Valuation Uncertainty and Disagreement in OTC Derivatives Markets: Evidence from Markit's Totem Service

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Models and Valuation Uncertainty in OTC Derivatives Markets

- In OTC derivatives markets, market participants' beliefs about asset valuations are typically encoded explicitly in "pricing models"
- "pricing model" $\approx$ parameterised price processes for assets underlying the derivative together with "no arbitrage" conditions
- Model parameters are calibrated to market prices available from liquid instruments
- Asset valuations for instruments where market data is sparse often obtained from calibrated models ("mark-to-model" rather than "mark-to-market")
- Disagreement on asset values across market participants most likely observed in regions where market data is sparse/absent (e.g. option contracts on extreme events)

Why Worry about Model Disagreement?

- Understanding of "model risk" for certain products essential for appropriate risk management (e.g. margin requirements for CCPs): How dependent are risk measures on the specification of asset price processes?
- Disagreement between market participants as an indicator for fundamental (Knightian) uncertainty about an asset's payoff distribution.
- In OTC derivatives markets, participants "communicate" through models (e.g. IVs from Black-Scholes model in the options market (MacKenzie, 2008)). A degree of common understanding might be essential for price formation process.

Objectives of Research

- Provide empirical evidence on the extent of disagreement on asset valuations in OTC derivatives market.
- Empirical analysis will focus on option contracts for major equity indices
- Examine valuation disagreement on option prices in the time-to-maturity / moneyness space.
- We document increase in disagreement on option valuations when we move "out-of-the-money" and into longer terms.
- Disagreement between market participants is also more persistent in these regions.

Challenges for Empirical Work: Data Availability

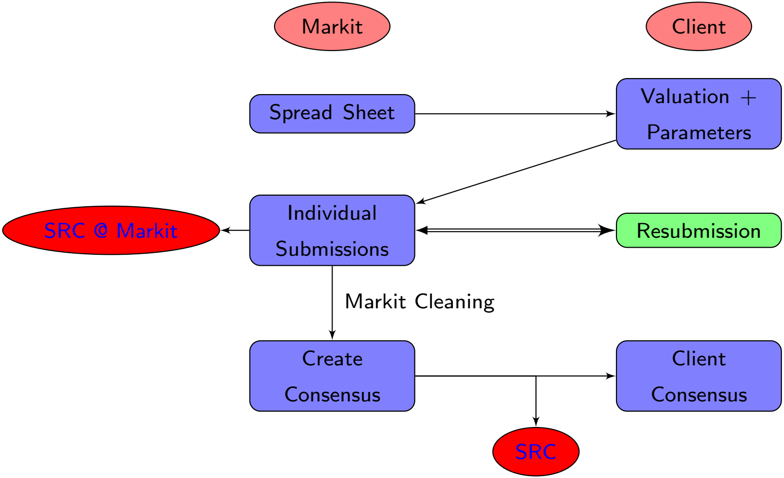
- Publicly available data on prices & quantities sparse for most OTC markets. Most transaction data is proprietary.
- Some recent initiatives to improve transparency through mandatory trade reporting (e.g. TRACE for US bond market; EMIR, Dodd-Frank for OTC derivatives market).
- Fundamental challenge for empirical work remains: illiquid markets tend to have few transactions.
- The most critical market episodes might be the ones without transactions: market freezes, liquidity dry-ups...
- Ideally we would want to know market participants' beliefs about asset values irrespective of frequency of trading.

Consensus Data: Markit Totem Service

- Markit Totem is a data service providing consensus prices to major OTC derivatives market-makers
- Consensus prices are neither transaction prices, nor firm quotes. They are price estimates for specific assets coming from market participants (see next slide).
- The Totem service covers a broad range of asset classes and enables market-makers to check their book valuations in the absence of liquid market prices.

Totem Data

Data Proccess



Data: Consensus Prices for Index Options

- We concentrate on plain-vanilla European put and call options on major equity indices: S&P 500, FTSE 100, Nikkei 225, and Euro Stoxx 50.
- Totem provides consensus data for times to maturity of up to 25 years, and moneyness (strike/spot price) ranging from 20 to 300.
- Why look at index options?
  - volatility surface central to calibrating price processes used for pricing variety of exotic derivatives
  - options vary in liquidity in the moneyness/maturity space, but homogenous underlying model structure

Consensus Pricing

- TOTEM submitters submit monthly price quotes $y_{i,t}^{p}$ for a range of derivatives contracts C
- $y_{i,t}^{c}$ designates the TOTEM quote for submitter i at time t for contract $c \in C$.
- The TOTEM consensus price for c at t with N_t^c submitters is (ignoring data cleaning)

$$\bar{y}_t^c = \frac{1}{N_t^c} \sum_{i=1}^{N_t^c} y_{i,t}^c$$

A First Look at the Data

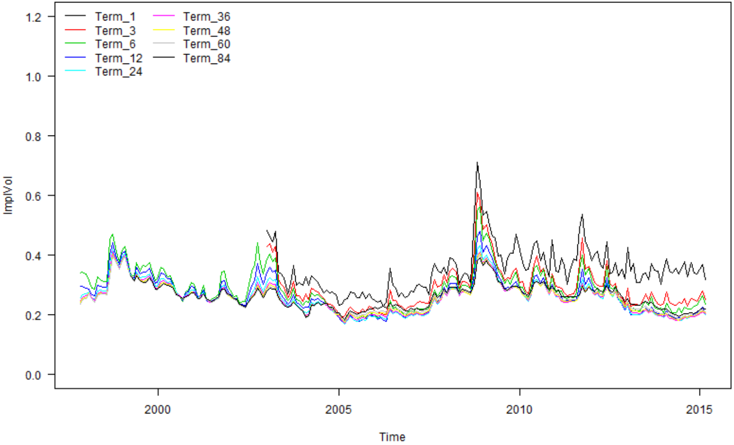


Figure : Consensus IVs, Put Option (moneyness 80) on FTSE 100

Measuring Disagreement

Holding c fixed (i.e. term,moneyness, and index) we decompose total (quadratic) variation in all submitters $y_{i,t}^{c}$s

$$V_w^c = \sum_{i=1}^{N} \sum_{t=1}^{T_i} (y_{i,t}^c - \bar{y}^c)^2$$

where $\bar{y}^c = \frac{1}{N} \sum_i \bar{y}_i^c$ and $\bar{y}_i^c = \frac{1}{T_i} \sum_t y_{i,t}^c$.

- into **Within Variation**: $V_w^c = \sum_{i=1}^{N} \sum_{t=1}^{T_i} (y_{i,t}^c - \bar{y}_i^c)^2$
- and **Between Variation**: $V_b^c = \sum_{i=1}^{N} T_i (\bar{y}_i^c - \bar{y}^c)^2$
- Use V_b^c / V^c as a measure of disagreement for contract c: How important are valuation disagreements between submitters compared to time-series variation in individual submissions?

Volatility Surface Decomposed: Between-to-Total Variation

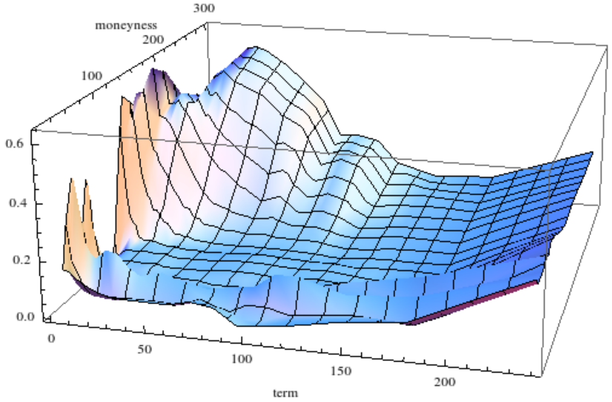
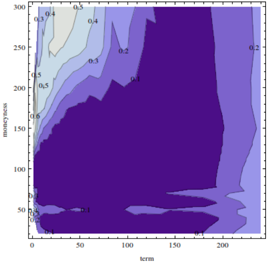
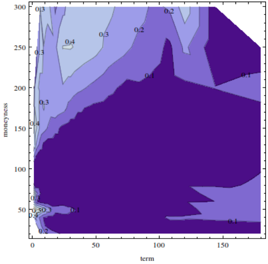


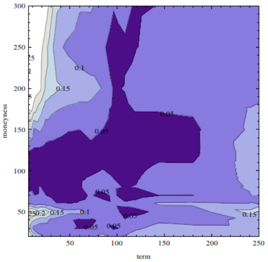
Figure : V_b^c / V^c for S&P 500 index options (Jan 2010 - Dec 2014)



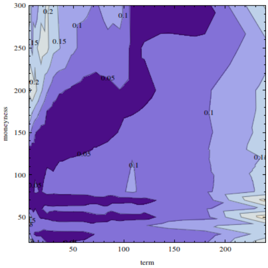
(a) S&P 500



(b) FTSE 100



(c) Nikkei 225



(d) Euro Stoxx 50

Figure : contour plots for major equity indices (2010-2014)

What is Nature of Disagreement

- We now consider deviations from consensus price $y^p_{i,t} - \bar{y}^p_t$
- Suppose submitters every month start from common prior, and each receives (short-lived) private information:
- Submitter i receives private signal $S_{i,t} = Y_t + \eta_{i,t}$ with $\eta_{i,t} \sim N(0, 1/\rho_{i,t})$.
- Submitter i's information set in t: $\mathcal{I}_{i,t} = \{S_{i,t}, \mathcal{I}_{t-1}\}$
- N consensus price submitters, each submitting $y_{i,t}$ in t with $y_{i,t} = \mathbb{E}(Y_t | \mathcal{I}_{i,t})$.

$$y_{i,t} = (1 - \lambda_{i,t})\hat{y}_t + \lambda_{i,t} S_{i,t} = \hat{y}_t + \lambda_{i,t} u_{i,t}$$

where $\lambda_{i,t} = \rho_{i,t}/(\rho_{i,t} + \rho_t)$ and $u_{i,t} = S_{i,t} - \mathbb{E}(Y_t | \mathcal{I}_{t-1})$.

Empirical Implications

- The consensus price in period t is

$$\bar{y}_t = \frac{1}{N} \sum_{j=1}^{N} y_{j,t}$$

- Individual deviations from consensus are then

$$y_{i,t} - \bar{y}_t = (\lambda_{i,t} - \bar{\lambda}_t) v_t + \left(\frac{N-1}{N} \right) \lambda_{i,t} \, \varepsilon_{i,t} + \frac{1}{N} \sum_{j \neq i} \lambda_{j,t} \, \varepsilon_{j,t}$$

where $u_{i,t} = v_t + \varepsilon_{i,t}$.

- Moment condition:

$$\mathbb{E}\left[(y_{i,t} - \bar{y}_t) z_{t-1} \right] = 0 \text{ for all } z_{t-1} \in \mathcal{I}_{t-1}$$

- Moment condition suggests the following setup:

$$y_{i,t} - \bar{y}_t = \alpha + \beta^T \mathbf{z}_{t-1} + \epsilon_{i,t}$$

  $H_0 : \alpha = 0$ and $\beta = 0$ for all $\mathbf{z}_{t-1} \in \mathcal{I}_{t-1}$.
- Reject H_0 for all contracts c in moneyness/term space.
- Particularly, lagged deviation $y_{i,t-1} - \bar{y}_{t-1}$ always significantly different from 0.

How persistent are disagreements?

- Estimate $AR(1)$ model to examine persistence of individual deviations from consensus
- For each contract c in the term/moneyness space we estimate

$$y_{i,t}^c - \bar{y}_t^c = \beta^c \left(y_{i,t-1}^c - \bar{y}_{t-1}^c \right) + \varepsilon_{i,t}^c$$

  pooled across submitters.
- Calculate half-life from coefficients β^c

$$-\frac{\log 2}{\log \beta^c}$$

  How many month does it take to close 1/2 of an initial gap between individual submission an consensus?

How persistent are deviations from consensus?

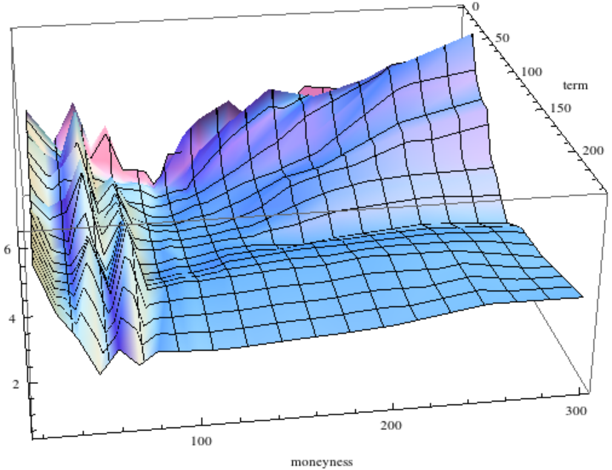
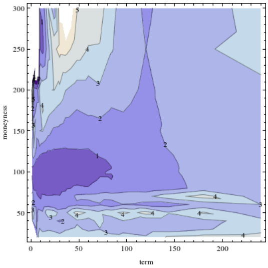
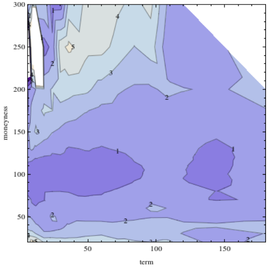


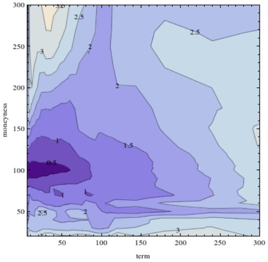
Figure : Half-lifes (in months), S&P 500 (2010-2014)



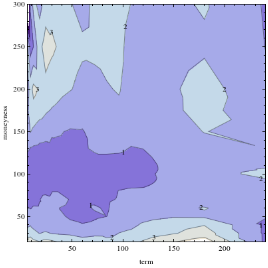
(a) S&P 500



(b) FTSE 100



(c) Nikkei 225



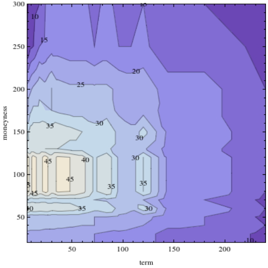
(d) Euro Stoxx 50

Figure : Half-lifes of deviations from consensus (2010-2014)

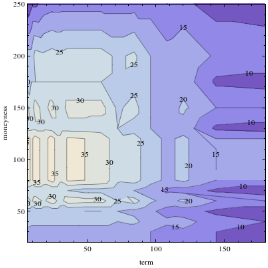
Summary of Results

- We provide (preliminary) evidence on the extent of disagreement on valuations in the market for index options
- Using TOTEM consensus price data we show that disagreement increases the further we move "out-of-the-money" or in "time-to-maturity" $\approx$ "illiquid" part of the market
- Persistence of disagreement also increases in this direction
- Given the nature of pricing in the options market, we interpret disagreement as differences in pricing models used by market participants
- Agreement is observed in areas where model can be calibrated to market data, disagreement where no reliable data exists

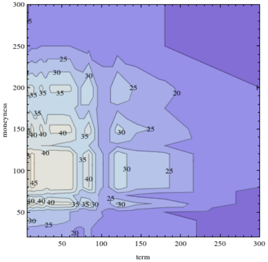
Number of TOTEM Submitters (2010-2014)



(a) S&P 500



(b) FTSE 100



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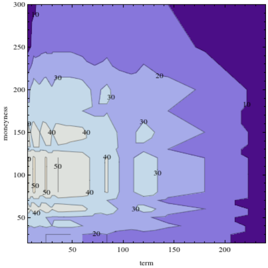

(d) Euro Stoxx 50