OSFI's Academic Foray

In March 2012, the Office of the Superintendent of Financial Institutions (OSFI) released a paper titled *Evidence for Mean Reversion in Equity Prices[1]*. This paper attempts to justify their decision not to allow equity return models that are based on the assumption of mean reversion with respect to segregated fund guarantee reserve and capital requirements for insurance companies.

I have long advocated that OSFI release their research and internal analysis to the public[2] but this paper simply aggravates my fears regarding OSFI's competence to execute its mandate to "monitor and evaluate system-wide or sectoral issues that may impact institutions negatively."[3] The arguments made in the paper do not fare well under examination.

Mean Reversion In Equity Prices

Mean reversion is often confused with sampling error in what is referred to as the "Regression Fallacy" or sometimes "Regression to the Mean".[4] For example, when we toss a coin, we can predict that the long-term expected proportion of heads and tails is 50:50. However, if our first three tosses are all heads, the chances of a head or tail on the fourth toss remains equal – the coin does not have a memory. The expected average will be 50%, but only because the probability on every toss is 50%.

This can be contrasted with an experiment of drawing from a box that contains an equal number of red and white balls, without replacing the balls once drawn. Just as with the coin-tossing experiment, the expected proportion on any sample is a 50:50 split between the alternatives. But in this case, if the first three draws are all white, then the probability of a red ball being drawn actually does increase, because the proportion of red balls in the box has changed.

The example of drawing balls from a box shows mean reversion, because there is a factor adjusting future probabilities based on prior results; the coin-toss experiment does not, because there is no such factor. Any unwary observer who believes the odds in the coin-toss have in fact changed as a result of the first three results has fallen victim to the Regression Fallacy. This fallacy is often evident in public policy – if, for instance, you put a stop sign up at every corner where the number of accidents has recently spiked, you may well observe that the number of

[1] Daniel Mayost (contact), *Evidence for Mean Reversion in Equity Prices*, Office of the Superintendent of Financial Institutions, March, 2012, available on-line at http://www.osfi-bsif.gc.ca/app/DocRepository/1/eng/notices/osfi/mnrv_e.pdf

[2] James Hymas, *OSFI and the Third Pillar,* Advisor's Edge Report, December 2008, available on-line at http://www.himivest.com/media/advisor_0812.pdf

[3] Office of the Superintendent of Financial Institutions, *Corporate Responsibility,* available on-line at http://www.osfi-bsif.gc.ca/app/docrepository/1/ra/0506/eng/responsibility_e.html

[4] Amos Tversky & Daniel Kahneman, *Judgment under Uncertainty: Heuristics and Biases,* Science, New Series, Vol 185, No. 4157, 1974-9-27, available on-line at http://psiexp.ss.uci.edu/research/teaching/Tversky_Kahneman_1974.pdf

accidents declines the following year. The decline could be due to the stop sign; but it could also be simply that the high rate was simply an instance from the high end of the normal distribution.

Our question is: do equity prices exhibit long-term (over a period of years) mean reversion? OSFI stated that the evidence was not strong enough to support "the large reduction in segregated fund guarantee reserve and capital requirements from assuming mean reversion in equity returns" and could have left it at that – but instead they chose to embarrass themselves with a series of arguments that show they simply do not understand the issue.

The arbitrary nature of their decision is exemplified by the fact that they contradict the Canadian Institute of Actuaries 2002 report that has heretofore served as the basis for segregated fund guarantee capital requirements in Canada[5] without ever even referring to it. This report specifically allowed state dependent models (a class that includes mean-reverting models) subject only to requirements that they were justifiable based on the historical data and met calibration criteria (i.e., a minimum probability of various levels of poor results over a variety of time frames). The intellectual dishonesty inherent in OSFI's derecognition of this report is breathtaking.

First Howler: The Efficient Market Hypothesis

OSFI claims that mean reversion contradicts the Efficient Market Hypothesis, stating that "traders would be able to earn excess returns … by buying stocks that have had lower-than-average returns in prior periods and short-selling stocks that have had higher-than-average returns".

Regrettably, this begs the question of whether mean reversion exists at the universe level. After a stock index has declined substantially, mean reversion implies that expected future returns for the index increase. This has no bearing on the relative returns of any two individual stocks; past winners and losers may be assumed to have precisely equal distributions of future returns.

Additionally, as stated by Burton Malkiel[6], one of the great defenders of the EMH: "In addition, it is highly unlikely that either real interest rates or required risk premiums are stable over time. Stock prices should adjust with changes in required rates of return, and such price volatility may be entirely consistent with EMH. … Over short holding periods, there is some evidence of momentum in the stock market, while for longer holding periods, mean reversion appears to be present."

Second Howler: Mean Reversion of Economic Indicators

OSFI claims that "Long run economic performance in real terms is generally a function of

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[5] Canadian Institute of Actuaries Tax Force on Segregated Fund Investment Guarantees, *Report*, Canadian Institute of Actuaries, 2002, available on-line at http://www.actuaries.ca/members/publications/2002/202012e.pdf

[6] Burton Malkiel, *The Efficient-Market Hypothesis and the Financial Crisis,* October 28, 2011, available on-line at http://www.russellsage.org/sites/all/files/Rethinking-Finance/Malkiel.%20The%20Efficient-Market%20Hypothesis%20and%20the%20Financial%20Crisis%20102611.pdf

population and productivity growth, neither of which are inherently mean reverting. Since the performance of many asset classes has a tendency to be broadly linked to economic growth prospects, this casts doubt as to whether mean reversion in equity prices will always occur."

The only difficulty in rebutting this reckless statement is deciding where to begin! Chib and Dueker noted[7] "Autoregressive models are popular in economics because many economic variables appear to respond more to their own past values than they do to a distributed lag of any other variable."

There are many government policies which seek to make population growth mean-reverting: these include the Government of Canada's immigration policy[8], the province of Quebec's population policy[9] and the Government of China's One-Child policy.[10]

In addition, there is the simple unpleasant fact that too large a population will simply outstrip the resources available, resulting in famine[11]; conversely, an increase in the productivity of arable land will allow a higher population. This implies mean reversion of global population towards a figure dependent upon food production.

It is in no means obvious that equity returns, as experienced by an investment portfolio, are intimately linked to economic growth as defined by GDP; a disproportionate share of the fruits of productivity improvement will be received by the innovators themselves.[12] Jay Ritter of the University of Florida goes so far as to state[13] that "economic growth does not benefit equity holders."

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[7] Siddhartha Chib & Michael Dueker, *Non-Markovian Regime Switching with Endogenous States and Time-Varying State Strengths,* Federal Reserve Bank of St.. Louis, Working Paper 2004-030A, available on-line at http://research.stlouisfed.org/wp/2004/2004-030.pdf

[8] Bruce Campion-Smith, *Stephen Harper vows big changes to retirement benefits and immigration policy,* Toronto Star, 2012-1-26, available on-line at http://www.thestar.com/news/canada/politics/article/1122179--stephen-harper-vows-big-changes-to-retirement-benefits-and-immigration-policy (accessed 2012-6-13)

[9] Catherine Krull, *Quebec's Alternative to Pronatalism,* Population Reference Bureau, Population Today, November/December 2001, available on-line at http://www.prb.org/articles/2001/quebecsalternativetopronatalism.aspx (accessed 2012-6-13)

[10] S. Henneberger, *China's One-Child Policy: History,* 2007, available on-line at http://iml.jou.ufl.edu/projects/fall07/Henneberger/History.html (accessed 2012-6-13) See also Laura Fitzpatrick, *China's One-Child Policy,* Time Magazine, 2009-7-27, available on-line at http://www.time.com/time/world/article/0,8599,1912861,00.html (accessed 2012-6-13)

[11] Congressional Tribute to Dr. Norman E. Borlaug Act of 2006, available on-line at http://www.gpo.gov/fdsys/pkg/PLAW-109publ395/html/PLAW-109publ395.htm (accessed 2012-6-13)

[12] MSCI-Barra, *Is There a Link Between GDP Growth and Equity Returns?,* May 2010, available on-line at http://www.mscibarra.com/research/articles/2010/Is_There_a_Link_Between_GDP_Growth_and_Equity_Returns_May_2010.pdf

[13] Jay Ritter, *Economic Growth and Equity Returns,* 2003-12-3, available on-line at http://www.bm.ust.hk/~fina/FinanceSymposium/2003symposium/Papers_Dec15/JayRitter.pdf
See also Ritter, J. R. (2012), *Is Economic Growth Good for Investors?*. Journal of Applied Corporate Finance, 24: 8–18. doi: 10.1111/j.1745-6622.2012.00385.x available on-line via http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6622.2012.00385.x/abstract

Christian-Marc Panneton, whose work is singled out for criticism in the second half of the OSFI paper, points out that actions taken by governments to stabilize the markets during the Credit Crunch are in and of themselves sufficient to show that there is some level of state-dependency in equity returns.

Third Howler: Option Pricing

OSFI states "If market participants truly believe that equity markets revert to the mean over the long run then this should be observable in option prices, which reflect the market price of hedging long-dated equity guarantees. In particular, the cost of purchasing put option protection against a long-run decline in equity markets should be minimal. However, the cost of purchasing such protection is in fact very expensive, if it is available at all, which suggests that the market does not believe in mean reversion."

This statement displays a lamentable ignorance of how long-dated options are priced in the market-place. Mr. Panneton points out[14] that long-term option costs and mean-reversion are not directly related. This is because the portfolio used to hedge the option must be rebalanced frequently and it is this constant need to rebalance that drives long-term option pricing, not the views of market participants regarding long-term price changes. Derman et al. pointed out in 1994:[15] "First, continuous weight adjustment is impossible, and so traders adjust at discrete intervals. This causes small errors that compound over the life of the option, and result in replication whose accuracy increases with the frequency of hedging. Second, there are transaction costs associated with adjusting the portfolio weights which grow with the frequency of adjustment and can overwhelm the profit margin of the option. Traders have to compromise between the accuracy and cost." It may be taken for granted that when traders quote prices for long-term options, they take care not to underestimate their transaction costs!

Bayliffe & Pauling go so far as to state[16] "market participants do not use a Black Scholes model to price these options. Models actually used are likely to reflect the non-normality of market returns, the high transactions costs of adjusting hedges over long time periods and a profit margin."

This is well known to OSFI – or at least, to some departments within OSFI! Their recently released paper title Life Insurance Regulatory Framework[17] states "The current approach to determining liability and regulatory capital requirements for financial guarantees embedded in segregated fund products has the following drawbacks: It can produce values that are materially lower than the cost of hedging…."

[14] Christian-Marc Panneton, personal communication, 2012-7-20

[15] Emanuel Derman, Deniz Ergener, Iraj Kani, *Static Options Replication,* Goldman Sachs, May 1994, available on-line at http://www.ederman.com/new/docs/gs-options_replication.pdf

[16] David Bayliffe and Bill Pauling, *Long Term Equity Returns,* Towers Perrin, September 2003, available on-line at http://www.towersperrin.com/tp/getwebcachedoc%3Fwebc=TILL/USA/2003/200309/Long_Term_Equity_Returns.pdf

[17] Office of the Superintendent of Financial Institutions, *Life Insurance Regulatory Framework,* September 2012, available on-line at http://www.osfi-bsif.gc.ca/app/DocRepository/1/eng/guidelines/LIRF_e.pdf

Fourth Howler: Ignoring Prior Examination of the Drawdown Model

The "Drawdown" model of Christian-Marc Panneton is specifically attacked in the latter part of the OSFI paper, but this attack does not include any reference to previously published analysis of the model. Researchers at the Statistics and Actuarial Science Department of the University of Waterloo examined the Drawdown model and several others.[18] Their paper concludes that other models provide estimates of capital requirements that are more accurate than those estimated by the Drawdown model, but is only able to reach this conclusion through a technique known as "oversampling" and reasoning dependent upon the authors' conclusion that there was "no evidence of negative correlation [i.e., mean reversion], over short or long-term accumulations" in their data.

It is unclear why OSFI chose to ignore this examination of the Drawdown Model in their paper.

Fifth Howler: Disproof by Counter-Example?

OSFI cites three instances of stock indices showing an extremely long – or not yet complete – recovery from their peaks and claims that this "calls into question whether this model accurately represents real-world equity returns".

These three instances are the Dow Jones Industrial Average, peaking in 1929 and not recovering until 1954; the NASDAQ Composite Index, peaking in 2000 and not yet recovered; and the Nikkei 225 index, peaking in 1989 and not yet recovered.

It will be noted the Canadian Institute of Actuaries' Committee on Life Insurance Financial Reporting specifically chose to ignore the Great Depression in their 2012 report[19], stating that this tragedy was caused, at least in part, by inept monetary policies.

It may indeed be considered a weakness of the Drawdown Model that it includes only positive adjustments to expected returns after a crash and does not include negative adjustments to expected returns after a bubble, although the OSFI condemnation of the model does not deign to go into this sort of detail; nor do they provide any tests of the model conclusions with respect to the capitalization of life insurance companies' segregated fund guarantees. Could such a company utilizing the Drawdown Model have been insufficiently capitalized under these conditions? OSFI does not bother to consider the question.

It is also unclear as to whether these three cherry-picked examples of poor equity performance are present in any of OSFI's more formal stress-testing: the projection period for these tests was

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[18] Mary R. Hardy, R. Keith Freeland and Matthew C. Till, *Validation of Long-Term Equity Return Models for Equity-Linked Guarantees*, North American Actuarial Journal, Volume 10, Number 4, available on-line at http://www.actuaries.ca/afc/documentations/Mary_Hardy_naaj0604_3.pdf

[19] Committee on Life Insurance Financial Reporting, *Calibration of Equity Returns for Segregated Fund Liabilities,* Canadian Institute of Actuaries, February 2012, Document 212004, available on-line at http://www.actuaries.ca/members/publications/2012/212004e.pdf

only five years at the time the model was proposed;[20] more recent guidelines[21] do not specify a duration, speaking only of "periods of severe and sustained downturns, including its ability to react over the time horizon appropriate for the business and risks being tested." If equity return models are to be judged based on their ability to replicate the Great Depression and a world war, I suggest that this requirement be publicized!

Sixth Howler: Prudence of Reduction in Capital Reserves

OSFI states "Given the large reduction in segregated fund guarantee reserve and capital requirements that would result from assuming mean reversion in equity returns, it would not be prudent for OSFI to approve equity return models that are based on the assumption of mean reversion without strong evidence that mean reversion actually occurs in the market and is likely to continue in the future."

However, as noted by Mary Hardy et al,[22] there is another risk to be considered: we waste resources if we insist on unnecessary solvency capital. It is the easiest thing in the world to insist that every risk be covered the maximum extent feasible; it is much more difficult to make a judgment regarding the proper trade-off between risk and cost; and more difficult still to formulate a coherent argument defending that judgment.

OSFI – and the federal ministry of finance in general - seems to pride itself on the safety of the Canadian financial system while paying very little attention to the cost of these various measures. This has led the Canadian banking system to become a monolithic bloated oligarchy, with bank assets equal to 199% of our Gross Domestic Product in 2010, versus 99% in the United States;[23] and with financial equities comprising approximately 33.4% of the S&P/TSX 60 Index[24] compared to the US figure of 14.4% of the S&P 500 Index.[25]

As anybody who has ever looked wistfully at a Lamborghini knows, one cannot look solely at benefits when making a decision – costs must also be considered. Unfortunately, this concept is absent from OSFI's rationale.

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[20] August Chow, *Stress Testing: Insurance Companies in Canada,* Paper presented at the Expert Forum on Advanced Techniques on Stress Testing: Applications for Supervisors, May 2-3, 2006, available on-line at http://www.imf.org/external/np/seminars/eng/2006/stress/pdf/acc.pdf
[21] Office of the Superintendent of Financial Institutions, *Stress Testing, Guideline E-18,* December 2009, available on-line at http://www.osfi-bsif.gc.ca/app/DocRepository/1/eng/guidelines/sound/guidelines/e18_e.pdf
[22] Hardy, Freeland and Till, supra
[23] International Monetary Fund, *Global Financial Stability Report, April 2012,* available on-line at http://www.imf.org/external/pubs/ft/gfsr/2012/01/pdf/text.pdf
[24] BlackRock Inc., *XIU - S&P/TSX 60 Index Fund,* available on-line at http://ca.ishares.com/product_info/fund/overview/XIU.htm
[25] Standard & Poor's, *S&P 500,* available on-line at http://www.standardandpoors.com/servlet/BlobServer?blobheadername3=MDT-Type&blobcol=urldata&blobtable=MungoBlobs&blobheadervalue2=inline%3B+filename%3Dfs-sp-500-ltr.pdf&blobheadername2=Content-Disposition&blobheadervalue1=application%2Fpdf&blobkey=id&blobheadername1=content-type&blobwhere=1244142397091&blobheadervalue3=UTF-8

Seventh Howler: Ignoring Calibration Criteria

As noted in the introduction the 2002 report by the Canadian Institute of Actuaries (CIA) included calibration criteria for equity return models; these standards were developed for periods of up to ten years; for instance, models had to incorporate a probability of at least 2.5% that total return over a ten year period would be -15% or worse.

This model was updated by OSFI in October 2010[26] to incorporate a longer period of data, but only the shortest-term standards (six months and one year) were affected; longer periods were left as is. Finally, an actuarial research group provided a further update of these calibrations – produced while explicitly excluding the assumption of mean reversion – in February, 2012.[27] These revisions result in standards for modeling periods of one year that are considerably more favourable for insurance companies than the OSFI 2010 standards (and include a rather breathtaking 8% mean expected return for broadly based US indices), but these revised actuarial guidelines have not received any formal recognition by the regulator.

Regrettably, this update of the actuarial research was ignored in OSFI's mean reversion commentary, despite the fact that the 2002 CIA report explicitly permitted state-dependent models with such assumptions. Ignoring this prior material is just another example of the intellectual dishonesty pervasive in the OSFI. It will be noted that the contact person for the OSFI Mean Reversion paper, Daniel Mayost, was included in the "Designated Group" that prepared the CIA's 2012 report. Mr. Mayost declined to answer eMailed questions regarding the OSFI Mean Reversion paper.

Eighth Howler: Outdated References

OSFI provides a grand total of eight references in the paper, of which one is 2002 paper in which the severely criticized Draw Down Model was developed.

Of the other seven, the most recent is from 1993. One would think that no work has been done in the last nineteen years on the question of Equity Mean Reversion – but this is most assuredly not the case.

Conclusion

The OSFI paper held great promise as a means whereby OSFI could explain to the investing public why it made a particular decision – a practice which would allow the investing public, whose decisions constitute the "Third Pillar" of effective bank regulation, to become more familiar with OSFI's priorities and the underlying philosophy that forms the framework for its decisions.

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[26] OSFI, *Revised Guidance for Companies that Determine Segregated Fund Guarantee Capital Requirements Using an Approved Model*, October, 2010, available on-line
 at http://www.osfi-bsif.gc.ca/app/DocRepository/1/eng/guidelines/capital/advisories/sgfndreq_e.pdf
[27] Committee on Life Insurance Financial Reporting, supra.

This promise was not fulfilled. The paper resembles nothing so much as a rather sophomoric essay, throwing unrelated and outdated irrelevancies together in a mewling effort to justify the conclusion that the professor supported in class.

If OSFI wishes to gain credibility as a knowledgeable and astute regulator of the Canadian financial system, it needs to ensure that supporting discussion is of much greater quality than is provided by their efforts on Mean Reversion. There is considerable expertise available on regulatory practice in Canadian academia and the private sector, more in North America as a whole and yet more if they were to cast their net worldwide. This expertise should be harnessed in order to ensure not only that OSFI's decisions are not only based upon a standard of research that reflects the importance of their work to the Canadian economy, but are also communicated to the public in such a way as to ensure that the investing public has confidence in OSFI's decision-making process and is equipped to make informed judgments regarding the response of our financial institutions when they are again subjected to stress. It may well be that OSFI made the correct prudential decision when it prohibited models incorporating mean reversion; a decision that took into account not only the benefits of more strongly capitalized insurance companies, but also the cost to society of having all that capital tied up in one sector of the economy – but the OSFI paper is of no use to investors and consumers seeking to understand the question.

It has been less than thirty years since the last Canadian financial crisis, 1983-85, when fifteen members of the Canadian Deposit Insurance Corporation, including two banks, failed.[28] Researchers at the Bank of Canada have identified many other instances of high-stress in the Canadian banking system.[29] Attempts by regulators and investors to mitigate the effect of the next crisis must be informed by far better research than embodied by OSFI's discussion of Equity Mean Reversion.

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[28] Gerard Caprio and Daniela Klingebiel, EPISODES OF SYSTEMIC AND BORDERLINE FINANCIAL CRISES, World Bank, January 2003, available on-line at http://siteresources.worldbank.org/INTRES/Resources/469232-1107449512766/648083-1108140788422/23456_Table_on_systemic_and_non-systemic_banking_crises_January_21_2003.pdf

[29] Mark Illing and Ying Liu, *An Index of Financial Stress for Canada*, Bank of Canada Working Paper 2003-14, 2003, available on-line at http://sbisrvntweb.uqac.ca/archivage/17626842.pdf