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Understanding Momentum

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The extensive literature on price momentum effects is a potential source of confusion for portfolio managers because conflicting explanations give rise to different implications for portfolio strategy. Analysis of the value-weighted large-capitalization universe represented by the MSCI World Index indicates that price momentum is driven largely by industry momentum, not individual-stock momentum, and that it is not a result of cross-sectional dispersion in industry mean returns or varying industry exposure to systematic risk. In a small-cap universe, stock-specific effects assume greater importance. For sample periods 1992–2003 and 1980–2003, value investors would have reduced risk by imposing sector neutrality on their portfolios whereas growth managers could have profited by relaxing sector constraints.

The literature on price momentum is one of the most extensive and potentially most confusing areas of research in finance. Although there is broad consensus about the size and duration of any pricing momentum effects, there is no consensus about what is driving them. Whether these violations of market efficiency can be given a behavioral explanation or whether they are the result of the rational response of investors to real market constraints is far from clear. No consensus exists either about whether momentum effects can be found only at the stock level or whether they are pervasive at the industry, country, or style levels.

For practitioners, the academic debate over the causes of momentum effects may appear arcane. For portfolio strategy, the key issue is what the implications of momentum effects are for risk control and alpha generation.

Risk

The implications for risk control are potentially far-reaching. The presence of short-term price momentum violates the assumption that each period is independent. As a consequence, the true annual variance and tracking variance of returns could be far greater than 12 times the monthly variance. We showed previously (Scowcroft and Sefton 2001) that the presence of short-term price momentum could produce an understatement of annual tracking-error forecasts by as much as 50 percent; Gardner, Bowie, Brooks, and Cumberworth (2000) made a similar point. If momentum is largely an industry phenomenon, as appears to be the case in our study, then exposure to additional momentum risk can be limited by running an industry-neutral fund. If this strategy is not desirable for investment reasons, at least exposure can be easily monitored by looking at the size of any industry tilts.

Generally, any style can exhibit strong momentum if the desired characteristic is currently being priced in the market. Such a characteristic could come from industry momentum, but it could come from any characteristic that investors expect to affect performance. Controlling the risk in any portfolio, therefore, requires monitoring style exposure.

Return

Momentum has obvious implications for alpha generation. If momentum is largely an industry phenomenon, then sector rotation strategies can be designed to capture this alpha at the industry level (see, for example, O'Neal 2000). Risk models underestimate the true risk of these types of strategies, however, so care must be taken in using risk-based measures, such as Sharpe ratios, to assess their performance.

Furthermore, if momentum is generally an industry phenomenon and inversely correlated with value, value strategies can reduce risk by constraining the weights to be industry neutral (Asness 1997). Generally, value managers can improve their risk-adjusted performance by constraining their portfolios to be neutral to nonvalue

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factors. In contrast, growth is likely to be positively correlated with momentum, so the imposition of industry neutrality would have a detrimental impact on the performance of growth managers.

Short History of Momentum

Researchers have identified many pricing anomalies in stock returns. One of many that have received a great deal of attention is a pervasive momentum in stock returns.

Thaler and De Bondt (1985, 1987) were the first to document a long-term overreaction in stock returns. They found that stocks that had performed poorly over the previous three to five years were more likely to be the better performers over the next three to five years. Using stock return data from different years and markets, such studies as Shleifer, Lakonishok, and Vishny (1994), Shleifer, Lakonishok, La Porta, and Vishny (1997), and Schiereck, De Bondt, and Weber (1999) found consistently that the contrarian strategy of buying the long-term poor performers and holding them for three to five years earned excess returns of 8 percent annually. Fama and French (1996) have argued, however, that this pricing anomaly is simply a disguised version of their value premium; previous poor performers are more likely to do well over the next three to five years because they are more likely to have become value stocks and hence to earn the value premium.

Jegadeesh (1990) and Lehmann (1990) also found reversals in stock returns but over the very short term. The best-performing stocks of the previous week or month were more likely to be one of the poor performers of the following week or month. Although this finding is relatively robust, Lo and MacKinlay (1990) argued that the effect is simply an artifact of how prices are recorded. If a stock is traded fairly infrequently, its trades are likely to generate a bid–ask "bounce." In one week, the ask price may be recorded; in the next week, the bid price is recorded, or vice versa. If the spread is sufficiently large, this phenomenon could induce short-term return reversals.

Jegadeesh and Titman (1993, 2001) and Lakonishok, Chan, and Jegadeesh (1996) discovered return continuation over the medium term (3–12 months). In this case, the better performing stocks from the previous six months were more likely to be among the better performing stocks of the next six months.

This medium-term pricing anomaly is the most intriguing of the momentum anomalies. It is at the center of a great deal of current academic debate on market efficiency as well as the main focus of this article. Of all the momentum pricing anomalies, this medium-term return momentum is the hardest to explain away by using rational pricing models; in the words of Fama and French, the main embarrassment of their three-factor risk model is its "failure to capture the continuation of short-term returns" (1996, p. 81).

To analyze the evidence for the long-, medium-, and short-term momentum theories, we used the data from our principal sample, all stocks in the MSCI World Index of developed countries for January 1992 through March 2003, and built portfolios every period of the best- and worst-performing 20 percent of stocks by market capitalization in the previous *J* months. We then held the self-financing portfolio that was long the best and short the worst performers for the following *K* months. (The methodology is described in detail in Appendix A.) We then recorded the average percentage monthly return to these self-financing portfolios over our sample period. **Table 1** presents our findings for this period.

Table 1 provides evidence supporting all three momentum phenomena. In the top left corner, for formation and holding periods of one month, a short-term average return reversal occurs for the self-financing portfolios of –0.78 percent a month (nearly –10 percent annually). Over the medium term, return continuation is most significant for formation periods of 6–12 months and holding periods of a similar length; the average return is about 1 percent a month (or 12 percent annually). For formation and holding periods of 36 months, a return reversal of –1.02 percent per month (or –12 percent annually) is reported.

What Drives Momentum?

Although the size and duration of the momentum anomalies enjoy broad acceptance, no such consensus exists for the cause of the excess returns. Are the momentum effects found only at the stock level, or can they be found at the industry or country level also?

There is no consensus in the literature on whether momentum is an industry or stock story. We found, however, that the literature can be divided into two distinct groups: The group that used equally weighted portfolios in broad universes for their research and the group that used market-cap-weighted portfolios in larger-cap universes for their research. **Exhibit 1** gives a summary of the findings of these two groups and notes which studies investigated whether *country* momentum strategies produce excess profits.

Table 1. Monthly Returns to Long–Short Momentum Strategies for Varying Portfolio Formation and Holding Periods, January 1992–March 2003
(standard errors in parentheses)

Formation Period (*J*, months)	Holding Period (*K*, months)					
	1	3	6	12	24	36
1	–0.78%	0.11%	0.31%	0.38%	0.18%	0.04%
	(0.48)	(0.34)	(0.27)	(0.20)	(0.16)	(0.12)
3	0.04	0.42	0.71	0.65	0.32	0.10
	(0.57)	(0.50)	(0.43)	(0.33)	(0.27)	(0.21)
6	0.59	0.87	1.00	0.86	0.38	0.14
	(0.63)	(0.59)	(0.51)	(0.42)	(0.36)	(0.28)
12	0.92	1.05	0.93	0.79	0.25	–0.02
	(0.64)	(0.60)	(0.56)	(0.53)	(0.46)	(0.36)
24	0.67	0.75	0.66	0.36	–0.34	–0.53
	(0.67)	(0.65)	(0.63)	(0.61)	(0.50)	(0.43)
36	0.35	0.48	0.37	–0.23	–0.75	–1.02
	(0.67)	(0.66)	(0.64)	(0.59)	(0.53)	(0.49)

Notes: All returns measured in U.S. dollars; there was no gap between formation and holding period.

Exhibit 1. Summary of Findings of Recent Literature on Returns to Momentum Strategies

Authors	Year	Data	Portfolio Weighting	Summary of Principal Findings
Jegadeesh and Titman	1993	U.S. CRSP data	Equal	Found a "delayed price reaction to company-specific information."
Jegadeesh and Titman	2001	U.S. CRSP data	Equal	Found evidence consistent with their earlier study.
Grundy and Martin	2001	U.S. CRSP data	Equal	Industry effects are not the primary cause of momentum profits.
Rouwenhorst	1999	2,190 European companies	Equal	Found momentum profits in all 12 European markets. Found little evidence for a country momentum factor but suggested momentum profits are driven by common component across markets.
Richards	1997	16 MSCI market indexes	Market cap	Found evidence of some profitability to country momentum strategies.
Chan, Hameed, and Tong	2000	23 DataStream market indexes	Market cap	Found evidence of profit to country momentum trading strategies over the short term.
Moskowitz and Grinblatt	1999	U.S. CRSP data	Market cap	Found industry momentum strategies significantly more profitable than industry-neutral momentum strategies.
O'Neal	2000	31 U.S. Sector Fidelity funds	Market cap	Found significant profits to industry momentum strategies.
Swinkels	2002	DataStream Global industry indexes	Market cap	Found significant profits to global industry momentum strategies.

The first group of studies all used the CRSP database, which currently includes almost 7,000 stocks listed on the Amex, NYSE, and NASDAQ exchanges; the researchers constructed momentum portfolios by using equal weights. This group found momentum only at the stock level. The second group used value-weighted portfolios on large-cap universes. They found, without exception, that momentum is pervasive at the industry level. Significant profits accrued to industry momentum strategies. Those that examined country momentum found some evidence of a small profit to country momentum strategies.

Perhaps the one paper that is an exception to this classification is Nijman, Swinkels, and Verbeek (2004). They used a different portfolio-based

regression approach to decompose momentum profits in a large-cap European universe. Although they found that industry momentum contributes more than country momentum to momentum strategy profits, they found the most important determinant to be momentum at the stock level.

Recent theoretical papers that have tried to model medium-term return continuation have all focused on the mechanism by which "news" about stock performance is slowly incorporated into prices. We discuss these papers in detail later, but for now, note that the process for small-cap stocks is likely to be subtly different from the process for large-cap stocks. If a large company announces better-than-expected earnings, the announcement is more likely to be interpreted as news that the industry's prospects are improving than if a small company makes a similar announcement. Thus, if Shell Oil Company, for example, announces better-than-expected earnings, the price of BP shares may rise along with those of Shell. Should BP also announce increased earnings later in the year, the effect could be further price rises across the industry as investors view these improvements as industry-wide. Thus, we would observe some momentum in the price of BP and Shell shares. What induces the price momentum is the difficulty investors have in interpreting how much of a change in a company's performance is a result of industrywide improvements and how much is a result of company-specific improvements. A possible testable implication of this story is whether there are positive cross-correlations between earnings news in one stock and future returns in another stock.

Positive news about a change in a smaller producer's earnings is much less likely to be interpreted as a change in the industry's fortunes. Thus, momentum in its price is far more likely to be induced by the slow diffusion across the investment community of the change in the company's prospects. In this case, the induced correlation between earnings news and future expected returns is within a stock.

The view that large and small companies incorporate news differently into prices is supported by recent research on the decomposition of individual stock returns into changes in cash flow news and changes in discount rate expectations. Vuolteenaho (2002, Table IV) found that for small companies, cash flow news is positively correlated with changes in discount rate expectations. This evidence supports the notion that small companies' prices underreact to cash flow news, which results in medium-term return momentum at the stock level. Vuolteenaho found little evidence, however, for this positive correlation in the data for large companies. The implication is that return momentum at the large-cap level is not induced by the slow diffusion of cash flow news into prices. A different process, therefore, must induce it. An interesting area for investigation would be the "cross-correlation" between cash flow news in one stock and return expectations in another stock. Unfortunately, Vuolteenaho did not look for these effects. But in a different framework, Lo and MacKinlay (1999) did find that such cross-correlations could account for the majority of the momentum effect.

Decomposing Momentum Returns

In the empirical work presented here, we used a new approach to decompose momentum profits to market-cap-weighted momentum portfolios. We used the large-cap MSCI World universe (about 1,300 stocks) for sample periods of January 1992 through March 2003 and January 1980 through March 2003. We performed a similar breakdown of momentum profits to equally weighted portfolios in the much broader Dow Jones Global Index universe (almost 5,500 stocks), but the data on this broader universe were available only for the shorter period.

Evidence of Industry Momentum. Moskowitz and Grinblatt (1999) argued that medium-term momentum profits are driven mainly by implicit sector rotation. To demonstrate this point, Moskowitz and Grinblatt (and O'Neal 2000 and Swinkels 2002) showed that the profits of a sector-based rotation strategy are similar to the profits generated by a stock-level momentum strategy.

In **Table 2**, we present results for a similar analysis of the MSCI World universe. For every period, we ranked the 10 MSCI sectors on their performance in the previous J months. The winner portfolio was the market-cap-weighted portfolio of all stocks in the two best-performing sectors, and the loser portfolio was a market-cap-weighted portfolio of all stocks in the two worst sectors. We held the self-financing, long–short portfolio for the following K months. (See Appendix A for the precise methodology.) Panel A of Table 2 reports the average percentage monthly return to the self-financing portfolios composed of the MSCI universe over the 1992–2003 sample period. For formation and holding periods of 6–12 months, Panel A shows that the sector-based rotation strategy generates profits that are, in fact, slightly or significantly larger than those reported in Table 1.

Because this data sample, 1992–2003, includes the period of the technology bubble (beginning in approximately mid-1998 and crashing in mid-2000), an obvious question is: How much of the profits was generated by a momentum play on the tech bubble? Therefore, we repeated the exercise

Table 2. Monthly Average Excess Returns of Long–Short (*J*,*K*,1) Sector Rotation Strategies for Various Periods
(standard errors in parentheses)

Formation Period (*J*, months)	Holding Period (*K*, months)				
	1	3	6	12	24
A. MSCI universe, January 1992–March 2003					
1	0.69%	0.47%	0.61%	0.51%	0.42%
	(0.59)	(0.37)	(0.31)	(0.23)	(0.19)
3	0.62	0.83	0.73	0.61	0.39
	(0.55)	(0.52)	(0.46)	(0.37)	(0.35)
6	1.36	1.18	1.09	0.80	0.36
	(0.63)	(0.61)	(0.56)	(0.49)	(0.46)
12	1.37	1.18	1.09	0.78	0.15
	(0.69)	(0.62)	(0.62)	(0.62)	(0.57)
B. MSCI universe ex information technology sector, January 1992–March 2003					
1	0.11%	0.18%	0.33%	0.42%	0.32%
	(0.42)	(0.24)	(0.20)	(0.15)	(0.11)
3	0.02	0.24	0.22	0.39	0.23
	(0.38)	(0.33)	(0.30)	(0.22)	(0.18)
6	0.54	0.35	0.55	0.51	0.16
	(0.43)	(0.42)	(0.37)	(0.30)	(0.27)
12	1.17	0.89	0.75	0.52	0.00
	(0.45)	(0.43)	(0.41)	(0.38)	(0.34)
C. MSCI universe, January 1980–March 2003					
1	0.11%	0.18%	0.22%	0.26%	0.13%
	(0.25)	(0.15)	(0.12)	(0.09)	(0.07)
3	0.34	0.44	0.34	0.40	0.16
	(0.24)	(0.20)	(0.18)	(0.14)	(0.12)
6	0.39	0.47	0.57	0.39	0.16
	(0.26)	(0.24)	(0.22)	(0.18)	(0.16)
12	0.66	0.69	0.54	0.30	0.07
	(0.28)	(0.26)	(0.24)	(0.22)	(0.19)

Notes: Market-cap-weighted index. Sectors are basic materials, consumer cyclical and noncyclical, energy, financial, health care, technology, telecommunications, and utility.

reported in Panel A, but this time, we omitted all stocks from the information technology sector from our sample. Panel B of Table 2 shows that the omission of tech stocks did reduce profits by an average for all formation/holding periods of 25–50 percent. But the implication is that more than 50 percent of the profits, amounting to an excess return of greater than 6 percent annually, came from rotation in and out of other sectors. For comparison, in Panel C, we report the profits to these sector rotation strategies over the longer period, 1980–2003. The profits shown in Panel C are of similar magnitude to those in Panel B. Therefore, we can conclude that, although the profits to this sector rotation strategy were present in the 1980s, they were lower than in the 1990s. (We show later that momentum profits also were lower, on average, over the longer period.)

Figures 1–4 allow a visual comparison of the sector makeup of the momentum portfolios constructed for a (6,6,1) stock-level momentum strategy [the notation (6,6,1) means that $J = 6$, $K = 6$, and the gap between formation and holding periods is 1 month; see Appendix A, Steps 3 and 4] with the comparable sector-based rotation portfolios constructed for Table 2. Figures 1 and 2 apply to the loser or short portfolios; Figures 3 and 4, to the winner or long portfolios. Figure 1 gives the percentage of stocks in each MSCI sector for the loser momentum portfolio over time. Figure 2 shows which sectors were held in the loser portfolio in the sector rotation strategy. Figure 3 presents the same decomposition as Figure 1 for the winner momentum portfolio, and Figure 4 shows the sectors held in the winner portfolio in the sector rotation strategy.

Figure 1. Loser Portfolio Sector Weights in (6,6,1) Momentum Strategy, January 1992–March 2003

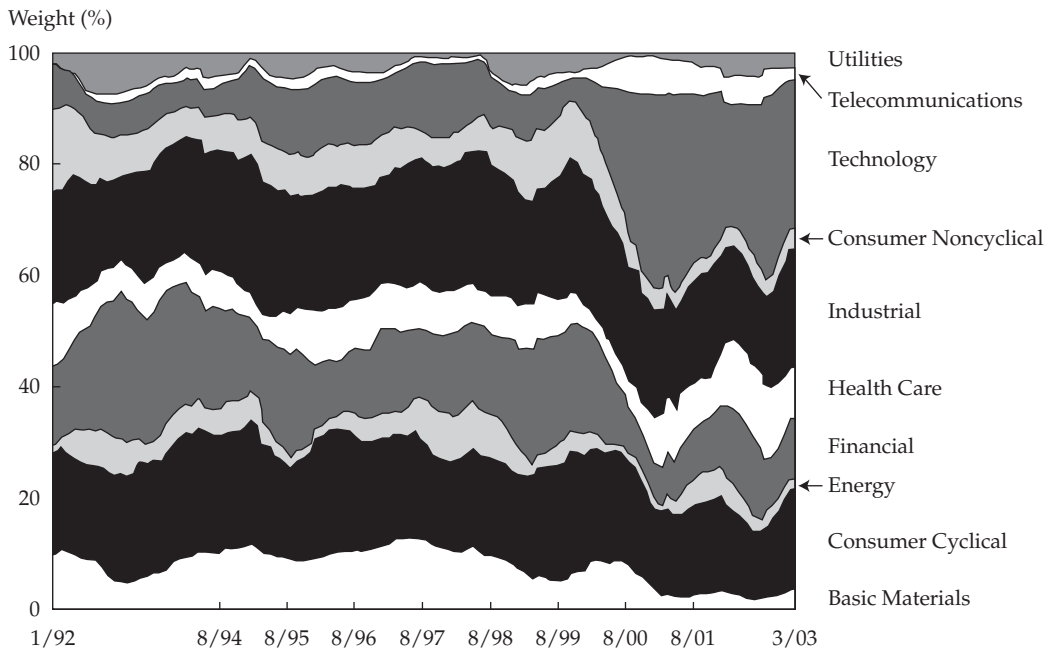
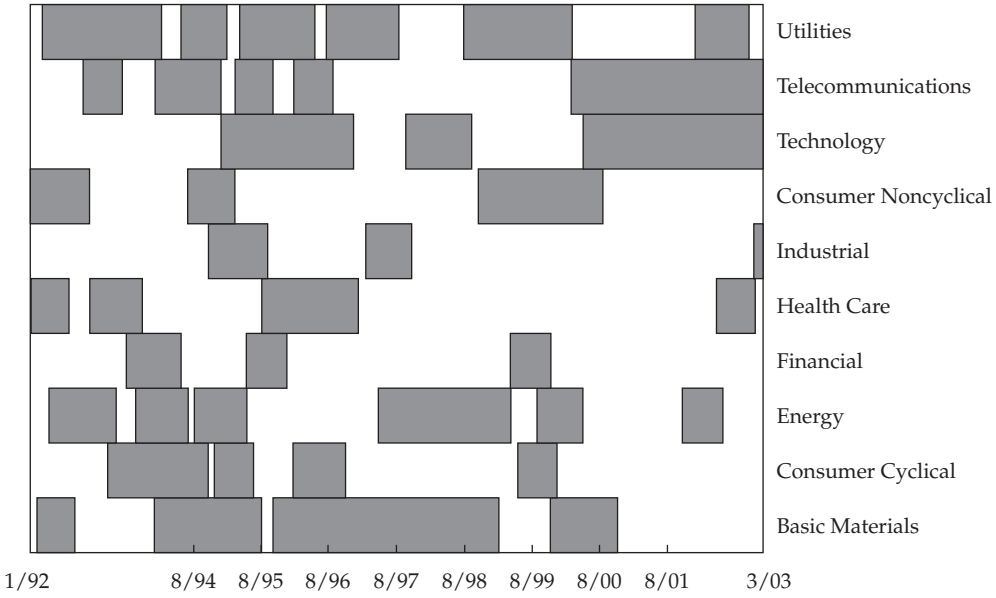


Figure 2. Composition of (6,6,1) Sector Rotation Short Portfolio, January 1992–March 2003



Several observations are worth highlighting from these figures:

- When an above-average number of stocks was held in a given sector in the loser or winner portfolios, then, almost without exception, that sector was held in the corresponding sector rotation portfolio. Similarly, when a below-average number of stocks was held in a given sector in the loser or winner portfolios, that sector was not held in the corresponding sector rotation portfolio. For example, Figure 1 shows that around August 1998 and August 2001, the loser momentum portfolio contained few utility stocks. These are the same periods when, as shown in Figure 2, the utility sector was not held in the loser portfolio in the sector rotation strategy.
- We can easily observe the effects of the tech bubble. In the momentum portfolios, more than an average number of technology stocks were held in the winner portfolio (Figure 3) during the boom years of 1998 to early 2000 and more

Figure 3. Winner Portfolio Sector Weights in (6,6,1) Momentum Strategy, January 1992–March 2003

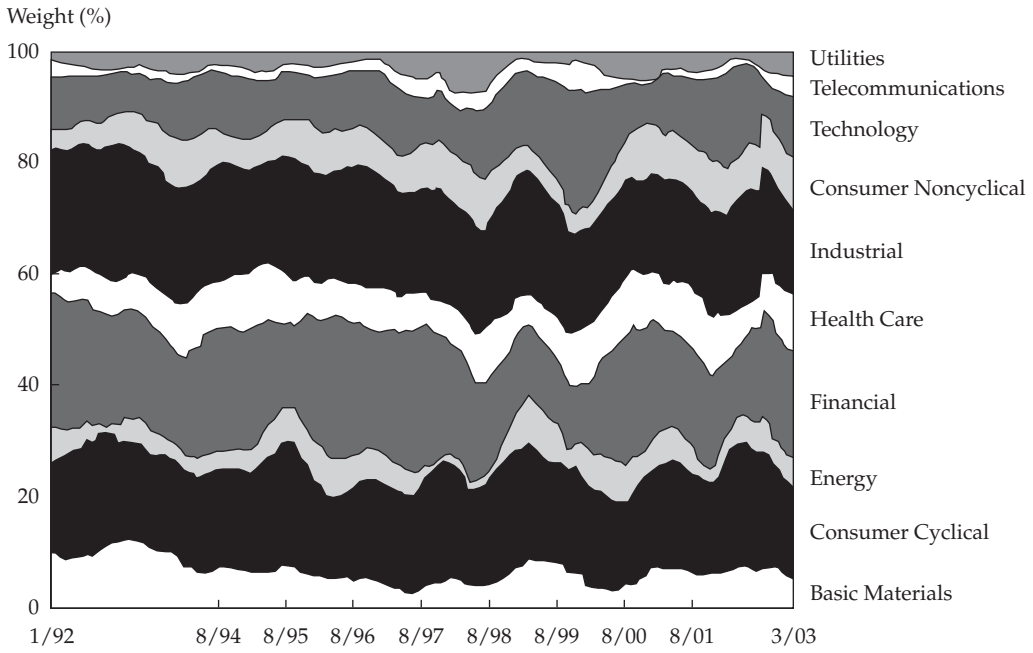
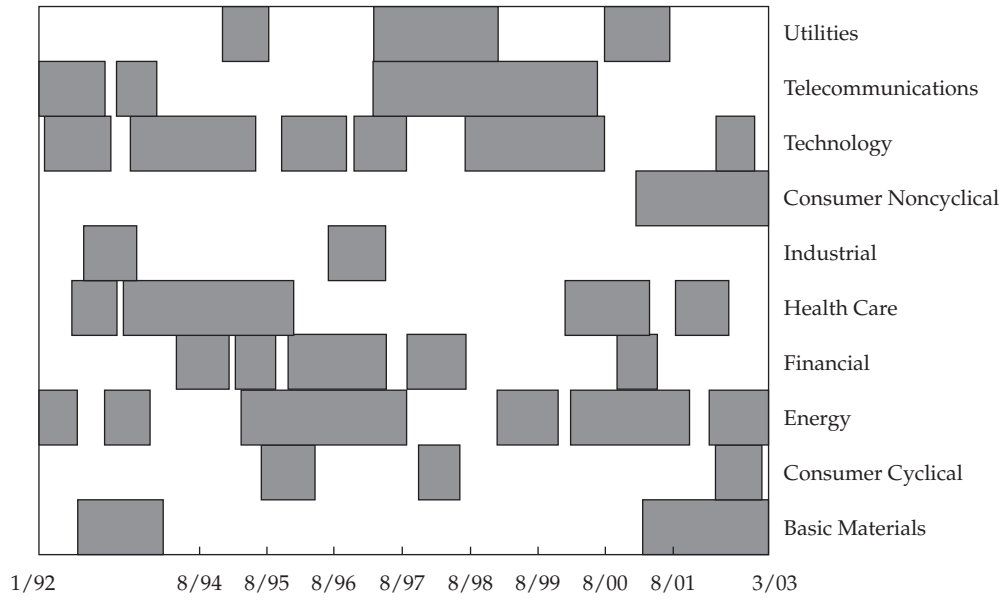


Figure 4. Composition of (6,6,1) Sector Rotation Long Portfolio, January 1992–March 2003



than an average number were held in the loser portfolio (Figure 1) during the crash of 2000 and 2001. The same sector rotation is visible in the breakdown of sector rotation strategies in Figures 2 and 4.

- Figures 2 and 4 provide strong evidence that the (6,6,1) strategy would lead to rotation in and out of sectors other than technology over this period. The rotation is particularly marked in the utilities sector, the consumer noncyclical sector after 1999, and telecommunications, energy, basic materials, and financials between 1995 and 1998.

Figures 1–4 and Table 2 provide compelling evidence that simple sector rotation strategies capture most of the information on medium-term momentum contained in the momentum portfolios. Figures 1–4 show that the momentum portfolios contain the same implicit sector rotation, and Table 2 provides evidence that the sector rotation strategy can generate the same level of profits as the momentum strategy shown in Table 1.

If the majority of profits to medium-term momentum strategies are generated by an implicit sector rotation strategy, then if we limit the universe to a particular global sector, we should observe a great reduction in profits to momentum strategies. **Table 3** reports the results from such an exercise; in this case, we limited ourselves to reporting the monthly profits to a strategy of using the six-month formation period and six-month holding period with the one-month gap. Table 3 clearly shows that in a large-cap market-cap-weighted universe (second and fourth columns), profits are indeed lower than the percentage generated by the global momentum strategy recorded in Table 1. The only exceptions are the industrial and financial sectors, which are relatively heterogeneous groups of stocks; perhaps, therefore, to remove the momentum profits, these sectors would have to be further disaggregated into more homogeneous groups.

The next-to-last column in Table 3 reports the results for equally weighted portfolios constructed using the entire Dow Jones universe (about 5,500 stocks; hence, the set of experiments giving the greatest weight to small-cap stocks). The momentum profits have returned to the level shown in Table 1 in nearly all the sectors. Therefore, at the small-cap level, industry-level momentum is apparently not the whole story; a company-specific approach may be more appropriate. We return to this idea later.

Evidence for Country Momentum. Richards (1997) found some evidence that country rotation strategies can deliver a small excess profit in the medium term. For this section, we repeated the experiment on sector rotation but for countries. In every month, we ranked the 22 countries in our universe on their performance in the previous *J* months. The winner portfolio was then the market-cap-weighted portfolio of all stocks in the four best-performing countries, and the loser portfolio was the market-cap-weighted portfolio of all stocks in the worst four countries. The construction process then proceeded as previously. **Table 4** reports the results.

Panel A of Table 4 shows that over the shorter sample period and for formation and holding periods of six months, the average excess return to this country rotation strategy is about 0.65 percent a month, or about 7.5 percent a year. For Panel B, we

Table 3. Monthly Average Excess Returns to Long–Short (6,6,1) Momentum Strategies by Global Sector in Various Universes, January 1992–March 2003
(standard errors in parentheses)

	Large-Cap Universes					
	MSCI		Large-Cap Dow Jones		Full Dow Jones Index	
Sector	Equally Weighted	Market Weighted	Equally Weighted	Market Weighted	Equally Weighted	Market Weighted
Basic materials	–0.11%	0.00%	–0.10%	0.10%	0.34%	0.02%
	(0.43)	(0.39)	(0.40)	(0.40)	(0.48)	(0.37)
Consumer cyclical	0.60	0.65	0.37	0.60	1.24	0.85
	(0.46)	(0.44)	(0.44)	(0.45)	(0.45)	(0.46)
Consumer noncyclical	0.83	–0.11	0.30	–0.09	1.02	0.17
	(0.44)	(0.37)	(0.41)	(0.44)	(0.44)	(0.37)
Energy	0.32	0.30	0.58	0.37	0.57	0.33
	(0.49)	(0.29)	(0.48)	(0.31)	(0.53)	(0.36)
Financial	0.91	1.00	0.78	0.75	0.97	0.77
	(0.59)	(0.54)	(0.58)	(0.52)	(0.49)	(0.48)
Health care	0.87	0.12	0.43	0.01	0.85	0.43
	(0.45)	(0.33)	(0.45)	(0.33)	(0.60)	(0.37)
Industrial	0.29	1.00	0.98	0.90	0.87	0.85
	(0.55)	(0.50)	(0.58)	(0.41)	(0.53)	(0.45)
Technology	0.47	0.75	0.19	0.65	0.26	0.89
	(0.88)	(0.63)	(0.88)	(0.62)	(0.71)	(0.62)
Telecommunications	0.95	–0.40	0.73	–0.16	1.19	–0.10
	(0.94)	(0.69)	(0.75)	(0.65)	(0.95)	(0.64)
Utility	0.21	0.81	0.27	0.96	0.50	0.73
	(0.47)	(0.44)	(0.51)	(0.48)	(0.33)	(0.38)

Table 4. Monthly Average Excess Returns of Long–Short (*J*,*K*,1) Country Rotation Strategies for Various Periods
(standard errors in parentheses)

	Holding Period (*K*, months)				
Formation Period (*J*, months)	1	3	6	12	24
A. MSCI universe, January 1992–March 2003					
1	0.53%	0.15%	0.27%	0.04%	–0.01%
	(0.46)	(0.27)	(0.23)	(0.16)	(0.13)
3	0.86	0.85	0.68	0.37	0.11
	(0.49)	(0.41)	(0.33)	(0.26)	(0.23)
6	0.60	0.71	0.65	0.34	0.15
	(0.51)	(0.43)	(0.37)	(0.34)	(0.28)
12	0.79	0.42	0.46	0.37	–0.05
	(0.47)	(0.45)	(0.43)	(0.43)	(0.36)
B. MSCI universe ex Singapore and Hong Kong, January 1992–March 2003					
1	0.51%	0.40%	0.33%	0.11%	0.04%
	(0.35)	(0.20)	(0.18)	(0.13)	(0.09)
3	0.36	0.50	0.46	0.11	–0.08
	(0.37)	(0.29)	(0.25)	(0.19)	(0.15)
6	0.67	0.37	0.38	0.03	–0.17
	(0.39)	(0.33)	(0.31)	(0.25)	(0.19)
12	0.51	0.16	0.04	–0.26	–0.33
	(0.38)	(0.37)	(0.35)	(0.32)	(0.24)
C. MSCI universe, January 1980–March 2003					
1	0.03%	0.38%	0.12%	0.06%	0.02%
	(0.28)	(0.19)	(0.14)	(0.10)	(0.07)
3	0.41	0.38	0.37	0.25	0.11
	(0.34)	(0.25)	(0.20)	(0.16)	(0.11)
6	0.44	0.51	0.37	0.16	0.13
	(0.31)	(0.27)	(0.23)	(0.19)	(0.14)
12	0.40	0.34	0.27	0.19	0.10
	(0.32)	(0.29)	(0.27)	(0.24)	(0.19)

Notes: The MSCI market-cap-weighted index covers the following 22 countries: Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Italy, Japan, the Netherlands, Norway, New Zealand, Portugal, Singapore, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

investigated the proportion of this profit that can be attributed to a play on the two small Asian markets in our sample—namely, Singapore and Hong Kong—during the Asian Crisis of mid-1997 to early 1999. When we reran the experiment after removing all stocks of companies domiciled in these countries, profits fell by about an average of 40 percent for formation periods of 6 and12 months and holding periods of up to 1 year.

Panel C reports the profits to a country rotation strategy (including the Asian countries) over the longer period, 1980–2003. These profits are of similar magnitude to those in Panel B for formation periods of 6 and 12 months and holding periods of up to 1 year, which suggests that profits to country rotation strategies were lower in the 1980s than in the 1990s.

If some of the profits to momentum strategies are generated by an implicit country rotation strategy, then limiting the universe to a particular country should reduce profits. **Table 5** shows profit results for the (6,6,1) long–short momentum strategy that we limited to the main economic regions or countries in our sample. Focusing first on the large-cap market-weighted columns, note that the average monthly return is between of 0.32 percent and 0.76 percent. This profit is significantly less than the return to that for the global stock-level momentum strategy shown in Table 1.

The next-to-last column of Table 5 reports the results in the broad Dow Jones universe when the portfolios were equally weighted. As for the sector-level findings, in this world that includes stocks of

Table 5. Monthly Excess Returns to Long–Short (6,6,1) Country or Region Momentum Strategies, January 1992–March 2003
(standard errors in parentheses)

	Large-Cap Universes					
	MSCI		Large-Cap Dow Jones		Full Dow Jones Index	
Country/Region	Equally Weighted	Market Weighted	Equally Weighted	Market Weighted	Equally Weighted	Market Weighted
EMU[a]	0.55%	0.43%	0.49%	0.38%	0.96%	0.58%
	(0.47)	(0.52)	(0.55)	(0.52)	(0.51)	(0.49)
Europe	0.62	0.61	0.48	0.53	1.02	0.78
	(0.48)	(0.56)	(0.60)	(0.58)	(0.51)	(0.52)
Far East ex Japan	0.60	0.44	0.51	0.57	1.76	0.92
	(0.62)	(0.63)	(0.73)	(0.67)	(0.60)	(0.64)
France	0.25	0.32	0.17	0.23	0.70	0.51
	(0.68)	(0.69)	(0.74)	(0.65)	(0.64)	(0.60)
Germany	1.06	0.53	0.40	0.57	1.48	0.76
	(0.70)	(0.67)	(0.61)	(0.64)	(0.68)	(0.61)
Japan	0.09	0.36	0.33	0.43	0.08	0.45
	(0.66)	(0.67)	(0.60)	(0.68)	(0.55)	(0.67)
United Kingdom	0.42	0.55	0.77	0.52	0.93	0.62
	(0.53)	(0.47)	(0.59)	(0.49)	(0.59)	(0.47)
United States	0.47	0.76	0.69	0.67	0.89	0.87
	(0.64)	(0.57)	(0.68)	(0.57)	(0.67)	(0.57)

[a]European Monetary Union.

the smaller-cap companies, profits were restored to levels similar to those for the basic global momentum strategies. This result is what Rouwenhorst (1999) found: In a broad universe, momentum strategies deliver similar profits in different markets.

We also found that in a large-cap world, limiting the strategy to specific markets does reduce profits. Therefore, some of the profits of global momentum strategies are generated by an implicit country/region rotation.

Decomposition of Momentum Returns. We decomposed the returns into the proportion that can be attributed to sector rotation, the proportion that can be attributed to country rotation, and the proportion that can be attributed to a momentum play on company-specific returns. The method is straightforward: We estimated a linear factor model (LFM) for stock returns in which both sector and country factors were included in the set of factors. The estimation procedure, described in detail in Appendix B, was based on the Heston and Rouwenhorst (1995) random coefficient model. In this model, stocks are assumed to have a beta of 1 with respect to the market, their own country, and their own sector factors and assumed to have a beta of 0 with respect to all other country and sector factors. A time series of country and sector factor returns can then be estimated by performing cross-sectional least-squares regressions of stock returns on the betas in every month. This model, therefore, allows decomposition of the returns to every stock into a component attributable to sector factors, a component attributable to the set of country factors, and a residual or company-specific component.

To use this decomposition of stock returns to decompose the profits to momentum strategies, we constructed momentum portfolios, as previously, by ranking all the stocks on their performance in the previous J months and then built market-cap portfolios of the top 20 percent and bottom 20 percent of performers. At this point, however, for calculating the return to these portfolios over the next K months, instead of using the total return to the constituent stocks, we repeated the procedure three times—once each for the sector component of returns, the country component, and the company-specific component. The sum of these three components, by construction, had to equal the earlier total return calculation. We recorded the percentage monthly return to the self-financing portfolios (portfolios that were long the best and short the worst performers) over the sample period, except that in this case, we did it one time for each different component. Our decomposition of the profits to the momentum strategies was then simply the decomposition of the average returns to these three different components.

Table 6 reports the decomposition of the returns of the momentum strategies. For formation periods of 3, 6, and 12 months and holding periods of up to 1 year, Panel B of Table 6 indicates that less than 25 percent, and an average of 8 percent, of the total momentum returns can apparently be attributed to a play on company-specific momentum; Panel C indicates that 48–70 percent, and an average of 58 percent, can be attributed to an implicit sector rotation strategy; and Panel D indicates that 17–54 percent, and an average of 34 percent, can be attributed to an implicit country rotation strategy.

Because our analysis so far has indicated that a small-cap universe behaves differently, we repeated the decomposition analysis for equally weighted portfolios in the broad Dow Jones Universe. **Table 7** reports the results. Indeed, in this universe, for formation periods of 3, 6, and 12 months and holding periods of up to 1 year, the amount of the return that can be attributed to company-specific effects rises to

Table 6. Decomposition of Monthly Average Excess Returns to Momentum Strategies in the Market-Cap-Weighted MSCI Global Universe, January 1992–March 2003
(standard errors in parentheses)

Formation Period (*J*, months)	Holding Period (*K*, months)				
	1	3	6	12	24
A. Total return					
1	0.16%	0.41%	0.48%	0.40%	0.21%
	(0.49)	(0.34)	(0.27)	(0.20)	(0.15)
3	0.71	0.63	0.74	0.59	0.31
	(0.55)	(0.49)	(0.40)	(0.31)	(0.27)
6	0.98	0.96	1.06	0.78	0.35
	(0.61)	(0.55)	(0.48)	(0.41)	(0.36)
12	1.13	0.98	0.89	0.67	0.21
	(0.60)	(0.56)	(0.55)	(0.53)	(0.45)
B. Company-specific return					
1	–0.19%	–0.06%	0.04%	0.09%	0.02%
	(0.25)	(0.18)	(0.14)	(0.11)	(0.09)
3	–0.07	0.04	0.10	0.03	0.00
	(0.31)	(0.28)	(0.22)	(0.19)	(0.15)
6	0.03	0.15	0.24	0.09	–0.03
	(0.33)	(0.29)	(0.26)	(0.24)	(0.21)
12	0.13	0.04	0.04	–0.03	–0.13
	(0.33)	(0.32)	(0.31)	(0.30)	(0.27)
C. Return to global sector factors					
1	0.28%	0.28%	0.29%	0.21%	0.08%
	(0.38)	(0.27)	(0.22)	(0.15)	(0.11)
3	0.38	0.36	0.38	0.34	0.11
	(0.43)	(0.38)	(0.32)	(0.23)	(0.20)
6	0.61	0.53	0.51	0.43	0.11
	(0.47)	(0.43)	(0.37)	(0.31)	(0.27)
12	0.78	0.65	0.56	0.36	0.00
	(0.47)	(0.43)	(0.42)	(0.40)	(0.34)
D. Return to country factors					
1	0.05%	0.19%	0.13%	0.10%	0.11%
	(0.31)	(0.23)	(0.18)	(0.14)	(0.10)
3	0.39	0.21	0.25	0.21	0.20
	(0.38)	(0.34)	(0.27)	(0.22)	(0.18)
6	0.32	0.28	0.29	0.26	0.27
	(0.41)	(0.37)	(0.33)	(0.29)	(0.24)
12	0.20	0.28	0.28	0.33	0.34
	(0.42)	(0.39)	(0.38)	(0.37)	(0.31)

Table 7. Decomposition of Monthly Average Excess Returns to Momentum Strategies in the Equally Weighted Dow Jones Global Universe, January 1992–March 2003
(standard errors in parentheses)

Formation Period (*J*, months)	Holding Period (*K*, months)				
	1	3	6	12	24
A. Total return					
1	0.02%	0.25%	0.34%	0.41%	0.20%
	(0.52)	(0.39)	(0.31)	(0.23)	(0.17)
3	0.41	0.43	0.77	0.67	0.28
	(0.62)	(0.55)	(0.46)	(0.35)	(0.26)
6	0.88	1.03	1.12	0.72	0.24
	(0.67)	(0.61)	(0.53)	(0.45)	(0.32)
12	1.06	1.00	0.79	0.32	–0.04
	(0.64)	(0.60)	(0.58)	(0.52)	(0.39)
B. Company-specific return					
1	0.03%	0.23%	0.29%	0.29%	0.16%
	(0.23)	(0.19)	(0.16)	(0.12)	(0.08)
3	0.41	0.47	0.55	0.46	0.24
	(0.31)	(0.28)	(0.24)	(0.18)	(0.13)
6	0.70	0.74	0.73	0.48	0.23
	(0.35)	(0.32)	(0.28)	(0.22)	(0.16)
12	0.66	0.60	0.47	0.22	0.06
	(0.34)	(0.31)	(0.29)	(0.24)	(0.18)
C. Return to global sector factors					
1	0.07%	0.08%	0.11%	0.10%	0.05%
	(0.40)	(0.32)	(0.25)	(0.18)	(0.13)
3	0.14	0.12	0.14	0.15	0.06
	(0.52)	(0.45)	(0.39)	(0.28)	(0.20)
6	0.25	0.20	0.21	0.16	0.03
	(0.55)	(0.51)	(0.44)	(0.35)	(0.25)
12	0.24	0.21	0.16	0.07	–0.04
	(0.53)	(0.49)	(0.46)	(0.39)	(0.28)
D. Return to country factors					
1	–0.01%	0.01%	0.00%	0.07%	0.04%
	(0.39)	(0.29)	(0.23)	(0.18)	(0.13)
3	–0.01	–0.06	0.16	0.15	0.06
	(0.46)	(0.42)	(0.34)	(0.28)	(0.21)
6	0.05	0.19	0.28	0.18	0.06
	(0.51)	(0.46)	(0.40)	(0.36)	(0.26)
12	0.26	0.28	0.24	0.13	0.02
	(0.49)	(0.47)	(0.46)	(0.42)	(0.32)

an average of 66 percent. The amount that can be attributed to implicit industry and country rotation falls to, respectively, 20 percent and 15 percent.

Table 8 reports the decomposition for the MSCI large-cap universe over the longer period. A comparison of Panel A in Table 8 with Panel A in Table 6 shows clearly that for formation periods of 6 and 12 months and holding periods up to 1 year, momentum profits over the longer period were on average 40 percent lower than over the shorter period. This fall in profits can be attributed almost entirely to the 1980–85 period rather than the 1985–92 period.[1] For example, profits to the (6,6,1) momentum strategy were, on average, only 0.19 percent a month between 1980 and 1985, whereas profits averaged 0.86 percent a month over the 1985–92 period.

As with the results for the shorter period (Table 6), the majority of the profits to the momentum strategies in the longer period can be attributed to either implicit sector rotation or country rotation, not to idiosyncratic stock returns. What does

Table 8. Decomposition of the Monthly Excess Returns to Momentum Strategies in the Market-Cap-Weighted MSCI Global Universe, January 1980–March 2003
(standard errors in parentheses)

Formation Period (*J*, months)	Holding Period (*K*, months)				
	1	3	6	12	24
A. Total return					
1	–0.36%	0.07%	0.11%	0.21%	0.09%
	(0.25)	(0.17)	(0.13)	(0.09)	(0.07)
3	0.01	0.11	0.30	0.30	0.14
	(0.28)	(0.24)	(0.19)	(0.14)	(0.11)
6	0.30	0.44	0.68	0.36	0.19
	(0.31)	(0.27)	(0.24)	(0.20)	(0.16)
12	0.65	0.61	0.45	0.22	0.07
	(0.30)	(0.29)	(0.27)	(0.24)	(0.20)
B. Company-specific return					
1	–0.46%	–0.11%	0.00%	0.06%	0.01%
	(0.23)	(0.15)	(0.11)	(0.08)	(0.06)
3	–0.24	–0.09	0.08	0.08	0.00
	(0.26)	(0.22)	(0.17)	(0.13)	(0.10)
6	–0.02	0.08	0.14	0.08	–0.01
	(0.28)	(0.25)	(0.21)	(0.18)	(0.14)
12	0.07	0.11	0.08	–0.05	–0.09
	(0.28)	(0.26)	(0.25)	(0.22)	(0.19)
C. Total monthly excess return from only the global sector factors					
1	0.07%	0.09%	0.08%	0.08%	0.02%
	(0.16)	(0.10)	(0.08)	(0.06)	(0.04)
3	0.11	0.09	0.10	0.11	0.02
	(0.17)	(0.14)	(0.11)	(0.09)	(0.08)
6	0.14	0.12	0.29	0.12	0.00
	(0.18)	(0.16)	(0.14)	(0.13)	(0.11)
12	0.33	0.24	0.17	0.03	–0.08
	(0.19)	(0.18)	(0.18)	(0.17)	(0.15)
D. Return to country factors					
1	0.03	0.09	0.03	0.06	0.06
	(0.18)	(0.11)	(0.08)	(0.07)	(0.05)
3	0.14	0.11	0.12	0.11	0.12
	(0.20)	(0.16)	(0.14)	(0.11)	(0.09)
6	0.17	0.24	0.25	0.16	0.19
	(0.21)	(0.21)	(0.19)	(0.16)	(0.13)
12	0.26	0.25	0.20	0.24	0.24
	(0.23)	(0.22)	(0.22)	(0.20)	(0.17)

change when data for the longer period are computed is the proportion that can be attributed to country rotation. For the 1980–2003 period, the magnitude of the profits attributable to country rotation is almost as large as that attributable to sector rotation. This result is consistent with the work of Cavaglia, Brightman, and Aked (2000), Phylaktis and Xia (2003), and Rouwenhorst (1999), who all found that sector factors have become a more important determinant of stock returns in the 1990s than in earlier periods.

Conclusion

We have suggested a consistent interpretation, and verified it through empirical work, of the multitude of research articles on momentum. The interpretation has important implications for fund management.

In a value-weighted large-cap universe, such as the MSCI World, price return momentum is driven largely by industry momentum; it does not appear to be explained by individual-stock momentum. Furthermore, the return momentum is

not a result of either cross-sectional dispersion in industry mean returns or differing industry exposures to systematic risk. As Fama and French noted, the linear factor model of returns does not capture the momentum of short-term returns. In addition, unlike the momentum returns in equal-weighted portfolios (where the return is typically generated by shorting losers), in value-weighted portfolios, the greater part of return accrues from being long the winners.

Practitioners are often critical of the equally weighted returns reported in many papers because of the costs of implementing a short portfolio. In the first row of **Table 9**, we report the quintile breakdown of the returns to the value-weighted momentum strategy and in the second row, the returns to the sector rotation strategy. It is clear that the statistically significant returns are largely generated by long positions in the winning quintiles.

Therefore, fund managers can apparently add alpha to their portfolios by building in sector tilts based on past return performance. This increase in performance will come at the cost of slightly increased risk, however—first, from the tilts and, second, from the increased exposure to momentum. O'Neal, however, in his work with U.S. sector mutual funds, calculated that, even after costs, such strategies do improve portfolio Sharpe ratios and other measures of performance.

In a small-cap universe, the evidence is that the majority of momentum profits are attributable to individual-stock momentum effects. Although this result is probably of little interest to all but small-cap fund managers, it does improve understanding of these pricing anomalies.

What Causes Momentum? Explaining momentum pricing has become one of the principal battlefields in finance between the behaviorists and the rationalists. In this section, we discuss how their models of price momentum might be adapted to explain why momentum in a large-cap world is industry driven but in a small-cap world is more stock specific.

The behaviorists focus almost exclusively on the mechanism by which new information or news is embedded in prices if investors are prone to exhibiting various psychological biases. Daniel, Hirshleifer, and Subrahmanyam (1998) considered the asymmetries induced by self-attribution bias—that is, the tendency of investors to attribute positive outcomes to skill and negative outcomes to bad luck. Self-attribution bias could induce both medium-term momentum and long-term price overreaction. Following a decision to buy, investors exhibiting this bias are more likely to later buy more of the stock if they receive further good news than they are likely to sell if they receive bad news. This asymmetry causes prices to rise too far in the short term and correct themselves later. In contrast, Barberis, Shleifer, and Vishny's (1998) investors exhibit conservatism. They are slow to update their prior beliefs in the event of good (bad) news. Therefore, prices do not adjust completely to new information at first but will adjust later if confirming news arrives. The result is short-term return continuation.

Either of these mechanisms could induce momentum at the industry level or the stock level. If investors focus on industry signals for large-cap companies (a form of the representativeness bias) and company-specific signals for small-cap companies, then return continuation will be at the industry level for large companies and at the stock level for small companies.

The rationalists focus not on psychological biases but on how "minimally rational" investors reacting to unpredictable changes in market conditions could induce the momentum anomalies. Although no single paper has managed to satisfactorily model the medium-term momentum as a rational response to market conditions or constraints, some avenues of research are promising. Empirically, O'Neal found that the winner industries performed well when the default risk premium on high-yield bonds fell. A fall in this premium suggests improving market conditions. Lo and MacKinlay (1999, Chapter 5) found that most of the momentum effect can be attributed, not to simple cross-correlations, but to positive "cross-autocovariances" (that is, when one stock does well, the tendency for similar stocks, rather than that specific stock, to do well later is what causes

Table 9. Monthly Average Returns to Quintile (6,6,1) Portfolios in a Market-Cap-Weighted MSCI Universe
(standard errors in parentheses)

Strategy	Losers	Quintile 2	Quintile 3	Quintile 4	Winners
Momentum	–0.27%	0.18%	0.33%	0.54%	0.80%
	(0.53)	(0.40)	(0.37)	(0.37)	(0.48)
Sector rotation	–0.16	0.23	0.35	0.59	0.92
	(0.55)	(0.39)	(0.40)	(0.37)	(0.45)

the above-average return to the momentum portfolios). These empirical observations suggest that as market conditions improve, news slowly diffuses into the prices of similar stocks—or stocks in the same industry; after all, industrial classification is simply a way of grouping similar stocks.

These observations relate well to those of Berk, Green, and Naik (1999), who showed theoretically that changes in a company's growth opportunities that are related to the company's systematic risk can generate medium-term momentum in returns. Because growth opportunities are most likely to be correlated within industries, this mechanism induces an industry momentum effect.

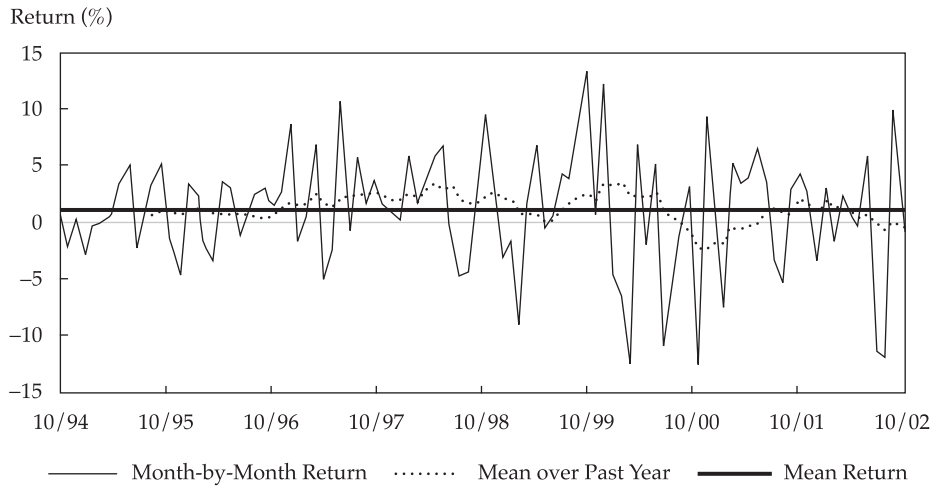
Also relating to the empirical observations is the paper by Lewellen and Shanken (2002), which starts by stating that investors do not know the true distribution of stock returns. Therefore, they must estimate this distribution from past data, and they update the distributions as new data become available. This description implies that, even though investors make entirely rational investment decisions based on their estimates of the distribution of returns, *ex post* returns may exhibit some correlation. The Lewellen and Shanken model can explain overreaction; it can also explain return continuation if investors place too much confidence in their prior beliefs.

A note of caution, however, is in order. **Figure 5** shows the recent performance of a (6,6,1) momentum strategy. Note that whereas the mean monthly return has been a healthy 106 bps, the month-to-month variation has been large and the 12-month rolling ("Mean over Past Year") return was negative throughout 2000. Clearly, such a momentum strategy should not be pursued in isolation; it should be used as part of a multifactor stock selection framework.

Implications for Portfolio Managers. The research we have reported has a number of implications for the principal portfolio management styles in use today. On the one hand, if momentum is an industry phenomenon, fund managers trying to follow a momentum strategy need to take small industry tilts in their portfolios. For these managers, a sector-neutral momentum strategy does not make sense. Furthermore, they should probably pay close attention to strategic views on likely future industry prospects. For value fund managers, the momentum phenomenon means that by running sector-neutral portfolios, they can reduce their exposure to risk from underweighting momentum. On the other hand, if price momentum is found only at the stock level, these recommendations would be almost reversed: Momentum managers would have to pay attention to news from the analysts on future individual stock prospects and would be able to run lower-risk sector-neutral portfolios. Value managers would need to pay more attention to exposure to momentum so as not to be caught by the medium-term market movements.

- *Value managers.* Asness (1997) reported that measures of momentum and value have historically been negatively correlated across stocks. This relationship was less pronounced in the 1995–2004 period, however, because of the long value rally from 2001 to 2004. This negative correlation implies that value managers generally find themselves underweighting momentum, so it is difficult for them to play the momentum game

Figure 5. Recent Performance of Long–Short (6,6,1) Momentum Strategy, October 1994–October 2002



simultaneously with the value game. This research suggests that value managers could reduce the possibility of underperformance as a result of underweighting momentum by holding a sector-neutral portfolio. This strategy would also have the added advantage of reducing long-run portfolio risk arising from transitory momentum effects (Scowcroft and Sefton 2001).

- *Growth managers*. Given that momentum appears to be industry driven at the large-cap level, growth managers could augment their portfolio alpha by also pursuing a sector momentum strategy. Their portfolios would incorporate a gentle tilt toward sectors that had performed well over the previous 6–12 months. They would need to accept that standard risk models might underestimate portfolio risk, however, so they would be well advised to remain cautious with respect to their risk mandate.

- *Momentum investors*. Momentum managers benchmarked to any of the standard value-weighted indexes should concentrate on spotting trends at the industry level, not at the stock level. This approach is likely to have the added advantage of reducing their transaction costs. In contrast, investors working in a small-cap universe should continue to focus on individual-stock momentum.

- *All investors*. Investors need to continuously monitor exposure to the additional risk from transitory momentum effects by measuring both momentum style exposures and industry tilts in their portfolios.

If we define a "style" to be a group of companies that share some common characteristic and have the potential to covary, then any such style can exhibit strong momentum. If the defining characteristic is being priced in the market, the prices of the group of related companies will move together. Such a characteristic could be as simple as the industry or the country—any characteristic that investors expect to affect performance. Controlling the risk in any portfolio, therefore, requires monitoring style exposure.

Momentum should not be regarded as a simple stock-level phenomenon. Portfolio managers have typically used momentum as a sentiment indicator primarily to complement a valuation metric affecting timing decisions. We have shown, however, that when one stock does well, the tendency is for similar stocks—not the specific stock—to do well later. This tendency is what causes the above-average return to momentum portfolios. At different points in the business cycle, momentum can be either an industry or a style phenomenon.

Appendix A. Building Momentum Portfolios

The approach we adopted is almost identical to the original method of Jagadeesh and Titman (1993). We used data on stock returns for the period January 1992 through March 2003 and limited our universe in any month to either all stocks in the Dow Jones Global Index or all stocks in the MSCI World Index. Then:

1. At every month-end, we ranked all stocks in the universe according to their cumulated price performance over the previous J months, time $t - J + 1$ to t, where t is in months.
2. We sorted the stocks into five equal portfolios by either number (equal weighting) or by market capitalization. Thus, the first (or winner) portfolio contained the top 20 percent, by number or market cap, of ranked stocks; the second portfolio, the next 20 percent; and so on. So, the fifth (or loser) portfolio consisted of the worst 20 percent of performers.
3. We measured the return to each of these portfolios in every month for the next K months after formation, $t + 1$ to $t + K$. In a variant to this approach, to reduce the impact of short-term price reversals, we left a month's gap between formation and holding. In this case, returns were measured for the months $t + 2$ to $t + K + 1$.
4. The return to momentum winners (losers) in period $t + 1$ is the average of the returns to the top (bottom) quintile portfolios formed at t, $t - 1, \ldots, t - K + 1$ in period $t + 1$. Thus, the return to the winners is the average return to the K winner portfolios formed consecutively over the previous K months. If a month's gap was left, the return at period $t + 1$ is the average of the returns to the top (bottom) quintile portfolios formed at $t - 1$, $t - 2, \ldots, t - K$.
5. The returns to the momentum strategy $(J,K,0)$ [or $(J,K,1)$ if a month's gap was left] is the average return to the self-financing portfolio of winners minus losers over the data sample.

In this article, we also examined the returns to momentum strategies based on picking the best-performing industries (or countries) over the previous J months and holding all stocks in those industries (countries) for the next K months. These portfolios were formed similarly to the way the whole universe was formed except that Steps 1 and 2 were modified as follows:

1a. At every month-end, we ranked all the industries (countries) according to their cumulated price performance over the previous J months.

2a. We sorted the stocks into five portfolios. The first (winner) portfolio contained all stocks in the top 20 percent of industries (countries)

either equally weighted or market-cap weighted. The fifth (loser) portfolio contained all stocks in the bottom 20 percent of industries (countries), again either equally weighted or market-cap weighted.

Steps 3–5 were identical in both processes.

Appendix B. Decomposing Momentum Returns

We assumed that a linear factor model (LFM) describes stock returns. Specifically, we assumed that stock returns are related to the returns of a given set of factors—a market index, a set of sector indexes, and a set of country indexes. Thus, if r_{it} denotes the return to stock i at time t and if f_{Mt}, $f_{Sj,t}$, and $f_{Ck,t}$ denote, respectively, the global market, global sector, and local country factor returns, we can write

$$r_{it} = \beta_{iM} f_{Mt} + \sum_{j \in Sectors} f_{Sj,t}\beta_{i,Sj} + \sum_{k \in Countries} f_{Ck,t}\beta_{i,Ck} + \varepsilon_{it}, \quad \text{(B1)}$$

where β_{iM}, $\beta_{i,Sj}$, and $\beta_{i,Ck}$ are the corresponding sensitivities of the stock's return to those factors and ε_{it} is the idiosyncratic or stock-specific return. The stock-specific return is assumed to be normally distributed and uncorrelated with the factors or with the stock-specific return of any other stock.

For this article, we used the Heston–Rouwenhorst random coefficient approach to unravel country and sector returns because it is the simplest approach.[2] Heston and Rouwenhorst assumed that all the sensitivities are either 1 or 0. Each stock has a sensitivity of 1 with respect to the market, its own sector, and its own country factors; its sensitivities otherwise are 0. Therefore, we can rewrite Equation B1 in matrix notation as

$$\begin{pmatrix} r_{1t} \\ r_{2t} \\ \vdots \\ r_{nt} \\ r_{(n+1)t} \\ \vdots \end{pmatrix} = \begin{pmatrix} 1\ 1\ 0\ \cdots\ 0\ 1\ 0\ \cdots\ 0 \\ 1\ 1\ 0\ \cdots\ 0\ 0\ 1\ \cdots\ 0 \\ \vdots\ \vdots\ \vdots\ \ddots\ \vdots\ \vdots\ \vdots\ \ddots\ \vdots \\ 1\ 0\ 1\ \cdots\ 0\ 1\ 0\ \cdots\ 0 \\ 1\ 0\ 1\ \cdots\ 0\ 0\ 1\ \cdots\ 0 \\ \vdots\ \vdots\ \vdots\ \ddots\ \vdots\ \vdots\ \vdots\ \ddots\ \vdots \end{pmatrix} \begin{pmatrix} f_{Mt} \\ f_{S1,t} \\ f_{S2,t} \\ \vdots \\ f_{SM,t} \\ f_{C1,t} \\ f_{C2,t} \\ \vdots \\ f_{CN,t} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \vdots \\ \varepsilon_{nt} \\ \varepsilon_{(n+1)t} \\ \vdots \end{pmatrix}, \quad \text{(B2)}$$

where, for illustration, we have assumed that Stocks 1 and 2 belong to Sector 1 and, respectively, Countries 1 and 2 and that stocks n and $n + 1$ belong to Sector 2 and also to, respectively, Countries 1 and 2.

Under this assumption, the factor returns in any period can be estimated by regressing the matrix of sensitivities on the vector of stock returns. This regression could be unweighted, however, so we followed Heston and Rouwenhorst and performed a weighted least-squares regression (WLS), where the weighting matrix is the diagonal matrix of the respective stock market caps.

Finally, there is a colinearity problem: If we sum the sensitivity vectors corresponding to the sector factors or the country factors, we get the vector of sensitivities to the market factor (the first column). To remove this problem, we performed the WLS regression subject to the following two constraints:

$$\sum_{k \in Country} \sum_{j \in Sector} w_{jk} f_{Sj,t} = 0$$

and

$$\sum_{k \in Country} \sum_{j \in Sector} w_{jk} f_{Ck,t} = 0, \quad \text{(B3)}$$

where w_{kj} is the market-cap-weight of sector j in country k as a percentage of world market cap. Now, by performing these constrained WLS regressions for each period of the data sample, we could estimate a time series of country and sector factor returns.

We can now describe how we used this LFM to decompose momentum returns. In Appendix A, we outlined the five steps to calculating the returns to our momentum strategies. To decompose this return, we constructed the portfolios as before for Steps 1 and 2. In Step 3, however, rather than calculating the total return to these portfolios, we decomposed the return into three components—the returns attributable to the sector factors, the returns attributable to the country factors, and the returns attributable to the company-specific factors.

Precisely, we denoted as w_{it} the weight of stock i in the portfolio of interest at time t. Then, to estimate the industry contribution to the momentum strategy, we used

$$\sum_{i \in Stocks} \sum_{j \in Sector} w_{it}\beta_{i,Sj} f_{Sj,t}$$

as the return to this portfolio in Steps 4 and 5, rather than

$$\sum_{i \in Stocks} w_{it} r_{it}.$$

Similarly, to estimate the country contribution, we used the returns to country factors, and to

estimate the company-specific returns, we used the stock-specific idiosyncratic returns,

$$\sum_{i \in Stocks} w_{it}\epsilon_{it}.$$

It follows immediately from Equation B1 that the sum of industry, country, and stock-specific contributions to the momentum strategy must equal the total return to this strategy.

Notes

1. Subperiod results are available from the authors upon request.
2. We detailed various approaches used to estimate this LFM in Scowcroft and Sefton (2002). In Scowcroft and Sefton (2001), we discussed refinements to this model that relax some of the assumptions of the Heston–Rouwenhorst approach.

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