Postgraduate VU-VBA programme
Investment Management

The Index effect in factor benchmarks

Abstract
This paper examines index rebalances of the MSCI Minimum Volatility World index between 2011 and 2016. I find evidence for a statistical significant index event in this factor benchmark. Stocks that increase in weight return an average of +1.58% between announcement and effective day. Stocks that are (partly) sold during the index rebalance return an average of -0.63% in same time period. This results in an index spread (difference between buy and sell basket) of +2.21%, making the rebalance 2.21% more expensive on effective day than on announcement day. For investors in this index, this accumulates to a performance drag of 0.44% annually. The findings are consistent with the price pressure hypothesis. Robustness checks and additional analysis show that the index effect is most likely the result of excess market impact in the index. Investors using this index are advised to take action, either by rebalancing their portfolio out of sync with the standard rebalance schedule of MSCI or by switching to a similar low risk index with fewer assets tracking. MSCI is encouraged to lower the market impact in this and potentially similar indices by creating additional versions with different rebalance schedules. Alternatively, MSCI could rebalance more often in their main index and thereby generating smaller trades, thus lowering market impact in each rebalance and in the overall index.

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Introduction

For passive investors, following a market cap weighted equity benchmark seems an attractive way to harvest the equity risk premium. This is due to the following main reasons:

1. **Efficient markets**. The Efficient Market Hypothesis (EMH) tells us that all public information is incorporated in stock prices. New information will also be directly reflected and stock prices can be described by a 'random walk'. Therefore it is not possible to consistently beat the market
2. **Low costs**. The market cap index is a 'buy & hold' strategy, which comes at very low turnover and implementation costs
3. **Active management is a 'zero-sum game'**. The return of the market portfolio is by definition the average return of all investors. This means that – before transaction costs – active management will be a zero-sum game: the gain of one is the loss of another. As costs are in fact involved in managing equity portfolios, the zero-sum game changes into a 'minus-sum game'. Research shows that it is very hard to consistently outperform the market cap weighted benchmark with active management (AFM, 2011)

The disadvantage of 'blindly' following a market cap weighted benchmark is the result of a slight underperformance relative to this benchmark. Fact is that with passive management a negative performance would occur each year, due to the inevitable costs involved with the management of a worldwide equity portfolio. One can think of custodian costs, broker commissions and taxes & fees. For large investors like pension funds, the annual costs can be as little as few basis points which is negligible compared to the equity risk premium which will be at least a factor 100 larger. The problem for passive investors is not the very easily observable underperformance due to portfolio management costs, the much bigger problem lies with what most people do not see: market impact costs associated with index changes. These 'hidden' costs will most certainly beat the visible costs by a large margin for the best known equity indices.

On a regular basis index providers announce index changes for their benchmarks: companies are added to an index, other companies deleted and for a third group of companies weights are adjusted. The index provider shall process these changes on a predefined date. Investors who manage their portfolio pure passively will incorporate the change as close to the effective date as possible, most likely literally at the close of said implementation day. This will cause a footprint in the price-making of the stock price concerned, better known as the 'index effect'. Exploitation of this micro-inefficiency was already documented by Beneish and Whaley (1996) in their study "S&P Game". By front-running the passive fund managers and prepositioning on or around the announcement date arbitrage profits can be earned. Passive fund managers and ETFs will wait for the effective date with execution of index changes to minimize tracking error risk. The excess flows generated cause price shifts and result in large liquidity premiums to be paid.

Investors concerned with the downside of passive investing described above may want to stay clear of following the index. The same holds true for investors that do believe that it is possible to consistently beat the market cap weighted index using systematic equity strategies, also known as factor investing.

Academic research have shown that investing in factors like Value, Momentum and Low Risk can yield better risk / return characteristics than the market cap weighted index offers. Due to long term anomalies in the stock market, stocks with specific characteristics outperform in the long run. Through factor investing the equity portfolio is less prone to stock market bubbles in one or more specific sectors or companies compared to the market cap weighted index. After all, the weight of a stock in the market cap weighted index is directly related to the price of the stock.

The concept of factor investing is not new. Already in the 1930s, Graham and Dodd described the principles of Value investing. In the early 1990s, the factors Value, Momentum and Size were analyzed in more in-depth papers by Fama and French (1992, 1993), Jegadeesh and Titman (1993) and Carhart (1997). PGGM was one of the first pension funds to allocate a significant portion of its listed equity portfolio to factor investing in 2005 when they started with Value investing. In 2007 PGGM added a low risk strategy (Minimum Variance) to its mix and two years later the factor Quality was added. In the years that followed factor investing became very popular among many institutional investors. Index providers like MSCI, Russell and FTSE seized the opportunity to attract passive investors by launching and marketing factor benchmark which could be passively implemented or accessed through ETFs.

Especially the factor strategies of MSCI and the corresponding ETFs have attracted a lot of investors, to such extent that the index-event problem hurting passive investors tracking market cap weighted indices also seem to present with factor benchmarks. An illustrative example of this took place during MSCI's semi-annually rebalance of its Minimum Volatility index on May 29th 2015. US chemical producer Sigma-Aldrich was added to MSCI's index at the close of that day. The company had already received a full cash takeover offer of 140.00 USD a share by its German competitor Merck eight months before. In the weeks prior to MSCI's rebalance Sigma-Aldrich had been trading in a tight range around 139.00 USD a share as the deal still took a half year to close. Just minutes before the market close on May 29th, Sigma-Aldrich's stock price quickly rose from 139.00 to and above 140.00 due to MSCI investors which were very anxious to get hold of the stock and even more so to not miss their benchmark entry point. The stock ended up trading up a high of 140.03 USD a share, indicating that some investors settled for a sure loss as they will never receive more than the takeover bid of 140.00.

This example clearly shows something very bad is happening and with the growing popularity of these indices is likely to become even worse. Factor investing is not for everyone as it requires advanced IT systems, skilled portfolio managers and traders. Benchmark providers like MSCI provide the easy alternative by doing all the work and offering benchmarks that can be passively implemented like the well-known market cap weighted ones. The end result of this is without any doubt disappointed investors as hardly anyone realizes the impact of market impact on performance. What should be more worrying, is the huge difference in annual turnover between market cap weighted indices and factor strategies. Whereas market impact is unlikely to destroy the absolute performance of the market cap weighted index due to the relative low turnover, similar market impact levels in factor indices are likely to give investors returns that are nowhere near indicated returns from research and back tests. Academic literature has yet to report on the index-effect for factor benchmarks. Therefore and also for our my curiosity, I would like to answer the following research question: Is there a significant index effect

in factor benchmarks? The paper is structured as follows: in the next section we will present a literature overview on the topic and discuss the contribution of this research. Next, the data and methodology used is explained, followed by a representation of the results. The results are checked for robustness next, after which we end with the practical implications and conclusion.

Literature review

There have been several explanations documented that seek to explain the existence of the index effect. The typical pattern is that stocks that are added (deleted) from a widely followed index experience positive (negative) abnormal returns in the period between announcement date and effective date of the index rebalance. Over the past decades numerous academic papers have documented a significant index effect for multiple indices. While most research has been conducted on changes of the S&500, the effect is also seen on Russell and MSCI indices and local indices like the FTSE 100, Hang Seng Stock Index, Nikkei and CSI 300. From past research five dominant hypotheses have been derived, which are will briefly discuss below.

From these studies several hypothesis have been tested that led to a couple of mainstream theories. First, Scholes (1972) brought forward the imperfect substitutes hypothesis (hypothesis-I), arguing that arbitrage between perfect substitutes implies a flat demand curve. This means that stocks with similar risk/return profiles should yield the same returns. If this is temporary not the case, perhaps through excess buying or selling pressure coming from an index rebalance, arbitrageurs should step in and capture the excess returns. Therefore the value of a stock cannot depend on supply and demand as they have close substitutes. Shleifer (1986) and Beneish and Whaley (1996) argued stocks added to an index cannot be perfect substitutes with stocks that have not been added. There is in fact a premium that investors are willing to pay to hold stocks that are part of an index. Therefore, the demand curve is downward sloping and Shleifer (1986) and Beneish and Whaley (1996) both find abnormal returns after announcement day. The abnormal returns are not reversed and of permanent nature, which suggests that there is value in index membership.

Another explanation is found in the price pressure hypothesis (hypothesis-II), first document by Harris and Gurel (1986). When stocks are added (deleted) to an index, temporarily excess demand (supply) moves the price away from their fundamental value. Stock prices should quickly revert to their fundamental value again after the index rebalance, which means the price pressure is only temporarily. This is what Harris and Gurel (1986) find when looking at price movements of stocks one month after the announcement date: stocks added revert back down and stocks deleted revert back up.

In line with Shleifer (1986) and Beneish and Whaley (1996), Amihud and Mendelson (1986) agree that stocks part of an index are not perfect substitutes to stocks that are not. By introducing the liquidity hypothesis (hypothesis-III), they argue that an inclusions (exclusion) of a stock should increase (decrease) the liquidity in the stock. All things equal, one should require a higher yield on a stock with less liquidity and bigger bid-ask spreads. When a stock gets added to an index, its cost of capital should therefore go down.

Using a similar line of reasoning, the investor awareness hypothesis (hypothesis-IV) was introduced by Merton (1987). It describes that when stocks are part of an prominent index, they will attract more attention from the media and investors. Also analysts will more likely cover the stock and overall recognizability of the company will increase. Therefore, the overall higher exposure should result in a premium. The reverse should apply to stocks deleted from an index, although the effect found is often less strong. For instance, Chen et al. (2009) find that stocks added have a permanent strong increase, but stocks deleted only face a temporarily decline. Reason behind this asymmetry could be that investors already are aware of stocks that are deleted and their awareness does not materially change after deletion.

Another explanation that believes there is value in index in- and exclusion, is the information signaling hypothesis (hypothesis-V). The argument is that index membership change should say something about the future prospects of a company. Within the announcement lies new non-public information to the market. The biggest effect should therefore be found on the day after announcement as an efficient market will reprice stocks quickly to new information. Accordingly, Jain (1987) finds significant abnormal returns in stocks added and deleted to the S&P500 the day after announcement.

Based on the above explanations, the five hypotheses can be classified in two groups: 1) one that assumes permanent price increases resulting from index additions and thus a long term downward sloping demand curve 2) one that only assumes temporarily price increases and thus a flat long term demand curve. The imperfect substitutes hypothesis belongs to the first group, just as the liquidity, awareness and information hypotheses. In fact, the latter three are based on the same theorem as the imperfect substitutes hypothesis, but each provides in addition a reason as why there would be a permanent price increase. The price pressure hypothesis only assumes a temporarily price increase due to a short term imbalance between demand and supply. This more technical driven event will automatically lead to a correction when stocks shift too far from their fundamental value. In table 1 an overview is presented of the papers I could find.

Table 1. Literature overview

Literature overview								
study	time window	index / indices	study	time window	index / indices	study	time window	index / indices
Imperfect substitutes			**Price pressure**			**Liquidity/awareness/information**		
Harris and Gurel (1986)	1973-1983	S&P500	Stoll (1978)	1973	Nasdaq	Scholes (1972)	1961-1965	NYSE
Woolridge and Ghosh (1986)	1973-1983	S&P500	Beneish and Gardner (1995)	1929-1988	DJIA	Shleifer (1986)	1966-1983	S&P500
Dhillon and Johnson (1991)	1978-1988	S&P500	Hedge and McDermott (2003)	1993-1998	S&P500	Beneish & Whaley (1996)	1986-1994	S&P500
Liu (2000)	1991-1999	Nikkei	Gregoriou (2011)	1997-2001	CAC	Hanaeda and Serita (2003)	2000	Nikkei
Madhavan (2003)	1996-2002	R2000-3000	Chakrabarti et al. (2005)	1998-2001	MSCI country	Bechmann (2004)	1989-2001	KFX Index
Chen et al. (2004)	1962-2000	S&P500	Chen and Lin (2016)	2005-2014	CSI300	Vespro (2006)	1997-2001	CAC, SBF & FTSE
Vespro (2006)	1997-2001	CAC, SBF & FTSE	Jain (1987)	1977-1983	S&P500	Bildik and Gülay (2008)	1995-2000	ISE index
Bildik and Gülay (2008)	1995-2000	ISE index	Lynch and Mendenhall (1997)	1990-1995	S&P500	Chakrabarti et al. (2005)	1998-2001	MSCI country
Yun and Kim (2010)	1995-2008	KOSPI 200	Liu (2011)	1970-2006	Nikkei	Fernandes and M. (2016)	1992-2010	FTSE 100
Shankar and Miller (2006)	1995-2002	S&P600	Marciniak (2010)	2002-2007	S&P400	Petajisto (2011)	1990-2005	S&P500 & R2000
Chakrabarti et al. (2005)	1998-2001	MSCI country	Ravi and Hong (2015)	2001-2010	S&P500			
Azevedo et al. (2013)	2005-2012	KLCI Index	Hacibedel and van Bommel (2006)	1996-2004	MSCI EM			
Wang, Murgulov and Haman (2015)	2005-2012	CSI 300	Chan, Kot and Tang (2013)	1962-2003	S&P500			
Cheung and Roca (2013)	2002-2010	DJSWI						
Green and Jame (2011)	1999-2005	S&P500						

From table 1 it can be seen that most research has been conducted on traditional market cap indices. Perhaps not surprisingly: the more popular the index, the more it has been researched, with the S&P500 index dominating the table. Another observation is that few research is of recent date. Only few papers

examine part of the last decade and none the most recent few years. This is important as market microstructure has changed rapidly over the past years and information has become more easily available. It is likely that this influences the way index investors and arbitrageurs approach index rebalances and thus possibly leading to a different development of the index effect and potentially new explanations. One possibility is that better awareness of the index effect and arbitrage profits that can be made forces both index investors as arbitrageurs to execute the rebalance and prepositioning earlier with more people front running the official announcement of the index provider. Additionally, the index effect could spread to non-traditional indices such as factor / style benchmarks. Our paper contributes specifically to these points by investing a possible index effect in the MSCI factor benchmark of Minimum Volatility. When I started with this research, I failed to find any published studies on the index effect in factor benchmarks. By incorporating rebalance data from the most recent years it can be examined whether the index effect still exists as prior documented. Additionally we can see which of the predominating theories apply for index changes in factor benchmarks: are price changes temporary in line with the price pressure hypothesis or are they permanent which is supportive of the imperfect substitutes hypothesis. Finally, by incorporating intraday tick data more insight can be gathered of the nature of the index effect. If the index effect intensifies towards the close of the day the index changes, the effect is most likely caused by excess market impact.

Data and methodology

The data for this research has been supplied by MSCI. MSCI is a leading benchmark provider, predominately known for its market cap weighted indices such as MSCI World, MSCI Emerging and MSCI All Country World Index (ACWI). Whereas the market cap indices have been around for long (MSCI World has been calculated since December 1969), indices based on factor and risk-based strategies have only been introduced in the last decade. The MSCI Minimum Volatility World index was launched in 2008, whereas regional versions followed in the years after. The ACWI and Europe version came in 2009, Asia ex Japan in 2012 and finally Japan followed in 2014.

The MSCI Minimum Volatility Indexes are calculated by optimizing a parent MSCI Index by using an estimated security co-variance matrix to produce an index that has the lowest absolute volatility for a given set of constraints. The starting universe is the regional underlying market cap weighted index and MSCI's Barra is used as risk model. The aim of the Minimum Volatility indices is to achieve a lower beta, volatility, lower market cap and a bias towards stocks with lower idiosyncratic risk vs the market cap weighted index. In the risk optimization various constraints are used on individual stock weights, country weights and sector weights. Furthermore, the index is constraint to 20% two way turnover at each semi-annual rebalance. In case no feasible solution is found, the turnover constraint is relaxed to a maximum of two way 60% and if necessary the minimum weight constraints are relaxed in steps of 0.01%.[1]

The data used comprises the semi-annual rebalances of the MSCI World Minimum Volatility index for years 2011 to 2016, totaling 12 rebalances. Rebalances take place at the end of May and end of

[1] The latest version of the methodology can be found here:
https://www.msci.com/eqb/methodology/meth_docs/MSCI_Minimum_Volatility_Methodology_November2017.pdf

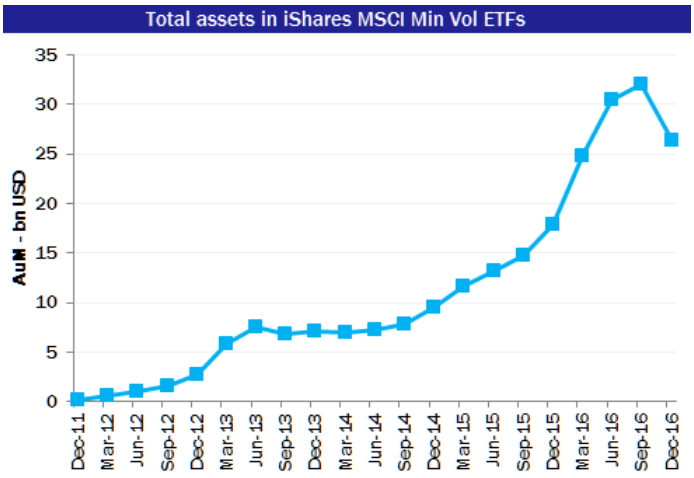
September, usually at month end, but the date may be shifted forwarded a (couple of) day(s) in case of market holidays. In table 2 below the review dates are listed. The choice for only researching the World index and not adding regional versions such as Europe and USA is that the overlap in rebalance outcomes is too large to be of any added value. Although MSCI uses regional risk models and slightly different optimization constraints, one can imagine that the larger changes within World, also take place in the regional version. A stock which is too risky to stay in the World index and thus triggers are relatively large trade is likely to also be too risky in the regional index. Similarly for stocks that have become so attractive that they enter the index. The fact that both the World and regional indices rebalance on the same date further increase the likelihood of similar stock movements. The reason for starting in 2011 is that in 2011 the iShares ETF was launched on the Minimum Volatility indices and from then on assets benchmarked on the index slowly started to grow. In figure 1 is graphically shown the growth in assets on the biggest Minimum Volatility iShares. It can be seen that assets initially grew to about 8bn USD in the first 1.5 years, then plateaued for the next 1.5 years before growing rapidly to a high of 32bn USD in 2016.

Table 2. Review dates of investigated rebalances

Year	Review Month	Effective Date
2016	Nov	11/30/2016
2016	May	5/31/2016
2015	Nov	11/30/2015
2015	May	5/29/2015
2014	Nov	11/25/2014*
2014	May	5/30/2014
2013	Nov	11/26/2013*
2013	May	5/31/2013
2012	Nov	11/30/2012
2012	May	5/31/2012
2011	Nov	11/30/2011
2011	May	5/31/2011

* deviating due to market holidays (Thanksgiving)

Graph 1. Review dates of investigated rebalances



Sum of AuM on MSCI Min Vol World, EAFE, USA, ACWI and EM, source: Bloomberg

The close after which the index rebalance is called effective day (ED). MSCI announce the next index rebalance 9 days ahead of ED on announcement day (AD), such that index trackers including iShares have a chance to preposition themselves for the event. In order to minimize tracking error vs the index, one has to perform the rebalance trades at the close, or for those from whom the resulting trade would be too big: leading into the close. In this research an event study is conducted which analyzes the period AD-6 to ED+7. Return and volume data is retrieved from Bloomberg. Wherever average volume is used, the Bloomberg 40-day median composite volume ahead of the rebalance AD is used.

To study the performance of each rebalance event, 'buy' and 'sell' stock baskets are constructed. The buy basket consists of stocks that face a weight increase (regardless of size) at the rebalance or stocks that are newly added to the index. The sell basket consists of stocks that face a weight decrease

(regardless of size) at the rebalance or stocks that are deleted from the index. In table 3 the number of stocks corresponding is shown for each rebalance, indicated by resp. change up and change down.

Table 3. Descriptive statistics of rebalances of the MSCI Min Vol Index

Overview rebalances				
	Total stocks	Change up	Change down	Turnover
2016 - II	334	66	268	20%
2016 -I	317	81	236	20%
2015 - II	312	99	213	20%
2015 - I	294	63	231	20%
2014 - II	291	100	191	20%
2014 - I	287	62	225	20%
2013 - II	269	54	215	20%
2013 - I	253	77	176	20%
2012 - II	244	62	182	20%
2012 - I	262	58	204	20%
2011 - II	251	215	36	20%
2011 - I	249	46	203	20%
Average	**280**	**82**	**198**	**20%**

Two main analyses are conducted: 1) on the basis of actual rebalance trade, this weighting method is called 'flow weighted' (FW) and 2) on the basis of liquidity, called 'adv weighted' (AW). For FW baskets are constructed such that they resemble the trade someone has to perform to track the index. The stocks with the biggest weight change will be assigned the biggest pro-rata weight in the basket. To illustrate: with a two way 20% index turnover, a stock with a weight increase of 0,5% will be given a weight of 5% in the basket of the buys (0.5% / 10%). The basket performance simply the sum of the average weighted performance of all stocks in the basket. In AW baskets, the stock that is least liquid will be assigned the biggest weight. Based on the weight change, the estimated volume to trade given a fixed notional is calculated, which on its turn is converted to a % of median volume. Similar to the FW method, buy and sell baskets are constructed of which the performance can be calculated. In addition to the FW results, this analysis allows us to further explain the outcomes. If a significant index effect is found in the FW analysis and this is primarily the result of market impact, one would expect the results in the AW baskets to be bigger as more market impact can be expected in less liquid stocks. Finally, intraday tick data from ITG is used to see whether the index effect gets bigger the close the trade progresses towards the close of the day. This could also indicate that the index effect is a result of market impact as index trackers predominantly trade towards the close of implementation day to minimize their risk.

To control for other effects that could potentially explain the results found, two additional analyzes are conducted. First, it is possible that stocks that have a weight change in the Minimum Volatility rebalance, have a weight change in the similar direction due to the rebalance in the market cap weighted index of MSCI World that takes place at the same time. When a stock gets added, deleted or has a big weight change in the Minimum Variance index as in MSCI World, it is difficult to assign which part of the index

effect can be attributed to the rebalance in the Minimum Variance index and which part to the rebalance in MSCI World. To control for this effect, stocks with a weight change greater than 0,1 basis point in MSCI World and in the same direction in the Minimum Variance index are excluded from the data set. The statistics are shown in table 4a. It can be seen that the effect on the total data sample is relatively mild: in the FW baskets about 15% of stocks are excluded ((8.77% + 21.73%) / 2) and in the AW baskets only about 10%. When further increase the threshold to a minimum of 0,2 basis point in MSCI World, resp. 10% (FW) and 8% (AW) of the dataset would be excluded, see table 4b. To be conservative, in the robustness check the lower threshold of 0,1 basis point is used to make sure that the results from the MSCI World rebalance do not cloud the results.

Tabel 4a. Effect of excluding MSCI World stocks with weight change bigger than 0.1 basis point on data set

				Effect of excluding stocks which have MSCI W change >0.1bps					
	Total stocks	Change up	Change down	Buy excluded	Sell excluded	Buy % mcap	Sell % mcap	ADV Buy	ADV Sell
2016 - II	334	66	268	4	32	5.36%	5.17%	10.67%	1.18%
2016 -I	317	81	236	32	46	6.47%	11.49%	3.41%	7.88%
2015 - II	312	99	213	4	43	4.03%	28.55%	11.62%	4.81%
2015 - I	294	63	231	32	46	4.60%	25.66%	4.44%	18.69%
2014 - II	291	100	191	4	37	1.05%	26.17%	5.40%	3.65%
2014 - I	287	62	225	46	32	12.83%	22.94%	15.30%	12.44%
2013 - II	269	54	215	4	27	19.81%	14.81%	23.45%	4.26%
2013 - I	253	77	176	46	33	4.62%	28.04%	10.22%	9.81%
2012 - II	244	62	182	2	19	3.32%	18.50%	1.10%	14.14%
2012 - I	262	58	204	43	65	16.08%	31.52%	12.02%	25.09%
2011 - II	251	215	36	2	4	7.60%	19.52%	0.77%	4.07%
2011 - I	249	46	203	43	38	19.50%	28.44%	30.15%	8.57%
Average	**280**	**82**	**198**	**22**	**35**	**8.77%**	**21.73%**	**10.71%**	**9.55%**

Tabel 4b. Effect of excluding MSCI World stocks with weight change bigger than 0.1 basis point on data set

				Effect of excluding stocks which have MSCI W change >0.2bps					
	Total stocks	Change up	Change down	Buy excluded	Sell excluded	FW Buy % mc	FW Sell % m	ADV Buy	ADV Sell
2016 - II	334	66	268	4	16	5.36%	2.59%	10.67%	0.33%
2016 -I	317	81	236	3	29	5.94%	4.44%	3.27%	6.47%
2015 - II	312	99	213	2	21	4.03%	13.75%	11.62%	1.14%
2015 - I	294	63	231	4	31	4.60%	18.85%	4.44%	9.14%
2014 - II	291	100	191	1	18	1.05%	13.08%	5.40%	1.12%
2014 - I	287	62	225	7	15	8.15%	4.55%	9.33%	0.96%
2013 - II	269	54	215	6	15	19.81%	12.39%	23.45%	2.14%
2013 - I	253	77	176	2	20	1.73%	16.14%	9.26%	4.16%
2012 - II	244	62	182	1	11	2.01%	16.82%	0.96%	13.97%
2012 - I	262	58	204	5	38	14.00%	17.74%	10.87%	9.43%
2011 - II	251	215	36	3	29	5.94%	4.44%	3.27%	6.47%
2011 - I	249	46	203	5	23	17.28%	19.70%	28.44%	7.10%
Average	**280**	**82**	**198**	**4**	**22**	**7.49%**	**12.04%**	**10.08%**	**5.20%**

Finally, controlling for possible country effects is done next. MSCI allow the Minimum Variance index to have 5%-point country over- or underweight vs MSCI World. Therefore, a rebalance can result in a sizeable increase or decrease of a country weight in the index. If a local market that experiences a relative large weight change significantly out- or underperforms the overall index this affects the index effect. To correct for this, abnormal returns are used by subtracting the market return from the individual stock returns. For market returns, the local MSCI country indices are used.

To test the index effect for significance, the standard Student's t-test is performed on the spread (excess returns of buy basket over the sell basket). This is done for both FW and AW baskets and for the following different time windows:

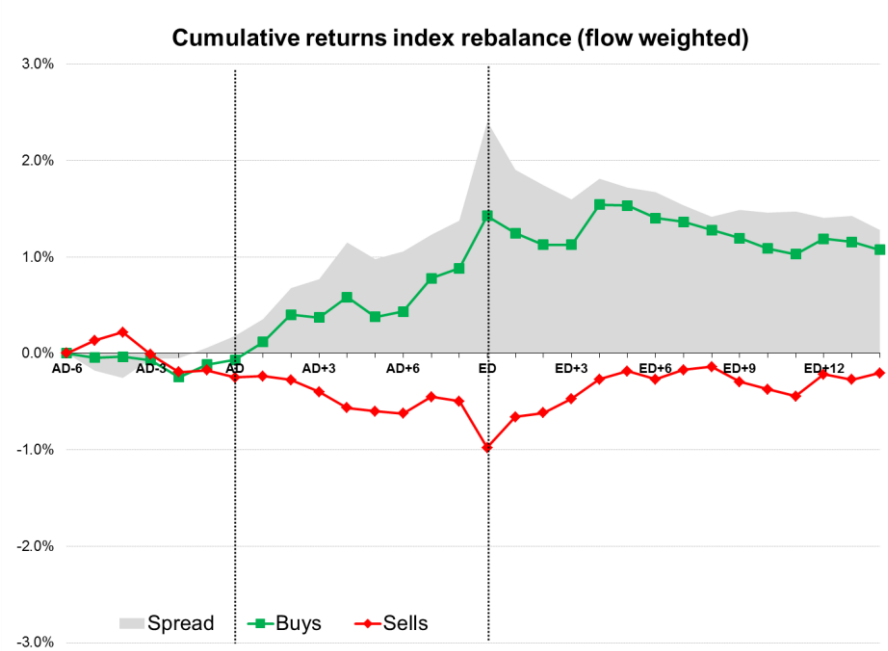
- *Pre-announcement period (AD-6 – AD-1);* in order to measure abnormal returns prior to the announcement of index changes. By including this period, we can assess whether risk arbitrageurs front run the official announcement consistent with Chakrabarti et al. (2005) and Bildik and Gülay (2008).
- *Announcement day (AD)*; first day after the announcement.
- *Post-announcement till effective day (AD+1 – ED-1)*; period up till the day the index changes. This period provides information about the market reaction after announcement date, in order to see whether abnormal returns are made in the days leading up to and the index change.
- *Effective day (ED)*; measurement of the market reaction on effective day. The highest abnormal returns are expected as this is the day the index changes and passive investors need to change their portfolios to be in line with the new index composition.
- *Day after effective day (ED+1)*; measurement of the market reaction on the day after effective day. If there is excess market impact in the index rebalance, potential reversion is expected to be the highest the first day after the index change.
- *Two weeks after effective day (ED+2 to ED+14)*; in order to measure persistence of abnormal returns and potential reversion.
- *Entire event window (AD-6 to ED+14)*; entire event window, used to determine whether abnormal returns are persistence and thus are in line with the permanent price pressure hypothesis or with the temporary price pressure hypothesis.

Results

In figure 2 the average cumulative returns are shown for the buy basket, sell basket and the spread between the two (abnormal return of the rebalance) for the flow weighted basket. The spread slightly moves negative in the first few days, turning small positive at AD and steadily increases past AD to reach a peak at the close of effective day (ED): +2.41%. Between AD and ED stocks that increase in weight outperform stocks that decrease in weight by +2.21%. After ED, small signs of reversion are visible, resulting in a drop of the spread to a cumulative return of +1.28% at ED+14.

This would suggest that over half of the effect is permanent. It could be that 14 days is not sufficient to draw this conclusion and one could argue that a longer time window is required. The disadvantage is that by extending the window, more stock specific news and price movements cause additional noise in the results, further reducing the reliability of the results.

Graph 2a.



NB. Average cumulative abnormal return of 12 rebalances between 2011 and 2016. Dotted lines represent resp. announcement day (AD) and effective day (ED). Spread peaks at the close of ED at +2.41% vs AD-6.

In table 5, the (cumulative) spread returns for various time windows are shown for each individual rebalance. From this overview, the overall abnormal return found between AD and ED seems persistent and of structural nature. The spread development is for most rebalances positive in the windows prior to and on ED. Of all rebalances, only one rebalance (2015-II) shows a negative return on ED (-0.08%). The pre-announcement and announcement effect seems muted at best with average returns of resp. +0.18% and +0.17% for AD-6 – AD-1 and AD. After ED, some reversal seems to take place. The first day after ED (ED+1), shows an average negative spread return of -0.50%. Further extending the window to two weeks after ED, increases the reversal to -1.13%, with a negative spread for all but the first two rebalances investigated. Over the entire time window, an average positive spread of 1.28% can be reported, although the last two years show negative spread returns of little over 1%.

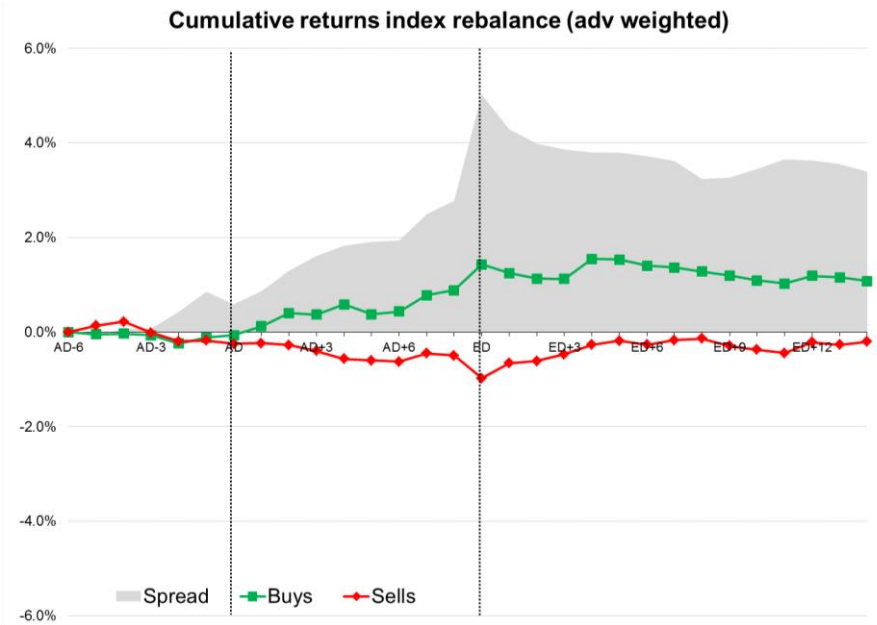
In figure 3 the average cumulative returns are shown for the buy basket, sell basket and the spread between the two (abnormal return of the rebalance) for the ADV weighted basket. The overall pattern is similar to the flow weighted basket: The spread slightly moves upwards in the days prior to AD, but only steadily starts increasing after AD and closer towards ED, peaking at the close of ED. After ED, reversal takes place just like with the flow weighted basket. The size of the spread peaking at ED is much greater with the basket constructed on the basis of (il)liquidity: a spread of over 5% vs +2.2% with flow weighed. The reversal is relatively mild, as 14 days after ED a positive spread of 3.4% remains.

Tabel 5. Overview of abnormal returns (buy-sell spread) across various event periods – flow weighted

Cumulative spread returns rebalancing periods (flow weighted)							
	AD-6 - AD-1	AD	AD+1 - ED-1	ED	ED+1	ED+2 - ED+14	AD-6 - ED+14
2016 - II	-1.47%	0.44%	0.45%	0.55%	-0.37%	-0.77%	-1.17%
2016 -I	-0.30%	0.43%	1.77%	0.10%	-0.52%	-2.64%	-1.13%
2015 - II	1.20%	-0.09%	2.00%	-0.08%	-0.32%	0.09%	2.78%
2015 - I	-0.05%	0.21%	1.07%	0.58%	-0.56%	-0.10%	1.17%
2014 - II	1.10%	0.11%	1.61%	1.61%	-1.28%	-1.86%	1.20%
2014 - I	0.26%	0.59%	0.59%	0.98%	-0.76%	-0.26%	1.48%
2013 - II	0.76%	0.46%	1.92%	2.03%	-1.07%	-1.15%	2.90%
2013 - I	0.39%	-0.04%	-0.21%	2.79%	-0.76%	-0.59%	1.53%
2012 - II	-1.37%	-0.42%	0.90%	1.59%	0.18%	-1.34%	-0.45%
2012 - I	1.85%	-0.08%	2.73%	1.11%	0.11%	-1.43%	4.31%
2011 - II	-0.68%	0.20%	-1.19%	0.94%	-0.73%	1.65%	0.18%
2011 - I	0.52%	0.25%	0.61%	0.21%	0.10%	0.80%	2.55%
Average	**0.18%**	**0.17%**	**1.02%**	**1.03%**	**-0.50%**	**-0.63%**	**1.28%**

Looking at various time windows in table 6, a similar conclusion can be drawn: the overall pattern holds up, but seems even more apparent. Just as with the FW baskets, prior to AD the results are somewhat mixed (5/12 negative spreads) and the effect on AD is rather weak (+0.17% average spread performance). After AD and especially on ED the spread development is strongly positive and uniform with no single rebalance showing a negative return on ED and only two rebalance with negative returns between AD+1 – ED-1. The average spread returns are twice as high as with the FW baskets: resp. +2.02% and +2.30% for AD+1 – ED-1 and ED. The first day after ED and the 14 days following show signs of reversal with a negative spread return of little over -1.6%.

Graph 3.



NB. Average cumulative abnormal return of 12 rebalances between 2011 and 2016. Dotted lines represent resp. announcement day (AD) and effective day (ED). Spread peaks at the close of ED at +5.03% vs AD-6.

Tabel 6. Overview of abnormal returns (buy-sell spread) across various event periods – ADV weighted

Cumulative spread returns rebalancing periods (ADV weighted)							
	AD-6 - AD-1	AD	AD+1 - ED-1	ED	ED+1	ED+2 - ED+14	AD-6 - ED+14
2016 - II	-1.53%	0.79%	0.94%	1.11%	-1.25%	-0.57%	-0.46%
2016 -I	0.45%	0.21%	1.38%	0.98%	-0.37%	-4.22%	-1.67%
2015 - II	2.37%	0.09%	2.45%	0.21%	-0.94%	-0.56%	3.58%
2015 - I	-0.63%	0.46%	2.41%	0.08%	-0.45%	-1.53%	0.35%
2014 - II	1.35%	-0.21%	3.40%	0.89%	-0.83%	-0.31%	4.23%
2014 - I	-0.65%	0.65%	1.59%	1.60%	-0.95%	-4.17%	-2.09%
2013 - II	0.18%	1.13%	1.44%	1.94%	-0.78%	-1.44%	2.42%
2013 - I	0.04%	-0.18%	-1.65%	3.97%	-2.30%	-1.20%	-1.26%
2012 - II	-0.21%	-0.32%	2.38%	9.26%	2.09%	-3.18%	10.40%
2012 - I	5.09%	0.15%	9.38%	2.48%	0.01%	1.58%	16.96%
2011 - II	-1.71%	-0.18%	-0.39%	4.28%	-2.23%	4.08%	3.42%
2011 - I	2.39%	0.70%	0.86%	0.87%	-0.66%	0.81%	4.84%
Average	**0.60%**	**0.27%**	**2.02%**	**2.30%**	**-0.72%**	**-0.89%**	**3.39%**

To gather more insight in persistence of the spread returns, a standard Student's T-test is used to determine statistical significance for the time windows for both the FW and AW baskets. In table 7 below it can be seen that there is no statistical significant pre-announcement effect with for both FW and AW t-values well below the threshold for AD-6 – AD-1. For announcement day (AD), AD+1 to ED-1 and on ED positive and statistical significant spread returns for both baskets are found. In the reversal period after ED, only the first day after ED (ED+1) shows significant negative spread returns, whereas returns for the two weeks after are statistically insignificant. Over the entire period (AD -6 – ED+14), the FW basket spread is not statistically significant, suggesting that the effect found is in line with the temporary price pressure hypothesis. However, the AW basket spread does show significance at the 5% level suggesting the index effect is of permanent nature in the least liquid part of the index change.

Tabel 7. T-statistics per time window

Average spread return and t-statistics		
	FW	AW
AD-6 - AD-1	0.031%	0.100%
	(0.561)	(1.001)
AD	0.172%	0.274%
	(2.051)	**(2.028)**
AD+1 - ED-1	0.146%	0.284%
	(2.906)	**(3.333)**
ED	1.035%	2.305%
	(4.210)	**(3.115)**
ED+1	-0.498%	-0.721%
	(-3.712)	**(-2.232)**
ED+2 - ED+14	-0.049%	-0.069%
	(-1.339)	(-1.457)
AD-6 - ED+14	0.044%	0.122%
	(1.585)	**(2.382)**

T-statistics below in brackets, bold figures represent significance at 5% level

To gather further insight into the nature of the rebalance spread return found, the time-series regression is extended with Fama French (FF) factors derived from the website from Kenneth French[2]. Using the Global 5 Factors and Momentum Daily data, spread returns of AD-6 to ED are regressed on right-hand variables market (MKT-rf), size (SMB), value (HML), profitability (RMW), investment (CMA) and momentum (WML). This is done this for both the FW and AW baskets. The results are shown in tables 8a and 8b[3]. The spread for both baskets is significant, in line with expectations based on the event windows in table 7, but remains significant and virtually unchanged when adding the FF factors. On the flipside, almost all of the FF factors are insignificant, expect for the value factor (HML) in two occasions for the FW basket. When regressing on MKT-rf, SMB and HML, none of the right-hand variables are significant. HML only becomes significant when controlling for quality through RMW and CMA. Although the differences in t-statistics are rather slim (-1.838 vs -2.393 and -2.066), one could argue it is needed to control for quality to find significant value exposure and in this case a negative loading. The negative loading implies that the stocks added or increased in the index are more expensive than the stocks deleted or decreased in weight. Intuitively this can be explained that newly added stocks usually have had good recent performance and grew large enough in market cap to enter the index. The recent outperformance make them at least temporarily overpriced. Vice versa for stocks that are deleted due recent underperformance which resulted in them becoming too small for the index. In appendix I additional time series regressions are shown for different time periods as defined on page 11.

Tabel 8a.

Time series regressions AD-6 - ED (FW)							
	Alpha	MKT-rf	SMB	HML	RMW	CMA	WML
Alpha	0.161%	0.161%	0.161%	0.162%	0.164%	0.165%	0.160%
	(3.986)	**(3.987)**	**(3.991)**	**(4.020)**	**(4.105)**	**(4.100)**	**(3.896)**
MKT-rf		-0.020	0.001	0.006	-0.027	-0.024	-0.009
		(-0.358)	(0.011)	(0.096)	(-0.441)	(-0.372)	(0.142)
SMB			0.134	0.164	0.138	0.145	0.145
			(1.003)	(1.229)	(1.033)	(1.055)	(1.048)
HML				-0.273	-0.412	-0.441	-0.364
				(-1.838)	**(-2.393)**	**(-2.066)**	(-1.574)
RMW					-0.364	-0.368	-0.369
					(-1.576)	(-1.585)	(-1.591)
CMA						0.067	-0.022
						(0.227)	(-0.069)
WML							0.091
							(0.857)

T-statistics below in brackets
Bold figures represent significance at 5% level

[2] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[3] Additionally regressions were performed with Newey-West estimators to control for potential autocorrelation and heteroscedasticity in the error terms (results not shown). The factor loadings did not materially change.

Tabel 8b.

Time series regressions AD-6 - ED (AW)							
	Alpha	MKT-rf	SMB	HML	RMW	CMA	WML
Alpha	0.344%	0.341%	0.341%	0.341%	0.343%	0.344%	0.338%
	(4.105)	**(4.062)**	**(4.058)**	**(4.074)**	**(4.077)**	**(4.072)**	**(3.941)**
MKT-rf		0.112	0.140	0.149	0.133	0.140	0.153
		(-0.984)	(1.155)	(1.227)	(1.027)	(1.046)	(1.106)
SMB			0.187	0.239	0.226	0.240	0.239
			(0.674)	(0.858)	(0.804)	(0.829)	(0.825)
HML				-0.468	-0.537	-0.593	-0.522
				(-1.510)	(-1.484)	(-1.325)	(-1.073)
RMW					-0.180	-0.188	-0.190
					(-0.372)	(-0.387)	(-0.389)
CMA						0.134	0.051
						(0.216)	(-0.077)
WML							0.085
							(0.381)

T-statistics below in brackets
Bold figures represent significance at 5% level

Perhaps surprisingly, a significant loading on momentum (WML) is not found, also when only regression on market, value and momentum (result not shown), the WML factor remains insignificant. Strangely enough the market factor itself is also insignificant whereas we would expect negative loading. The goal of the index rebalance is to achieve the lowest volatility possible under the given constraints of the index. It can be expected that low volatility stocks are thus bought and high volatility stocks are sold. The reason for not finding significance could be due to the fact that a significant part of the turnover used is used to bring the index in compliance again with the given constraints and not to actually reduce volatility. Also, it is hard to reduce volatility of an index with already very low volatility. To illustrate: during the last rebalance in the dataset (November 2016), the 20% turnover used caused in an ex-ante beta drop of the Minimum Volatility index vs MSCI World from 0.67 to 0.66 and added 1% extra risk reduction (measured in Bloomberg's PORT Regional Risk model). Additionally, MSCI's Barra measures the volatility over the year prior to the index rebalance. While stocks with higher volatility are exchanged for lower volatility stocks based on that estimation period, the short window investigated here can easily deviate from the prior trend. Given the almost lack of FF factor exposure in the FW spread basket and complete lack of FF factor exposure in the AW spread basket, the conclusion can be drawn that the index rebalance is a very idiosyncratic event. For arbitrageurs this is good news as abnormal returns can be made without facing a lot of factor risk.

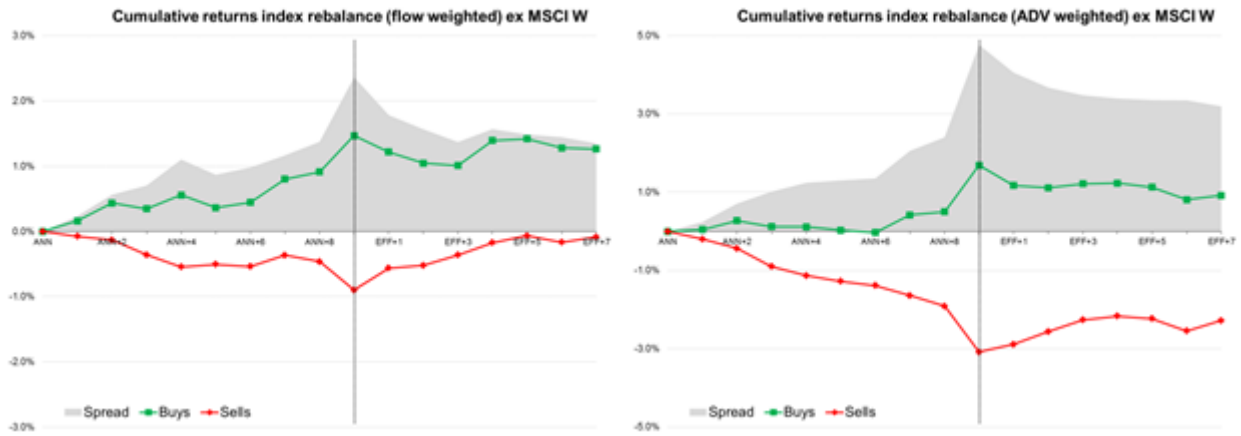
The seemingly more persistent abnormal return before ED and reversal after ED in the basket based on liquidity, could suggest that the effect is primarily caused by market impact. All things equal, one would expect more market impact in stocks that are less liquid. As MSCI allow for a maximum of 20 times the individual stock weight vs the weight in the underlying market cap weighted index, a relative small and illiquid stock can have a large weight change in the rebalance. Whether the positive spread return is the result of market impact in the index rebalance or the result of other factors is further explored in the next chapter. In short, the results found are tested for robustness by 1) excluding stocks that also have a weight change in the MSCI market cap weighted index and 2) looking at abnormal returns by subtracting the local market return. Finally, using intraday data it can identified whether the spread increases

towards the close of ED, which is the moment the index changes and thus most trading concentrates around this point. If that is the case, the effect found is most likely the result of excess market impact.

Robustness checks

To investigate whether the significant index effect found is the primarily the result of market impact in the Minimum Volatility index, additional analysis is conducted. First, AW and FW baskets are constructed where stocks are excluded that have a weight change bigger than 0.1 basis point in the same direction in the MSCI World rebalance, in line with table 3a. This is done to see whether the index effect still exists if only stocks that need to be traded due to their weight change in the Minimum Volatility index are incorporated. In figure 4 the cumulative returns are plotted for AD to ED+7 for the FW baskets (left graph) and AW baskets (right graph). The pattern is very similar to the pattern observed before: steady increase of the spread leading up to ED and a slight reversal after ED. The spread measured from AD to ED even increases with resp. 0.2% to 2.4% (FW) and 0.3% to 4.8% (AW). The result suggests that the abnormal return for stocks with a weight change in both Minimum Volatility and MSCI World is *smaller* than for stocks that only change in the Minimum Volatility index. This is counterintuitive: bigger market impact and thus a bigger spread should be expected for stocks that require a bigger trade due to more market impact. Therefore, the differences found are more likely noise, especially as they are quite small. More importantly: it can be concluded that the index event found in the Minimum Volatility rebalances remains persistent when correcting possible effects coming from the concurring rebalance in the market cap index.

Graph 4. FW baskets (ex MSCI World stocks) left graph, AW baskets (ex MSCI World stocks) right graph



To exclude possible country effects on the rebalance, abnormal returns are investigated next by subtracting MSCI local country returns from the individual stock returns. This is necessary as MSCI allow for up to +/- 5% country deviations vs the market cap index. Stocks from one country can significantly out- or underperform the global index in the event window due to reasons not linked to the rebalance itself, for instance due to macro-economic data or central bank policy announcements. By subtracting the country local returns, it is possible to correct for potential noise in the analysis. From the abnormal

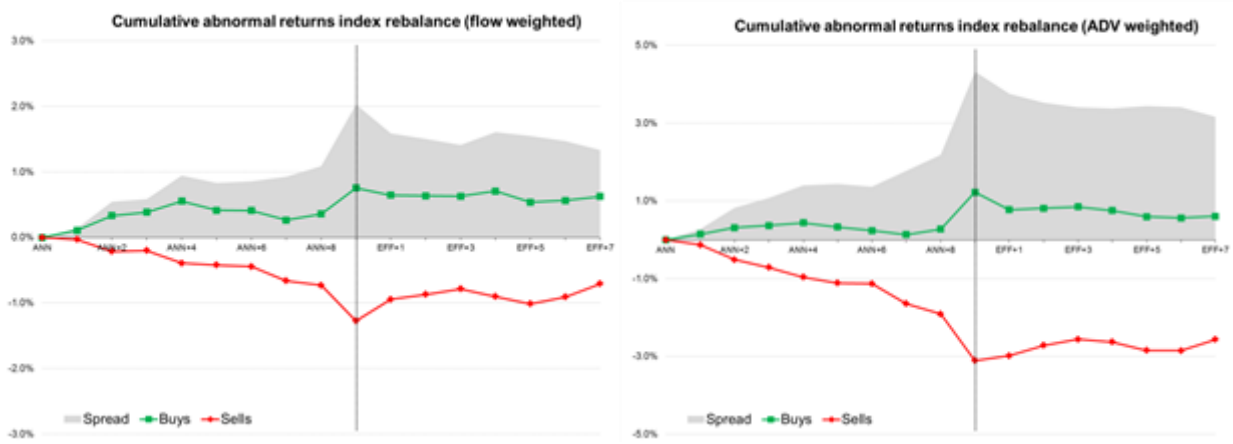
stock returns are FW and AW baskets constructed the same way as before. In table 9 below the country indices used are listed.

Tabel 9.

MSCI local country indices					
Ticker	Country	Ticker	Country	Ticker	Country
MXAT Index	AUSTRIA	MXES Index	SPAIN	MXIT Index	ITALY
MXAU Index	AUSTRALIA	MXFI Index	FINLAND	MXJP Index	JAPAN
MXBE Index	BELGIUM	MXFR Index	FRANCE	MXNL Index	NETHERLANDS
MXCA Index	CANADA	MXGB Index	UNITED KINGDOM	MXNZ Index	NEW ZEALAND
MXCH Index	SWITZERLAND	MXHK Index	HONG KONG	MXPT Index	PORTUGAL
MXDE Index	GERMANY	MXIE Index	IRELAND	MXSG Index	SINGAPORE
MXDK Index	DENMARK	MXIL Index	ISRAEL	MXUS Index	USA

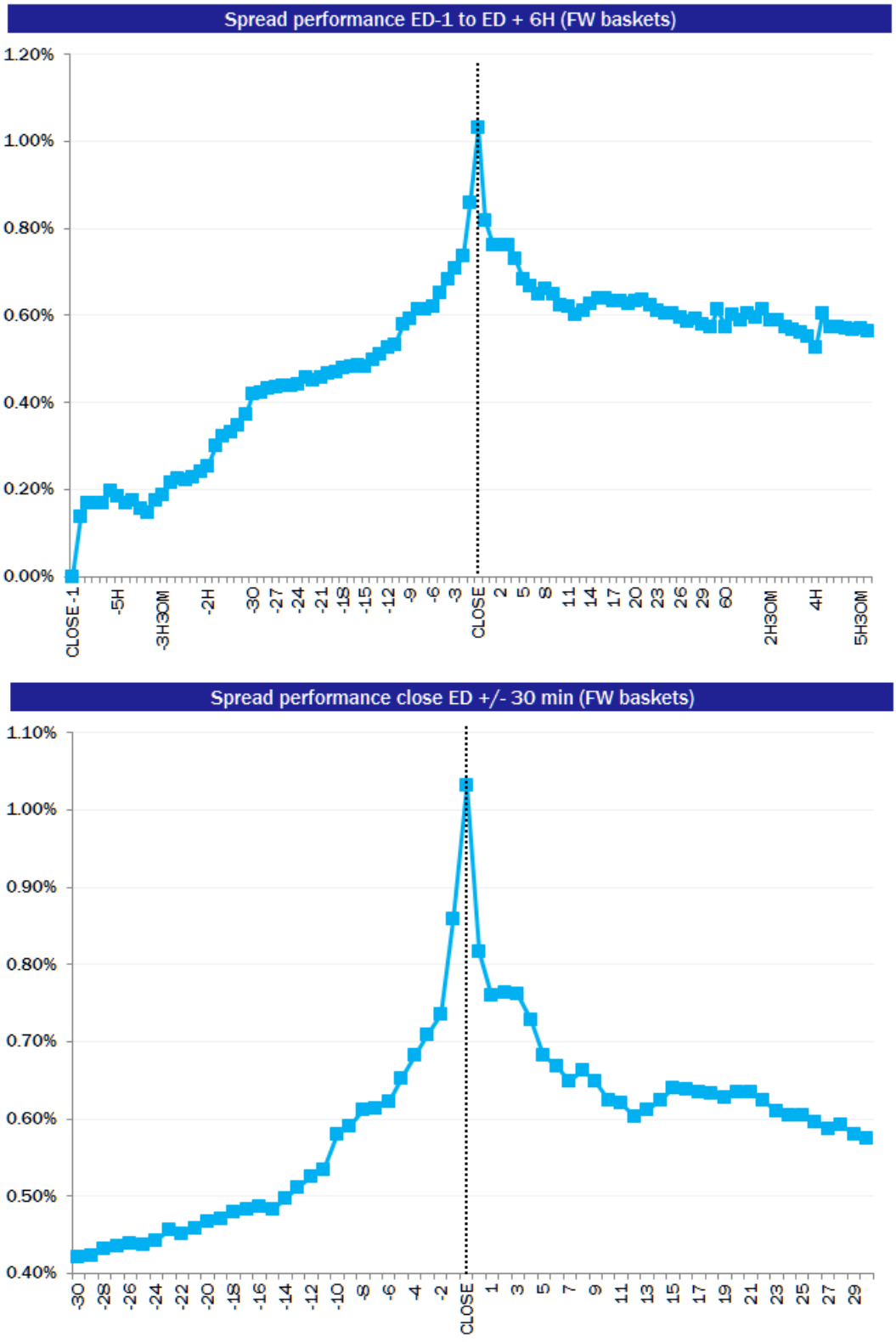
The cumulative abnormal returns are shown in graph 5, left for the FW baskets, right for the AW baskets. Similarly to the robustness check for MSCI World index changes, the overall results are not substantially different. The pattern of an increasing spread up to ED and slight reversal after ED holds up, the size of the spread is virtually unchanged: AD to ED resp. 2.03% for FW and 4.33% for AW.

Graph 5. FW baskets abnormal returns left graph, AW baskets abnormal returns right graph



These robustness checks show that the significant index effect of the MSCI Minimum Volatility rebalance found is most likely the result of market impact associated with the trade that is necessary to track the index. If this is indeed the case, we can expect to see most of the market impact towards and on the close of ED. That is when the index changes and everyone with a minimum tracking tolerance wants to trade at that point in time. Using intraday tick data, we can keep track of the spread performance just before, on and after the close of ED.

Graph 6. Intraday spread performance hours before and after close ED (top) and 30min around close ED (bottom)



In graph 6 a clear spike is visible in spread performance just before the close and a sharp reversal just after the close on the next day. The spread shown here is for FW baskets, for AW see appendix II. Each

marker in the bottom graph represents 1 minute. As such, it can be seen that investors would be better off by 29 basis points if only they would execute the rebalance a mere 2 minute before the close or 2 minutes after the open the next day.

Before moving to the practical implications and conclusion, it may be worth investigating whether more recent rebalances differ in spread development from older rebalances. Although the dataset with 12 rebalances over 6 years is somewhat limited, it is possible to divide the rebalances in two equal periods of 3 years: 2011 to 2013 and 2014 to 2016. This lets us see whether the increase of assets benchmarked against the Minimum Volatility index as indicated in graph 1 has an impact on the spread return found. If the primary reason of the significant index effect found is market impact, then more assets benchmarked against the index will most likely result in a bigger index effect. In graph 7 below the dataset is divided in two parts with the first three years in the left graph and the last three years shown in right. The overall spread is of similar size: in both cases just excess of +2% between AD and ED. Whereas the size of the spread does not change, the development of the pattern is different. In the first three years the spread does not move substantially until AD+6 and most of the +2% gain is achieved in the last day. The last three years a different pattern is visible with a more gradual spread development, increasing steadily from the first day and the effect on the final day is more muted. It could be that investors have become aware of the (excessive) market impact they were having on the rebalance and decided to start earlier than just a day or few days prior to ED. Another possibility is that index arbitrageurs became aware of the abnormal profits to be made and decided to 'front-run' the index trackers by shortly after announcement entering positions in line with the rebalance. They would then exit their position at or just before the close of ED, thereby providing contra directional flow to the index rebalance. This could explain the reason for a more muted reaction on ED the last three years.

Graph 7. FW baskets returns 2011-2013 left graph, FW baskets returns 2014-2016 right graph

Practical implications

The findings in paper have several implications for investors. The robustness of the index effect found shows that investors replicating the index are faced with sizeable hidden costs. If they were to implement the semi-annually rebalance with minimal tracking error by trading on the close of effective day, they pay a steep premium. Stocks that go up in weight outperform stocks that go down in weight by an average of 2.21% between the close of effective day and announcement day. Hypothetically, if one were to trade the entire index rebalance at announcement day prices, an annual loss of 0.44% (2.21% x 10% turnover x 2 rebalances per year) can be avoided. Of course this is only possible for very small investors as larger investors need liquidity that is usually found at or close towards the close of a trading day. However, this finding shows that that liquidity clearly has a price. Investors with at least some tracking error room are advised to not wait until effective day to perform the index rebalance. Based on the data collected for this research, trading the entire rebalance shortly after the announcement (first day or first few days), would prevent the majority of the 0.44% loss. It appears that the index effect is only priced in slowly in the days following announcement day, instead of fully priced in right after the announcement. Although surprisingly, this is in line with what Petajisto (2010) finds for index changes for the S&P 500 and Russell 2000.

The persistence of the index effect is not easily explained. Especially for index changes on main stream market cap weighted indices as the S&P 500 and MSCI World, numerous papers have been published which document the effect and show that arbitrage profits can be made. In efficient markets one would assume this effect is arbitraged away. One of the reasons named why this is still not the case include the risk that is involved to do so. The index rebalance often means a shift in country and sector weights. Although it is possible to hedge this risk up to a point, the liquidity in country and sector ETFs and futures may not be big enough to trade at large scale. Furthermore, idiosyncratic stock risk as earning events and other company specific news cannot be hedged. As long as the index effect is present in major indices such as the S&P 500, one would expect the effect in less focused indices such as factor benchmarks. The only requirement is that the index is tracked by a sufficient amount of AuM from passive investors. This latter is the case for the MSCI Minimum Volatility index.

When we assume the index effect is here to stay in market cap weighed and factor indices, investors can do a couple of things to limited their losses due to the market impact occurring during the rebalances. First, they should trade a different time from when everybody else is trading. For now it seems that shortly after announcement is sufficient to prevent most of the losses otherwise caused. In the future when more people become aware of the index effect in factor benchmarks, it may be required to predict (most of) the rebalance and trade ahead of announcement. In market cap weighted index rebalances the more sophisticated investors already do this. Another option is to ask the index provider to make them a custom index with the exact same rules, but a different rebalance schedule than the standard one. One downside of this, is that the index will most likely differ slightly from the standard one due to different stocks enter and existing the index as a consequence of rebalancing at different dates. From a fiduciary standpoint (especially important for pension funds), this may be less desired as the benchmark and its return is no longer comparable to the standard, non-customized index. Management of the pension fund may to be willing to make the call to rebalance out of sync with the standard index as they will be

responsible for any potential underperformance. Therefore the third option is may be even better: convince the index provider (perhaps by presenting research pieces as this one) that there is significant market impact in their index rebalances. The index provider should feel responsible to counter this as much as possible for two reasons: 1) it is in direct interest of their current passive clients as it raises their portfolio returns and 2) it makes them more attractive for future investors, especially when other index providers do nothing to counter market impact. One way to lower market impact would be to rebalance more often while keeping overall annual turnover the same, for instance monthly instead of semi-annually. Another option is to only use turnover when the turnover actually is worth to use and thus use less turnover overall. In case of the Minimum Volatility index: set a minimum risk reduction (or beta reduction) that needs to be achieved for every 1% additional turnover. Finally, for those with the necessary IT systems and skilled people: it may be wise to develop your own low risk strategy which puts you in control of portfolio construction and rebalance timing and execution.

Conclusion

In this research the results of the MSCI Minimum Volatility index rebalances between 2011 and 2016 are presented. The main finding is that stocks that increase in weight return an average of +1.58% between announcement and effective day. Stocks that are (partly) sold during the index rebalance return an average of -0.63% in same time period. This results in an index spread (difference between buy and sell basket) of +2.21%, making the rebalance 2.21% more expensive on effective day than on announcement day. Investors lose every rebalance (10% turnover) 0.22% and with two rebalances per year this accumulates to a performance drag of 0.44% annually. Additionally the following conclusions can be drawn:

1. The index effect is persistent, of structural nature and statistically significant. Only one rebalance (November 2011) of the 12 rebalances investigated yields a marginal negative spread between AD and ED. On effective day, all but one (2015-II) rebalances show positive spread returns. Furthermore, no single rebalance result dominates the overall average.
2. The spread between AD and ED doubles to +4.5% when constructing baskets on basis of liquidity (less liquid stocks get a higher weight). This indicates that the index effect is caused by market impact.
3. The index effect found is statistically significant with significance at 5% level found for event windows on announcement day (AD), between announcement day and effective day (AD+1 – ED-1) and on effective day (ED). The reversal effect is mainly observed on the first day after effective day. For both baskets statistical significant negative spread returns are found. No significance is found for the flow weighted baskets for the overall time period suggesting that there is no permanent price change, which adheres to the price pressure hypothesis.
4. No loadings on Fama French factors are found in time series regressions on the spread returns. For index arbitrageurs this is good news as it suggests that the index rebalances is mainly an idiosyncratic event with little factor risk. For passive investors this may be less desirable as even a negative tilt on market is not found. It seems that the turnover used in the index rebalance does not yield a substantial amount of risk reduction.

5. Robustness checks do not alter the results. When correcting for possible country effects and accounting for stocks that face a similar rebalance in the market cap weighted index of MSCI World, the overall results are very similar to the original findings.
6. Analysis with intraday tick data reveals that the spread increases rapidly towards the close of effective day. In the last 30 minutes buys outperform sells by 60 basis points, fully reversing in the first 30 minutes of the next day.
7. The strong increase of assets benchmarked against the Minimum Volatility index has not increased the overall index effect. Roughly the same spread is found for the period between 2011-2013 as between 2014-2016. There is a difference in the development of the spread however: in the first years the spread mainly increases in the final few days, whereas in more recent years the spread development is more gradually and increasing from the first day after announcement. Whether this market impact is caused only by passive investors that track the index or also by index arbitrageurs is hard to say. The difference in spread development between 2011-2013 and 2014-2016 suggests that the rebalance trade is executed earlier and investors do not wait till effective day. It could be that passive investors that track the index feel that they need to start earlier to minimize their trading impact, or index arbitrageurs are stepping in and execute the rebalance trade shortly after announcement. If they unwind their positions shortly prior to effective day, in aggregate there is no excess flow and thus no excess market impact. This could explain that the overall spread has not increased over the years.

This paper provides empirical evidence for the index effect in factor benchmarks. For future research, it would be interesting to first extent this research to other versions of the MSCI Minimum Volatility index (for instance, the USA, EAFA and Emerging indices) and furthermore investigate other factor indices such as popular Value, Growth, Momentum, Dividend and multifactor indices. As long as the number of assets tracking the index is large enough, it is likely that an index effect can be found.

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APPENDIX I

Time series regressions on all Fama French factors for different time periods. The same method is applied as in tables 8a and 8b.

Time series regressions FW							
	AD-6 - AD-1	AD	AD+1 - ED-1	ED	ED+1	ED+2 - ED+14	AD-6 - ED+14
Alpha	0.006%	0.036%	0.161%	1.488%	-0.625%	-0.048%	0.047%
	(0.122)	(0.211)	**(3.079)**	**(2.246)**	**-(3.712)**	-(1.319)	(1.660)
MKT-rf	-0.164	0.036	-0.016	-0.495	-0.141	-0.179	-0.077
	-(1.814)	(0.084)	-(0.199)	-(0.622)	-(0.575)	**-(2.863)**	-(1.658)
SMB	-0.422	0.316	0.345	0.081	1.144	-0.037	0.064
	-(2.425)	(0.690)	(1.834)	(0.047)	(1.116)	-(0.300)	(0.655)
HML	-0.167	1.304	-0.140	-6.651	0.500	0.123	-0.108
	-(0.593)	(1.293)	-(0.467)	-(1.490)	(0.836)	(0.637)	-(0.722)
RMW	-0.250	1.436	-0.567	-1.702	-0.778	0.005	-0.168
	-(0.922)	(1.277)	-(1.656)	-(0.712)	-(0.628)	(0.022)	-(1.015)
CMA	-0.535	-1.252	0.037	5.437	-1.461	-0.203	-0.175
	-(1.251)	-(1.237)	(0.096)	(1.251)	-(1.144)	-(0.749)	-(0.830)
WML	0.148	0.577	-0.136	-1.101	-0.355	-0.119	-0.005
	(1.166)	(1.138)	-(0.953)	-(0.800)	-(0.640)	-(1.167)	-(0.061)

Time series regressions AW							
	AD-6 - AD-1	AD	AD+1 - ED-1	ED	ED+1	ED+2 - ED+14	AD-6 - ED+14
Alpha	0.088%	-0.127%	0.251%	4.038%	-0.679%	-0.069%	0.125%
	(0.869)	-(0.529)	**(2.747)**	(1.788)	-(1.392)	-(1.427)	**(2.401)**
MKT-rf	-0.176	0.851	0.151	-2.092	-0.150	-0.067	0.072
	-(1.017)	(1.429)	(1.060)	-(0.771)	-(0.212)	-(0.801)	(0.835)
SMB	-0.208	0.892	0.273	-6.043	2.885	0.045	0.174
	-(0.623)	(1.395)	(0.830)	-(1.028)	(0.972)	(0.271)	(0.974)
HML	-0.566	3.364	-0.353	-5.376	-1.421	-0.225	-0.457
	-(1.049)	**(2.393)**	-(0.678)	-(0.353)	-(0.821)	-(0.872)	-(1.657)
RMW	-0.387	2.700	0.639	-4.194	-1.118	-0.224	-0.225
	-(0.744)	(1.723)	(1.070)	-(0.515)	-(0.312)	-(0.760)	-(0.737)
CMA	-0.413	-3.293	0.056	-2.954	2.299	0.060	0.085
	-(0.504)	**-(2.334)**	(0.083)	-(0.199)	(0.622)	(0.164)	(0.218)
WML	0.177	1.592	0.021	-1.222	0.176	0.035	0.071
	(0.728)	**(2.251)**	(0.086)	-(0.261)	(0.109)	(0.256)	(0.508)

APPENDIX II

Intraday spread development for AW baskets, in line with methodology used in graph 6.