Benchmark Selection Analysis

Analysis for the Norwegian Ministry of Finance

MSCI

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Contents

Notice: This research is a supplement to the report "Selected geographical issues in the global listed equity market: Analysis for the Norwegian Ministry of Finance. Oct 2019."

This report contains analysis of historical data, which may include hypothetical, backtested or simulated performance results. There are frequently material differences between backtested or simulated performance results and actual results subsequently achieved by any investment strategy.

The analysis and observations in this report are limited solely to the period of the relevant historical data, backtest or simulation. Past performance — whether actual, backtested or simulated — is no indication or guarantee of future performance. None of the information or analysis herein is intended to constitute investment advice or a recommendation to make (or refrain from making) any kind of investment decision or asset allocation and should not be relied on as such. You cannot invest in an index.

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Executive Summary

Standard indexes are often designed to be suitable for a typical institutional[1] investor and therefore may not be the absolute optimal solution for all investors. To have an index which better aligns with their objectives and constraints, investors often opt for custom indexes.

Because of its size, Government Pension Fund Global of Norway (GPFG) is not a typical investor and therefore a custom benchmark that better fits the funds objectives and constraints could be considered. In practice, the design of the custom index will be a thorough process with inputs from different parties involved to achieve the most efficient index. Simulations in this report are only presented as a proof of concept.

In the first part of this report we look at a few custom ACWI IMI indexes, with two dimensions of customization in mind: smaller universe and lower turnover. The lower turnover means less annual trading and less cost associated with it. Given the size of the GPFG portfolio, any small improvement in the annual turnover of the index can result in large savings for the fund.

The coverage of the investable universe in the index has different implications and selecting the optimal coverage entails balancing different trade-offs. Having an index with slightly smaller universe coverage (e.g. 97% coverage instead of 99% in standard ACWI IMI) could be beneficial from different aspects. The 2% difference between these two universes accounts for several thousands of small stocks. Cost savings as well as operational and governance efficiencies can be realized by reducing the number of stocks.

Another potential benefit of a smaller universe is reduction in the annual turnover costs. Some of the annual turnover of the index is due to addition and deletion of the smallest stocks at the bottom of the index. Covering 97% instead of 99%, means these additions and deletions are larger and potentially more liquid stocks and likely less costly to trade. A hypothetical analysis around this potential saving is presented in Appendix II.

We show that there are possibilities to decrease the size of universe without having a significant impact on the risk/return characteristics of the index. We also show that turnover and therefore the cost associated with it can be lowered, however there are trade-offs that need to be balanced. [2]

[1] The typical investors have various characteristics. They have very limited investment constraints in their investments, their individual investment decision usually does not impact the market.

[2] E.g. some index turnover is associated with smaller stocks getting out of the index due to their size or liquidity being reduced. A buy-and-hold investor may save some turnover cost by not deleting these stocks from their

Smaller universe and lower turnover could help reduce cost in three dimensions:

1) Lower cost of covering and governing the stocks in the universe by eliminating several thousand small stocks.

2) Lower overall turnover results with fewer trades and less cost associated with the trades.

3) Eliminating very small and often the least-liquid stocks means eliminating trading in these stocks which may have higher trading costs due to lower liquidity.

In the second part of this report we look at the cost associated with changing the benchmark for the GPFG portfolio. We use the MSCI liquidity model[3] to estimate the cost of switching from the GPFG's current benchmark to a custom MSCI benchmark and investigate approaches to reduce the cost of benchmark switch.

The GPFG portfolio tracks its benchmark with some active share and tracking error. We show that both active share and active risk stay almost unchanged if the benchmark is changed from the current benchmark to the MSCI benchmark. This means that if the benchmark is changed and GPFG portfolio stays the same, the headline active risk of GPFG portfolio does not change.

If the concerns were simply headline risk, the transition could happen without incurring any trades and there would be no trading cost associated with it. However, the sources of active risk may be different when the GPFG portfolio is compared to each of the benchmarks. In practice some trades may be required to adjust the risk positions of the portfolio.

In the analysis in this report we assume the GPFG portfolio perfectly tracks the current benchmark and therefore the switch means trading the difference between the two benchmarks. In a sense this provides us with an estimate of the upper bound on the transition cost.

The GPFG's current benchmark and the MSCI benchmark are close in terms of their constituents and weight, but there are still some differences (a small active share). Therefore, switching from the current benchmark to the MSCI benchmark may require some trading.

While the difference between the two benchmarks (current and MSCI benchmark) is not large, the large size of the fund makes it prohibitively expensive to switch in one day. We show that transitioning the benchmark over a longer horizon reduced the

index and portfolio. This, however, in a long run may mean holding a large tail of small or illiquid stocks. This trade-off needs to be balanced when designing the index.

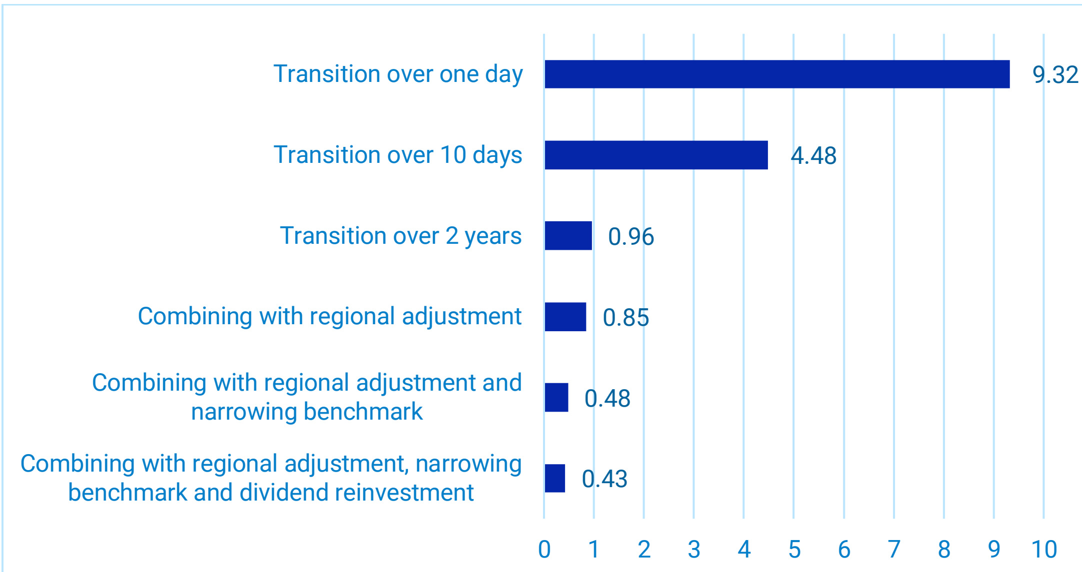
[3] Virtu Liquidity Surfaces in LiquidityMetrics, MSCI, 2020.

estimated cost significantly (c. 90% reduction in cost if the transition happens over a two-year period).

We further show that, spreading the cost over two years, not only can reduce the cost by mitigating the potential market impact, but also some of the difference in the two benchmarks could be offset by the natural changes in the index over the transition period (e.g. two years) and therefore the marginal turnover associated with transition could be significantly reduced. The hypothetical historical analysis in this report showed a potential turnover saving of about 50% over two years.

Moreover, combining the benchmark switch with other potential changes to the benchmark such as changes in the regional weights, narrowing the benchmark and reinvestment of dividends, could further reduce the marginal cost of a switch.

Estimated cost of transitioning the GPFG's portfolio from its current benchmark to an MSCI benchmark under different scenarios. Costs are represented as basis points total AUM.



Optimization techniques could be used to further reduce the benchmark-switch cost by trading off some tracking error for lower costs. This approach could especially be useful since the GPFG portfolio tracks its current benchmark with some tracking error. The optimization can be used to minimize the trading cost while aligning active risk of the portfolio with the new MSCI benchmark.

It should be emphasized that all the costs are estimates using the MSCI liquidity model and not the actual costs. While these estimates are insightful, attention should to be given to the different strategies that are examined to reduce the cost and make the benchmark switch efficient.

To give the cost estimates a frame of reference, we use the same liquidity model to also estimate the cost of the natural turnover of the standard MSCI ACWI IMI over the past three years.

Introduction

Indexed investing is an active management process and investors need to actively select indexes that will help them achieve their investment objectives. Selected index(es) can act as a common language to provide clarity in the investment process. Therefore, selecting the right index is an important active decision by institutional investors which not only affects the outcome of the asset allocation process, but reflects the key characteristics of the investor.

For example, a large institutional investor may be interested in gaining exposure to the entire global equity opportunity set but may be constrained to invest in micro-cap securities due to liquidity and other investability constraints. Such an investor will constrain her index choice to an index like MSCI ACWI Investable Market Index (MSCI ACWI IMI), which provides exposure to 99%of the global opportunity set across the large-, mid- and small-cap segments of 23 developed and 27 emerging market[4] countries, but avoids micro caps.

From a return perspective, the difference in performance between MSCI All Country All Cap Index, an index, which includes global micro caps along with large-, mid- and small-caps stocks, relative to MSCI ACWI IMI is quite small, but from an index tracking or replication perspective, the MSCI All Country All Cap Index would need approximately 5,800 additional securities to be actively maintained for corporate events as well as other index calculation and management data points.

Even without micro caps, the universe covered by MSCI ACWI IMI includes close to 9,000 securities, of which more than 6,000 are small caps. While an investor may be interested in having exposure to small caps, the cost of covering and maintaining 6,000 securities may be prohibitive. A custom index can be designed to balance this trade-off and provide the desired exposure to small caps while limiting their number to a manageable level for the investor.

Standard indexes are often designed for the average and typical institutional investor and may not perfectly meet the needs of every investor. Some investors may face unique investment constraints ranging from security- and country-level investment restrictions to more complex investability, liquidity, currency, taxation and rebalancing needs. For such investors, use of standard indexes may result in benchmark misfit since the chosen index may not appropriately reflect the

[4] As of Dec. 31, 2020

investment objectives. Customization is an effective way for investors to fine-tune their benchmark index to their objectives and constraints.

MSCI at a Glance

MSCI is a global firm with 3500+ employees in 35 offices across the globe. Over the past 50 years MSCI has provided services to a wide range of investors and currently has more than 7,800 clients across the world. MSCI provides a wide range of financial services to its clients.

Indexes: MSCI is a leading provider of equity indexes and calculates more than 230,000 indexes daily with 99.7%[5] accuracy. About $12.1 trillion[6] in assets under management are benchmarked to MSCI indexes. The MSCI equity indexes range from ACWI IMI, World, and Emerging Markets to ESG and Climate, Factors and Thematic Indexes. MSCI also offers a range of fixed income indexes such as corporate bonds ESG, Low Carbon and Factor indexes.

Analytics: The global risk and performance engine of MSCI analytics runs up to one trillion calculations per day and covers more than 70 million client positions. The products cover Risk Management, Asset Allocation, Fixed Income Analytics and Multi-asset Class Factor Models.

ESG and Climate Research: MSCI is the world's largest provider of ESG and climate metrics data, research[7] and indexes[8]. Over 1500 ESG and climate equity and fixed income indexes use MSCI ESG Research ratings and data. Some of the data and

[5] Accuracy rate is calculated based on the number of corrected data points in comparison to the total number of data points processed over a one-month period. Corrected data points are identified through internal quality control procedures or through client feedback. Index corrections are subject to a 50bp correction method. Monthly figures are averages for the period Jul 2019 – Jun 2020)

[6] Assets under management (AUM) as of Jun. 30, 2020, reported on Sep. 30, 2020 using data from eVestment for active institutional funds and Morningstar for active retail funds. Equity ETF values were based on data from Refinitiv and MSCI. In addition, AUM includes passive assets using available internal data. AUM includes notional open interest in futures and options using internal data from MSCI. Active retail funds include open-ended funds, closed-ended funds and insurance product funds. Active institutional AUM includes separate/segregated AUM, pooled/commingled AUM and mutual fund institutional AUM. AUM includes equity and multi-asset classes. AUM includes the MSCI only portion of hybrid/blended benchmarks from Morningstar and excludes feeder funds and funds of funds. For funds where the AUM was not reported as of Jun. 30, 2020, the previous period AUM was utilized as an estimate. MSCI does not guarantee the accuracy of third-party data.

[7] By coverage of companies and by number of ESG clients based on public information produced by Sustainalytics, Vigeo/EIRIS and ISS ESG as of December 2020.

[8] By number of indexes and by assets tracking the indexes compared with publicly available information produced by FTSE and S&P Dow Jones as of December 2020.

products are: ESG issuer and fund ratings, ESG governance metrics, climate solutions, climate value at risk and sustainable impact.[9]

Private Assets: MSCI is a global leader in Real Estate investment tools and covers 32 markets worldwide. The coverage spans USD 2 trillion of private real estate assets. Product and services include performance attribution, risk analytics, global market information and indexes. In January 2020, MSCI entered into a strategic relationship with The Burgiss Group, LLC to enhance its capabilities and offerings in private equity.

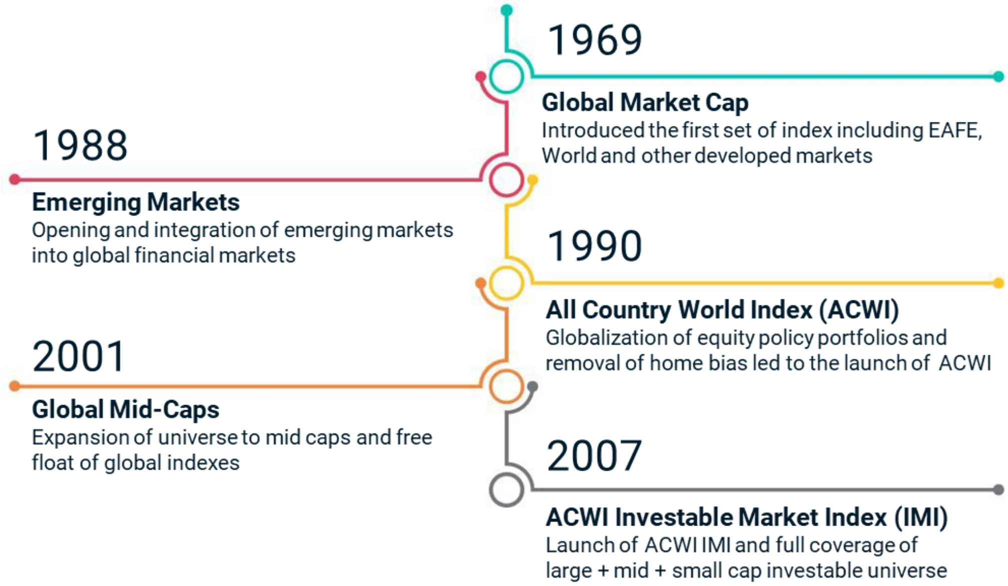
MSCI Indexes

Market-Cap Indexes:

MSCI launched its first equity index more than 50 years ago in 1969. The first set of indexes were global market-cap indexes including EAFE and World covering a total of 16 countries. Since then, MSCI index offering has evolved and broadened to reflect the evolution of institutional investment process.

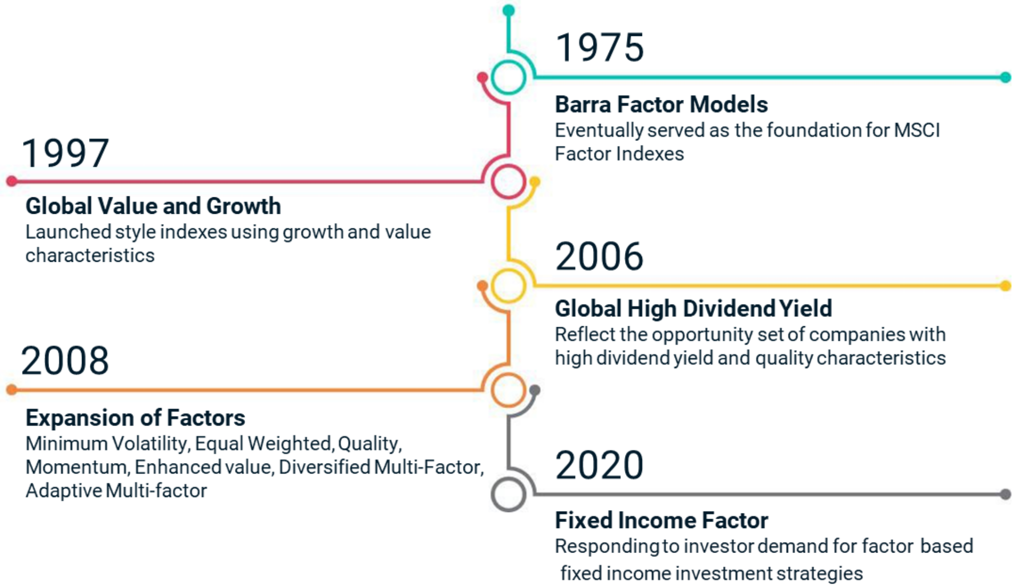
With the opening and integration of emerging markets (EM) into global financial markets, MSCI launched its EM indexes in 1988. This was followed by the broad ACWI Index in 1990 which covers both developed and emerging markets. ACWI IMI which covers the full large-, mid- and small-cap investable universe was launched in 2007. Currently the MSCI equity universe covers equities in 84 countries.

[9] MSCI ESG ratings and data are produced by MSCI ESG Research LLC. MSCI ESG Indexes and Analytics utilize information from, but are not provided by, MSCI ESG Research LLC. MSCI Indexes and Analytics are products of MSCI Inc. MSCI Indexes are administered by MSCI Limited (UK).



Style and Factor Indexes:

MSCI's factor models and factor indexes are backed by over four decades of factor research and innovation. The first Barra factor model dates back to 1975. The global Value and Growth style factors were launched in 1997 and since have been benchmark for many such investments. The first group of MSCI factor indexes was the high dividend yield indexes, launched in 2006, and since then different factor and multi-factor indexes have been created to offer solutions for wide range of investor needs. To respond to investor demand and complement its equity factor index offerings, in 2020, MSCI launched a suit of factor indexes for fixed income.



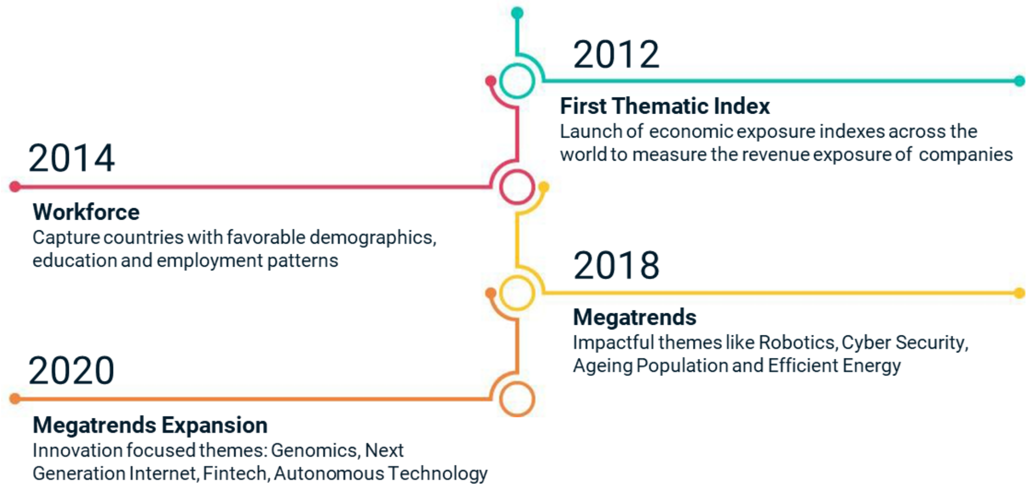
ESG and Climate Indexes:

MSCI leverages the knowledge, expertise, data and research from its ESG team to construct and offer innovative ESG and climate indexes. The first MSCI ESG index (now the MSCI KLD 400 Social Index) dates back to 1990. MSCI ESG Leaders and SRI indexes serve as benchmarks for many institutional investors and the basis for many financial products. The Global Climate Change indexes enable investors to holistically integrate climate risk considerations in their investment process. The recently launched Climate Paris Aligned and Fixed Income ESG and Climate indexes are the latest addition to the MSCI ESG and climate index offerings.

Thematic Indexes:

Thematic investing could be defined as investment approaches that identify (usually) long-term and structural trends which could drive stock performance in a rapidly changing world.

MSCI's recent innovation in this space includes several megatrends indexes based on impactful themes such as Robotics, Cyber Security, Aging Population, Energy Efficiency, Genomics, Next Generation Internet, Fintech and Autonomous Technology.



The MSCI Way to Build and Manage Indexes

MSCI's Research and Product Development team seeks to bring clarity to the dynamic and increasingly complex financial markets through continuous innovation. By providing a choice of indexes for a variety of uses, MSCI aims to help institutional investor seeking to create better portfolios and monitor their investments.

MSCI calculates and publishes more than 230,000 indexes across market-cap, ESG, Climate, factors, thematic, real estate and fixed income categories of which more than 14,000 are calculated in real time. These indexes are all based on robust, transparent methodologies. The index production team, comprised of 230 employees, is strategically positioned in eight locations around the globe for 24/7 production and support.

The robust production system and quality control has helped MSCI consistently maintain high levels of accuracy while increasing its data coverage. To prepare for scenarios that could impact index production, teams have business continuity and disaster recovery plans in place.

MSCI delivers its index data through multiple channels including over 30 third-party platforms and APIs. This data is consistently delivered well in advance of target deadlines. A customer service team of more than 40 people are available 24/7 to address potential client queries in a timely manner.

MSCI's governance process focuses on creating and maintaining an organizational structure that promotes high benchmark quality as well as independence from inappropriate investor influence. Two internal MSCI committees oversee the indexes. The Equity Index Committee (EIC) oversees index-level methodology and related decisions for MSCI's equity indexes. The Index Policy Committee (IPC) is responsible for policy-level decisions, often with input from the EIC.

Many index-related decisions are made with input from broad range of clients. Broad public consultations are used to ensure index decisions are made based on market consensus and with full transparency.

Conflicts of interest can compromise the integrity of indexes if the appropriate physical and policy infrastructures are not established., MSCI does not have any stock exchange, asset management, broker dealer, bank or trading/clearing facility in its corporate group. Therefore, we believe there are no inherent conflicts of interest in connection with benchmark administration. A strict confidentiality wall (governed by strict rules) physically separates staff involved in index design, calculation and maintenance from those who are not.

Index Construction:

MSCI creates and maintains indexes based upon the considerations of international institutional investors when assessing a market. The two tenets to MSCI index construction are accessibility and investabilty. For a brief summary of MSCI Global Investable Market Index (GIMI) methodology which is the basis for construction of MSCI market-cap indexes including ACWI IMI, please see Appendix I.[10]

Accessibility is about how easily an international institutional investor can enter and exit an equity market in any given country. A transparent market-classification framework and country eligibility criteria is a central feature to the market accessibility.

Investability criteria aim to ensure companies that are included in the index have sufficient liquidity and free float (publicly available shares) while aiming to achieve broad market coverage.

[10] The complete methodology book can be found here: https://www.msci.com/eqb/methodology/meth_docs/MSCI_GIMIMethodology_Oct2020.pdf

For market capitalization equity indexes the only filters for inclusion are the accessibility of the equity markets and the investability of the listed securities. For indexes derived from market-cap indexes, such as Factors or ESG the inclusion is based on additional filters like relative company valuation, ESG ratings etc.

In addition to its standard indexes, MSCI offers a wide range of customization features that can be used to create custom indexes. MSCI custom indexes are rules-based and transparent and follow the same processes as standard indexes.

A Customized MSCI Benchmark Fit for GPFG

Standard indexes are designed to be as generic and accessible as possible for a wide range of investors. While there are many standard indexes offered to cover investors' diverse needs, including global, regional, country, sector, size segments, capped, ESG and factors, all these variations are also designed with a typical investor in mind. Standard indexes usually address most of the objectives and constraints of investors, but often they may not be the perfect solution for all investors. As a result, many investors opt for customized indexes.

The customizations are often applied on a standard index methodology and can range from applying a simple security exclusion list (e.g. ESG-based exclusions) to implementing more sophisticated strategies (i.e. a customized multi-factor index). The construction, maintenance and governance of MSCI custom indexes follow the same principles as MSCI standard indexes. Like MSCI standard indexes, custom indexes follow transparent and rules-based methodologies.

The size and scale of GPFG puts it outside the typical-investor range. Therefore, a customized benchmark to fit the scale, constraints and objectives of the fund can be beneficial. The current GPFG benchmark is a custom index that applies exclusions as well as regional reweighting to a standard index. But customization can go beyond that to achieve more efficiency based on the fund's objectives.

For instance, the standard ACWI IMI is designed with the aim to cover the broadest investment universe across large-, mid- and small-cap stocks in developed and emerging markets. As such it holds c.99% of investable public equity universe which is about 8,800 securities as of Aug. 31, 2020. The weight of the smallest 2,300 securities in the index only adds up to 1%, and if we add up the weight of 3,400 smallest, it is only 2%. In other words, 40% of the securities make up only 2% of the weight.

While these small securities help broaden the investment universe and the opportunity set, which may be attractive to many investors, the cost of covering that large set of securities may not be justified for some. The analysis in the report done by MSCI for the Norwegian Ministry of Finance in 2019[11] showed that the historical contribution of these bottom small stocks to the risk/return characteristics of the index has been insignificant (Exhibit 1). Investors may consider lowering the size of

[11] Selected geographical issues in the global listed equity market: Analysis for the Norwegian Ministry of Finance. Oct 2019.

the universe by removing these securities in their custom index[12] and eliminating the cost of covering them.[13]

Exhibit 1: Comparison of Market Coverage Levels for Global Benchmarks[14]

	ACWI	ACWI IMI 90 PCT	ACWI IMI 95 PCT	ACWI IMI 97 PCT	ACWI IMI 98 PCT	ACWI IMI
Total return*	7.40%	7.54%	7.55%	7.54%	7.53%	7.50%
Total risk	15.37%	15.35%	15.41%	15.44%	15.46%	15.50%
Return / risk	0.48	0.49	0.49	0.49	0.49	0.48
Tracking error	0	0.27%	0.50%	0.62%	0.69%	0.78%
Avg no of stocks**	2632	3490	5318	6650	7648	9418
Number of stocks***	2994	3169	4842	6077	7016	8766
Effective no of stocks**	430	469	521	543	554	568
ATVR***	187.8%	183.4%	189.7%	213.7%	214.7%	216.8%
Gini Coefficient***	0.63	0.6	0.62	0.63	0.64	0.66

Period: Dec 30, 1994 to Sep 30, 2020. * Gross returns annualized in USD ** Monthly averages *** As of September 30, 2020

Another consideration in creating most standard indexes is liquidity. One of the liquidity considerations is that funds can easily invest in (and divest from) an index-tracking portfolio. For instance, if the liquidity of the stock, its free float or foreign room changes, its weight may change in the index. This type of liquidity requirement may be less important for a long-term and buy and hold investor like the Norwegian Ministry of Finance and the trading cost associated with these types of adjustments may not be justified.

A custom index could be designed, within limits, to add or remove features to the index to optimize it for the investor's specific objectives and constraints.

Simulations

In this section we present a few simulated custom indexes (based on MSCI ACWI IMI) as examples of customization. The simulations focus on two dimensions of customization: 1) narrowing the index by eliminating the smallest stocks and 2) reducing the turnover in order to lower the cost of maintaining a tracking portfolio.

In practice, the MSCI index research and product development team will work closely with the client to design the index based on the objectives and constraints. This may involve a few iterations to achieve the optimal solution for the client.

[12] In the smaller universe where some of the smaller stocks are removed, their weight is redistributed on the remaining stocks in the universe. However, given the small total weight of stocks being removed (e.g. 2%), the impact on stock ownership percentage is insignificant and negligible.

[13] In addition, there may be some trading costs associated with rebalancing a narrower benchmark. Please see the analysis in Appendix II.

[14] Average number of stocks is the average number of the index constituents using monthly data and over the period of analysis. The effective number of stocks is a measure of index concentration and ranges between 1 (for an index with just one stock in it) and the number of stocks in the index (for an equal-weighted index). It is calculated as the inverse of the Herfindahl-Hirschman Index (HHI). Effective number of stocks = 1/ (sum of weight-squared)

A simple Change to the Benchmark

In the first set of simulations we simply cut the bottom 2% of the ACWI IMI Index reducing the coverage of the global investible equity universe from 99% to about 97%. Here to maintain the country weight balance close to ACWI IMI, the 97% selection is applied to each individual country.[15] This will be our base case scenario.

To eliminate churning and unnecessary turnover during regular rebalancing, most indexes incorporate buffers. These buffers help avoid stocks in the boundary (smaller stocks) getting in and out of the index with small changes in their market cap. Case 1 and case 2, apply buffers of 1% and 2%, respectively on the base case (target 97%). A buffer of 1% means that in each rebalance, the top 96% of market cap is included in the index, for the securities between the 96% and 98%, only those which have already been in the index stay in the index. Finally, additional securities are added to reach the target 97% coverage of the investable equity universe.

Exhibit 2 shows the key metrics for these three cases. For comparison, we have included the standard MSCI ACWI IMI (first column) and an equivalent of the MSCI ACWI IMI re-created in the simulation environment.[16] As we can see, over the period of analysis, the risk/return characteristics remained the same across all the indexes. As expected, the number of stocks went down as we moved from the MSCI ACWI IMI with 99% coverage to the 97% coverage cases. The turnover for the simple base case 97% where no buffer was applied was higher than ACWI IMI (4% vs. 3.2%), but as soon as we applied the buffers, the turnover reduced to 3.1% and 3% for cases 1 and 2, respectively.

[15] Entire Europe is considered as one country, in line with the GIMI methodology.

[16] This simulated index is created to make the comparisons between custom indexes and the standard index more apple to apple. While all simulated indexes are calculated using the same process as for the live indexes, some daily corporate actions are only applied on the rebalance dates for the simulated index, while in live indexes, these are applied on the daily basis. This may create some minor difference as we can see in the exhibit. This minor difference usually does not affect risk/return characteristics but may have some small impact on the turnover and number of stocks.

Exhibit 2: Simple 97% Coverage Custom Index: Key Metrics

Key Metrics

	MSCI ACWI IMI Index	ACWI IMI Sim*	Base case (97%)	Case 1 (1% buffer)	Case 2 (2% buffer)
Total Return* (%)	5.3	5.3	5.3	5.3	5.3
Total Risk (%)	16.6	16.6	16.5	16.5	16.5
Sharpe Ratio	0.27	0.27	0.27	0.27	0.27
Tracking Error (%)	0.0	0.0	0.2	0.2	0.1
Historical Beta	1.00	1.00	0.99	1.00	1.00
No of Stocks***	8661	8653	6348	6347	6409
Turnover** (%)	2.9	3.2	4.0	3.1	3.0

Period: 30-May-2008 to 28-Feb-2020

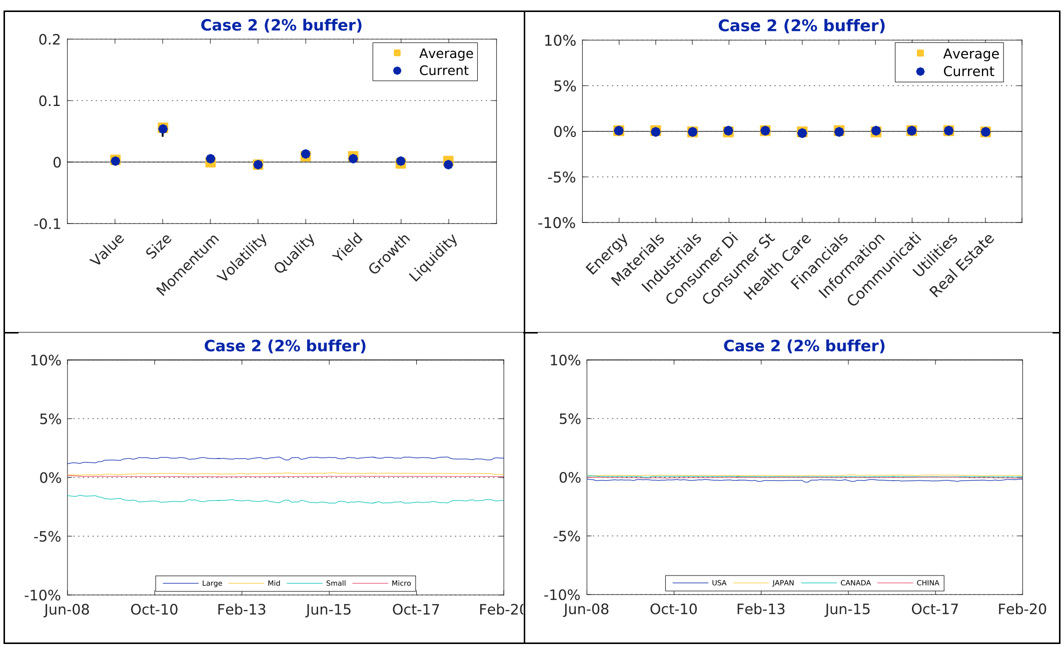
* Gross returns annualized in USD

** Annualized one-way index turnover over index reviews

*** Monthly averages

Exhibit 3 shows the differences between the 97% custom index and the standard ACWI IMI. Here we are comparing the case 2 index with the standard ACWI IMI. There were no notable sector or country differences. In terms of style, we saw a minimal large-cap bias in the custom index which is intuitive since we are eliminating stocks from the smaller side. The base case and case 1 showed similar results.

Exhibit 3: Simple 97% Coverage Custom Index: Style/Sector/Country/Size Biases



An Extreme Case – Benchmark for a Buy and Hold Investor

If the only consideration in customization were to minimize the turnover and the cost associated with it, additions, deletions and weight changes in the index could be limited to the minimum necessary. The minimum necessary in this case is deletions due to stocks being eliminated from the investible universe (due to bankruptcy, M&A, etc.). We simulate two indexes based on this assumption. In both cases, once a stock is in the index, it only gets deleted if it is no longer in the investible universe.

In case 3 (the most extreme case), if there is no deletion, then there is no rebalance. If there are deletions, then stocks in the top 95% of the investible universe that are currently not present in the index will be added. The total weight of the additions will be equal to the total weight of the deletions. Therefore, no weight adjustment will be applied to the rest of the stocks in the index.

In case 4, any stocks in the top 85% of the investable universe (large- and mid-cap stocks) that are currently not in the index will be added. The rules for deletions and additions between 85% and 95% follow the rules of case 3.

Exhibit 4 presents key metrics for these two extreme cases and compares them with the base case and the ACWI IMI. These extreme rules have some small impact on risk/return characteristics of the index. But what's notable is the turnover of these two indexes. The turnover for the most extreme, case 3, goes down to 0.3% (compared to 4% for the base case) and to 0.8% for case 4.

The methodology achieves what it aims to which is minimizing turnover. This, however, comes with relatively severe compromises in other metrics (Exhibit 5). While there are some active exposure to style factors, what is striking is the gradual increase in size and country biases for this index. The static nature of these extreme buy-and-hold cases also has a large impact on capacity of the index, as shown in Exhibit 6. Maximum stock ownership as the percentage of full market cap and free float market cap are as high as 7.9% and 9.6% respectively. And the index can significantly deviate from the ACWI IMI in terms of active share.

Exhibit 4:Extreme case for a Buy and Hold Investor: Key Metrics

Key Metrics

	MSCI ACWI IMI Index	ACWI IMI Sim*	Base case (97%)	Case 3 (Extreme Buy and Hold)	Case 4 (Extreme Buy and Hold)
Total Return* (%)	5.3	5.3	5.3	5.6	5.6
Total Risk (%)	16.6	16.6	16.5	16.4	16.4
Sharpe Ratio	0.27	0.27	0.27	0.29	0.29
Tracking Error (%)	0.0	0.0	0.2	0.6	0.5
Historical Beta	1.00	1.00	0.99	0.99	0.99
No of Stocks***	8661	8653	6348	6024	6024
Turnover** (%)	2.9	3.2	4.0	0.3	0.8

Period: 30-May-2008 to 28-Feb-2020

* Gross returns annualized in USD

** Annualized one-way index turnover over index reviews

*** Monthly averages

Exhibit 5: Extreme case for a Buy and Hold Investor: Style/Sector/Country/Size Biases

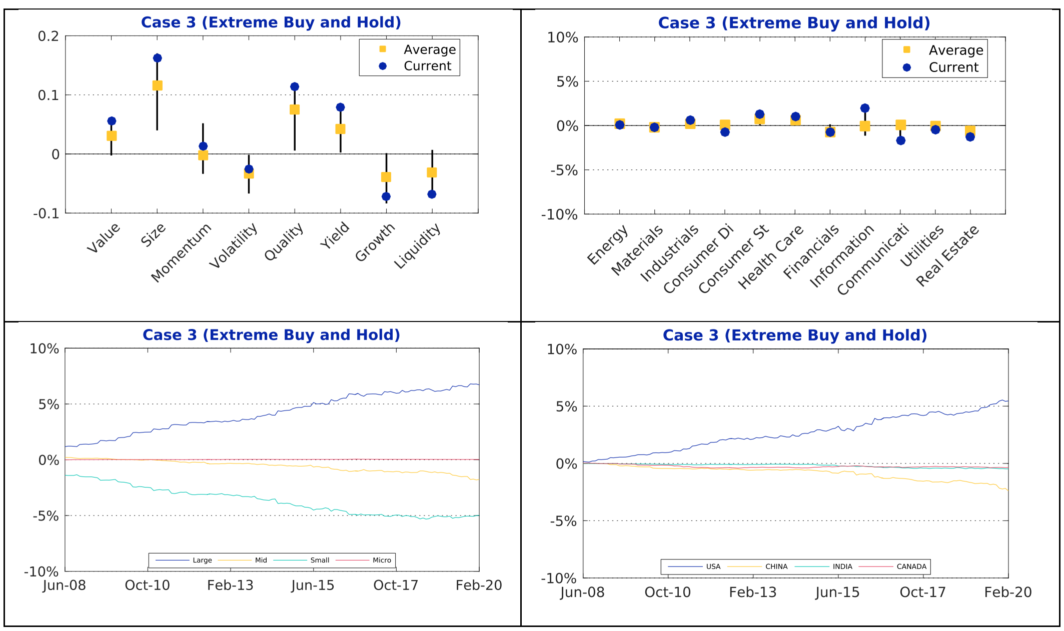


Exhibit 6: Extreme case for a Buy and Hold Investor: Capacity and Concentration Metrics

Capacity & Concentration Metrics	MSCI ACWI IMI Index	ACWI IMI Sim	Base case (97%)	Case 1 (1% buffer)	Case 2 (2% buffer)	Case 3 (Extreme Buy and Hold)	Case 4 (Extreme Buy and Hold)
Concentration*							
Avg No of Stocks	8661	8653	6348	6347	6409	6024	6024
Effective No of Stocks	566	565	543	542	541	452	476
Parent Index Coverage (%)	100.0	99.9	97.8	97.8	97.7	97.9	97.9
Top 10 Sec Wt (%)	8.0	8.0	8.1	8.1	8.1	9.2	8.9
Size Family Exposures**							
Large (%)	72.3	72.3	73.8	73.8	73.9	76.5	75.9
Mid (%)	14.7	14.7	15.0	15.0	15.0	14.1	14.4
Small (%)	13.0	13.0	11.2	11.1	11.0	9.4	9.7
Micro (%)	0.0	0.0	0.1	0.1	0.1	0.0	0.0
Capacity of the Index***							
Stock Ownership (% of Float Market Cap)							
Average	1.22	1.22	1.26	1.26	1.27	0.96	1.01
95th percentile	1.25	1.25	1.28	1.28	1.28	1.92	1.84
Maximum	1.25	1.25	1.28	1.28	1.28	7.68	9.63
Stock Ownership (% of Full Market Cap)							
Average	0.85	0.86	0.90	0.91	0.91	0.74	0.77
95th percentile	1.25	1.25	1.28	1.28	1.28	1.68	1.60
Maximum	1.25	1.25	1.28	1.28	1.28	3.84	7.92
Degree of Index Tilt*							
Active Share (%)	0.0	0.1	2.2	2.2	2.3	11.1	8.9
Avg Weight Multiplier	1.0	1.0	1.0	1.0	1.0	0.9	0.9
Max Weight Multiplier	1.0	1.0	1.0	1.0	1.0	4.9	6.9
Max Strategy Weight (%)	1.5	1.5	1.6	1.6	1.6	1.9	1.8

* Monthly average

** Monthly average, size family data available from June 2008

*** Assuming a fund size of USD 700.0 bn as of the latest index review

Solution Is Likely Somewhere In-between

Cases 1 to 4 above showed a range of customization: the impact was minimal in cases 1 and 2 and extreme for cases 3 and 4. The ideal solution could be somewhere in-between and as we discussed before, would require clear guidance from the client. In this section, we present three additional cases which fit between the two extremes we saw in previous sections. In all these cases we continue to focus on reducing the turnover of the index.

For simplicity, in the following simulations we implement the customization on ACWI IMI rather than the 97% case. For the initial construction (index inception), the custom index is the same as the MSCI ACWI IMI. For the ongoing rebalances:

Case 5: Focusing the turnover on large caps

- The weights of mid-and small-cap stocks are kept unchanged.
- Large-cap stock weights are adjusted to balance additions/deletions.

Case 6: Focusing the turnover on the top 10% largest stocks with country weight balance

- For each country, find the securities in the top decile by weight (call this group A).

- The weight of securities outside group A for each country are unchanged.
- For each country, the weight of group A is adjusted to account for additions/deletions and to keep the weight of the country in the custom index in line with its weight in the standard ACWI IMI.

Exhibit 7 shows the result of simulations for these two cases. The two approaches achieve some savings in terms of turnover (2.4% and 1.9%) compared to the 3.2% of the standard index. The savings sits somewhere between the two ends of extremes we saw in previous sections. The exposure charts in Exhibit 8 also show mild deviation from the standard ACWI IMI.

Exhibit 7: Low-Turnover Custom ACWI IMI: Key Metrics

Key Metrics

	MSCI ACWI IMI Index	ACWI IMI Sim	Case 5 (Trade Only Large CAP)	Case 6 (Trade Only Top 10%)
Total Return* (%)	5.3	5.3	5.3	5.2
Total Risk (%)	16.6	16.6	16.6	16.5
Return/Risk	0.32	0.32	0.32	0.31
Sharpe Ratio	0.27	0.27	0.27	0.27
Active Return (%)	0.0	0.0	0.1	-0.1
Tracking Error (%)	0.0	0.0	0.1	0.4
Information Ratio	NaN	0.63	0.80	-0.12
Historical Beta	1.00	1.00	1.00	1.00
No of Stocks***	8661	8653	9237	9237
Turnover** (%)	2.9	3.2	2.4	1.9
Price To Book***	1.9	1.9	1.9	1.9
Price to Earnings***	17.4	17.4	17.4	17.3
Dividend Yield*** (%)	2.6	2.6	2.5	2.6

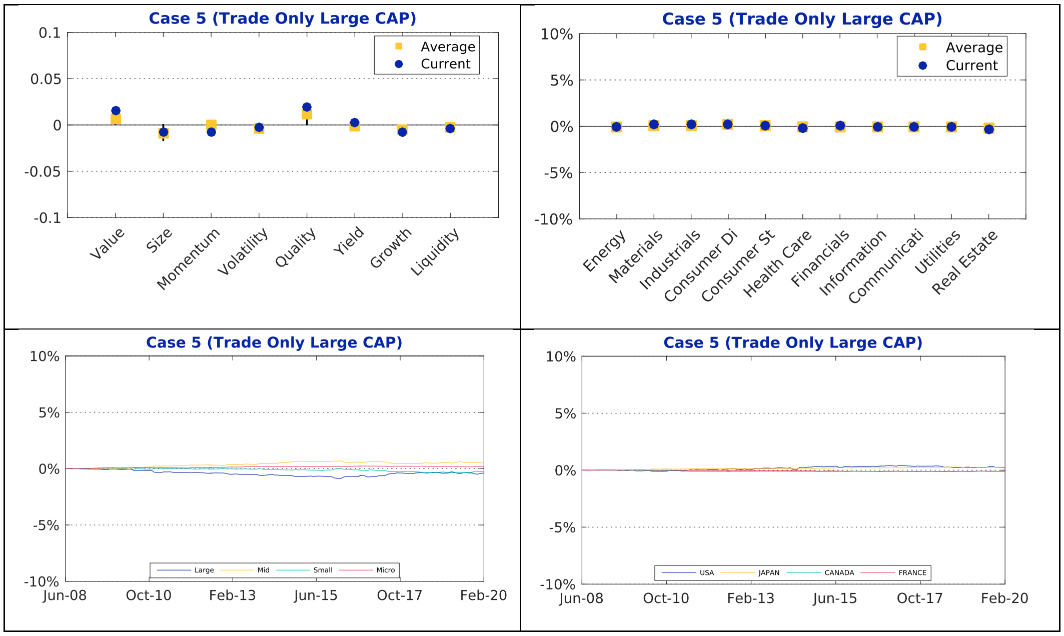
Period: 30-May-2008 to 28-Feb-2020

* Gross returns annualized in USD

** Annualized one-way index turnover over index reviews

*** Monthly averages

Exhibit 8: Custom Indexes with a Focus on Turnover: Style/Sector/Country/Size Biases



An Optimized Index to Understand the Limits

While optimization techniques are often used to create standard and custom indexes, use of optimization in this case may be a bit extreme. That said, the flexibility of optimization can help us understand what is achievable and what are the limits. Within an optimization framework we can explicitly specify our objectives and constraints and use the solution as the north star when developing a simpler non-optimized methodology.

As the last set of simulations, case 7, we use optimization to create a custom index. The focus remains reducing turnover and the optimization is set up as:

Case 7: A simple optimization set up

- For initial construction we take the standard ACWI IMI
- Ongoing rebalances
    - Objective: minimize tracking error to the standard ACWI IMI
    - Subject to:
        - Country and sector weights the same as ACWI IMI
        - (Weight in ACWI IMI) x 0.5 ≤ weight of each stock ≤ (weight in ACWI IMI) x 2.0

- (Weight in ACWI IMI) - 0.1% ≤ weight of each stock ≤ (weight in ACWI IMI) + 0.1%
- Turnover ≤ 1% (This is a soft constraint, which means, it is relaxed if the optimizer cannot find a feasible solution within this limit.)

Key metrics of the optimized index are compared to the standard ACWI IMI in Exhibit 9. The customized index closely tracks the standard index with a tracking error of 10 basis points (bps) and has similar risk/return characteristics to the standard index. Because of the explicit constraints on stock weights, the custom index also has the same number of constituents as the standard index. The sector and country constraints also mean there is no significant or permanent active exposures (Exhibit 10). The style exposures are also negligible, but the index, gradually and over time has developed a large cap bias.

Exhibit 11 shows the capacity and concentration metrics for the optimized index and also cases 5 and 6 from the previous section. The explicit constraints applied in the optimization are reflected in the results. The maximum ownership as a percentage of full market cap is at 2.5%, which is twice as high as the standard index. This is governed by the constraint on weight of each security to be, at most, twice the weight of the security in the parent index. There is a +/- 0.1% limit on the active weight of each security which has resulted in the maximum weight in the optimized index being in line with the standard ACWI IMI at 1.5%.

Exhibit 9: Optimized Custom Index: Key Metrics

Key Metrics

	MSCI ACWI IMI Index	ACWI IMI Sim	Case7 (Optimized)
Total Return* (%)	5.3	5.3	5.3
Total Risk (%)	16.6	16.6	16.6
Return/Risk	0.32	0.32	0.32
Sharpe Ratio	0.27	0.27	0.27
Active Return (%)	0.0	0.0	0.1
Tracking Error (%)	0.0	0.0	0.1
Information Ratio	NaN	0.63	0.51
Historical Beta	1.00	1.00	1.00
No of Stocks***	8661	8653	8653
Turnover** (%)	2.9	3.2	1.7
Price To Book***	1.9	1.9	1.9
Price to Earnings***	17.4	17.4	17.2
Dividend Yield*** (%)	2.6	2.6	2.6

Period: 30-May-2008 to 28-Feb-2020

* Gross returns annualized in USD

** Annualized one-way index turnover over index reviews

*** Monthly averages

Exhibit 10: Optimized Custom Index: Style/Sector/Country/Size Biases

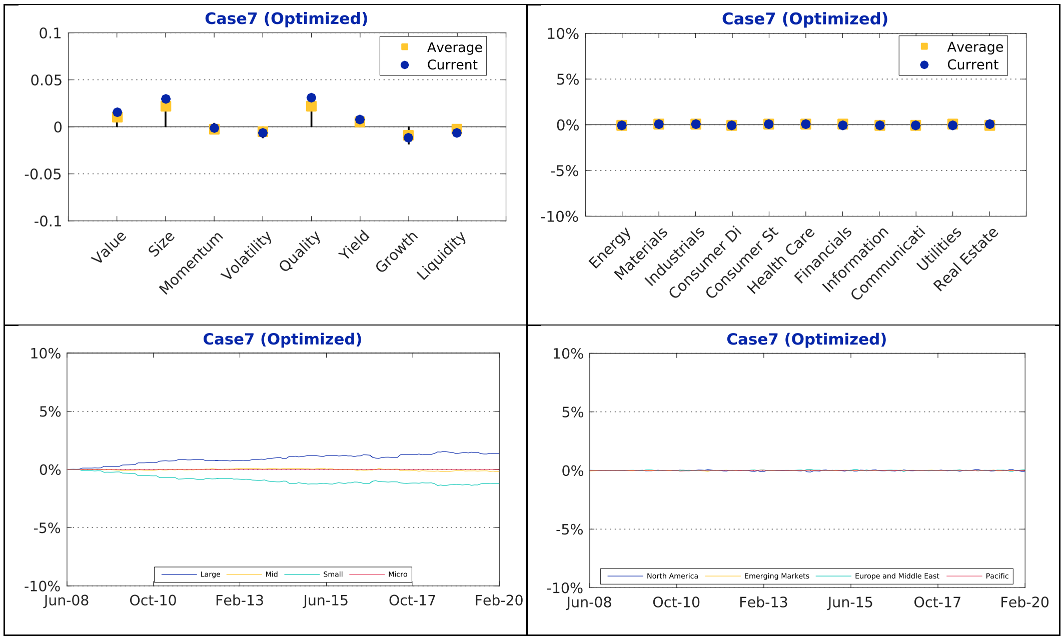


Exhibit 11: Cases 5-7: Capacity and Concentration Metrics

Capacity & Concentration Metrics

	MSCI ACWI IMI Index	ACWI IMI Sim	Case 5 (Trade Only Large CAP)	Case 6 (Trade Only Top 10%)	Case7 (Optimized)
Concentration*					
Avg No of Stocks	8661	8653	9237	9237	8653
Effective No of Stocks	566	565	571	682	555
Parent Index Coverage (%)	100.0	99.9	99.9	99.9	99.9
Top 10 Sec Wt (%)	8.0	8.0	7.9	6.1	8.0
Size Family Exposures**					
Large (%)	72.3	72.3	71.9	72.4	73.2
Mid (%)	14.7	14.7	15.1	15.0	14.6
Small (%)	13.0	13.0	12.9	12.5	12.1
Micro (%)	0.0	0.0	0.1	0.1	0.0
Capacity of the Index***					
Stock Ownership (% of Float Market Cap)					
Average	1.22	1.22	1.21	1.16	1.14
95th percentile	1.25	1.25	1.79	2.00	2.50
Maximum	1.25	1.25	7.67	7.82	5.01
Stock Ownership (% of Full Market Cap)					
Average	0.85	0.86	0.84	0.80	0.79
95th percentile	1.25	1.25	1.45	1.61	1.63
Maximum	1.25	1.25	4.82	4.59	2.50
Degree of Index Tilt*					
Active Share (%)	0.0	0.1	2.1	9.3	5.2
Avg Weight Multiplier	1.0	1.0	1.0	1.0	0.9
Max Weight Multiplier	1.0	1.0	4.5	4.9	2.1
Max Strategy Weight (%)	1.5	1.5	1.5	0.9	1.5

* Monthly average

** Monthly average, size family data available from June 2008

*** Assuming a fund size of USD 700.0 bn as of the latest index review

The analysis in this section showed that there were possibilities to decrease the size of universe without having a significant impact on the risk/return characteristics of the index. We also showed that turnover and therefore the cost associated with it could be lowered, however there were trade-offs that needed to be balanced.

GPFG Transition to an MSCI Benchmark

The objective of this section is to analyze the potential cost of switching GPFG's current benchmark to an MSCI benchmark. We first compare the current benchmark, the MSCI benchmark and the portfolio that GPFG holds to highlight their differences and the potential impact on cost of switching. This will be followed by a set of cost estimate analysis for the benchmark switch. We will show that while a naïve transition could be costly and prohibitive, the cost can be significantly reduced by transitioning over a longer period. Additional techniques are presented that can be used to further reduce the cost of the benchmark switch. The analysis in this section, unless otherwise mentioned, are based on the data as of Sept. 30, 2019, provided to MSCI by the Norwegian Ministry of Finance. This includes the GPFG portfolio and the current benchmark. The MSCI indexes and the liquidity model used in the analysis are also based on the same date.

Overview of Current Benchmark and GPFG's Portfolio

Current Benchmark

Current GPFG's benchmark is a global market-cap-based index with several exclusions and a regional over/underweight overlay. The index includes both emerging markets and developed markets (DM) and covers size ranges from large caps to small caps. As of Sept. 30, 2019, the index had 8,814 constituents covering 47 countries. A breakdown is shown in Exhibit 12.

An MSCI Equivalent Benchmark

For the purpose of the analysis and to measure the cost of switch from the current benchmark to an MSCI benchmark, we created a custom index based on MSCI ACWI IMI (EM and DM, large, mid and small caps) as of Sept. 30, 2019, and applied the exclusion and weighting overlay provided by the Norwegian Ministry of Finance. The custom index includes 8,687 securities. A country breakdown of the MSCI index is presented in Exhibit 12.

Exhibit 12:Comparing Current Benchmark, MSCI Benchmark and GPFG Portfolio: Country Weights

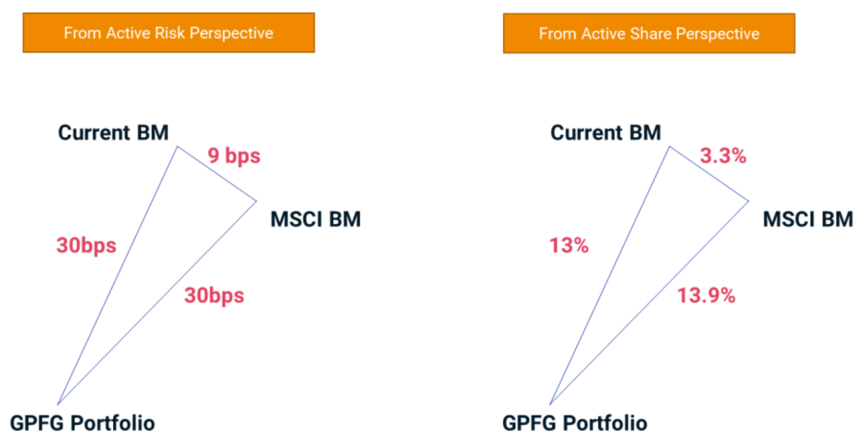
Country	Current BM	MSCI BM	GPFG Portfolio	Current BM - MSCI BM	GPFG Portfolio - Current BM	GPFG Portfolio - MSCI BM
ARGENTINA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AUSTRALIA	2.4%	2.3%	2.1%	**0.1%**	**-0.3%**	**-0.2%**
AUSTRIA	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%
BELGIUM	0.6%	0.7%	0.7%	0.0%	0.0%	0.0%
BRAZIL	1.0%	0.9%	0.9%	0.0%	0.0%	0.0%
CANADA	2.3%	2.3%	2.3%	0.0%	0.0%	0.1%
CHILE	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
CHINA	3.7%	3.6%	3.9%	**0.1%**	**0.2%**	**0.3%**
COLOMBIA	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%
CZECH REPUBLIC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DENMARK	0.9%	1.0%	0.9%	0.0%	0.0%	0.0%
EGYPT	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
FINLAND	0.7%	0.6%	0.7%	0.1%	0.0%	0.1%
FRANCE	5.4%	5.6%	5.1%	**-0.2%**	**-0.3%**	**-0.5%**
GERMANY	4.5%	4.4%	4.6%	0.0%	0.1%	0.2%
GREECE	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
HONG KONG	1.2%	1.1%	1.2%	0.1%	0.0%	0.1%
HUNGARY	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
INDIA	1.2%	1.2%	1.2%	0.1%	0.0%	0.0%
INDONESIA	0.3%	0.3%	0.2%	0.0%	0.0%	0.0%
IRELAND	0.1%	0.3%	0.1%	**-0.2%**	**0.0%**	**-0.2%**
ISRAEL	0.2%	0.2%	0.2%	-0.1%	0.0%	-0.1%
ITALY	1.4%	1.4%	1.4%	0.0%	0.0%	0.0%
JAPAN	8.3%	8.4%	8.7%	**0.0%**	**0.3%**	**0.3%**
KOREA	1.5%	1.5%	1.5%	0.0%	0.0%	0.0%
KUWAIT	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
MALAYSIA	0.3%	0.3%	0.3%	0.0%	0.0%	0.0%
MEXICO	0.3%	0.3%	0.3%	0.0%	0.0%	0.0%
NETHERLANDS	2.0%	2.1%	1.9%	-0.1%	0.0%	-0.1%
NEW ZEALAND	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
NORWAY	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PAKISTAN	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PERU	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PHILIPPINES	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
POLAND	0.2%	0.1%	0.2%	0.1%	0.0%	0.1%
PORTUGAL	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
QATAR	0.1%	0.1%	0.0%	0.0%	-0.1%	-0.1%
RUSSIA	0.5%	0.4%	0.4%	0.0%	0.0%	0.0%
SAUDI ARABIA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SINGAPORE	0.4%	0.4%	0.5%	0.0%	0.0%	0.0%
SOUTH AFRICA	0.6%	0.6%	0.6%	0.0%	0.0%	0.0%
SPAIN	1.5%	1.5%	1.6%	0.0%	0.1%	0.1%
SWEDEN	1.6%	1.6%	1.5%	-0.1%	0.0%	-0.1%
SWITZERLAND	4.7%	4.8%	4.7%	-0.1%	0.0%	0.0%
TAIWAN	1.6%	1.5%	1.7%	0.1%	0.1%	0.1%
THAILAND	0.4%	0.4%	0.4%	0.1%	0.0%	0.0%
TURKEY	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
UNITED ARAB EMIRATES	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
UNITED KINGDOM	9.1%	9.0%	8.6%	**0.0%**	**-0.5%**	**-0.5%**
USA	40.0%	40.1%	40.0%	-0.1%	0.1%	-0.1%
Sum	**100.0%**	**100.0%**	**99.8%**			

GPFG Portfolio Vs. Current and MSCI Benchmark

Exhibit 12 compares the two benchmarks to the GPFG's portfolio. The two benchmarks cover the same countries and have 7,131 securities in common. The portfolio comprises 9,741 securities which includes stock in and outside of the benchmark (e.g. includes some frontier markets).

In terms of active share, the difference between the two benchmarks is about 3.3%[17] and in terms of active risk[18] it is about 9 bps. The GPFG portfolio tracks the current benchmark with an active share of c.13% and active risk of 30 bps (Exhibit 13). The difference between the GPFG portfolio and the MSCI index in terms of active share and active risk are 13.9% and 30 bps, respectively which is similar to the difference between the GPFG portfolio and the current benchmark.

Exhibit 13: Comparing Current Benchmark, MSCI Benchmark and GPFG Portfolio: Active Share and Active Risk (TE)



The similar difference between the GPFG portfolio to each of the benchmarks suggests that if the benchmark was switched to the MSCI benchmark, the active share and active risk of the portfolio relative to its benchmark would not be significantly impacted. While in aggregate, the active risk of the GPFG portfolio to both benchmarks are the same, the sources contributing to active risk are slightly different when the portfolio is measured against the current benchmark vs. the MSCI benchmark.

[17] A small portion of this difference is due to use of different listings of the same company in the current benchmark vs MSCI BM.

[18] Estimated active risk or tracking error (TE) using MSCI Global Equity Model for Long Term Investment (GEMLT)

Exhibit 14 breaks down the active risk to its components. Countries, styles and stock specific risks, in aggregate, contributed to the 9 bps of active risk between the MSCI benchmark and current benchmark. The majority of risk came from country allocation while styles and industry differences were quite small. Comparing the GPFG portfolio to each of the benchmarks, the 30 bps of active risk of the portfolio was attributed to industries, styles and stock specific risk.

Exhibit 15 compares the factor exposures of the GPFG portfolio and the two benchmarks. The active exposures were insignificant especially between the two benchmarks. This suggests style factors' potential impact on the relative performance of the two benchmarks was insignificant.

Exhibit 14: Comparing Current Benchmark, MSCI Benchmark and GPFG Portfolio: Sources of Active Risks

Risk Source	Current BM relative to MSCI BM	GPFG Portfolio relative to Current BM	GPFGPortfolio relative to MSCI BM
Total	**0.09%**	**0.30%**	**0.30%**
Local Excess	**0.09%**	**0.30%**	**0.30%**
Residual	**0.09%**	**0.30%**	**0.30%**
Common Factor	**0.07%**	**0.19%**	**0.19%**
Industry	**0.01%**	**0.08%**	**0.08%**
Risk Indices	**0.01%**	**0.09%**	**0.06%**
Beta	0.00%	0.02%	0.02%
Book-to-Price	0.00%	0.00%	0.00%
Dividend Yield	0.00%	0.00%	0.00%
Earnings Quality	0.00%	0.00%	0.00%
Earnings Variability	0.00%	0.00%	0.00%
Earnings Yield	0.00%	0.00%	0.00%
Growth	0.00%	0.00%	0.00%
Investment Quality	0.00%	0.00%	0.00%
Leverage	0.00%	0.00%	0.00%
Liquidity	0.00%	0.00%	0.00%
Long-Term Reversal	0.00%	0.00%	0.00%
Mid Capitalization	0.00%	0.00%	0.00%
Momentum	0.00%	0.01%	0.01%
Profitability	0.00%	0.00%	0.00%
Residual Volatility	0.00%	-0.01%	0.00%
Size	0.01%	0.05%	0.03%
Country	**0.05%**	**0.02%**	**0.05%**
Specific	**0.02%**	**0.11%**	**0.11%**
Currency	**0.01%**	**0.00%**	**0.00%**

Exhibit 15: Comparing Current Benchmark, MSCI Benchmark and GPFG Portfolio: Relative Factor Exposures

Risk Source	Current BM relative to MSCI BM	GPFG Portfolio relative to Current BM	GPFGPortfolio relative to MSCI BM
Beta	0.00	0.02	0.02
Book-to-Price	0.00	0.03	0.03
Dividend Yield	0.00	-0.02	-0.02
Earnings Quality	0.00	0.00	0.00
Earnings Variability	0.00	0.02	0.01
Earnings Yield	0.00	0.01	0.01
Grow th	0.00	0.01	0.00
Investment Quality	0.01	-0.02	-0.01
Leverage	0.00	-0.04	-0.04
Liquidity	0.00	0.01	0.00
Long-Term Reversal	0.00	0.00	0.01
Mid Capitalization	0.01	0.02	0.03
Momentum	0.00	-0.02	-0.02
Profitability	0.00	0.01	0.01
Residual Volatility	0.01	-0.01	-0.01
Size	0.02	-0.08	-0.06

Benchmark Switch

The difference between the current benchmark and the MSCI benchmark means that a tracking portfolio would need to be adjusted were it to switch benchmarks. In the case of GPFG, the portfolio tracks the benchmark with a tracking error of about 30 bps and the size of tracking error would not change if its benchmark changed to an MSCI benchmark.

In our analysis, however, we assume that the GPFG portfolio perfectly tracks the benchmark (zero tracking error) and therefore, if it switches from using the current benchmark to using the MSCI benchmark, the entire difference between the two benchmarks needs to be traded in the portfolio to maintain the zero tracking error between the portfolio and the new benchmark.

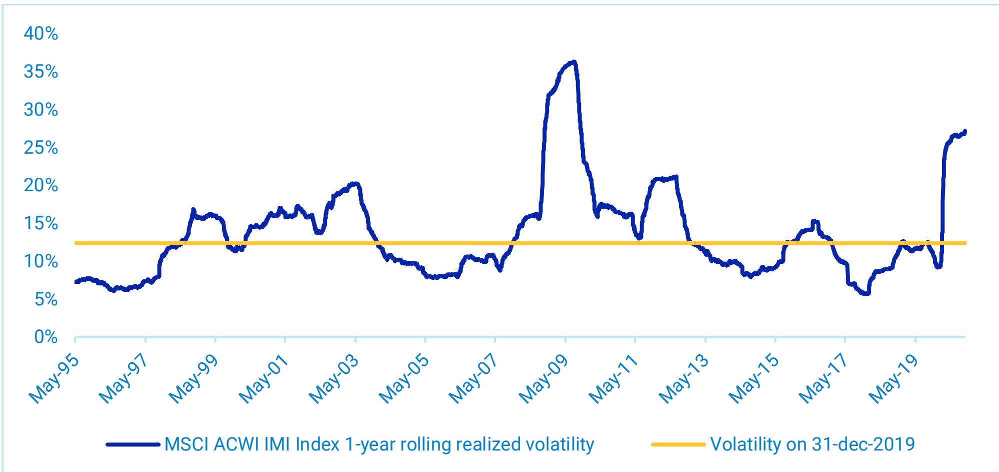
The perfect tracking assumption provides us with an upper bound on the cost of the benchmark switch. Given that there is a tracking error budget for the portfolio, benchmark transition can be optimized to minimize the cost while achieving the objectives of the GPFG portfolio and maintaining the target tracking error. We touch on using optimization to minimize the cost of transition at the end of this section. In practice, however, the optimization would be done by the manager with the objectives of the portfolio clearly defined in the optimization setup.

Cost Analysis Setup

For cost analysis we have assumed a portfolio size of USD 700 billion. Throughout this paper, the costs are presented in basis points of this total AUM. The cost estimates are based on the MSCI liquidity model that accounts for market impact.

The model is calibrated based on actual transaction costs data for each individual security provided by Virtu.[19] Benchmarks and liquidity models are based on data as of Sept. 30, 2019. This date represents a relatively normal market environment where volatility and liquidity levels are in-line with longer term averages (Exhibit 16).[20]

Exhibit 16: Historical volatility of MSCI ACWI IMI (1-Year Rolling Using Daily Returns)



A Naïve Transition Is Costly

The most naïve benchmark switch strategy is to trade the full difference between the two benchmarks (3.3%) in one day. Given the size of the portfolio, the trades may not be possible in just one day in practice, and even if possible, it would have a large

[19] MSCI LiquidityMetrics model constructs a liquidity surface based on Virtu Financials' estimates of average trading cost. MSCI LiquidityMetrics combines the extensive benefits of the Virtu liquidity model with the long term intuition that the trading cost should decline as the trading horizon increases. This model derives the marginal transaction cost curve, which measures the cost of trading the next unit, provided that a certain order size had been executed. In order to derive the marginal cost curve, the model performs two transformations on the Virtu's data. Firstly, MSCI LiquidityMetrics performs a quadratic optimization that calibrates the marginal cost curve that is monotonically increasing and the closest to the native Virtu cost curves. The marginal cost curve is required to be monotonically non-decreasing with increasing order size. This implies a higher traded volume brings a higher expected cost. Secondly, MSCI changes the long horizon behavior. MSCI LiquidityMetrics captures the well documented fact that the market impact cost of trading declines as time horizon increases. A longer period of execution implies less urgency and the ability by the manager to fragment the order into small trade sizes and by doing so, limit the market impact and reduce the cost.

In summary, the structure of the MSCI model is similar to the Virtu Financial model but it is calibrated (in a quadratic optimization) to closely match the Virtu model for short horizon and converge to half bid-ask spread for long horizon. The decaying function, which is a combination of a slow and fast decaying components is calibrated to minimize the difference between the estimates of Virtu model and MSCI model for the short horizon (first three days).

[20] For more discussion on liquidity over time please see MSCI Blog, "Alternative Views of Equity-Market Liquidity During Covid-19"

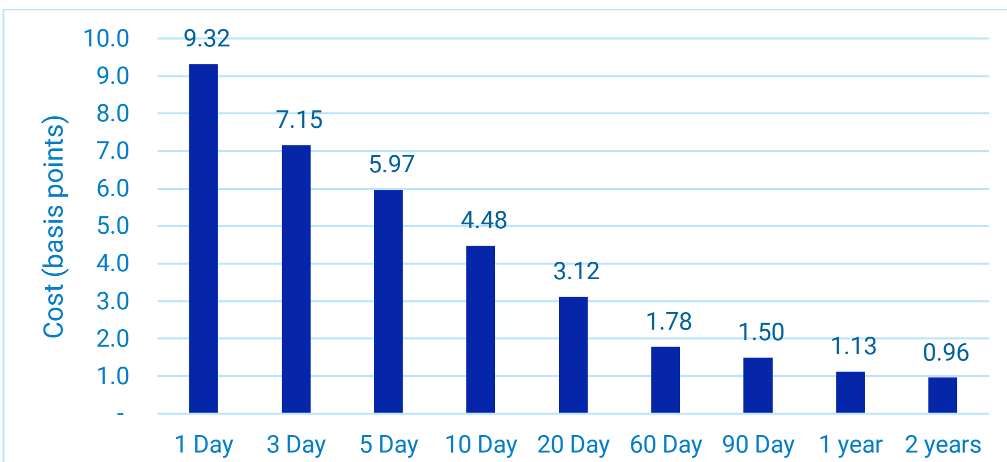
impact on the market and the transaction costs would be prohibitive. The total size of trades (spread over c. 8,000 securities) would be about USD 47billion, and the estimated cost of trading would be about 9.32 bps.

Spreading Trades Over Time Helps

Trades of this size, however, are seldom executed over just one day. Large trades are often spread over longer time periods, and the longer the period, the less stress it applies to the market and less market impact cost is incurred. As we increase the trade period, the market impact can disappear, and the cost could converge to the simple half of the bid/ask spread.

Exhibit 17 shows the estimated cost of the same trades for different time horizons. While the total size of the trade is the same for all points in this exhibit, the size of the trade on each day goes down as we increase the time horizon. As a result, the market impact and the total cost of transition goes down significantly. Based on these estimates, transitioning over two years resulted in a nearly 90% savings in the trading cost. Costs are presented as basis points of total assumed AUM of USD 700 billion.

Exhibit 17: Perfect Transition of the Full Portfolio Over Different Time Horizons



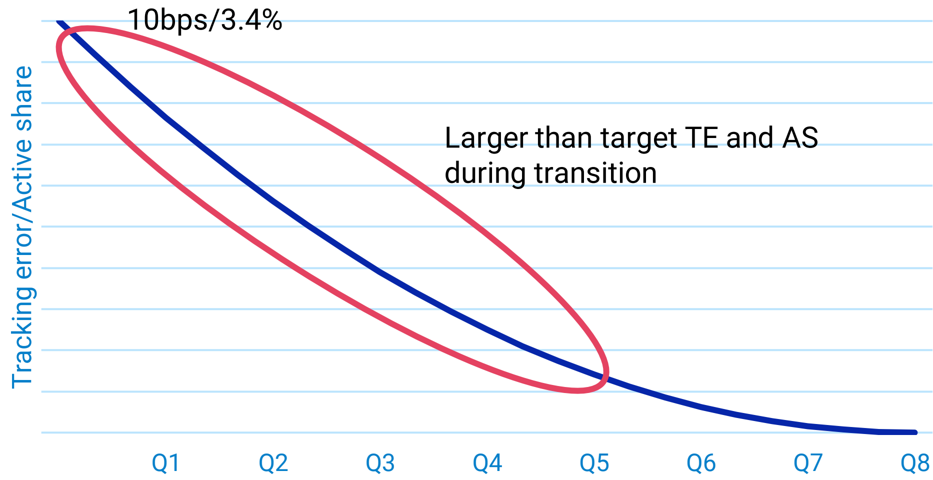
The costs do not include commissions. Tables with commissions included in the costs are presented in Appendix III.

While spreading the trades over one to two years is a sensible approach to reduce cost; over the period of transition the tracking error between the portfolio and the benchmark may be outside of the acceptable range. In this case, the starting tracking error is c.9 bps[21] and goes down to reach zero at the end of transition period. For our

[21] 9 bps is the difference between the current benchmark and the MSCI BM

hypothetical perfectly tracking portfolio, the tracking error budget may be considerably below 9 bps and therefore, the tracking portfolio would be breaching its target tracking error over this period (Exhibit 18).

Exhibit 18: The Tracking Error Between Portfolio and Benchmark Can Be Above the Acceptable Level in a One-Step Benchmark Switch



Managing Tracking Error over the Transition Period

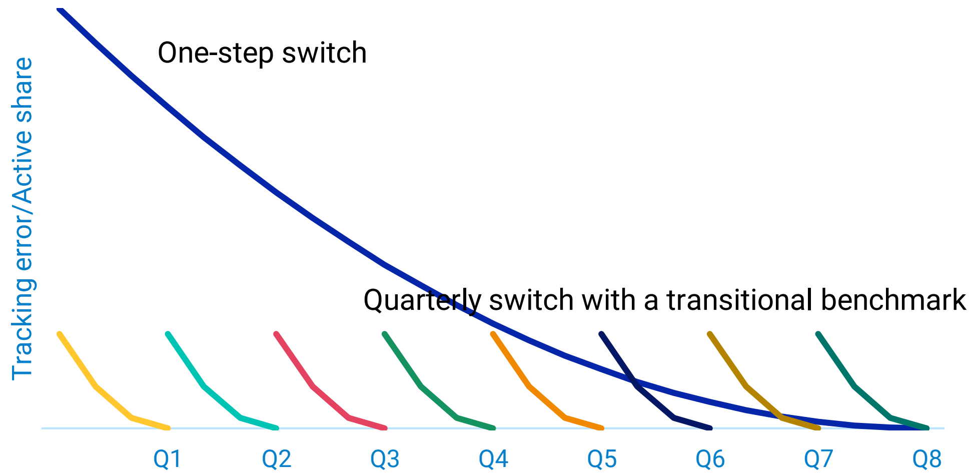
To achieve the benefits of spreading trades over longer periods and avoid higher than acceptable tracking error over this period, a transition benchmark can be used.

One simple approach is to break down the difference between the two benchmarks (e.g. 3.3%) into eight equal steps (e.g. 40 bps). The transition benchmark will initially be equal to the current benchmark and on each quarter will move1/8th = 12.5% (40 bps) closer to the MSCI benchmark. The GPFG portfolio will be tracking the transition benchmark over the period of transition.

The trades for each quarterly change are distributed over that quarter (i.e., 90 days) and at the end of each quarter the portfolio converges to the transition benchmark (zero tracking error). Given that each step is relatively small (1/8th of the total difference between the two benchmarks), the tracking error between the portfolio and transition benchmark will be much lower than the one-step switch discussed in previous section.

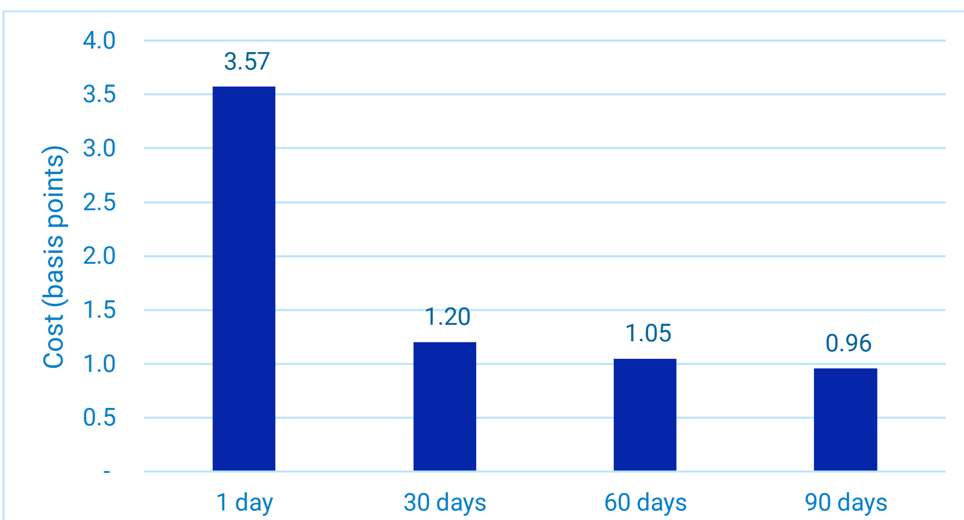
The transition benchmark will follow a similar process as any standard index, including being rules-based and transparent. Using the transition benchmark, over the transition period, the tracking portfolio remains close to the benchmark and within an acceptable tracking error range (Exhibit 19).

Exhibit 19: A Transition Benchmark Can Help Limit the Tracking Error During the Transition Period



All else being equal, using the transition benchmark over the transition period should not have a significant impact on the transaction cost. To confirm, we repeat the cost estimation calculation of the previous section for the quarterly transitions (using the transition benchmark) in Exhibit 20. As expected, the cost for the 90 days (spread over the full period of one quarter) is 0.96 bps, similar to the cost for the one-step transition over two years.

Exhibit 20: Estimated Cost of Transition - Using Quarterly Transitional Benchmark



Combining the Benchmark Switch with Other Benchmark Changes

Switching the benchmark could potentially be combined with other changes in the benchmark to reduce the marginal cost of the switch. For instance, if there is a desire (independent from benchmark switch) to change the weighting of a specific region in the benchmark, the regional adjustment and benchmark switch can be done simultaneously to potentially save some offsetting trades and eventually the overall cost.

To make it clear, suppose we intend to increase the weight of the U.S. market in the benchmark. One option is to do this in the current benchmark and then transition to the MSCI benchmark. Another option is to transition to MSCI benchmark and then re-adjust the U.S. weight. The third option is to transition to an MSCI benchmark with the adjusted weight for the U.S. The savings for the last scenario comes when there are offsetting trades.

Let's say a U.S. stock "A" has a weight of 2% in the current benchmark and 1.5% in the MSCI benchmark. Assume the U.S. weight adjustment means the weight of stock A becomes 2.2% in the current benchmark and 1.7% in the MSCI benchmark. In scenario one, first we need to add 0.2% of stock A to adjust the U.S. weight in the current benchmark (2% → 2.2%) and then for switching to MSCI, 0.5% of the same stock needs to be sold (2.2% → 1.7%). In scenario two, first 0.5% of the stock must be sold during the benchmark switch (2% → 1.5%) and then 0.2% added for the U.S. weight adjustment (1.5% → 1.7%).

In these first two scenarios, the total trade on stock A would be 0.7%. In the third and preferred case, only 0.3% of stock A needs to be sold (2% → 1.7%), which means a savings of 0.4 percentage point in the total trade size, or about 60%.

Combining Benchmark Transition with Regional Adjustment

The hypothetical example above highlights the potential benefits of combining a benchmark switch with a regional weight adjustment. The current benchmark and GPFG portfolio are underweight North America and overweight developed Europe. In the following analysis we assume there is an intention to increase the weight of North America by 5% and decrease the weight of developed Europe by the same amount. To show the marginal benefit of combining the benchmark switch and the regional weight adjustment, we have estimated two costs:

Cost 1: Switching from current benchmark to an MSCI benchmark with adjusted regional weights

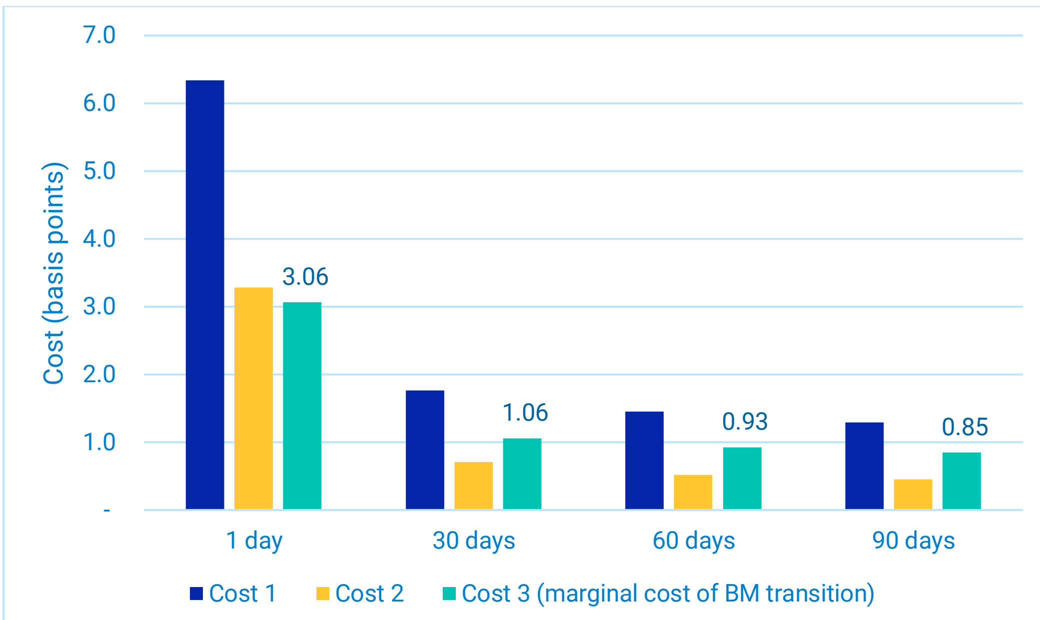
Cost 2: Adjusting the regional weight of the current benchmark

And from these two costs, the marginal cost of the benchmark switch can be calculated as:

Cost 3 = Cost 1 – Cost 2

Exhibit 21 shows these costs for the different time periods of transition. For the 90-day transition, the marginal cost of transition goes down to 0.85 bps, which is about 11% savings compared to the 0.96 bps cost of just the transition (Exhibit 20).

Exhibit 21: Estimated Marginal Cost of Transition



Combining Benchmark Transition with the Narrowing of the Benchmark

Previous research by MSCI for the Norwegian Ministry of Finance[22] showed that the contribution of the bottom 2% - 3% of stocks (in terms of weight) to the risk/return of the index has been insignificant over time. The number of stocks making up this 2% - 3%, however, has been quite large. For instance, in the current benchmark (as of

[22] Selected geographical issues in the global listed equity market: Analysis for the Norwegian Ministry of Finance. Oct 2019.

Sept. 30, 2019), the smallest stocks with a combined weight of 2% represented 40% of the benchmark in terms of the number of stocks.

For some investors, the potential benefits of holding these small stocks may not justify the cost of covering them. Also, removing very small stocks (narrower coverage) could potentially have a positive impact on the ongoing cost of index rebalances.[23]

In this section, we combine the switch to an MSCI benchmark with a benchmark regional weight adjustment (as previous section) and, at the same time, eliminate the bottom 2% of stocks (in terms of weight). To show the marginal cost of the benchmark switch using this approach we estimate two costs:

Cost 1: Switching from current benchmark to an MSCI benchmark with adjusted regional weights and the bottom 2% cut

Cost 2: Adjusting the regional weight and cutting the bottom 2% of the current benchmark

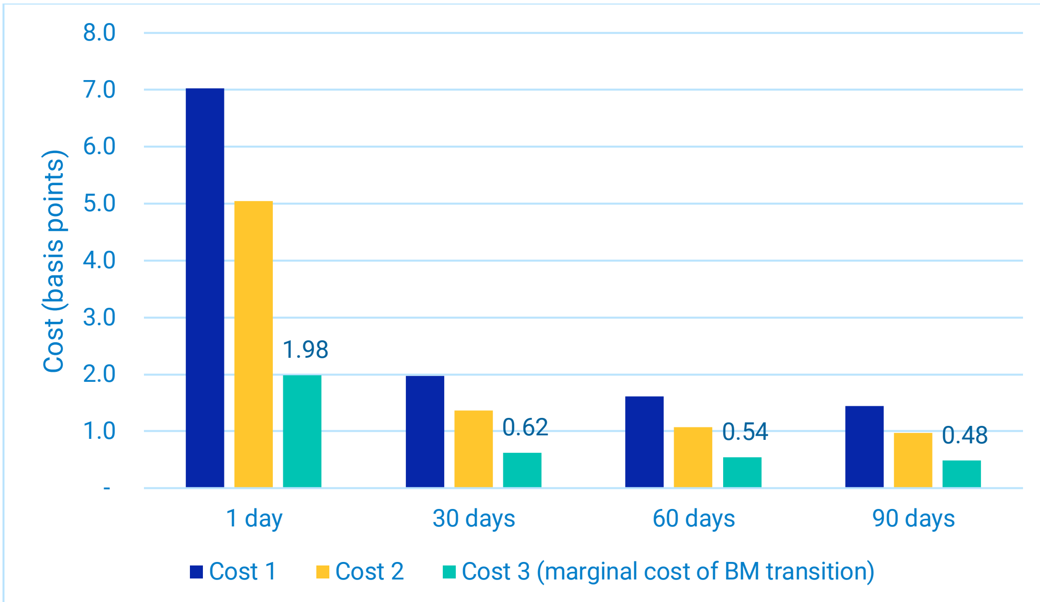
And from these two costs, the marginal cost of switching the benchmark can be calculated as:

Cost 3 = Cost 1 – Cost 2

Exhibit 22 shows the costs for the different time periods of transition. For the 90-day transition, the estimated marginal cost of transition goes down to 0.48 bps, which is about 50% savings compared to 0.96 (cost of only switching the benchmark).

[23] Smaller stocks may be less liquid and have higher transaction costs.

Exhibit 22: Estimated Marginal Cost of Transition – with Regional Adjustment/Narrower Benchmark



Use of Dividend to Offset Some of Transition Trades

In the index calculation, it is often assumed that dividends are used to purchase constituents of the index proportional to their weights. This means a tracking portfolio would have to reinvest the dividends on all constituents.

In the benchmark switch process, shares of some of the constituents are sold and some others are bought. If dividend reinvestment is combined with the benchmark switch, some of the selling due to the switch is offset with the dividend reinvestment and therefore the overall trades and the costs associated with them could be less than the sum of the cost of dividend reinvestment and a benchmark switch, if done separately.

In addition to dividends, the percentage of investment in equity vs. fixed income is regularly adjusted to keep their weights within a target range. Therefore, based on the relative performance of fixed income vs. equity, a fraction of fixed income investment may be liquidated and invested in equities or vice versa.

In our analysis we assume a 1.5% annual dividend yield and 1.5% fixed income/equity annual adjustment. This means over the period of two years (the period of benchmark transition), 6% cash is injected into the equity portfolio.[24] In order to estimate the marginal cost of transition, we calculate two costs as follows:

Cost 1: Transitioning to a regional-adjusted/narrow MSCI benchmark and a 6% cash investment

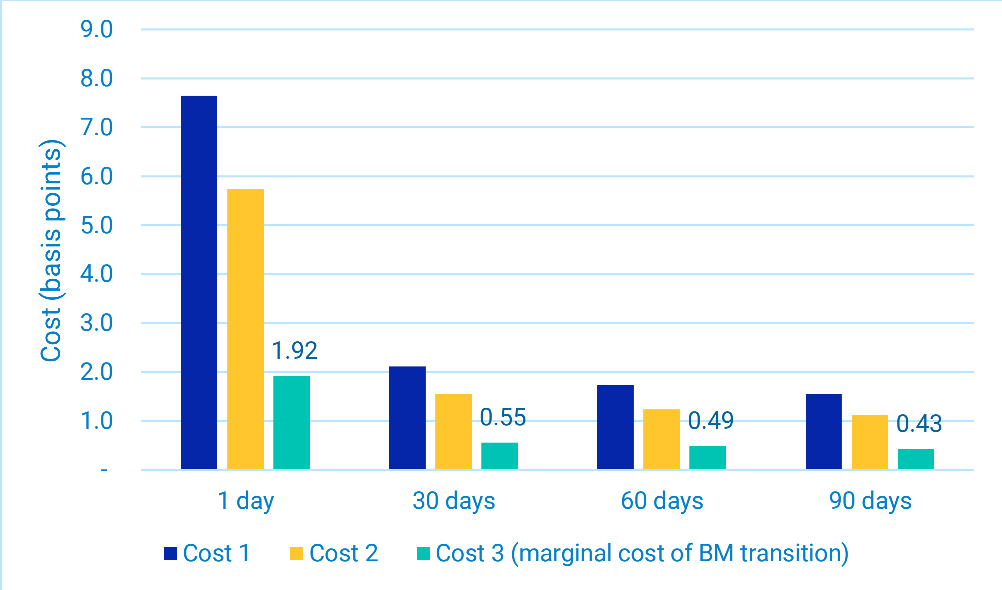
Cost 2: Adjusting regional weight/narrow index with a 6% cash investment (current benchmark)

And from these two costs, the marginal cost of the benchmark switch can be calculated as:

Cost 3 = Cost 1 – Cost 2

Exhibit 23 shows the estimated costs for the different time periods of transition. For the 90-day transition the estimated marginal cost of the benchmark switch comes down to 0.43 bps, which is about a 55% savings compared to 0.96 bps (cost of only switching the benchmark).

Exhibit 23: Estimated Marginal Cost of Transition - Regional Adjustment/Narrower Benchmark / Dividend Reinvestment



The above analysis showed that the costs associated with the benchmark switch could have been significantly reduced if the switch were combined with other intended changes in the benchmark, such as adjustment of regional weights. The

[24] Here we are reducing holdings in FI and increasing investment in equities. Without the FI/equity adjustment, the impact on cost would only come from dividend yield and therefore at a smaller scale.

analysis also showed that multiple changes in the benchmark could be combined to further reduce the marginal cost associated with a switch to the MSCI benchmark.

Giving Context to the Benchmark Switch Cost

To put the benchmark transition costs into perspective, we use the same model to estimate the cost of trading the changes in the index due to regular quarterly rebalance of the benchmark. We use turnover of the MSCI ACWI IMI over a 3-year period for our cost estimates. Exhibit 24 shows the turnover of the index for each quarterly rebalance over the years 2017 to 2019 and the estimated costs based on a USD 700 billion portfolio.

The turnover and the costs associated with them change over time. Over this period, the average quarterly turnover of the index was around 0.65%. For comparison, the quarterly turnover for the benchmark switch (for a transition over two years) was about 0.4%. In terms of cost, average annual cost for the natural turnover of a portfolio tracking the index (using a 90-day horizon) was about 67 bps.

Exhibit 24: Estimated Cost of Natural Quarterly Turnover of MSCI ACWI IMI index

		Transaction Costs (bps)		
Rebalancing Dates	Turnover	30 Days	60 Days	90 Days
20191126	0.79%	0.32	0.23	0.20
20190827	0.47%	0.19	0.13	0.11
20190528	1.32%	0.64	0.46	0.40
20190228	0.41%	0.13	0.09	0.07
20181130	0.55%	0.41	0.30	0.25
20180831	0.33%	0.07	0.05	0.05
20180531	1.17%	0.83	0.59	0.50
20180228	0.27%	0.04	0.03	0.02
20171130	0.60%	0.25	0.17	0.14
20170831	0.42%	0.10	0.06	0.04
20170531	1.02%	0.36	0.24	0.19
20170228	0.38%	0.06	0.04	0.03
Average per Quarter	**0.64%**	**0.28**	**0.20**	**0.17**
Aerage annual	**2.58%**	**1.13**	**0.80**	**0.67**

A Positive Side-Effect of Transitioning over Longer Period

In all our quarterly transition cost analyses, we looked at the difference between the current benchmark and the MSCI benchmark and divided it in to eight equal steps to be implemented over eight quarters or two years. This ignores the fact that the final benchmark (the benchmark that we want to end up with after the transition period) itself goes through several rebalances and changes over the two-year period. In this section we estimate the impact of this dynamism in the target MSCI benchmark on the overall turnover due to the benchmark switch and the associated cost.

Let's assume the transition started on Feb. 28, 2018, (aligned with MSCI quarterly rebalance). On this day, the difference between the MSCI benchmark and the current benchmark was about 4%. For simplicity and accuracy of calculations all the constituents of the current benchmark that are not part of the MSCI benchmark on this date are removed (sold in a tracking portfolio). This amounts to about 1.8% turnover.

To balance the benchmark to add up to 100%, the same amount (1.8%) is invested in constituents of the MSCI benchmark that are not part of the current benchmark. The resulting index will be the starting transition index. By construction, this transition index will have an active share of 1.8% with the current benchmark and c.2.2% (4% - to 1.8%) active share with the MSCI benchmark.

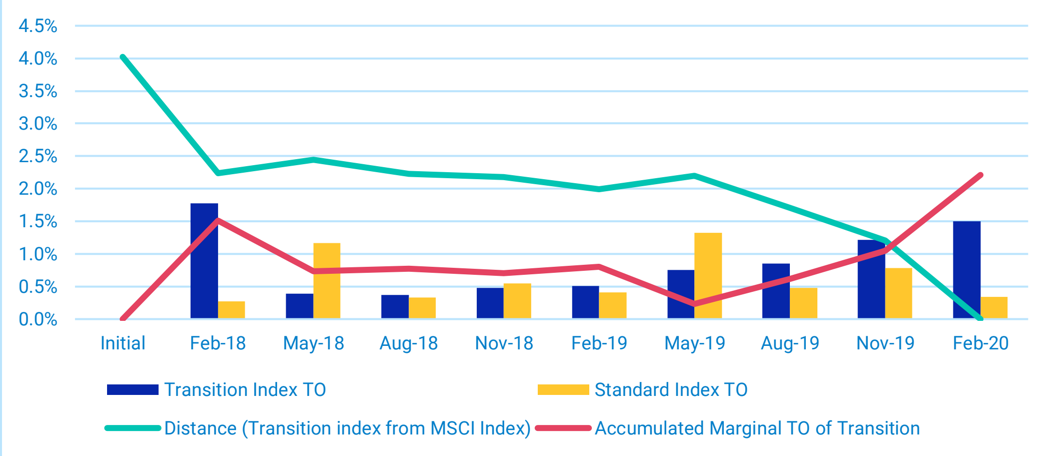
During the following quarterly rebalances, the transition benchmark adheres to the following rules. At each quarter, the difference between the transition benchmark and the MSCI benchmark on that date are calculated and 1/Nth of the difference is added to the transition benchmark (N here is the number of quarters left in the transition period). In the first transition N =8 and we move 1/8th of the difference closer to the MSCI benchmark. On the second quarter N = 7 and we move 1/7th of the difference closer to the MSCI benchmark, and so on until, finally, at the last quarter, N=1 and the transition benchmark converges to the MSCI benchmark.

We measure the turnover during each of these quarterly transitions to calculate the overall turnover of the benchmark over the two-year transition period. We also measure the natural turnover of the MSCI benchmark over this period (both current benchmark and the MSCI benchmark would incur turnover). The difference between these two turnover numbers (transition turnover – natural turnover of the benchmark) is the marginal turnover associated with the benchmark switch.

Exhibit 25 shows the quarterly turnover numbers for the transition index as well as the standard MSCI ACWI IMI in tabular and chart form. It also shows the difference between the transition index and the target MSCI benchmark (in terms of active share) as well as the accumulated marginal cost of benchmark transition.

Exhibit 25: Estimated Marginal Transition Turnover

Date	Transition Index TO	Standard Index TO	Distance (Transition index from MSCI Index)	Accumulated Marginal TO of Transition
Initial	0.00%	0.00%	4.02%	0.00%
Feb-18	1.78%	0.27%	2.24%	1.51%
May-18	0.39%	1.17%	2.45%	0.73%
Aug-18	0.37%	0.33%	2.22%	0.77%
Nov-18	0.48%	0.54%	2.18%	0.71%
Feb-19	0.50%	0.41%	2.00%	0.80%
May-19	0.75%	1.32%	2.19%	0.23%
Aug-19	0.86%	0.47%	1.71%	0.61%
Nov-19	1.22%	0.79%	1.20%	1.05%
Feb-20	1.50%	0.34%	0.00%	2.21%



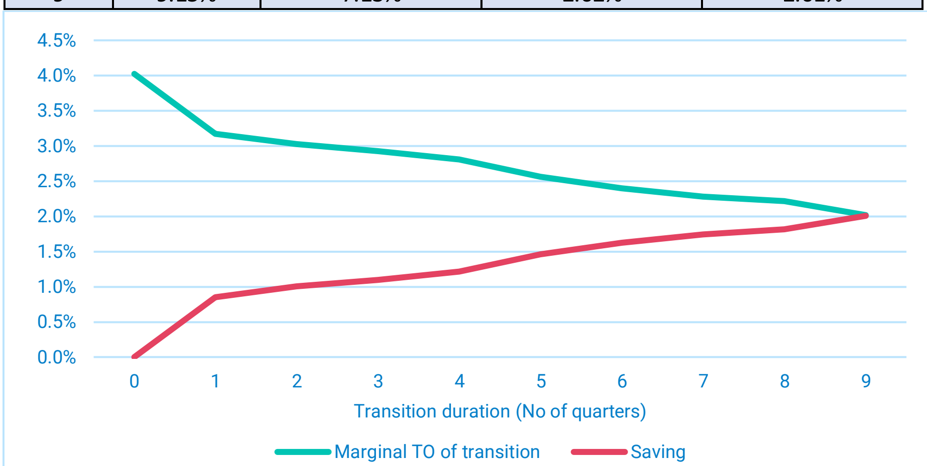
After the eight-quarter transition period, the total turnover (including the initial turnover) is 7.85%. Over the same period, the natural turnover of the MSCI index is 5.64%. The marginal turnover of the benchmark transition therefore is 2.21% (7.85% - 5.64%.) Compared to the 4% active share between the two benchmarks at the start of the period, there is a 1.81% saving in turnover (or 45%). The rationale behind the saving here is similar to the one discussed for the savings when combining the benchmark switch with other changes in the benchmark.

The analysis above is based on a two-year transition period. Exhibit 26 shows the same analysis for different time horizons. As we can see, the longer the horizon, the higher the potential savings.

It is important to note that all the cost analyses in previous sections were done without accounting for this potential savings (i.e., the numbers reflected in the total active share between the two benchmarks).

Exhibit 26: Transaction Cost Savings Estimated for Different Time Horizons

Steps	Total Transition Index TO	Standard Index TO	Marginal TO of transition	Saving
0	4.02%	0.00%	4.02%	0.00%
1	4.61%	1.44%	3.17%	0.85%
2	4.79%	1.77%	3.02%	1.00%
3	5.24%	2.32%	2.93%	1.09%
4	5.54%	2.73%	2.81%	1.21%
5	6.61%	4.05%	2.56%	1.46%
6	6.92%	4.52%	2.40%	1.62%
7	7.59%	5.31%	2.28%	1.74%
8	**7.85%**	**5.64%**	**2.21%**	**1.81%**
9	9.15%	7.13%	2.02%	2.01%



An Alternative Path

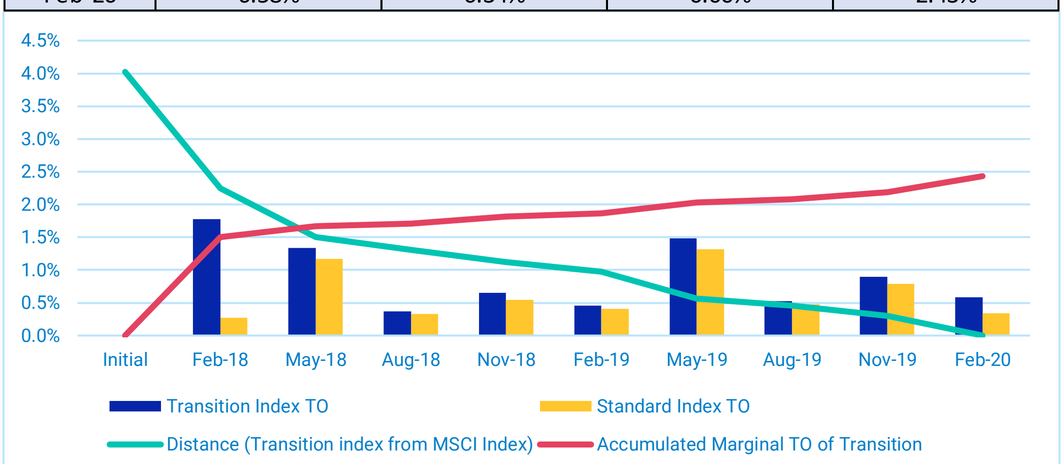
In the above analysis, the amount of turnover on each quarter was simply the total remaining active share divided by the number of quarters left in the transition period. As we saw in Exhibit 25, the turnover at each rebalance varied and was very different from the natural turnover of the index. If desired, the turnover could be linked to the natural turnover of the target MSCI benchmark. For instance, we can constrain the turnover over the transitional period to be 110% of the natural turnover of the MSCI benchmark at each quarterly rebalance.[25] Exhibit 27 shows the results after applying

[25] Note that this constraint needs to be relaxed at the last quarter to ensure the transitional benchmark converges to the MSCI BM.

this constraint. The overall savings did not improve, but the transition turnover was more in-line with the natural turnover of the index during the transition period.

Exhibit 27:Estimated Marginal Transition Turnover – Linking Turnover to Natural Turnover of Index

	Transition Index TO	Standard Index TO	Distance (Transition index from MSCI Index)	Accumulated Marginal TO of Transition
Initial	0.00%	0.00%	4.02%	0.00%
Feb-18	1.78%	0.27%	2.24%	1.51%
May-18	1.33%	1.17%	1.50%	1.67%
Aug-18	0.37%	0.33%	1.31%	1.71%
Nov-18	0.65%	0.54%	1.12%	1.82%
Feb-19	0.46%	0.41%	0.98%	1.86%
May-19	1.48%	1.32%	0.57%	2.03%
Aug-19	0.52%	0.47%	0.46%	2.08%
Nov-19	0.89%	0.79%	0.30%	2.18%
Feb-20	0.58%	0.34%	0.00%	2.43%



Using Optimization to Further Improve Cost

The cost estimation analyses of previous sections were all based on the assumption that the portfolio perfectly tracks the benchmark and tracking error is zero. However, the GPFG portfolio tracks the benchmark with some tracking error and by switching to the MSCI benchmark, the tracking error between portfolio and benchmark does not change, even though the sources of risk contributing to the tracking error changes.

Putting that aside, the fact that there is a tracking error budget for the portfolio to deviate from the benchmark, gives it the flexibility to schedule the required trades for the benchmark transition strategically to minimize the cost of the transition. This can be achieved through optimization. In this section we set up a simple optimization problem to show how allowing some tracking error can help lower the cost. In practice, managers often employ similar optimization tools to manage the cost while achieving the desired investment objectives.

For our simple analysis we set up the optimization as follows:

Objective: Minimize transaction cost through a penalty on active share

Initial Portfolio: Current benchmark

Benchmark: MSCI benchmark

Constraints:

- Tracking error <= 3bps (tracking error at the end of transition period)
- Asset-level bounds:
  - Lower bound: Minimum (current benchmark, MSCI benchmark)
  - Upper bound: Maximum (current benchmark, MSCI benchmark)
- Five scenarios with the following target active shares
  - **A**: 6 bps
  - **B**: 10 bps
  - **C**: 30 bps
  - **D**: 60 bps
  - **E**: 100 bps

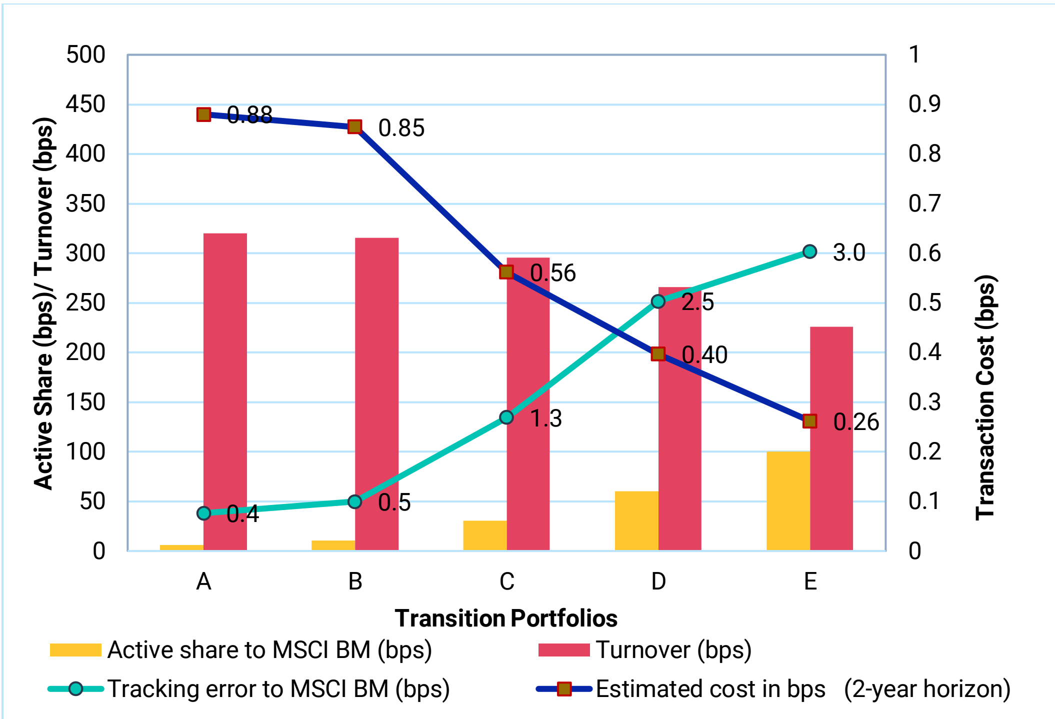
- **Transaction cost:** Piece-wise linear model based with 90-day, 252-day, 2-year and 3-year horizons.
- **Risk Model:** MSCI Barra Global Equity Model - Long Term (GEMLTL)

As an example, in case C, the optimizer will tell us which stocks and how much of those stocks to trade over the desired period so that the trading cost is at the minimum while we achieve a tracking error of less than 3 bps and active share of 30 bps or less.

Exhibit 28 shows the results of the optimization for these five scenarios over different time horizons. Please note that, for simplicity, the analysis is done for the case of a one-step benchmark switch. The same tools can be used for the case with the quarterly transitional benchmark that we discussed and used in previous analysis.

Exhibit 28: Balancing Tracking Error and Transaction Costs Using Optimization

Portfolio	Active share to MSCI BM (bps)	Tracking error to MSCI BM (bps)	Estimated cost in bps (2-year horizon)
A	6	0.4	0.88
B	10	0.5	0.85
C	30	1.3	0.56
D	60	2.5	0.40
E	100	3.0	0.26



Appendixes

Appendix I: MSCI Global Investable Market Indexes Methodology Summary

This is a summary of selected provisions of the MSCI Global Investable Market Indexes Methodology. It is provided for informational purposes only in order to highlight some of the key elements in the methodology's framework. It does not contain nor purport to contain all elements of the methodology. For a complete understanding of the methodology, please refer to the full methodology book available on MSCI's web site at the following link:

https://www.msci.com/eqb/methodology/meth_docs/MSCI_GIMIMethodology_Oct2020.pdf

Criteria	MSCI Global IMI
Eligible securities	All listed equity securities including REITs and some income trusts in Canada
Number of Market	23 developed and 26 emerging markets.
Multiple share classes	All eligible share classes of the same company may be included in the index
Size Segmentation	MSCI defines a Global Minimum Size Reference (GMSR) for each size-segment to set a minimum company size-range for all markets of a given universe (e.g. DM, EM). EM GMSR is set at half of the respective DM size-segment. DM Large Cap targets 70% coverage of the universe, DM Standard 85% coverage and DM IMI 99% coverage. The Target Number of Companies and Market Size-Segment Cutoff for each Country Size-Segment is set at the company in each market with company full market capitalization as close as possible to the target size and coverage.
Minimum Full Market Capitalisation Requirement	The full market capitalisation of the company at the 99th %-ile of free-float adjusted market capitalisation in the DM Equity Universe. As at Nov 2019 SAIR, the EUMSR was US$233 million. It is reviewed semi-annually.
Min Free Float Market Capitalisation size	To be included in the investable universe, securities should have free float market captialization equal or higher than 50% of the EUMSR for newly eligible securities. Securities assigned to the Standard Size-segment should have free float market capitalization above 50% of the Standard Size-segment

	cutoff while securities in the Small Cap Size-Segment should be above 50% of the Small Cap Size-Segment cutoff
Liquidity	12m and 3m Annual Traded Value Ratio (ATVR) of 20% (DM) and 15% (EM) 3m Frequency of Trading at 90% (DM) and 80% (EM) For new inclusion – stock price threshold of US$10K max.
Min Foreign Inclusion Factor*	>= 15% *in general*, or float-mcap at least 1.8× Standard Index Minimum Size Reference
Min Length of Trading	Small IPOs – at least 3m before the SAIR Large IPOs - may be included after 10 days
Free Float	Free-float >15%: rounded up to the closest 5% Free-float <15: rounded to the closest 1%
Foreign Room	New constituents: 0.5x weight if foreign room <25%, >15% or ineligible if foreign room <15% Existing constituents: 0.5x weight of foreign room <15%, >7.5% or 0.25x weight if foreign room <7.5%, >3.75% or ineligible if foreign room <3.75%
Classification of Securities	The country classification of a company is generally determined by the company's country of incorporation and the primary listing of its securities. MSCI will classify a company in the country of incorporation if its securities have a primary listing in this country. In such cases where a company's securities have a primary listing outside of the country of incorporation, an additional analysis is performed to determine the company's country classification, (criteria includes secondary listings, shareholder base, headquarters, operations, history, market perception) with a set of criteria, including: • The security's secondary listings if any; • The geographic distribution of the company's shareholder base; • The location of its headquarters; • The geographic distribution of its operations (in terms of assets and revenues); • The company's history, and • The country in which investors consider the company to be most appropriately classified
Rebalancing Frequency	Semi-Annual and Quarterly Index Reviews
Rebalancing Period	Countries are usually reviewed semi-annually in May and November, and reviewed quarterly in February and August
Fast Entry Thresholds	Calculated on a daily basis - dynamic
Sector classification	Global Industry Classification Standard (GICS)
Market classification process and criteria overview	18 measures to assess the market accessibility of countries, as well as A) Size and Liquidity and B) Economic Development

Appendix II: Narrower Benchmark and Cost of Rebalance

Historically, narrowing benchmark coverage by eliminating some of the smallest stocks (e.g., the bottom 2% in terms of weight) did not have a significant impact on the risk/return characteristics of the index. But it may bring the advantage of not having to hold and monitor thousands of small stocks and the cost associated with doing so.

In addition, it may help with the cost of maintaining the index, in terms of regular index rebalances. There is turnover associated with each regular index rebalance. Some of the turnover is due to smaller stocks being added to and deleted from the index, at the bottom (smaller stocks).

Intuitively speaking, the larger these stocks, the easier and potentially less costly to trade them. Therefore, all else being equal, the cost of trading this portion of the rebalance turnover may be lower for a narrower benchmark, as the smallest stocks in a narrower benchmark are larger than the ones in the standard index. To see if the hypothesis is true and to get a sense of the potential cost saving, we have done a simple analysis.

The average quarterly turnover of the ACWI IMI in 2019 was 75 bps. Let's assume 10 bps of this is associated with the additions and deletions at the bottom of the index. Also assume this 10 bps is distributed over the bottom 500 names in the index. Using USD 700 billion as the size of portfolio and using the MSCI liquidity model, we estimated the cost for ACWI IMI as well as for a narrow version of it (97% coverage instead of 99% coverage).

The results are shown in Exhibit 29. While the size of the trades is the same in both cases, the cost of trading them is quite different. Based on this analysis, trading smaller stocks (99% level) is more than twice as high as the larger stocks at 97%. While this is a simple hypothetical analysis and the numbers are crude estimates, the direction and magnitude of the size is interesting to observe.

Exhibit 29: Estimated Cost of Trading Smaller Stocks

			Cost (in bps)		
Index	Turnover (%)	Total Traded Value (USD)	30 days	60 days	90 days
Bottom 500 names in ACWI IMI	0.10%	1,400,000,000	0.33	0.28	0.26
Bottom 500 names in 97% narrow index	0.10%	1,400,000,000	0.15	0.13	0.12

Appendix III: Summary of Costs with Commissions

The tables below show the summary of the cost estimate charts presented in the paper in addition to the same costs where a commission of 6 bps is incorporated.

Exhibit 30: One-Step Full Transition over Different Time Horizons

Time horizon	1 Day	3 Day	5 Day	10 Day	20 Day	60 Day	90 Day	1 year	2 years
Wihtout commission	9.32	7.15	5.97	4.48	3.12	1.78	1.50	1.13	0.96
With commission (6bps)	9.71	7.54	6.36	4.87	3.51	2.17	1.89	1.52	1.35

Exhibit 31: Full Transition Distributed over Eight Quarters

Time horizon			1 day	30 days	60 days	90 days
Benchmark switch only	w/o commission		3.57	1.20	1.05	0.96
	w commisssion		3.97	1.61	1.45	1.36
Benchmark switch and regional adjustment	w/o commission	Cost 1	6.34	1.77	1.45	1.30
		Cost 2	3.28	0.71	0.52	0.45
		Cost 3 (marginal cost of BM transition)	3.06	1.06	0.93	0.85
	w commission	Cost 1	7.21	2.63	2.31	2.16
		Cost 2	3.88	1.31	1.12	1.05
		Cost 3 (marginal cost of BM transition)	3.33	1.32	1.19	1.11
Benchmark switch, regional adjustment and narrowing the benchmark	w/o commission	Cost 1	7.02	1.97	1.62	1.45
		Cost 2	5.04	1.36	1.07	0.97
		Cost 3 (marginal cost of BM transition)	1.98	0.62	0.54	0.48
	w commission	Cost 1	7.95	2.90	2.54	2.37
		Cost 2	5.81	2.13	1.84	1.73
		Cost 3 (marginal cost of BM transition)	2.14	0.77	0.70	0.64
Benchmark switch, regional adjustment, narrowing the benchmark and reinvesting dividends	w/o commission	Cost 1	7.65	2.11	1.73	1.55
		Cost 2	5.73	1.55	1.24	1.12
		Cost 3 (marginal cost of BM transition)	1.92	0.55	0.49	0.43
	w commission	Cost 1	8.70	3.16	2.78	2.60
		Cost 2	6.66	2.48	2.17	2.05
		Cost 3 (marginal cost of BM transition)	2.04	0.68	0.61	0.55

Exhibit 32: Estimated Cost of Natural Quarterly Turnover of MSCI ACWI IMI

		Without commission			With commission		
		Transaction Costs (bps)			Transaction Costs (bps)		
Rebalancing Dates	Turnover	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days
20191126	0.79%	0.32	0.23	0.20	0.36	0.28	0.25
20190827	0.47%	0.19	0.13	0.11	0.22	0.16	0.14
20190528	1.32%	0.64	0.46	0.40	0.72	0.54	0.48
20190228	0.41%	0.13	0.09	0.07	0.15	0.11	0.10
20181130	0.55%	0.41	0.30	0.25	0.44	0.33	0.28
20180831	0.33%	0.07	0.05	0.05	0.09	0.07	0.07
20180531	1.17%	0.83	0.59	0.50	0.91	0.66	0.57
20180228	0.27%	0.04	0.03	0.02	0.06	0.04	0.04
20171130	0.60%	0.25	0.17	0.14	0.29	0.20	0.17
20170831	0.42%	0.10	0.06	0.04	0.12	0.08	0.07
20170531	1.02%	0.36	0.24	0.19	0.42	0.30	0.26
20170228	0.38%	0.06	0.04	0.03	0.09	0.06	0.06
Average per Quarter	**0.64%**	**0.28**	**0.20**	**0.17**	**0.32**	**0.24**	**0.21**

Appendix IV: Additional Turnover Analysis

This appendix presents historical turnover numbers for several simulated indexes. The turnover numbers, unless otherwise mentioned, are the turnover for quarterly rebalances.

Exhibit 33: Turnover for quarterly rebalances (simulated ACWI IMI 99% equity universe coverage, simulated ACWI IMI with 97% coverage)

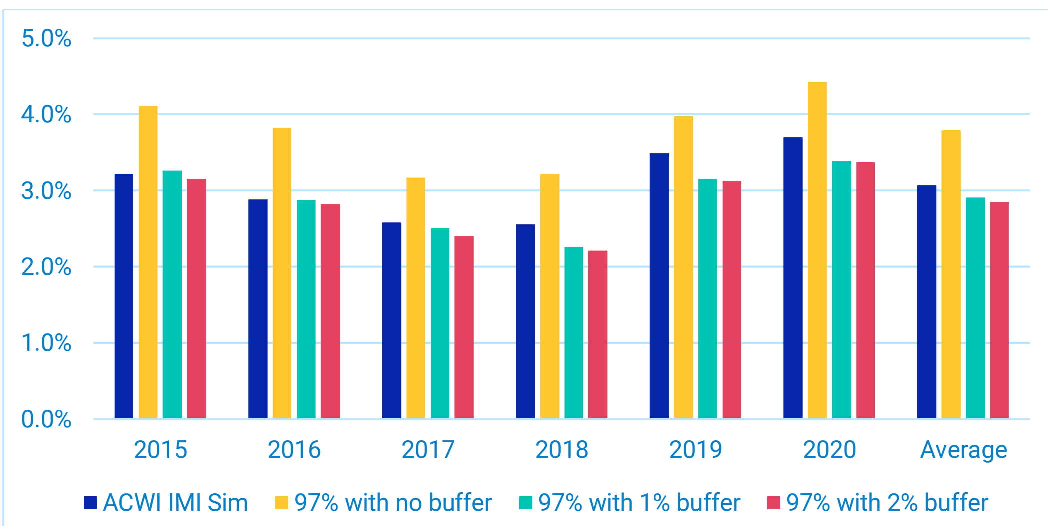


Exhibit 34: Historical simulated saving in turnover (97% coverage with 1% buffer compared to ACWI IMI)

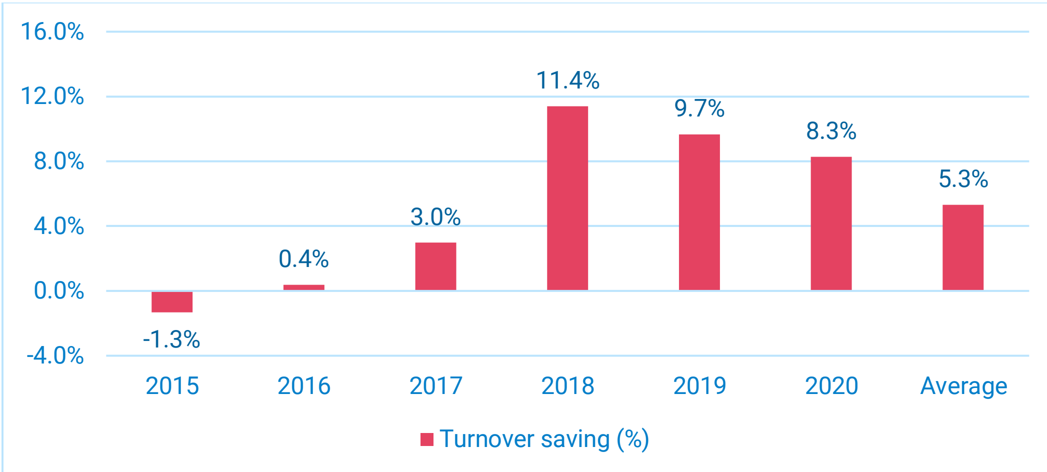


Exhibit 35: Estimated transactions cost of quarterly rebalances for different simulated indexes (in bps). Cost estimates are based on MSCI liquidity model and using a 3-day window trading assumption.

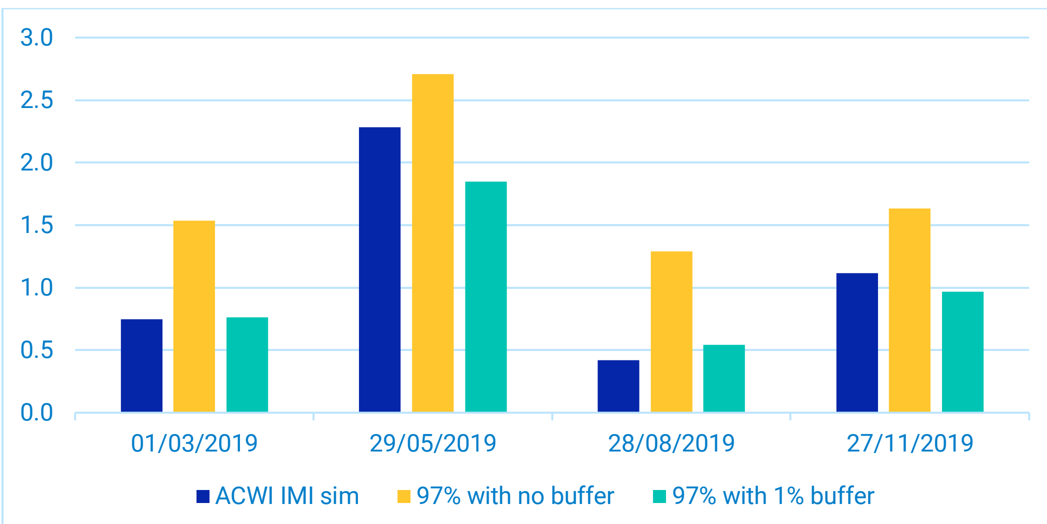


Exhibit 36: Estimated transactions cost of quarterly rebalances for different simulated indexes (total for the year 2019)

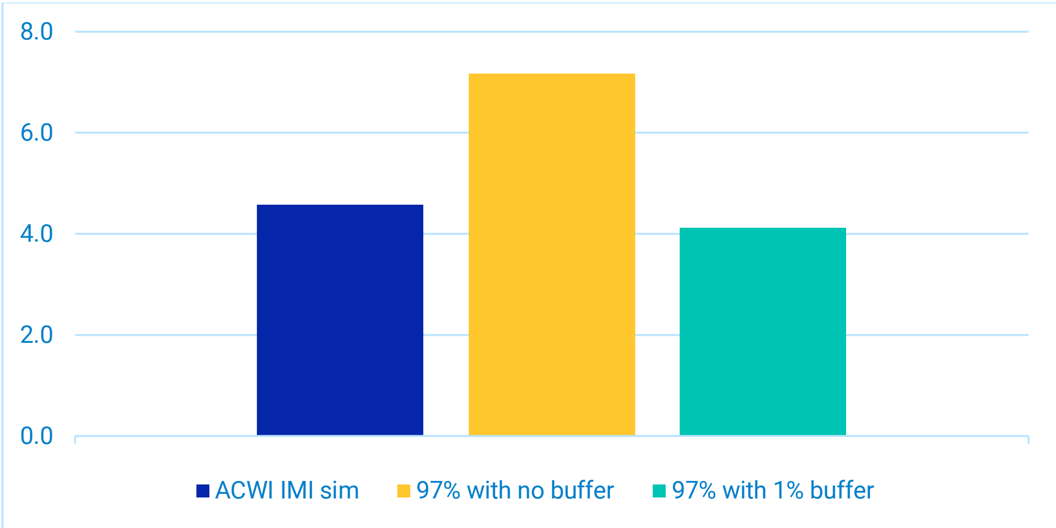


Exhibit 37: Turnover for quarterly rebalances (simulated ACWI IMI 99% equity universe coverage, simulated ACWI IMI with 96% coverage)

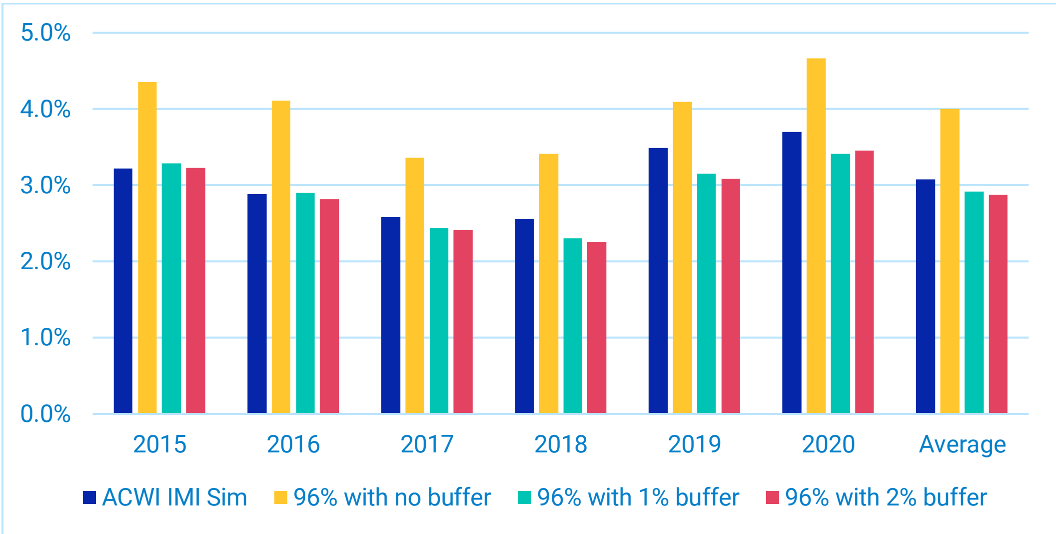


Exhibit 38: Historical simulated saving in turnover (96% coverage with 1% buffer compared to ACWI IMI)

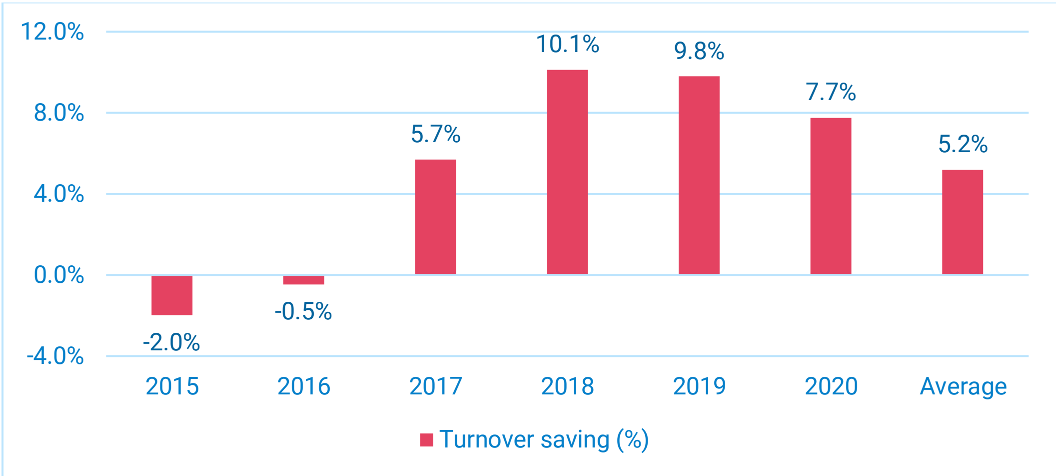


Exhibit 39: Turnover for quarterly rebalances (simulated ACWI IMI 99% equity universe coverage, simulated ACWI IMI with 95% coverage)

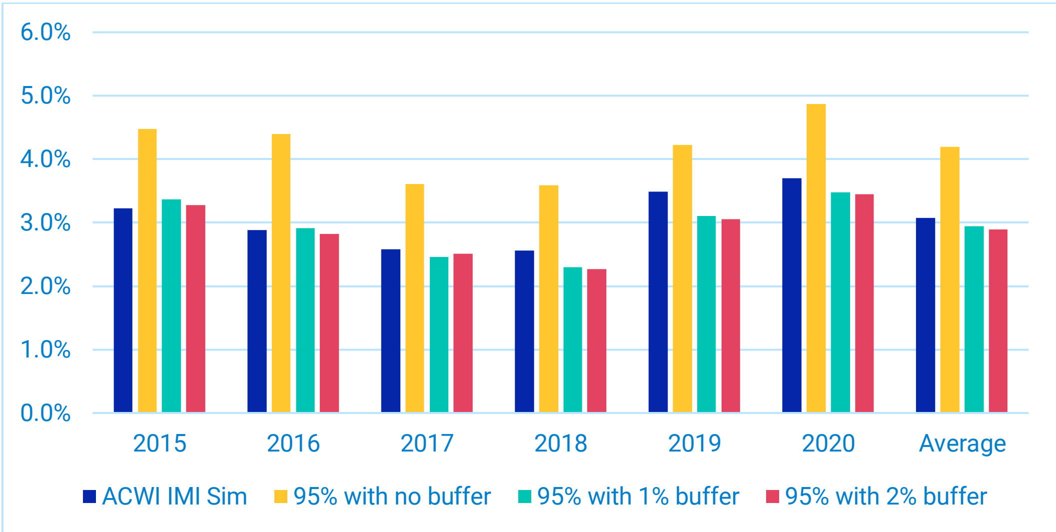
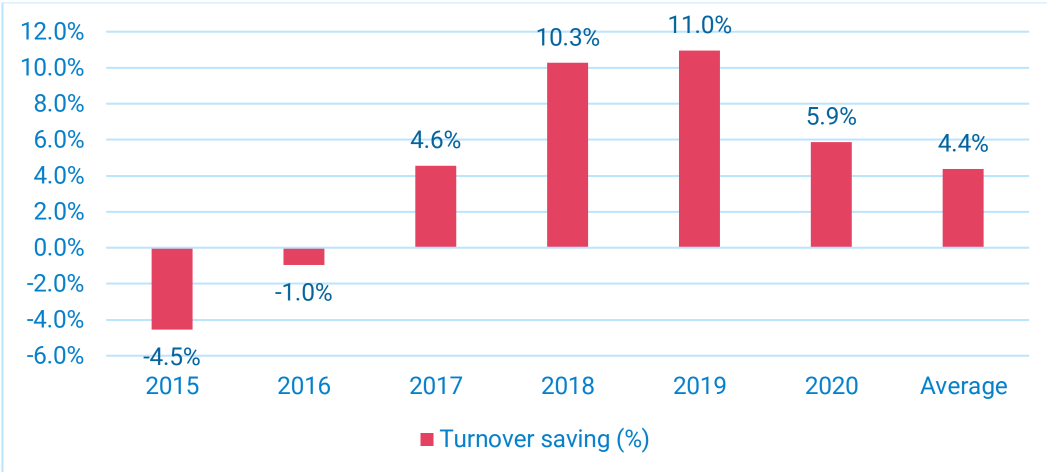


Exhibit 40: Historical simulated saving in turnover (95% coverage with 1% buffer compared to ACWI IMI)



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