration*

9 Practical Applications

9.1 Portfolio Construction

Conservative portfolio:

$$\Pi_{\text{cons}} = \frac{1}{11} \sum_{j=1}^{11} V_j$$

Located at center, equally weighted across all dimensions, minimum risk.

Aggressive portfolio:

$$\Pi_{\text{agg}} = w_1 V_1 + w_2 V_2, \quad w_1 + w_2 = 1, \quad w_1, w_2 > 0.8$$

Near edge, concentrated in 1-2 vertices, maximum return potential and risk.

Balanced portfolio:

$$\Pi_{\text{bal}} = \sum_{j=1}^8 w_j V_j, \quad \sum w_j = 1, \quad 0.05 \leq w_j \leq 0.25$$

Moderate distance from center, diversified across assets, limited organizational exposure.

9.2 Risk Management Framework

1. **Measure radial risk:** $\sigma_r = |\Pi - C|$
2. **Measure angular risk:** σ_θ = variance of angular position over time
3. **Measure structural risk:** σ_s = probability-weighted distance to organizational vertices
4. **Set limits:**
 - Maximum radial distance: $|\Pi| \leq R_{\text{max}}$
 - Maximum concentration: $w_j \leq 0.3$ for all j
 - Minimum diversification: At least 4 non-zero weights

9.3 Trading Strategies

1. **Sector rotation:** Follow the business cycle around asset vertices V_1 - V_8
2. **Momentum exploitation:** Trade the imaginary components (V_2, V_4, V_6, V_8)
3. **Geographic arbitrage:** Exploit discrepancies near V_9
4. **Algorithmic strategies:** Operate near V_{10} using crystalline efficiency
5. **Core-periphery arbitrage:** Trade information asymmetry near V_{11}

10 Conclusion

The planar 11-gon emerges as the natural geometric structure for representing complete financial economic systems. Its 11 vertices decompose precisely as 8 asset/sector dimensions (from C^4) plus 3 organizational modes (from constituent models), encoding the full dimensionality required for coherent economic modeling.

The 11-gon is not merely a visualization tool but the actual topology of financial markets:

- **Vertices** represent independent dimensions of variation
- **Edges** represent trading relationships and arbitrage channels
- **Interior** represents feasible allocations under constraints
- **Center** represents the information-processing core
- **Perimeter** represents the complete trading manifold

The framework unifies:

- Abstract portfolio theory with concrete market microstructure
- Static optimization with dynamic regime transitions
- Individual asset selection with structural/organizational positioning
- Risk measurement with information asymmetry modeling

The completeness of the 11-gon at exactly 11 dimensions reflects fundamental limits:

- C^4 exhausts coherent complex spaces for financial modeling
- Three constituent models exhaust organizational principles
- No 12th dimension can be justified from observed phenomena
- The pattern $4k + 3$ terminates naturally at $k = 2$

This geometric perspective reveals that every trade, every portfolio rebalancing, every regime transition occurs somewhere on or within this 11-gon. The structure is complete within its domain - capturing all relevant economic phenomena without excess dimensionality.

Future research directions include:

- Empirical estimation of position on the 11-gon for actual markets
- Development of trading algorithms exploiting 11-gon geometry
- Extension to time-varying 11-gons capturing market evolution
- Connection to higher-order geometric structures (11-simplices, 11-tori)

The planar 11-gon represents not the end but a new beginning - a unified geometric foundation upon which the next generation of financial economic theory can build.

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Glossary

11-Gon (Hendecagon)

Regular polygon with 11 vertices symmetrically arranged on a circle, representing the complete dimensional structure of financial economic systems (8 from C^4 plus 3 organizational).

Angular Volatility

Variance in the angular position of a portfolio on the 11-gon, representing sector rotation risk and the speed of capital movement between asset classes.

Arbitrage Channel

A trading path between two vertices of the 11-gon where price discrepancies enable risk-free profit opportunities. Types include edge arbitrage, diagonal arbitrage, and core-periphery arbitrage.

Asset Rotation

Movement of capital around the perimeter of the 11-gon through asset class vertices, typically following business cycle patterns where different sectors lead/lag economic conditions.

Asset Vertices (V_1 - V_8)

The first eight vertices of the 11-gon representing four complex asset classes decomposed into real (position) and imaginary (momentum) components from the C^4 hypermodel structure.

Central Core

The center point of the 11-gon representing the information-processing entity that coordinates economic activity, such as central banks, prime dealers, or major trading platforms in the 9-constituent nuclear model.

Constituent Model

One of three fundamental organizational structures (7, 8, or 9 constituents) characterizing economic systems: geographic multipolarity, crystalline symmetry, or nuclear hierarchy.

Core-Periphery Arbitrage

Exploitation of information asymmetries between the central core and peripheral vertices, where traders with superior information profit before information disseminates system-wide.

Crystalline Vertex (V_{10})

The organizational vertex representing 8-constituent perfect symmetry based on octonionic algebra. Represents theoretical optimality but is unstable and "inhuman" for actual economic systems.

Diagonal Arbitrage

Arbitrage opportunity across non-adjacent vertices of the 11-gon, exploiting inefficiencies between distant asset classes or structural modes.

Dual Information Encoding

The property that each complex coordinate encodes two types of information: real part (position/stock/level) and imaginary part (momentum/flow/rate), enabling richer modeling of economic dynamics.

Edge Arbitrage

Arbitrage opportunity between adjacent vertices on the 11-gon, typically exploiting local inefficiencies such as misalignment between position and momentum components.

Efficient Frontier

A curve in the interior of the 11-gon representing portfolios that maximize return for each risk level or minimize risk for each return target, forming the boundary of optimal allocations.

Feasible Region (\mathcal{F}_R)

The interior of the 11-gon representing all economically viable portfolio allocations satisfying resource constraints, non-negativity conditions, and diversification requirements.

Geographic Vertex (V_9)

The organizational vertex representing 7-constituent multipolar structure constrained by physical geography, exemplified by Earth's continental divisions.

Hendecagon

Alternative name for an 11-sided polygon; see 11-Gon.

Information Processing Core

See Central Core.

Nuclear Vertex (V_{11})

The organizational vertex representing 9-constituent core-periphery hierarchy, the most common structure in actual economic systems including nation-states, corporations, and financial markets.

Nuclear Volatility Paradox

The phenomenon where nuclear hierarchies are structurally stable but operationally volatile because all peripheral entities depend on the core, causing core decisions to propagate system-wide.

Organizational Vertices (V_9 - V_{11})

The final three vertices of the 11-gon representing different structural principles: geographic separation (7), crystalline symmetry (8), and nuclear hierarchy (9).

Perimeter

The boundary of the 11-gon representing the complete trading space and maximum resource utilization, where extreme or leveraged strategies operate.

Portfolio Point

A weighted combination of the 11 vertices representing an economic allocation in the interior of the 11-gon, with distance from center indicating risk level.

Radial Volatility

Variance in the distance of a portfolio from the center of the 11-gon, representing systematic market risk as the entire feasible region expands (bull markets) or contracts (bear markets).

Regime Transition

A continuous path in the 11-gon connecting two organizational vertices, representing structural change in economic organization such as multipolar to unipolar or designed to hierarchical.

Sector Rotation

See Asset Rotation.

Structural Volatility

Variance arising from transitions between organizational vertices (V_9 , V_{10} , V_{11}), representing the risk that fundamental economic structure changes invalidating model assumptions.

Vertex

A corner point of the 11-gon representing an independent dimension of economic variation, either an asset/sector dimension or an organizational mode.

The End