The Capacity of an Equity Strategy

Defining and estimating.

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As emerging markets posted strong returns in recent years, a number of emerging markets equity managers have experienced both tremendous interest in their strategies and large inflows of new money. Given the relative illiquidity of the asset class, a number of firms have closed their emerging markets equity strategies in recent months.

The decision to close a strategy is an important one for an investment management firm, for it affects many aspects of its operations. From a business standpoint, closing a strategy limits the amount of revenues and therefore the profits the firm can extract from it. From an investment management standpoint, closing a strategy preserves its ability to deliver value added (or alpha). From a marketing standpoint, closing a strategy improves the firm's brand by reinforcing the firm's integrity in the eyes of the marketplace and its commitment to putting its clients' interests ahead of its profit motives.

Theoretically, a strategy is closed when it reaches capacity, yet clearly defining and measuring capacity has been an elusive goal.

WHAT IS CAPACITY?

The basic idea behind the concept of capacity is that the cost of implementing a strategy will increase with assets under management (AUM), thereby eroding the strategy's ability to generate alpha.

Capacity is very hard to measure. The main problem is that the level of AUM is only one of many factors

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affecting the performance of a strategy. In the case of a strategy with a clear style bias (e.g., value, growth, or momentum), an increase in AUM might coincide with a time that style is in favor. This leads to an overestimation of the true capacity of the strategy.

Characteristics imposed upon a strategy by increasing AUM might also affect performance and thus the estimation of capacity. For example, as AUM increase, a strategy will gradually gravitate toward stocks and countries with greater liquidity. If countries and stocks with greater liquidity happen to be performing well as the strategy tilts toward them, one would tend to overestimate capacity.

Finally, the issue of capacity is usually a consequence of large flows into a strategy because of the popularity of its style or asset class. The very performance of the strategy might have been driven by large inflows into the strategy. This could lead to unrealistic assumptions as to the alpha of the strategy once interest in that style or asset class moderates or reverses.

One reasonable way to study capacity is in a simulated environment, allowing the same strategy to be implemented under the same historical circumstances while changing only one control variable—AUM. Yet we need to be cautious about interpreting the results obtained through historical simulations.

DEFINING CAPACITY

In order to study capacity one first needs to define it. If we define capacity as the amount of AUM that maximizes alpha, an argument could be made that capacity is effectively zero, as Perold and Salomon [1991] point out. When a paper portfolio is implemented as an actual portfolio, we see a significant deterioration in alpha that gradually increases as AUM grow.

One could argue there are efficiencies of scale, especially for custody and ticket costs, but also in terms of negotiating better commission rates with brokers. For our purposes, I assume that economies of scale are fully realized by the time one reaches $1 billion in AUM. If *implementation capacity* is the asset level at which those efficiencies are fully realized, the implementation capacity would have very little relationship to the alpha the strategy might be able to deliver.

We therefore need a different definition of capacity. I propose three—threshold capacity, wealth-maximizing capacity, and terminal capacity.

Threshold capacity is defined as the amount of AUM beyond which a strategy is no longer able to achieve its stated investment return objectives. Let's assume the investment return objective is 5% annualized alpha net of transaction costs (but gross of management fees) over a business cycle.

Wealth-maximizing capacity is defined as the AUM that maximize the amount of wealth created (alpha times AUM), where alpha is net of transaction costs. Perold and Salomon [1991] argue that the right amount of AUM is the wealth-maximizing capacity. Alpha is assumed to be declining more than linearly as AUM increase, and wealth created increases with AUM even as alpha declines, at least up to the wealth-maximizing capacity.[1]

Terminal capacity is defined as the level of AUM that reduces the net alpha to zero; in other words, the amount of AUM that causes transaction costs to be as high as the alpha the strategy can potentially deliver. At terminal capacity, the alpha delivered after implementation costs is zero.

Note that in the absence of performance fees the aim of maximizing the investment management firm's revenues would lead to amassing assets in excess of even the terminal capacity (at least until its clients finally recognize the problem and make the decision to move their assets somewhere else). The financial incentives for the typical investment management firm are therefore to gather assets in excess of the wealth-maximizing or threshold capacities.

I believe the appropriate definition of capacity is the threshold capacity based on the strategy's investment objectives. An investment management firm should close a strategy when the AUM in a strategy reach a point beyond which the strategy's ability to deliver on its stated return objectives would be compromised.

CAPACITY IS NOT A NUMBER

Increasing AUM causes two problems, one linked to the trading activity required to implement the strategy, and one linked to the size of the positions being accumulated in the portfolio. These two problems will suggest two complementary methodologies for estimating the capacity of a strategy.

Even if we are using simulations to determine the capacity of an equity strategy according to the chosen methodology, we still have a number of choices to make. What time period are we going to use to estimate capacity? What assumptions will we make for various components of transaction costs? Are we going to scale down the simulation alpha by a certain factor to reflect the

EXHIBIT 1
Simulation Results

AUM (in $B)	Alpha	Net Alpha	Transaction Costs	Net Value Added (in $M)	Turnover
1	11.10%	9.42%	1.68%	94.2	119.7%
2	10.71%	8.74%	1.97%	174.8	105.3%
3	10.40%	8.29%	2.11%	248.7	96.1%
4	10.17%	7.96%	2.21%	318.4	89.5%
5	9.96%	7.69%	2.27%	384.5	84.5%
6	9.76%	7.44%	2.32%	446.4	80.3%
7	9.58%	7.21%	2.37%	504.7	76.9%
8	9.40%	7.00%	2.40%	560.0	73.9%
9	9.23%	6.81%	2.42%	612.9	71.3%
10	9.08%	6.63%	2.45%	663.0	69.1%
11	8.93%	6.46%	2.47%	710.6	67.1%
12	8.79%	6.29%	2.50%	754.8	65.3%
13	8.65%	6.13%	2.52%	796.9	63.7%
14	8.53%	6.00%	2.53%	840.0	62.2%
15	8.41%	5.86%	2.55%	879.0	60.8%
16	8.29%	5.72%	2.57%	915.2	59.6%
17	8.17%	5.60%	2.57%	952.0	58.4%
18	8.06%	5.47%	2.59%	984.6	53.0%
19	7.96%	5.34%	2.62%	1014.6	56.3%
20	7.86%	5.24%	2.62%	1048.0	55.4%

disappointing real-life performance of a typical back-tested simulation?

Given all these possible choices, capacity (threshold, wealth-maximizing, or terminal) should not be viewed as an exact number but as a range of possible estimates.

CAPACITY THROUGH THE LENS OF TRANSACTION COSTS

For simplicity, I will use only one estimate of capacity for each of the two methodologies suggested above. The estimates are built using the time period January 1993 – December 2004, with our best estimate of transaction costs.

Let's initially tackle the first problem caused by increasing AUM and look at capacity through the lens of transaction costs. The capacity of a quantitative equity strategy is more easily studied as it lends itself to historical simulations. We can run the same strategy through the exact same historical circumstances changing only one variable—AUM.[2]

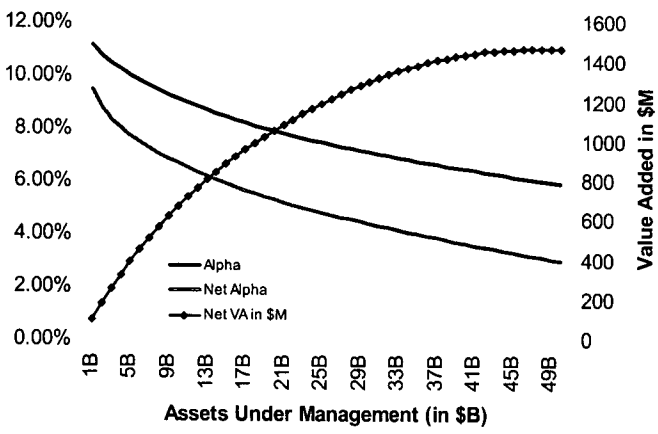
I use the S&P/IFC Investable Composite as the benchmark and the universe. I run a monthly optimization trading off: alpha (based on the attractiveness of the country of membership and the value and momentum characteristics of a stock); the risk of deviating from the benchmark along a number of risk dimensions (countries, MSCI sectors, and size); and the cost of trading. There are penalties for trading and holding large illiquid positions.

The simulations for January 1993 through December 2004 increase AUM by $1B each time. As AUM increase, the optimizer gives up some alpha in order to reduce both transaction costs and the concentration of the portfolio, which results in a reduction in turnover.

The transaction costs assumptions are 20 basis points for commission costs and 30 bp for each 10% of average daily volume traded—a conservative estimate according to our experience investing in emerging markets. I then measure the realized annualized alpha of the simulated portfolios over the period under study for each level of AUM.

The results are in Exhibit 1. As AUM increase, the optimizer gives up some alpha in order to control transaction costs. Net value added is simply the product of net alpha and AUM—the total dollar amount extracted from the inefficiencies of the market by the strategy.

EXHIBIT 2
Effect of Increasing AUM on Alpha and Value Added



According to our definition, the threshold capacity is around $22 billion, and the wealth-maximizing capacity is around $50B; see Exhibit 2. Since the portfolio construction process is aware of the increasing market impact costs as AUM increase, it will gradually move toward holding the benchmark, effectively becoming an index fund. In other words, the terminal capacity is infinite.

Clearly, these estimates of capacity are based on the results of a series of historical simulations (backtests). Yet it is dangerous to take the results of simulated investment strategies at face value. However realistic a transaction cost assumption in a simulation may be, or however carefully one avoids survivorship biases, look-back biases, excessive data mining, and other backtesting foibles, real-life investment strategies always seem to fall short of the expectations created by the historical simulations that led to their development.

To say that the threshold capacity is $22 billion, or that the wealth-maximizing capacity is $50B, we must trust the accuracy of the historical simulations, a dangerous leap of faith indeed. So, rather than trusting the accuracy of the net alpha obtained by the historical simulations, we could look at the *rate* at which net alphas deteriorate with increases in AUM. Notice, for example, that going from AUM of $1B to $6B causes roughly a 20% deterioration in net alpha, and increasing AUM from $1B to $10B causes a 30% deterioration.

Let's assume we manage to run a real-life strategy that exactly delivers on its investment return objective of 5% net alpha annualized since inception with a median of $1B under management. Then we could say that the threshold capacity of the strategy is $1B, because we know from the historical simulation that any increase in AUM beyond $1B would have caused deterioration in performance, and therefore would have prevented the strategy from delivering on its investment return objective.

If, on the other hand, the same strategy had delivered, say, 6.2% annualized since inception, then, based on the rate at which the net alpha deteriorated in our historical simulations, we could assume that the strategy has a threshold capacity of $6B. In other words, since the strategy delivers 20% more than promised with $1B under management, and knowing from the historical simulation that going from $1B to $6B costs a 20% reduction in net alpha, we could conclude that the same deterioration in performance would have occurred in the real-life strategy due to a similar increase in AUM.

It is important to realize that this particular simulation and the capacity estimates derived from it are very much a function of the specific strategy tested. A strategy that relies more heavily on momentum, for example, would lead, according to this method, to a lower estimate of capacity, because the strategy would require a higher turnover to be implemented than a strategy with a greater emphasis on value.

CAPACITY THROUGH THE LENS OF BREADTH

The second problem with increasing AUM is the accumulation of large illiquid positions in the portfolio. This problem suggests one more way to look at capacity, which has to do with possible constraints on the percentage ownership of stocks in the portfolio. The issue with capacity, in the final analysis, is being unable to buy enough of the stocks one likes, and therefore having to buy and own the second-best ideas, and third-best, and so on.

We define concentration as follows:

$$C = \sum_i W_{pi} \left(\frac{W_{pi}}{W_{bi}} \right) \tag{1}$$

where W_{pi} is the weight of asset i in the managed portfolio, and W_{bi} is the weight of asset i in the benchmark portfolio.

Concentration is a measure of the ratio between the average weight of the assets held in the portfolio over their weight in the benchmark (in fact, it is the weighted average of that ratio weighted by the portfolio weights). For example, a portfolio concentration of five means that the portfolio weight in an asset is on average roughly

EXHIBIT 3
Alpha, Transaction Costs, and Turnover as a Function of Breadth 1/93 – 12/04

Breadth	Concentration	Gross Alpha	Alpha Net of Transaction Costs	Turnover
10%	10.0	15.9%	12.8%	130%
15%	6.7	14.7%	11.9%	129%
20%	5.0	13.5%	11.1%	126%
25%	4.0	12.3%	10.2%	121%
30%	3.3	11.1%	9.3%	116%
35%	2.9	10.0%	8.5%	109%
40%	2.5	9.0%	7.6%	102%
45%	2.2	7.9%	6.8%	94%
50%	2.0	6.8%	5.8%	85%
55%	1.8	5.4%	4.6%	74%
60%	1.7	3.5%	2.9%	57%

five times its benchmark weight. This measure of concentration can be interpreted as the distance between the portfolio and the benchmark.[3]

If the portfolio has a concentration of one, it is identical to the benchmark, for each asset must be held at exactly the benchmark weight. The only way to take active positions is to hold some stocks at higher weight than their benchmark weight.

Therefore, to achieve a certain level of alpha, the portfolio needs to have a certain level of concentration. Given a minimum required concentration, the amount of capital that can be deployed in a strategy is determined by the percentage of the free float of a stock one is willing to hold. For example, if one is required to have a minimum concentration of three, and one is not willing to hold more than 1% of the free float of a stock, the maximum amount of capital one can deploy in the strategy is 33 basis points of the total free float of the market.[4]

Next we need to study the relationship between alpha and concentration to determine the minimum level of concentration that would allow us to still deliver 5% alpha net of transaction costs. Let's define breadth as the inverse of the concentration:[5]

$$B = \frac{1}{C} \tag{2}$$

Exhibit 3 shows the results of a number of simulations using the same inputs as before but targeting a certain level of breadth. If we trust the numbers from the backtest, it would seem we can deliver an alpha net of transaction costs of about 5% with a breadth in the neighborhood of 50% to 55%.[6]

If that's the case, we would be looking at the capacity as in Exhibit 4. Let's assume we are comfortable with holding on average 3% of the outstanding capitalization of a stock. Then, if we trust the backtest, the threshold capacity seems to be around $23B. If we don't trust the numbers from the backtest (which would be a wise precaution), we can use the slippage method noted earlier.

Again, let's assume that the hypothetical strategy has delivered 6.2% alpha annualized since inception with a breadth of 17%. We can then look at a breadth increase from 17%, which would cause a 20% decline in alpha. According to our analysis, moving from a breadth of 17% to a breadth of 30% would cause a 20% slippage in alpha.

In other words, if a strategy delivers 6.2% with a breadth of 17%, it could have delivered 5% with a breadth of 30%. Therefore, the threshold capacity for the strategy would be as in Exhibit 5, based on the maximum percentage of the free float of a stock one is willing to hold.

If one settles on a maximum ownership of 3% of the free float of a stock, the threshold capacity for the strategy according to the liquidity method would be around $13 billion.

CAPACITY OVER TIME

An estimate of capacity is a function of current market conditions. Anyone who has managed an emerging markets equity strategy for a few years knows that managing $2 billion during the Asian crisis of 1997 was a completely different experience from managing $2B at

EXHIBIT 4

Breadth and Concentration

A. Capacity as a Percentage of Market Capitalization

		Max Holding as Percentage of Float				
		1%	2%	3%	4%	5%
Portfolio Breadth	45%	0.45%	0.90%	1.35%	1.80%	2.25%
	50%	0.50%	1.00%	1.50%	2.00%	2.50%
	55%	0.55%	1.10%	1.65%	2.20%	2.75%
	60%	0.60%	1.20%	1.80%	2.40%	3.00%

B. Capacity in $M (based on S&P/IFCI market capitalization as of 12/31/2004)

		Max Holding as Percentage of Float				
		1%	2%	3%	4%	5%
Portfolio Breadth	45%	6,567	13,135	**19,702**	26,269	32,837
	50%	7,297	14,594	**21,891**	29,188	36,485
	55%	8,027	16,054	**24,080**	32,107	40,134
	60%	8,756	17,513	**26,269**	35,026	43,782

EXHIBIT 5

Portfolio Breadth of 30%

A. Capacity as Percentage of Market Capitalization

Max Holding As Percentage of Float				
1%	2%	3%	4%	5%
0.3%	0.6%	0.9%	1.2%	1.5%

B. Capacity in $M (based on S&P/IFCI market capitalization as of 12/31/2004)

Max Holding As Percentage of Float				
1%	2%	3%	4%	5%
4,378	8,756	13,135	17,513	21,891

the end of 2004, when trading volumes were high and market cap had been increasing.

On a macroeconomic level, the two main drivers of capacity are total investable market capitalization and total investable trading volume. Our estimates of capacity assume the market conditions as of year-end 2004. The capacity estimates derived looking at the impact of trading should therefore be indexed over time on the total investable trading volume. The capacity estimates derived looking at the impact of accumulating large positions should be indexed on the total investable market capitalization.

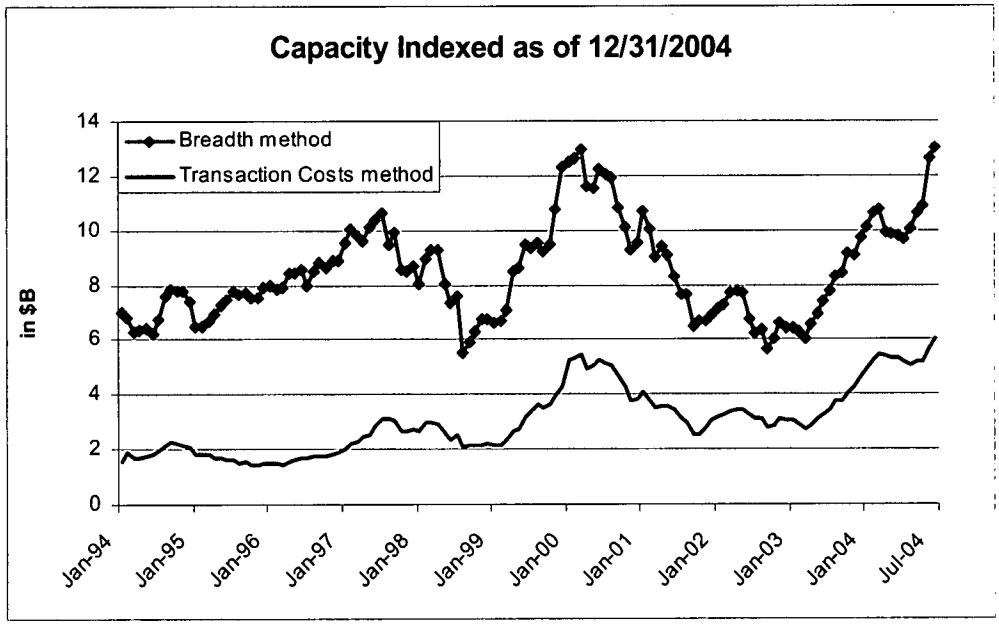
Exhibit 6 graphs the way this looks.

So we now have a dynamic range of possible estimates for capacity that provides a guide for determining when to close a strategy. Clearly, measures to control the inflows into a strategy and a plan for closing it should be put in place as the level of AUM approaches the lower bound of the range of capacity estimates. The strategy should be hard-closed (closed to all inflows) by the time it approaches the high end of the range.

A number of factors can modify the capacity constraints on a hard-closed strategy. First, a hard-closed strategy would be in redemption-only mode, so as clients rebalance their allocations to emerging markets, the AUM would decline relative to the indexed capacity estimates. Note that if the market goes up 10%, chances are the AUM in the strategy would also appreciate by about 10% (the difference would be due to the strategy's alpha), so the position of the AUM relative to the indexed estimate of capacity based on the breadth method does not change significantly with market moves. But new capital issuance would have the effect of increasing the capacity of a strategy according to both estimation methods (consider the recent slew of IPOs in India and China or relaxation of the Limited Investability Factor in Taiwan). Also, any increase in the overall trading volume brought about by an increase in the average shares turnover would boost the transaction cost-based capacity estimate.

On the other hand, if and when a country graduates to developed status—Korea seems the most likely candidate in the next five years—it will remove a percentage of any emerging market benchmark liquidity and capitalization, effectively reducing the capacity of all emerging markets strategies. In the case of Korea, the

EXHIBIT 6
Capacity Estimates over Time



reduction in capacity would be somewhere between 20% and 30%.

CONCLUSIONS

I have attempted to define the concept of capacity more clearly, and have proposed two ways to estimate capacity of a quantitative equity strategy. The work shows there is no exact answer to the question of the capacity of a strategy.

Yet, granted the uncertainty around an estimate, in order to preserve a firm's ability to deliver on its stated investment objectives, we must have a framework for monitoring the capacity of a strategy and guiding decisions to close or reopen a strategy.

ENDNOTES

The author thanks Forrest Berkley, Paul Bostock, Jack Gray, Tom Hancock, Simon Harris, Ben Inker, and Sam Wilderman for helpful comments and discussion.

[1]Market impact costs are assumed to grow more than linearly with AUM, and thus alpha declines more than linearly with increases in AUM.

[2]In a quantitative investment process, investment decisions are to a great extent automated, so one can know with greater certainty what *would* have occurred historically.

[3]If the benchmark and the portfolio are equal-weighted, a portfolio with concentration C will own stocks at exactly C times their weight in the benchmark. If the benchmark or the portfolio is not equal-weighted, the relation is only approximately true.

[4]If on average we have to hold at least three times the benchmark weight in a stock, then we would have to hold all the stocks at three times their benchmark weight to maximize the capital we can deploy in the strategy. This means that we would hold in the portfolio stocks representing 33% of the market capitalization (we are assuming the portfolio has only long positions and is fully invested). Since we want to hold only 1% of the free float, the maximum amount of AUM in the strategy would be 33 basis points (33% × 1%) of the total market free float.

[5]The nice thing about breadth is that it goes from 0 to 1 (or 100%) while concentration goes from 1 to potentially a very large number (if the portfolio holds only one stock with a tiny weight in the benchmark).

[6]This, by the way, would mean that the strategy can hold stocks representing about half of the market capitalization.

REFERENCE

Perold, Andre, and Robert Salomon. "The Right Amount of Assets Under Management." *Financial Analysts Journal*, May/June 1991, pp. 31-39.