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December 15, 2016

Multidimensional Futures Rolls

Calendar rolls are a characteristic feature of futures contracts. Because contracts expire at monthly or quarterly intervals, and because investors prefer to maintain positions in a few heavily traded maturities which may not correspond to their real investment horizon, in order to maintain their desired economic exposure they must regularly roll their positions forward from the expiring contracts into ones with further expirations.

QB's Roll Tracker analyses the structure of futures rolls. As currently constructed, it applies primarily to futures contracts for which open interest is almost entirely concentrated in the front month product, such as interest rate, equity, and foreign exchange products. For such contracts, as the front month product approaches expiration, the open interest shifts rapidly and entirely into the deferred-month product. The Roll Tracker exploits a proportionality between shifts in open interest (which are available only at end of day) and the traded volume in the calendar spread contract (which is available in real time; see Figure 5) to provide intraday estimates for open interest shifts. This helps traders find the optimal time to perform their rolls.

This note extends the proportionality approach of the Roll Tracker to more complicated products such as agricultural, energy, and short term interest rate (STIR) futures. In particular, we have two main goals:

1. To estimate the intraday shift in open interest based on traded volumes, and
2. To describe where the open interest goes. That is, does open interest move from the front month to the second month, or is it distributed further forward across a broader range of maturities?

In an earlier report[1] we identified four broad types of futures products, based on the "effective number" of active maturities. For this study, we select one representative product from each category.

1. *Single-maturity* products are the simplest. For these, outside the roll interval, the open interest is nearly entirely concentrated in the front month. In the roll, open interest shifts to the second maturity. Products in this category include interest rates, equities, and foreign exchange, and are well described by the current Roll Tracker. We include this category here to highlight the differences with the more complicated products. For our example from this category, we take the CME 10-year Treasury futures (ZN).
2. *Seasonal non-energy* products have 3–4 active maturities, typically with strong seasonality. These products are primarily agricultural futures, though precious metals also have this structure. For our example from this category we take the CME Corn futures contract (ZC).
3. *Energy* products have 6–8 active maturities, and strong seasonality. For our example from this category we take the CME Crude Oil contract (CL).
4. *Short term interest rates (STIRs)* have an extremely broad range of maturities, and almost no seasonal structure. We include these as an extreme example with almost no identifiable roll behavior. For our example from this category we take the CME Eurodollar futures contract (GE).

[1] Isaac Carruthers, "Entropy and futures contracts," QB Technical Report, August 2015

Roll Structure The first question we wish to address is the overall structure of the roll process for these products, and to evaluate whether the QB Roll Tracker can provide value beyond its existing product set. Figures 1–4 show the overall roll structure for our four example products. These pictures show open interest, as a fraction of total open interest across all maturities, for each separate maturity as a function of time to expiration, across three years 2014–2016. Since they are normalized by total open interest, they filter out changes in the overall level of open interest through this time.

Treasury futures (Figure 1) have the cleanest and sharpest roll structure: the entire open interest shifts within a few days, just about one month before expiration (just before the First Intention Date[2]).

For Corn (Figure 2) and for Crude Oil (Figure 3) the open interest shifts during 1–2 months. This suggests that the QB Roll Tracker will be less useful for these products than for U.S. Treasury futures, since the total shift of open interest in any single day is rather small.

Eurodollars (Figure 4) have no discernible roll structure: expiring contracts simply expire and there is no evidence of traders moving the open interest to the further maturities. This is likely a consequence of the cash-settling mechanism, where there is no delivery risk.

Roll Destination The second question we wish to address is where the open interest goes, when it shifts out of the expiring front month contract. For "single-maturity" products, this question is very simple: essentially every reduction in open interest in the expiring contract is matched by an increase in open interest in the deferred contract. But for more complex roll structures, simply knowing the changes in open interest does not tell us which contract has rolled to which. If there are N active maturities, then there are $N-1$ changes in open interest if we filter out changes in the total open interest. But there are $N(N-1)/2$ directional flows, constrained only by the requirement that inflows and outflows on each contract balance the observed net change in open interest.

As with the QB Roll Tracker, our tool for extracting the individual flows is the approximately linear relationship between open interest shifts and traded volume in the calendar spread contracts. That is, if K contracts are rolled from maturity A to maturity B, then an approximately constant fraction ρK of those will be traded via market makers, and a complementary fraction $(1-\rho)K$ through the calendar spread contracts. Empirically, this fraction ρ is approximately constant across the set of calendar spreads for a particular product complex. Since we can observe the traded volume in each calendar spread, we can estimate the flows in open interest.

Figure 5 verifies this relationship. The vertical axis is the change in open interest in the front month contract; each point represents one month of trading. The horizontal axis is the *sum* of traded volumes in all calendar spreads having that maturity as the first leg. A linear relationship suggests that traded volume in individual calendar spreads is a good predictor of the flow in open interest between corresponding contract pairs. For instance, if we are in the middle of the roll period for the September crude contract, and we observe large volume in the Sep-Dec spread, then we should expect that a high proportion of September positions are being rolled into December positions.

The linear relationship is very clean for single-maturity products, reasonable for seasonal products, and very poor for STIRs.

[2]See "The Treasury Futures Delivery Process, 6th Edition," CME Group, July 2016, http://www.cmegroup.com.

Based on this reasoning, in Figures 6–9 we break down the distribution of back legs for the spread volume of each product, averaged across roll periods. In each row of these figures, the relative sizes of the disks show the relative traded volume in the corresponding calendar spread. These are thus an illustration of where the open interest goes when it trades out of the front month contract. We see a clear and distinct pattern for each product.

1. For the 10-Year Treasury futures contract (Figure 6), each contract rolls entirely into the next.
2. The Corn futures contract (Figure 7) has a more complex structure:
   - Each contract primarily rolls to the following maturity.
   - Some quantity rolls to each of the next several contracts.
   - All contracts have a slight preference for rolling into December contracts.
   - December contracts have a slightly higher propensity to roll into farther-out contracts.
3. The Crude Oil roll (Figure 8) has a characteristic structure:
   - CL contracts have a more pronounced tendency to roll into the December contract.
   - December contracts have a distinct tendency to roll to either the following June or December.
4. The Eurodollar futures contract (Figure 9) has essentially no apparent roll structure:
   - All GE contracts roll largely into quarterly contracts.
   - Quarterly contracts roll consistently into relatively far-out quarterly contracts, and only a small fraction roll into the following serial contract.
   - Serial contracts roll either into the following serial, or the following quarterly, with only a tiny fraction rolling into far-out quarterly contracts.

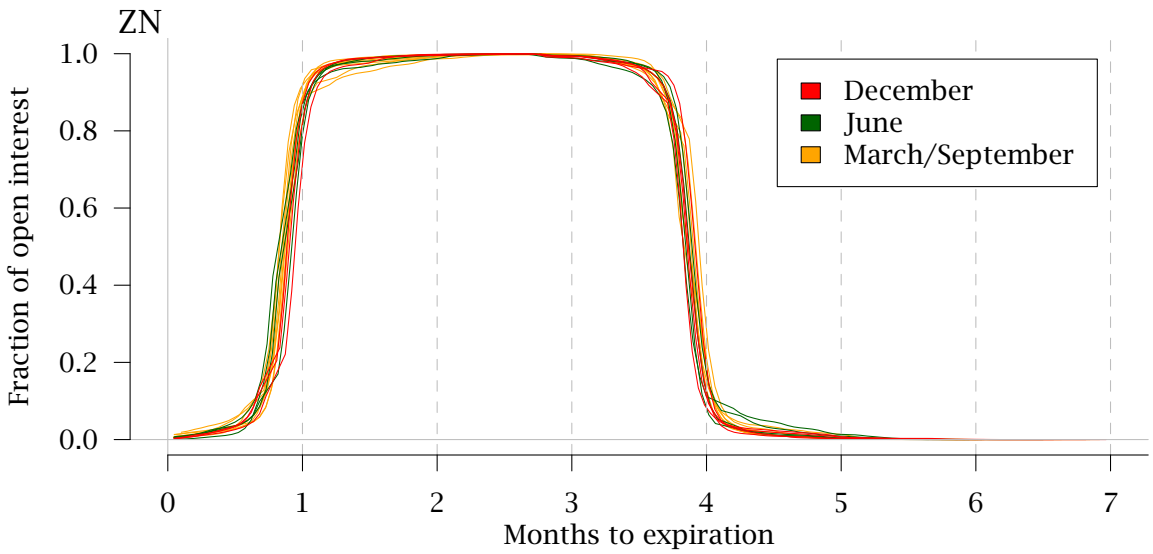

Figure 1: 10-year treasury futures show a highly concentrated, quarterly roll structure. In general, 100% of the open interest is in the front-month contract, and this open interest shifts rapidly during the roll period.

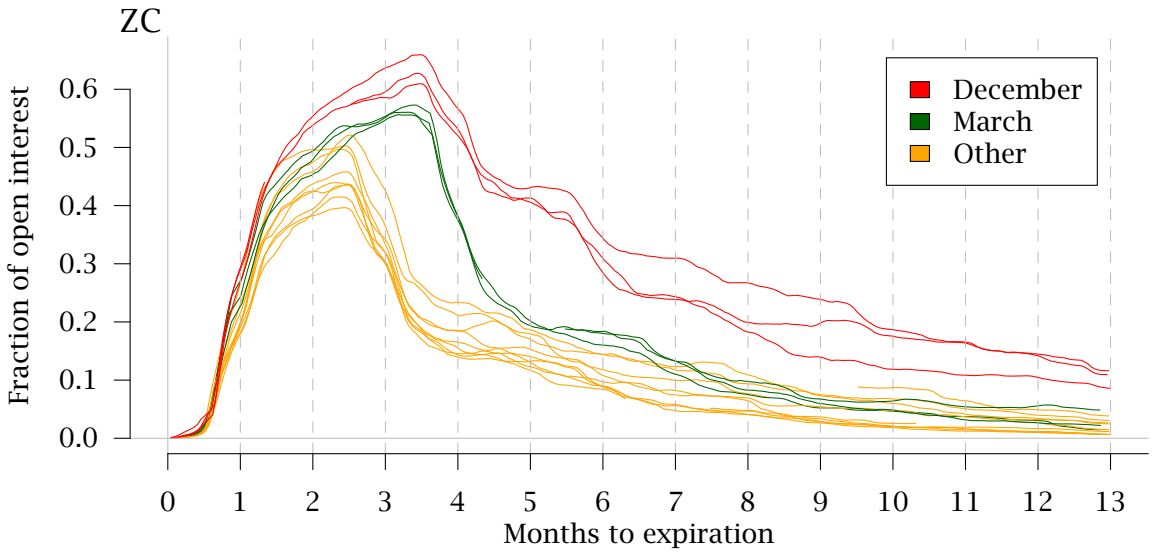

Figure 2: Corn futures show a more complex structure than treasury futures. Contracts reach their peak interest at different times relative to expiration, as they spend different amounts of time as the front-month contract. Additionally, the December contracts show relatively higher open-interest prior to becoming the front-month.

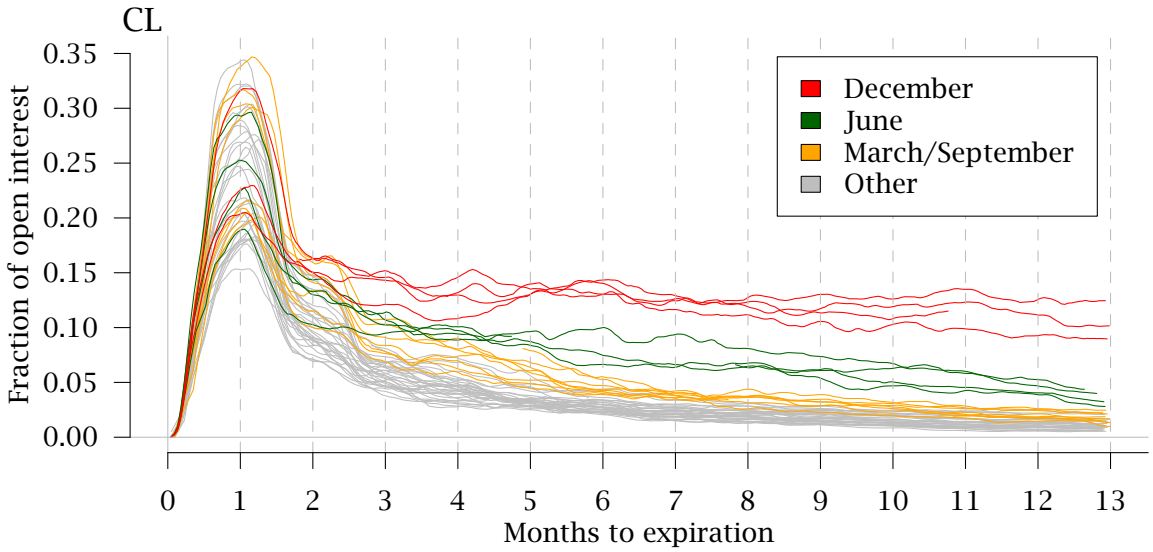

Figure 3: Crude oil futures show a distinct structure for far-out contracts, with quarterly contracts having more early interest than non-quarterly, June contracts having more early interest than March/September contracts, and December contracts having the most early interest.

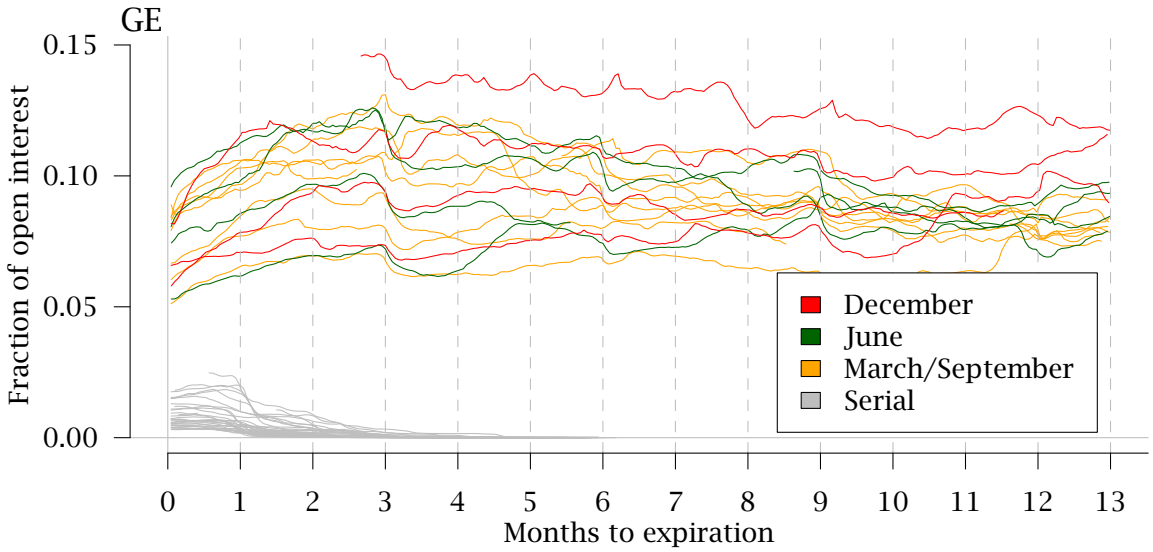

Figure 4: Eurodollar futures show minimal structure in their open-interest trajectories. Because contracts are cash-settled, there is little incentive to roll positions prior to expiration.

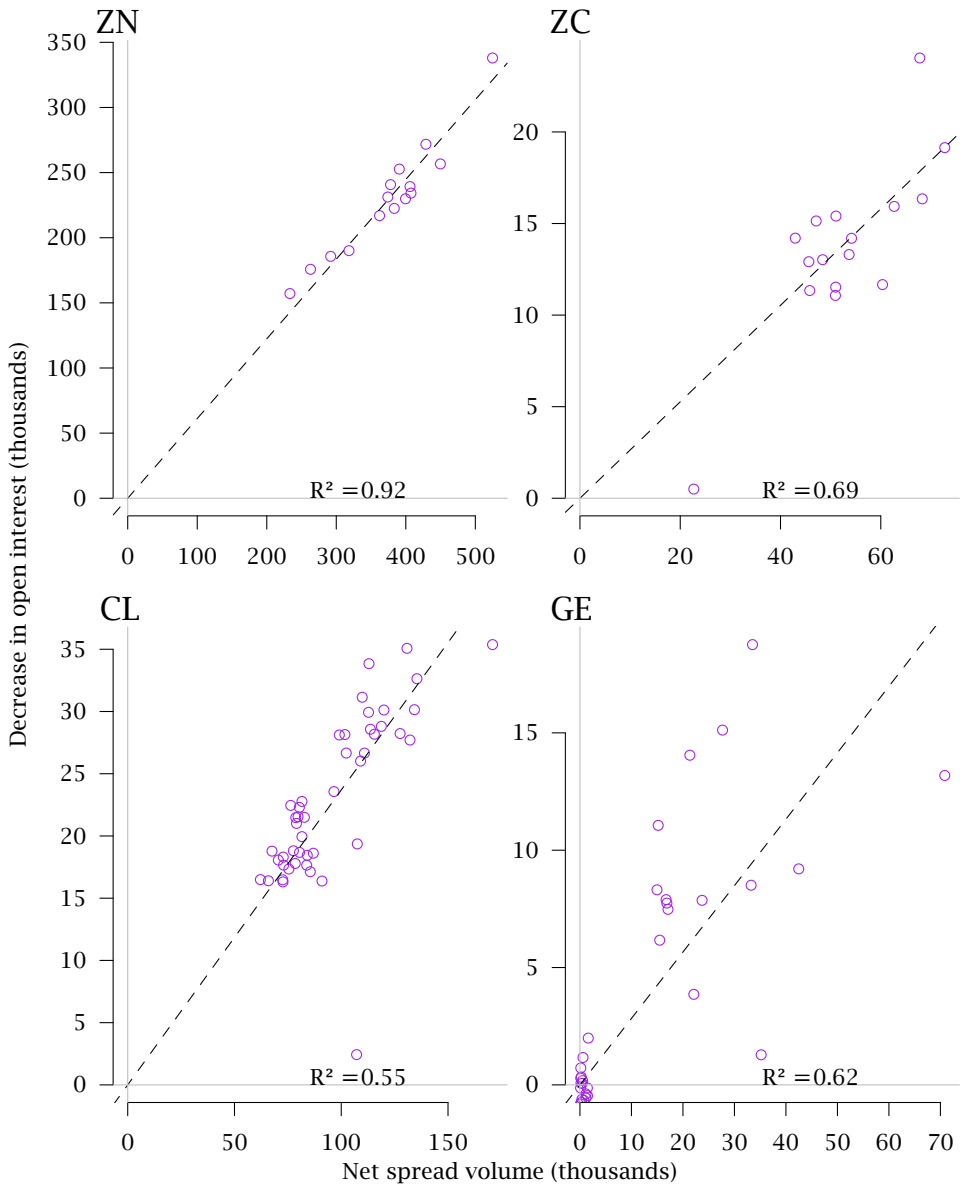

Figure 5: There is a strong relationship between the traded volume in calendar spreads connecting to the front month contract and the decrease in open interest in the front month. Vertical axis is decrease in open interest in the front month contract during the last month of trading, or during the month preceding First Intention Date for Treasury futures. Horizontal axis is sum of traded volume in all spread contracts having the front month as near leg.

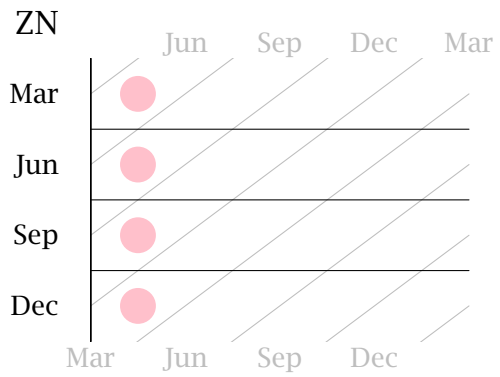

Figure 6: 10-year Treasury futures have a very simple roll structure. Contracts roll exclusively from the front month to the following month. In each row, the relative sizes of the dots are the relative traded volumes in the corresponding calendar spread contracts. As argued in the text, this is an illustration of the flow of open interest.

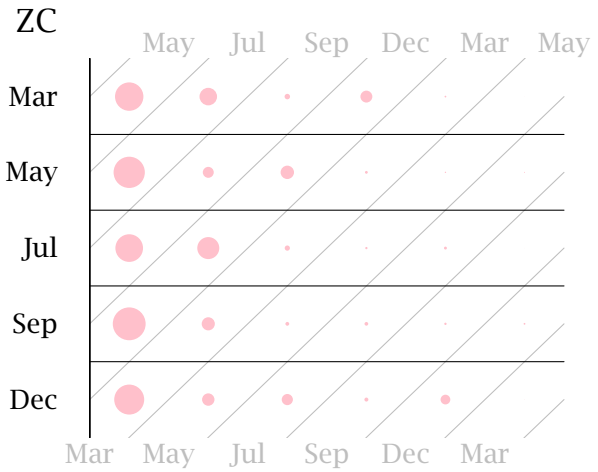

Figure 7: Corn futures show more structure than Treasury futures. Contracts roll between multiple maturities, with all contracts showing a slight preference for rolling into December, and December contracts showing a higher tendency to roll into far-out contracts.

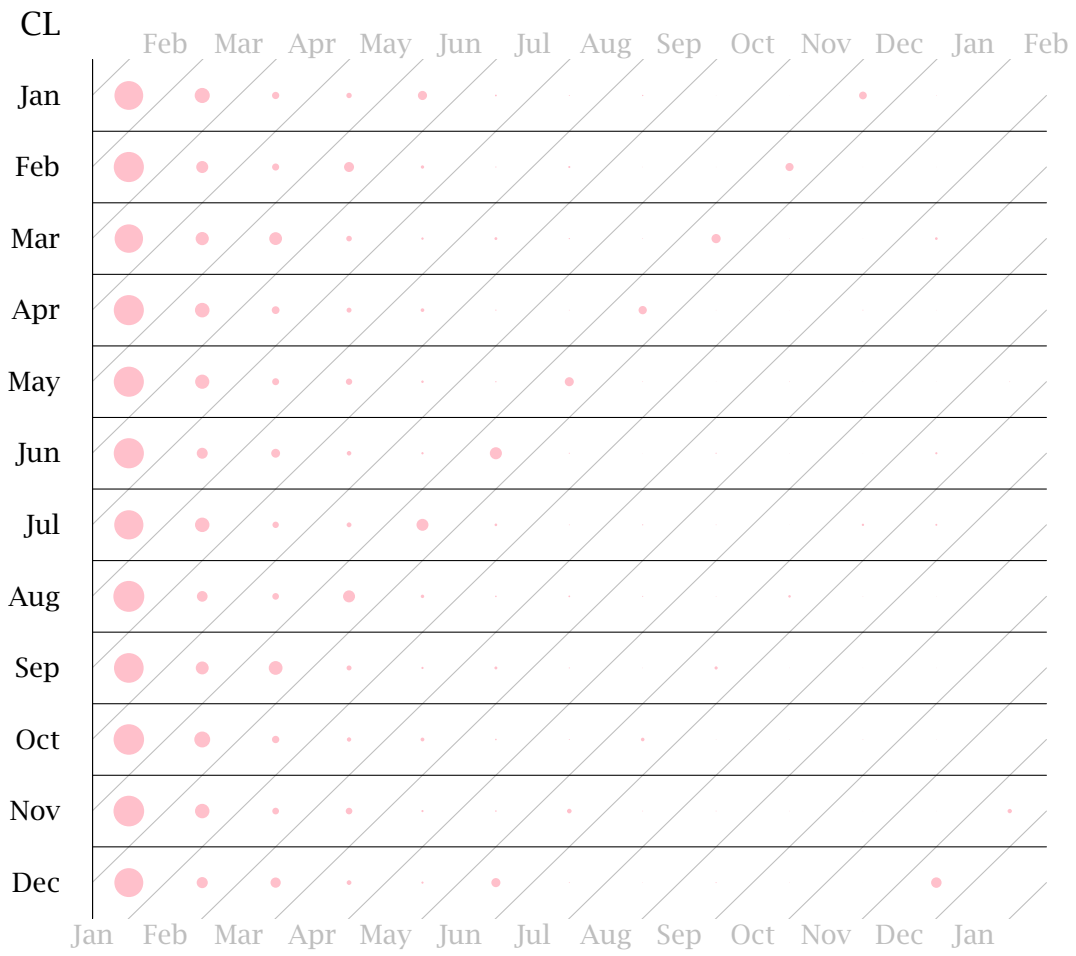

Figure 8: Crude Oil futures largely roll from the expiring contract into the next deferred contract. But in addition, all contracts show a preference for rolling into the following December contract, and December contracts show a relatively high tendency to roll either into the following June, or into the following December.

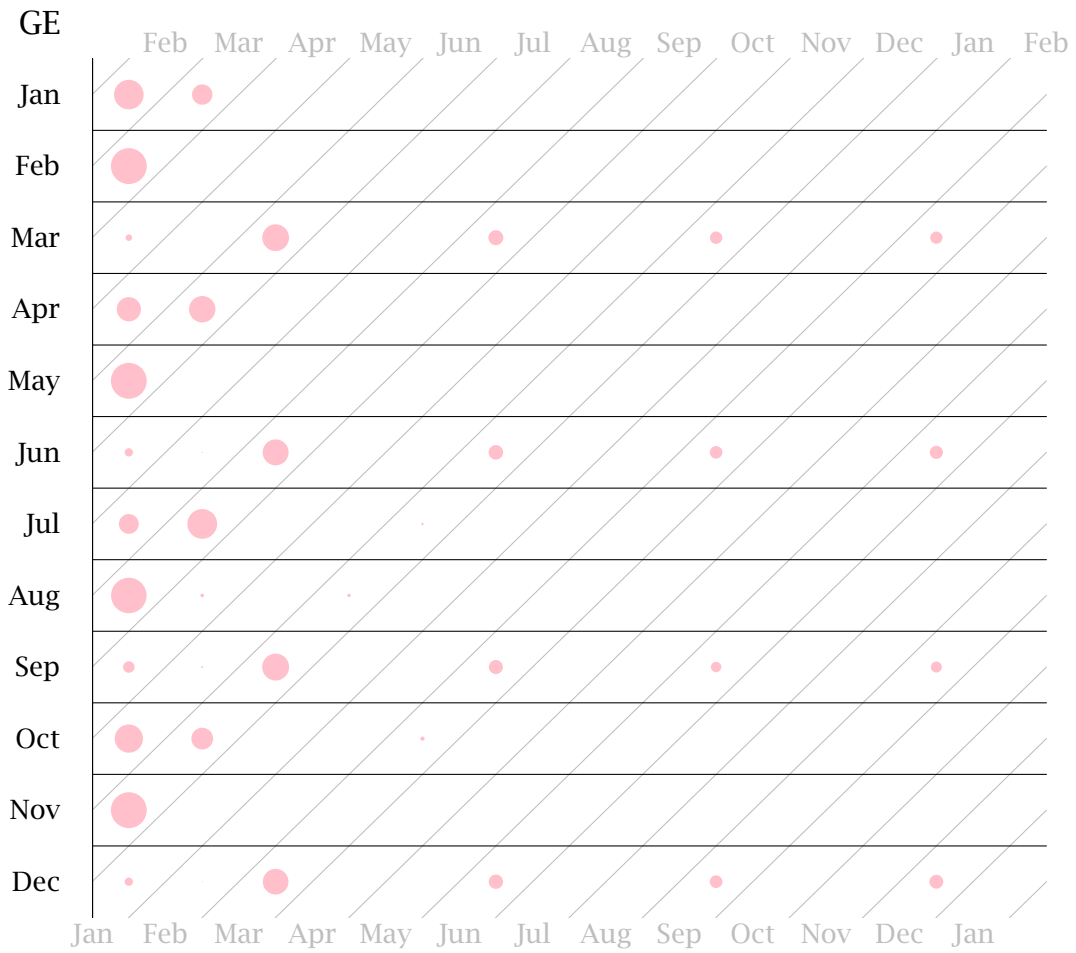

Figure 9: Eurodollar futures largely roll from the expiring quarterly contract into the next quarterly contract. Although serial contracts do exist with a few intermediate monthly expirations, they are very inactive.