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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



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



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



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



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



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



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*



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



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



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]



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



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



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*



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



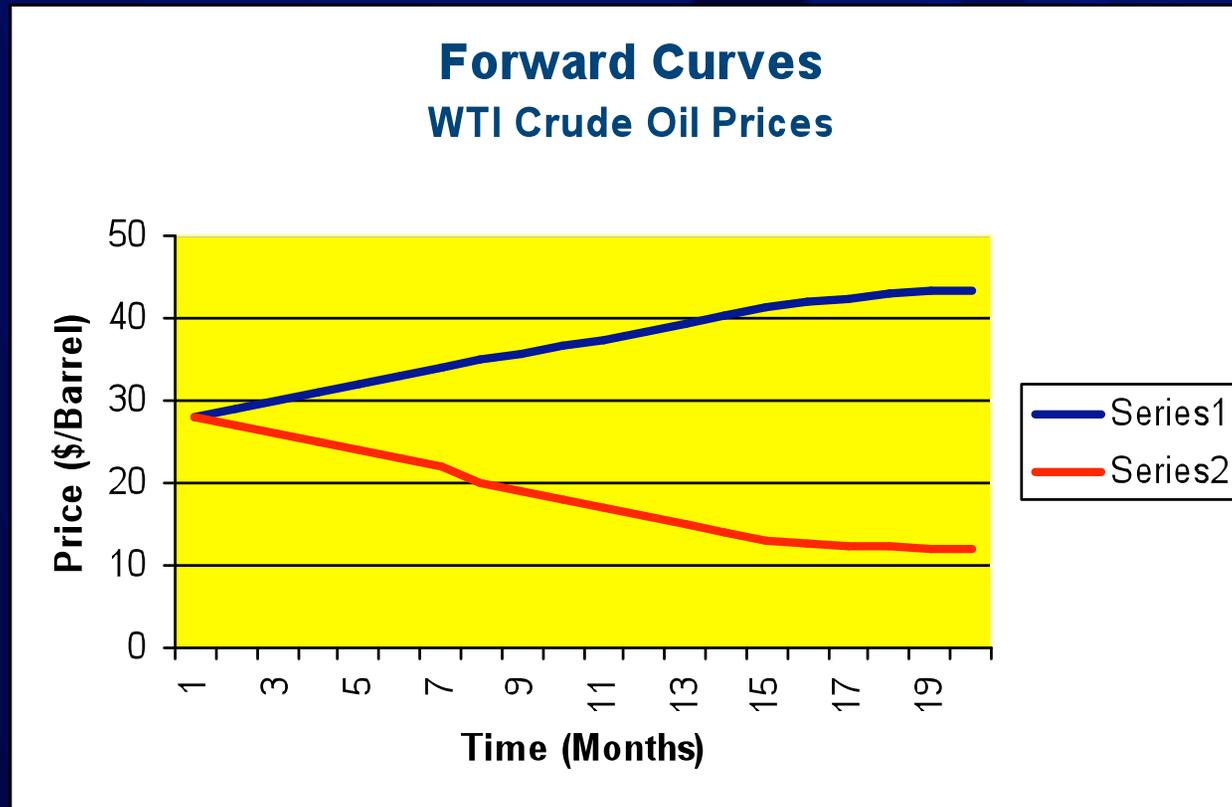
Forward Curve Standard Shapes

- *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



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*



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

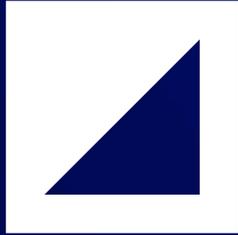


Conclusions



- 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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