UNIVERSITY OF CHICAGO
Booth School of Business

Bus 35120 – Portfolio Management Prof. Lubos Pastor

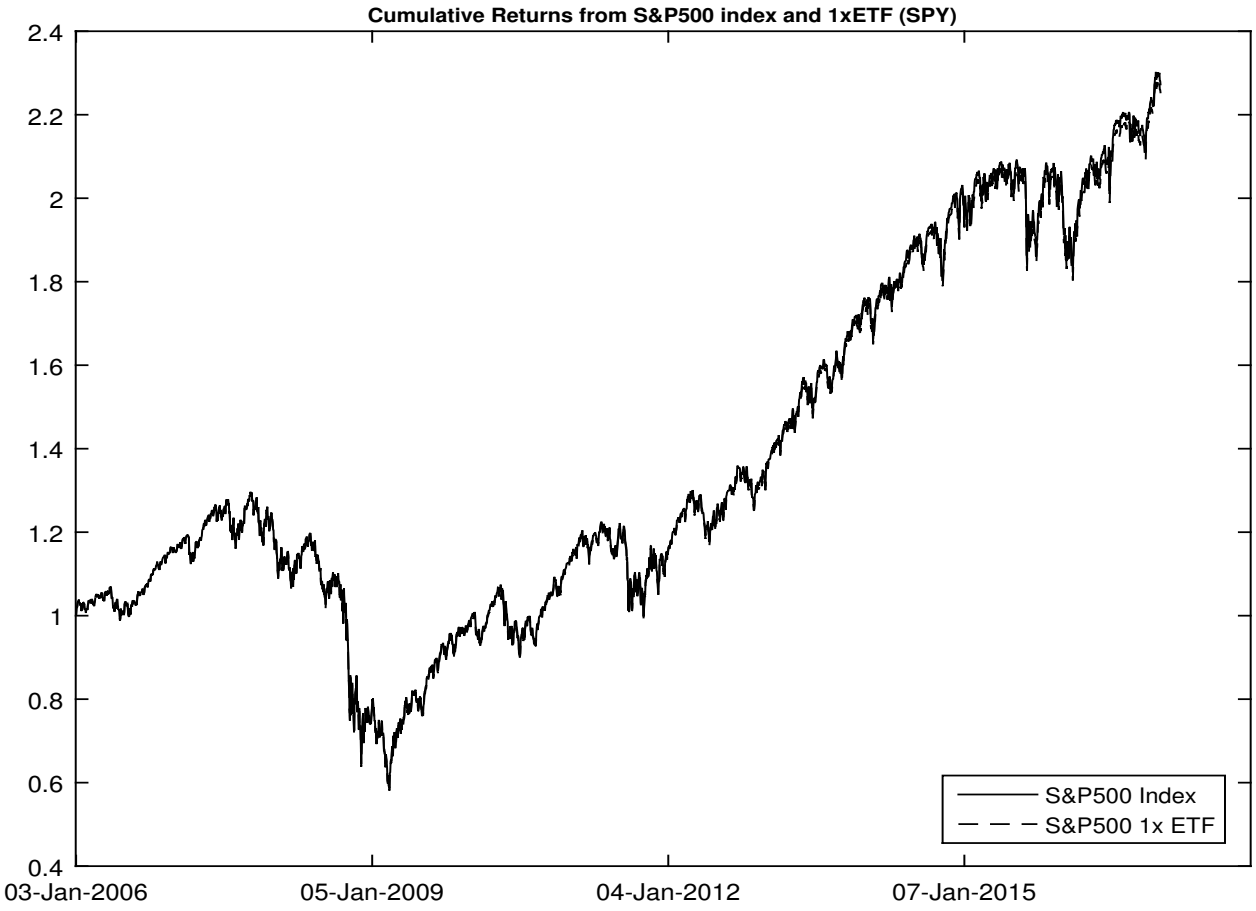
Assignment #7
Solutions

B.

The solutions given below were obtained in MATLAB using the program hwk7_solutions.m and the function analysis_h7.m. You can download both programs from Canvas into your current directory and run them by typing "hwk7_solutions" at the command line.

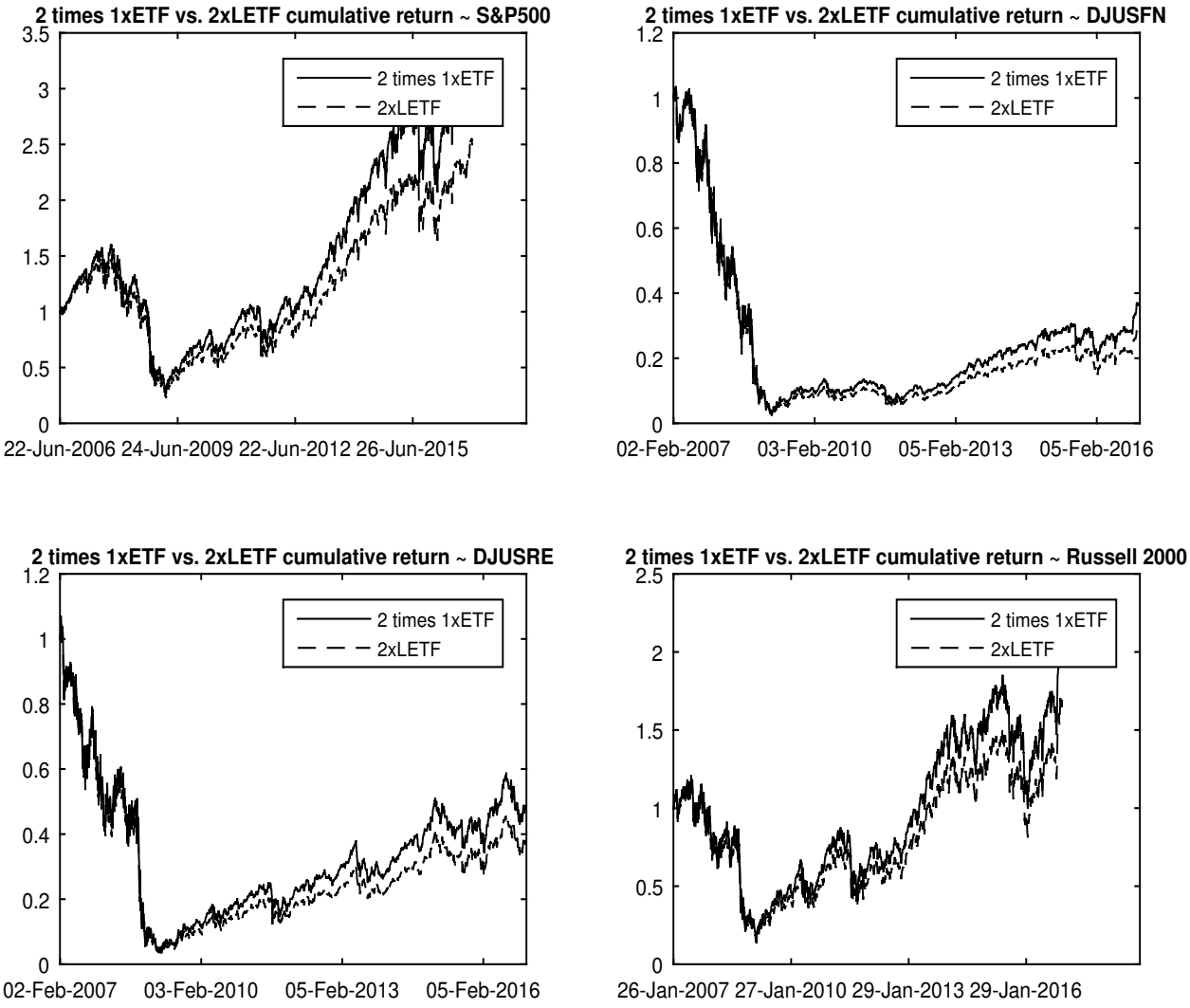
1.

As shown in the figure below, the unlevered ETF (SPY, 1x) tracks the performance of the underlying index (S&P 500) very closely. Unlevered ETFs typically simply buy and hold the underlying index portfolio, which allows them to track their index closely.



2.a

As shown in the figure below, the 2x LETF held over longer periods of time does not deliver the same performance as a double-levered investment in the unlevered ETF. In fact, for all four indexes, the 2x LETF underperforms. This underperformance is due to the fact that LETFs are rebalanced daily to the desired leverage ratio, as explained below.



As a result of the daily rebalancing, the 2x LETF delivers the 2x return on the underlying index on any given day. However, that is not the case over multiple days, due to compounding effects. For example, if the underlying index returns 10% on day 1 and -10% on day 2, its cumulative return for the 2-day period is 1.10*0.90-1=0.99-1=-0.01, or -1%. In contrast, the 2x LETF on the same index returns 20% on day 1 and -20% on day 2, so its cumulative return for the 2-day period is 1.20*0.80-1=0.96-1=-0.04, or -4% (as opposed to -2% as one might expect). This effect may help or hurt the performance of the LETF, depending on

whether the successive daily index returns tend to be of the same sign or not. In volatile markets with a lot of short-term reversals, the LETFs tend to suffer.

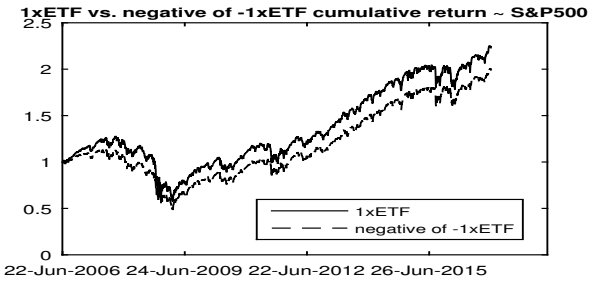
To better understand the nature of the daily rebalancing, consider a 2x LETF that uses $100 of equity capital and $100 of borrowed capital to take a $200 levered position in the underlying index. Suppose the index goes up 10% today, so that the LETF's portfolio is now worth $220. The $20 gain increases the equity investment, so the LETF now has $120 in equity plus $100 of borrowed capital. To restore the desired 2x leverage ratio, the LETF must immediately borrow another $20 and invest it in the index. As a result, the LETF buys more of the index after the index goes up.

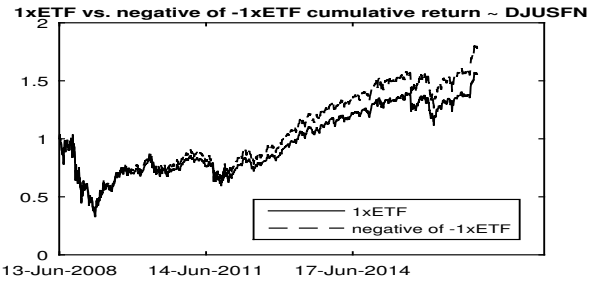
Analogously, if the index drops by 10% instead, the LETF's portfolio will be worth $180, financed by $80 in equity plus $100 of borrowed capital. To maintain the desired 2x leverage, the LETF must immediately sell $20 worth of the index and return $20 to the lender. As a result, the LETF sells the index after the index goes down. This daily rebalancing—buying after the price goes up and selling after the price goes down—often amounts to buying high and selling low, especially if there is a lot of volatility in the market.

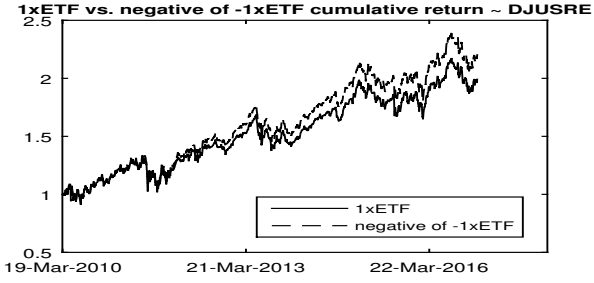
In addition to the effect discussed above, the daily rebalancing incurs direct trading costs that further reduce the buy-and-hold LETF return. While it is possible for LETFs to outperform, for example if there is little volatility and short-term momentum in the market (i.e., if the successive daily index returns tend to be of the same sign), the underperformance is more likely, as illustrated in the four prominent cases shown in the above figure.

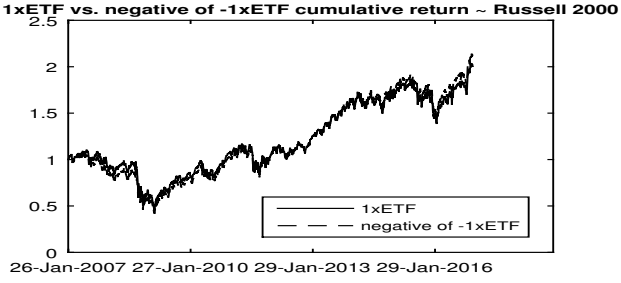
2.b

On any given day, the 1x ETF and the -1x LETF on the same index should yield the opposite returns, and so should the 2x and -2x LETFs. However, that relationship is generally not sustained over longer investment horizons, as shown in the charts below.

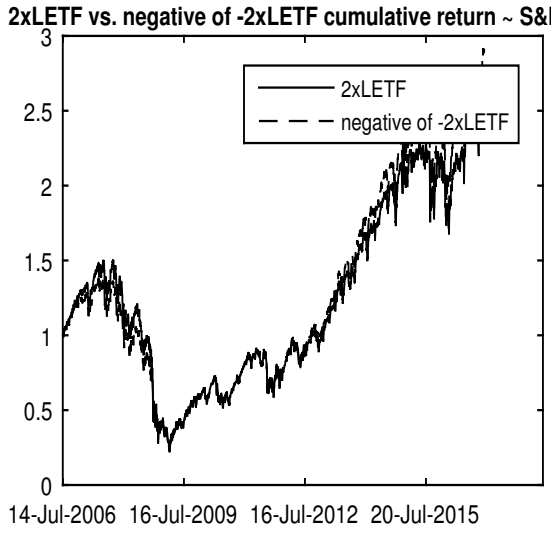


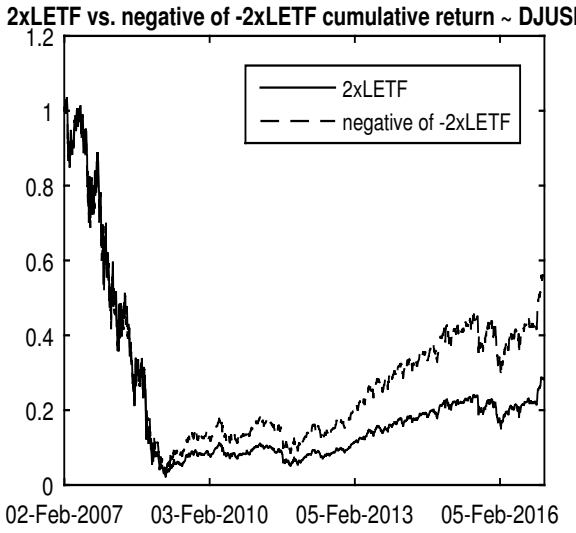


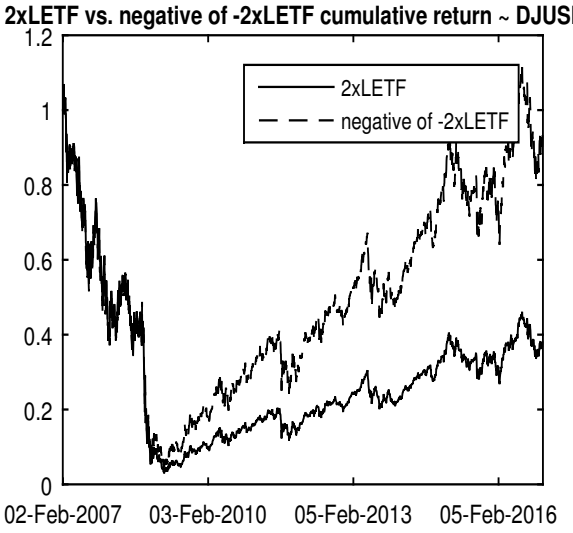


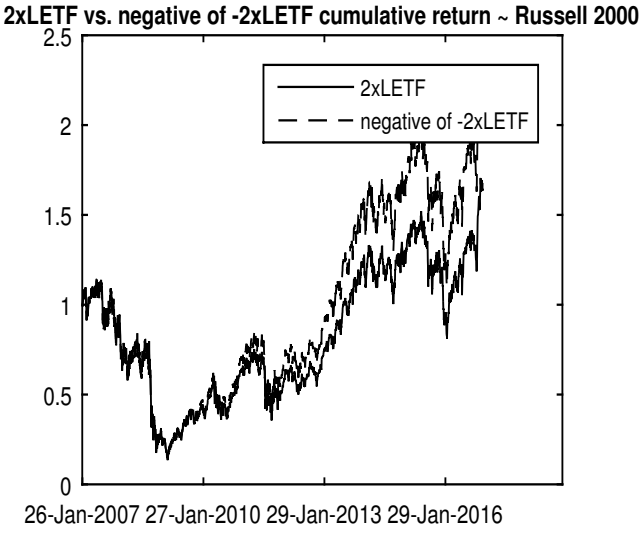


The reason is that the two LETFs rebalance differently on a daily basis, as noted earlier. The general answer is the same for 1x vs -1x and 2x vs -2x.





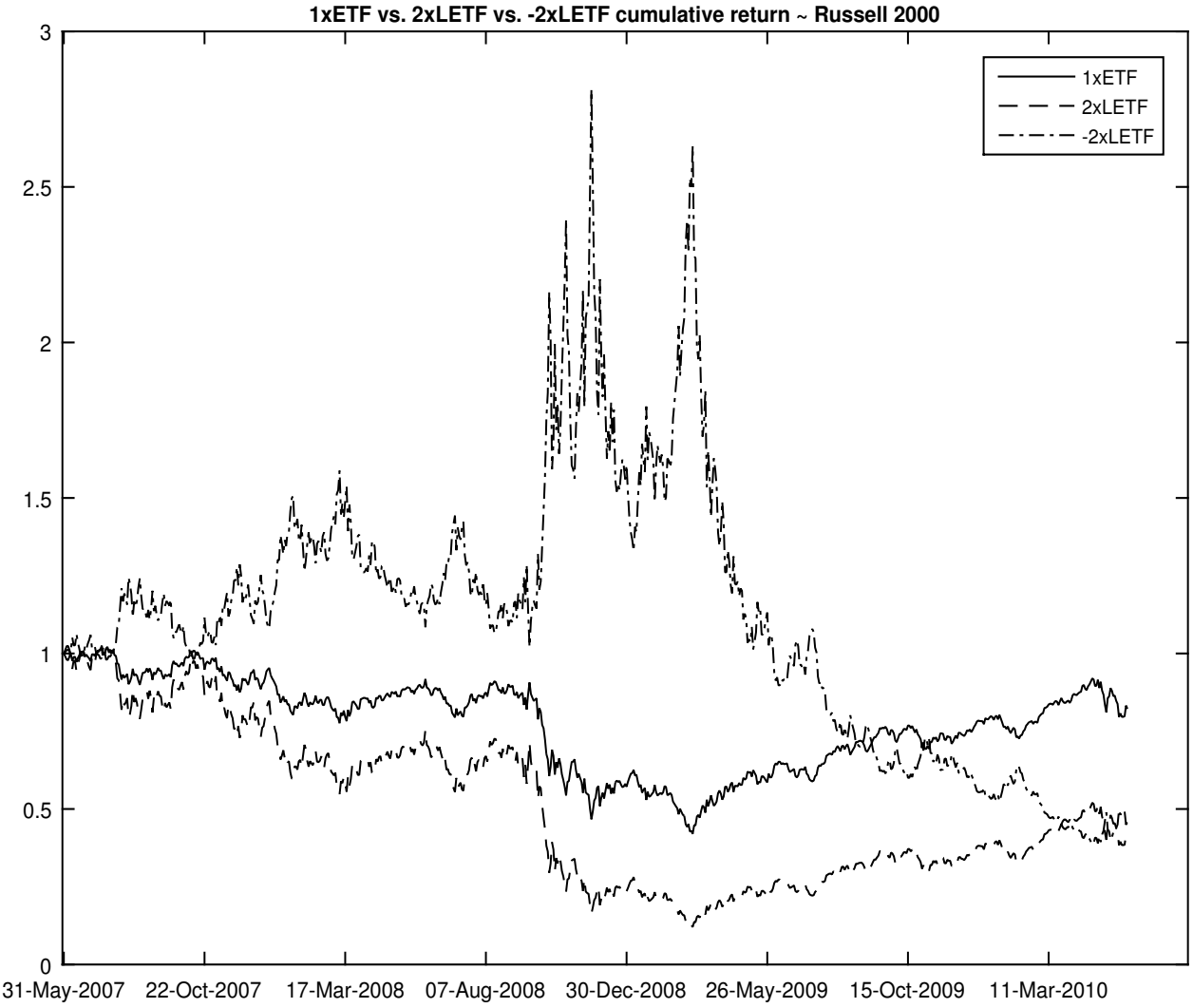




2.c

See the plot below. During the three years from 05/31/2007 to 05/31/2010, the 1x ETF lost 18.2%, while the 2x LETF lost 59.7%, and the -2x LETF lost 53.6%. This is a striking departure from what naive investors in LETFs might expect. First, the 2x LETF lost much more than twice the index return ($59.7\% > 2 \times 18.2\%$). Second, not only the 2x LETF but also the -2x LETF lost money over the same period! One might have expected the -2x LETF to make money when the 2x LETF loses money but no, both LETFs actually lost more than 50%! These results further illustrate the complicated long-run performance

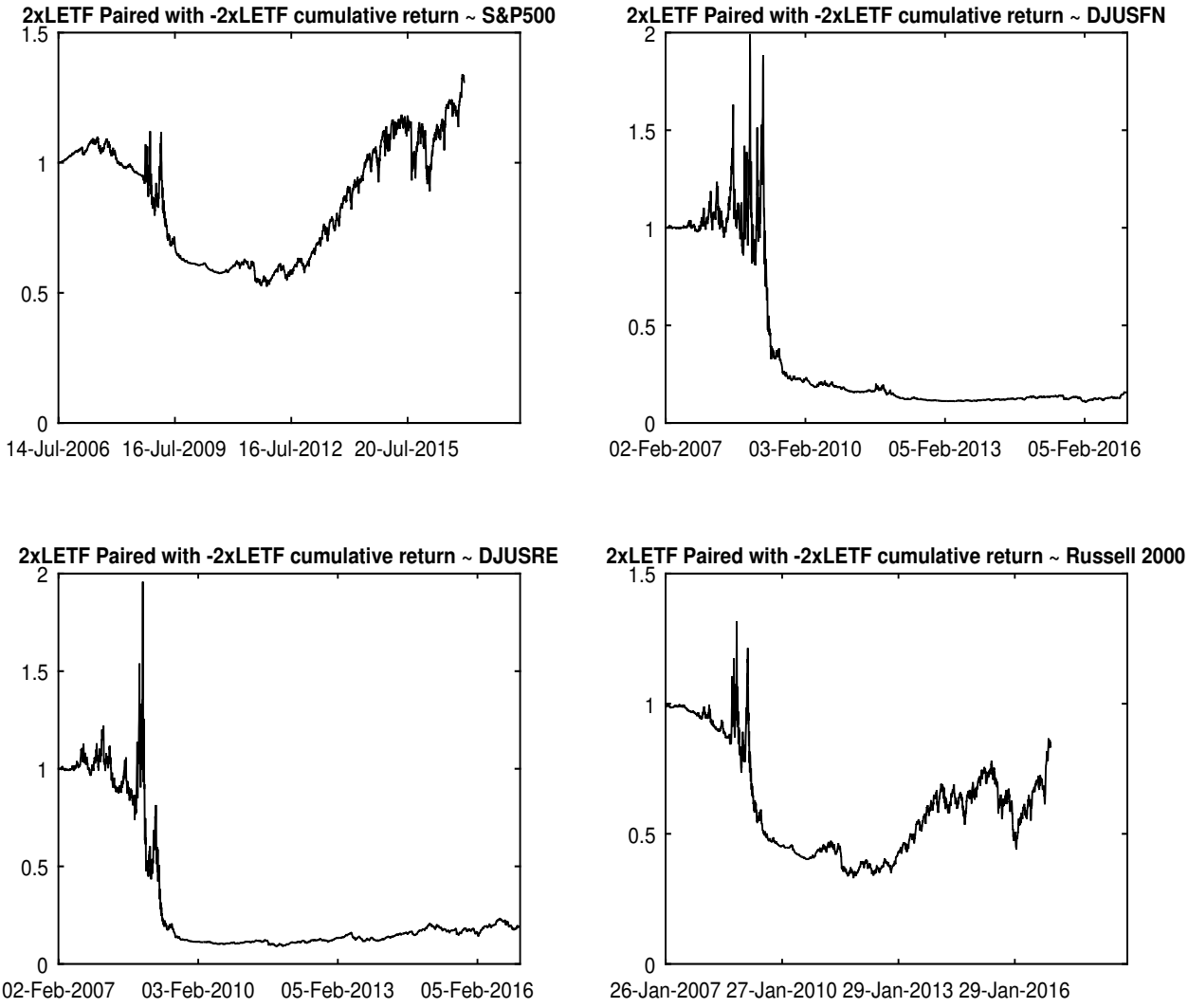
patterns of LETFs, which are designed for daily return amplification. Volatility during the financial crisis was unusually large, helping to make this illustration particularly vivid.



3.

(a) On any given day, holding \$0.50 in a 2x LETF and \$0.50 in a -2x LETF on the same underlying index yields a return of approximately zero. However, this relationship need not hold over longer periods because of the different daily rebalancing of the two LETFs (one of them is buying after the price went up while the other is selling) and the non-random-walk nature of daily index returns. An investor pursuing a buy-and-hold strategy holding both 2x and -2x LETFs generally experiences negative long-term returns, as illustrated in the figure below. While this strategy can make money over certain periods of time, it generally loses money over long horizons, especially if those periods include periods of high volatility. For the four prominent pairs studied here, the loss can be as high as 90% (see the plot below)!

The reason is that both the 2x and -2x LETFs are generally poor long-run investment vehicles due to their costly daily rebalancing, as explained earlier. Putting them together does not alleviate the long-term problem.



The investment strategy of buying pairs of 2x and -2x LETFs on the same index tends to lose money in general, not only for the pairs analyzed here, as shown by Jiang and Yan (2012). The authors argue that the underperformance results from a combination of two factors. First, ETF returns appear to slightly underreact to NAV (net asset value)-implied returns. Specifically, when the NAV of an ETF increases by 1%, the ETF price increases by only 94 to 95 basis points, on average. Long LETFs thus become underpriced relative to their NAVs whereas short LETFs become overpriced. Second, the daily rebalance in the long-long strategy is contrarian in nature: It moves investment out of the winner of the ETF pair, and into the loser of the pair. Given the underreaction of ETFs, after a positive index return, the daily rebalance moves investment from the underpriced long ETF to the overpriced short ETF. As the ETF prices converge to their corresponding NAVs in the future,

the future returns of the long-long strategy tend to be lower than the NAV returns. See the Jiang and Yan paper for more information.

(b) Given this evidence, a natural attractive investment strategy is to *short* the pairs of LETFs and hold the short positions over longer periods of time. (If the long strategy performs poorly, the short strategy performs well.) The main impediment to this strategy is likely to be the difficulty in borrowing the LETF shares for shorting purposes. In order for someone to lend you the shares, they must be holding these shares over longer periods of time. Since it is suboptimal to hold LETFs over periods longer than one day, as argued earlier, not many smart investors are likely to do so. Having said that, there are plenty of naive investors out there, so 'difficult' does not mean 'impossible'. If you are able to borrow pairs of LETF shares and short them, go ahead!

4.

The main lesson here is that LETFs are not suitable investment vehicles for long-term investors. Along the same lines, the Financial Industry Regulatory Authority, the independent regulator of U.S. security firms, issued a tersely worded notice to brokers in June 2009, reminding them that "LETFs that are reset daily typically are unsuitable for retail investors who plan to hold them for longer than one trading session, particularly in volatile markets."

C. EXAM-LIKE QUESTIONS.

1. This is the Grossman-Stiglitz paradox. Markets are likely to be only partially efficient in the sense that information gathering can produce benefits, but those benefits should only cover the costs of information gathering (including fair wages and normal profits). When the benefits of information gathering exceed the costs, competition brings in more information-gatherers until benefits = costs again.

2. In this approach, a passive fund that is trying to track an index holds a carefully selected subset of the index. The stocks in the index are independently divided into several groups/strata according to their characteristics such as the industry affiliation, market capitalization, book-to-market ratio, etc. The intersection of these groups is taken, creating sets of stocks with similar characteristics. The fund manager chooses a subset of stocks from each of these sets, so the characteristics of the fund's overall portfolio are similar to those of the index, which reduces the tracking error.

3. Investors who demand trading flexibility (e.g., the ability to trade during the day, the ability to short, etc.) generally prefer ETFs. So do some long-term investors because ETFs often have lower costs than passive funds. Investors who want to make small regular trades (e.g., purchases from monthly savings) tend to prefer passive funds because they want to avoid paying broker commissions on a regular basis.

4. Smart beta products tend to have higher trading costs because they need to rebalance often if they aim to be true to their stated objectives. For example, consider a smart

beta product that weights stocks by company sales. Whenever new sales numbers come out, the product needs to rebalance (away from firms with high sales and toward firms with low sales). In contrast, market cap-weighted index products rebalance themselves automatically. The only trading required for cap-weighted products is related to index reconstitutions, an aspect that is also present in smart-beta products.

5. Recall from Investments that the efficient markets hypothesis (EMH) argues that asset prices always reflect all available information and, as a result, it is impossible to consistently achieve abnormal risk-adjusted returns.

   The article presents several wrong arguments against EMH. For example, EMH does not require asset returns to be normally distributed, or to exhibit constant correlations. Yes, there can sometimes be seven-sigma price movements because the bell curve can be a bad approximation for asset returns, and yes, correlations tend to increase sharply during crises, but neither fact has anything to do with EMH. These facts do contradict some of the assumptions of modern portfolio theory, but they do not violate EMH.

   EMH implies that dramatic news should move asset prices quickly and dramatically. We received a lot of bad news during the crisis; for example, house prices declining nationwide for the first time. Big bad news should lead to large and potentially many-sigma drops in asset values, according to EMH.

   EMH does not assume that all investors act rationally. It only assumes that there are enough rational and well-capitalized investors who quickly fix the mistakes of others, making money in the process and keeping markets efficient for the rest of us. Even if 99% of investors make mistakes, markets can in principle be efficient if the remaining 1% are smart and control a lot of capital.

   It also seems a bit shallow to blame EMH for toxic derivatives.

   More generally, a popular post-crisis view in the media is that the 2007–2008 financial crisis clearly disproved EMH. I don't think this is obvious at all.

   Asset prices fell by a lot during the crisis, so we know *ex post* that assets were overvalued before the crisis, but what is relevant for EMH is whether this overvaluation was obvious *ex ante*. That is far from clear. Some smart people indeed claimed before the crisis that real estate, oil, stocks, and other assets were overvalued, but there were also many other smart people who had argued the opposite (remember Goldman Sachs predicting that oil would go to $200 per barrel? and the Fed economists justifying the high house prices by immigration growth and low interest rates?). It is easy to identify asset price "bubbles" ex post (Monday morning quarterback), but the only bubbles that would violate EMH are those can be clearly identified ex ante. And that is very hard to do (ask Alan Greenspan or Ben Bernanke).

   Some of today's celebrated gurus who correctly argued that real estate was overvalued in the mid-2000s, or that the stock market was overvalued in 2000, had been arguing the same thing for many years. A good example is the 2013 Nobel prize winner Robert Shiller. If you had listened to Shiller, you would have sold your house in early 2003 (and lost a lot of money because house prices did not peak until over three years later), and you would have sold your stocks in 1996 (and lost a lot of money because stock

prices did not peak until four years later). Even economists as smart as Shiller have a hard time identifying overvalued assets in real time.

Journalists also tend to confuse informational efficiency (which is what EMH is about) with allocative efficiency. Free markets have their deficiencies and there were certainly some market failures during the crisis (externalities, asymmetric information, monopoly power of rating agencies, etc.). As a result of these market failures, markets allocated too much capital to home-building, for instance. However, such allocative market failures do not imply informational inefficiency. Prices can reflect all available information even in the presence of market failures.

One might even argue that EMH was strengthened by the crisis. First, the core of EMH is that sharp price moves are unpredictable and there are no free lunches. How many of today's EMH-bashers were able to correctly predict the crisis and make money off of it? My guess is not many. Second, a key principle of EMH is that the only way to make extra money is to take on extra risk. Indeed, many investment strategies that appeared to be abnormally profitable before the crises (all sorts of carry trades, liquidity trades, etc.) lost a lot of money during the crisis. The "abnormal profitability" of these strategies turned out to be simply compensation for risk that manifests itself during the crisis (e.g., liquidity risk), precisely as EMH would suggest.

I am not arguing that markets are always perfectly efficient; not at all, in fact, I doubt they are. I am simply saying that the "evidence" against market efficiency as presented in the media is far exaggerated. The media loves to write about failures, inefficiencies, and irrationalities because they are sexy, but that doesn't make them true.