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Converting true returns into reported returns: A general theory of linear smoothing and anti-smoothing

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ABSTRACT

In this paper, we present a unified theory of linear smoothing, which looks at the problem from a time-series perspective. We use the term 'conversion' to refer to generic operations that create a difference between true returns and reported returns. 'Smoothing' occurs when that conversion process leads to a reduction in the variance of the reported returns and we establish the conditions which guarantee smoothing. Most importantly, we discuss situations where 'anti-smoothing' can occur, i.e. reported returns become more volatile than their true counterparts. Finally, we present empirical evidence of the presence of both smoothing and anti-smoothing in returns data for a number of different classes of asset.

1. Introduction

For many assets, current valuation data are not readily available at the time when financial reporting takes place. In such cases, the analyst is forced to use an estimate of the current value. We use the term 'conversion' to refer to the generic operations by which this current estimate is created. This conversion process may result in the smoothing of the reported returns, whereby the variance of the reported returns is lower than that of the true returns. Alternatively, a counter-intuitive situation may arise whereby the conversion leads to 'anti-smoothing', which refers to a situation where the reported returns are more volatile in comparison to the true returns.

Conversion processes are most commonly used to report the performance of assets in the alternative investment domain.[1] For example, the literature has discussed the smoothing of real estate returns (e.g. Fisher et al., 1994; Geltner, 1991, 1993; Geltner et al., 2003), hedge fund (Bollen and Pool, 2008; Bollen and Whaley, 2009; Getmansky et al., 2004) and mutual fund returns

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[1] We note that self-reporting is a common feature among these asset classes. *Self-reported* performance data are collected by data vendors who solicit performance metrics from managers. The managers report these numbers to the vendors, but it is not practical for the vendors to test such data on an item by item basis.

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(Chalmers et al., 2001; Dimson, 1979; Qian, 2011), and the performance of private equity (Cumming and Walz, 2010; Cumming et al., 2012, 2013), and venture capital fund return data (Cumming, 2008; McKenzie et al., 2012; Woodward, 2009; Woodward and Hall, 2003).[2]

There are a wide range of reasons why the true and reported returns may differ. These include issues related to the use of appraisals, stale data, misreporting, and conservatism in marking to market and so on. These causes of smoothing, however, are likely to vary from one asset class to another. For example, while issues related to the use of appraisals seem to be a key feature of private equity data (Cumming et al., 2013), it does not appear relevant to venture capital (Woodward, 2009). Indeed, there may be other explanations to smoothing and this list should by no means be considered mutually exclusive or exhaustive.

Most of the existing models of smoothing focus on a *smoothing* equation that linearly relates reported returns to the true returns. The nature of this equation is typically a simple ARMA model, where the reported return is the observed variable, and the true return is the residual term, often endowed with certain properties according to the philosophical beliefs of the scholar.[3] Well-known examples include Geltner (1991), who uses an AR(1); Okunev and White (2002), who use an ARMA (1;n); and Getmansky et al. (2004), who use an MA(n). An earlier reference is Dimson (1979), who uses a similar MA(n) framework to investigate infrequent trading of shares, but in a bivariate (linear factor model) context.

In this paper, we present a unified theory of linear smoothing in asset returns. We establish the necessary conditions for smoothing to take place and we also extend the literature by proposing a new concept of *anti-smoothing*, where the variance of reported returns is not reduced, but inflated. This phenomenon is not only possible in an abstract world, but evidence of its existence can readily be found in the financial performance data of many different types of asset, including venture capital; see McKenzie et al. (2012).[4] For real-estate performance data, "smoothing" has been shown to possibly increase volatility. For example, Lai and Wang (1998) provide an explanation as to why an aggregate appraisal index may exhibit higher variance than the true index. Likewise, Edelstein and Quan (2006) examine the volatility of an aggregate real estate index, and show analytically that, depending on relevant parameter values, the volatility of the reported returns can be greater than, equal to, or less than the true volatility (see in particular their derivation in Appendix 1).

While the primary focus of this paper is on the development of a general theory of smoothing, a natural extension of this work is to consider its practical application. To this end, we also provide empirical evidence in support of our theoretical construct using a data set including venture capital, private equity, real estate and hedge fund data. As such, we view this paper as consolidating the theoretical foundations of smoothing/anti-smoothing, while our statistical analysis provides some first insights into this issue and raises a number of interesting empirical questions.

The rest of the paper is organised as follows. In Section 2, we present the fundamental structure of the smoothing problem, discussing cases where reported returns over- and under-report true returns. While the literature is not entirely clear as to when smoothing will occur, we show that in the case of linear smoothing, one can give a precise result, which we present in Section 3. Section 4 presents and discusses empirical examples of *anti-smoothing* in returns on illiquid investments. Finally, Section 5 concludes and proposes further research.

2. Some considerations with respect to return conversion

This section presents a fundamental framework of return smoothing, which we view as a conversion mechanism that converts true returns on assets into reported returns. We argue that while the standard approach often assumes equal means for true and reported returns, this is not necessary. This extension leads to a more fruitful interpretation of the problem.

2.1. Partial adjustment models

We start by considering a generic linear smoothing model,

$$r_t^* = \alpha r_{t-1}^* + (1-\alpha) r_t \tag{1}$$

where r_t^* denotes the reported return at time t, r_t is the unobservable true return, and α is the smoothing coefficient. This specification was originally proposed by Blundell and Ward (1987) in the real estate literature. The distributional assumption of r_t will be central to our subsequent analysis, and shall be discussed later on. The coefficient α is usually assumed to lie between 0 and 1, but as we will discuss shortly, the mathematical structure of Eq. (1) does not automatically impose such a restriction. Nevertheless, it does imply that the reported returns must have the same mean as the true returns, provided that the first moment exists — we call this *the full payout condition*.

We may rewrite Eq. (1) as a partial adjustment model,

$$r_t^* - r_t = \alpha (r_{t-1}^* - r_t). \tag{2}$$

[2] Note that Dimson (1979), Chalmers et al. (2001) and Qian (2011) focus on the implications of stale prices and non-synchronicity, and do not formally discuss 'smoothing'.

[3] A commonly employed assumption is that true returns are white noise due to the operation of efficient markets.

[4] Note we have previously referred to this phenomenon as 'negative smoothing'.