White Paper

Macroeconomic Effects on the Modeling of Private Capital Cash Flows

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Contents

In our previous paper discussing private capital cash flows, When Private Capital Funds Come Knocking – Guidance on Answering the "Call", a perspective on an investor's need and utilization of cash flow information was provided. As stated, the growth trajectory of this asset class has continued, leading to an increasing number of investors. Thus, the need to provide a larger number of investors (primarily in funds) with better means to assess the impact of these investments on portfolio allocations, cash flows, etc. In this paper we provide the results of the modeling efforts undertaken to address these needs and some of the methodology applied to achieve the results.

Investments in private capital are made primarily by way of funds in which investors are limited partners and the private capital firm (equity, debt, real assets) is the general partner. Private capital investments are very illiquid – there is no public trading of these securities. Another attribute of these investments is the somewhat limited lifespans of these investments, having been equated to a closed-end fund with a finite life.[1] Investors are typically institutions of differing types; pensions, foundations, endowments, etc. These investors have a need to understand prospective cashflows; maintain asset allocations, anticipate funds required to meet capital calls, and model portfolio behavior based on specific assumptions and/or stressed scenarios.

The private nature and limited lifespan of these investments provides a significant challenge to investors and researchers interested in the data on private capital investments. Because the investments are not traded on a public venue, there is little data generated beyond the data received by existing investors. Additionally, there are a limited number of commercial offerings which provide data for a fee.

The need for a better understanding of this asset class has been noted in a number of academic papers; in some cases the methodologies raised have become well utilized in industry. One of the more prominent examples, Takahashi and Alexander (2002) Illiquid Alternative Asset Fund Modeling[2], is often used along with investor and/or fund data to provide some guidance as to cash flows. The Takahashi and Alexander model, and the limited asset performance data available, provided an opportunity for FRG to develop a solution to this issue that would provide more insight and understanding of the probable cashflows intrinsic to specific fund investments.

Takahashi and Alexander (2002) utilizes a straightforward and relatively simple methodology to model the cash flows of private capital funds. The model is premised on age and the capital contribution (or capital still to be called). The model input consists of: rate of contribution, capital commitment, life of the fund, a factor describing changes in the rate of distribution over time, annual growth rate, and yield. What is missing from this model are macroeconomic variables that have been found to influence cash flows and improve the forecasting probabilities significantly.

By including fund, macro-economic, and capital markets variables (among others) we find that significant improvements can be made over a "base model" analogous to Takahashi and Alexander. These improvements include a more accurate understanding of four separate elements of the outcome, necessary for a more robust model. These four elements are:
The timing of capital calls
The magnitude of capital calls
The timing of investment distributions
The magnitude of investment distributions

These elements are constructed as individual models that, once aggregated, create the popular *J curve* commonly associated with private capital investments. This framework can be used in a simulation to allow investors to better understand the distribution of likely cash flows through time. Further, the inclusion of macro-economic variables enables scenario and stress testing analysis.

The results of the FRG model show a significant improvement over the base model in accurately forecasting of cash flows in over 98% of the quarters beginning with fund vintage year 1996 thru 2015 as reported thru 2017. This performance increase

[1] Gompers and Lerner (1999), Lerner (2001)
[2] *Takahashi* and *Alexander (2002),* The Journal of Portfolio Management Winter 2002, 28 (2) 90-100;

is consistently maintained throughout the time period examined, as well as in out of sample tests. The detailed results of the FRG model performance are contained in the "Model Results" section of the paper.

Approach

The approach taken in this paper is organized in the following sections: a review of our methodology, a description of the data applied, the results achieved and a comparison of our findings to those in a "base model", and a direct comparison with the Takahashi and Alexander model.

Review of Methodology

Takahashi and Alexander have based their model on factors that reflect aspects of the fund itself (primarily fund value and remaining capital to be called), rather than exogenous factors, e.g. macroeconomic variables. These factors used by Takahashi and Alexander not only represent a point in time but allow the model to be run periodically to account for environmental changes, for example the effect of the growth of this asset class on other variables.

While there is a body of work related to the subject of private capital cash flow[3], primarily related to private equity, FRG sought to deviate from these in both approach and underlying data. Utilizing current (at this writing) computational tools and methods allowed for an approach to this problem previously unavailable. The development, fitting, and assessment of the models has been completed using proprietary machine learning techniques.

There is a need to create not one model, but four distinct models, to completely address the four aspects of cash flows: capital call timing, capital call magnitude, distribution timing, and distribution magnitude.

Expected cash flows are:

$$E(CF_t) = E(Dist_t) - E(Call_t)$$

Expected calls and distributions are described as:

$$E(Call_t) = P\left(I_{Call,t}\right) * E(Call_t \,|I_{Call,t} = 1)$$
$$E(Dist_t) = P\left(I_{Dist,t}\right) * E(Dist_t \,|I_{Dist,t} = 1)$$

*Where $I_{X,t}$ is an indicator variable signaling that a capital call or distribution has occurred.

The reasoning behind this tact is that although there may be some relationship between the four events, by pursuing the causals for each independently FRG found that it provided a more robust outcome.
The base model is a function of the time and fund type variables and is used to assess probable cash flows of different funds. Fund type is a categorical variable, describing the fund classification. Time enters the models in a non-linear fashion to capture the complex dynamics. In this sense, the base model is more advanced than the Takahashi and Alexander model, in which time only factors into the exponential decay of expected values.

Data Description

The nature of private capital funds precludes the robust research data available to those doing work in publicly traded assets. As such, data used for research can be generated from actual investments and/or purchased from a limited number of commercial purveyors of this information. This issue of data availability is likely the reason for some of the challenges experienced by investors and researchers alike, some of which have been addressed in

[3] Takahashi and Alexander (2002), Malherbe (2004, 2005), and Buchner, Kaserer and Wagner (2009), etc.

this work. Detailed data was acquired through the commercial means mentioned, consisting of a number of historic attributes for this asset class, including:

Manager
Fund Name
Type of Fund
Geographic Focus
Vintage
Fund Size
Transaction Types
Transaction sizes
Transaction Dates

The time period (expressed in terms of the fund vintage) examined for this work were quite large beginning in 1980 and culminating in 2017 encompassing 3,990 unique funds of various types. Unlike Buchner, Kaserer, and Wagner (2009) [4] the fund universe in the analysis was not only almost 10x larger, it was also much more diversified.

In addition to the fund performance data utilized, macroeconomic and capital markets data was acquired from publicly available sources for variable assessment and application.

Model Results

As with any research of this type a detailed understanding of the subject matter, question to be answered, and solutioning was required for success. In this regard the authors have significant experience working with the assets in practice and utilizing the modeling techniques that proved most appropriate. The model development utilized accepted practices and incorporated machine learning to assist in fitting and in the assessment phase. This was confirmed through robustness tests to insure the variables selected for the modeling were appropriate.

The variables tested, and ultimately selected, allow for various iterations of the model. These iterations can be used to "stress" the models, as well as to reflect proprietary capital market and/or macroeconomic assumptions on the probable cash flows modeled. This is of interest for the private capital assets as well as to assess these characteristics in terms of a portfolio, whether constructed of private capital or diversified assets.

The nature of fund reporting and the data dictate that this type of analysis is best conducted on a quarterly basis. As such, the reporting and references are in terms of quarterly periods for the remainder of this section to provide a consistent point from which to review the findings. Below the four models are presented with the respective results to provide insight into the methodology and reasoning behind the increase in predictive power over the base case. Following these are the results of the aggregated models, which provide a complete view of the performance of the life of funds and the individual vintages.

Capital Call Timing

The illustration of the probability of a Capital Call (Fig. 1) demonstrates the out of sample improvement over the base model, a lift of .0724. As impressive as this may be Fig .2 shows that bootstrapped sampling has a significant improvement in the root mean square error (RMSE) of *P=.0001, t=405, n=100.*

[4] Axel Buchner, Christoph Kaserer and Niklas Wagner (2009), "Modeling the Cash Flow Dynamics of Private Equity Funds – Theory and Empirical Evidence"

Fig. 1

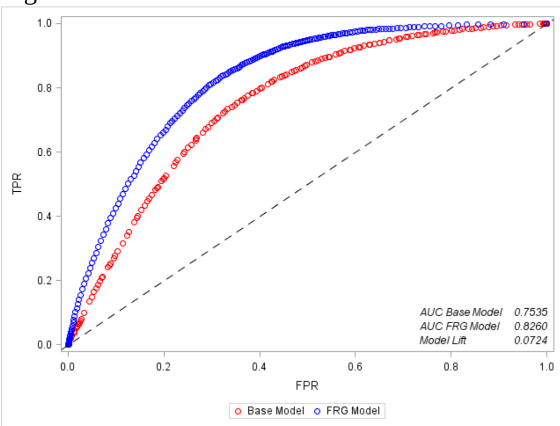
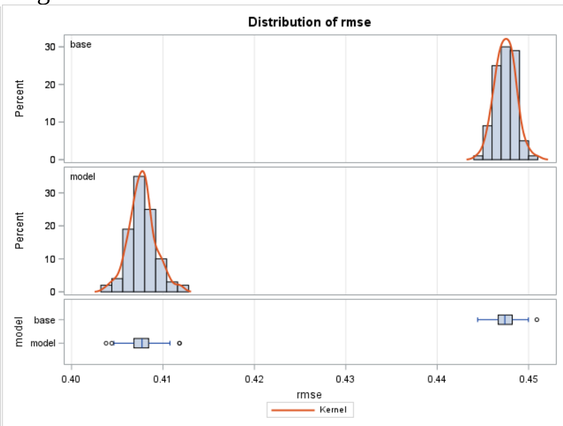


Fig. 2



Capital Distribution Timing

As is the case with the capital call, the probability of the timing of capital distribution demonstrates a significant improvement over the base model at .0876 as illustrated in Fig. 3. Just as significant is the out of sample bootstrap improvement that is illustrated in Fig. 4 of the RMSE (P=.001, t=390, n=100).

Fig 3

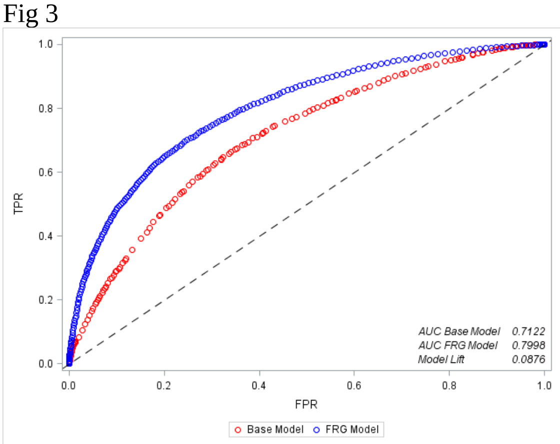
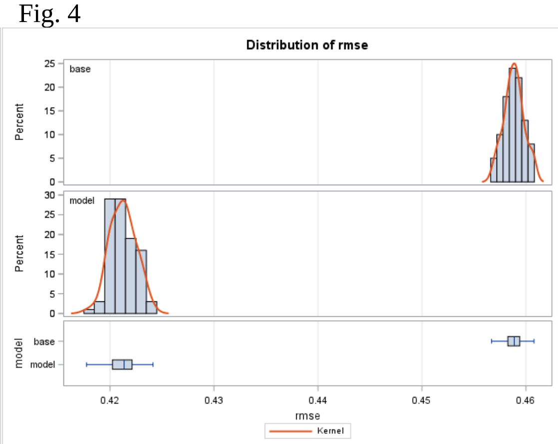


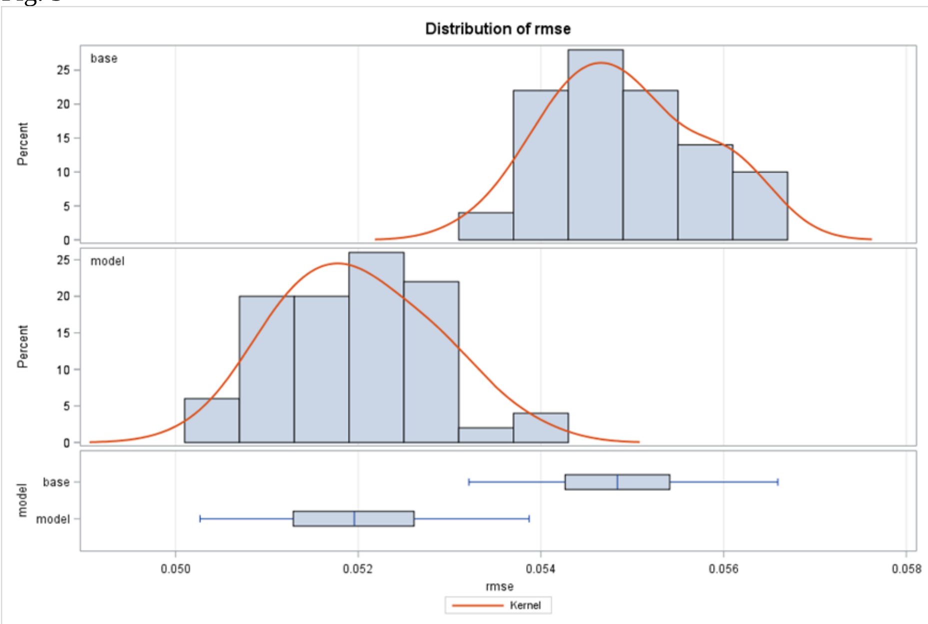
Fig. 4



Severity of Capital Calls and Distributions

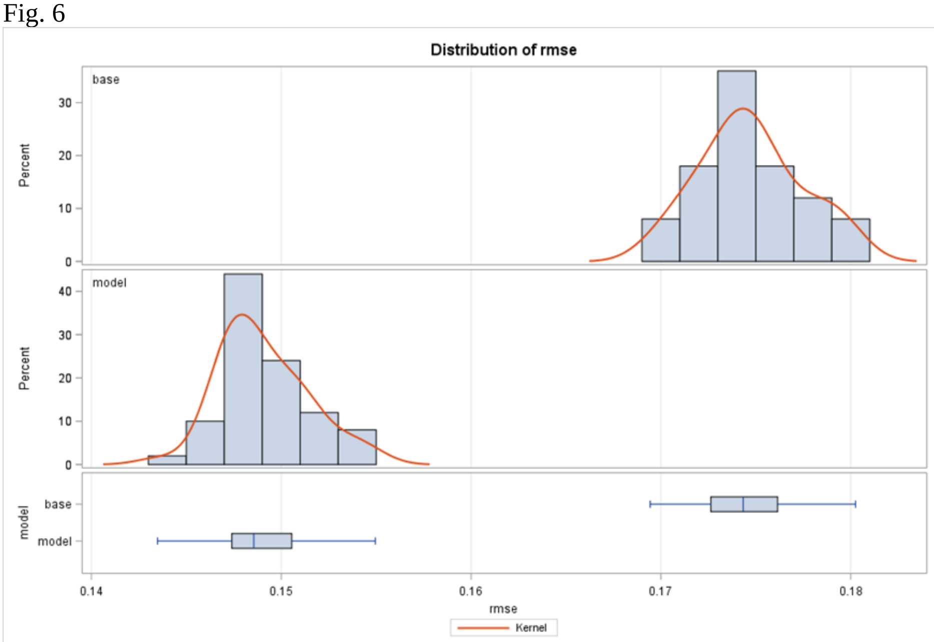
The magnitude of the calls and distributions that occur over the life of a fund are necessary to understand along with the probability of a call and/or distribution. The magnitude of the calls is illustrated in Fig. 5 and in Fig. 6 the magnitude of distributions.

Fig. 5



Bootstrapped sampling shows definitive improvement in RMSE (P < 0.0001, t=98, n=50) of capital calls.

Fig. 6



Bootstrapped sampling shows definitive improvement in RMSE (P < 0.0001, t=89, n=50) of capital distributions.

Aggregate Private Capital Model (PCM) versus Takahashi and Alexander

The results of the individual and aggregate fund cash flows reflect the *"J-curve"* familiar to readers who have worked with this particular asset class. However, a *J-curve* provides little perspective on the relative accuracy of the model versus the realized results. The use of the four individual models and the broader application of variables is best illustrated by calculating the improvement over the Takahashi and Alexander (TA) model.

Assuming a $10,000,000 commitment to each fund, the FRG model and the TA model next period forecasts are calculated. The difference or residual in actual and forecasted dollar amounts are compared. The improvement in the FRG model over the TA model is given by

$$Improvement = |Residual\ TA| - |Residual\ FRG|$$

The improvements are averaged across observed years and fund vintage. Fig. 7 lists these values.

Fig. 7

vintage	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1996	$9,128	($22,145)	$45,727	$774,024	$354,121	$424,438	$535,540	$536,352	$699,504	$801,879	$840,455
1997	$38,053	($1,017)	($81,154)	$52,947	$150,694	$288,402	$436,036	$503,185	$641,558	$756,321	$838,036
1998	.	$19,185	$12,459	($2,640)	$61,554	$96,682	$237,119	$301,188	$471,712	$568,355	$792,737
1999	.	.	$28,908	$45,547	$17,370	$13,521	$61,975	$124,941	$289,797	$443,465	$695,114
2000	.	.	.	$15,261	$104,070	$43,707	$5,292	$65,757	$236,300	$495,364	$866,716
2001	.	.	.	.	$177,003	$108,639	$15,235	$18,540	$132,452	$251,520	$582,342
2002	.	.	.	.	.	$144,429	$70,990	($1,692)	($856)	$97,943	$349,286
2003	.	.	.	.	.	.	$121,433	($13,038)	($64,643)	$2,018	$96,785
2004	.	.	.	.	.	.	.	$80,887	$24,622	($29,103)	$14,053
2005	.	.	.	.	.	.	.	.	$64,502	$7,865	($11,261)
2006	.	.	.	.	.	.	.	.	.	$69,820	$5,251
2007	.	.	.	.	.	.	.	.	.	.	$51,325

vintage	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1996	$876,588	$495,453	$525,491	$674,902	$445,652	.	.	.	.	.
1997	$998,151	$1,176,141	$1,223,915	$1,240,824	$698,210	$694,545	.	.	.	.
1998	$1,011,166	$1,285,613	$1,226,075	$1,071,186	$1,060,779	$870,355	$823,096	.	.	.
1999	$1,072,942	$1,276,590	$1,382,119	$1,414,579	$1,393,874	$1,195,013	$1,393,251	$2,519,336	.	.
2000	$1,348,478	$1,672,487	$1,730,692	$1,874,510	$1,878,242	$2,027,169	$2,083,566	$2,068,528	$2,237,865	.
2001	$1,072,981	$1,403,311	$1,618,839	$2,001,762	$2,147,502	$2,187,165	$2,383,582	$2,233,017	$2,223,060	$914,283
2002	$736,313	$1,140,868	$1,278,758	$1,632,774	$1,741,055	$1,976,585	$2,280,354	$2,097,947	$1,955,687	$1,680,199
2003	$317,654	$638,989	$820,426	$1,147,393	$1,466,299	$1,709,200	$1,943,546	$2,103,420	$2,261,287	$1,982,233
2004	$143,777	$435,252	$616,183	$1,172,688	$1,619,579	$1,967,553	$2,473,780	$2,535,693	$2,444,061	$2,459,056
2005	$30,988	$145,858	$280,683	$595,339	$965,730	$1,381,860	$1,832,781	$2,200,951	$2,333,301	$2,402,835
2006	$13,279	$56,409	$125,969	$353,739	$620,112	$943,590	$1,343,835	$1,627,253	$1,828,660	$1,921,377
2007	$52,715	$82,414	$45,229	$145,775	$336,138	$717,693	$1,094,831	$1,529,100	$1,996,827	$2,000,663
2008	$90,083	$166,693	$12,981	$40,644	$158,225	$350,823	$661,202	$1,142,221	$1,501,058	$1,625,491
2009	.	$233,635	$71,119	$36,170	$37,865	$184,629	$399,010	$670,638	$1,074,710	$1,178,251
2010	.	.	$58,982	$55,697	$12,459	$45,075	$123,867	$283,693	$585,881	$801,149
2011	.	.	.	$70,524	$29,624	$29,300	$39,827	$198,243	$445,684	$788,111
2012	.	.	.	.	$35,006	$73,346	$18,049	$71,175	$206,290	$357,866
2013	.	.	.	.	.	$105,779	$50,316	$8,486	$46,031	$95,883
2014	.	.	.	.	.	.	$60,462	$44,534	$23,564	$58,324
2015	.	.	.	.	.	.	.	$56,781	$43,433	$11,313
2016	.	.	.	.	.	.	.	.	$48,508	$67,634
2017	.	.	.	.	.	.	.	.	.	$52,689

The table above (Fig. 7) is the average quarterly forecasting improvement of the FRG model over the Takahashi and Alexander model. The table is structured by the observed year in each column with each row reflecting a specific fund vintage year. The performance of the model over the time frame illustrated is important from several perspectives. The first is the consistency observed throughout the vintages, this is made more so by the significant change in the size and complexion of this asset class. The second are the dramatic changes in the economic environment that the analysis period covers; from the DOT.COM boom/bust, to the financial crisis, to the period of Quantitative Easing, the model performs in a variety of economic situations. Lastly is the spectrum of funds incorporated in the analysis, the universe is not limited to a specific type of fund.

Summary

The Private Capital Model presented here displays significant improvements to one of the most common models used in academia and industry to forecast private capital cash flows. FRG's unique use of separate models and macroeconomic (and other) variables, allows for the user to model various conditions. The historic analysis was conducted on almost 4,000 funds of different types and vintages, illustrating the model's consistent performance in a number of different economic conditions.

More Information

FRG would welcome the opportunity to speak with you concerning the findings of this paper, as well as how the approaches developed may fit into specific environments. For more information contact the FRG Research Institute at Research@frgrisk.com or 919.439.3819.

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