Implementing Momentum: What Have We Learned?

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An abundance of academic evidence and theory exists on the efficacy and intuition behind momentum investing, yet a limited number of studies discuss the feasibility of running momentum portfolios in practice. And no study to date has directly analyzed implementation costs for a live momentum portfolio.

As a result, many are still quick to dismiss momentum as difficult or costly to implement because of its high turnover. In this paper, we use seven years of live data to evaluate the implementability of momentum investing. We show that live momentum portfolios are capable of capturing the momentum premium, even after accounting for expenses, estimated trading costs, taxes, and other frictions associated with real-life portfolios.

Introduction

Momentum is the phenomenon that securities that have performed well relative to their peers ("winners") over the recent period tend to continue to outperform, and securities that have performed relatively poorly ("losers") tend to continue to underperform. The existence of a momentum premium is a well-established empirical result, supported by several decades of academic research.[1] While the original momentum studies covered the period 1963-1990 in U.S. equities, subsequent studies have found a momentum premium in earlier periods (as far back as the Victorian age!), out-of-sample (after the original research was published), across markets and for assets other than stocks (such as bonds, commodities, currencies, global stock market indices, and even sports betting contracts).[2] The additional data samples showing the efficacy of momentum dissuade the notion that the momentum effect is due to statistical chance. The literature also provides insight into why momentum investing works and why we believe it can continue to do so going forward; these insights largely center on behavioral-based theories, but some risk-based explanations also exist.[3]

While a wealth of academic evidence and theory exists on the efficacy and intuition behind momentum investing, a limited number of studies discuss the feasibility of running momentum portfolios in practice.[4] In this paper, we use seven years of live data from standalone momentum strategies to answer a key question: can momentum survive the frictions associated with implementing real-life portfolios? In particular, we show that long-only momentum investing in practice does not have to produce excessive turnover, large trading costs, or significant tax burdens that prohibit capturing the momentum premium — showing that momentum is an implementable strategy.[5]

We start by reviewing the case for momentum investing and portfolio construction of AQR's momentum strategies; we then assess the trading costs of the live strategies, review the impact of taxes, and finally, outline the various portfolio construction choices that may improve the capture of momentum, while still mitigating the impact of transaction costs and taxes.

The Genesis of AQR's Momentum Strategies

AQR launched its first standalone momentum style strategy ("MOM") in July 2009 to provide investors with an opportunity to harvest the momentum premium and to diversify value exposure in their portfolios.[6] The long-run evidence for a hypothetical standalone long-only momentum strategy is compelling: a gross information ratio of around 0.2 to 0.3 with an average level of active risk (relative to the corresponding market capitalization benchmark) of around 5%; this translates into a historical gross average return of around 1% to 1.5% per year over the benchmark.[7] Academic evidence shows that not only has momentum tended to outperform the market, but also that it has been negatively correlated to the value premium - another factor that outperforms the market. Thus, momentum tends to outperform

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1 Jegadeesh and Titman (1993); Asness (1997); Asness, Moskowitz, and Pedersen (2013); Asness, Ilmanen, Israel, and Moskowitz (2015); Asness, Frazzini, Israel, and Moskowitz (2014).

2 See Asness, Moskowitz, and Pedersen (2013) and Asness, Ilmanen, Israel, and Moskowitz (2015) for more on momentum investing across asset classes. Momentum here is cross-sectional momentum, where winners and losers are defined relative to their peers, as opposed to time-series momentum, which is about trend-following for a single asset, where a winner or loser is defined based on its own return being positive or negative (see Moskowitz, Ooi, and Pedersen (2012)).

3 Behavioral theories for momentum posit short-term underreaction to new information due to anchoring or inattention, and/or overreaction to price moves in the medium-term due to feedback trading and investor herding.

4 Frazzini, Israel, and Moskowitz (2015) provide detailed insight on real-world trading costs of academic-style portfolios, with references to other papers attempting to do the same. Gray and Vogel (2017) survey the literature on whether factors survive trading costs and show that the results depend on the data and assumptions used.

5 While we focus on standalone long-only momentum implementation, the main takeaways apply to momentum implemented in a multi-style portfolio and long/short portfolios, too. In fact, the conclusions are likely stronger for an integrated multi-factor portfolio given the benefits of turnover netting across lowly correlated styles (Fitzgibbons et al., 2016).

6 Note that AQR has longer experience running momentum as part of multi-factor portfolios since the inception of the firm in 1998 for long/short strategies and since 2000 for long-only institutional strategies.

7 Based on backtest data for the U.S. over the period 1983-2016 and for International data over the period 1993-2016. Please see the appendix for an explanation of the backtest construction. Hypothetical data has inherent limitations, some of which are disclosed in the appendix. The hypothetical gross performance presented herein does not represent the return to an actual fund or trading account that an investor could directly participate in and does not reflect the deduction of any fees or expenses. It is intended for illustrative purposes only.

when value underperforms (and vice versa), yet both have outperformed the market over time.[8] Combining styles that tend to outperform the market on average, but at different times, can be quite powerful: the resulting portfolio offers even more potential for consistent market outperformance. Based on the sample evidence that momentum works in many markets, the strategies were launched in three regions: U.S. Large Cap, U.S. Small Cap, and International.[9]

At the same time that AQR launched the suite of momentum strategies, they also created a set of momentum indices to help evaluate the implementation of live momentum portfolios. Given that no real momentum benchmark or index existed at the time, the thought was that such indices would give widespread access to this important investment style that investors could follow. These indices are maintained by S&P and provide access to daily returns as well as daily holdings. They are constructed in a similar way to an academic-style portfolio, such as Fama-French's "Up-Minus-Down" (UMD) long/short factor: first, rank stocks on total returns over the past year skipping the most recent month, select the top third of stocks, weight them in proportion to market capitalization, and then rebalance on a quarterly basis. In fact, even though the AQR Momentum Indices are long-only and UMD is long/short,[10] regression analysis shows that the two portfolios capture a similar premium: the indices have both economically and statistically significant exposure to UMD, which highlights how the indices may represent a good 'proxy' for the theoretical momentum return stream.[11]

Compared to the indices, the live strategies utilize a number of more sophisticated portfolio construction decisions – many of which are meant to improve expected net returns. In particular, the live strategies utilize an evolved model that includes multiple measures of momentum[12] and tilts towards higher momentum scoring names: weighting the top third of stocks based on a combination of their market capitalization and signal strength (in this case their momentum characteristic).[13] The strategies rebalance more frequently than the indices (monthly rather than quarterly) to effectively capture the gross momentum premium. And, importantly, the live strategies include additional controls to manage liquidity, turnover, transaction costs, as well as other risk management concerns.

Since we have access to holdings for both the live strategies and theoretical indices, we can decompose the performance differences to provide a careful evaluation of implementation costs.[14] We aim to answer a crucial question: how much did implementation costs impact the returns from momentum investing over the last seven years of live performance? While the last seven years have been difficult for momentum in general (which is not the point of this paper),[15] it's important to study whether the lower than average performance was due to high implementation costs or a more general inability to capture momentum. If either are true, it could be problematic for the momentum strategy

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8 Asness, Moskowitz, and Pedersen (2013) study value and momentum across eight diverse markets and asset classes over the period 1972-2011 and find that value and momentum are consistently negatively correlated within and across asset classes. They also show that value and momentum deliver positive expected abnormal returns in a variety of markets and asset classes, and that their combination performs even better than either alone. Past performance is not a guarantee of future performance.

9 An emerging markets momentum strategy also launched later in 2012.

10 There are other small differences between the long-only AQR Momentum Indices and the UMD long/short factor, including monthly rebalance frequency and larger universes for UMD.

11 A four-factor regression model of the index returns on a set of factors pioneered by Fama and French (consisting of the market, a small stock factor SMB, a value factor HML, and the momentum factor UMD) over the period 1980-2016 shows that the beta coefficient on UMD is 0.4 with a t-statistic of 27.8. Since UMD is long/short, a beta of about 0.5 is expected if the long and short sides contribute equally to UMD's returns (which has been shown to be an empirically reasonable estimate; see Israel and Moskowitz, 2013). When regressing the index returns on the long-side of UMD only and controlling for universe differences, the beta is 0.9 (note that this is over a shorter period, 2009-2016).

12 In addition to the most common measure of price momentum, which is based on total return performance over the past year (skipping the most recent month), the strategies also employ alternate ways to capture momentum, such as Earnings Announcement Momentum, which compares stocks based on average earnings announcement surprises over the past year, and Residual Momentum, which ranks stocks based on volatility-adjusted cumulative idiosyncratic returns over the same period. Portfolio construction is subject to change at any time without notice.

13 Higher scoring names are those that have more significant momentum measures. For more on the benefits of different ways to select and weight securities within a style portfolio, see Israel, Jiang, and Ross (2017).

14 Note that the theoretical indices provide a good proxy for long-only theoretical returns to momentum investing and allow us to decompose implementation costs for the live strategies. As it relates to the stated market benchmarks for the strategies, please see the composite information in the Appendix.

15 As a quick summary, the live period of the strategies has experienced extreme macro-economic events and sharp reversals for markets (as well as industries) and helps explain the lower returns to momentum over the last seven years, relative to its long-run history. Of course, even a good strategy (one with a 0.2-0.3 information ratio) can go through a bad period and seven years of underperformance isn't enough to make us change our beliefs on momentum. For context, the probability that a 0.3 information ratio strategy underperforms (delivers active returns less than zero) over a 7-year period is 21%. See Cliff's Perspectives, "Little Things Mean a Lot," September 15, 2017 for more on this.

in real life implementation; if not, there is still cause for optimism (especially when combined with the long-term performance results).

How Has Implementation Been?

The live experience allows us to address some of the misconceptions of momentum investing. In particular, one of the most common myths about momentum is that it does not survive trading costs because it turns over too quickly. A related claim is that its higher turnover also generates a large tax bill, making it less attractive on a post-tax basis. Finally, some believe that attempts to manage transaction costs and taxes introduce distortions that reduce the ability to capture momentum, which meaningfully decrease gross returns and therefore render a momentum portfolio ineffective.[16]

We can drill down into the real world frictions mentioned above by decomposing the performance differences between the live momentum strategies and the theoretical AQR Momentum Indices based on expenses, trading and rebalancing costs, as well as other portfolio construction differences. Of course, we expect that trading costs and expenses will always be a drag on performance, but 'smarter' portfolio construction decisions should offset these detractions; as such, at best, we expect the live momentum strategies to perform in line with the theoretical AQR Momentum Indices. **Exhibit 1** compares the annualized return of the live strategies relative to the corresponding theoretical indices in the U.S. Large Cap, U.S. Small Cap, and International universes. Over the live period, the strategy outperformed the index in U.S. Large Cap by 0.9%, but underperformed in U.S. Small Cap and International by -1.2% and -1.1%, respectively. As expected, expenses (line item 1) explain a large portion of the difference in performance between the live strategy and the theoretical momentum indices, subtracting 44, 60, and 58 basis points (bps) for the U.S. Large Cap, U.S. Small Cap, and International strategies, respectively.

Exhibit 1 | *Decomposing Implementation*

AQR Momentum Strategies vs. AQR Momentum Indices
July 9, 2009 – December 31, 2016

	U.S. Large Cap	U.S. Small Cap	International	Simple Averages
AQR Live MOM Strategy (Net)	14.3%	15.4%	5.8%	11.8%
AQR Theoretical MOM Index (Gross)	13.5%	16.6%	6.8%	12.3%
Excess (vs. Index)	0.9%	-1.2%	-1.1%	-0.5%
(1) Expenses*	-0.44%	-0.60%	-0.58%	-0.54%
(2) Trading Costs	-0.12%	-0.32%	-0.25%	-0.23%
(3) Portfolio Construction & Other**	1.42%	-0.28%	-0.24%	0.30%
Total	0.87%	-1.19%	-1.08%	-0.47%

Source: AQR. *Expenses calculated as the average over the period. Net strategy performance is net of Expenses, Trading Costs and Portfolio Construction & Other in USD. Net expenses are 0.40% for U.S. Large Cap, 0.60% for U.S. Small Cap and 0.55% for International. Prior to 2015, the expense ratios were 0.49% for U.S. Large Cap, 0.65% for U.S. Small Cap and 0.65% for International. **Other reflects other real-world frictions, such as provisions for flows. See below for more on portfolio construction and other frictions. This information is supplemental to the GIPS® compliant presentations for the Large Cap Momentum Style Composite, Small Cap Momentum Composite, and International Momentum Style Composite as of 12/31/2016. All composites incepted 07/31/2009 and are included in the Appendix. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Also in line with expectations, trading costs (line item 2) were also uniformly negative, but for those who believe the turnover of momentum is prohibitively costly, these actual costs appear rather meager (on average, 23 basis points); we now turn to a detailed discussion of trading costs.

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16 Other myths about momentum, for instance that it works mostly on the short-side or works only among small stocks are addressed in Asness, Frazzini, Israel, and Moskowitz (2015) and Israel and Moskowitz (2013).

Trading Costs

There are a number of techniques that can be used to manage trading costs for any live strategy (not just momentum). When trading momentum, AQR uses a simple optimization framework and employs a transaction cost model to minimize transaction costs per dollar traded. For example, allowing trade substitutions across stocks with similar momentum characteristics and replacing securities that are expensive to trade for those that are cheaper to trade. This substitution is based on expected trading costs that are in turn a function of expected participation rate (i.e., trade size as a fraction of daily volume traded) and information about stock characteristics and market conditions. AQR has developed and calibrated a proprietary trading cost model using data based on their own trading experience in global equities from 1998 to present from all of their hedge fund and institutional portfolios. Importantly, the model depends on the size of trades, which is a key input in determining price impact. Frazzini, Israel, and Moskowitz (2015) use the AQR live trading data to build a simple trading cost model that illustrates how this is done and apply the model to various style portfolios, including momentum. The live strategies also employ a number of techniques to explicitly manage trading costs, such as managing participation rate, trading patiently, and utilizing smart algorithmic trading techniques that try to minimize the price impact of trades.

So, how have these decisions affected the performance of the live portfolios? To better understand the trading costs of the Momentum strategies over the live period, **Exhibit 2** takes the trading cost estimates from Exhibit 1 (line 2) and breaks them down further into the average realized trading cost per dollar traded, annualized turnover, and overall trading costs and their impact on gross returns.

Exhibit 2 | *Decomposing Trading Costs*

AQR Momentum Strategies, Average Trading Costs
July 9, 2009 – December 31, 2016

	U.S. Large Cap	U.S. Small Cap	International	Simple Averages
Turnover (net, ann, 1-sided)	81.9%	79.3%	89.9%	83.7%
Overall Trading Costs (bps, per $ traded)	6.40	18.27	13.16	12.61
Commissions, Fees and Taxes (bps, per $ traded)	0.21	0.35	4.89	1.82
Market Impact (bps, per $ traded)	6.19	17.91	8.28	10.79
Overall Trading Costs (% NAV)	**0.12%**	**0.32%**	**0.25%**	**0.23%**
Commissions & Market Fees (% NAV)	0.00%	0.01%	0.09%	0.03%
Market Impact (% NAV)	0.11%	0.31%	0.16%	0.19%

Source: AQR. Turnover numbers are annualized one-sided and net of flows. The trading costs as a % of NAV are based on turnover numbers including flows. Market Impact is defined as the difference between trade-weighted average execution price and the price at the time the manager enters the market. This information is supplemental to the GIPS® compliant presentations for the Large Cap Momentum Style Composite, Small Cap Momentum Composite, and International Momentum Style Composite as of 12/31/2016. All composites incepted 07/31/2009 and are included in the Appendix. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Realized transaction costs per dollar traded have generally been modest at 12.61 bps per year per dollar traded on average across regions.[17] While not shown here, these realized costs were in line with the predicted estimates of trading costs from AQR's transaction cost model (in fact, they were a bit smaller).

In terms of turnover, the Momentum strategies have experienced roughly 80%-90% average one-sided net turnover per year over their live period (2009-2016). In other words, the strategies bought and sold stocks worth

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17 Using an implementation shortfall method (i.e., including slippage, market impact, commissions, etc.). See Frazzini, Israel, and Moskowitz (2015) for a discussion of this method.

about 80 to 90 cents per dollar of Net Asset Value (NAV) on average per year. This is on the lower side of backtested longer-term expected turnover, which ranges from 80% to 150% annualized turnover per year.[18]

From this analysis, we can address one of the most common myths or misconceptions of momentum investing: that momentum's returns do not survive trading costs. We disagree with that claim and believe the drag from trading costs can be considerably smaller than the expected gross return to momentum. Recall, the gross average historical excess return of momentum is around 1.0% to 1.5% per year. This means that even if transaction costs were twice as high as what we have realized (on average 23 bps), they may only put a small dent in the expected performance of momentum strategies. Put differently, trading costs would need to be more than five times higher than what we experienced with live trades to fully wipe out the expected returns to our momentum strategies. These results are consistent with those in Frazzini, Israel, and Moskowitz (2015), who similarly find that trading costs would need to be many multiples larger than those actually experienced in order to render momentum strategies unprofitable.[19] These results are in stark contrast to much of the literature that estimates trading costs based on liquidity-demanding orders for immediate execution, which can result in many times larger trading costs, or for theoretical models that are not based on actual, live trading costs. The analysis in our paper and Frazzini, Israel, and Moskowitz (2015) is based on actual, live trading costs. Moreover, the analysis here is based off of a live momentum strategy and hence represents the actual realized costs of a live momentum implementation and *not* the estimated costs from a model.

So far we have focused on average realized trading costs over the whole seven year period, but it is also useful to get a sense of the variability of transaction costs and turnover over time, as well as over different periods, with varying flows and asset growth of the strategies. **Exhibit 3** shows trading costs per dollar traded and asset growth by year; for brevity, the figure aggregates across regions, weighted by the dollar value of trades. The patterns are similar across regions and shown in Appendix A. On average, across regions and years, the live strategies have realized some variability in net turnover year-to-year: from a low of 70% in 2013 to highs of 144% in 2011 and 151% in 2010. To a large extent, this variability is intended as the strategy does not explicitly constrain turnover and allows for slightly more turnover when warranted by larger changes in the underlying momentum portfolio. That is, when momentum characteristics vary more across companies and time, the momentum portfolio will naturally experience more turnover. Flows will also cause some variability in net turnover.

The market impact varies between 0.7 bps in 2010 to 16.6 bps in 2013, with smaller variability in commissions, which range from 0.8 bps in 2011 to 1.8 bps in 2016. It is difficult to ascertain a clear relationship between trading costs per dollar traded and net turnover during the live period of the strategies. For example, the strategies experienced higher net turnover in 2010 and 2011, but market impact was lower. Further, general market conditions, like market volatility as measured by VIX, which was highest in the first half of 2009 and second half of 2011, showed little relation to market impact, which was at low to medium levels in those periods.[20]

Importantly, even if transaction costs going forward are at the highest realized level (in 2013 they were close to 17 bps) and we take into account average gross turnover in that year, momentum would still survive and deliver sizeable positive net returns (based on the historical implied gross return expectations previously mentioned). Finally, as mentioned, while the momentum style has had a tough period over the past seven years, transaction costs were not the culprit and were actually lower than expected. Ultimately, the trading costs for momentum have generally been fairly low, and despite the higher turnover relative to other style strategies, such as value and defensive (noted in Frazzini, Israel, and Moskowitz (2015)), momentum still survives transaction costs.

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18 Based on backtest data for the U.S. over the period 1983-2016 and for International over the period 1993-2016. Please see the appendix for an explanation of the backtest construction. Hypothetical data has inherent limitations, some of which are disclosed in the appendix.
19 It's important to note that less efficient trading may result in higher transaction costs.
20 A simple regression of average realized market impact per year on average VIX and average gross or net turnover confirms no strong relationship over this period (small and statistically insignificant coefficients). In general, everything else equal, we do expect market impact to increase with turnover and market volatility, but over shorter periods the relationship can be noisy.

Exhibit 3 | *Decomposing Average Trading Costs Over Time*

AQR Momentum Strategies, Average Trading Costs Over Time
July 9, 2009 – December 31, 2016

	2009	2010	2011	2012	2013	2014	2015	2016
Net Turnover*	83.7%	151.4%	143.8%	72.6%	70.4%	91.1%	88.9%	83.7%
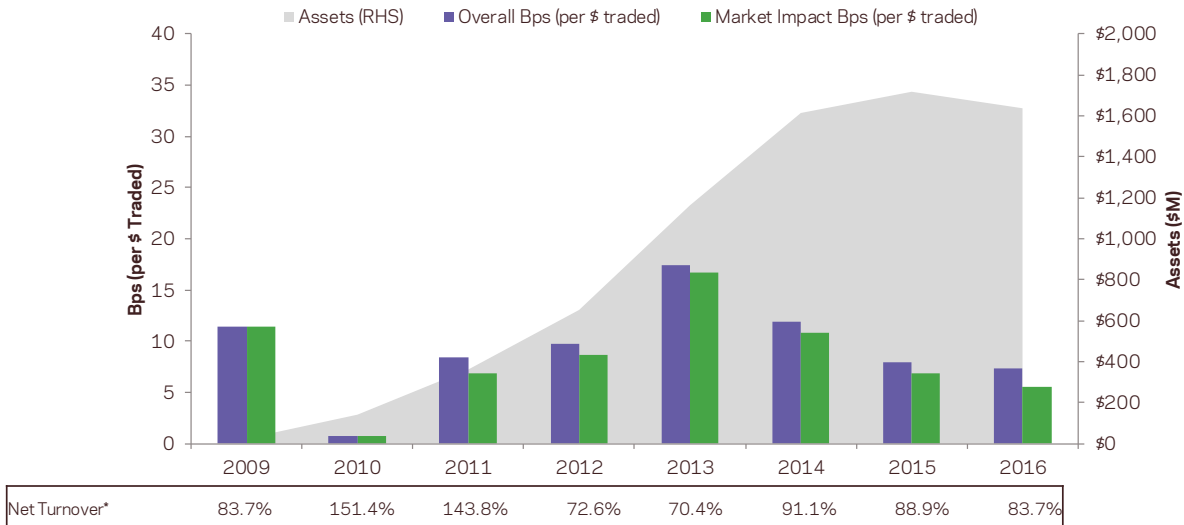
* One-sided annualized turnover. Net turnover excludes flows. The trading costs and net turnover are averaged across all three strategy universes.
Source: AQR. Market Impact is defined as the difference between trade-weighted average execution price and the price at the time the manager enters the market. This information is supplemental to the GIPS® compliant presentations for the Large Cap Momentum Style Composite, Small Cap Momentum Composite, and International Momentum Style Composite as of 12/31/2016. All composites incepted 07/31/2009 and are included in the Appendix. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Taxes

The second largest misconception about momentum relates to its tax efficiency. Many claim that due to its higher turnover, especially relative to value or defensive styles, momentum is considerably more tax inefficient. However, as shown in Israel and Moskowitz (2012), higher turnover does not necessarily equal higher taxes, especially if it generates relatively more short-term losses, which are beneficial from a tax perspective. In fact, by design, momentum tends to hold winners longer and sell losers more quickly, which means it realizes short-term losses and generates more long-term capital gains than short-term capital gains, both of which are tax advantageous. In addition, momentum stocks tend to have relatively lower dividend yield than value or defensive stocks, and hence will generate lower income tax. Furthermore, as explained and tested in Israel and Moskowitz (2012), momentum is more amenable to tax optimization compared to other styles, such as value and defensive, because it is more efficient to make trade-offs across long-term vs. short-term capital gains and losses without incurring meaningful style drift.[21] Put differently, momentum is a more substitutable characteristic than say value from a tax optimization perspective, in the sense that it is easier to find similar momentum stocks with different tax liabilities than it is to find a similar value stock with very different tax consequences. Accelerating the realization of short-term losses or deferring the realization of gains from short-term to long-term status (which often requires only delaying a trade by a month) has a small effect on the momentum exposure of the portfolio, but a large tax effect given the difference in tax rates between short- and long-term capital net gains.

To address the misconceptions related to taxes and momentum investing, we can also look to the live strategies AQR launched in January 30, 2012, which are tax-aware versions of the momentum strategies in the three regions

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21 In the case of value, avoiding high dividend paying stocks or reducing the income of the portfolio simultaneously reduces value exposure; as such, tax-aware optimization for a value portfolio coincides with value reduction.

previously discussed.[22] These strategies follow similar processes, with the tax-aware versions utilizing a tax optimization that aims to minimize capital gains tax liabilities, while maintaining meaningful exposure to momentum. The tax-management techniques include deferring realizations of capital gains and attempting to generate long-term capital gains, accelerating the realization of short-term losses to offset realized gains, and limiting portfolio turnover that may result in taxable gains. It is similar in spirit to the kinds of trade-offs that can be made to reduce transaction costs, where a tax optimization will make substitutions between stocks with similar momentum characteristics but different tax impacts. In order to accommodate such tax cost-benefit tradeoffs, we expect the tax-aware process to incur a reduction in pre-tax return on average, albeit a small one.

As a result of the techniques described above, the tax-aware versions are designed explicitly for tax sensitive investors, who want to reduce taxes and are more concerned with after-tax returns. Conversely, the tax-agnostic strategies are better suited for tax exempt investors, who are more concerned about pre-tax returns. The two types of strategies also allow us to evaluate the tax-efficiency of momentum, and, importantly, the efficacy of the tax optimization techniques. To do so, we compare the tax-experience of the regular momentum strategies versus the Tax-Managed ("TM") strategies over their common overlapping period (2012-2016); the summary results across universes are shown in **Exhibit 4**.[23]

Exhibit 4 | *Decomposing the Impact of Taxes*

AQR Momentum Strategies, Tax Characteristics
February 1, 2012 – December 31, 2016

	Simple Averages Across Universes			
	Regular MOM *(Tax-Agnostic)*	**Tax-Managed MOM** *(Tax-Aware)*	**Difference** *(Aware – Agnostic)*	**Market Index**
(1) Pre-Tax Return	10.1%	10.2%	**0.1%**	10.7%
(2) Potential Federal Taxes	-1.2%	-0.5%	**0.7%**	-0.6%
(3) Post-Tax Return	8.9%	9.7%	**0.8%**	10.1%
(4) Effective Tax Rate	11.4%	5.3%	**-6.1%**	7.2%
(5) Turnover	81%	47%	**-34%**	8%

Excess Returns: Tax-Agnostic vs Tax-Aware

Correlation	**0.97**
Tracking Error	**0.8%**

Source: AQR. Analysis is run since the inception of the Tax-Aware AQR strategies. Time period based off longest common time period between the tax-agnostic and tax-aware strategies. Calculation methodology is the Morningstar methodology for computing pre-tax and after tax returns; it accounts for federal taxes only. Returns are net of fees and expenses: net expenses are 0.40% for U.S. Large Cap, 0.60% for U.S. Small Cap and 0.55% for International. Prior to 2015, the expense ratios were 0.49% for U.S. Large Cap, 0.65% for U.S. Small Cap and 0.65% for International. Net expenses are 1 bp higher for the Tax-Aware Strategy. Effective tax rate is calculated as (pre-tax return – after-tax return)/pre-tax return. Tax rates are as follows: 43.4% for ordinary dividends, 23.8% for qualified dividends and 23.8% for capital gains. Benchmark taxes are computed based on the assumption that passive exposure is taken with corresponding ETFs: IWB for U.S. Large Cap, IWM for U.S. Small Cap and a weighted combination of the EFA and EWC for International. Benchmark turnover is based on the turnover of the corresponding tracking ETF. Both the pre-tax and after-tax return on the benchmark are gross of transaction costs and fees, while the corresponding numbers for the strategies are net of both transaction costs and fees. Correlations and relative tracking error are based on monthly returns in excess of the respective benchmarks. Relative tracking error is annualized. This material is intended for informational purposes only and should not be construed as legal or tax advice, nor is it intended to replace the advice of a qualified attorney or tax advisor. The recipient should conduct his or her own analysis and consult with professional advisors prior to making any investment decisions. This information is supplemental to the GIPS® compliant presentations for the Large Cap Momentum Style Composite, Small Cap Momentum Composite, International Momentum Style Composite, Tax Managed Momentum Composite, Tax Managed Small Cap Momentum Composite, and Tax Managed International Momentum Composite as of 12/31/2016. The tax-agnostic composites incepted 07/31/2009 while the tax-managed incepted in 01/31/2012 – all are included in the Appendix. Past performance is not a guarantee of future performance. Please

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22 This material is intended for informational purposes only and should not be construed as legal or tax advice, nor is it intended to replace the advice of a qualified attorney or tax advisor. The recipient should conduct his or her own analysis and consult with professional advisors prior to making any investment decisions.

23 In Appendix B, we include a breakdown for each region rather than simple averages across universes.

see Disclosures for additional information regarding the calculation of the Potential Federal Tax Benefit and after Tax returns.

The results show that both the regular and TM strategies have had similar pre-tax returns (line 1), but have paid different amounts of taxes (line 2). Importantly, the tax benefit, measured by the difference in taxes paid by the tax-agnostic versus tax-aware strategy, has been positive and on the order of 0.7% per year on average across regions. As a result, the tax-aware strategies have realized higher after-tax returns (line 3) than the tax-agnostic strategies; while this result is largely due to lower taxes, it also stems from similar or slightly higher pre-tax returns over this period. Even though we expect the tax-aware strategies to have slightly lower pre-tax returns over the long-run, we can observe similar pre-tax outcomes over shorter periods (that is, the TM got a bit lucky over this period). The results in Exhibit 4 also show the effective tax rates of the two types of strategies (line 4): the effective tax rates for the TM strategies have been roughly 5% on average across regions (lower than our long-term expectation of around 10%),[24] while the effective tax rate for the tax-agnostic strategies have been higher, at around 11% on average for the full live period (which is still within long-term expectations of about 17%). Finally, also consistent with the benefits of tax optimization, the TM strategies have realized lower turnover than the regular strategies: roughly 30%-40% lower, as shown in line 5. These results illustrate the feasibility and benefits of tax-optimization for momentum strategies. The TM strategies have captured a similar return premium as the regular MOM strategies in a tax-efficient manner, further evidenced by the high correlation of excess returns (> 0.95) and low realized tracking error ($< 1\%$).

While the tax-aware strategies have generated higher after-tax returns than their tax-agnostic counterparts, we can also compare how they have fared relative to a passive index approach. These results are also shown in Exhibit 4; they highlight how the TM strategies have realized similar or lower taxes than their corresponding passive market index – across regions, the passive market index paid roughly 0.6% in taxes per year, while the TM strategies paid roughly 0.5%. These outcomes were realized despite the fact that the passive strategies experienced considerably lower turnover over this period.[25]

The results shown in Exhibit 4 address one of the most prominent myths about momentum and show that its higher turnover does not appear to result in prohibitively larger tax costs. Based on the evidence from live data, it does not appear that momentum strategies carry a heavy tax burden. Most importantly, simple tax optimizations may significantly reduce taxes: over this period, the TM Momentum strategy incurred a tax liability in line or better than the passive benchmark, without altering the nature of the portfolio and maintaining its momentum exposure.

So far we have focused on transaction costs and taxes, both of which impact gross expected returns. Compared to the gross excess return expectation of 1.0-1.5%, we have shown that transaction costs on average would have detracted 0.23%. Importantly for tax-aware investors, the tax-aware strategies actually had a tax benefit relative to the cap-weighted benchmark, and contributed 0.10% on average across universes over this period.[26] As such, the 1.0-1.5% gross excess return would survive the major implementation costs associated with running a live strategy for both tax-exempt investors (who invest in the tax-agnostic strategy and care only about transaction costs) as well as for taxable investors (who invest in the tax-aware strategy and care about both transaction costs and taxes).

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24 The expectations are based on historical simulations from November 1983 to December 2016 in the U.S. and February 1993 to December 2016 in International, using a similar set-up as those used in the live strategies. The estimates are also in line with those from Israel and Moskowitz (2012).

25 Our tax liability estimates for the benchmarks are conservative estimates of taxes paid by a passive strategy due to the fact that they are based on tracking ETFs, which generate minimal capital gains owing to the favorable tax regulation on AP intermediates. The majority of the benchmark tax liability is due to dividend payments, which are largely qualified. If, however, the benchmark exposure were obtained through a different vehicle – such as a mutual fund or L.P. structure - we would expect the capital gains tax burden of the benchmark to be considerably higher. Furthermore, both the pre-tax and after-tax return on the benchmark are gross of transaction costs and fees, while the corresponding numbers for the live strategies are net of transaction costs and fees.

26 The cap-weighted benchmarks paid roughly 0.6% on average across universes, while the tax-agnostic momentum strategies paid 1.2% and tax-aware paid 0.5%. As a result, the taxes paid relative to the cap-weighted benchmark were -0.60% for tax-agnostic and + 0.10% for tax-aware (that is, tax-aware had a tax benefit relative to the cap-weighted benchmark).

Many critics also believe that the implementation techniques previously discussed (to help control transaction costs and taxes) can distort the portfolio and reduce the gross return of momentum. While we do agree and expect these types of techniques will have a cost, our backtests and real life experiences show the costs to be quite small. On top of that, there are various portfolio construction choices that can potentially add value by improving the gross return to momentum; these choices include rebalancing more frequently (monthly rather than quarterly), tilting towards stocks with higher momentum versus a pure market-capitalization weighting scheme, as well as adding momentum metrics that go beyond the simple academic price momentum, such as momentum around earnings announcements or momentum based on residual rather than total returns.[27] Such portfolio construction choices add value that we believe more than offset the mild costs associated with slowing down turnover and making substitutions towards cheaper to trade stocks. Finally, it is prudent that the live strategy pays close attention to risk management in the form of constraining maximum active exposure to sectors and countries[28] that can represent unintended bets unrelated to momentum that the index construction can expose an investor to. These unintended bets represent added risks that may not be rewarded with a momentum premium, so managing them can create a more efficient momentum exposure.

Compared to the theoretical AQR Momentum Index, the live portfolios get hurt a bit by having to trade more optimally, and helped by better portfolio construction and more robust measurement of momentum. On net, these decisions have added about 30 bps on average per year across regions over the live period of the momentum strategies (as seen in line 3 from Exhibit 1), primarily in U.S. Large Cap and International universes.[29] Even though this may not be the case in every period, we expect that over time these portfolio improvements can enhance expected returns. We expect and find that the costs of implementation are small, while the benefits of portfolio construction are significant, so that the net effect is a live strategy that captures the theoretical momentum premium without incurring substantial real-world costs and potentially adds value.

Conclusion

While seven years of live experience is still too short to evaluate the efficacy of a style portfolio such as momentum (i.e., what is the true gross momentum premium?), it is sufficient to learn something about its implementability in practice. Through an examination of the live track record and trades of AQR's momentum strategies in three regions, U.S. Large Cap, U.S. Small Cap, and International, we find that many implementation concerns about momentum may be overstated. Over the past seven years, through efficient portfolio construction and trading techniques, we show that the momentum style has been captured in an efficient, low cost manner. Comparing tax-aware and tax-agnostic versions of the same strategy that have been run concurrently over the last five years, we also find significant tax improvements from the tax-optimized portfolios that are consistent with – or actually better than– historical estimates from academic studies.

The results show that momentum is an implementable strategy and that the live experience of trading has not necessarily produced excessive turnover, large trading costs, or significant tax burdens. These results contradict common myths about momentum investing, but are in line with recent academic studies that attempt to address these issues (Frazzini, Israel, and Moskowitz (2015), Israel and Moskowitz (2012), and Sialm and Sosner (2017)). Our live experience running momentum portfolios matches the conclusions of these academic studies, which highlight the momentum strategies can easily survive these implementation costs.

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27 For an overview of the various 'craftsmanship' choices that can be made when constructing style portfolios, see Israel, Jiang, and Ross (2017).

28 The strategies limit sector and country deviations relative to market capitalization benchmarks and also place a maximum on total stock level exposure.
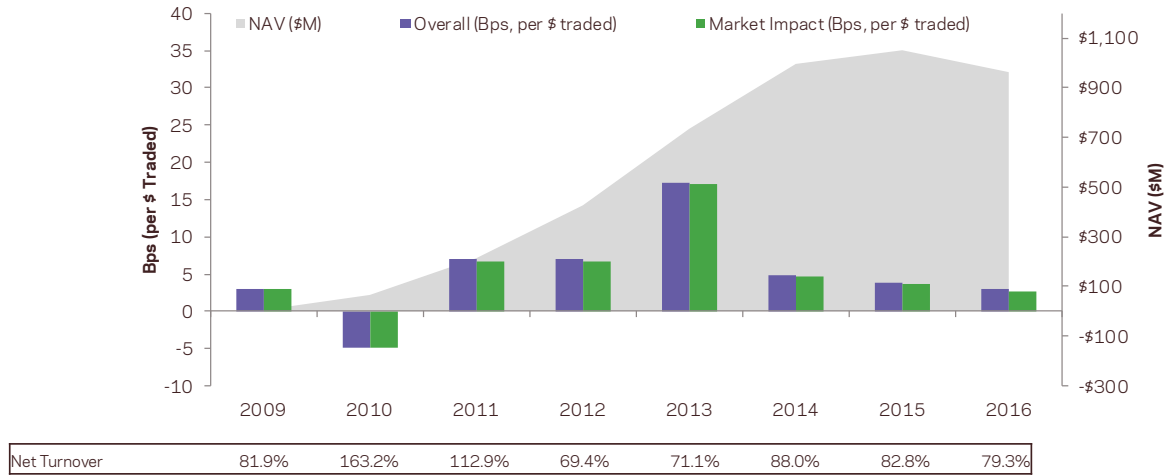
29 This information is supplemental to the GIPS® compliant presentations for the Large Cap Momentum Style Composite, Small Cap Momentum Composite, and International Momentum Style Composite as of 12/31/2016. All composites incepted 07/31/2009 and are included in the Appendix. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

We remain advocates of momentum investing and believe it is implementable in practice as a stand-alone strategy. Further, alongside other themes like value and profitability, momentum is not only more valuable from a portfolio efficiency standpoint (as shown in Asness, Moskowitz, and Pedersen (2013) and Asness, Ilmanen, Israel, and Moskowitz (2015)), but may also be more implementable when combined with other themes and integrated into a multi-style portfolio.
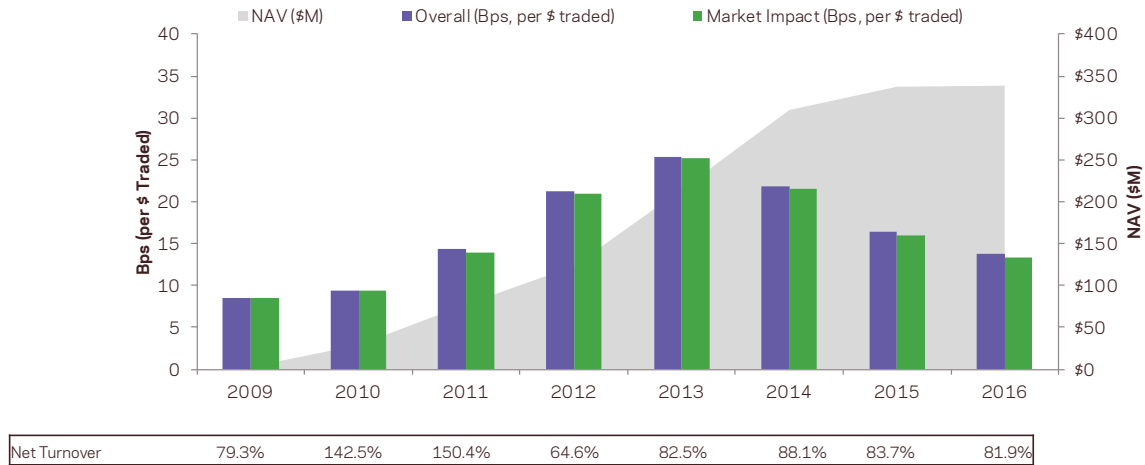
Exhibit A1: *Momentum Strategies, Average Trading Costs Over Time Broken Out by Universe*
July 9, 2009 – December 31, 2016
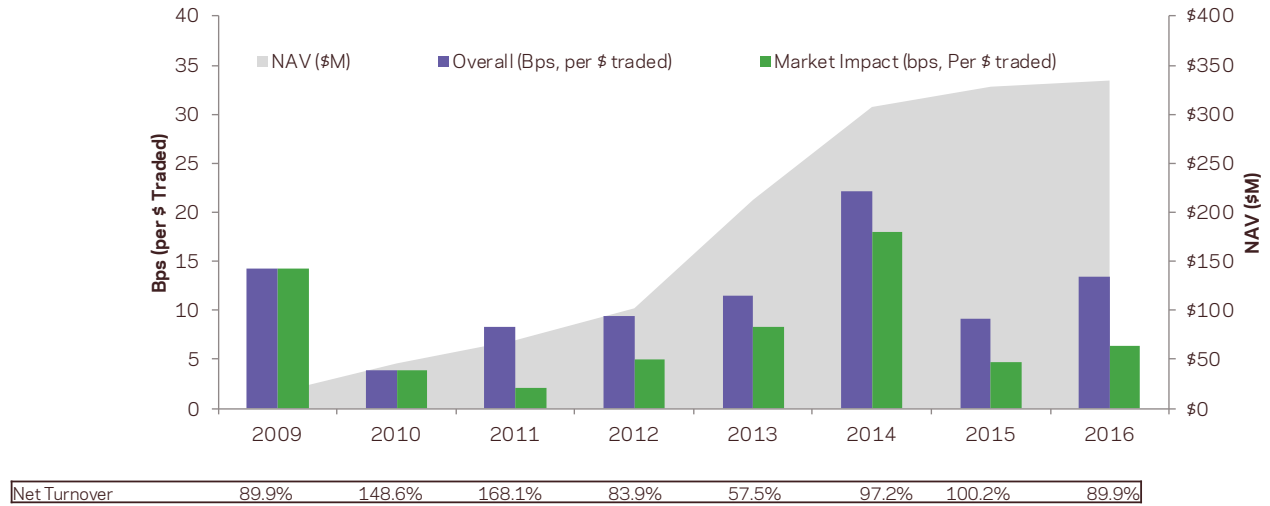
U.S. Large Cap

Net Turnover	81.9%	163.2%	112.9%	69.4%	71.1%	88.0%	82.8%	79.3%

U.S. Small Cap

Net Turnover	79.3%	142.5%	150.4%	64.6%	82.5%	88.1%	83.7%	81.9%

International

Chart legend: NAV ($M) | Overall (Bps, per $ traded) | Market Impact (bps, Per $ traded)

Left axis: Bps (per $ Traded) 0–40. Right axis: NAV ($M) $0–$400. X-axis years 2009–2016.

	2009	2010	2011	2012	2013	2014	2015	2016
Net Turnover	89.9%	148.6%	168.1%	83.9%	57.5%	97.2%	100.2%	89.9%

Source: AQR. Turnover numbers are annualized one-sided and net of flows. The trading costs as a % of NAV are based on turnover numbers including flows. Market Impact is defined as the difference between trade-weighted average execution price and the price at the time the manager enters the market. This information is supplemental to the GIPS® compliant presentations for the Large Cap Momentum Style Composite, Small Cap Momentum Composite, and International Momentum Style Composite as of 12/31/2016. All composites incepted 07/31/2009 and included in the Appendix. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix.

Appendix B: Tax Details
AQR Momentum Strategies, Tax Characteristics Broken Out by Universe
February 1, 2012 – December 31, 2016

	U.S. Large Cap				U.S. Small Cap				International			
	Regular MOM (Tax-Agnostic)	Tax-Managed MOM (Tax-Aware)	Difference (Aware-Agnostic)	Market Index (Russell 1000)	Regular MOM (Tax-Agnostic)	Tax-Managed MOM (Tax-Aware)	Difference (Aware-Agnostic)	Market Index (Russell 2000)	Regular MOM (Tax-Agnostic)	Tax-Managed MOM (Tax-Aware)	Difference (Aware-Agnostic)	Market Index (MSCI World, ex. U.S.)
(1) Pre-Tax Return	12.9%	12.9%	**-0.1%**	13.9%	13.0%	13.1%	**0.1%**	13.1%	4.3%	4.6%	**0.3%**	5.1%
(2) Potential Federal Taxes	-1.8%	-0.5%	**1.3%**	-0.5%	-1.3%	-0.5%	**0.7%**	-0.4%	-0.4%	-0.4%	**0.1%**	-0.8%
(3) Post-Tax Return	11.1%	12.4%	**1.2%**	13.3%	11.7%	12.6%	**0.8%**	12.8%	3.8%	4.2%	**0.4%**	4.3%
(4) Effective Tax Rate	14.0%	3.8%	**-10.2%**	3.7%	9.8%	3.9%	**-5.9%**	2.9%	10.4%	8.3%	**-2.1%**	15.1%
(5) Turnover	78%	47%	**-31%**	4%	80%	41%	**-39%**	15%	86%	53%	**-33%**	4%
Excess Returns: Tax-Agnostic vs Tax-Aware												
Correlation			**0.98**				**0.95**				**0.99**	
Tracking Error			**0.8%**				**1.0%**				**0.7%**	

Source: AQR. Analysis is run since the inception of the Tax-Aware AQR strategies. Time period based off longest common time period between the tax-agnostic and tax-aware strategies. Calculation methodology is the Morningstar methodology for computing pre-tax and after tax returns; it accounts for federal taxes only. Returns are net of fees and expenses: net expenses are 0.40% for U.S. Large Cap, 0.60% for U.S. Small Cap and 0.55% for International. Prior to 2015, the expense ratios were 0.49% for U.S. Large Cap, 0.65% for U.S. Small Cap and 0.65% for International. Net expenses are 1bp higher for the Tax-Aware Strategy. Effective tax rate is calculated as (pre-tax return – after-tax return)/pre-tax return. Tax rates are as follows: 43.4% for ordinary dividends, 23.8% for qualified dividends and 23.8% for capital gains. Benchmark taxes are computed based on the assumption that passive exposure is taken with corresponding ETFs: IWB for U.S. Large Cap, IWM for US Small Cap and a weighted combination of the EFA and EWC for International. Benchmark turnover is based on the turnover of the corresponding tracking ETF. Both the pre-tax and after-tax return on the benchmark are gross of transaction costs

and fees, while the corresponding numbers for the strategies are net of both transaction costs and fees. Correlations and relative tracking error are based on monthly returns in excess of the respective benchmarks. Relative tracking error is annualized. This material is intended for informational purposes only and should not be construed as legal or tax advice, nor is it intended to replace the advice of a qualified attorney or tax advisor. The recipient should conduct his or her own analysis and consult with professional advisors prior to making any investment decisions. This information is supplemental to the GIPS® compliant presentations for the Large Cap Momentum Style Composite, Small Cap Momentum Composite, International Momentum Style Composite, Tax Managed Momentum Composite, Tax Managed Small Cap Momentum Composite, and Tax Managed International Momentum Composite as of 12/31/2016. The tax-agnostic composites incepted 07/31/2009 while the tax-managed incepted in 01/31/2012 – all are included in the Appendix. Past performance is not a guarantee of future performance. Please read important disclosures in the Appendix. Please see Disclosures for additional information regarding the calculation of the Potential Federal Tax Benefit and after Tax returns.

Appendix C: Backtest Description

Universe
- Liquid tradable universes for U.S. Large and Small Cap (roughly equivalent to the Russell 1000 or Russell 2000 respectively), International (roughly equivalent to the MSCI World Index)

Monthly rebalancing frequency with the following backtesting period
- U.S. Large Cap Momentum: January 1984 to December 2016
- U.S. Small Cap Momentum: January 1984 to December 2016
- International Momentum: February 1993 to December 2016

Risk model
- U.S. Large Cap and Small Cap Momentum: Barra USE3L Model
- International Momentum:
    - Barra Global Equity Model (GEM) from 1993 to 1999
    - Barra Integrated Model Long-Term (BIMDEV_301L) from 1999 to current

Performance is measured after AQR's proprietary t-cost estimates and backtests are discounted.

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AQR claims compliance with the Global Investment Performance Standards (GIPS®) and has prepared and presented this report in compliance with the GIPS standards. AQR has been independently verified for the period August 1998 through December 2016. The verification reports are available upon request. Verification assesses whether (1) the firm has complied with all the composite construction requirements of the GIPS standards on a firm-wide basis and (2) the firm's policies and procedures are designed to calculate and present performance in compliance with the GIPS standards. Verification does not ensure the accuracy of any specific composite presentation.

Firm Information: AQR Capital Management, LLC ("AQR") is a Connecticut based investment advisor registered with the Securities and Exchange Commission under the Investment Advisors Act of 1940. AQR conducts trading and investment activities involving a broad range of instruments, including, but not limited to, individual equity and debt securities, currencies, futures, commodities, fixed income products and other derivative securities.

For purposes of firm-wide compliance and firm-wide total assets, AQR defines the "Firm" as entities controlled by or under common control with AQR (including voting right). The Firm is comprised of AQR and its advisory affiliates, including CNH Partners, LLC ("CNH").

Upon request AQR will make available a complete list and description of all of Firm composites, as well as additional information regarding the policies for valuing portfolios, calculating performance, and preparing compliant presentations.

Past performance is not an indication of future performance.

New accounts that fit the Composite definition are added at the start of the first full calendar month after the assets come under management, or after it is deemed that the investment decisions made by the investment advisor fully reflect the intended investment strategy of the portfolio. Composites will exclude terminated portfolios after the last full calendar month performance measurement period that the assets were under management. The Composite will continue to include the performance results for all periods prior to termination. Effective for periods beginning July 1, 2010 through February 28, 2015, the Composite defined a significant cash flow as an external cash flow within a portfolio of 50%. Additional information is available upon request.

Calculation Methodology: All portfolios except mutual funds and UCITS are valued monthly and intra-month for large cash flows as defined by Firm policy. The Modified Dietz calculation methodology is used when calculating monthly and intra-month returns. Mutual funds and UCITS are valued daily and performance is calculated on a daily basis. Gross of fees returns are calculated gross of management and performance fees, administrative and custodial costs and net of transaction costs beginning January 1, 2010. Prior to January 1, 2010, gross of fees returns are gross of management and performance fees, and net of administrative, custodial, and transaction costs. Additional information regarding fees and the calculation of gross and net performance is available upon request.

Composite net of fees returns are calculated by deducting the maximum management or advisory fee charged by AQR from the gross composite monthly returns to all portfolios in the Composite. The standard model management fee per annum for this Composite is specified below. Composite assets may have been exposed to the impact of performance fees.

The dispersion measure is the equal-weighted standard deviation of accounts in the Composite for the entire year. Dispersion is not considered meaningful for periods shorter than one year or for periods during which the Composite contains five or

fewer accounts for the full period. The three-year annualized ex-post standard deviation measure is inapplicable when 36 monthly returns are not available.

Fees: Returns are calculated net of all withholding taxes on foreign dividends. Accruals for fixed income and equity securities are included in calculations. AQR's management or advisory fees are described in Part 2A of its Form ADV. In addition, AQR funds may have a redemption charge up to 2.00% based on gross redemption proceeds that may be charged upon early withdrawals. Consultants supplied with gross results are to use this data in accordance with SEC, CFTC and NFA guidelines.

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Large Cap Momentum Style Composite
7/31/2009 – 12/31/2016

Year	Gross Return %	Net Return %	Benchmark * Return %	Number of Portfolios	Composite 3-Yr StDev %	Benchmark * 3-Yr StDev %	Composite Assets ($M)	Total Firm Assets ($M)
2009	14.92	14.78	14.87	1	N/A	N/A	6.93	23,571.55
2010	19.18	18.83	16.71	1	N/A	N/A	124.52	32,701.21
2011	-2.20	-2.50	2.64	1	N/A	N/A	302.72	43,540.99
2012	18.05	17.70	15.26	1	17.55	15.66	490.50	71,122.42
2013	35.93	35.53	33.48	1	13.01	12.18	921.42	98,302.69
2014	10.36	10.03	13.05	1	9.87	9.59	1,072.34	122,655.99
2015	3.30	2.99	5.67	1	11.27	10.70	1,030.63	142,173.39
2016	5.02	4.70	7.08	1	10.97	11.15	896.29	175,089.36

Russell 1000 Growth Index

Composite Characteristics: The Large Cap Momentum Style Composite (the "Composite") was created in August 2009. The account included invests its assets primarily in equity or equity-related securities of large and mid-sized companies traded on a principal U.S. exchange or over-the-counter market that the Adviser determines to have positive momentum. The remainder is generally invested in interest-bearing money market accounts and treasury bills. The Composite is denominated in U.S. Dollars. The Composite benchmark is the Russell 1000 Growth Index (the "Benchmark"). The index measures the performance of the large-cap growth segment of the U.S. equity universe.

Fees: AQR's asset-based fees for portfolios within the Composite may range up to 0.30%** of assets under management and are generally billed monthly or quarterly at the commencement of the calendar month or quarter during which AQR will perform the services to which the fees relate.

** AQR retroactively revised the Composite's highest model fee from 0.40% to 0.30% per annum on January 1, 2016.

Small Cap Momentum Composite

7/31/2009 – 12/31/2016

Year	Gross Return %	Net Return %	Benchmark * Return %	Number of Portfolios	Composite 3-Yr StDev %	Benchmark * 3-Yr StDev %	Composite Assets ($M)	Total Firm Assets ($M)
2009	6.36	6.15	12.06	1	N/A	N/A	3.24	23,571.55
2010	28.47	27.85	29.09	2	N/A	N/A	126.48	32,701.21
2011	-1.88	-2.37	-2.91	2	N/A	N/A	165.89	43,540.99
2012	20.22	19.63	14.59	2	22.39	20.72	215.21	71,122.42
2013	45.75	45.05	43.30	2	17.71	17.27	424.89	98,302.69
2014	3.39	2.88	5.60	2	13.84	13.82	429.77	122,655.99
2015	-3.64	-4.12	-1.38	1	15.25	14.95	339.25	142,173.39
2016	13.89	13.33	11.32	1	16.08	16.67	337.85	175,089.36

Russell 2000 Growth Index

Composite Characteristics: The Small Cap Momentum Composite (the "Composite") was created in August 2009. Accounts included their invest assets primarily in equity or equity-related securities of Small Cap companies traded on a principal U.S. exchange or over-the-counter market that AQR determines to have positive momentum. The Composite is denominated in USD. The Composite will include participants at their subscription date. The Composite benchmark is the Russell 2000 Growth Index (the "Benchmark"). The index measures the performance of the Small Cap growth segment of the U.S. equity universe.

Fees: AQR's asset-based fees for portfolios within the Composite may range up to 0.50% of assets under management and are generally billed monthly or quarterly at the commencement of the calendar month or quarter during which AQR will perform the services to which the fees relate.

International Momentum Style Composite
7/31/2009 – 12/31/2016

Year	Gross Return %	Net Return %	Benchmark * Return %	Number of Portfolios	Composite 3-Yr StDev %	Benchmark * 3-Yr StDev %	Composite Assets ($M)	Total Firm Assets ($M)
2009	11.20	11.02	11.92	1	N/A	N/A	29.89	23,571.55
2010	14.07	13.62	13.06	1	N/A	N/A	61.91	32,701.21
2011	-13.54	-13.89	-12.71	1	N/A	N/A	77.23	43,540.99
2012	18.37	17.90	15.48	1	20.02	18.64	127.38	71,122.42
2013	22.98	22.50	20.53	1	16.29	15.58	298.56	98,302.69
2014	-8.59	-8.96	-3.26	1	11.89	11.88	316.19	122,655.99
2015	1.42	1.01	1.65	1	12.06	11.50	339.90	142,173.39
2016	-3.05	-3.44	-1.87	1	10.70	11.91	327.22	175,089.36

MSCI World ex-USA Growth Net Index

Composite Characteristics: The International Momentum Style Composite (the "Composite") was created in August 2009. The strategy invests primarily in equity or equity-related securities of non-US companies deemed to have positive momentum. The remainder is generally invested in interest-bearing money market accounts and treasury bills. The Composite is denominated in USD. The Composite benchmark is the MSCI World ex-USA Growth Net Index (the "Benchmark"). The index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of developed markets' country indices across the world, excluding the U.S.

Fees: AQR's asset-based fees for portfolios within the Composite may range up to 0.40%** of assets under management and are generally billed monthly or quarterly at the commencement of the calendar month or quarter during which AQR will perform the services to which the fees relate.

** AQR retroactively revised the Composite's highest model fee from 0.50% to 0.40% per annum on January 1, 2016.

Tax Managed Momentum Composite
1/31/2012 – 12/31/2016

Year	Gross Return %	Net Return %	Benchmark * Return %	Number of Portfolios	Composite 3-Yr StDev %	Benchmark * 3-Yr StDev %	Composite Assets ($M)	Total Firm Assets ($M)
2012	13.55	13.24	8.77	1	N/A	N/A	4.71	71,122.42
2013	35.67	35.28	33.48	1	N/A	N/A	48.84	98,302.69
2014	11.43	11.10	13.05	1	N/A	N/A	117.02	122,655.99
2015	3.23	2.92	5.67	1	11.18	10.70	137.52	142,173.39
2016	4.54	4.23	7.08	1	10.99	11.15	145.80	175,089.36

* Russell 1000 Growth Index

Composite Characteristics: The Tax Managed Momentum Composite (the "Composite") was created in February 2012. Accounts included invest primarily in equity or equity-related securities of large and mid-sized companies traded on a principal U.S. exchange or over-the-counter market that are determined to have positive momentum. The remainder is generally invested in interest-bearing money market accounts and treasury bills. Portfolios are managed in a tax efficient manner. The Composite is denominated in U.S. Dollars. The Composite benchmark is the Russell 1000 Growth Index (the "Benchmark"). The index measures the performance of the large-cap growth segment of the U.S. equity universe.

Fees: AQR's asset-based fees for portfolios within the Composite may range up to 0.30% of assets under management and are generally billed monthly or quarterly at the commencement of the calendar month or quarter during which AQR will perform the services to which the fees relate.

Tax Managed Small Cap Momentum Composite
1/31/2012 – 12/31/2016

Year	Gross Return %	Net Return %	Benchmark * Return %	Number of Portfolios	Composite 3-Yr StDev %	Benchmark * 3-Yr StDev %	Composite Assets ($M)	Total Firm Assets ($M)
2012	13.74	13.22	6.61	1	N/A	N/A	3.35	71,122.42
2013	44.61	43.91	43.30	1	N/A	N/A	9.22	98,302.69
2014	2.62	2.11	5.60	1	N/A	N/A	17.25	122,655.99
2015	-1.79	-2.28	-1.38	1	15.08	14.95	24.85	142,173.39
2016	13.57	13.01	11.32	1	16.16	16.67	36.88	175,089.36

* Russell 2000 Growth Index

Composite Characteristics: The Tax Managed Small Cap Momentum Composite (the "Composite") was created in February 2012. Accounts
included their invest assets primarily in equity or equity-related securities of Small Cap companies traded on a principal U.S. exchange or over-the-counter market that AQR determines to have positive momentum. The remainder is generally invested in interest bearing money market accounts and treasury bills. Portfolios are managed in a tax efficient manner. The Composite is denominated in USD. The Composite will include participants at their subscription date. The Composite benchmark is the Russell 2000 Growth Index (the "Benchmark"). The index measures the performance of the Small Cap growth segment of the U.S. equity universe.

Fees: AQR's asset-based fees for portfolios within the Composite may range up to 0.50% of assets under management and are generally billed monthly or quarterly at the commencement of the calendar month or quarter during which AQR will perform the services to which the fees relate.

Tax Managed International Momentum Composite
1/31/2012 – 12/31/2016

Year	Gross Return %	Net Return %	Benchmark * Return %	Number of Portfolios	Composite 3-Yr StDev %	Benchmark * 3-Yr StDev %	Composite Assets ($M)	Total Firm Assets ($M)
2012	15.00	14.58	9.42	1	N/A	N/A	5.75	71,122.42
2013	23.38	22.89	20.53	1	N/A	N/A	43.78	98,302.69
2014	-7.22	-7.59	-3.26	1	N/A	N/A	55.48	122,655.99
2015	1.43	1.03	1.65	1	12.09	11.50	80.03	142,173.39
2016	-3.52	-3.91	-1.87	1	10.82	11.91	73.97	175,089.36

MSCI World ex-USA Growth Net Index

Composite Characteristics: The Tax Managed International Momentum Composite (the "Composite") was created in February 2012. The strategy invests primarily in equity or equity-related securities of non-US companies deemed to have positive momentum. The remainder is generally invested in interest-bearing money market accounts and treasury bills. Portfolios are managed in a tax efficient manner. The Composite is denominated in USD. The Composite benchmark is the MSCI World ex-USA Growth Net Index (the "Benchmark"). The index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of developed markets' country indices across the world, excluding the U.S.

Fees: AQR's asset-based fees for portfolios within the Composite may range up to 0.40% of assets under management and are generally billed monthly or quarterly at the commencement of the calendar month or quarter during which AQR will perform the services to which the fees relate.

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Accordingly, the potential federal tax benefit and potential federal after-tax return reflected in this simulated performance summary may be materially higher than the actual federal tax benefit and federal after-tax return experienced by any particular investor based on such investor's specific facts and circumstances. Factors that may cause an investor's actual federal tax benefit and federal after-tax return to be lower than the potential federal tax benefit and potential federal after-tax return include, but may not be limited to, an investor's actual marginal federal tax rates (including the alternative minimum tax), the lack of realized net long-term gains and net short-term gains outside of this portfolio at least equal to any realized net long-term losses and net short-term losses, respectively, that have been included in AQR's computation of the potential federal tax benefit and potential federal after-tax return, and the effect of various other limitations, special rules, and elections that apply at the investor level in some but not all circumstances. As with all reported after-tax returns, actual investor after-tax returns will vary. Importantly, it has been assumed that the investor has, or will have, sufficient long-term capital gains and short-term capital gains, respectively, from sources outside of this portfolio to fully offset any net long-term capital losses and short-term losses, respectively, realized within this portfolio and taken into account in calculating the potential federal tax benefit and potential federal after-tax return reflected within this performance summary.

Index Descriptions:

The **Russell 1000 Index** measures the performance of the large-cap segment of the U.S. equity universe. It is a subset of the Russell 3000 Index and includes approximately 1,000 of the largest securities based on a combination of their market cap and current index membership. The Russell 1000 represents approximately 90% of the U.S. market.

The **Russell 2000 Index** measures the performance of the small-cap segment of the U.S. equity universe. The Russell 2000 Index is a subset of the Russell 3000 Index representing approximately 8% of the total market capitalization of that index. It includes approximately 2,000 of the smallest securities based on a combination of their market cap and current index membership.

The MSCI World ex USA Index captures large and mid cap representation across 22 of 23 Developed Markets (DM) countries*--excluding the United States. With 1,020 constituents, the index covers approximately 85% of the free float-adjusted market capitalization in each country. * DM countries include: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland and the UK.

The **Cboe Volatility Index®** (VIX)® is based on the S&P 500® Index (SPX), the core index for U.S. equities, and estimates expected volatility by averaging the weighted prices of SPX puts and calls over a wide range of strike prices.