The Lifecycle of Exchange-traded Derivatives

Grant Cavanaugh

Ph.D. Candidate

Agricultural Economics

University of Kentucky

gcavanaugh@uky.edu

Michael Penick

Senior Economist

US Commodity Futures Trading Commission

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA Annual Meeting, Washington, DC, August 4-6, 2013

The Lifecycle of Exchange-traded Derivatives

Grant Cavanaugh
Ph.D. Candidate
Agricultural Economics
University of Kentucky
gcavanaugh@uky.edu
Michael Penick
Senior Economist
US Commodity Futures Trading Commission

Agricultural & Applied Economics Association's 2013 AAEA Annual Meeting, Washington, DC, August 4-6, 2013

THIS CHAPTER DOES NOT REFLECT THE OPINIONS OF THE CFTC

Using a comprehensive dataset covering most derivatives trades reported to US exchanges since 1954, we present distributional estimates of the rate at which derivative trading volumes rise and fall. Our results suggest that the lifecycle of cleared derivatives changed fundamentally in the 2000's. In that decade, derivatives with low trading volumes moved to modest volumes with increased probability. Prior to that, 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 1990's and 2000's, despite the fact that a larger percentage of contracts traded at low volume in any given year. These findings suggest that trends in futures markets growth first noted in Silber [1981] and Carlton [1984] and subsequently cited widely in literature on derivatives innovation are less relevant than in the past. We also discuss the relative influence of exchange, product type, and decade of trading on volume patterns. We find that trading volumes varied more decade to decade than from exchange to exchange or product type to product type. Looking in detail at trading on the New York Mercantile Exchange, an exchange that shifted abruptly to electronic trading, we find evidence that the widespread adoption of electronic trading was the driver behind the shift in the lifecycle of derivatives across US exchanges in the last decade.

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 article, technological innovation and organizational changes at derivatives

[1] G. Gorton and K.G. Rouwenhorst. Facts and fantasies about commodity futures. Technical report, National Bureau of Economic Research, 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

exchanges between 1990 and 2010 altered the economics of derivatives trading [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.

Such statistics are particularly important because the policy debates surrounding overhauls of 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, have grown to a notional outstanding value of USD 639 trillion in 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.

This regulatory change suggests that the coming years will see substantial 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 in late 2011 suggesting that central clearing of trades and greater price transparency will result in high rates of failure for then-unregulated derivatives [7]. This suggestion is misleading. It both ignores the comparable failure rates for bilateral swaps and relies on an assumption

[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 futures is often murky. For example, some swaps trades are negotiated bilaterally and then converted into futures trades on markets such as the CME Group's ClearPort. Those trades are reported to exchanges and are consequently included in the dataset used in this article. The CME and ICE, the two largest US futures exchanges, have recently announced plans to convert many of their most popular swaps markets into futures markets with physical delivery of swaps contracts at settlement (i.e. futures trades that become swaps), providing yet another hybrid model.

[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`

[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

tested here - that derivatives fail at high rates - which is not robust to recent changes in the underlying structure of cleared derivatives markets.

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 trading volume figures for US traded derivatives. These figures 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). However, for ease of analysis, we used:

- An electronic database maintained by the CFTC aggregating basic, market-level trade data from *designated contract markets (DCMs)*, regulated futures and options exchanges. 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 1980's.

- We supplemented this basic dataset by adding in futures trading figures compiled by hand by co-author of this article Michael Penick, senior economist at the CFTC. As part of a previous internal analysis of trading volumes, Penick compiled annual trading figures for all listed futures contracts dating back to 1954. 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 published to date.

Markov model for the lifecycle of derivatives

We present our primary results in the form of a Markov model. Contracts are assigned a vector (θ) that describes the probability of moving to any of a set of discrete states of annual trading volume in the following year given their state of trading volume today

(Volume $\text{level}_{\text{year t+1}}$|Volume $\text{level}_{\text{year t}}$). 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 trading of 0.

Since we are working with discrete values and the probabilities of moving between those states sums to 1, θ can be described by a Dirichlet distribution (commonly used for the probability of ending in an exhaustive set of categorical states). These transition probabilities were estimated using Bayesian Gibbs sampling using the statistical package JAGS[8]. These methods treat the underlying probabilities of moving between states of trading volume as randomly distributed parameters.

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

$$\begin{aligned}\text{Volume level}_{\text{year t+1}}|\text{Volume level}_{\text{year t}} &\sim \text{Categorical}(\theta)\\ \theta &\sim \text{Dirichlet}(x_{\text{vol level 0}}, x_{\text{vol level 1}}, \ldots, x_{\text{vol level }10^8})\end{aligned} \quad (1)$$

Combining simulated values from this transition matrix with a histogram of initial values (giving the historical probability of a new contract starting in any given state of annual trading volume), we provide expected value estimates for the aggregate trading volume of a new contract over an arbitrary number of years. (We present all our expected trading volumes at a ten year horizon, but the Markov model is flexible in this regard.)

We believe that these methods, applied a larger dataset than was previously available, allow us to:

- avoid most of the arbitrary assumptions that underlay most previously published measures of derivative contract success and failure. The informational value of contract delisting, a popular measure of failure, has eroded in the era of electronic trading, as the marginal cost of maintaining a low volume contract has fallen rapidly.
- provide statistics that will be robust to fundamental changes in the derivatives markets. One such change may be the shift of many OTC swaps markets onto exchanges.
- facilitate simulation and out-of-sample prediction
- describe the full lifecycle of a derivatives contract without any specific focus on newly launched contracts
- provide distributional information for key parameters that facilitates easy statistical comparison between market niches

- avoid the sample bias problems in some previous studies

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 1) 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 2 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.

Changes in derivatives markets over time

Concentration of trading volume over time

Figures 1 and 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 1 clearly shows that most contracts trade at low volumes in any given year, with roughly 80% of contracts with little or no volume in any given year since 1954.

However, figure 1 obscures substantial variation in the concentration of volume over time. Figure 2 zooms in on the same annual

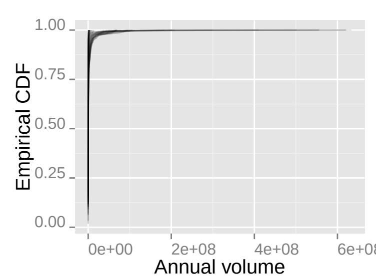

Figure 1: Empirical cumulative distribution function of annual trading volumes by contract

ECDFs displayed in figure 1. The ECDF for each year is colored chronologically, with the lines representing the oldest years in the sample in red and the most recent years in purple. Each panel of figure 1 shows the same ECDFs, but the years in a specific decade are highlighted (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 1950's and 1990's (perhaps with some retrenchment between the 1980's and 1990's), shown by the ECDFs for each succeeding decade flattening. That trend reversed sharply in the 2000's, with the annual ECDFs approaching a right angle. In the 1980's the range of $15,000$ to $30,000$ roughly marked the 50^{th} percentile for annual trading volumes, with half of the listed contracts trading above that range and half below. By the 2000's that range had fallen to between 300 and $8,000$.

Figure 2 itself highlights one likely cause of this shift - the explosion of innovation during the 2000's. The ECDFs for the 2000's 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 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 standardized derivatives contracts reporting annual volume in 2011.

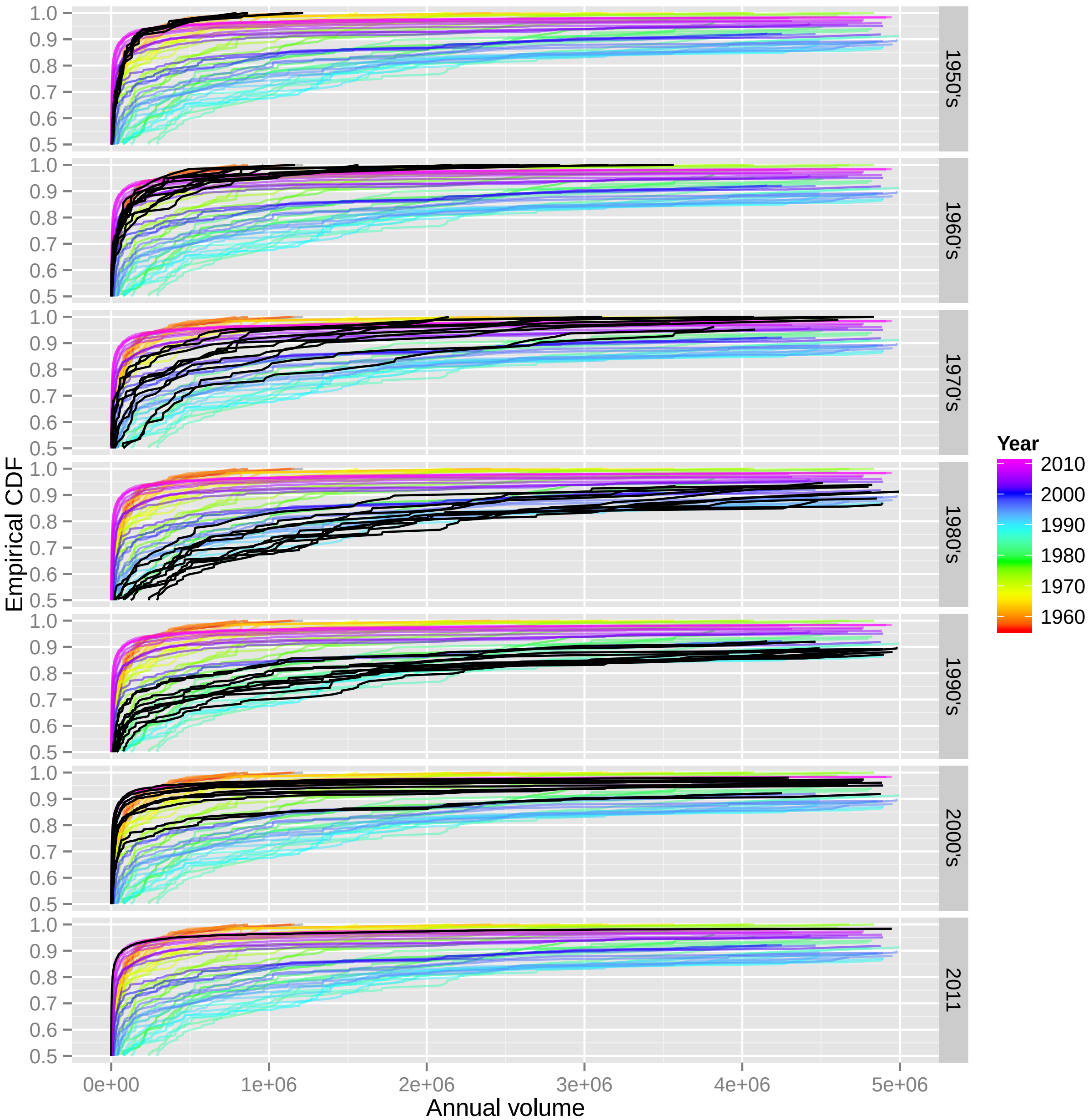

Figure 2: Empirical cumulative distribution function (ECDF) of annual trading volumes by contract with scale adjusted to distinguish between decades - Each line represents the ECDF for a different year. Each of the stacked panels highlights the years in a particular decade in black. Note that an ECDF approaching a right angel represents a year in which volume was concentrated in a few contracts. Hence, with some exceptions in the 1990's the market as a whole becomes less concentrated, until the 2000's when it abruptly becomes highly concentrated.

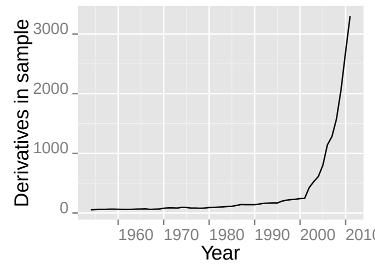

Figure 3: Number of contracts in sample by year

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

Figures 4 and 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 1, 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 move up or down. This is particularly true 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 roughly between 80 and 90% (see lower right-hand corner of figure 5).

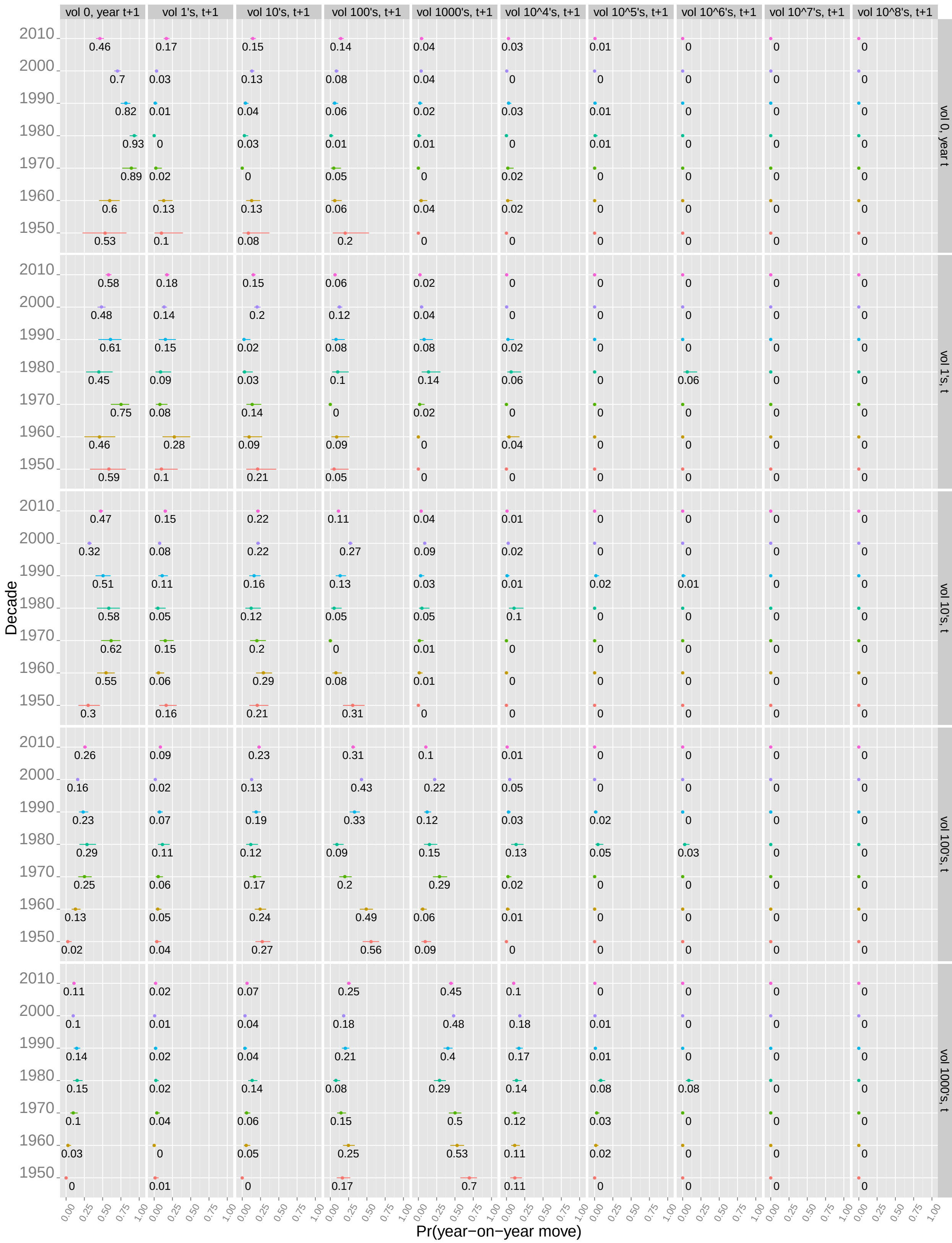

Figure 4: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - row represents state in year t, column represents state in year $t+1$, median estimate indicated by dot, 95% probability interval indicated by line - part 1: transitions given annual volumes ≥ 0 and $< 10,000$

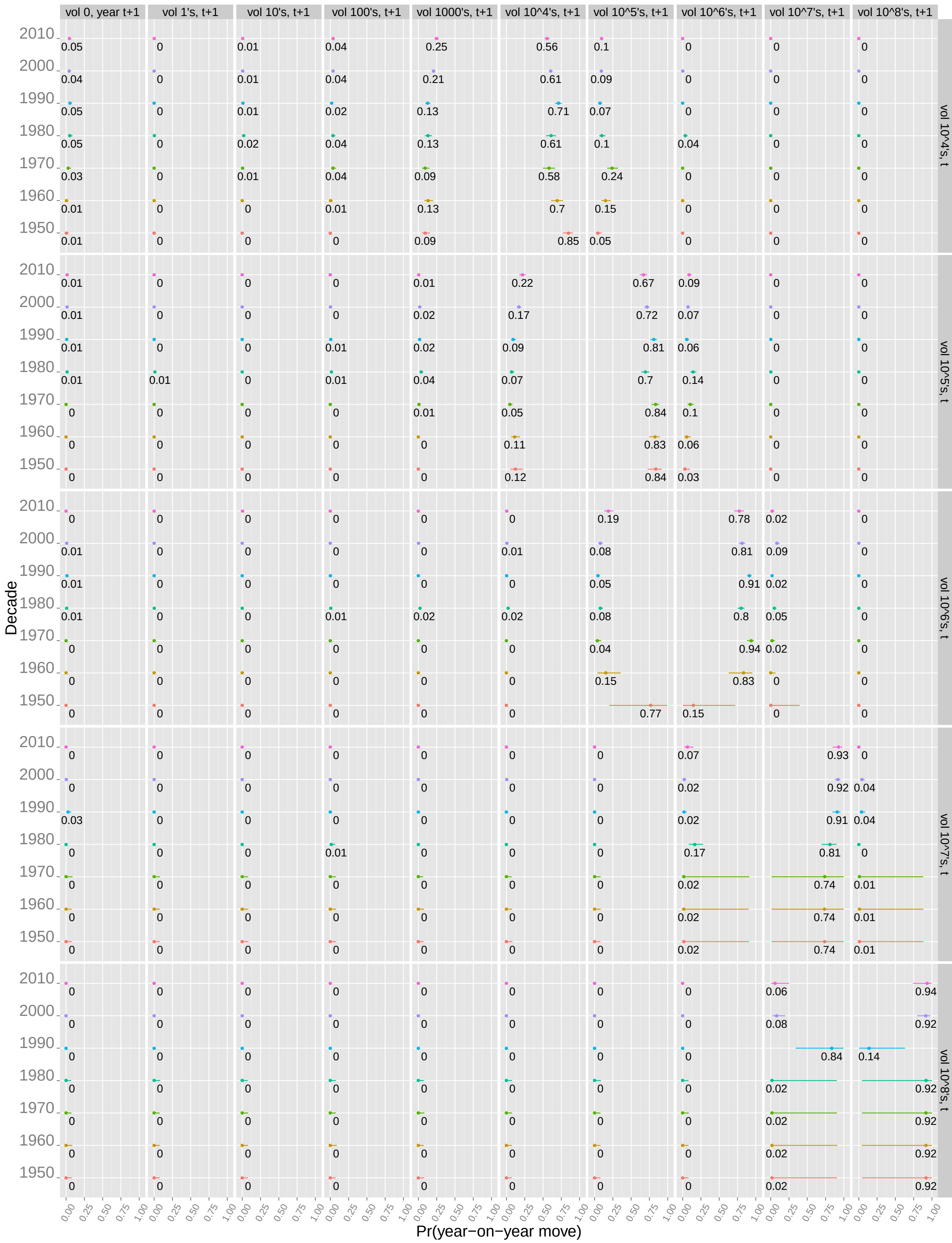

Figure 5: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - row represents state in year t, column represents state in year $t+1$, median estimate indicated by dot, 95% probability interval indicated by line - part 2: transitions given annual volumes $\geq 10,000$

Similarly we see substantial historical evidence of inertia at very low levels of trading. From 1970 till 2000, the median probability that a contract with trading volume of zero would remain at zero the next year, ranged between 80 and 95% (see upper left-hand corner of figure 4).

However, 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 2000's. (See the top rows of figure 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% (figure 6). While zero volume contracts remained unlikely in absolute terms to rise to higher volume levels, the 95% probability interval for the transition probability for the 2000's does not overlap with those for recent decades, meaning that the difference holds with high probability.

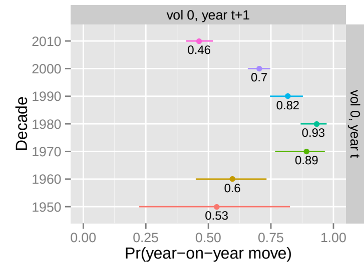

Figure 6: Probability of remaining at annual volume of zero from year to year by decade

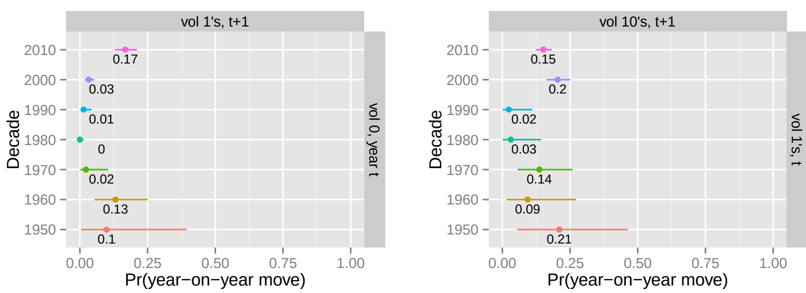

Figure 7: Probability of transition from annual volume of 0 to annual volume in the single digits (left) and from annual volume in the single digits to annual volume $\geq 10, < 100$ (right)

During the decade of the 2000's, 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 4 and 7.) Combined with the apparent trend toward maintaining rather than delisting contracts, this suggest that there was less path-dependence for trading volumes in the 2000's. While more contracts traded at a volume of 0 in any given year (see figure 2), contracts were substantially more likely to jump up from such low trading volumes in the 2000's.

Having reached annual trading volumes in the 10's or 100's (see 8), contracts in the decade of the 2000's were again substantially more likely to continue increasing their trading volume in the 2000's than in the 1980's or 1990's. Only after reaching trading volumes in the 1000's (figure 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 general, the transition matrix in the 2000's favored low volume contracts moving up to an annual trading volume in the thousands relative to

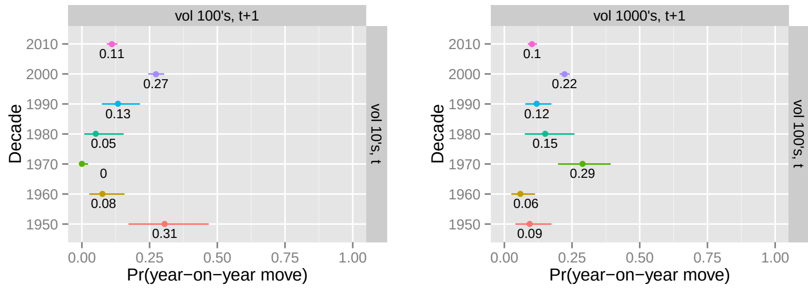

Figure 8: Probability of transition from annual volume in the hundreds to annual volume in the thousands (left) and from annual volume in the thousands to annual volume tens of thousands (right)

previous decades.

Contracts trading in the 10,000's were 8% more likely to fall back to lower levels of annual volumes in the 2000's 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 came at the expense of contracts mid-range levels of trading. (However, as we see in figure 12, discussed below, that retrenchment from trading in the 10,000's was not enough, on balance, to lower the prospects of a new contract over the course of ten years.)

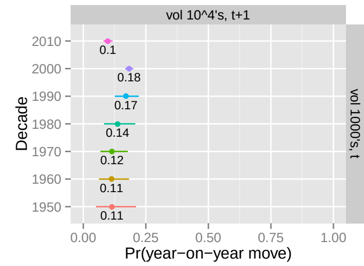

Figure 9: Probability of transition from annual volume in the tens of thousands to annual volume in the hundreds of thousands

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

Table 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

Annual trading in the 10,000's appears to represent an important benchmark 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 10). Table 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 10,000's, a full collapse becomes relatively unlikely at 4%. In fact, for contracts that achieve annual trading in the 10,000's, the probability of falling more than one volume level is below 10%. (See sixth row of table 1) Note that these full sample estimates are biased toward recent decades because the sample contains more observations from recent decades.

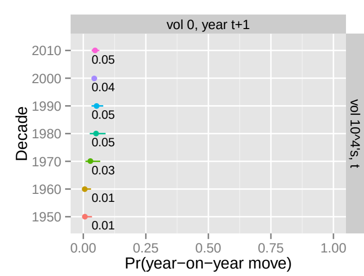

Figure 10: Probability of transition from annual volume in the tens of thousands to annual volume of 0

As suggested above, one logical hypothesis regarding the recent shift in derivatives lifecycles is that the additional flexibility that low volume contracts enjoyed in the 2000's came directly at the expense of mid-range to higher volume contracts, meaning that the overall outlook for lifetime trading of derivatives declines. 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 4 and 5 with draws from a histogram representing the probability of a contract starting in each of the available states of annual trading volume (estimated using the same basic model presented in equation 1) 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 figure 11. Figure 11 makes clear the resilience of contracts trading at low levels in the 2000's. A contract had only a 32% of still trading at zero volume after ten years in the 2000's, whereas those probabilities were 46%, 48%, and 52% in the 1990's, 1980's and 1970's respectively (See the first column of boxes in figure 11). [9] Instead, contracts were more likely to migrate over ten years to moderate levels of trading. (See the columns of boxes in figure 11 corresponding to annual trading volume between 100 and 10,000.) Contracts were, however, less likely to reach the highest levels of trading ($\geq$ 100,000). The 1980's does appear to be the best decade for such blockbuster contracts, as suggested in Gorham and Kundu [2012].

[9] Note these simulated values simply describe the dynamics of the transition 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.

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 comparison, we estimate the overall expected trading after ten years, we normalize the probabilities in figure 11 by the lower bound of each trading range (i.e. multiplying the probability of being in the trading state $\geq$ 100 and $<$ 1,000 by 100). This give a conservative estimate of the expected trading volume of a new contract after ten years, displayed in figure 12. Based on that graph, we can conclude:

- the expected trading volume after 10 years for a contract has varied 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 2000's was firmly in the middle of the historical range - the 2000's were lower than the 1980's, higher than the 1990's, and all three decades showed substantial overlap with the earlier decades in the sample
- the increased tendency of low volume contracts in the 2000's to rise to modest levels of trading did adequately balance any downward trend in the probability of seeing blockbuster contracts.

While a larger percentage of contracts were at very low levels of trading volumes in the 2000's than in previous decades (figure 1), individual contracts were considerably more likely to jump up from very low volumes to moderate volumes (figure 7). The net effect of these trends set the expected volume of contracts at year ten were well within the historical range of earlier decades (figure 12). This is

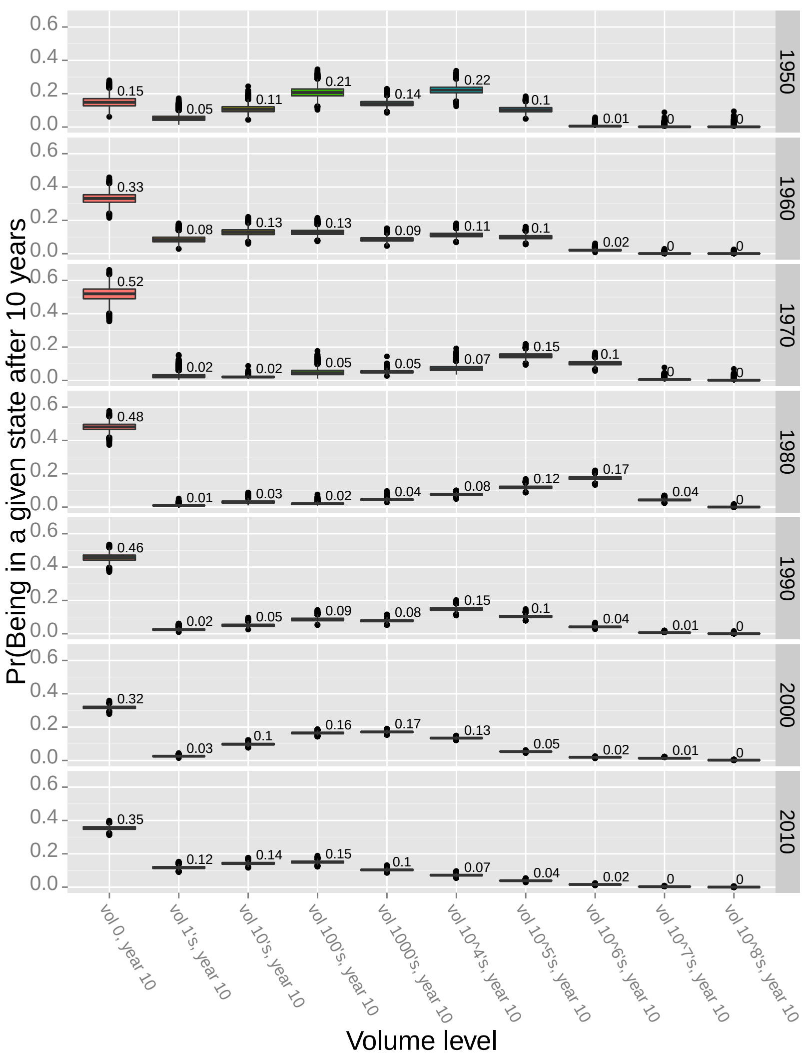

Figure 11: Box and whiskers plot of probability of a new contract being in different levels of trading after 10 years by decade - median simulated probability marked in text, upper and lower hinges of the box plot correspond to the first and third quartiles (the 25th and 75th percentiles)

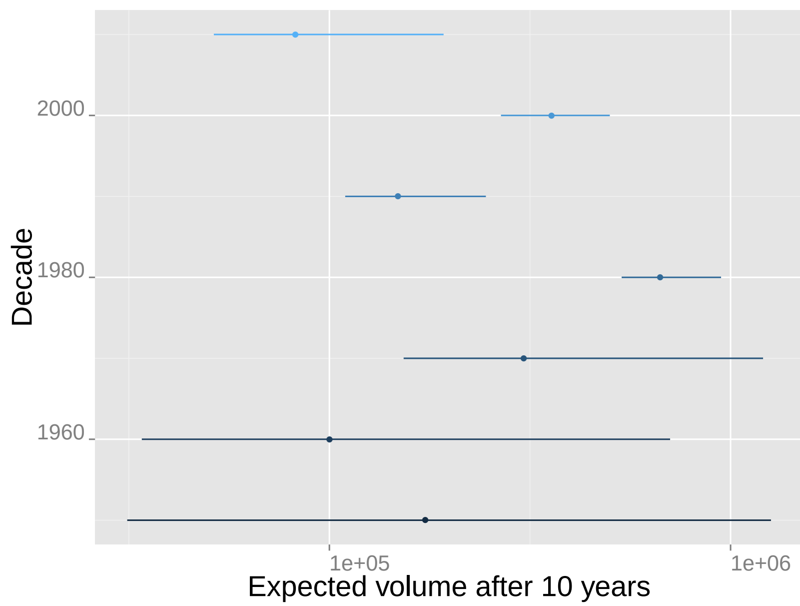

Figure 12: Expected trading volume over ten years by decade

remarkable given the explosion in the number of contracts launched (figure 3). It suggests that trading activity in derivatives markets, approximated by expected annual volume of a new contract after ten years multiplied by the number of contracts offered, was at historical highs in the 2000's.

This is a striking pattern because it suggests that the marginal value of an innovative contract (approximated by its expected trading volume at year ten) did not fall in the 2000's, despite exponentially higher rates of innovation than in past decades.

This shift is consistent with the hypothesis that electronic trading made trading activity more mobile across derivatives markets and substantially cut the costs of launching and sustaining a derivatives contract. However, given the myriad changes to the structure of US exchanges that took place during the 2000's, it is difficult to isolate the influence of electronic trading by looking at trading on a decade by decade basis alone. Instead, we need to look at the individual exchange level for a natural experiment where electronic trading was introduced suddenly. As we will discuss in the following section, we do have such a natural experiment on the New York Mercantile Exchange (NYMEX).

Differences in derivatives trading 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 contracts 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.

Innovative exchanges may also enjoy a first-mover advantage [10] [11]. (Gorham and Kundu [2012] provides the most comprehensive evaluation of this question to date and does not find a strong first-mover effect.) If indeed there is a first-mover advantage, then we would expect innovative exchanges to distinguish themselves in terms of expected trading in year ten. Figure 13 presents expected volume in year ten for contracts on all exchanges in the sample. The distinction between exchanges is not as pronounced as in figure 12 which compares trading patterns across decades. While it is possible to distinguish individual exchanges from one another (for example contracts on the Chicago Board of Trade seem to clearly have an advantage in expected value terms over those on the NYMEX) no exchanges clearly distinguish themselves from the pack with greater than 95% probability. Possible exceptions include:

[10] C.J. Cuny. The role of liquidity in futures market innovations. *Review of Financial Studies*, 6(1):57–78, 1993

[11] A. Holland and A. Fremault. Features of a successful contract: Financial futures on liffe. *Bank of England Quarterly Bulletin*, 37(2):181–186, 1997

- 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 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.

Recent mergers of exchanges, where traded contracts continued to be reported as distinct exchanges provide a natural experiment to test the effects of large exchanges on trading volumes. The Chicago Mercantile Exchange (CME) is particularly interesting in this respect. Gorham and Kundu [2012] suggested that the exchange did indeed have 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. The CME was also involved in two particularly high profile mergers in recent years, with its parent CME Group taking 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). Figures 14 and 15 for the NYMEX and annex figures 29 and 30 present the transition matrices for each of the merged exchanges in the years before and after the merger. [13]

[13] 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.

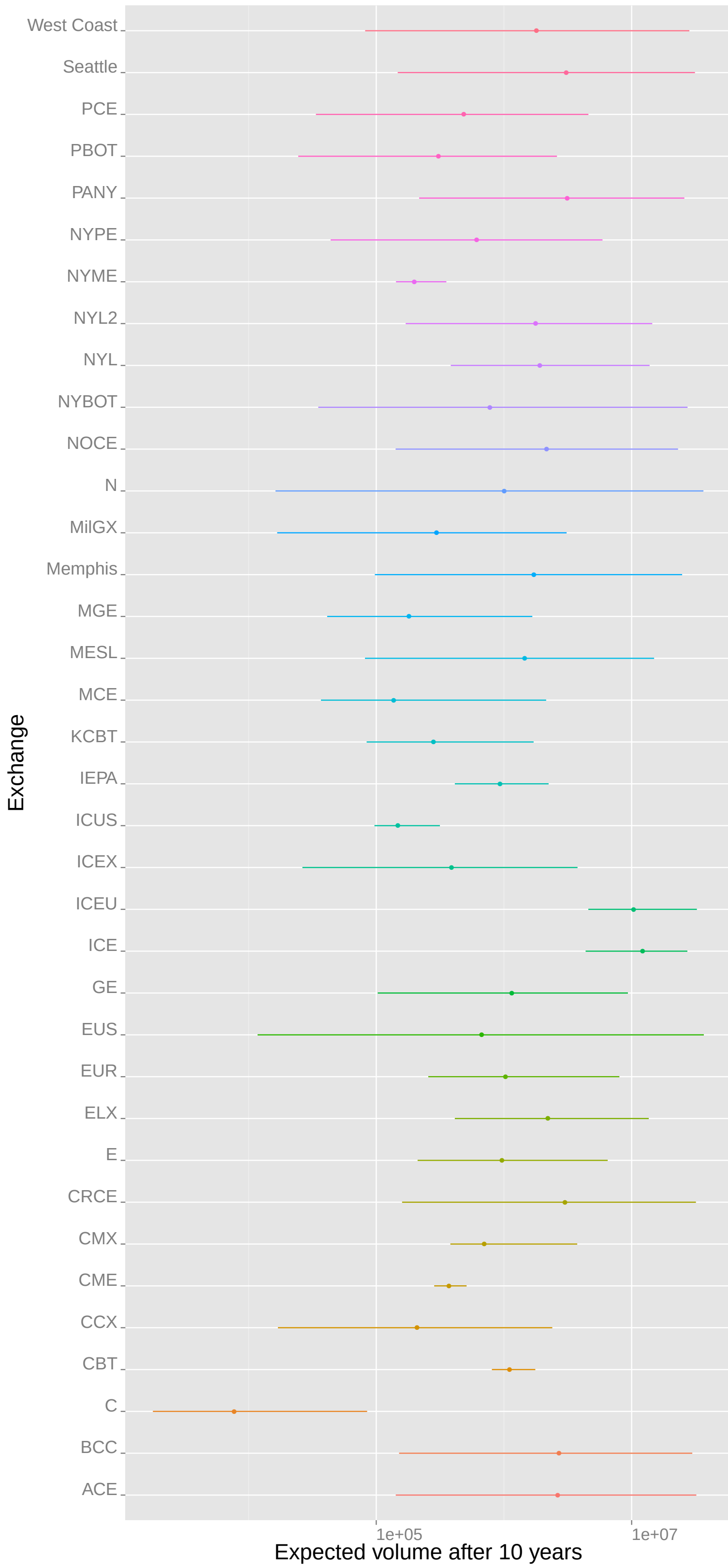

Figure 13: Expected trading volume over ten years by exchange

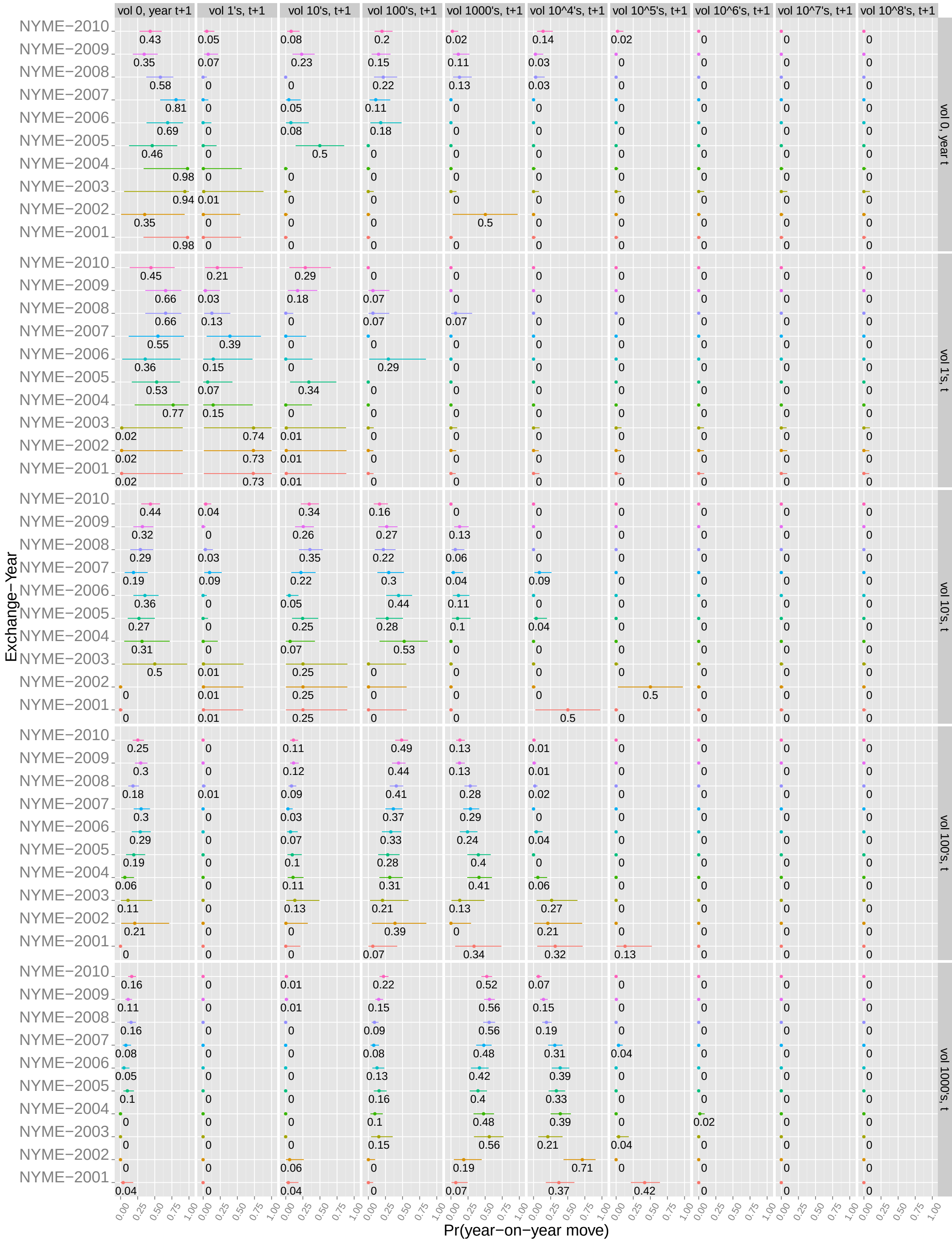

Figure 14: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - NYMEX before and after CME merger (announced March 2008, finalized September 2009) and before and after switch to electronic trading (September 2006) - part 1: transitions given annual volumes ≥ 0 and $< 10,000$

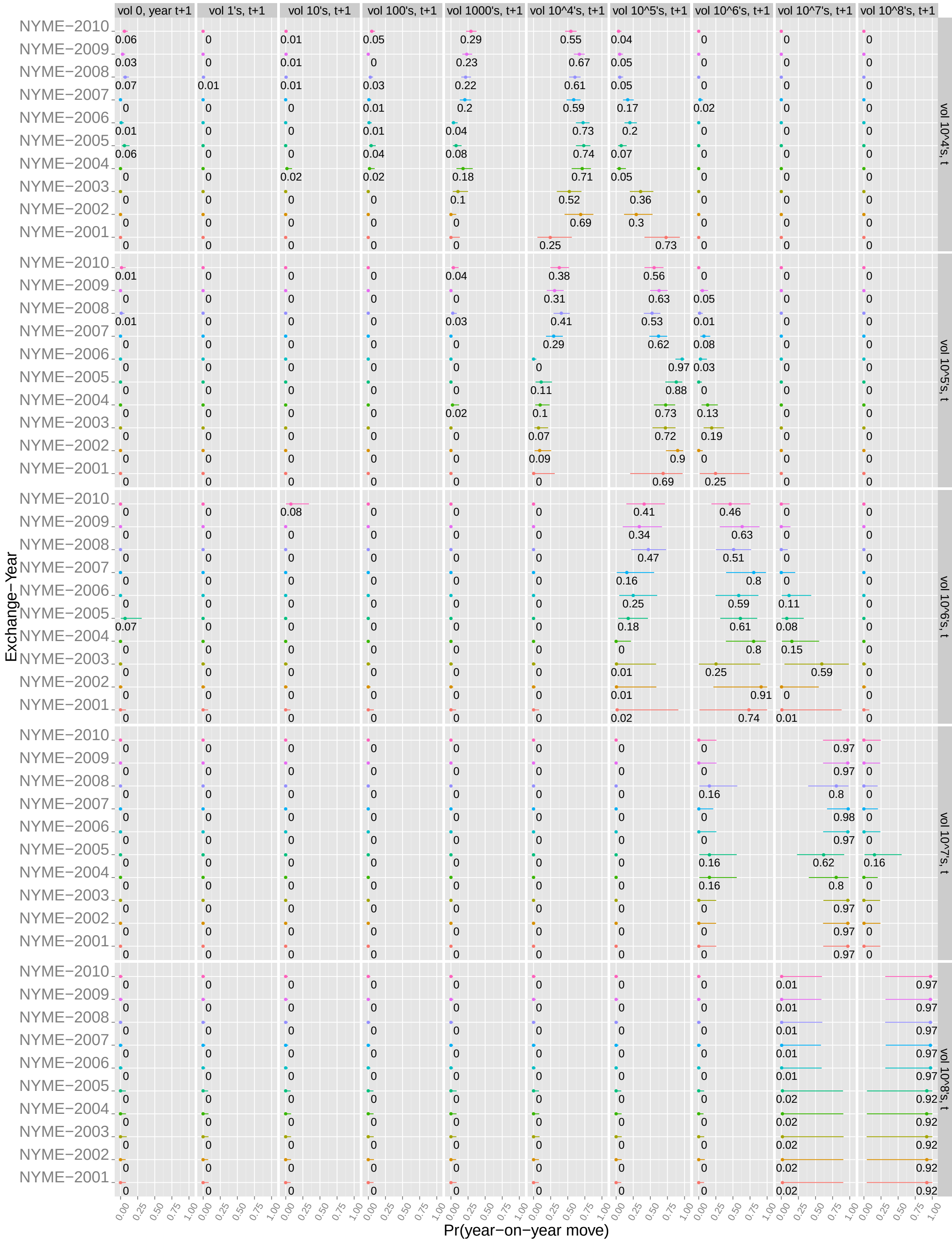

Figure 15: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - NYMEX before and after CME merger (announced March 2008, finalized September 2009) and before and after switch to electronic trading (September 2006) - part 2: transitions given annual volumes ≥ 10,000

The CBT's transition matrices (annex figures 29 and 30) 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.

Unlike the transition matrix for the CBT, the NYMEX shows a clear trend in its transition probabilities. On the rows in figures 14 and 15 indicating trading volume between ≤ 10 and $< 1,000,000$ (rows three through five in figures 14 and rows one and two in figures 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 trading levels between ≤ 10 and $> 10,000$ become sinks (rows three through five in figures 14). The probability of staying at these levels year on year increases gradually. The probability of rising from these levels falls. At levels above that sink, $\leq 10,000 < 1,000,000$ (rows one and two in figures 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. Combined with the transition matrices for the CBT (annex figures 29 and 30) the NYMEX fails to support the hypothesis that the CME's systems and network effects boost trading volumes substantially relative to competing exchanges. Instead, pronounced trends on the NYMEX seem to begin in 2006, when the exchange abruptly switched from open-outcry to electronic trading. This provides strong support for the hypothesis that the large changes in derivatives markets in the 2000's were driven by the switch to electronic trading.

Differences in derivatives trading by product type

Figure 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% 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 non-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 [14] 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.)

[14] This is consistent with figure 13 which shows OneChicago, the exchange specializing in single-stock futures as a relative under-performer in expected trading volume at year ten.

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 17 and 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 figures 24 and 25 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.

Conclusion

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 finding in the

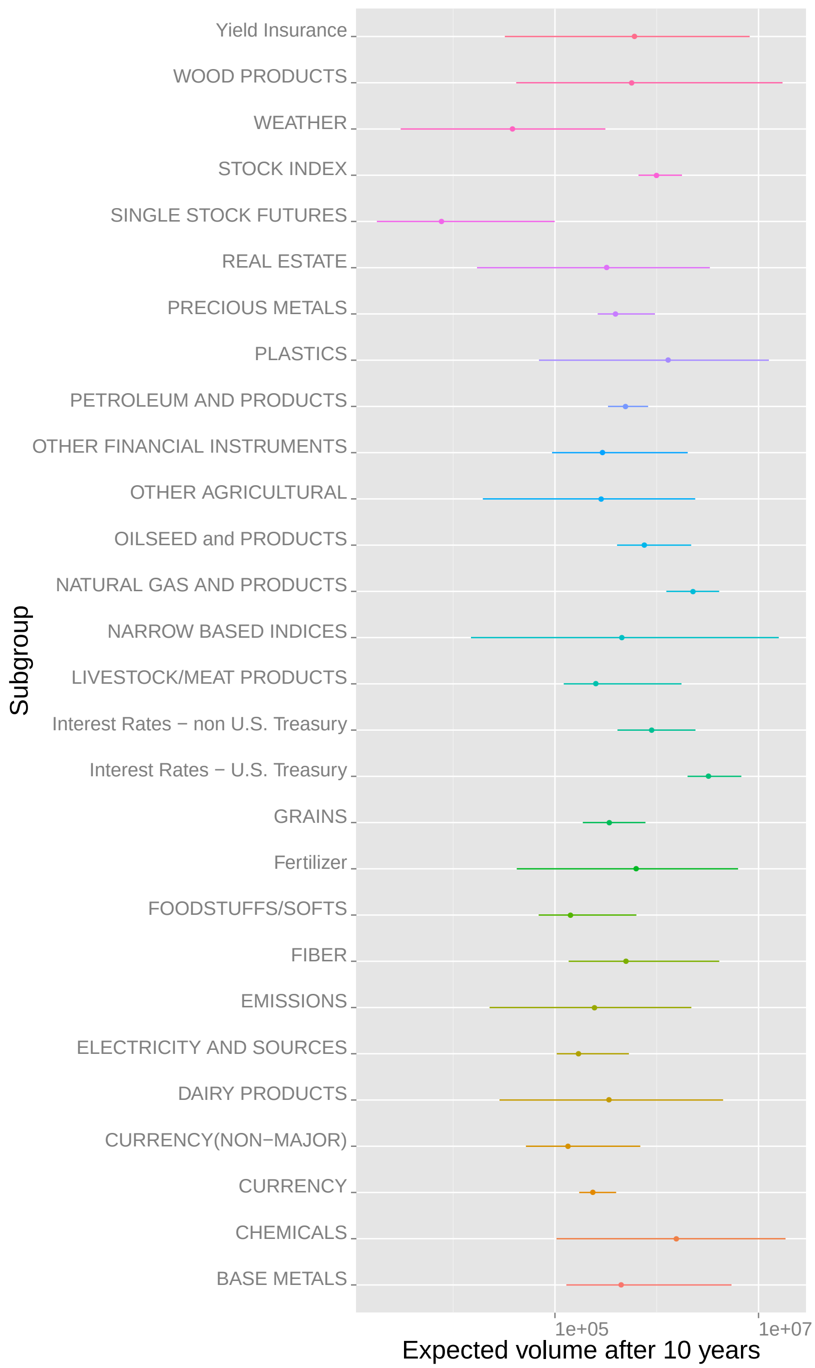

Figure 16: Expected trading volume over ten years by product type

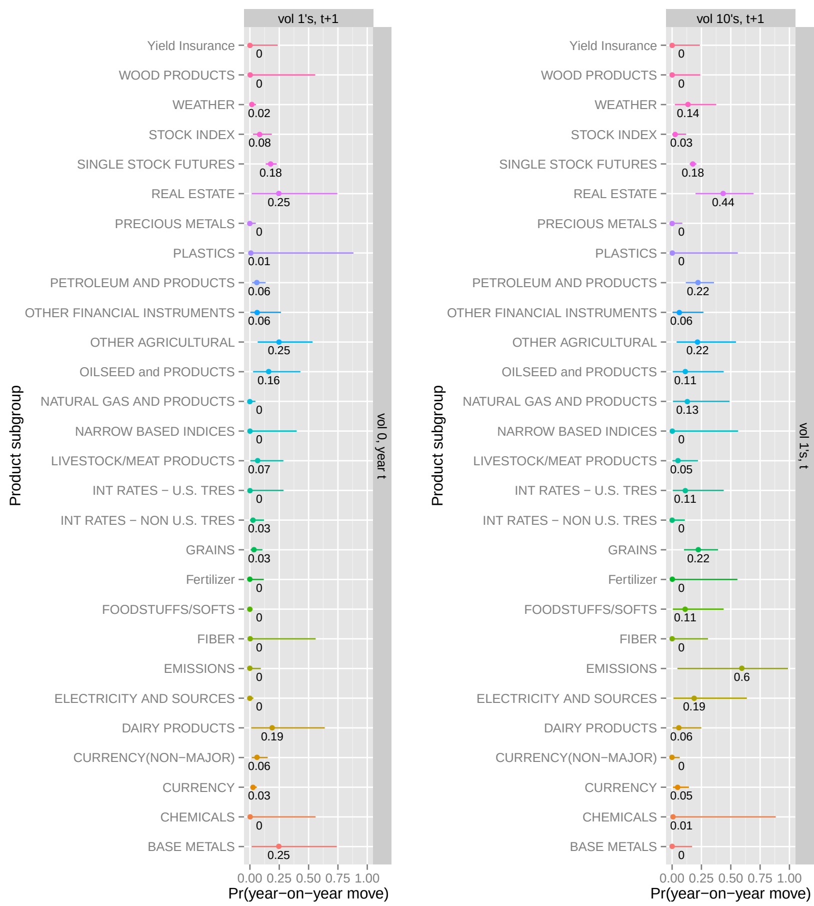

Figure 17: Probability of transition from annual volume in the hundreds to annual volume in the thousands (left) and from annual volume in the thousands to annual volume tens of thousands (right) by product type

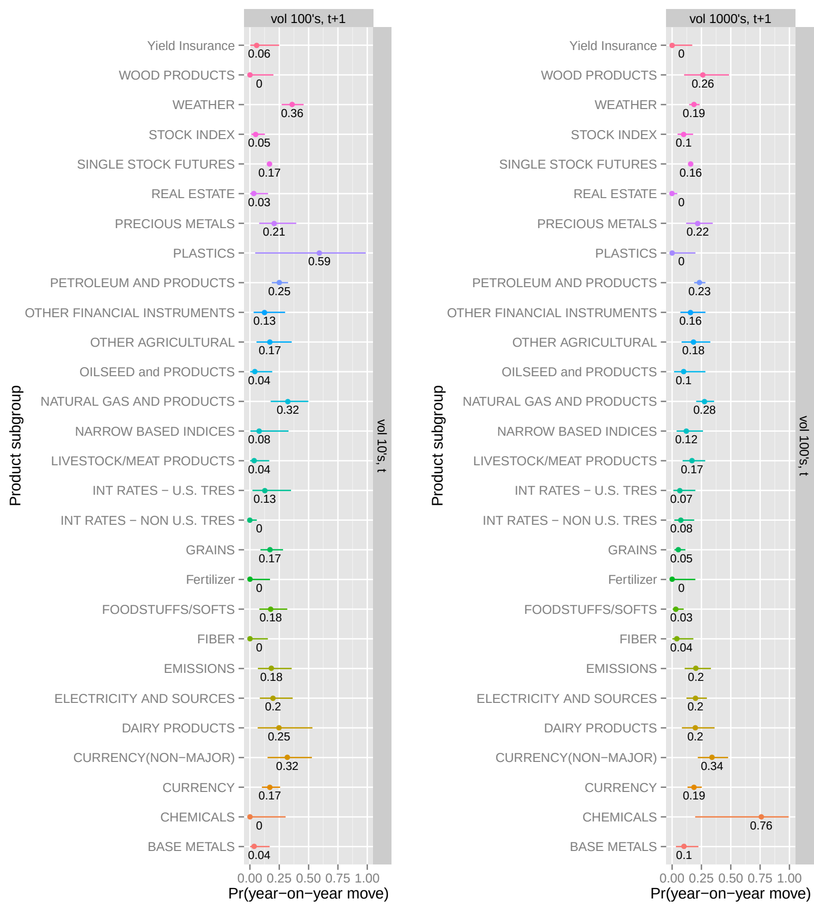

Figure 18: Probability of transition from annual volume in the hundreds to annual volume in the thousands (left) and from annual volume in the thousands to annual volume tens of thousands (right) by product type

literature.

While a larger percentage of contracts had little or no volume in any given year of the 2000's, 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 2000's the expected volume of a new contract after ten years was above that of the 1990's 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 variations in 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 was largely indistinguishable on any given exchange from 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.

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 4 and 5 it is particularly clear that the probability of remaining at a given level of annual volume varies greatly conditional on the level on the level of volume. These differences hold with greater than 95% probability as do variations in the volume dynamics across time (indicating that normal or log-normal models of trading volume would suffer from stationary 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 [15]. 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.

One limitation of our analysis is that it may be too discrete to pro-

[15] 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

vide for short-term simulation of new contracts. If, as we suspect, there is a strong auto-correlation between the absolute annual volumes of contracts, then a hidden Markov model may provide a better fit over shorter time scales.

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 and the economy. 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 discrimination. 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. Many of the highly specialized cleared derivatives contracts are "swaps-to-futures", bilaterally negotiated deals that are turned into futures contracts, with central counter parties after they are consummated. As Tashjian and Weissman [1995] predicted, exchanges charge a substantial premium on these specialized transactions. Fees on CME's ClearPort platform, which specializes in bilateral trades converted into futures, were more than 350% those on conventional electronic futures trades as of late 2012 [16]. 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.

[16] 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].

References

Bank of International Settlements. Statistical release: Otc derivatives statistics at end-june 2012, June 2012. URL http://www.bis.org/publ/otc_hy1211.pdf.

D.W. Carlton. Futures markets: Their purpose, their history, their growth, their successes and failures. *Journal of Futures Markets*, 4(3): 237–271, 1984.

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.

C.J. Cuny. The role of liquidity in futures market innovations. *Review of Financial Studies*, 6(1):57–78, 1993.

D. Duffie and M.O. Jackson. Optimal innovation of futures contracts. *Review of Financial Studies*, 2(3):275–296, 1989.

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

Michael Gorham and Poulomi Kundu. A half-century of product innovation and competition at U.S. futures exchanges. *The Review of Futures Markets*, 20:105–140, July 2012.

G. Gorton and K.G. Rouwenhorst. Facts and fantasies about commodity futures. Technical report, National Bureau of Economic Research, 2004.

A. Holland and A. Fremault. Features of a successful contract: Financial futures on liffe. *Bank of England Quarterly Bulletin*, 37(2): 181–186, 1997.

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.

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.

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.

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

R.J. Shiller. *Macro Markets: Creating Institutions for Managing Society's Largest Economic Risks: Creating Institutions for Managing Society's Largest Economic Risks*. Clarendon Press, 1994.

W.L. Silber. Innovation, competition, and new contract design in futures markets. *Journal of Futures Markets*, 1(2):123–155, 1981.

E. Tashjian and M. Weissman. Advantages to competing with yourself: Why an exchange might design futures contracts with correlated payoffs. *Journal of Financial Intermediation*, 4(2):133–157, 1995.

A. Tversky, D. Kahneman, et al. The framing of decisions and the psychology of choice. *Science*, 211(4481):453–458, 1981.

Annex

volume level	0	1	10	100	1000	10^4	10^5	10^6	10^7	10^8
0	0.78	0.14	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1	0.16	0.63	0.14	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10	0.01	0.16	0.63	0.14	0.01	0.01	0.01	0.01	0.01	0.01
100	0.01	0.01	0.16	0.63	0.14	0.01	0.01	0.01	0.01	0.01
1000	0.01	0.01	0.01	0.16	0.63	0.14	0.01	0.01	0.01	0.01
10^4	0.01	0.01	0.01	0.01	0.16	0.63	0.14	0.01	0.01	0.01
10^5	0.01	0.01	0.01	0.01	0.01	0.16	0.63	0.14	0.01	0.01
10^6	0.01	0.01	0.01	0.01	0.01	0.01	0.16	0.63	0.14	0.01
10^7	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.16	0.63	0.14
10^8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.16	0.76

Table 2: Priors on transition between volume states - with annual trading volume state in year t denoted by row, trading volume state in year t denoted by column

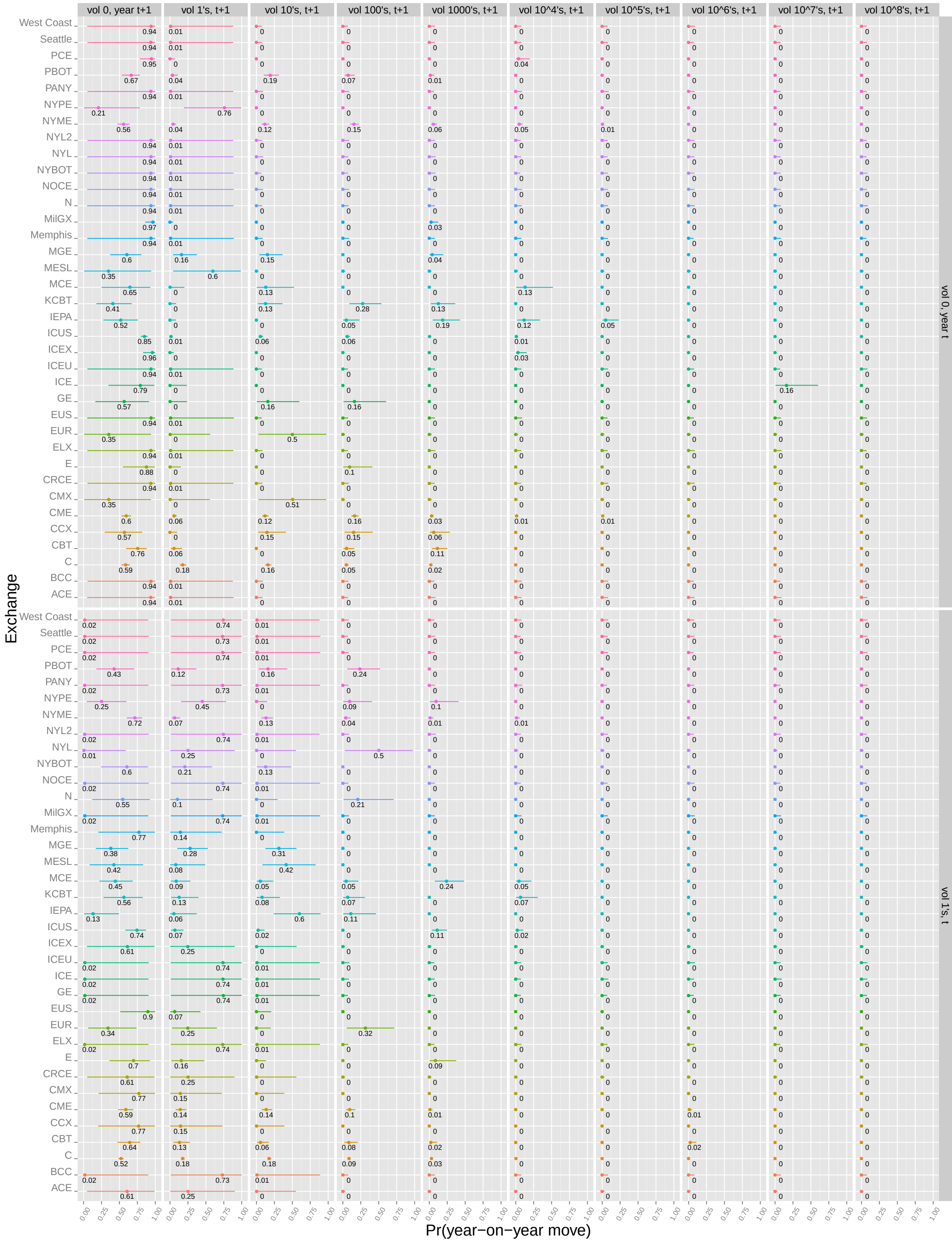

Figure 19: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by exchange - part 1: transitions given annual volumes ≥ 0 and < 10

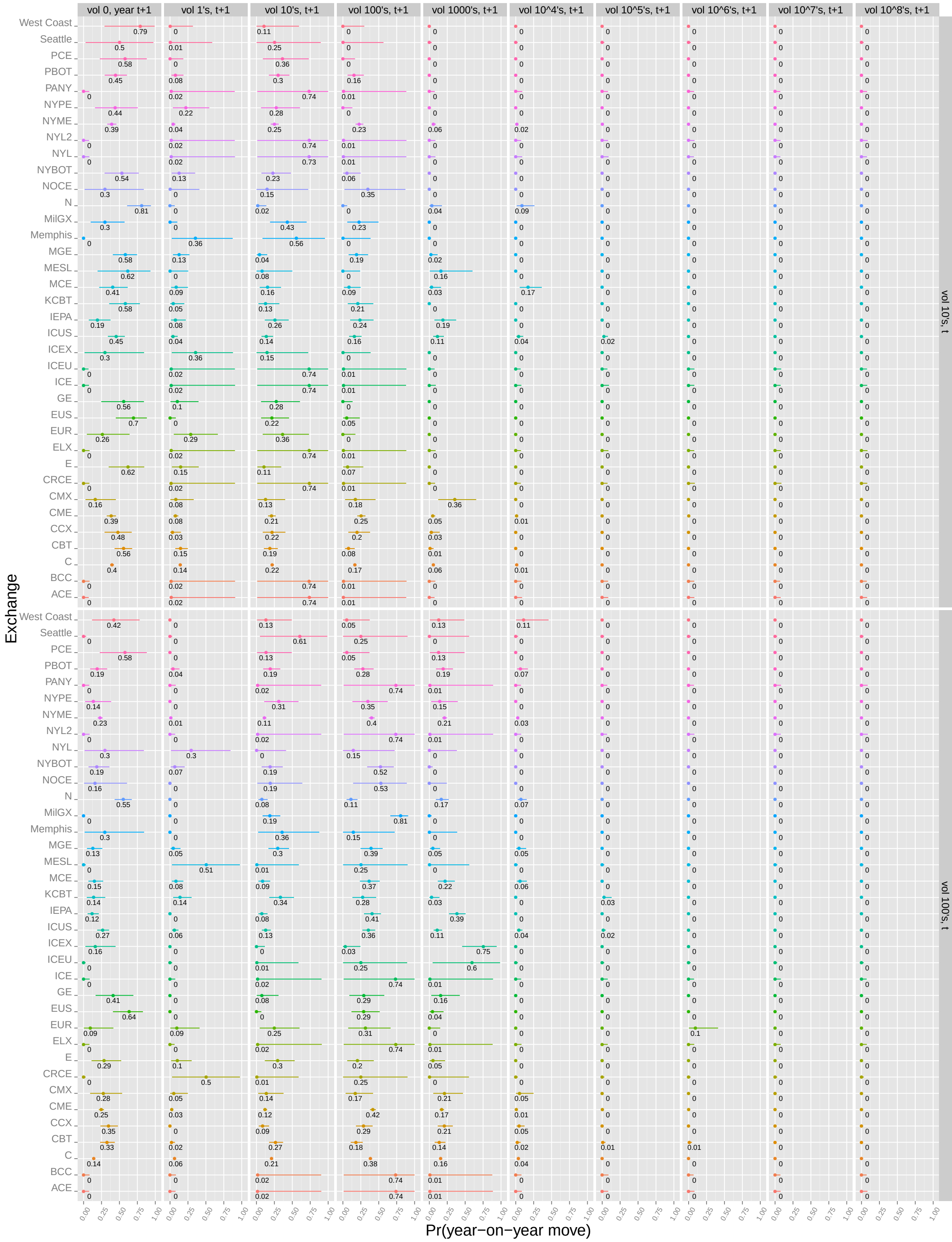

Figure 20: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by exchange - part 2: transitions given annual volumes ≥ 10 and $< 1{,}000$

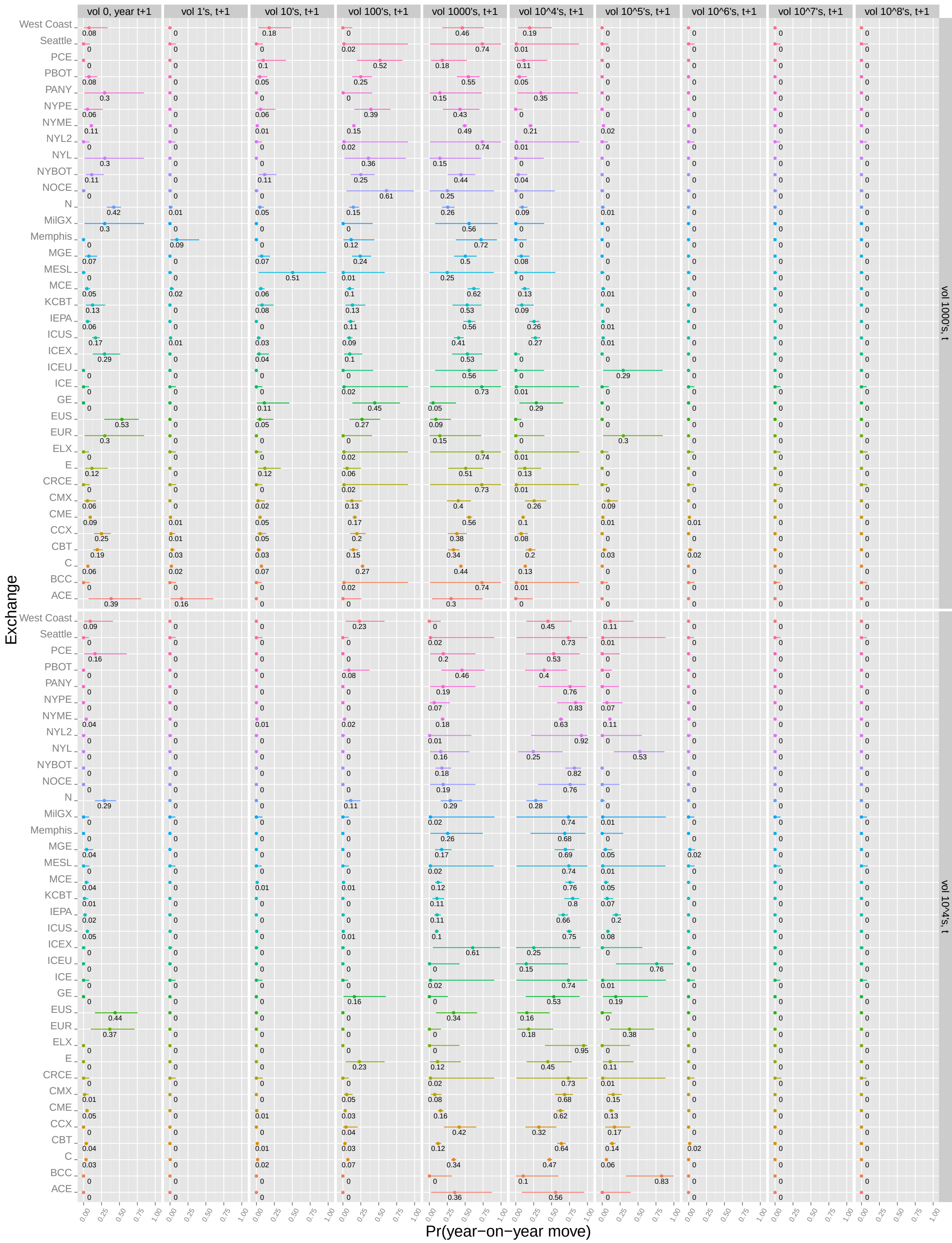

Figure 21: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by exchange - part 3: transitions given annual volumes $\geq$ 1000 and $< 10,000$

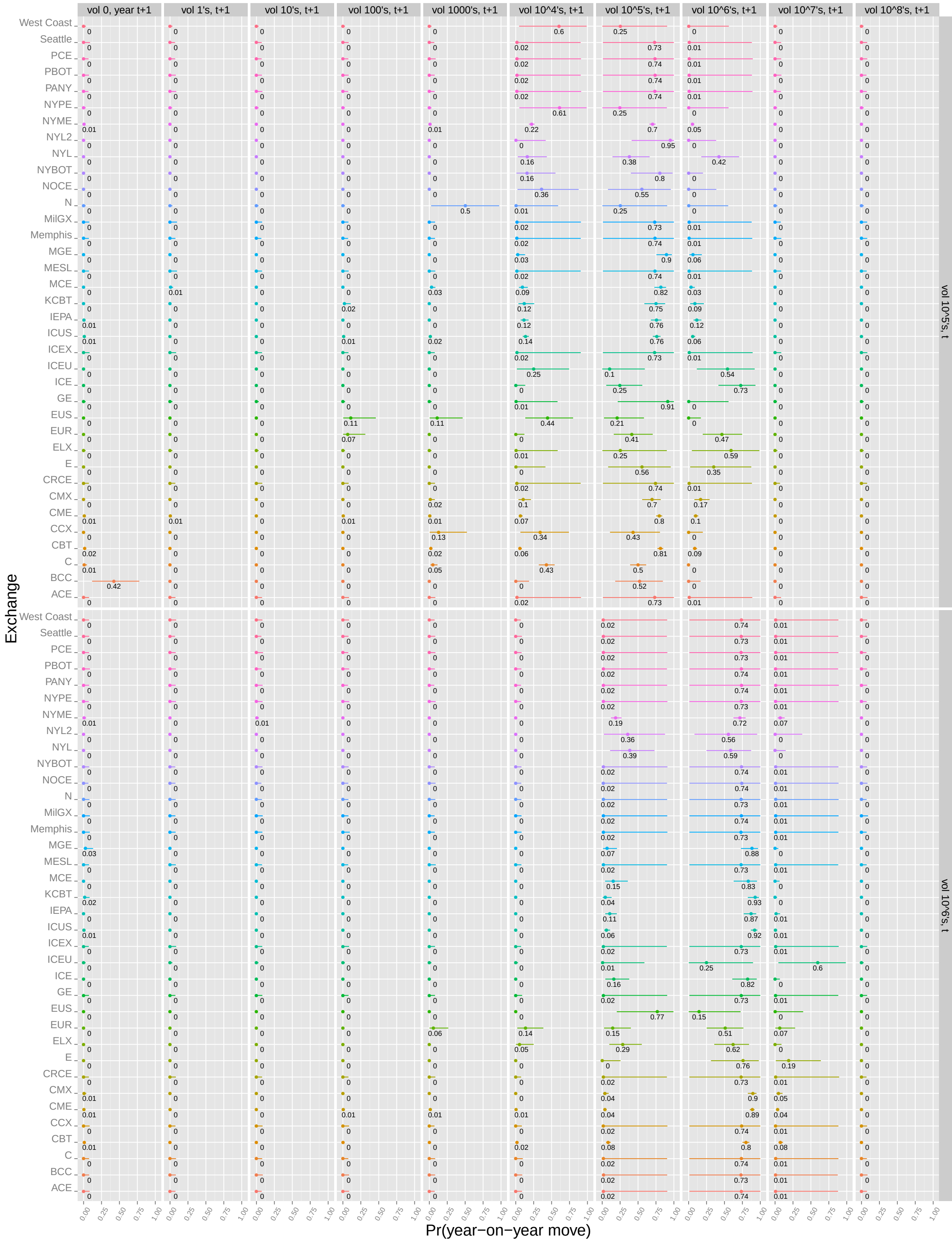

Figure 22: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by exchange - part 4: transitions given annual volumes $\geq 10,000$ and $< 1,000,000$

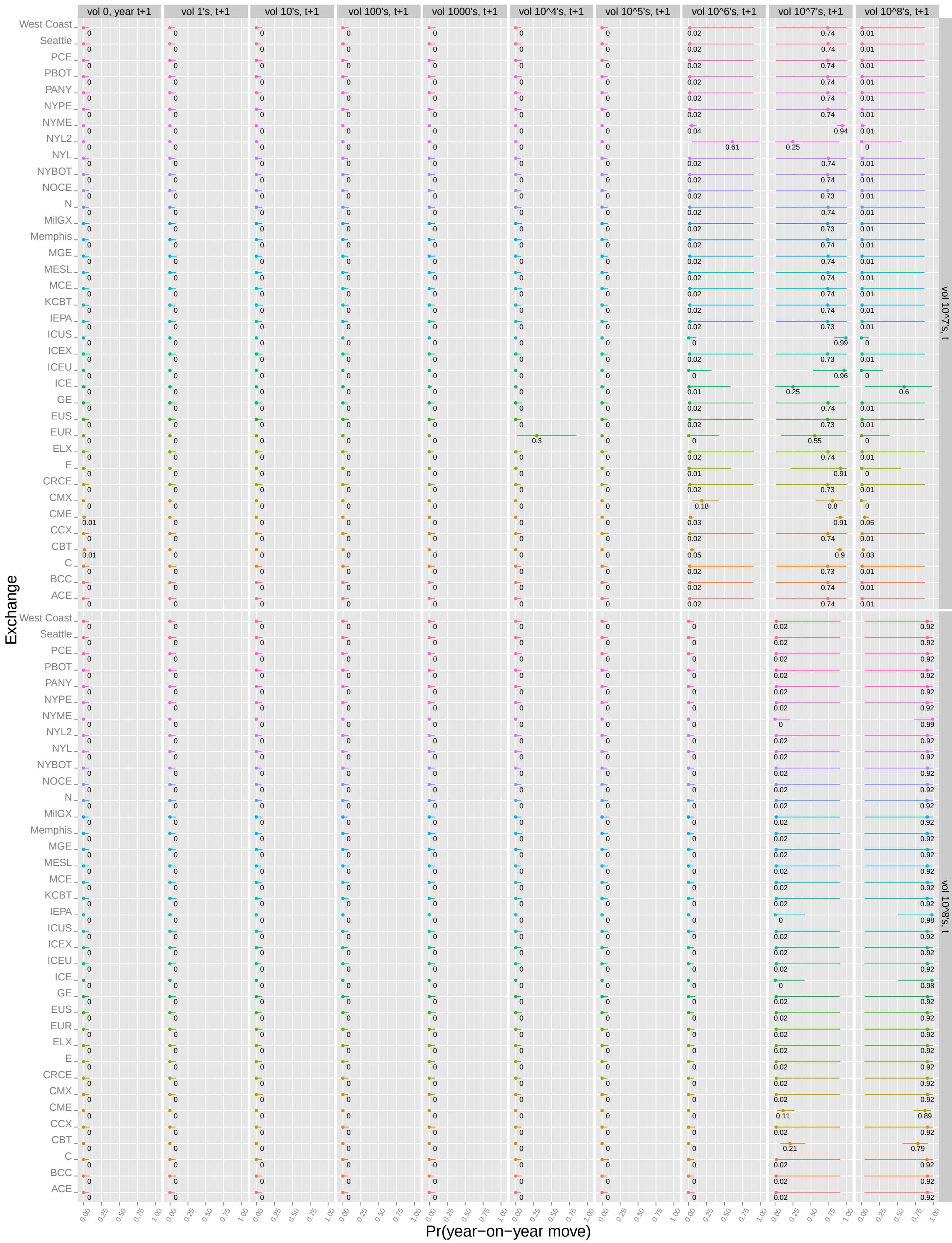

Figure 23: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by exchange - part 5: transitions given annual volumes $\geq 1,000,000$

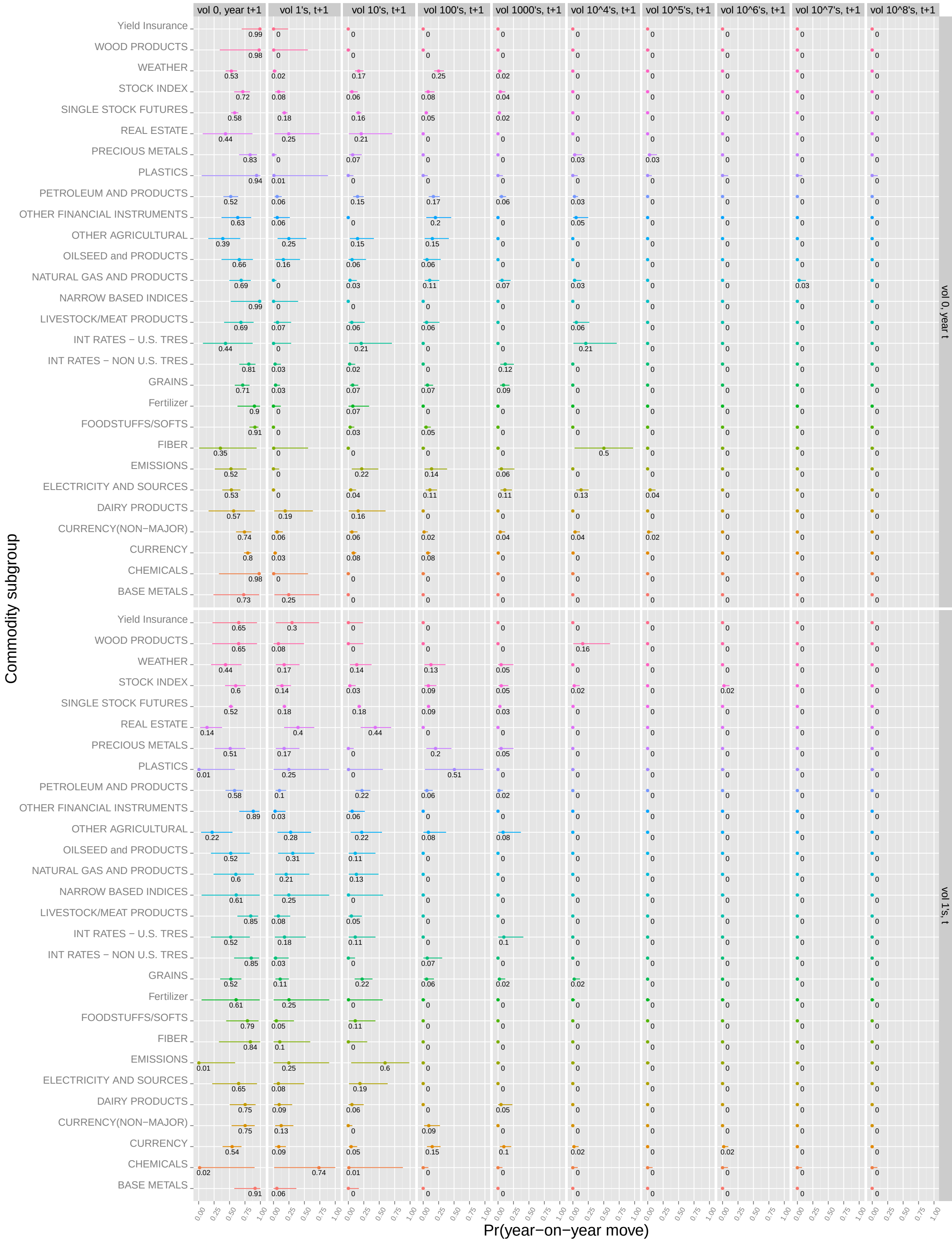

Figure 24: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by product type - part 1: transitions given annual volumes ≥ 0 and $< 10,000$

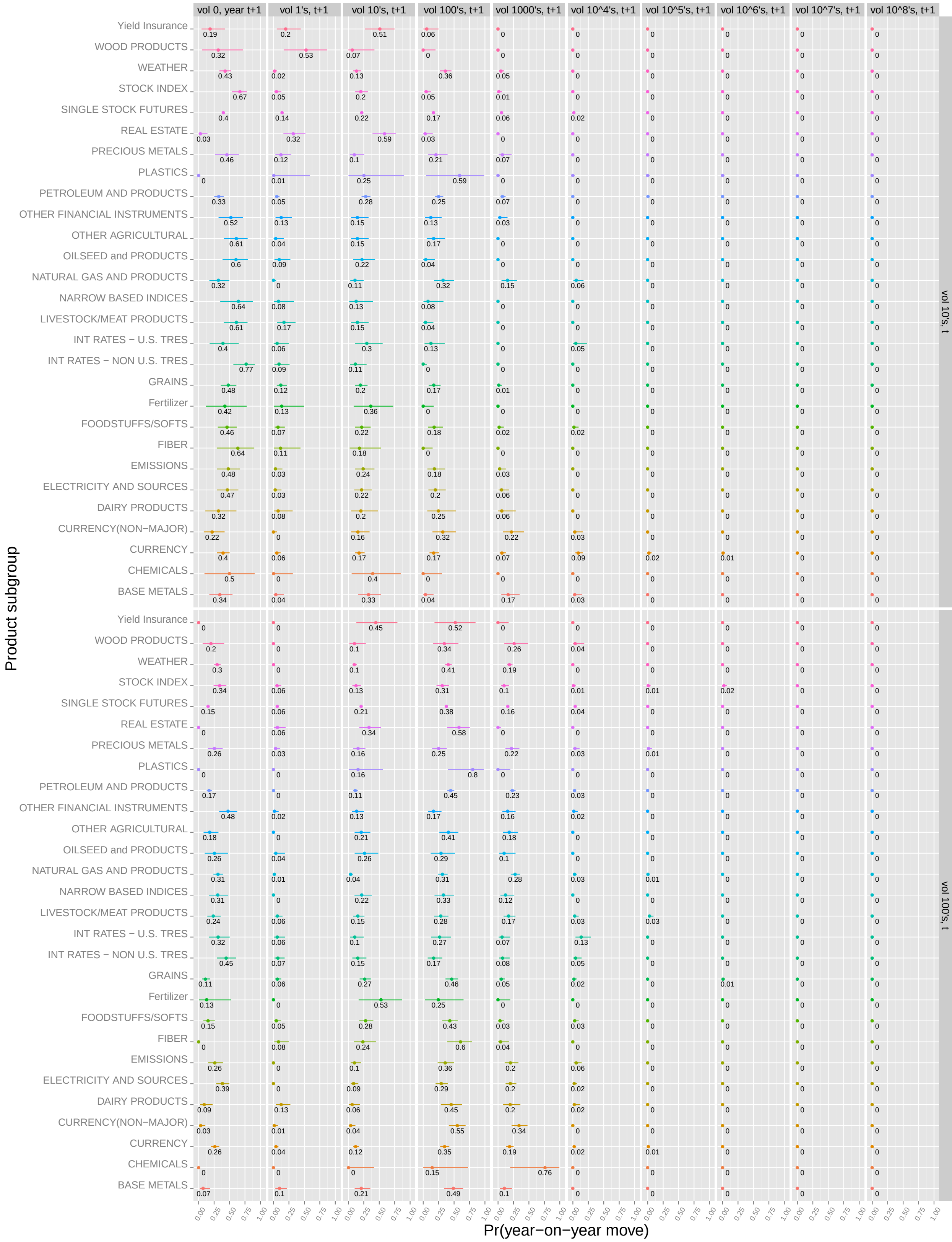

Figure 25: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by product type - part 2: transitions given annual volumes ≥ 10 and $< 1,000$

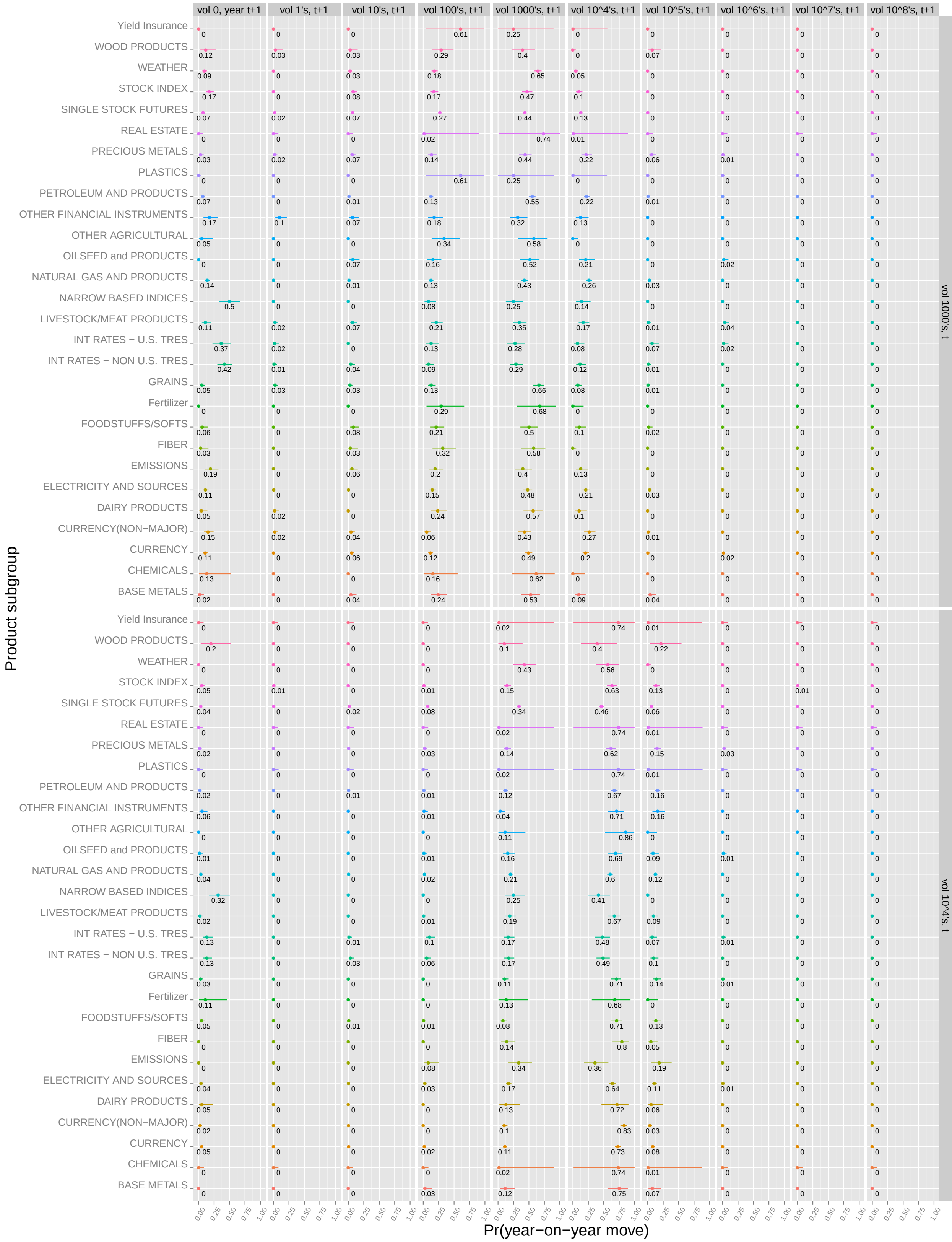

Figure 26: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by product type - part 3: transitions given annual volumes ≥ 1000 and $< 10,000$

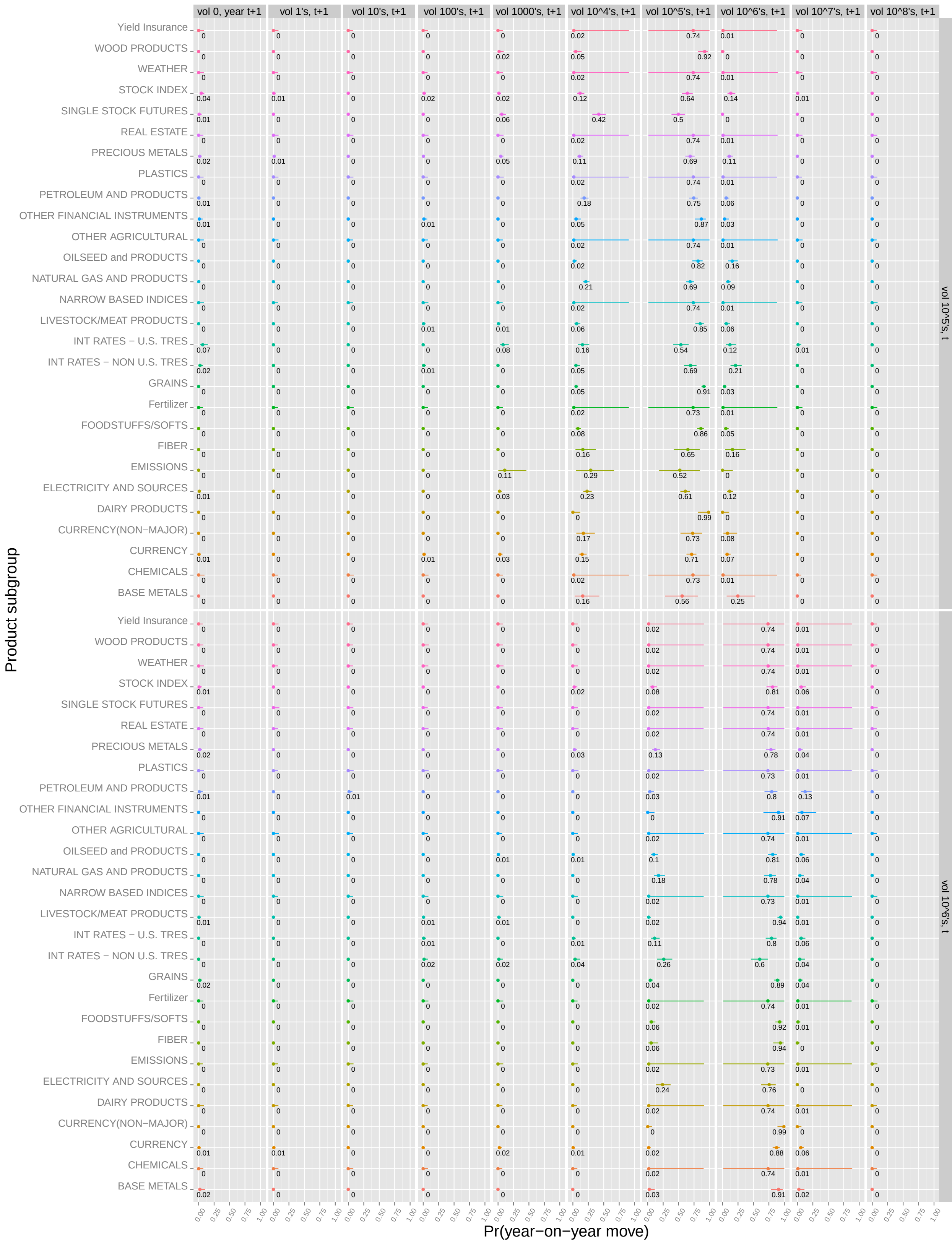

Figure 27: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by product type - part 4: transitions given annual volumes $\geq 10,000$ and $< 1,000,000$

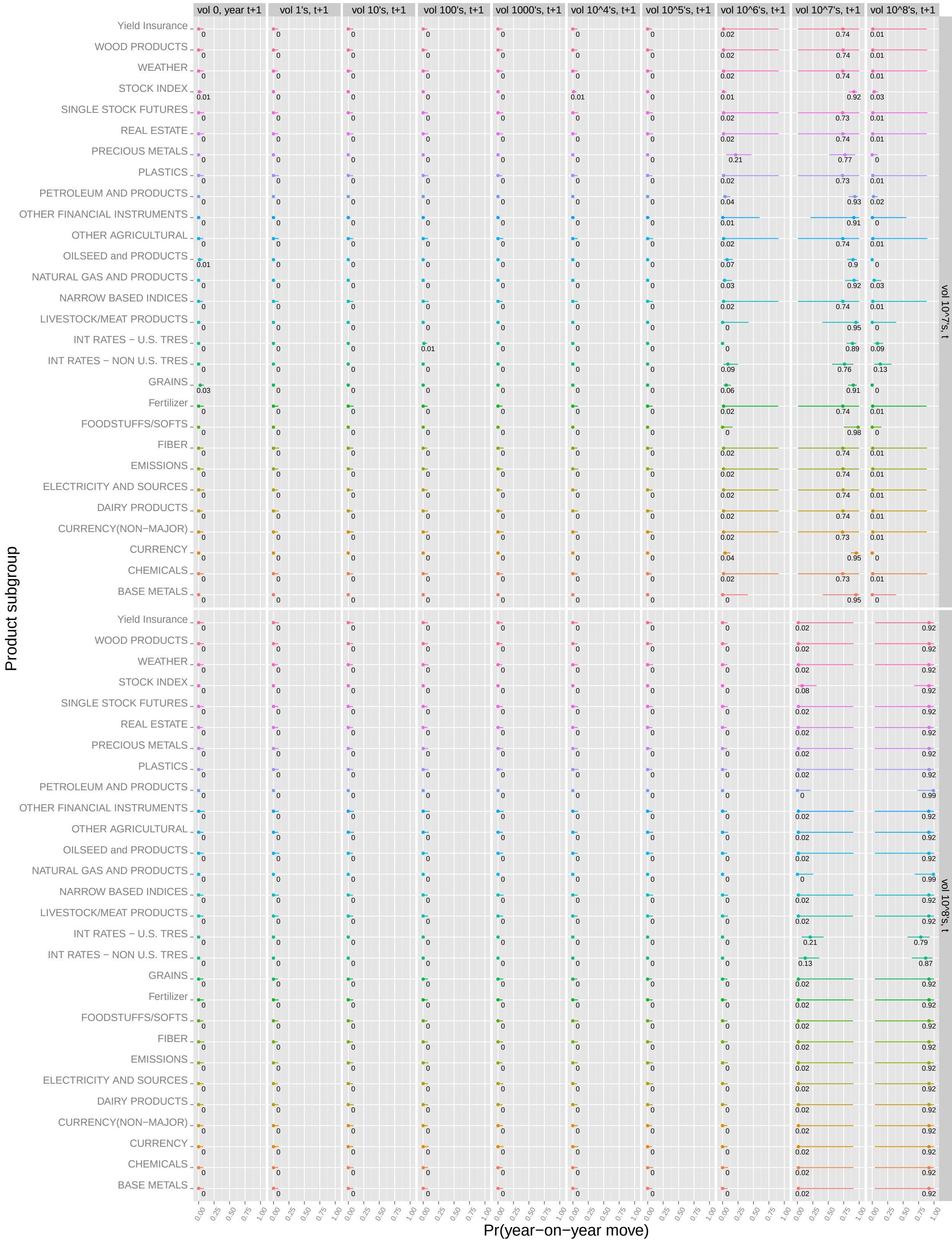

Figure 28: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by product type - part 5: transitions given annual volumes $\geq 1,000,000$

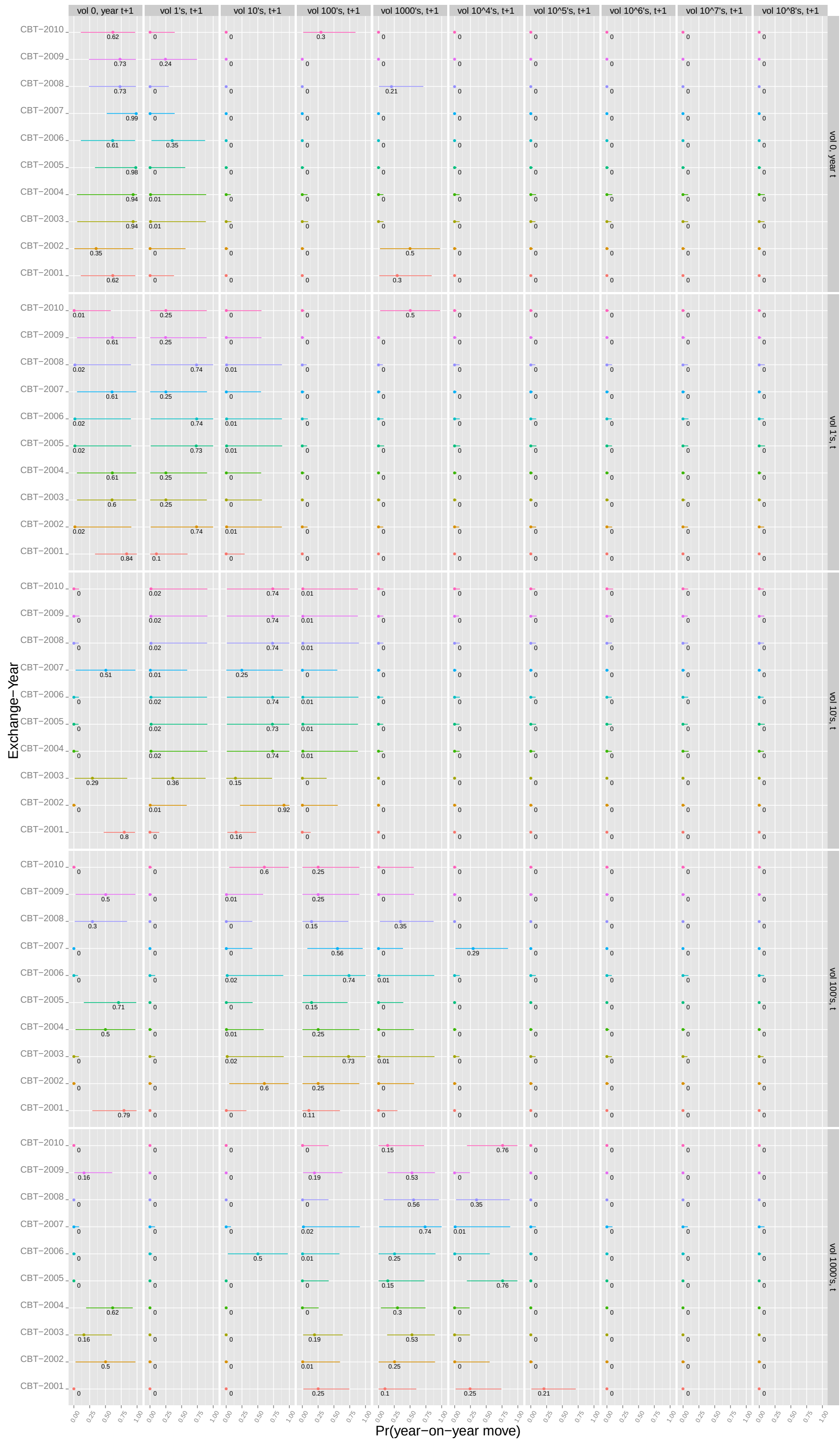

Figure 29: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - CBT before and after CME merger (announced October 2006, finalized January 2008) - part 1: transitions given annual volumes $< 10,000$

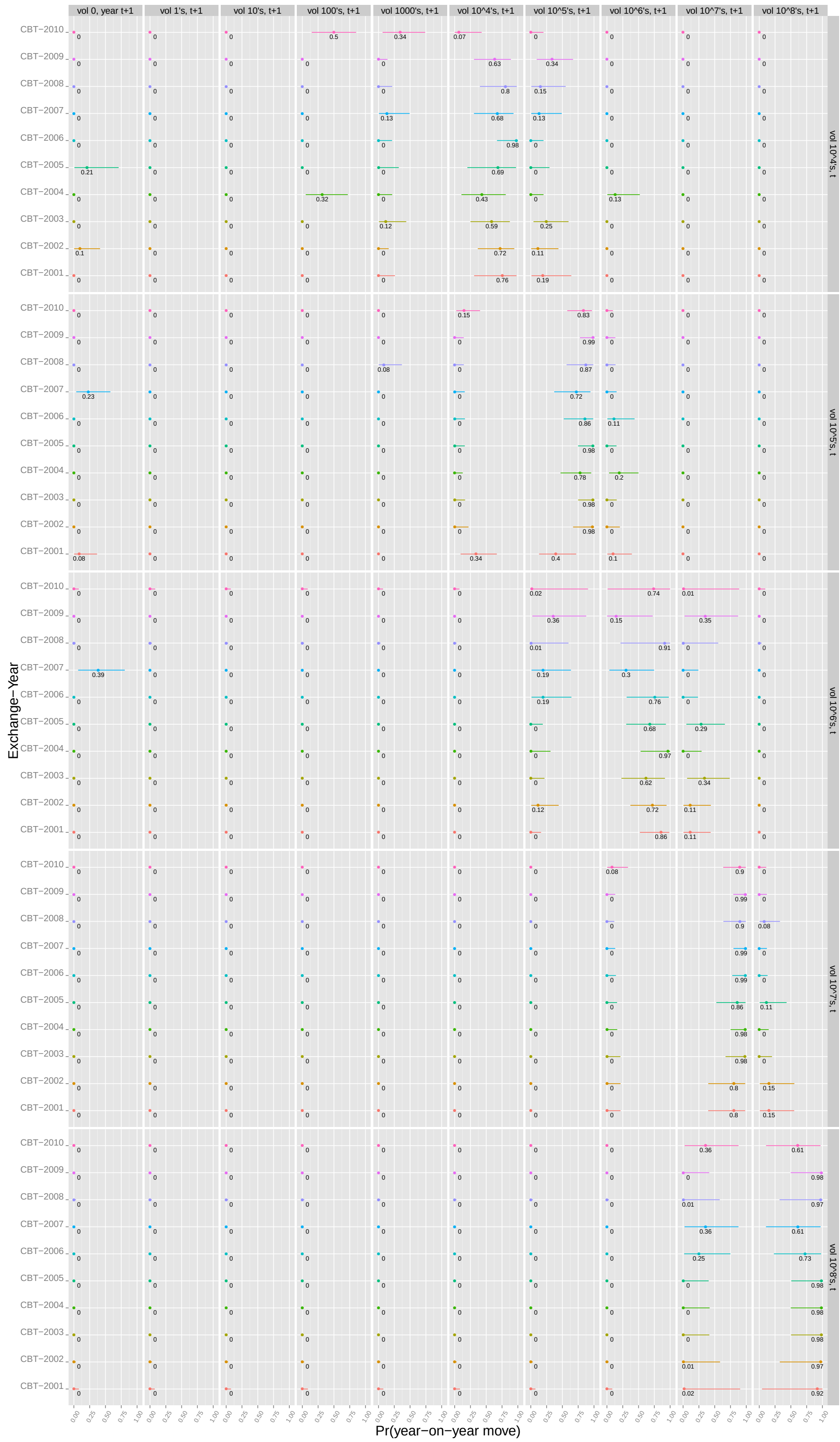

Figure 30: Transition matrix for Markov model of derivatives contract moving between states of annual trading volume by decade - CBT before and after CME merger (announced October 2006, finalized January 2008) - part 2: transitions given annual volumes $\geq 10,000$