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

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In OTC derivatives markets, market participants’ beliefs about asset valuations are typically encoded explicitly in “pricing models”

“pricing model” ≈ 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)
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.
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 Process

Markit

Spread Sheet

Valuation + Parameters

Individual Submissions

Resubmission

SRC @ Markit

Markit Cleaning

Create Consensus

Client Consensus

SRC
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)
Figure: contour plots for major equity indices (2010-2014)
What is Nature of Disagreement

- We now consider deviations from consensus price $y_{i,t}^P - \bar{y}_t^P$
- 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
  \[ y_{i,t} - \bar{y}_t = (\lambda_{i,t} - \bar{\lambda}_t) \nu_t + \left( \frac{N - 1}{N} \right) \lambda_{i,t} \varepsilon_{i,t} + \frac{1}{N} \sum_{j \neq i} \lambda_{j,t} \varepsilon_{j,t} \]
  where $u_{i,t} = \nu_t + \varepsilon_{i,t}$.

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

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

pooled across submitters.
- Calculate half-life from coefficients $\beta^c$

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

*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)
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” ≈ “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
(c) Nikkei 225
(d) Euro Stoxx 50