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# Building the Forward Curve

## *Concepts & Methodology*



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# Forward Curve Significance

- Forward Curve Development Is Crucially Important To Market Development
  - No Trades Without One
- Obviously Important To A Firm's Forward Trading, Pricing And Hedging Activity
  - Lots Of Money At Stake In Emerging Market Trading



# Forward Curve Significance

- Need Forward Curve Before Options Market Can Develop
  - Fundamental Necessary Step
  - Basis For Volatility Analysis
- Fixed Forward Pricing



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# Requirements For A Forward Market

- Size Of Physical Market
  - Minimum Volume In Underlying Physical Spot Trading
- Spot Price Must Exhibit Some Degree Of Volatility
- Coal Market In Prior Times Did Not Meet The Conditions Needed For Forward Market To Develop



# Sophistication Of The Market

- Financials
- Pricing Concepts
  - Not In Terms Of Physical Operation Sophistication
  - Practitioners And Academic



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# What Is The Forward Curve?

- Typical Definition Is...
- Forward Curve Is The Curve Representing The Prices At Which The Market Is Willing To Transact Future Business, Today.



## What It Isn't

- Forward Curve Is Not A Predictor Of Future Spot Prices
  - Or Certainly Not A Good One
  - As Shown By A Number Of Academic Studies Of Various Markets Such As Foreign Exchange



# Availability Of Price Indicators

- In Liquid Traded Markets A Question Of Sourcing The Data
  - Price Transparency
  - Or Difficult Access For Outsiders
- Possibly Some Difficulty In Access, But Not A Problematic Modeling Or Mathematical Issue





# Sourcing Market Data

- Lack Of Price Transparency
  - Private Market Affect
  - Standardization Of Transaction Hubs Or Index Points
  - NG & Petrochemical Examples
- Survey Methods & Reporting
  - US NG At Basis Points Other Than Henry Hub



# Overcoming The Lack Of Data

- An Issue Faced In Each Emerging Market
  - Common Problem, But...
  - Not To Say It Is Easy Or Has A Standard Solution
- Degree Of Difficulty Posed Depends On Characteristics Of Each New Market



# Historical Pricing

- Known Seasonality Pattern In Historical Pricing
- But What If There Are No Historical Prices
  - Meaning, No Price History Of Spot Prices
  - In Some Emerging Traded Markets, There Has Not Been Forward Physical Trading, No Futures, No OTC Forward Financials Like Swaps – But ...



# Historical Pricing

- If There Is A Known Price Series Of Historical Spot Prices
- Or Relevant Spot Prices
  - Structural Change Of Market (NG)
  - No Published Or Accessible Transaction Pricing (Steel)



# Building The Curve

- In New Or Illiquid Markets
  - What Are The Alternatives For Building The Curve?
- Unfortunately, No Standard Or Easy Solutions



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# Building The Curve

- Similar Need May Arise In Active Or Mature Markets For Development Of Long-Dated Pricing Curve
  - Taking The Forward Out 5, 10, or 15 Years
- Typically, A Bit Less Problematic In That Spot And Short-Term Price Histories Exist
  - Market Familiarity & Sophistication Exist



# Emerging Market Examples

- Forward Curve Development Is A Concern In The Power Markets
  - But Concept Is Not A New Issue
- Same Issue Arises In Every Emerging Market, By Definition



# Emerging Market Examples

- *For Example...*
- US Natural Gas Market, 1991
  - Now Well Established 20 Year Curve
- Petrochemicals Market, 1997
  - Still Evolving, But Multi-Year Curve For Select Products



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# Emerging Market Examples

- Pulp (& Paper) Market, 1994
  - Trading & Forward Pricing Development Has Languished
  - For Other Structural Reasons
- Coal Market, 1999
  - Developing Rapidly
- Steel, 1995
  - Languished



# Power Market Uniqueness

- Special Complexities In Power Markets Such As US With Extreme Price Volatility
- Determining A Probable Range Is The Best Goal
  - Not Absolute Precise Forward Curve, But Logical Range
  - Model Output Best Not Treated As A Precise Point Estimate



# Categories Of Modeling Approaches

- Cash & Carry
- Econometric
- Arbitrage
- Constrained Interpolation & Extrapolation
- Market Maker / Intuitive
- None Are Perfect, Precise, Or Easy, But...
  - In Aggregate May Provide Range Boundary



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# Modeling Approaches – Cash & Carry

- Simplistic Model
  - Also Referred To As Cost Of Carry
- But Applicable In Some Physical Commodities & Financial Assets
- A Starting Point
- Not Directly Applicable In Power Because Electricity Is Not Storable



# Modeling Approaches – Econometric

- Fundamentals Projections
- Supply / Demand Balance
  - Current & Future
- Establishing Components In Supply & Demand Equation
- Modeling Factors Influencing These Components In The Future
- Poor Performance Record As A Predictor



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# Modeling Approaches – Arbitrage

- Between Prices Available For Future Dates On Different Markets Or Instruments
  - Futures, Physical Forwards & Fixed Price Swaps
- Growth Of One Market Or Instrument Can Support Another In Price Discovery
- Value Of Having Futures Markets With High Transparency To Support OTC Swaps Development



# Modeling Approaches – Interpolation & Extrapolation

- Uses Limited Number Of Known Forward Transaction Prices To Establish A Full Curve
  - With Assumed Guidelines & Constraints, Such As Seasonal Pricing, Mean Reversion
- Perhaps Not As Sophisticated A Method, But Popular And Possibly Useful



# Modeling Approaches – Market Maker Or Intuitive

- Specialized Participant Willing To Make Prices In Illiquid Markets
  - May Be Intuitive Pricing Rather Than Mathematical Model Driven, But Effective If Exists
  - Long-Term US Natural Gas Market Development





# Econometric Modeling

- All Factors Affecting Current Supply & Demand Should Determine The Current Price
  - Spot Pricing Based On Supply/Demand Balance
  - Absent Constraints
- Supply / Demand Balance At Some Future Time Point Should Determine Future Price
  - *If The S / D Factors Could Be Predicted*



# Econometric Modeling

- The Forward Curve Is Not A Forecast
- It Is Not A Predictor Of Future Prices



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# Regulatory Considerations – Affecting Fundamentals

- A Wild Card Driving Fundamentals
  - Difficult To Predict
  - Contributes To Uncertainty In Forward Pricing
- Predicting The Political Process
  - How?
  - When?
- Prior US Power Market Example



# Econometric Modeling

- Highlights The Weakness Of Econometric Approach
  - Uncertainty Of Inputs
- Even If An Accurate Deterministic Model Formula Can Be Constructed
- Running Of Deterministic Solutions With Different Scenario Inputs Or Distributions To Establish Probable Boundaries
- And Estimating Variability & Certainty



# Arbitrage Modeling

- Based On Correlation Of Market Prices
- Stability Of Correlations
- *Correlations Tend To Break Down When You Need Them*



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# Arbitrage Modeling

- Based On Assumptions Regarding Correlations Between Markets
  - And Stability Of That Correlation Level
  - Does Not Necessarily Require That There Be A Perfect Price Correlation
- *Petrochemical And US Power Examples*



# Arbitrage Modeling – US Power Example

- A Primary Basis Of Pricing At Beginning Of US Wholesale Power Market
  - Major Market Makers Were Enron & DLD
  - From Financial, Not Physical Markets Side
  - With Extensive Experience In Gas
- Trading The Presumed Spark Spread



# Arbitrage Modeling – US Power Example

- For Each Region
  - Modeling Supply Curve
  - Generation Mix
  - Conversion Or Heat Rates
  - Expected Participant Behaviors
- Likely Transmission Constraints Between Regions





# Petrochemicals Forward Market Development

- Huge Physical Market
- Lack Of Price Discovery
  - Established Indices
  - Concentration Of Market In Some Products On Both Supply And Consumption
  - Fragmented Products
  - But Standard Specifications



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# Arbitrage Modeling – Petrochemicals

- Primary Basis Of Forward Pricing Petrochemicals Swaps Market
  - Major Market Makers, Enron, Dreyfus & Morgan Stanley
  - Econometrics Supply / Demand Modeling Quite Complex And Uncertain On Supply Side
- Surrogate Hedging With Ratios Of Oil Complex



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# US Natural Gas Evolution

- Futures Began Trading April 4, 1991
  - During Period Of Rising Price Volatility
- Over-The-Counter Market Trading Had Already Begun
- Demand High For Very Long-Term Hedge Instruments For NG Price Exposure On Project Finance [IPP's]



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# Interpolation & Extrapolation

- Basis Of Some Of The “Black Box” Models Offered By Some Firms
- Another Reference Point In Estimation Of A Probable Range Or Distribution Of Forward Prices



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# Interpolation & Extrapolation

- Uses Scarce Number Of Known Transactable Forward Prices To Establish A Full Curve
  - Presumption That Some Valid Data Points On Bid / Offer Are Known
  - For Active Participants Likely That Some Few Select Transacted Deals Will Be Done Or Observed Past Normally Quoted Forward Curve
  - Shows The Value Of Vigorous Market Information Gathering



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# Interpolation & Extrapolation

- Extrapolation And / Or Interpolation Is Used With Imposed Constraints
  - Provided By Model Supplier Or Input By User
- For Parameters Such As...
  - Predicted Mean Reversion Level
  - Observed Seasonality Of Prices
  - Observed Relationship Of Volatility To Absolute Price Levels



# Cash & Carry

- Cash And Carry Arbitrage
  - Referring To Risk-Free Arbitrage
  - Not “Spec’ing The Market”
- Indicates The Maximum For Forward Prices
- And Is Transactable To Drive The Market Pricing In Line
- *Picking Up Dimes In Front Of Steamroller*



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# Cash & Carry Factors

- For Commodities, Cost Of Carry Typically Includes:
  - Storage Charges & Input / Output Handling Fees
  - Any Incremental Transportation To / From Storage Facilities
  - Cost Of Funds
  - Insurance, Taxes, & Any Other Logistics Fees





# Cash & Carry Application

- Why Not Applicable For Power Markets?
  - *No Electricity Storage Available*, Or At Least Not Meaningful Amounts Of Storage
  - Even If Considering Pumped Storage
  - Is Hydro Storage?



# Cash & Carry – US Natural Gas Example

- Suppose The Spot Cash Market Price For Natural Gas Is US\$ 2.00 / MMBtu
- And The Cost Of All Storage, Storage Related Fees, And Insurance Is US\$ 0.25 / MMBtu Per Month
- The Yield On A 1-Month T-Bill Is 6%
- Then The Maximum Forward Price For The Same Location Point Should Be US\$ 2.7625



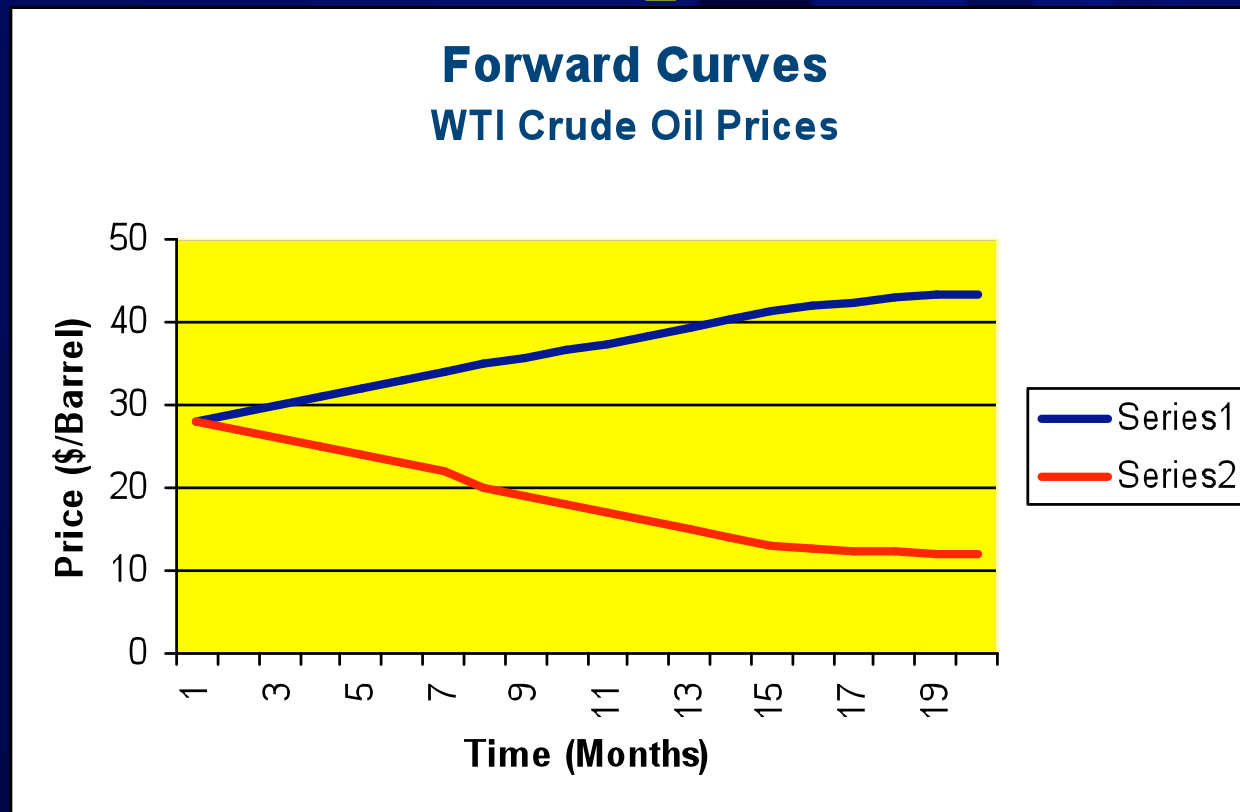
# Forward Curve Standard Shapes

- *Backwardation & Contango*
  - Why Would A Commodity Forward Curve Be Downward Sloping (In Backwardation)?



# Forward Curve Standard

## Shapes



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# Crude Oil Forwards Market

- Why Is The Crude Oil Curve Typically In Backwardation?
- For Total US Market Consumption, Only A Few Days Of Total Storage
- Hence Market Is Willing To Pay A *Prompt Premium*
- What Would Swing Curve Into Contango?



# Forward Curve Standard Shapes

- Equivalents In Capital Markets
- Inverted & Normal Curves In Interest Rate Markets



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# Market Maker Approach

- Trader's View On Indicated Forward Bid Offer Range
  - Back-To-Back Capability
  - Willingness To Make A Price
- Degree Of Difficulty, Degree Of Certainty



# Market Makers

- Market Makers May Have Hedge Techniques Or Mechanisms Not Available To Others
  - Which Allows Them To Take “Spec” Positions With Risk Profiles Unacceptable To Other Market Participants
- *To Trade It, Need To Be Able To Price It And To Hedge It*



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# Market Makers

- Existence Of Market Makers In A New Market
  - To Establish A Clearing Price
  - Two-Way Market, Bid / Ask Pricing
- **“Any Deal At Some Price”**
  - **“But You May Not Like The Price”**



# Testing Market

- Exploring Market For Forward Transactional Prices
  - Bid / Offer Spreads
- Market Maker Technique
- Important Role Of Brokers As Intermediaries Providing Price Discovery



# Cobalt Example

- Well Known Transactional Spot Pricing
  - No Forwards, Futures, Swaps
  - No Forward Transactional Activity Of Any Kind
- Highly Concentrated Market In Supply And Consumption Sides
- Extreme Instability In Supply
  - Volatile Price



# Cobalt Example

- Truly Undeveloped Forward Market
  - But Valuable To Have Had Spot Price Histories
- Cost Of Production
- Average Prices In Stable Periods
- But Structural Changes Of The Market
- Bank Was In Unique Market Maker Role
  - Profitability Exceptional



# Conclusions

- Any Actual Transaction Pricing For Future Dates Is Valuable Input In Deciphering The Full Forward Curve
  - Even If Differing Tenors Than Forward Time Point Most Of Interest To You
  - Even If In A Different Instrument [Futures, OTC Fixed Price Swaps, Forward Physicals]
  - Or From A Highly Correlated Market

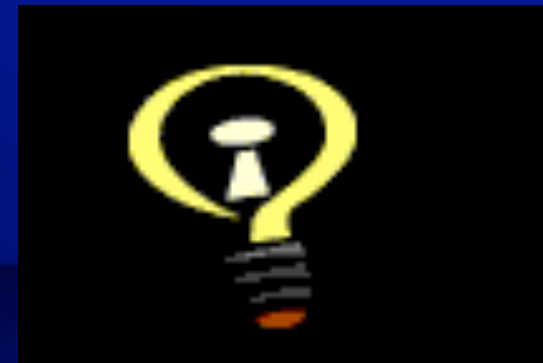


# Conclusions

- Other Prior Emerging Markets Offer Some Guide To Probable Directions For Power Curve Development
  - But Unique Complexities In Power
- Pros & Cons For Each Of The Various Estimation Approaches And Techniques
  - Best Used In Aggregate



# Conclusions



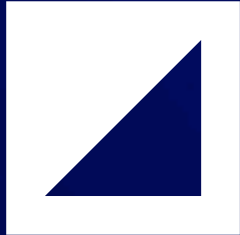
- Recognize Model Output As Estimate, Not Absolutes
- Best Objective Is Projecting A Useable Range For The Forward Curve
- Considerable Resources In Quantitative Research And Trading Market Intelligence Need To Be Applied For Best Curve Development



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