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The Lifecycle of Derivatives Contracts

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   In chapter 4, I suggested that the natural home for teleconnection risk is on a derivatives exchange. But my reasoning assumed that ENSO markets will reach a sustainable level of liquidity. That assumption begs a follow-up question: what is the probability that ENSO markets will reach a sustainable level of liquidity? Or, more fundamentally: what is the probability that any new market will reach any given level of liquidity?

   To that end, this chapter provides:

- a statistical description of the lifecycle of exchange-traded derivatives in the United States.

   Using annual volumes for most derivatives reported to US exchanges since 1954, we present distributional estimates of the rate at which derivative trading volumes rise and fall. Our results provide the first published statistics on the full lifecycle of derivatives and illustrate fundamental changes in cleared derivatives markets over the 2000s. In that decade, derivatives with low trading volumes moved to modest volumes with increased probability. Prior to the 2000s, low volume contracts were more likely to remain stuck at low volumes or be delisted altogether. This additional resilience from low levels of trading meant that the expected trading volume for a new cleared derivative after ten years of trading actually grew between the 1990s and 2000s. This is surprising given that many new contracts were launched in the last decade and a historically large percentage of contracts traded at low volume in any year.

We also discuss the relative influence of exchange and product type on volume patterns. We find that trading volumes varied more decade to decade than from exchange to exchange or product type to product type.

The results are presented as a Markov model with a non-stationary transition matrix. Each row in the Markov model's transition matrix (the probabilities of a derivative moving from a given state of trading to any other) consists of posterior draws from a Dirichlet process estimated using Bayesian methods in R and JAGS. This approach to the lifecycle of a derivative allowed us to make simple distributional comparisons among subsamples (including significance testing) and facilitated further simulation of new derivatives emerging over time.

Introduction and Literature Review

Silber [1981] and Carlton [1984] provided some of the first summary statistics on the survival of new futures contracts. Their core conclusions - that most new derivatives fail and that they do so soon after their launch - remain widely cited[1,2]. However, since those articles, technological innovation and organizational changes at derivatives exchanges have altered the economics of derivatives trading in ways that may have also upended long standing patterns in product lifecycles[3].

Recently, Gorham and Kundu [2012] used a large dataset from the Futures Industry Association (FIA) to demonstrate a steep increase in the rate at which new futures contracts are launched. They also provide point estimates for multiple metrics for the success of new futures contracts. Here we extend the work in Gorham and Kundu [2012], providing distributional estimates of contracts' movement between states of annual trading volume using a dataset that includes cleared derivatives and options as well as many historical contracts that are absent from most electronic databases.

Derivatives reform and lifecycle statistics

Basic statistics on the lifecycle of derivatives are particularly valuable now because ongoing policy debates on derivatives regulation in the US and Europe have hinged on projections of how new regulations will impact liquidity and trading patterns. Better baseline statistics of the lifecycle of derivatives, particularly statistics that take into account recent shifts in the dynamics of exchange reported derivatives trading, can inform that debate.

Title VII of the Dodd-Frank reforms focuses on swaps markets[4,5], the hitherto unregulated derivatives markets that, since the first publicly disclosed swaps trade in 1981, had grown to a notional outstand-

[1] G. Gorton and K.G. Rouwenhorst. Facts and fantasies about commodity futures. Working paper, 2004

[2] M.W. Hung, B.H. Lin, Y.C. Huang, and J.H. Chou. Determinants of futures contract success: Empirical examinations for the asian futures markets. *International Review of Economics & Finance*, 20(3):452–458, 2011

[3] M. Gorham and N. Singh. *Electronic Exchanges: The Global Transformation From Pits to Bits*. Elsevier Science, 2009

[4] Swaps trades have generally been negotiated bilaterally, often over the phone through or with large *swap dealers*, rather than via the central limit order book system used by exchange-traded derivatives. This distinction, between markets using bilateral negotiation and those using central order books, has important implications for how information spreads among market participants and how counter-party risk is managed.

[5] The distinction between swaps and

ing value of USD 639 trillion by June 2012. (By contrast, options and futures had a combined notional outstanding value of USD 60 trillion[6].) Title VII mandates that swaps markets adopt practices related to many critical market functions (such as information dissemination, counter-party risk, and margining) comparable to those of exchange-traded futures and options.

[6] Bank of International Settlements. Statistical release: OTC derivatives statistics at end-june 2012, June 2012. URL http://www.bis.org/publ/{OTC}_hy1211.pdf

This regulatory change suggests that the coming years will see convergence between previously unregulated swaps markets and standard exchange-traded derivatives markets. This convergence, in turn, raises both normative questions (How desirable is the move toward increased clearing, public disclosure of pricing information, and greater standardization of margins?) and positive questions (What will the likely costs or regulation be in terms of trading volume?) that would benefit from reliable statistical descriptions of the lifecycle of derivatives.

The relative scarcity of basic statistics on the lifecycle of derivatives has already introduced confusion into the policy debate surrounding Title VII. In one prominent example, the International Swaps and Derivatives Association (ISDA) released a position paper on regulations mandating price transparency and clearing in swaps markets comparable to that in exchange-traded derivatives markets in late 2011[7]. The paper highlights previous research showing high rates of failure among exchange-traded derivatives. Assuming a connection between those failure rates and exchanges' price transparency and clearing, the paper goes on to argue that swaps contracts subject to proposed regulations would subsequently lose their liquidity and begin to fail. That suggestion is misleading. First, it ignore the comparable failure rates for bilateral swaps, which are difficult to quantify. Second, it relies on the assumption tested here - that derivatives continue to fail at the rates documented decades ago. Our results suggest that assumption is not robust to recent changes in the underlying structure of cleared derivatives markets.

[7] ISDA Research Staff and NERA Economic Consulting. Costs and benefits of mandatory electronic execution requirements for interest rate products. Discussion Paper 2, International Swaps and Derivatives Association, November 2011

In addition to providing common ground for policy debates, we hope that the following analysis will inform the decisions of derivatives innovators. In general, contracts are showing greater flexibility, moving up from low levels of annual trading. This may have implications for how exchanges allocate their limited budgets for marketing and education. Contracts previously considered too uneven in their year-to-year trading to succeed may indeed have substantial growth potential given proper marketing and educational support.

Data

Our analysis is based on annual volume figures for US exchange-traded derivatives (primarily futures, options, and cleared swaps). These fig-

ures are/were freely available to the public through trade publications, directly from exchanges, in newspapers, and from the website of the Commodity Futures Trading Commission (CFTC). For ease of access, we used:

- An electronic database maintained by the CFTC aggregating basic, market-level daily trade data (such as volume and open interest) regulated futures and options exchanges, called *designated contract markets (DCMs)*, This dataset covers all recent trading volumes reported to US exchanges of futures, options and swaps, cleared pursuant to DCM rules. Most contracts in that database have volume figures dating back to the early 1980s.

- We supplemented this basic dataset by adding in futures trading figures compiled by hand from historical publications released by derivatives exchanges. The resulting dataset includes many short-lived contracts listed on now-defunct exchanges that are unlikely to appear in most electronic databases of trading statistics.

The merger of these resources may represent the most comprehensive dataset on derivatives trading volume to date.

Markov model for the lifecycle of derivatives

We present our primary results in the form of a Markov model. That model begins by imagining that a derivative contract moving between discrete states (x) of trading volume at discrete times (t as in x_t)according to a discrete-time Markov chain, defined generally as in equation 5.1.

$$P(X_t = x_t | X_{t-1} = x_{t-1}, X_{t-2} = x_{t-2}, \ldots, X_0 = x_0) = P(X_t = x_t | X_{t-1} = x_{t-1})$$
$$(5.1)$$

In the context of derivatives, the left side of equation 5.1 can be restated as in equation 5.2.

$$P(\text{Volume level}_{\text{year t+1}} | \text{Volume level}_{\text{year t}}) \qquad (5.2)$$

Contract are assigned a martix (P as in equation 5.3) that describes the probability of moving to any of a set of discrete states (time j) of annual trading volume in the following year given their state of trading volume today (time i). This is the transition matrix commonly used to describe a Markov process[8].

[8] Scott Page. Model thinking: Markov models. Video lectures, April 2012. URL http://www.youtube.com/watch?v=0FumwlqGRa8

$$P = \begin{pmatrix} p_{1,1} & p_{1,2} & \cdots & p_{1,j} & \cdots \\ p_{2,1} & p_{2,2} & \cdots & p_{2,j} & \cdots \\ \vdots & \vdots & \ddots & \vdots & \ddots \\ p_{i,1} & p_{i,2} & \cdots & p_{i,j} & \cdots \\ \vdots & \vdots & \ddots & \vdots & \ddots \end{pmatrix} \qquad (5.3)$$

Volume level for any given contract-year is equivalent to the common logarithm of the annual trading, rounded down to the nearest integer. (For example, annual trading of $10,500$ is assigned a volume level that groups it with all contract-years with volume $\geq 10,000$ and $< 100,000$.) We assigned a special level for annual trading of 0.

For ease of estimation we work with the rows of the transition matrix P which we denote as θ. Those rows sum to 1, so, assuming that row entries are randomly distributed, each row can be assigned a Dirichlet distribution, commonly used for the probability of ending in an exhaustive set of categorical states. That assignment is defined in equation 5.4.

$$\text{Volume level}_{\text{year } t+1} | \text{Volume level}_{\text{year } t} \sim \text{Categorical}(\theta)$$
$$\theta \sim \text{Dirichlet}(x_{\text{vol level } 0}, x_{\text{vol level } 1}, \cdots, x_{\text{vol level } 10^8}) \qquad (5.4)$$

We modeled these transition probabilities via Bayesian Gibbs sampling through R and the Bayesian statistical package JAGS[9]. (We used the "rjags" package[10].) These methods treat the underlying probabilities of moving between states of trading volume as randomly distributed parameters, as in equation 5.4.

After estimation, we combine the vectors θ to reconstruct the transition matrix for a Markov model P. As with any Markov model, we can multiply a vector, $\boldsymbol{\pi}_0$ describing the probability that a new derivative will start in any given state (at time 0) by the transition matrix to produce a vector of probabilities that a new market will be in any state over an arbitrary number of periods (k) as in equation 5.5.

$$\boldsymbol{\pi}_0 P^k = \boldsymbol{\pi}_k. \qquad (5.5)$$

We can multiply the vector $\boldsymbol{\pi}_k$ by yet another vector of annual trading volumes corresponding to each possible state to get an approximation of the expected trading volume in that arbitrary year. We present all our expected trading volumes at a ten year horizon (setting $k = 10$), but the Markov model is flexible in this regard.

Note that we do not assume that the transition matrix P is stationary across time. We measure transition matrices for various contract groupings including decades, product categories, and exchanges to test whether they are distinct. Given that we do not assume stationarity

[9] M. Plummer. *JAGS: A Program For Analysis of Bayesian Graphical Models Using Gibbs Sampling*, 2003

[10] Martyn Plummer. *rjags: Bayesian graphical models using MCMC*, 2013. URL http://CRAN.R-project.org/package=rjags. R package version 3-10

our expected value estimates do not describe an equilibrium, only the general direction of the market.

Prior probabilities on moving between states of annual volume

Our model presumes that the data on the volume level next year (Volume level$_{\text{year t}+1}$) is segregated by the volume this year (Volume level$_{\text{year t}}$) and we assigned each of those subsets prior probabilities (corresponding to parameter x in equation 5.4) of moving to any volume level in the next year. Those priors came from an informal survey of economists at the CFTC.

That survey found beliefs corresponding roughly to:

- $\Pr(\text{Volume level}_{\text{year t}+1} = \text{Volume level}_{\text{year t}-1}) = 0.16$

- $\Pr(\text{Volume level}_{\text{year t}+1} = \text{Volume level}_{\text{year t}}) = 0.63$

- $\Pr(\text{Volume level}_{\text{year t}+1} = \text{Volume level}_{\text{year t}+1}) = 0.14$

The probability of a contract jumping more than one order of magnitude up or down was assigned a value of 0.01. In edge cases (Volume level$_{\text{year t}} = 0$ and Volume level$_{\text{year t}} = 10^8$) where a move up or down would take the contract below annual trading of 0 or to annual trading $\geq 10^9$, we combined the probabilities of moving up or down with the probability of remaining in the same state. Table 4 at the end of this article shows the full matrix of transition probability priors.

We chose to assign informative priors on transition probabilities because flat priors (equal weighting to the probability of a transition to any state) unfairly biased the estimation, giving exchanges or product subgroups with few observations a relatively high probability of jumping to extraordinary levels of trading.

Derivatives volumes over time

Concentration of trading volume over time

Figures 5.1 and 5.2 display the empirical cumulative distribution function (ECDF) of annual trading volumes by contract for every year in the sample. In each figure, individual lines represent the ECDFs for a single year, with lines approaching a right angle showing greater concentration of trading volume in a few contracts. Figure 5.1 clearly shows that most contracts trade at low volumes in any given year, with roughly 80 percent of contracts showing little or no volume in any given year since 1954.

However, figure 5.1 obscures substantial variation in the concentration of volume over time. Figure 5.2 zooms in on the same annual
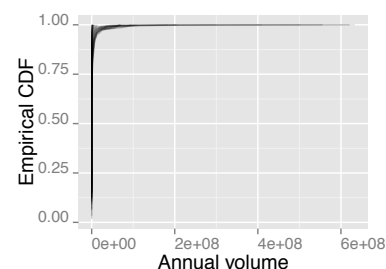

Figure 5.1: Empirical cumulative distribution function of annual trading volumes by contract

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ECDFs displayed in figure 5.1. The ECDF for each year is colored
chronologically, with the lines representing the oldest years in the sam-
ple in red and the most recent years in purple. Each panel of figure 5.1
shows the same ECDFs, but the years in a specific decade are high-
lighted (in black) to give a sense of how concentration has varied from
decade to decade.

In this graphic we see clear patterns in concentration over time.
Markets grew steadily less concentrated between the 1950s and 1990s
(perhaps with some retrenchment between the 1980s and 1990s),
shown by flattening ECDFs for each succeeding decade. That trend
reversed sharply in the 2000s, with the annual ECDFs approaching a
right angle. In the 1980s the range of 15,000 to 30,000 roughly marked
the 50th percentile for annual trading volumes, with half of the listed
contracts trading above that range and half below. By the 2000s that
range had fallen to between 300 and 8,000.

Figure 5.2 itself highlights one likely cause of this shift - the ex-
plosion of innovation during the 2000s. The ECDFs for the 2000s
are appreciably smoother than those of previous decades, with 2011
looking almost like a continuous function. This smoothness is due to
the inclusion of additional contracts. Figure 5.3 directly displays the
number of contracts with annual reported volume (which is allowed
be zero) in the sample by year. It shows the same explosive trend in
innovation discussed in Gorham and Kundu [2012], with over 3000
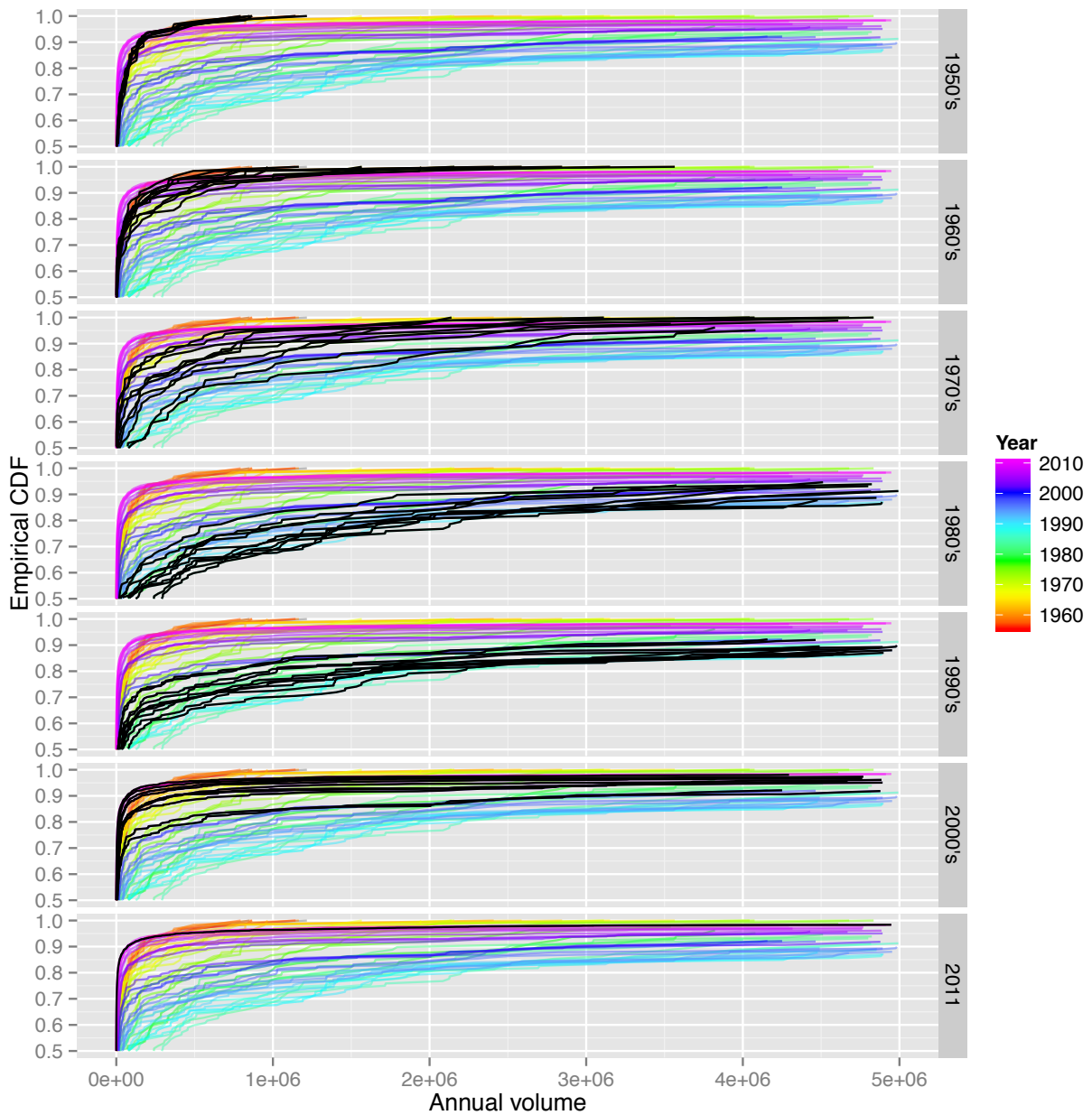derivatives contracts reporting annual volume in 2011.

Figure 5.2: Empirical cumulative distribution function (ECDF) of annual trading volumes by contract with scale adjusted to distinguish between decades - Each line represents the ECDF for a different year. Each of the stacked panels highlights the years in a particular decade in black. Note that an ECDF approaching a right angle represents a year in which volume was concentrated in a few contracts. Hence, with some exceptions in the 1990s the market as a whole becomes less concentrated, until the 2000s when it abruptly becomes highly concentrated.

Probability of individual contracts moving to different levels of trading by decade

Figures 5.4 and 5.5 give the probabilities of individual contracts moving between volume levels in a given year t (indicated by the row of estimates) and volume levels in year t+1 (indicated by the column of estimates). These probabilities, estimated separately for each decade in the sample via equation 5.4, combine to form the transition matrix for a Markov model of a contract emerging over time.

The parameter estimates indicate that there is substantial inertia across every decade keeping contracts with a given level of trading volume at that same volume in the following year. In virtually all decades in the sample, contracts trading at or above 1,000 in annual volume were more likely to remain at their trading volume level than to move up or down. This dynamic is particularly strong at higher levels of trading. In most decades where relevant observations were available, contracts with annual volume of one million or above remained in that range the following year with probabilities between ∼80 and ∼90 percent (see lower right-hand corner of figure 5.5).
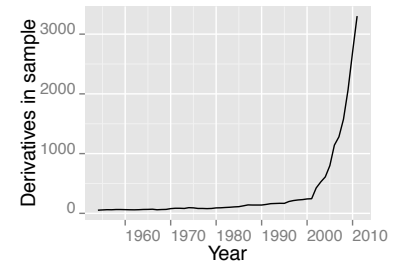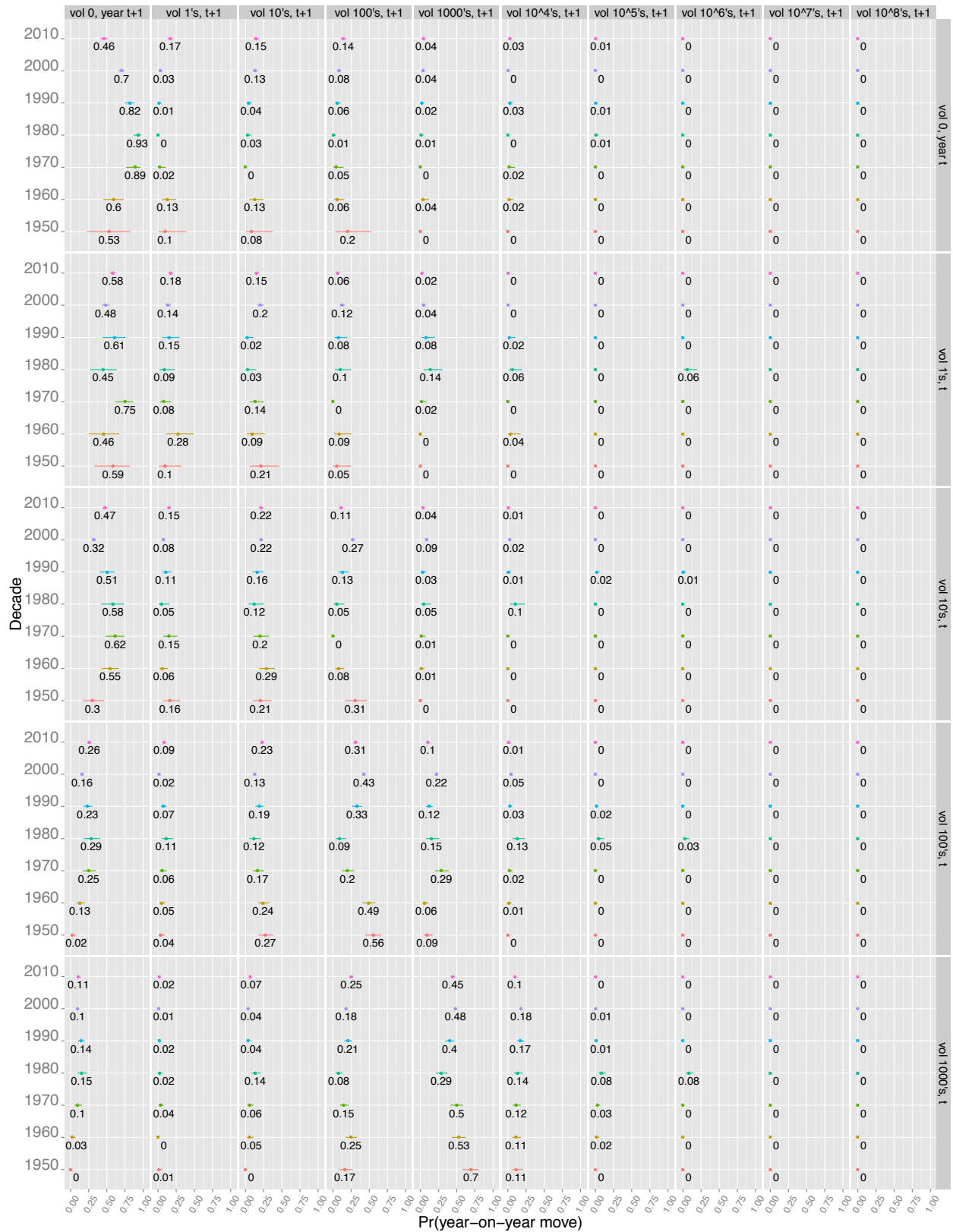

Figure 5.3: Number of contracts in sample by year

Figure 5.4: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - row represents state in year t, column represents state in year $t+1$, median estimate indicated by dot, 95 percent probability interval indicated by line - part 1: transitions given annual volumes ≥ 0 and $< 10,000$
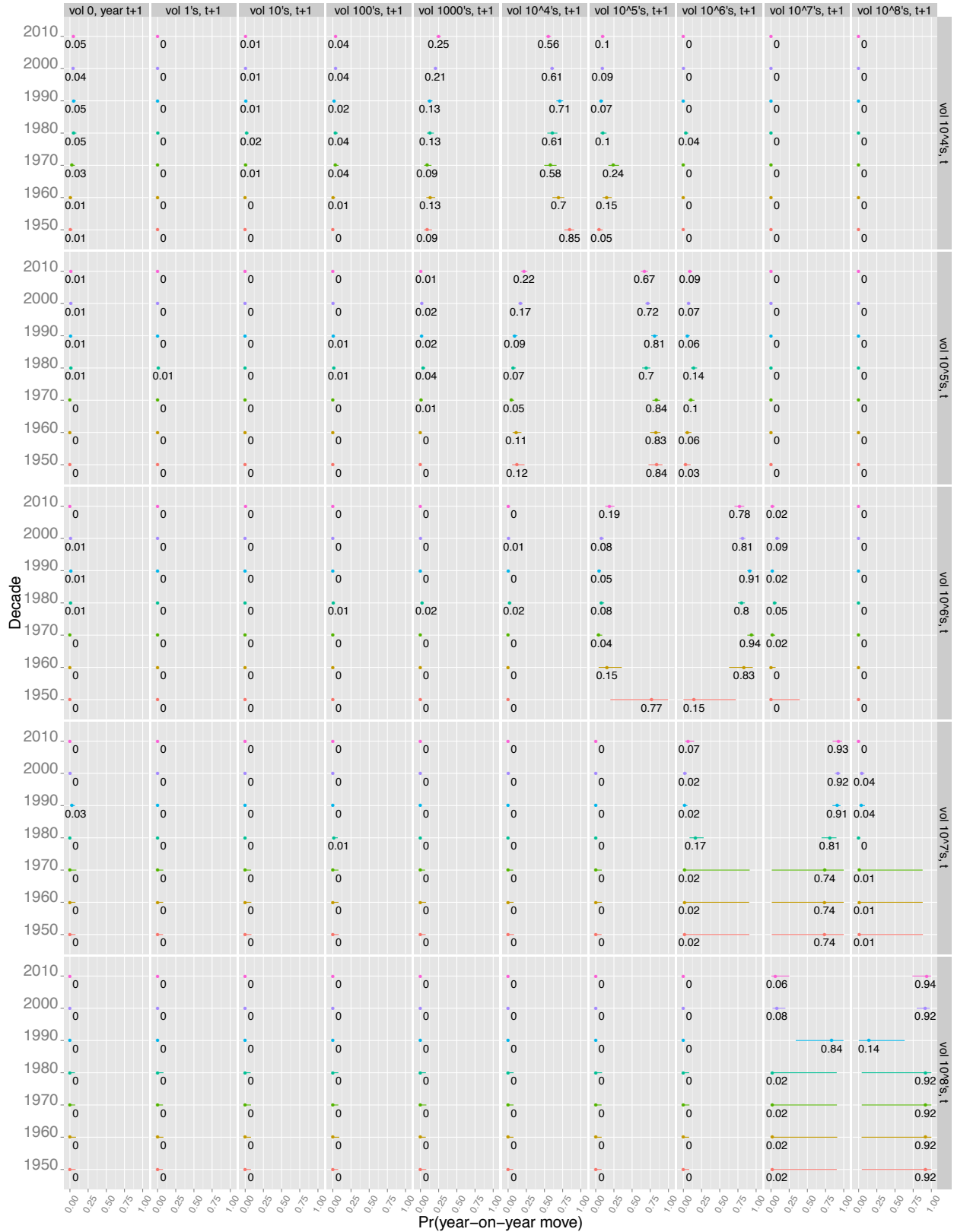
Figure 5.5: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - row represents state in year t, column represents state in year $t+1$, median estimate indicated by dot, 95 percent probability interval indicated by line - part 2: transitions given annual volumes $\geq 10,000$

We also see substantial historical evidence of inertia at very low levels of trading. From 1970 until 2000, the median probability that a contract with trading volume of zero would remain at zero the next year, ranged between 80 and 95 percent (see upper left-hand corner of figure 5.4).

The transition matrix begins to depart from the prevailing story in Silber [1981] and Carlton [1984] when you look at contracts at lower levels of trading in the 2000s. (See the top rows of figure 5.4.) The inertia for those contracts is lower than in previous decades, with the median probability of a contract at an annual volume of zero remaining at zero falling to 70 percent (figure 5.6). While zero volume contracts remained unlikely in absolute terms to rise to higher volume levels, the 95 percent probability interval for the transition probability for the 2000s does not overlap with those for recent decades, meaning that the difference holds with high probability.
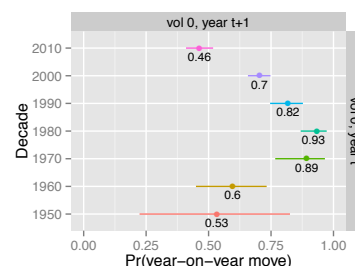

Figure 5.6: Probability of remaining at annual volume of zero from year to year by decade

Figure 5.7: Probability of transition from annual volume of 0 to annual volume in the single digits (left) and from annual volume in the single digits to annual volume $\geq 10, < 100$ (right)

During the decade of the 2000s, contracts were substantially more likely to jump from an annual trading volume of 0 to trading volumes between 10 and 1000 than in previous decades. (See top row of figure 5.4 and 5.7.) Combined with the apparent trend toward maintaining rather than delisting contracts, this suggests that there was less path-dependence for trading volumes in the 2000s. While more contracts traded at a volume of 0 in any given year (see figure 5.2), contracts were substantially more likely to jump up from such low trading volumes in the 2000s.

Having reached annual trading volumes in the 10s or 100s (see 5.8), contracts in the decade of the 2000s were again substantially more likely to continue increasing their trading volume in the 2000s than in the 1980s or 1990s. Only after reaching trading volumes in the 1000s (figure 5.9) did the probability of an individual contract progressing to higher levels of annual trading volume fall roughly back within the same range as those from previous decades. In the 2000s, contracts generally moved up to annual trading in the thousands with an ease not seen in previous decades.
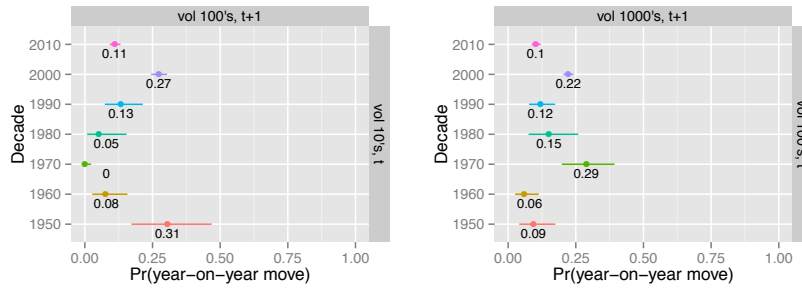
Figure 5.8: Probability of transition from annual volume in the hundreds to annual volume in the thousands (left) and from annual volume in the thousands to annual volume tens of thousands (right)

Contracts trading in the tens of thousands were 8 percent more likely to fall back to lower levels of annual volumes in the 2000s than in previous decades, a difference that holds with high probability. This indicates that some of the flexibility gained for contracts at lower levels of trading may have come at the expense of contracts at mid to high levels of trading. (However, as we see in figure 5.12, discussed below, that retrenchment from trading in the tens of thousands was not enough, on balance, to lower the prospects of a new contract over the course of ten years.)
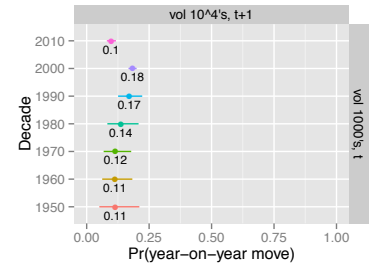

Figure 5.9: Probability of transition from annual volume in the tens of thousands to annual volume in the hundreds of thousands

volume level	vol 0's, t+1	1	10	100	1000	10^4	10^5	10^6	10^7	10^8
vol 0's, t	0.66	0.08	0.11	0.09	0.03	0.02	0.00	0.00	0.00	0.00
1	0.56	0.16	0.16	0.08	0.03	0.01	0.00	0.00	0.00	0.00
10	0.42	0.12	0.21	0.18	0.06	0.02	0.00	0.00	0.00	0.00
100	0.20	0.05	0.17	0.38	0.17	0.03	0.00	0.00	0.00	0.00
1000	0.10	0.01	0.05	0.20	0.47	0.15	0.01	0.00	0.00	0.00
10^4	0.04	0.00	0.01	0.03	0.19	0.62	0.10	0.00	0.00	0.00
10^5	0.01	0.00	0.00	0.00	0.02	0.14	0.74	0.08	0.00	0.00
10^6	0.01	0.00	0.00	0.00	0.01	0.01	0.08	0.84	0.04	0.00
10^7	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.90	0.03
10^8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.87

Annual trading in the 10,000s appears to represent an important milestone for contracts across the sample. Having reached this level of trading, the likelihood of outright collapse (annual trading volume falling to 0 in the next year) fell to very low levels and was largely indistinguishable across the decades (figure 5.10). Table 5.1 presents the median estimates of transition probabilities estimated across the full sample (i.e. aggregating across decades). They show clearly that having reached annual trading of in the 10,000s, a full collapse becomes relatively unlikely (4 percent). In fact, for contracts that achieve annual trading in the 10,000s, the probability of falling more than one

Table 5.1: Median estimates of transition matrix between volume states on full sample - with annual trading volume state in year t denoted by row, trading volume state in year t denoted by column

volume level is below 10 percent. (See the sixth row of table 5.1.)
Note that these full sample estimates are biased toward recent decades
because the sample contains more observations from recent decades.

As suggested above, one hypothesis regarding the recent shift in
derivatives lifecycles is that the additional flexibility that low volume
contracts enjoyed in the 2000s came directly at the expense of mid-
range to higher volume contracts. In volatile markets, hedgers might
be choosing niche contracts with lower basis risk over more liquid
cross-hedges. What would that mean for the overall outlook for life-
time trading of derivatives? We test this by looking at the expected
trading volume of a new derivative over the course of ten years.

Combining draws from the transition matrix in figures 5.4 and 5.5
with draws from a vector representing the probability of a contract
starting in each of the available states of annual trading volume (esti-
mated using the same basic model presented in equation 5.4) we can
get the probability that a new contract will be in any given state of
volume after ten years of trading. Those values are displayed in fig-
ure 5.11. Figure 5.11 makes clear the resilience of contracts trading
at low levels in the 2000s. Only 32 percent of contract that debuted
with zero volume were still trading at zero volume after ten years in
the simulation representing the 2000s. Those probabilities were 46,
48, and 52 percent in the 1990s, 1980s and 1970s respectively (See the
first column of boxes in figure 5.11).[11] Instead of languishing, con-
tracts simulated from the 2000s were more likely to migrate over ten
years to moderate levels of trading. (See the columns of boxes in figure
5.11 corresponding to annual trading volume between 100 and 10,000.)
Those same contracts were, however, less likely to reach the highest
levels of trading ($\geq 100,000$) than contracts from other decades. The
1980s appears to be the best decade for such blockbuster contracts, as
suggested in Gorham and Kundu [2012].

Simply comparing the raw probabilities of reaching various levels of
volume after ten years, it is difficult to discern which decade provided
a better overall environment for new contracts. To make that compar-
ison, we normalize the probabilities in figure 5.11 by the lower bound
of each trading range (i.e. multiplying the probability of being in the
trading state ≥ 100 and $< 1,000$ by 100). This give an approxima-
tion of the expected trading volume of a new contract after ten years,
displayed in figure 5.12. Based on that graph, we can conclude:

- The expected trading volume after 10 years for a contract has var-
  ied substantially from decade to decade;

- There is no clear trend that emerges from these variations over
  time;

- The expected trading volume at year ten for a contract in the 2000s

Figure 5.10: Probability of transition
from annual volume in the tens of
thousands to annual volume of 0

[11] Note these simulated values simply
describe the dynamics of the tran-
sition matrices when compounded.
They ignore delisting. If we accounted
for delisting, a practice that was more
common in previous decades, the
probabilities of failure would likely be
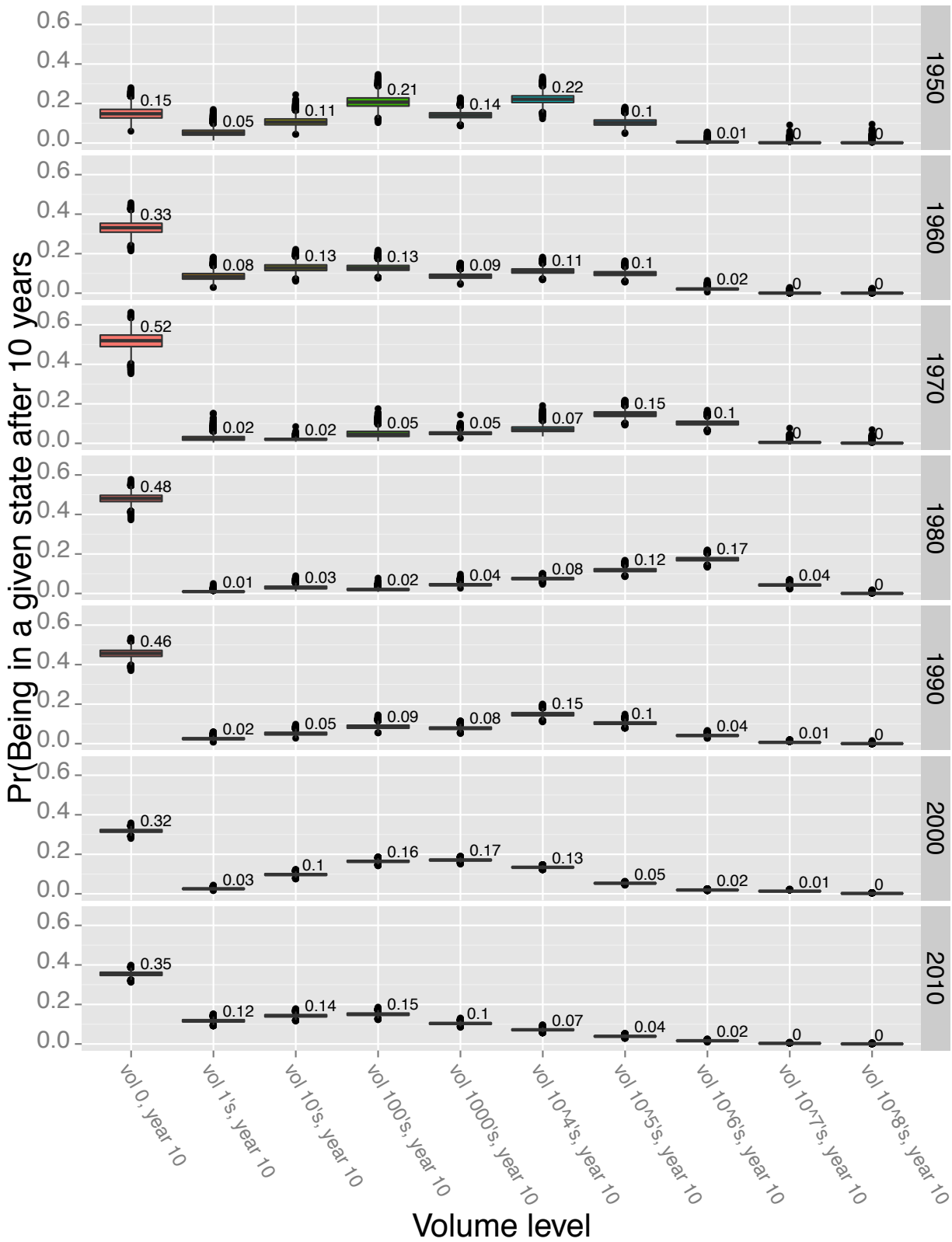higher for those decades.

Figure 5.11: Box and whiskers plot of probability of a new contract being at different levels of trading after 10 years by decade - median simulated probability marked in text, upper and lower hinges of the box plot correspond to the first and third quartiles (the 25th and 75th percentiles)

was firmly in the middle of the historical range - the 2000s were
lower than the 1980s, higher than the 1990s, and all three decades
showed substantial overlap with the earlier decades in the sample;

- In the 2000s, low volume contracts tended to rise to modest levels
of trading, balancing any fall in the probability of reaching the
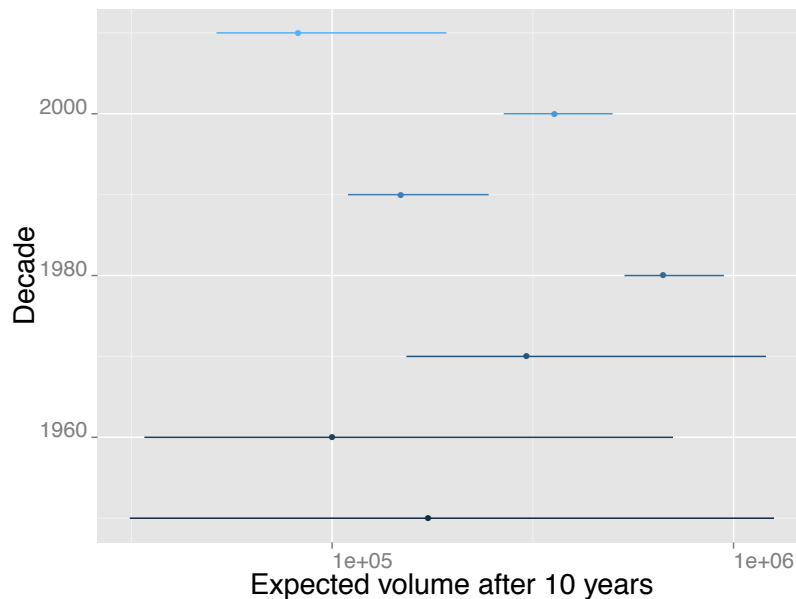highest trading levels.

Figure 5.12: Expected trading volume
over ten years by decade

While a larger percentage of contracts were at low volumes in the
2000s than in previous decades (figure 5.1), individual contracts were
considerably more likely to jump up from very low volumes to mod-
erate volumes (figure 5.7). The net effect of these trends set the ex-
pected volume of contracts at year ten well within the historical range
of earlier decades (figure 5.12). This is remarkable given the explo-
sion in the number of contracts launched (figure 5.3). It suggests that
the marginal value of an innovative contract (approximated by its ex-
pected trading volume at year ten) did not fall in the 2000s, despite
exponentially higher rates of innovation than in past decades.

This shift is consistent with the hypothesis that electronic trad-
ing made trading activity more mobile across derivatives markets and
substantially cut the costs of launching and sustaining a derivatives
contract. But changes went above and beyond the introduction of elec-
tronic trading on US and European exchanges in the 2000s, making
it difficult to identify the causes of product lifecycle shifts in aggre-
gate statistics. For example, many of the new contracts launched in
the 2000s (and included in this sample) are bilaterally-negotiated,

but centrally-cleared swaps. In the wake of Enron's collapse, which threatened energy firms with counter-party defaults on their swaps trades, exchanges launched popular new facilities devoted to these cleared-swaps, including the CME's ClearPort. While those contracts benefited from a suite of tools associated with electronic trading, they were not subject to electronic trading in the narrow sense of actually having buy and sell orders matched on an electronic platform.

To isolate the influence of electronic trading, we look at contracts trading on the New York Mercantile Exchange (NYMEX), where electronic trading was introduced suddenly. The NYMEX does not offer an ideal natural experiment. Its trading patterns were likely influenced by the shift toward cleared swaps throughout the 2000s. However, the abruptness of the exchange's switch to electronic trading does offer some scope for teasing out the relative import of electronic trading.

Derivatives volumes by exchange

Differences in trading volume patterns over the life of a derivatives contract may be influenced by the exchange offering the contract. Carlton [1984] hypothesized that economies of scale in designing and launching a contract gave those on larger exchanges a relative advantage in terms of trading volumes. Similarly, there may be network effects stemming from an exchange's ability to cross-margin trades.

Cuny [1993] and Holland and Fremault [1997] suggest that innovative exchanges may enjoy a first-mover advantage, capturing a disproportionate share of trading on those contracts that they launch. Gorham and Kundu [2012] tests this hypothesis and finds little persistent advantage. In the context of a Markov model of trading volumes, if indeed there is a first-mover advantage, then we would expect innovative exchanges to distinguish themselves with higher expected trading in year ten.

Figure 5.13 presents expected volume in year ten for contracts on all exchanges in the sample. Contracts show greater distinction across decades (as in figure 5.12) than across exchanges. It is possible to distinguish individual exchanges from one another. For example, contracts on the Chicago Board of Trade have an advantage over those on the NYMEX in expected value terms. But no exchanges clearly distinguish themselves from the general tendency with greater than 95 percent probability. Possible exceptions include:

- the single-stock futures traded on OneChicago which show particularly low expected trading volumes over ten years

- the two registered exchanges in the IntercontinentalExchange group,

marked ICE and ICEU in figure 5.13, which likely have higher expected trading volumes than most other exchanges. It is important to note that these exchanges specialize in OTC markets, only a handful of which have been reported to the CFTC as futures. Consequently, some of their performance may represent selection bias.[12]

[12] In late 2012, the IntercontinentalExchange announced that many of its most popular OTC contracts will begin trading as futures.

CME acquisitions test the important of exchange to lifecycles

Recent exchange acquisitions offer the chance to test the effects of particular exchanges on trading volumes. Gorham and Kundu [2012] singled out the CME as the exchange with a persistent advantage over its rivals - leading other major exchanges in mean volume in the 5th year of trading, mean lifetime volume, and their approximations of present value discounted fee generation. In the late 2000s, the CME Group effectively[13] took over both the New York Mercantile Exchange (designated in the database as NYME but commonly referred to as the NYMEX) and the Chicago Board of Trade (CBT). After the acquisitions, the exchanges' contracts continued to be reported as before (i.e. NYMEX contracts continued to be reported in the dataset as NYMEX contracts).

[13] Technically, the CME and CBOT merged. However, the CME was the dominant firm in the merger, initiating the transaction and retaining most of the key staff positions. Olson [2010] provides an inside account of the fight between the CME and ICE for control of the CBOT.

If indeed the CME did enjoy a persistent advantage on multiple volume metrics, then presumably the transition matrices for NYMEX and CBOT contracts, calculated using the Markov models profiled here, would improve following their acquisitions. These acquisitions could also test a weaker form of that same hypothesis. If exchange management is important to contract lifecycles, then the CBOT and NYMEX's contracts' transition matrices should converge to the CME's, regardless of whether the CME has an advantage over other exchanges or not.

Figures 5.14 and 5.15 for the NYMEX and Lifecycle Appendix's figures 18 and 19 present the transition matrices for each of the merged exchanges in the years before and after the merger.[14]

The CBT's transition matrices (Lifecycle Appendix's figures 18 and 19) show no consistent trends in post-merger years relative to the earlier years in the sample. Post-merger years with strong performance (contracts showing a high probability of advancing to a higher level of liquidity - such as 2010, where many of the contracts previously trading with annual volumes in the thousands advanced to the tens of thousands) do not stand out relative to the pre-merger era. To the extent that the CBT shows any post-merger trend, it stems from 2010, an especially volatile year for the CBT, where many contracts advanced to trading in the tens of thousands and a particularly large percentage fell back from annual volumes in the tens of thousands.

[14] We chose to present the full transition matrix for the exchange-year comparisons rather than the expected value figures because we believe that the former provide more robust inference. Expected value calculations are sensitive to the initial trading volumes of the contracts that happened to launch after the merger.

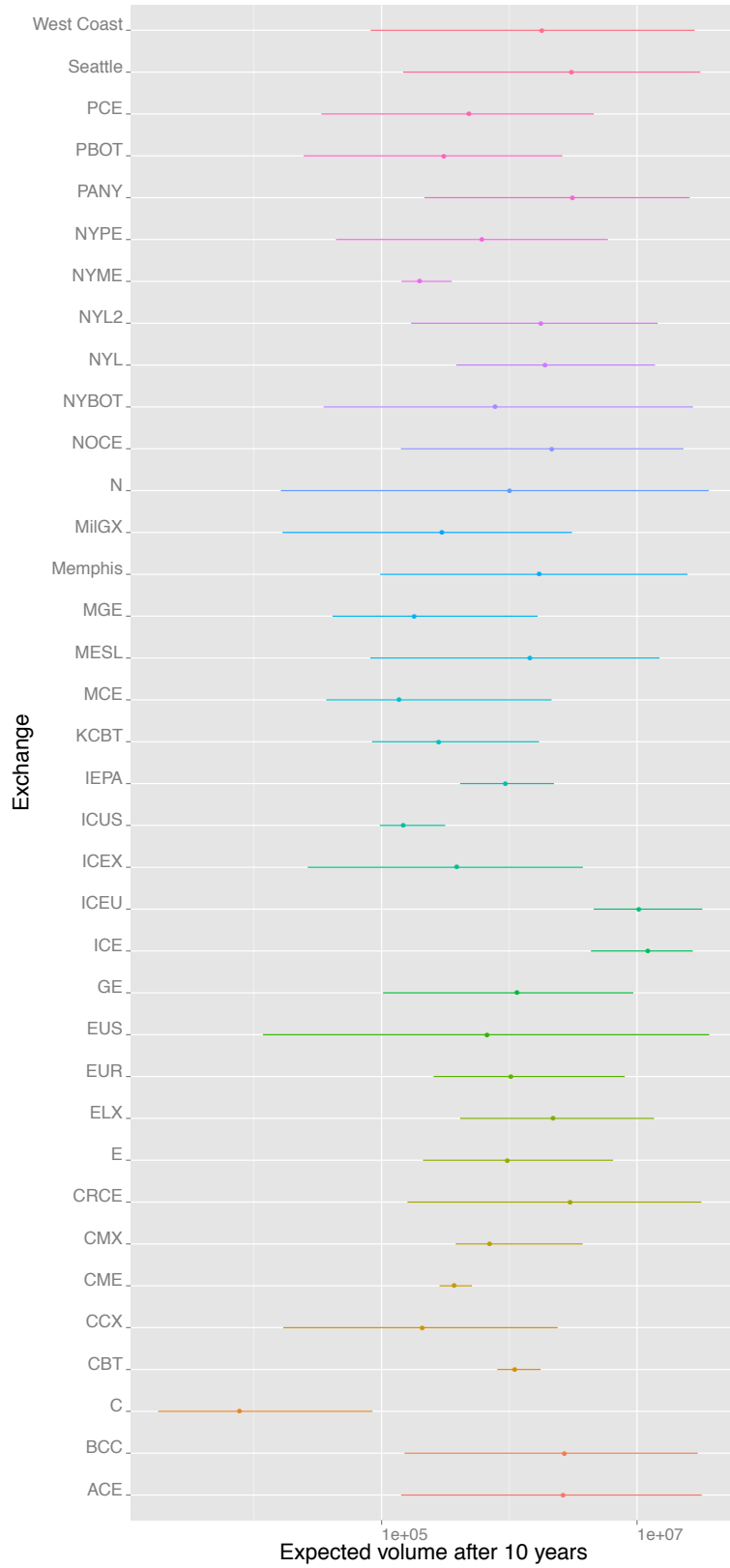Unlike the transition matrix for the CBT, the NYMEX shows a

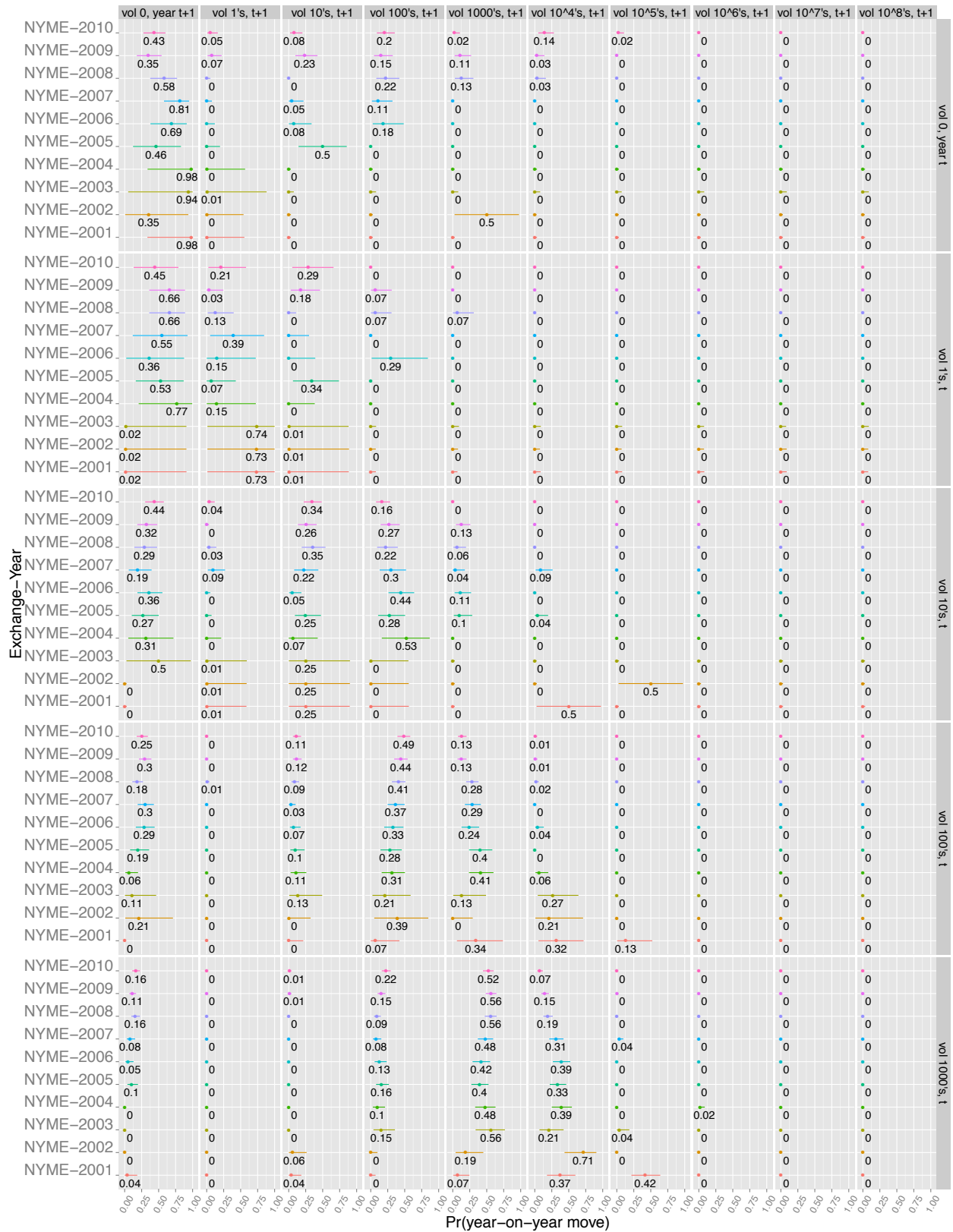Figure 5.13: Expected trading volume over ten years by exchange

Figure 5.14: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - NYMEX before and after CME merger (announced March 2008, finalized September 2009) and before and after switch to electronic trading (September 2006) - part 1: transitions given annual volumes ≥ 0 and
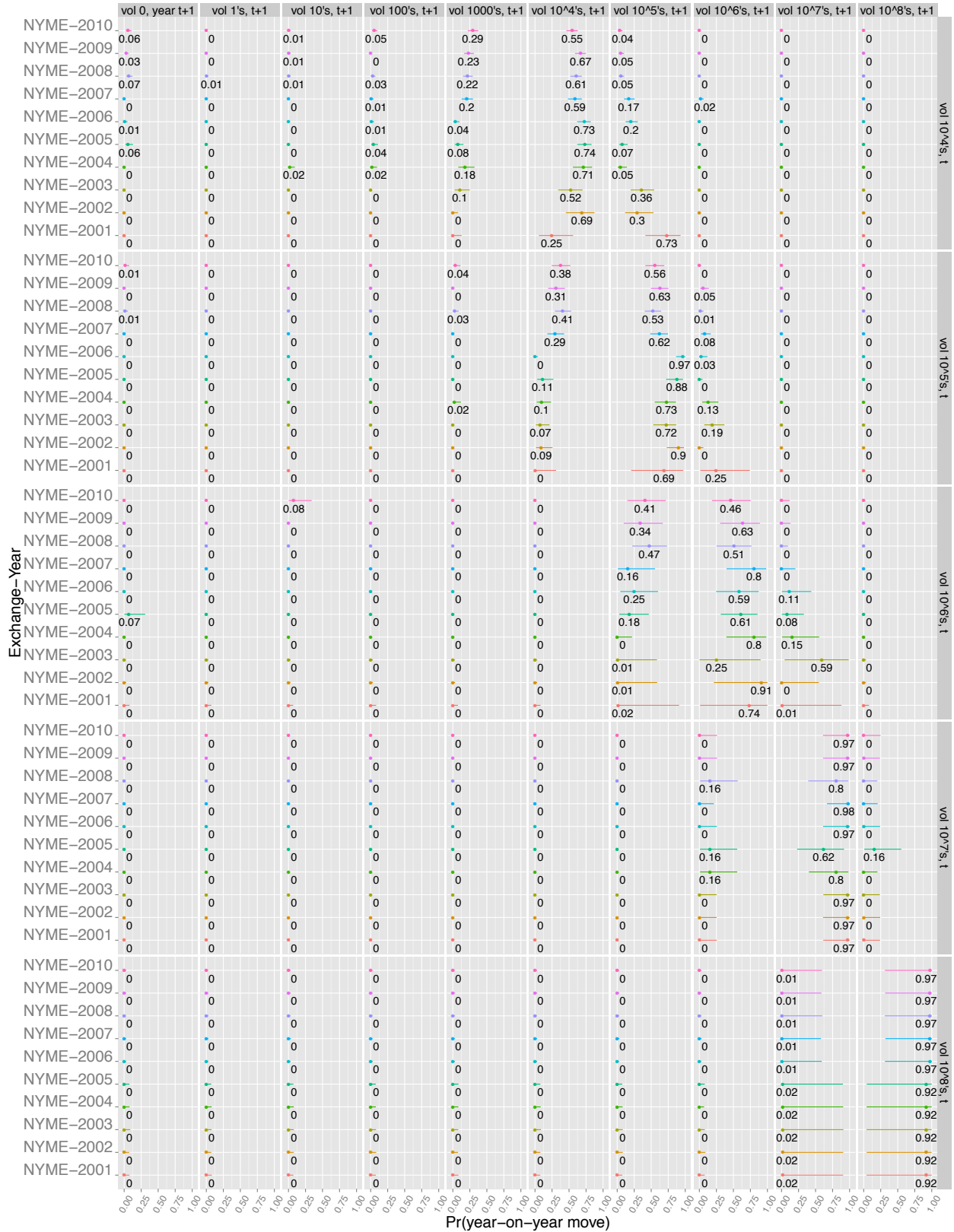
Figure 5.15: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - NYMEX before and after CME merger (announced March 2008, finalized September 2009) and before and after switch to electronic trading (September 2006) - part 2: transitions given annual volumes ≥ 10,000

clear trend in its transition probabilities. On the rows in figures 5.14 and 5.15 indicating trading volume between ≤ 10 and $< 1,000,000$ (rows three through five in figure 5.14 and rows one and two in figure 5.15), a gradual pattern in volume level transitions emerges that is strong enough, by the end of the decade, to hold with high probability. Starting roughly in 2006, the 10s, 100s, and 1000s became sinks (rows three through five in figures 5.14). The probability of staying at these levels year on year increases gradually. The probability of rising out of that range falls. At levels immediately above that sink (rows one and two in figures 5.15), the probability of falling into the sink rises at the clear expense of the probability of staying put or rising. This trend predates, and is uninterrupted by, the CME merger.

Neither transition matrix support the hypothesis that exchange management is an important factor in lifecycle patterns, much less the hypothesis that CME's systems and network effects boost trading volumes substantially relative to competing exchanges.

Recent trends in NYMEX lifecycles and the importance of electronic trading

While they do not show a strong influence from the CME acquisition, figures 5.14 and 5.15 may speak to the influence of electronic trading. Pronounced lifecycle trends on the NYMEX seem to begin in 2006, when the exchange abruptly switched from open-outcry to electronic trading. These trends mirror the more general tendency across derivatives markets over the last decade, with more flexible trading at low volumes, more contracts moving up to modest volumes, and a small decline in the probability of trading at high levels.

As mentioned above, it is difficult to separate out the effects of electronic trading per se from those of the whole suite of new tools that arrived with electronic trading, such as clear swaps platforms. NYMEX, within its specialization in energy contracts threatened by Enron, was a pioneer in cleared swaps transactions. In 2003, it launched ClearPort, the platform now used for all of the CME's cleared swaps trades. ClearPort was marketed as an *electronic trading system* because it disseminated information about specialized swaps trades via screens[15]. However, most cleared swaps transactions are negotiated bilaterally, over the phone. That means that ClearPort trades are supported by electronic infrastructure, but they are not fully electronic. So, while NYMEX's abrupt shift from pit-based to electronic trading offers a prime opportunity to isolate the influence of electronic trading on derivatives volumes, the advent of cleared swaps complicates both the analysis of NYMEX data and the definition of electronic trading.

[15] Reuters News. NYMEX launches Cleaport electronic trading system., January 17 2003

To the extent that we can identify the influence of fully electronic trading on its own, then 2006, the year that NYMEX abruptly closed pit trading, should produce discontinuities in ongoing lifecycle trends. 2006 does indeed show evidence of a discontinuity. That evidence is not overwhelming, but it does support the hypothesis that the large changes in derivatives markets in the 2000s were driven specifically by the switch to electronic trading.

Derivatives volumes by product type

Figure 5.16 shows expected value estimates for trading at year ten for each product type. Derivatives based on US treasuries, and, to a lesser extent, derivatives based on natural gas and stock indexes enjoy higher expected volumes than other product types.

The distinction between these strong performers and most of the other product types in the sample is appreciable but does not hold with high probability. The 95 percent probability interval for each of those high expected volume product types sits within the upper tails of the distributions for other product types. The long upper tails that shadow the three top performers are largely a function of uncertainty in estimating the parameter for relatively uncommon product types rather than stellar historical performance. They reflect the fact that we have relatively few observations of derivatives based on wood products, for example, and so our model allows for the possibility that out-of-sample wood products may show high trading volumes in the future.

Major currencies, grains, precious metals, petroleum-related products, and interest rates not derived from US treasuries define the middle of the pack for expected year ten volumes. They are joined by a large group of product types whose expected volumes are subject to great uncertainty, thanks to a scarcity of data.

Among these average performers, plastics and chemicals may be promising niches for innovation. While their estimated expected volumes are subject to considerable uncertainty, the data points we have indicate that they are relatively strong performers.

On the low end of our expected year ten volume estimates are single-stock futures[16] and weather derivatives. Both are relatively new product types with many correlated contracts launched in recent years. Interestingly, these contract types appear to under-perform relative to some product types like yield insurance and emissions in which trading was effectively smothered by external events (the proliferation of subsidized crop insurance in the US in the case of yield insurance and the failure of the US to consistently promote cap-and-trade legislation in the case of emissions).

[16] This is consistent with figure 5.13 which shows OneChicago, the exchange specializing in single-stock futures as a relative under-performer in expected trading volume at year ten.
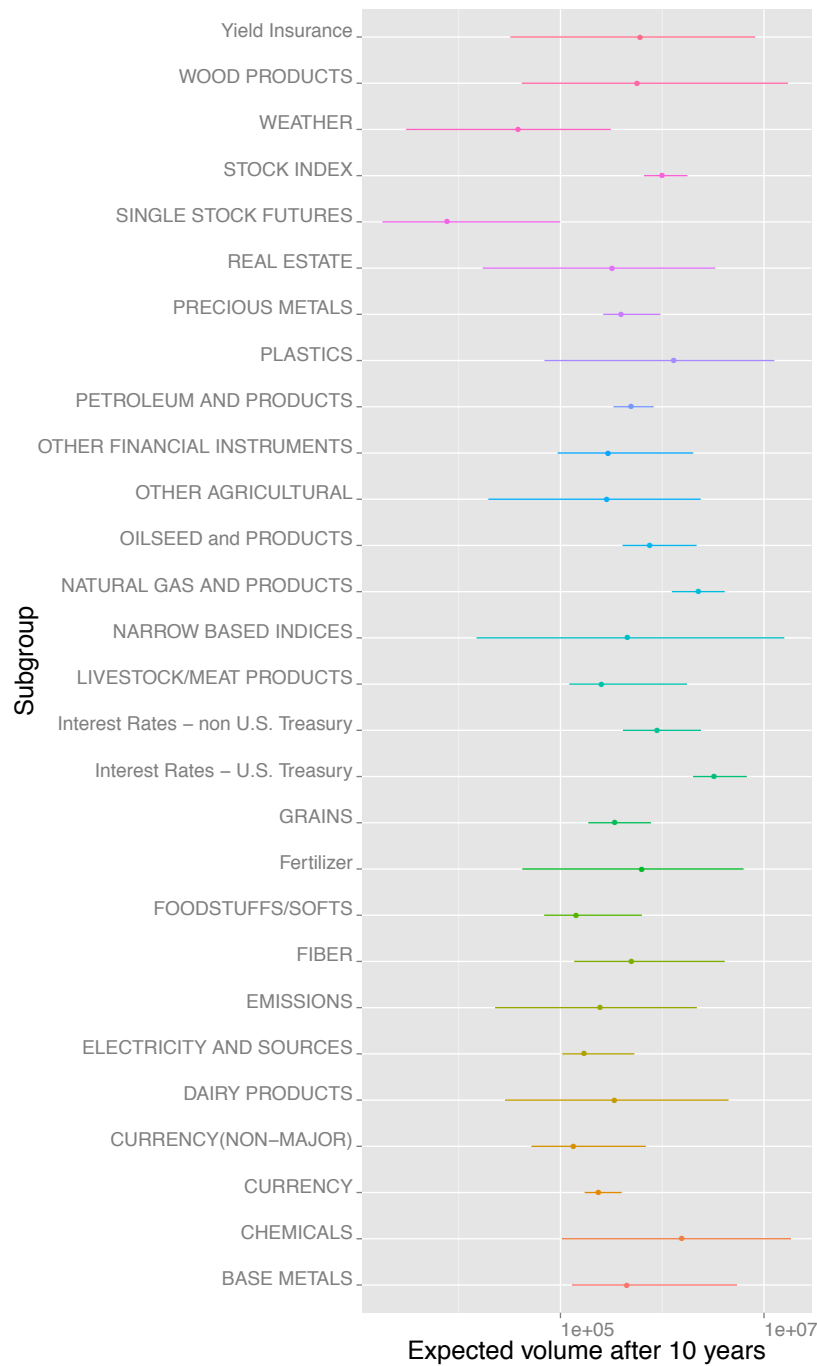
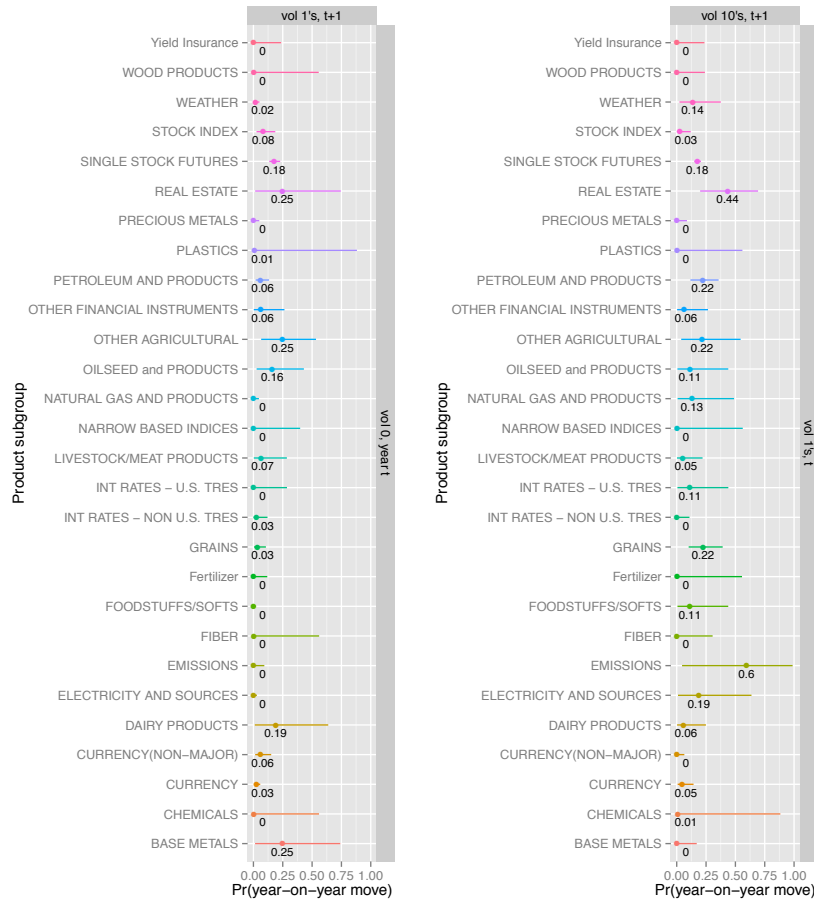Figure 5.16: Expected trading volume over ten years by product type

Figure 5.17: Probability of transition from annual volume in the hundreds to annual volume in the thousands (left) and from annual volume in the thousands to annual volume tens of thousands (right) by product type
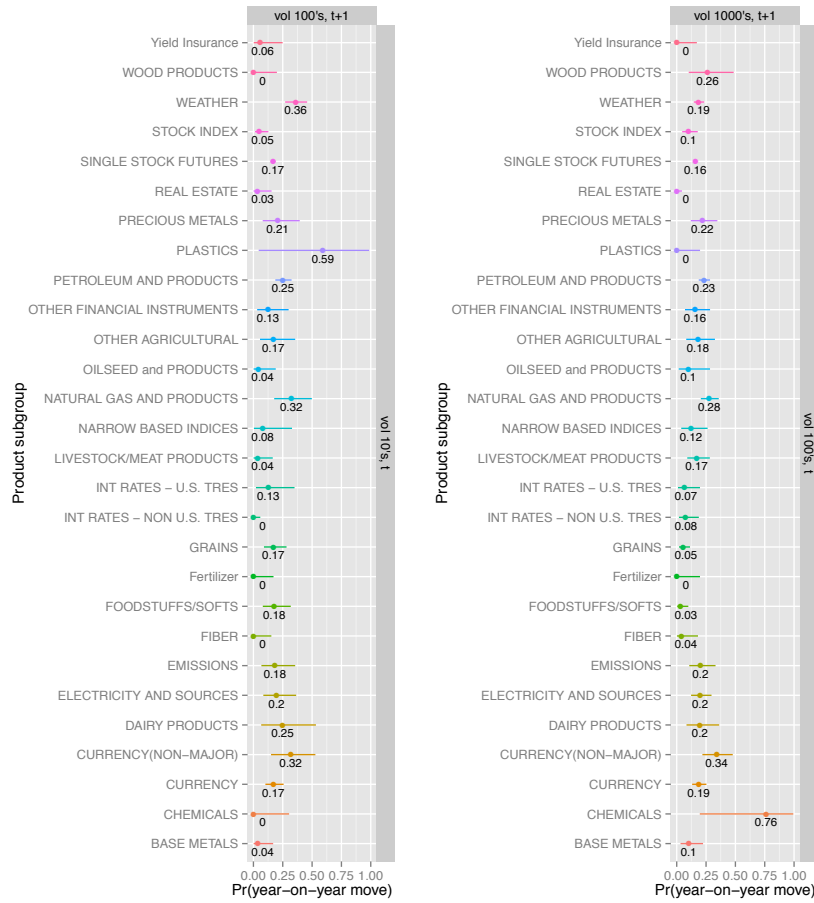
Figure 5.18: Probability of transition from annual volume in the hundreds to annual volume in the thousands (left) and from annual volume in the thousands to annual volume tens of thousands (right) by product type

Interestingly, single-stock futures and weather derivatives were more likely than most other product types to climb up from low levels of trading volume. Figures 5.17 and 5.18 present the probability of any contract moving to higher levels of annual trading volume for each product type in the sample. Single-stock futures are particularly likely to recover from years of zero trading volume and weather derivatives are particularly likely to move up to annual trading volumes in the thousands. (See Lifecycle Appendix's figures 13 and 14 for additional details.) Insofar as these product types move fluidly up and down from low levels of annual trading volumes they are representative of recent trends across derivatives markets.

Conclusions

In this article we have presented a comprehensive analysis of trading volumes for derivatives reported to exchanges in the United States. Looking across decades, exchanges, and product types we see multiple trends that challenge or significantly modify findings of existing studies.

While a larger percentage of contracts had little or no volume in any given year of the 2000s, contracts did not fail at the high rates noted in previous analyses. Instead, they remained at low levels of trading until they were needed, transitioning back into active trading with greater probability than in previous decades. Interestingly, this flexibility from low levels of trading meant that the long term outlook for a new contract did not erode despite remarkable levels of new contract innovation. During the 2000s the expected volume of a new contract after ten years was above that of the 1990s and within the range of previous decades. On balance, the explosion of innovation catalyzed by electronic trading did not hurt the prospects for the marginal contract.

We find that expected year ten trading volumes varied more decade to decade than from exchange to exchange or product type to product type. In particular, the lifecycle of a derivative on any given exchange was largely indistinguishable from that on any other, with the likely exception of OneChicago, which specializes in single-stock futures.

We find evidence that the decadal changes in derivative lifecycles were driven by the switch to electronic trading rather than the consolidation of exchanges by looking at trends on the New York Mercantile Exchange. The effects of electronic trading are difficult to separate from the the related innovation of cleared swaps. However, trends in NYMEX volumes following the 2006 launch of widespread electronic trading tentatively support the hypothesis that electronic trading is indeed driving recent trends in derivatives lifecycles across all sampled

markets.

The statistical characteristics of derivative volumes

In addition to facilitating quick distributional comparisons across various contract groupings (decade, exchange, and product type), our framework (Markov models) allows us to explore some basic questions about derivative markets in general. For example, based on our Markov models it appears that trading volumes do not follow a normal or log-normal random walk over time. In figures 5.4 and 5.5 it is clear that the probability of remaining at a given level of annual volume varies dramatically from one level to the next. These differences hold with greater than 95 percent probability as do variations in the volume dynamics across time (indicating that normal or log-normal models of trading volume would suffer from stationarity problems as well). Furthermore, switches to higher and lower levels of trading are often not symmetric. In particular, an outright crash to zero trading volume appears more likely than would be predicted by a symmetrically distributed random walk.

However, our analysis does affirm the common observation that it is unusual for a contract to experience initial popularity and to crash subsequently[17]. After reaching a trading volume in the tens of thousands, the probability that a contract will have annual trading volume of zero in the subsequent year drops appreciably.

[17] E.T. Johnston and J.J. McConnell. Requiem for a market: An analysis of the rise and fall of a financial futures contract. *Review of Financial Studies*, 2(1):1–23, 1989

Optimal contract innovation

Much of the literature on derivative innovation focuses on the problem of choosing the optimal derivatives contract to launch next. This analysis does not directly address that question, but it does present some trends relevant to previous theoretical work which could inform further investigation.

One interpretation of Duffie and Jackson [1989] provides that revenue maximizing marginal innovations are uncorrelated with existing contracts. However, recent trends suggest that one of the key assumptions underlying this finding only holds weakly. Historically, correlated contract innovations have not shown diminishing marginal volumes. In general, innovation in derivatives markets has exploded in the last decade seemingly without dragging down expected trading volumes at year ten. Indeed, some of the highest volume product types (in expected volume terms) are highly correlated both to other derivatives of their product category but also to the average returns of the economy as a whole (US treasuries and stock indexes).

Tashjian and Weissman [1995] explains the proliferation of correlated (and often redundant) contracts as a form of price discrimina-

tion. They assume, that an exchange can charge higher fees on the transaction for parties with larger and more concentrated exposure to a given underlying index. This framework for understanding product innovation holds up well in light of recent trends. As we have discussed, many recently launched contracts are cleared swaps, which tend to be more specialized than conventional futures or options. As Tashjian and Weissman [1995] predicted, exchanges charge a substantial premium on these specialized transactions. Fees on CME's ClearPort platform were more than 350 percent those on conventional electronic futures trades as of late 2012[18]. However, Tashjian and Weissman [1995] suggested that exchanges would charge more for single-asset-based derivatives (such as gold) than for derivatives that represented the holding of multi-product firms (like the crack-spreads used to reproduce petroleum refiners' returns). In practice, cleared-swaps contracts, with their relatively high fees, appear to be biased toward the latter.

[18] CME Group. Press release: CME Group volume averaged 11.9 million contracts per day in september 2012, up 16 percent from august 2012, October 2012. URL `http://investor.cmegroup.com/investor-relations/releasedetail.cfm?ReleaseID=710622`. Thanks to Silla Brush of Bloomberg for directing us to this press release

A third explanation of recent patterns in derivative innovation is psychological. Based on Tversky et al. [1981], Shiller [1994] suggests that a hedge "appears more attractive when it's presented as the elimination of risk rather than when it is described as the reduction of risk." This tendency to overvalue hedges tailored to the needs of specific firms may explain the proliferation of correlated contracts (and their relative success) above and beyond the price discrimination suggested in Tashjian and Weissman [1995].

What kind of economic goods are derivatives?

The present analysis could also suggest new ways of understanding the economic value of derivatives. If indeed derivatives are simply contingent contracts that move cash flows across time and states of nature, then they should derive all their value from the way that they mesh with hedger's risk preferences. It follows from that idea, that if risk preferences remain stable over time, then derivative trading patterns should also remain stable.

But trading patterns have not been stable over the last decade. Instead, they bear a striking qualitative resemblance to those of information goods, particularly media:

- Each class of economic goods was, until recently, simple to classify: normal goods with elastic demand and network effects.

- Starting a new derivatives market, just like producing a new music album or launching a magazine, was a high risk, high reward proposition.

- In the last decade both saw paradigm shifts in their marginal cost

structure (i.e. there were fundamental changes in supply).

- At the same time, new technologies allowed consumers ubiquitous access to goods (i.e. there were also fundamental changes in demand).

- After those twin revolutions, markets:

    - Rewarded specialty products more than in the past;

    - Hosted blockbusters as large as/larger than ever;

    - Did not offer the same opportunities for strong but less-than-blockbuster products.

In media (and informational goods more generally) this transition has upended many long-profitable business models and catalyzed a great deal of innovation. In derivatives it has certainly opened up the door to many new entrants like ICE, which now is one of two large futures exchanges in the US today. But it is not clear whether those new entrants are using fundamentally new business models.

How strong is the parallel? Should economists study derivatives alongside informational goods? What does the possible connection suggest for the future of derivatives? We believe that these questions provide a solid foundation for future research.