Implementation Shortfall

From concept to practice.

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Implementation shortfall has become the industry standard for evaluation of portfolio transitions. Perold [1988] introduced the notion, which he defines as the difference between the calculated performance of a paper portfolio and the actual performance of an identical real portfolio based on actual market transactions. Perold's key innovation was to extend the traditional perception of transaction costs to incorporate the opportunity cost of delaying the sale of a security intended for disposition or the purchase of a security targeted for acquisition.

We present a comprehensive empirical analysis of implementation shortfall using a unique sample of individual security transactions. The sample includes detailed information for more than 800,000 transactions, including information about how the trades were implemented. Beyond the empirical analysis, we introduce an adjustment to implementation shortfall to account for liquidity and risk, based on a smaller sample of transition-level data. We argue that without adjustment it is impossible to compare the quality of portfolio transitions.

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DATA AND METHODOLOGY

Institutional investors reallocate portfolios periodically to shift their asset mix, reshuffle investment managers, deploy new cash flows, or disburse funds. They face a variety of costs when they undertake these transitions, including commissions, bid-ask spreads, market impact, opportunity cost, taxes, and foreign exchange costs. Market impact and opportunity cost account for most of the cost. Market impact refers to the adverse price movement that occurs in response to the purchase and sale of securities,

while opportunity cost refers to price movements arising from exogenous forces.

In an effort to contain these costs, many institutional investors retain transition managers to implement reallocations. Transition managers implement portfolio transitions cost-effectively because they cross many trades internally rather than trade the securities in the open market, thereby avoiding commissions and bid-ask spreads and reducing market impact and opportunity cost.

We analyze 1,541 equity transitions performed by the world's leading transition manager during the period from January 2004 through January 2006. The sample includes 877,657 buy and sell transactions covering 10,070 securities in 10 sectors and 64 countries. The total value traded exceeds $300 billion.

For each of these transitions we begin by recording the prices of the securities to be bought and sold as of the inception of the transition. These prices are called the *benchmark prices*. We then track the performance of the securities in the target portfolio, assuming they are acquired instantaneously without cost. We also track the performance of the securities in the actual portfolio, which represents a shifting mix between the legacy portfolio and the target portfolio until the completion of the transition, when it is allocated entirely to the target portfolio.

The performance of the securities in the actual portfolio is diluted by explicit costs, such as commissions, bid-ask spreads, taxes, and foreign exchange costs. It is also impacted by the implicit cost of transacting at prices that differ from the benchmark prices. These differences arise from market impact and opportunity cost.

Equation (1) shows how implementation shortfall is related to these costs for the purchase and sale of a single security:

$$\text{Shortfall when Buying} = \frac{P - P^{\text{Bought}} - C - O}{V_0}$$

$$\text{Shortfall when Selling} = \frac{P^{\text{Sold}} - P - C - O}{V_0} \qquad (1)$$

where:

P = benchmark price;
P^{Bought} = transaction price of a purchase (reflects bid-ask spread, market impact, and opportunity cost);
C = commission;
O = other costs, including taxes and foreign exchange costs;
V_0 = initial value of position; and
P^{Sold} = transaction price of a sale (reflects bid-ask spread, market impact, and opportunity cost).

Commissions are quoted in cents per share or basis points, while the bid-ask spread is based on the Bloomberg quote, which we divide by two. The implicit costs comprise market impact and opportunity cost, which we estimate as total shortfall less commissions, bid-ask spreads, taxes, and foreign exchange costs. It is not possible to separate market impact from opportunity cost without modeling market impact. We therefore choose to bundle these implicit costs.

IMPLEMENTATION SHORTFALL BY COMPONENT AND BY METHOD OF TRADING

Our analysis discloses the components of implementation shortfall for three different methods of trading: internal crosses, external crosses, and market trades. An *internal cross* is a transaction that uses the internal flow of the transition manager. The transition manager matches buy and sell orders from a transition with orders arising from the management of its own index funds, or the manager crosses buy and sell orders of one transition with orders of other transitions that occur during the same period. There are no commissions or bid-ask spread associated with internal crosses. Although commissions and bid-ask spreads represent only a small fraction of total cost, on a risk-adjusted basis internal crossing offers substantial savings.

An *external cross* is a trade that occurs over a buy-side-to-buy side electronic crossing network. A *market trade* is a trade executed by a broker at a securities exchange.

Exhibit 1 shows weighted average shortfall by component and by method of trading for our sample of 877,657 transactions across 10,070 different securities. Implicit cost includes market impact and opportunity cost; other costs are taxes and foreign exchange costs.

There are no commissions or bid-ask spreads associated with internal crosses, and there are no bid-ask spreads associated with external crosses. Bid-ask spreads apply only to trades that occur in the open market.

EXHIBIT 1

Implementation Shortfall (basis points)

	Internal Cross	External Cross	Market Trade
Commissions	0.0	5.1	5.2
Bid–Ask Spreads	0.0	0.0	8.7
Implicit Costs	6.5	24.7	24.5
Other Costs	0.6	1.0	1.1
Implementation Shortfall	7.1	30.8	39.6

Our results show that internal crossing produces substantially less implementation shortfall than other methods of trading. This advantage arises in part from the absence of commissions and bid-ask spreads, but the great majority of this benefit reflects lower implicit costs.

There are two reasons for lower implicit costs. Transition managers first seek to cross trades internally before resorting to external crossing networks or the open market. As a result of this priority, internal crosses are likely to occur earlier in the transition than external crosses and market trades. They are therefore less vulnerable to opportunity cost, which increases approximately with the square root of time. Internal crosses also may have lower implicit costs because these trades do not leave a footprint. They occur away from the market and away from public crossing networks, which reduces the likelihood that information will be conveyed to the market.

Our results also show that external crossing suffers less from implementation shortfall than market trading, which is explained almost entirely by the bid-ask spreads associated with market trading.

ADJUSTED IMPLEMENTATION SHORTFALL

It may be tempting to conclude that a smaller implementation shortfall signifies that a transition manager executed a portfolio transition more efficiently than a transition manager who experienced greater shortfall, but such a comparison fails to account for the relative difficulty of the transitions. It is costlier to trade small stocks, growth stocks, and illiquid stocks, for example. Therefore, we should expect an emerging market transition to be more expensive than a transition involving large U.S. stocks.

It thus makes sense to adjust the implementation shortfall of transitions to account for difficulty, just as we risk-adjust the performance of investment managers by computing a Sharpe ratio, Jensen's alpha, or an information ratio. We propose a method of adjustment that scales implementation shortfall as a function of illiquidity and tracking error. Illiquidity is the main determinant of market impact costs, while tracking error between the legacy and target portfolios corresponds directly to opportunity cost.

We use information from 402 transitions to measure the sensitivity of implementation shortfall to illiquidity and tracking error and to calibrate the adjustment we propose.[1] These transitions occurred between May 25, 2005, and January 12, 2006, and represent over $90 billion in total value traded. They include: two-sided transitions, where the manager shifts from a legacy portfolio to a target portfolio; buy-in transitions, where the manager deploys cash to purchase a target portfolio; and liquidations, where the manager sells a legacy portfolio for cash.

EXHIBIT 2
Implementation Shortfall and Implicit Costs

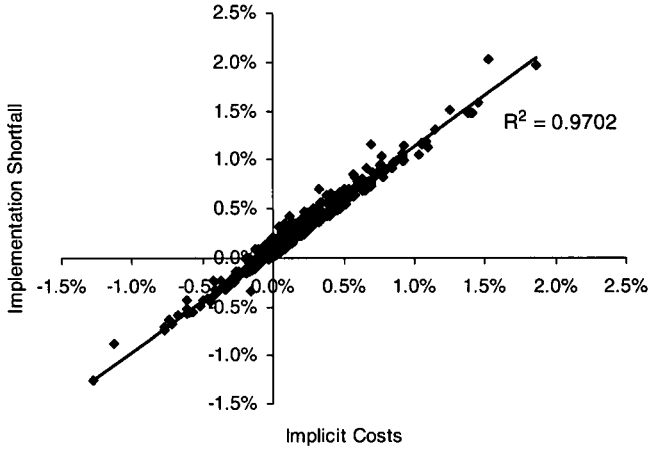


Exhibit 2 shows that these implicit costs explain over 97% of the variation in implementation shortfall across the 402 transitions.

To adjust implementation shortfall for illiquidity, we begin by describing market impact as a function of trade size and average daily volume:

$$MI = kV^{\gamma}$$
$$\textit{with}$$
$$k > 0,\ 0 \le \gamma \le 1 \qquad (2)$$

where V = the weighted average by trade size of the ratio of trade size to average daily volume for a transition.

This market impact function is widely used both by academics and practitioners.[2] We use a value of 1/2 for the parameter γ, following Loeb [1983], Barra's "Market Impact Handbook" [1997], Grinold and Kahn [1999], Hasbrouck and Seppi [2001], and Gabaix et al. [2003, 2005]. The coefficient k is a scaling factor that we estimate empirically, assuming opportunity cost is the residual of total shortfall less explicit costs and market impact, and that on average it should approach 0. We find that $k = 0.0079758$. Exhibit 3 shows the resulting function applied to our sample of transitions.

Transition managers face the risk that the price of the legacy portfolio will drift down relative to the target portfolio or that the price of the target portfolio will drift up relative to the legacy portfolio before the transition is

EXHIBIT 3
Market Impact Function

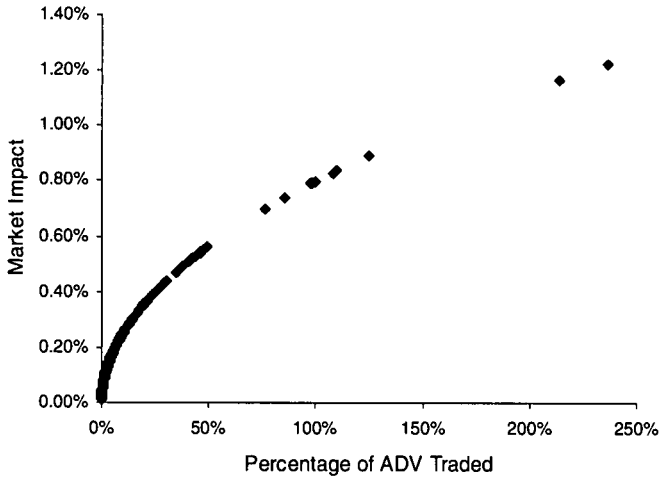


EXHIBIT 4
Shortfall Risk and Tracking Error

Tracking Error Quintile	Average Daily Tracking Error	95% Confidence Interval of Realized Shortfall Around Mean	
1	0.21%	-0.50%	+0.50%
2	0.31%	-0.72%	+0.72%
3	0.44%	-0.79%	+0.79%
4	0.62%	-0.82%	+0.82%
5	1.00%	-0.99%	+0.99%

complete. The realization of this risk is opportunity cost, and it is directly proportional to the tracking error between the legacy and target portfolios. Low tracking error reduces the likelihood of adverse divergent performance, and high tracking error increases the probability.

We define tracking error as the volatility of the relative returns between the target and legacy portfolios, measured on daily data for the 30 days preceding the transitions. We adjust this calculation for the number of days it took for the portfolio transition.

In Exhibit 4 we rank transitions by tracking error quintile, from low to high tracking error. Our results reveal that tracking error does indeed correspond to higher realized shortfall risk. We find that the confidence interval based on the realized volatility of shortfall across transitions corresponds to the average tracking error of the quintiles.

In light of the intuition that illiquidity affects market impact and tracking error explains opportunity cost, together with our empirical validation of these relationships, we define adjusted shortfall as shown in Equations (3) and (4):

$$\text{Adjusted Shortfall} = \frac{EC}{E[EC]} + \frac{IC - \text{Expected Market Impact}}{TE} \quad (3)$$

$$\text{Adjusted Shortfall} = \frac{EC}{E[EC]} + \frac{IC - 0.0079736 \times V^{1/2}}{TE} \quad (4)$$

where:

$\frac{EC}{E[EC]}$ = ratio of realized to expected explicit costs;

IC = implicit costs;

TE = tracking error between the legacy and target portfolios; and

V = size of the trade, expressed as the weighted average percentage of daily volume traded for the buys and the sells.

Our measure of adjusted implementation shortfall is calibrated to equal 1.0 if three conditions prevail.

1. The ratio of explicit costs to the expectation of explicit costs equals 1.0, which implies that realized commissions and bid-ask spreads accord with the estimates given by the transition manager to the client.
2. Realized market impact equals the market impact implied by our market impact function.
3. Opportunity cost equals zero, which should occur on average across a large sample of transactions, assuming our market impact function is properly calibrated.[3]

Next we apply our adjusted shortfall measure to a representative sample of transitions. Exhibit 5 shows the distribution of adjusted shortfall, assuming the ratio of realized explicit costs to expected explicit costs equals 1.0.

One-half of the values fall within a range of 0.8 to 1.2, while 90% of the values fall within a range of 0.3 to 1.6. If a portfolio transition receives a score higher than 1.0, the transition is considered relatively expensive; an adjusted shortfall score of less than 1.0 implies that the transition was executed relatively inexpensively.

Our sample, however, is biased relative to the typical transition manager because our data come from a very large transition manager, which internally crosses a higher fraction of trades than perhaps any other transition manager. It would be unrealistic to expect the typical transition manager to achieve a score of less than 1.0.

The adjusted shortfall of a transition often differs dramatically from the absolute cost of the transition, as shown in Exhibit 6. These results represent five actual

transitions. While transition A produced the best outcome in terms of unadjusted shortfall, transition C yielded the best result after adjusting for liquidity and tracking error. As the table reveals, both absolute and adjusted shortfall are sometimes negative. This outcome occurs when there is less realized market impact than expected from the market impact function. It may also occur when the securities in the legacy portfolio rise above the benchmark prices before they are sold, or when securities in the target portfolio fall below the benchmark prices before they are acquired, resulting in negative opportunity cost.

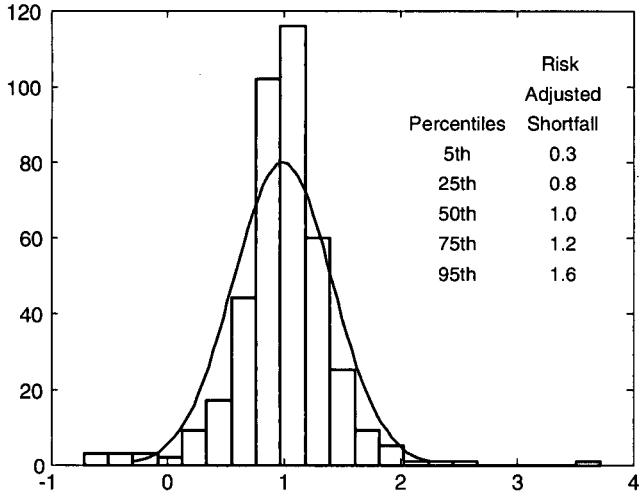
CONCLUSION

We use a proprietary sample of transaction data from a large transition manager to analyze implementation shortfall on more than 1,541 transactions that occurred between January 2004 and January 2006, and we relate these costs to three methods of trading: internal crosses, external crosses, and market trades. Our analysis reveals that the average implementation shortfall is 7 basis points for internal crosses, 31 basis points for external crosses, and 40 basis points for market trades.

Internal crosses benefit from the absence of commissions and bid-ask spreads. They also have substantially lower implicit costs, which we conjecture is because they occur sooner in the transition than other types of trades, and because they are less vulnerable to information leakage.

We also introduce an adjustment to implementation shortfall to correct for the relative difficulty of executing transitions involving different types of securities. Our adjustment scales implementation shortfall for illiquidity and tracking error, which respectively explain the two components of implicit costs, market impact and opportunity cost. Adjusted shortfall would be a more reliable measure of the quality of portfolio transitions.

EXHIBIT 5
Adjusted Shortfall Distribution



ENDNOTES

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[1]We use a more limited database for this analysis because we rely in part on tracking error between the legacy and target portfolios, which is available only for a smaller sample than the transaction-level data.

[2]See, for example: Hasbrouck [1991], Hisata and Yamai [2000], Lillo, Farmer, and Mantegna [2002, 2003], Plerou et al. [2002, 2004], Kissell and Glantz [2003], Lim and Coggins [2003], Lo, Petrov, and Wierzbicki [2003], Brown et al. [2004], Farmer and Lillo [2004], and Almgren et al. [2005].

[3]It is also possible to observe an adjusted implementation shortfall value of 1.0 even when none of these conditions prevails independently, but the components offset each other in such a way to produce a value of 1.0.

EXHIBIT 6
Shortfall and Adjusted Shortfall

Transition	Shortfall	Rank	EC/E(EC)	Realized Implicit Cost	Expected Market Impact	Tracking Error	Adjusted Shortfall	Rank
A	-0.16%	1	1.00	-0.20%	0.44%	1.75%	0.86%	3
B	0.15%	2	1.00	0.13%	1.02%	0.35%	1.50%	5
C	0.31%	3	1.00	0.15%	0.98%	0.43%	-0.47%	1
D	0.46%	4	1.00	0.30%	0.24%	0.59%	0.85%	2
E	0.61%	5	1.00	0.45%	0.30%	0.48%	1.03%	4

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