Quantitative Monographs

The seasonality in factor returns

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Hiding in plain sight

Seasonality is easily dismissed in an era of alternative data and artificial intelligence. Conventional wisdom maintains that outperformance comes only at the expense of less informed investors; every investor has access to a calendar, thus we should expect that all investors trade with this information in mind. The clear counterargument to this claim is that of investor inattention—*seasonality can produce mispricings not despite its widespread availability, but rather because of it*. Many investors deem it too trite and therefore delegate its price discovery (and forfeit any gains) to the market instead.

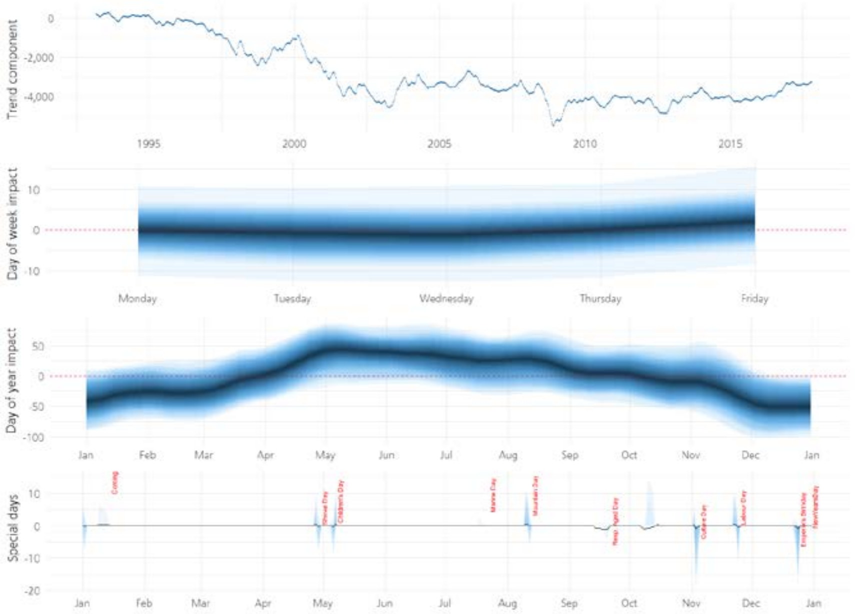
A powerful new technique worth knowing

We adopt a powerful technique known as a Bayesian structural timeseries model, to jointly estimate trends, multiple seasonal components and holiday effects; arguably a more robust approach than the literature has followed, and the first application of such a model for this purpose. *We think the significance of our results makes a compelling case for the incorporation of seasonal tilts into a tactical style allocation strategy*. We believe investors can lower turnover and enhance returns by modelling these effects.

Key takeaways from the global results

Markets show a globally consistent pattern of risk aversion mid-week and risk seeking at the end of the week (Japan excluded); this exists across all common proxies for risk. Annual seasonal effects are an order of magnitude larger than the weekday effect, but vary significantly regionally due to specific local influences. We find investors should: buy US small caps, sell low momentum and negative revisions into May; buy Japanese low volatility in January, sell it post-Golden Week; buy high EPS revisions after Australia 1H earnings amid low earnings visibility; sell low volatility ahead of 3Q in Asia ex-Japan.

Figure 1: A low-volatility effect found in Japan from New Year to Golden Week



Source: TSE, Factset, UBS Quant

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Introduction

Seasonality is easily dismissed in an era of big data, alternative data and artificial intelligence breakthroughs. Conventional wisdom maintains that outperformance of any strategy is only at the expense of less informed investors; every investor has access to a calendar, thus we should expect that all investors are trading with this information in mind[1].

Every investor has access to a calendar; ergo markets should be 'seasonally efficient'

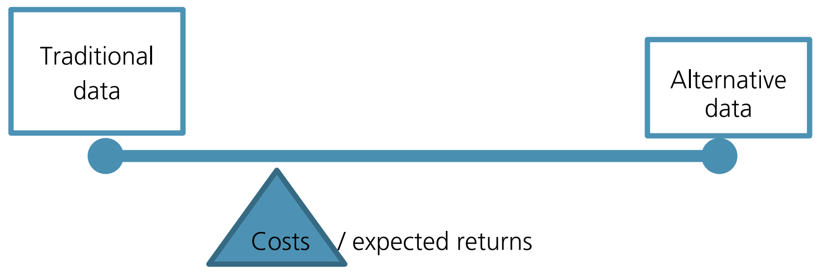
The most compelling counterargument to this claim is that of investor inattention. Seasonality can produce mispricings not in spite of its widespread availability, but rather because of it. Seemingly too trivial for investors to concern themselves with, many investors might simply delegate its price discovery (and forfeit any gains) to the market.

But evidence of seasonal anomalies persists despite this

Evidently a balance must be struck between the difficulty of information gathering and such price efficiency, ie, how can investors maintain a positive expected return after search costs? [2]. While this is perhaps unsatisfying, seasonal effects appear to be off this scale entirely; they are widely available but simply too uninteresting for investors to focus on them!

Seasonal anomalies perhaps suffer from investor inattention

Figure 2: The stylised equilibrium of data search costs and expected returns



Source: UBS Quant

Opponents of such premia argue that seasonal effects are weak at best, spurious at worst, but unprofitable after costs either way. While seasonality in stock prices and equity indices is barely discernible following a spate of research some 40 years ago, we find evidence of economically significant seasonal components within global factor indices—the focus of this report.

Seasonal anomalies are not without their critics, naturally

We adopt a powerful, modern technique to isolate the seasonal components from our style indices (the first application in the literature to our knowledge), which is robust to noisy data and overfitting. We describe that while seasonal effects might remain faint, they can be incorporated as an overlay into a tactical style allocation effectively.

We apply a rigorous seasonal analysis to factor returns

[1] By this logic, then all readers of this report (and everyone else) are already explicitly trading on such information, which seems rather unlikely

[2] In their seminal report, Grossman and Stiglitz (1980) described such an equilibrium

Explanations

An essential question to ask is "what is the source of these effects?". If we are not to simply dismiss these as data dredging, there should be a plausible explanation as to their underlying cause.

Is this just data mining, or are there underlying causes?

Here we address the widely accepted explanations for seasonal effects in markets, as a framework for understanding any seasonal components occurring in our style indices later. The findings in this space are truly too numerous to mention so we aim to distil them to the most influential few.

This frames our understanding of style seasonality later

Tax-loss selling

The tax-loss selling explanation relies on the premise that small caps tend to have more price volatility and are thus more likely to experience large price declines. Rational investors sell into the tax year-end to realise their capital losses, thereby depressing stock prices. From this lower base, these small caps outperform in the subsequent months as this temporary selling pressure is released.

Tax-loss selling is a popular explanation offered for small cap performance around the year-end

Critics of this explanation argue that such tax-loss selling does not necessarily imply price declines in the absence of downward-sloping demand curves[3]; it is generally accepted that stocks with similar characteristics make close substitutes. Even then, the existence of such substitutes suggests that one small cap would be replaced by another.

Complicating this further is that investors are subject to different tax year-ends or are perhaps not subject to capital gains taxation at all. Nonetheless this hypothesis still fails to explain why those stocks that have not been subject to selling pressure during the year often go on to outperform strongly in January.

Figure 3 shows the annual seasonal component of the Dow Jones small cap indices for each country, overlaid with the personal tax fiscal year. The method by which this seasonal component is extracted is explained in the subsequent section (Method), but for now we observe that there does appear to be some interaction between small cap seasonality and the tax year-end; the fiscal year as highlighted typically indicates a period of underperformance near its start/end—although this is largely coincident with the calendar year-end for most countries.

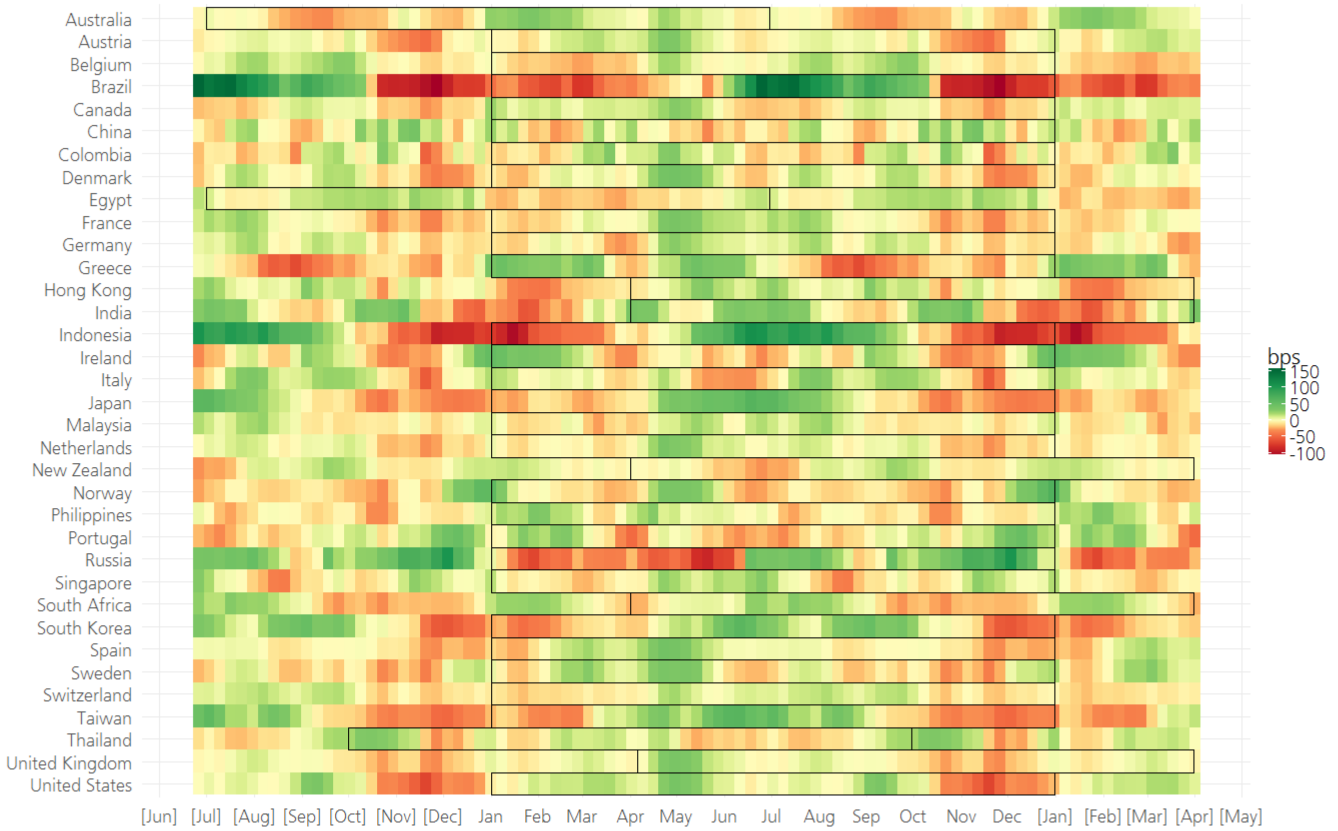
We do observe small cap underperformance near the turn of the year with our method

Naturally investors also have an incentive to sell *ahead* of this selling pressure, and rational investors would realise their capital losses immediately. However we know that the disposition effect (the tendency for investors to hold on to their losers for too long and sell their winners too soon) is a pathologically very difficult behaviour to break[4]; lending some credibility to a behavioural explanation.

There is some behavioural support for this explanation also

[3] Notwithstanding the index inclusion premium, see Shleifer (1986), Petajisto (2005)
[4] Refer to our report, *Irrational asset management* (26 October 2016)

Figure 3: The annual seasonal component of small cap indices vs the tax fiscal year



Source: UBS Quant

Risk

Another explanation offered for (if only) the January effect is that a latent seasonal component exists in the risk-reward framework; this seasonal effect is the premia that the rational equilibrium investor demands for bearing systematic market risk.

Some argue January is not only a source of increased return, but of increased risk also

Rogalski and Tinic (1986) argue that the risk of small caps have significantly higher total, systematic, and residual risks in January than any other time; thus the return that investors demand is higher accordingly and thus any asset pricing models that account for the time variation of risk are validated.

However, most other findings conclude that the positive risk/return relationship in both up and down markets is incongruous with this equilibrium explanation; rather it is merely an artefact of using impractical equal-weighted indices.

A recent explanation argues that seasonal effects arise from their time-varying relationship with other common factors

An alternative and compelling explanation is offered in what we think is an excellent report[5]; which describes seasonal anomalies as not necessarily requiring their own explanation but rather as a manifestation of a time-varying relationship with other common factors and impossible to disentangle. This argument would suggest that any seasonal components in the factors we observe arise from their exposure to these latent seasonal influences. As is the case for the enigmatic momentum premia; we argue that a robust empirical observation suffices for most investors; they need not seek a higher truth before exploiting it.

[5] Keloharju, Linnainmaa, Nyberg (2014)

'Window dressing'

Another popular explanation thoroughly explored in the literature is that asset managers may 'window dress' their holdings prior to their reporting date at year-end or otherwise; intentionally selling off their losers and buying stocks with recent positive performance to make their portfolio appear more attractive to their sponsors.

Lakonishok et. al. (1991) notes in their analysis of pension funds that smaller funds tend to window dress their holdings more than large funds, which provides some explanation to the localisation of this effect to small caps, being targeted more by smaller funds. Furthermore, larger funds are typically subject to a more frequent and rigorous monitoring of their portfolio holdings, which may ameliorate the incentive to 'window dress'.

There is some evidence supporting this theory, although this could also be explained by typical contrarian investment strategies

However they do caution that this behaviour is perhaps less misleading than outward appearances suggest, and not a radical departure from the norm—the turn of the year just accentuates an implicit contrarian investment strategy that many investors pursue.

More recently, Agarwal (2014) still found evidence of window dressing amongst US mutual fund managers. They find that managers are still incentivised to window dress their holdings even in the presence of rational investors, and the practice of window dressing is usually associated with less-skilled managers that have recently underperformed.

Further research suggests a clear incentive to engage in this; more so for less-skilled manager with recent underperformance

Sentiment

All humans need sunlight[6]; there is a serious medical condition that affects many people subject to extreme changes in their daylight hours (typically those living at higher latitudes), known as seasonal affective disorder. Milder symptoms of this might be referred to as the "winter blues", but this still profoundly impacts the mood, sleep and appetite of afflicted persons.

"Winter blues" affects risk appetite of many investors typically living at high latitudes

Unsurprisingly, there is also substantial clinical evidence describing how this affects investor behaviour. An investor's mood influences: their interpretation of abstract judgements about which they lack concrete information, how critically they view an argument with weak evidence, and their reliance on heuristics to aid decision making, to name just a few effects.

Although the influence of weather on asset prices dates at least as far back as Roll (1984), subsequent research found that sunshine is strongly correlated with stock returns, and that seasonal variation in risk can be explained using the length of day within the context of a conditional CAPM model[7]. Assuming home bias, we would expect this effect to be more pronounced in, for example, Canada and Scandinavia. We may explore this further in a subsequent report.

[6] Quant analysts excluded

[7] Hirshleifer, Shumway (2003), Garrett, Kamstra, Kramer (2004); Bassi, Colacito, Fulghieri (2013)

Behavioural

Behavioural effects are often posed in terms of news under/overreaction

There is a substantial body of literature that explains behavioural effects in terms of the under-reaction/overreaction to newsflow[8]. If this under/overreaction occurs in response to seasonally influenced factors then it is reasonable to assume that such behavioural responses may be themselves seasonally impacted in turn.

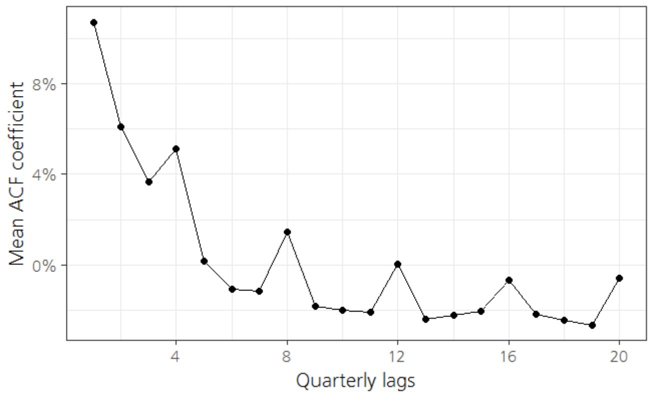
Analyst forecast errors evidently have seasonal components…

Recent research[9] suggests that analyst forecast errors contain seasonal components themselves; were markets to then react in an entirely systematic fashion to these earnings surprises then it would stand to reason that a seasonal component is still induced in the market reaction to such analyst errors.

…which may lead to under/overreaction to news within markets

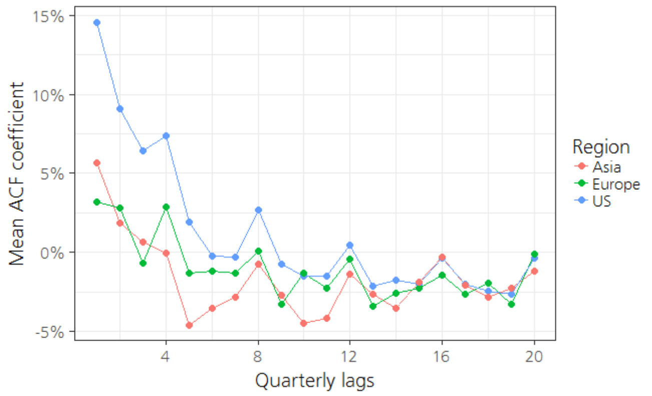
To illustrate this, we take all quarterly earnings surprises[10] for every company in the MSCI ACWI over the past 30 years, over 120,000 earnings surprises in total, and then calculate the mean autocorrelation coefficient at each lag (Figure 4). However faint, we can clearly observe spikes occurring at annual frequencies, which indicate there is a seasonal component in analyst forecast errors. These errors appear to be consistent throughout global regions, as shown in Figure 5.

Figure 4: Mean autocorrelation of EPS surprises (SUE)



Source: MSCI, IBES, UBS Quant

Figure 5: Mean autocorrelation of SUE by region



Source: MSCI, IBES, UBS Quant

Business cycles

The relationship between the economy and security markets is well researched

There is of course seasonal variation occurring within the economy itself; seasonal artefacts in return expectations might simply reflect a rational equilibrium response to these exogenous influences instead. Indeed, there is a wealth of evidence in the literature concluding that stock returns are related to business conditions[11], eg, GDP growth, industrial products and capital investment.

Uncertainties in the economic cycle may be reflected in securities markets

Fama (1990) argued that stock returns reflect the expectations on future economic activity, resulting from the efficient price discovery conducted by market agents. Ogden (2003) further explored this notion and concluded that while expectations of macroeconomic conditions are indeed infused into securities markets, the lack of forecasting power due to uncertainties and the lack of visibility in the annual economic cycle subsequently give rise to seasonal components within securities markets itself.

[8] DeBondt, Thaler (1987); Barberis, Shleifer, Daniel, Hirshleifer, Subrahmanyam (1998); Barberis, Vishny (1998), Hong, Stein (1999)
[9] Chang, Hartzmark, Solomon, Soltes (2014); read our July 2015 Academic Research Monitor
[10] As measured in the absolute value of standardised unexplained earnings (SUE) from IBES
[11] Fama (1981, 1990), Schwert (1990), Fama, French (1989), Barro (1990), Cochrane (1991)

Transaction costs/liquidity

One argument that cedes the possibility of legitimate seasonal effects in markets, but precludes them as a potentially gainful opportunity, is that these seasonal effects are functions of matching seasonal components in transaction costs due to liquidity constraints.

An important paper in the space, Keim (1989) investigated whether investors can actually exploit the turn-of-the-year effect in small caps, or merely observe them. Their conclusion was that in light of the high bid-ask spreads induced in small caps near the turn of the year, investors stand to gain little from trading this strategy—even without making accommodations for market impact.

Vacation periods are associated with depressed market volume and returns

Hong and Yu (2009) confirmed there is significantly lower stock turnover in summer; the widely held belief maintains that this is due to market participants being away on vacation. They subsequently included proxies for vacation activity, including hotel occupancy rates and airline passenger traffic, to explain this lower stock turnover, citing a strong positive correlation between these volume dips and return dips.

Mutual fund timing

There is evidence that indirect investment flows are seasonally influenced also

Closely related to the sentiment explanation described above is the indirect effect arising from seasonal variation in fund flows. Recent research[12] finds that seasonal variation within flows across asset classes is economically significant and consistent with the explanation provided by seasonal affective disorder introduced above.

Historically, mutual funds were the dominant mechanism by which investors gained exposure to equity markets. Given the growing popularity in exchange-traded funds today, we might expect this derivative effect of fund flows to only grow more pronounced.

Parking the proceeds

Retail investors have a predisposition towards small caps

Another possible explanation for the outperformance of small caps in January is the so called "park the proceeds" hypothesis proposed by Ritter (1988). This is essentially due to the predisposition that individual investors maintain towards small cap stocks relative to institutional investors.

Such investors sell their holdings and sit in cash until January

Such investors sell their holdings in December (or whenever their personal tax year-end occurs), to realise losses for tax purposes, but do not require close substitutes immediately—opting to rather sit in cash until January. Compounding this effect is that many individuals receive bonuses corresponding to a December year-end, and thus invest more heavily (with a predisposition into small caps), at the start of the year.

Although today direct retail investors represent a shrinking proportion of all market participants, in favour of exchange-traded funds or other investment vehicles, this does not preclude the possibility that any redemptions could be parked in cash due to seasonal influences.

[12] Kamstra, Kramer, Levi, and Wermers (2013)

Information release/insider trading

One relatively unpopular explanation for high seasonal returns related to the risk explanation is offered by an insider trading hypothesis from Seyhun (1988); as most companies have a December fiscal year-end, their management become aware of non-public information in early January then subsequently uses it to trade against uninformed investors. These investors in turn then rationally demand a higher expected return to protect themselves from this event, and this gives rise to the January/fiscal year-end effect.

Management may become aware of inside information immediately prior to results and trade accordingly

Subsequent findings generally seem to conclude that insider trades do not predict market movements meaningfully, and these insider trades instead rather load on well-known risk factors; insiders in aggregate are essentially contrarian investors, selling when valuations are expensive and buying when valuations are cheap[13].

Index rebalancing

Another possible cause of seasonality is periodic index rebalancing. MSCI indices, for example, have quarterly and semi-annual index reviews, from which pro-forma index changes are published first and enacted later. All indices express either an implicit factor tilt on the market, eg, liquidity, size, or a sector exposure; if not an explicit style exposure in a smart beta index product. With the growing popularity in smart beta indices, there is perhaps good reason to assume that such seasonal components might become more pronounced.

Periodic index rebalancing potentially induces a growing impact on factor returns

Data snooping

In the absence of a rigorous theoretical model, proponents of efficient markets claim this entire pursuit is nothing more than data snooping[14]. Essentially the argument is that no theory a priori drove researchers to investigate the anomalous seasonal effects; rather this research was conducted the other way around by retrofitting explanations to anomalies.

We reject this argument because a rigorous theoretical model is a near-impossible task; its lack thereof is a red herring in light of the many empirically robust yet theoretically unexplained anomalies that persist today, eg, price momentum.

The lack of theoretical models is a red herring in light of empirically robust market anomalies

Some argue that long data series are the best prescription against data snooping, noise and boredom[15]. We argue that additionally, robust statistical methods and intuition, rather than fixating on an arbitrary threshold for statistical significance, are also essential.

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[13] Lakonishok and Lee (2001). This concurs with our earlier research on insider trades (*Q-Series: Can social network analysis enhance strategies following trading by corporate insiders?*, 15 June 2017)
[14] Lo, Mackinlay (1990), Sullivan, Timmermann, White (1999), Malkiel (2003), Fama (1998)
[15] Lakonishok, Schmidt (2001)

Effects

Armed with the accumulated knowledge of several decades of academic research, we turn our attention to how these sources of seasonality can manifest themselves within equity markets, ie, how might we actually observe them?

In this report, we jointly model and address three components of our style indices, largely consistent with the bulk of the efforts in the literature: an annual seasonal, a weekday seasonal, and a holiday (special day) effect. Missing from this list is the turn-of-the-month effect and intraday effects.

We model annual and weekly seasonal effects, and holiday effects, jointly

January effect

The January effect (also referred to as the turn-of-the-year effect) is arguably the best known and most widely studied of all seasonal anomalies. First identified by Rozeff and Kinney (1976), stock returns were found to be disproportionately higher in January than other months. This finding spawned a flurry of academic interest, and subsequent investigations found that this was not only confined to small caps, but largely attributable as the source of the entire small cap premia[16].

The January effect is the best known of all seasonal effects

This has been claimed by many of the explanations listed above, to little consensus. If this were a tax year-end effect it would not persist in markets with a non-January tax year-end; if it were window dressing, it would be expected to appear in large caps, rather than small caps, as evidence suggests. Behavioural explanations seem plausible notwithstanding the global and open nature of equity markets today; one investor's summer is another's winter, making seasonal affective disorder less convincing.

Although its explanation still lacks consensus…

Even so, many of these causes are likely impossible to disentangle; tax year-end selling by some investors might be coincident with window dressing for others and seasonal affective disorder for others still. Nonetheless, the January effect remains present in equity markets today; in this report we more generally model the effect of the day of the year instead.

…and likely always will

Day of week

There has been no shortage of research conducted on shorter seasonal frequencies also; intra-week and even intra-day seasonal effects have been addressed throughout the literature. In this report we use daily end-of-day data exclusively, and model the effect of weekdays on factor returns.

We also incorporate an intra-week seasonal effect

The earliest references on this topic date back to Fields (1931), who found that US stock prices typically rose on Saturdays[17]. Subsequent findings revealed that returns are disproportionately high on Friday relative to Monday. Further refinements still found stock prices typically fall from the Friday close to the Monday open, yet rise on Monday from the open to the close; hence the term "the weekend effect"[18].

Stocks perform strongly at the end of the week; poorly at the start of the week

[16] Roll (1981), Reinganum (1983)
[17] The NYSE traded on Saturday until 1952
[18] Cross (1973), French (1980), Gibbons and Hess (1981)

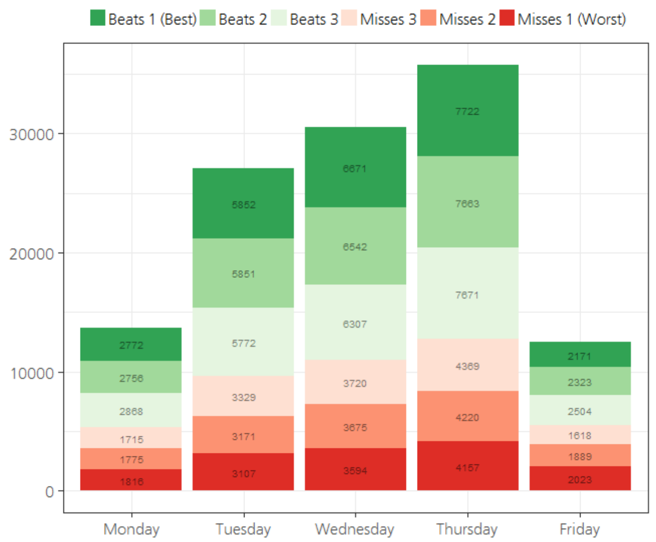
Again, no consensus has been reached on the cause of this weekday seasonal

Many explanations have been offered for the weekend effect; the most appealing and widely accepted of which is the increased settlement time for stocks traded on Friday. However this explanation seemingly fails to account for differences in settlement time in different countries[19]. Behavioural effects also seem plausible; "Monday blues" are perhaps not an unreasonable explanation.

Some argue that positive news is released during trading hours on Monday; bad news is delayed until after-close Friday

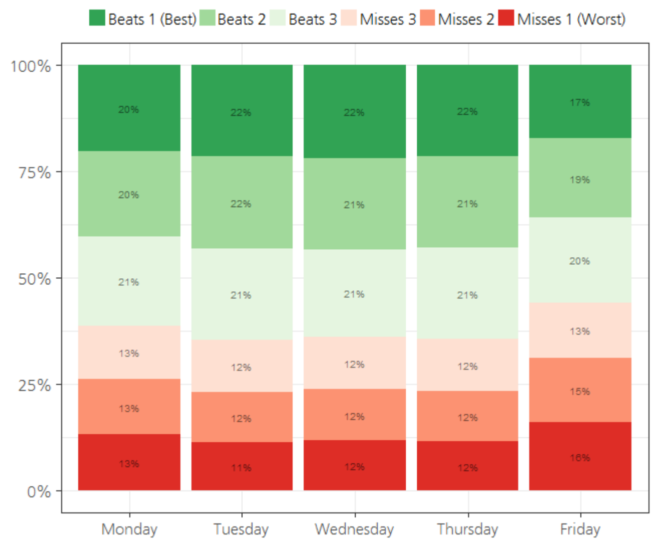
Other explanations rather suggest that positive newsflow tends to be released on Monday when possible and negative news is released after the close on Friday[20]. For a simple counterargument to this claim, below we break down global quarterly earnings surprises over the past 20 years into weekdays of their release (captured by the local timezone of the security), ignoring market opening hours.

Figure 6: Number of quarterly surprises by weekday



Source: IBES, MSCI, UBS Quant

Figure 7: Percentage of quarterly surprises by weekday



Source: IBES, MSCI, UBS Quant

Any weekday skew in earnings newsflow is marginal, if apparent

Evidently Friday's data releases are not anomalous; while there have been roughly as many earnings surprises released on Friday as Monday, this is still far less than during the mid-week; and while there have been proportionally more of the largest misses released on Friday than other days (16%), this is only marginally more than Monday (13%).

We find no economically significant results intra-week

In either case, in the subsequent results we find that the weekday effect in factor indices is essentially economically negligible; there are no instances of this seasonal component exceeding even a conservative estimate of trading costs.

Holidays

Finally, we also include the effect of holidays in our analysis. The literature around holiday effects on equity markets is less extensive but still noteworthy. In short, the evidence suggests that pre-holiday period is instrumental in forming equity returns; Thaler (1987) notes 51% of the Dow Jones since inception was attributable to only 10 pre-holiday days each year. We incorporate the effect of many of the important regional holidays in our model for completeness, but nonetheless find them to be of negligible impact. Markets are of course closed for all of the actual holidays; we model the pre-holiday effects by the preceding three weekdays.

[19] Lakonishok, Levi (1982), Agrawal, Tandon (1994)
[20] Fortune (1991), Damodaran (1989)

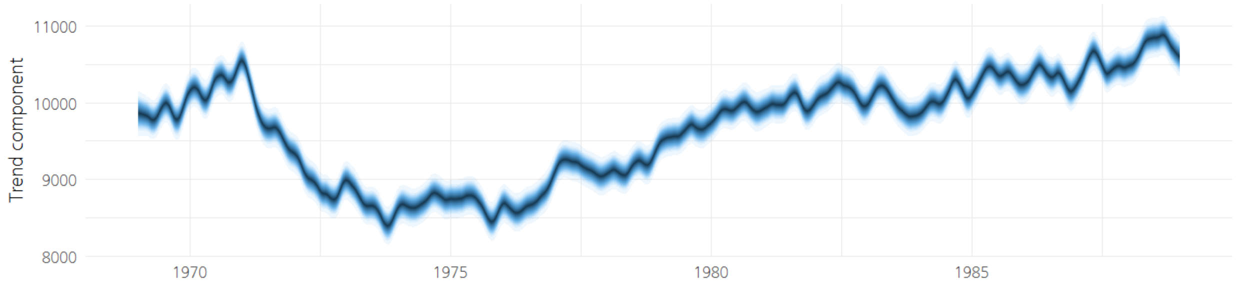
Method

For illustrative purposes we first demonstrate our method on a seasonal data set studied extensively outside of finance. Below we show our decomposition of the daily US birth number over 1969-1988, from the US Centre for Disease Control [21].

Figure 8 shows the overall trend in the timeseries. The technical details of this are discussed in the appendix, but suffice to say that this is a flexible representation that accommodates long-term trends and short-term deviations. In this report we do not further explore the nature of this trend—but it can be used for forecasting.

This model can also be used for forecasting; we will explore this in a later report

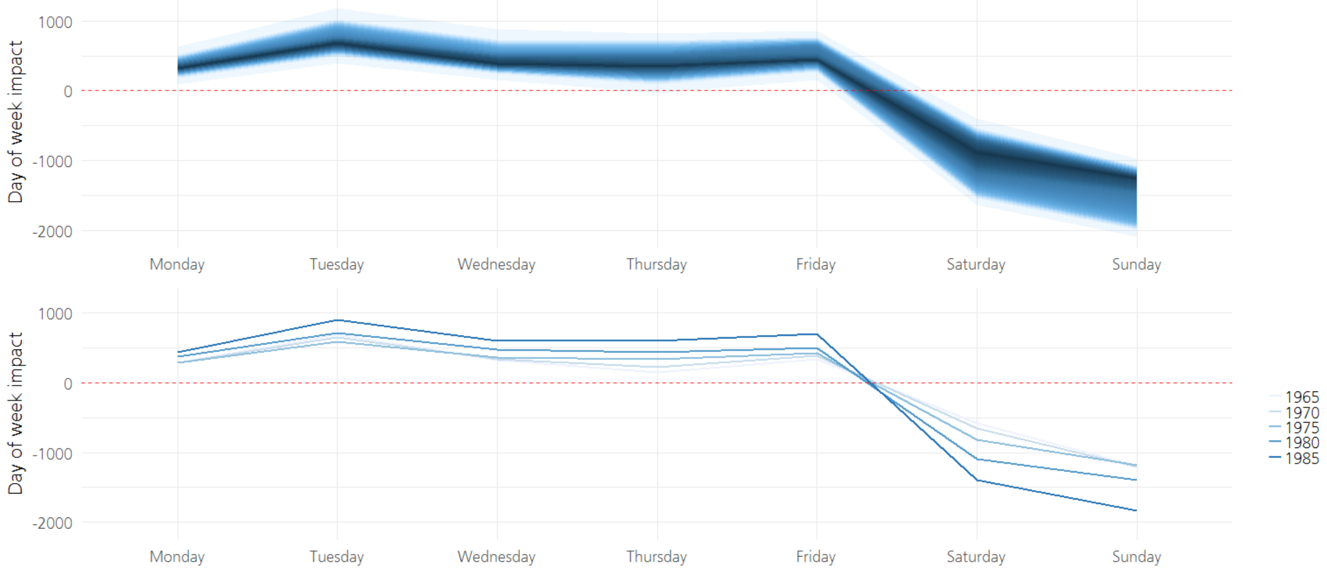
Figure 8: The trend component looks similar to the original timeseries



Source: US Centre for Disease Control, UBS Quant

We show the weekly seasonal component in Figure 9, which indicates a strong weekday effect, with roughly 1,000 fewer births on the weekends. Fewer clinics and doctors are available over the weekends, so deliveries are often scheduled during the week where possible.

Figure 9: The weekday seasonal shows the effect attributable to each day



Source: US Centre for Disease Control, UBS Quant

[21] A similar analysis of this data features in the book *Bayesian Data Analysis* by Andrew Gelman et. al., who rather implemented a Gaussian Process model built using Aki Vehtari's GPstuff framework—but their findings closely match ours

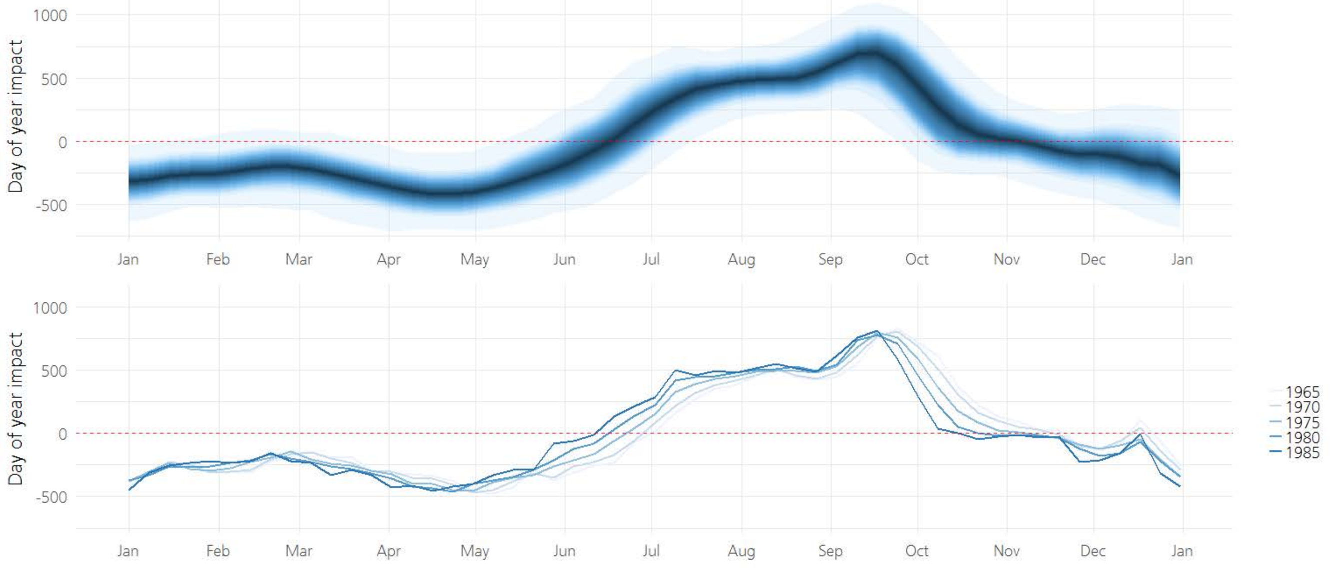
The 'fuzziness' in these charts actually represents the posterior distribution of these parameters from a Monte Carlo estimation process; these can be simply interpreted as the significance of their contribution.

A distribution with significant probability mass near zero indicates that the effect is negligible and of weak statistical power. The lower chart in Figure 9 shows the evolution of this weekday component over time; evidently this weekend effect became stronger near the end of the data set for reasons unknown to us.

We can simply visualise the strength of these effects without resorting to noisy test statistics

Figure 10 below shows the day of year seasonal, *holding the intra-week period as constant*. As expected, this timeseries has a strong annual component; Christmas holidays are a romantic period, which means more births occur in October.

Figure 10: The annual (day of the year) effect is typically the most impactful seasonal component



Source: US Centre for Disease Control, UBS Quant

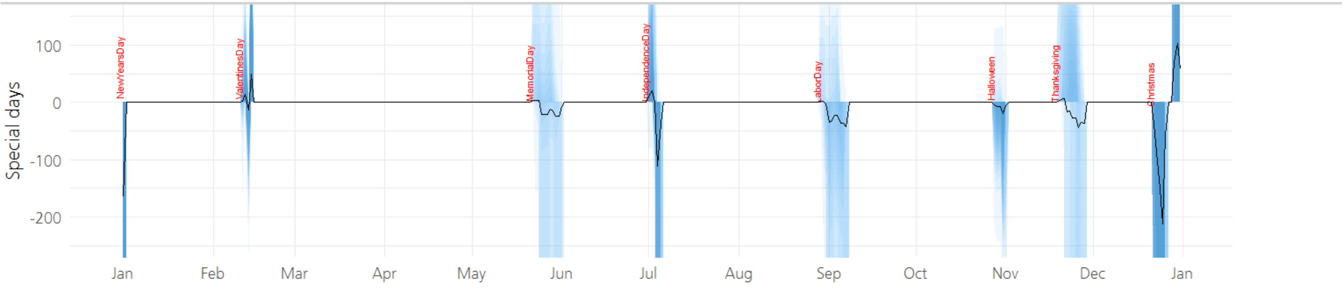
We observe that September is the most common month to be born, as expected; roughly an additional 500 births per day in this month alone. Note the probability mass is significantly removed from the x-axis; indicating the statistical significance of this result.

The *seasonal components sum to zero by definition*; more births in one month means fewer births in another (otherwise this would be accounted for by the trend component).

All seasonal components sum to zero by definition

Figure 11 shows the effect of holidays (special days); some dates are considered inauspicious in the US, eg, Halloween, so births might be delayed when possible. The line shows the average impact associated with the pre-holiday period; the shading represents the uncertainty in this average.

Figure 11: We can also measure the effect of holidays



Source: US Centre for Disease Control, UBS Quant

The model is additive; all the components sum back to the original data (less noise)

Important to note is that the model is additive; the original data is the sum of all these components, minus noise. That is:

Original data = trend + annual seasonal + weekly seasonal + holiday + noise

While unrelated to finance, this data serves as a useful illustrative example of how to interpret the subsequent charts. As will be shown in the following results, many style indices have marginal seasonal components compared to this. If the seasonal effects in financial markets are as weak as the mounting evidence suggests, then it is important we use a technique that is robust to noise, outliers and "p-hacking".

This technique differs from more rudimentary approaches to modelling seasonality, eg, simply taking the average returns by month. Such monthly returns might be confounded with part of a market trend or business cycle we are not interested in; this technique is much more granular and offers an intuitive visualisation of the uncertainty in these parameter estimates.

Results

We now analyse the seasonal components within our daily global factor indices

We now analyse the style indices for many of the most commonly studied factors; these series are cumulative daily price returns quoted in US dollar (currency unhedged), rebalanced monthly, and value-weighted to minimise microstructure effects and reflect more practical trading costs.

- Size = log (small cap / large cap)
- Momentum = log (high 12-1M momentum / low 12-1M momentum)
- Value = log (high trailing Book to Price / low trailing Book to Price)
- EPS Revisions = log (high 3M EPS revisions/low 3M EPS revisions)
- Volatility = log (high 52W daily return volatility / low volatility)

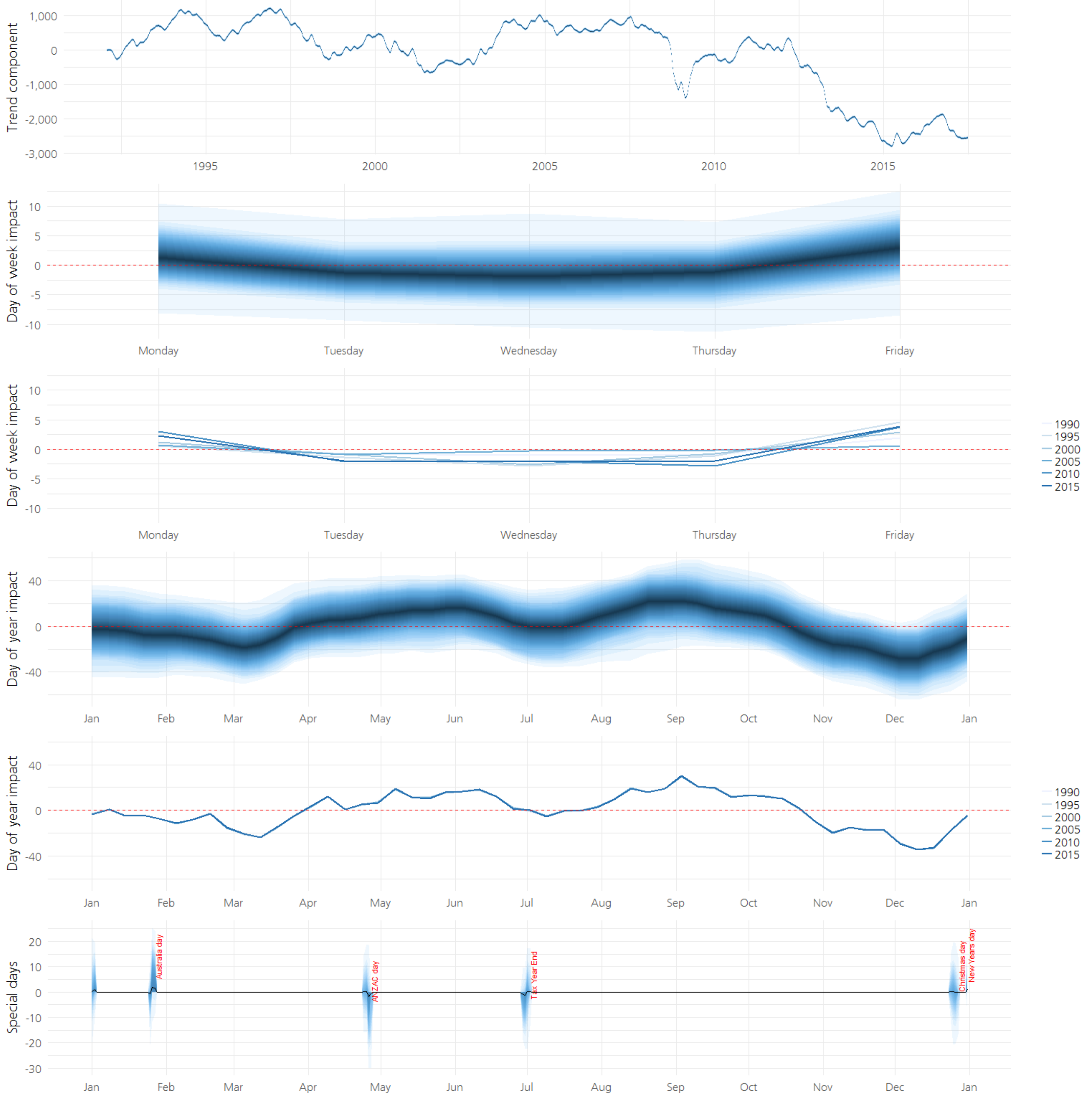
These style returns are the log ratio of the high/low factor baskets as specified, expressed as basis points (x100 x100). Thus the y-axis of a seasonal component quoted as +50bps actually has an impact of $10^{50/(100\times100)}$, ie, a 1.2% increase in the nominal ratio of these high/low baskets. The scales are otherwise comparable across all the charts; the weekday and holiday effects are generally an order of magnitude less impactful than the annual effects in general.

S&P/ASX 300: Size

Brown et. al. (1983) found evidence of both a December-January and July-August seasonal effect within the Australian stock market. Our findings largely concur with theirs; over the ASX 300 we see small caps sell off into the July tax year-end, then outperform again in August to the tune of 20bps. However the December-January seasonal effect is much more muted; December (the Australian summer) invokes strong underperformance that extends into the calendar 2Q; it is difficult to imagine that seasonal affective disorder plays a role in this.

Australian small caps show a strong tax year-end seasonal effect

Figure 12: ASX 300 small caps vs large caps



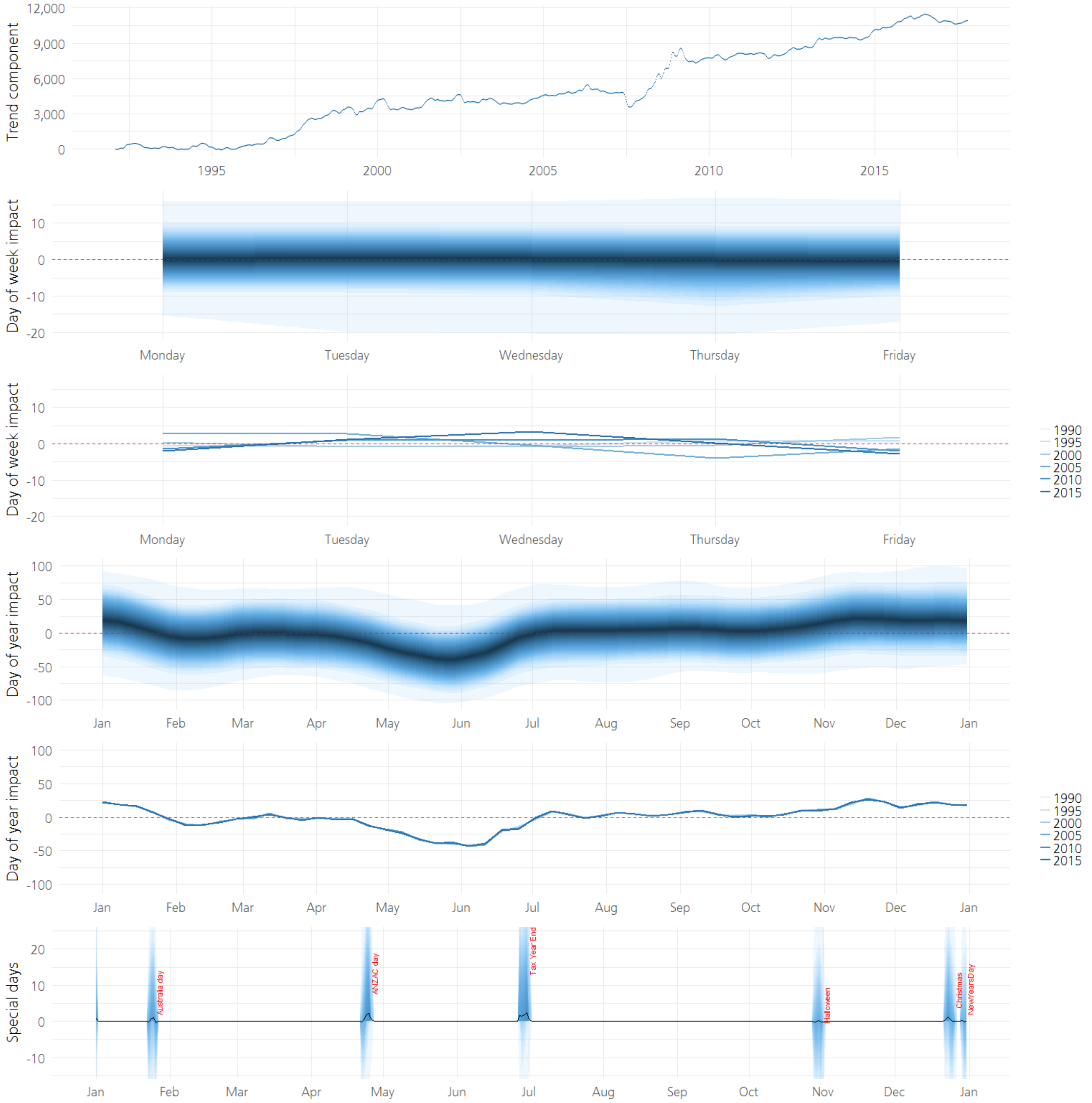
Source: S&P/ASX, Factset, UBS Quant

S&P/ASX 300: Momentum

Momentum is empirically a strongly performing factor in Australia[22]. However, this factor has minimal seasonal components; the weekday momentum component is admirably flat, showing inconsistent contributions over time, but overall negligible. Nonetheless, there is a moderate annual seasonal effect showing high momentum styles are discounted 30bps around the turn of June, which then disappears into the new fiscal year. This difference in the July/June seasonal effect would present itself as a positive return month on month, all else being equal.

There is also modest momentum seasonality coincident with the tax year-end

Figure 13: ASX 300 high momentum vs low momentum



Source: S&P/ASX, Factset, UBS Quant

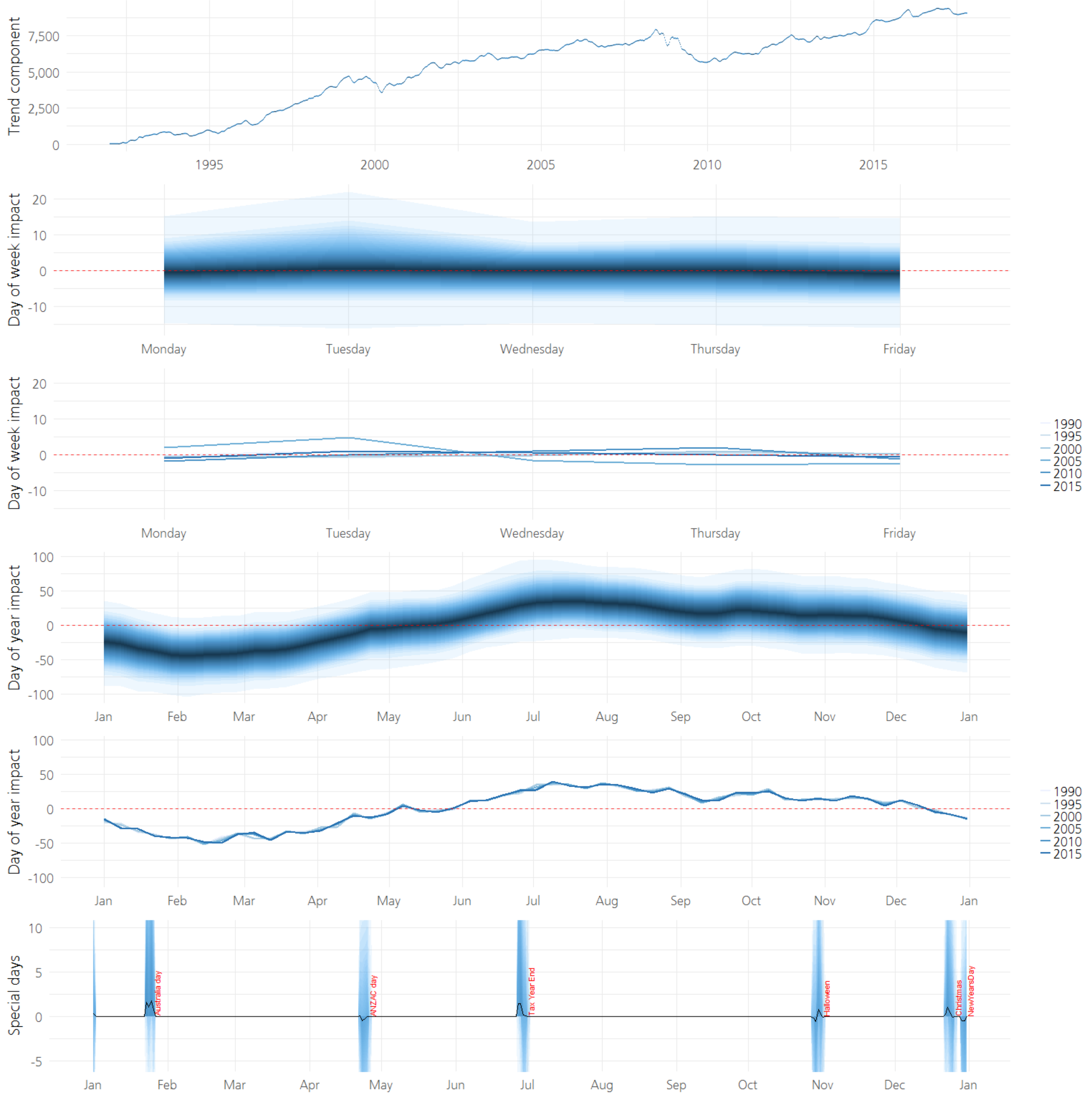
[22] See our report, [How to beat the market in Australia]() (18 September 2017)

S&P/ASX 300: EPS revisions

S&P/ASX 300 earnings revisions show a strong annual seasonal pattern; for the first half of the calendar year it strongly underperforms, before peaking following the fiscal year-end in July. We see a possibility that a potential source of this seasonal effect is the increasing visibility into earnings after the fiscal year-end (ending June). While this hypothesis is not validated by the presence of a similar seasonal anomaly in earnings revisions in other regions, Australian companies are somewhat unique in that they typically report semi-annually, making a direct comparison difficult.

Seasonal anomalies in earnings revisions might arise from the earnings calendar

Figure 14: ASX 300 EPS revisions



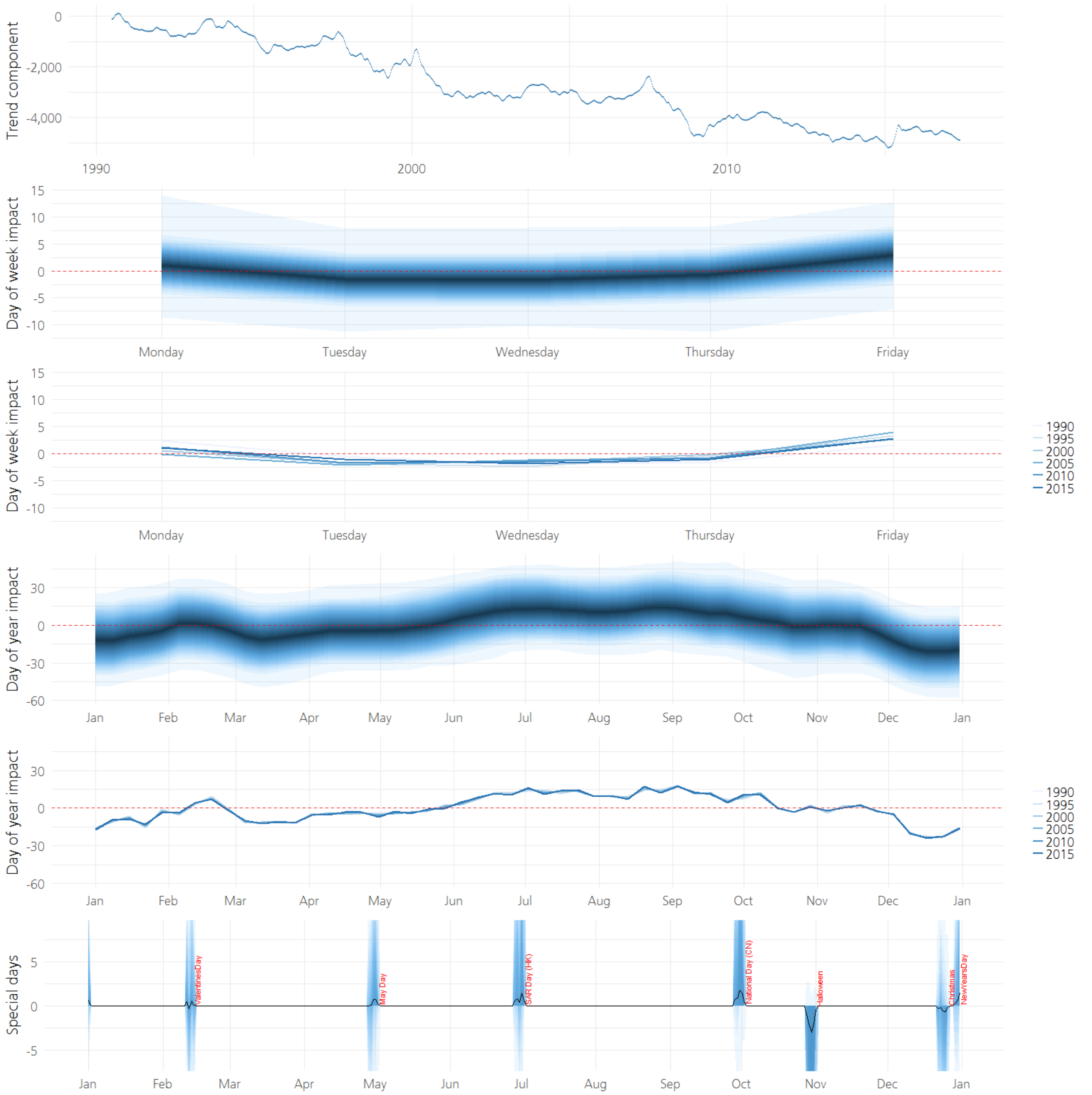
Source: S&P/ASX, Factset, UBS Quant

MSCI Asia ex-Japan: Size

Breaking from a strong seasonal presence in other regions, Asia ex-Japan small versus large caps is an underwhelming non-result. Although there is a familiar indication of a weekday effect common across most other markets (small caps outperform on Friday, and underperform mid-week), the annual seasonal component is weak enough to not exist at all. However MSCI Asia ex-Japan is a very lopsided index, dominated by China (H shares), and even within China, financials and information technology dominate the country representation. No other regional index analysed has this little breadth in it, which perhaps provides some explanation as to why the seasonal affects are minimal in the headline index.

Asia ex-Japan small caps indicate practically no seasonality

Figure 15: MSCI Asia ex-Japan small caps vs large caps



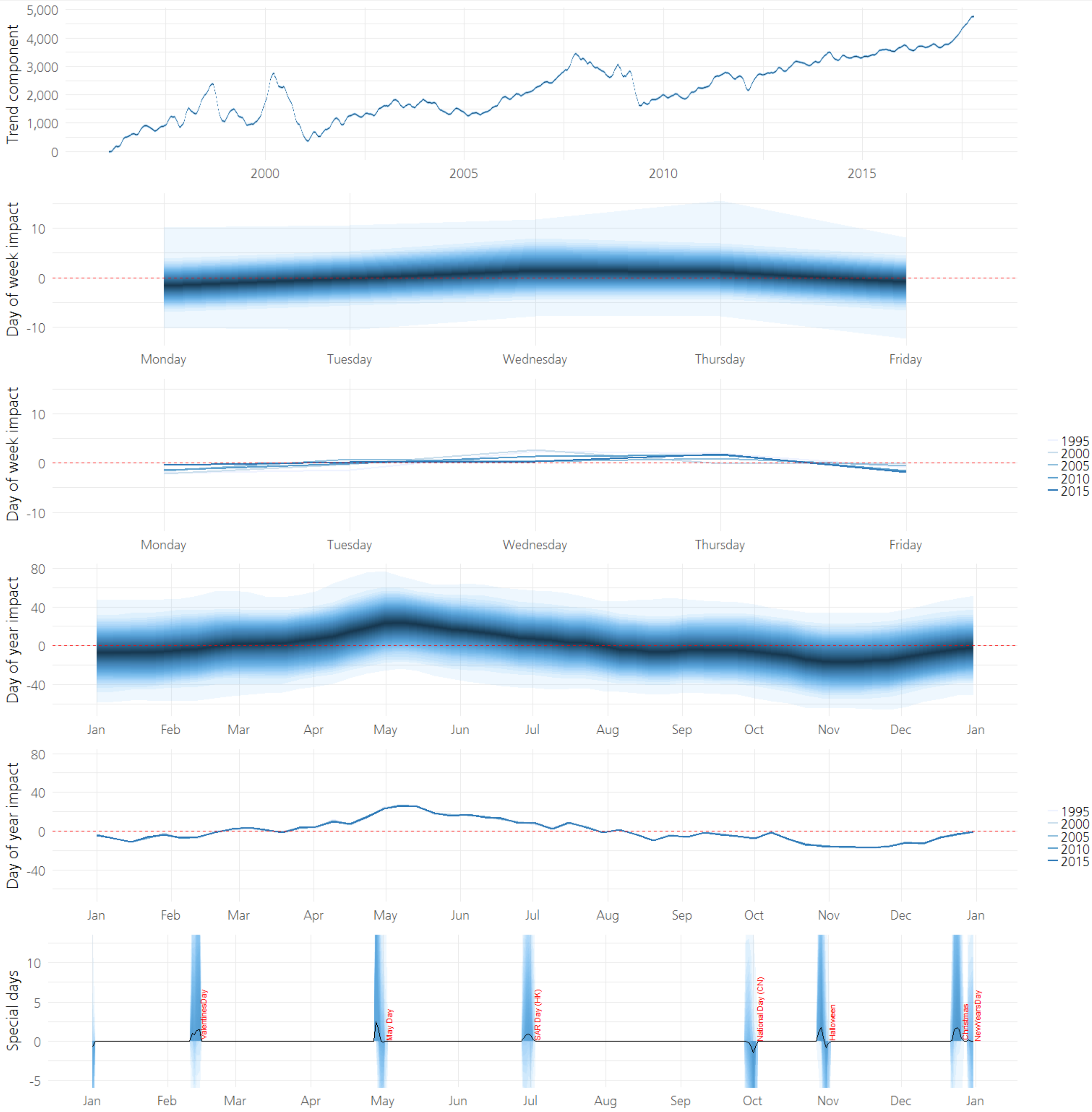
Source: MSCI, Factset, UBS Quant

MSCI Asia ex-Japan: Momentum

Another underwhelming seasonal result appears in the Asia ex-Japan momentum strategy, despite the impressive performance of this strategy over the past 20 years. Neither the weekday nor annual components are sufficiently removed from zero to indicate they exist at all. We do note a small seasonal uplift at the start of May; however, the posterior median is barely 20bps, with significant probability mass around zero. The first of May is Labour Day, as celebrated throughout Asia (and almost everywhere else globally), but the explicit holiday has little attributable effect; perhaps 2bps (which is comparable with the largest holiday effects globally).

Asia ex-Japan momentum also indicates essentially no seasonal influences

Figure 16: MSCI Asia ex-Japan high momentum vs low momentum



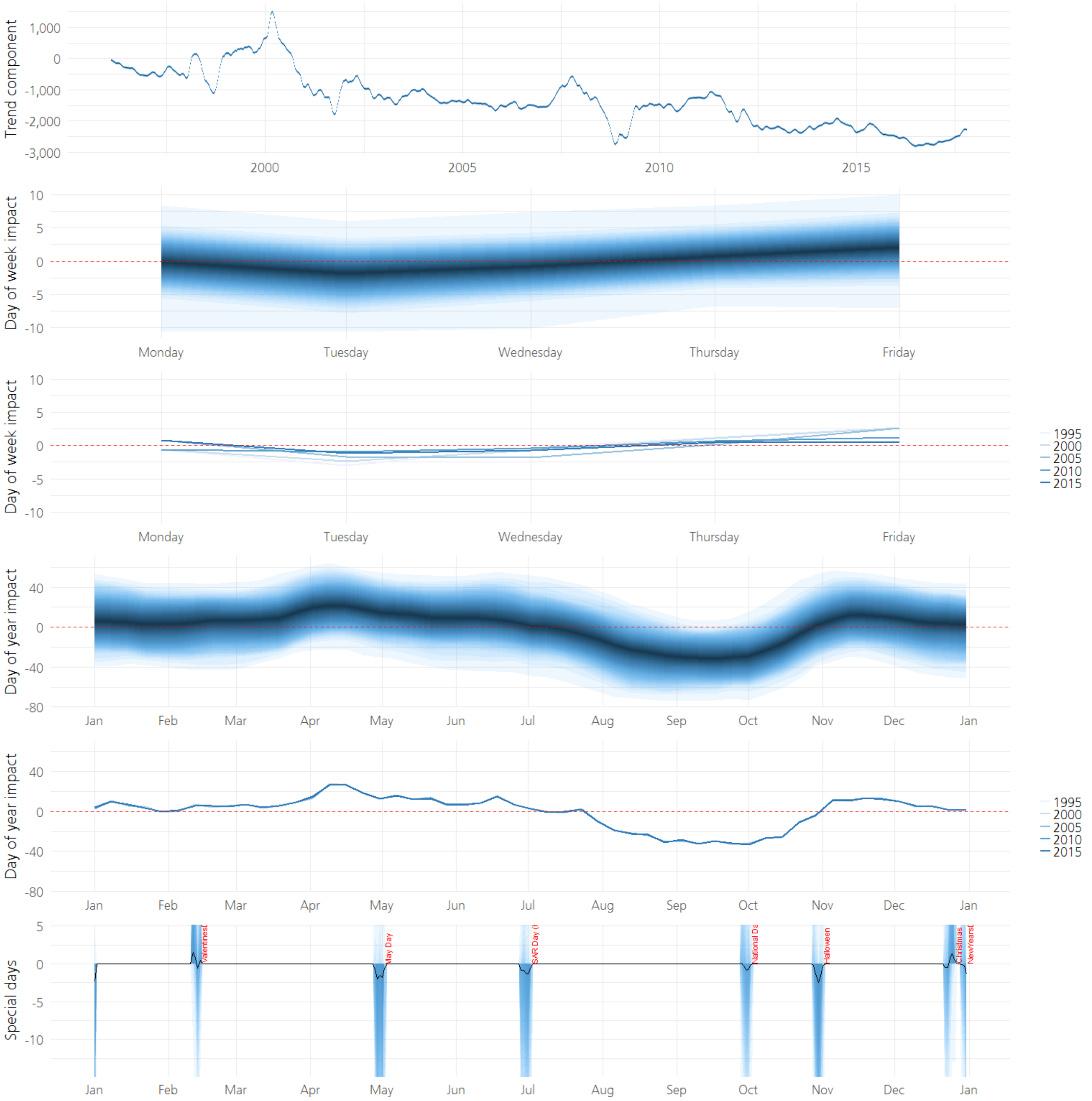
Source: MSCI, Factset, UBS Quant

MSCI Asia ex-Japan: Low volatility

A much stronger seasonal effect appears within Asia in the low volatility style. Q3 of the calendar year is associated with a strong decline in performance for low volatility stocks; roughly 40bps of underperformance is attributable to this month alone. There is no obvious explanation for this effect; while mid-Autumn festival is widely celebrated throughout Asia around this time, there is no comparable effect around Chinese New Year, which is arguably more culturally significant. Although it is missing from our current model, further refinements of the timeseries model will incorporate the lunar New Year calendar typically used in Chinese holidays.

Asia ex-Japan has a modest depressed appetite for volatility in the calendar 3Q

Figure 17: MSCI Asia ex-Japan low volatility vs high volatility



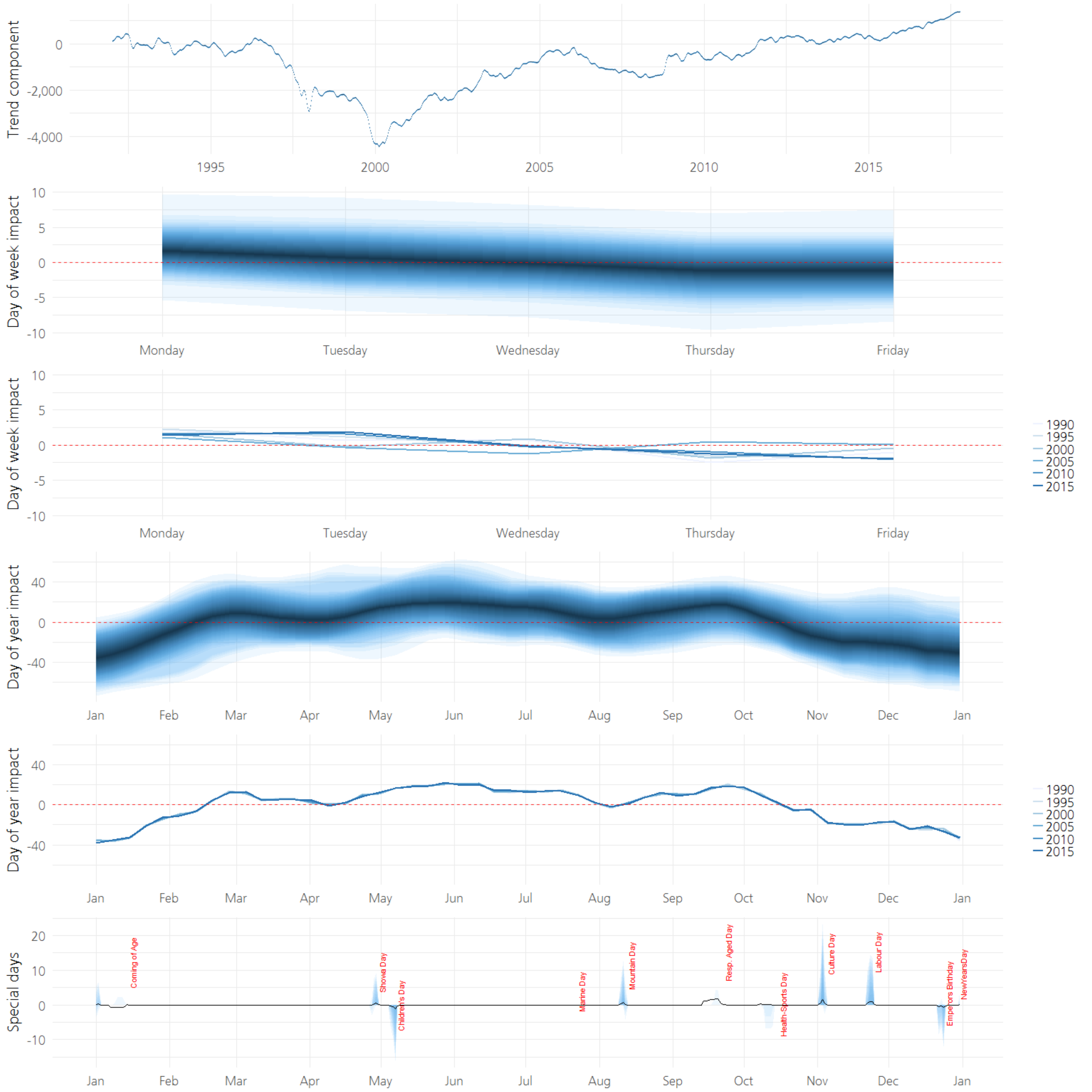
Source: MSCI, Factset, UBS Quant

TOPIX: Size

Japan is ever the exception to the rule; although the performance of small caps has vastly exceeded that of large caps over recent history (the converse of the Asia ex-Japan result), the weekday effect in Japan also stands in contrast to every other market we analyse; small caps marginally underperform later in the week, ie, there is no weekend effect. Agrawal and Tandon (1994) also found evidence of a weekday effect in rather the market indices in Japan[23], whose results concur with these.

There is no weekend effect in Japan; however small caps underperform around year-end

Figure 18: TOPIX small caps vs large caps



Source: TSE, Factset, UBS Quant

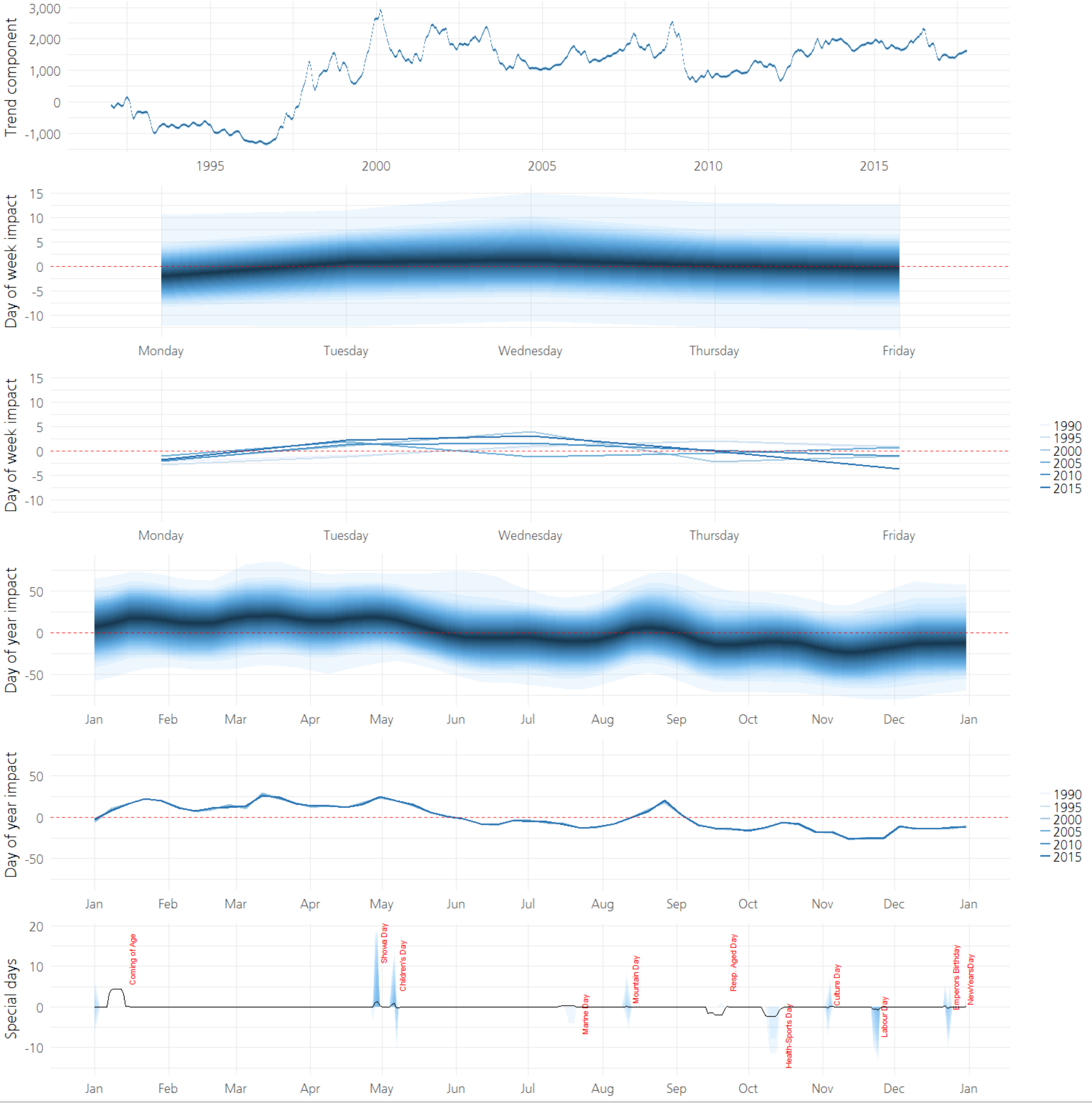
[23] As measured by an F-test of equality in weekday returns

TOPIX: Momentum

The failure of momentum in Japan is a well-known enigma; the underperformance of this strategy stands in contrast to almost every other market in the world and seemingly challenges the confidence investors have in this strategy[24]. Unfortunately our seasonal findings shed no further light on this puzzle; there is no discernible weekday pattern evident whatsoever, and the annual effect is sufficiently weak as to not exist at all, yet again. There is perhaps a slight positive uplift during the first half of the calendar year (negative in the second), but it is very slight.

Seasonal explanations shed no further light on the Japan momentum puzzle

Figure 19: TOPIX high momentum vs low momentum



Source: TSE, Factset, UBS Quant

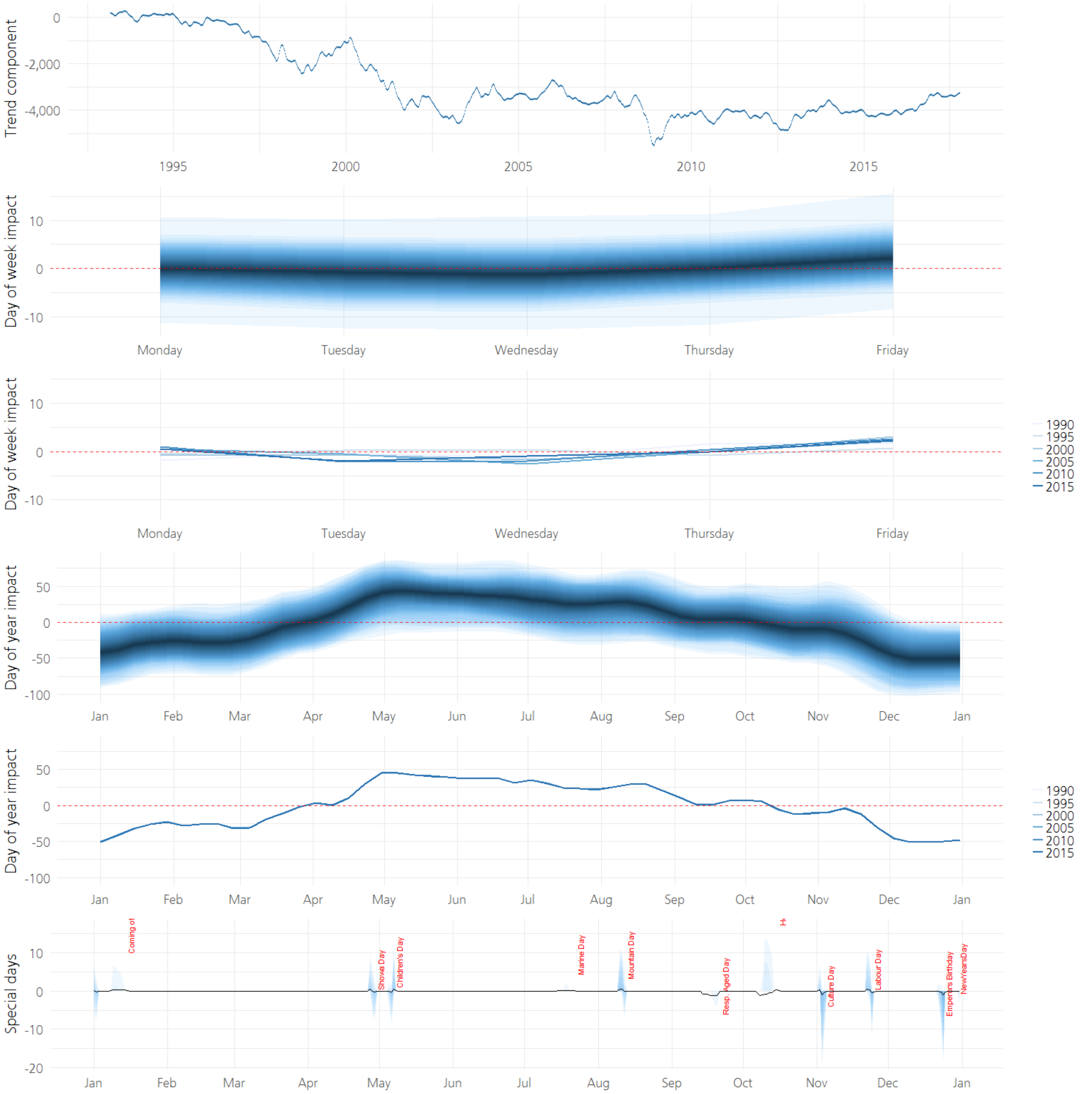
[24] Asness, Moskowitz, Pedersen (2010), Fama, French (2010), Griffin, Ji, Martin (2003)

TOPIX: Low volatility

One of the strongest results in our global analysis is the seasonal anomaly of low volatility in Japan. This indicates a significant turn-of-the-year effect, with almost 50bps of underperformance of low volatility stocks in January, which increases to rather a 50bps premium during Golden Week (roughly a week of national holidays clustered together at the start of May). Both Golden Week and the calendar New Year are culturally significant events in Japan; it is not unreasonable to think these influence volatility, as a proxy for investor risk appetite. This peak-trough impact is roughly 100bps in the log ratio, or 2.3% percent in the original index ratio.

Japan has a significant low volatility effect at the turn of the year, and into Golden Week

Figure 20: TOPIX low volatility vs high volatility



Source: TSE, Factset, UBS Quant

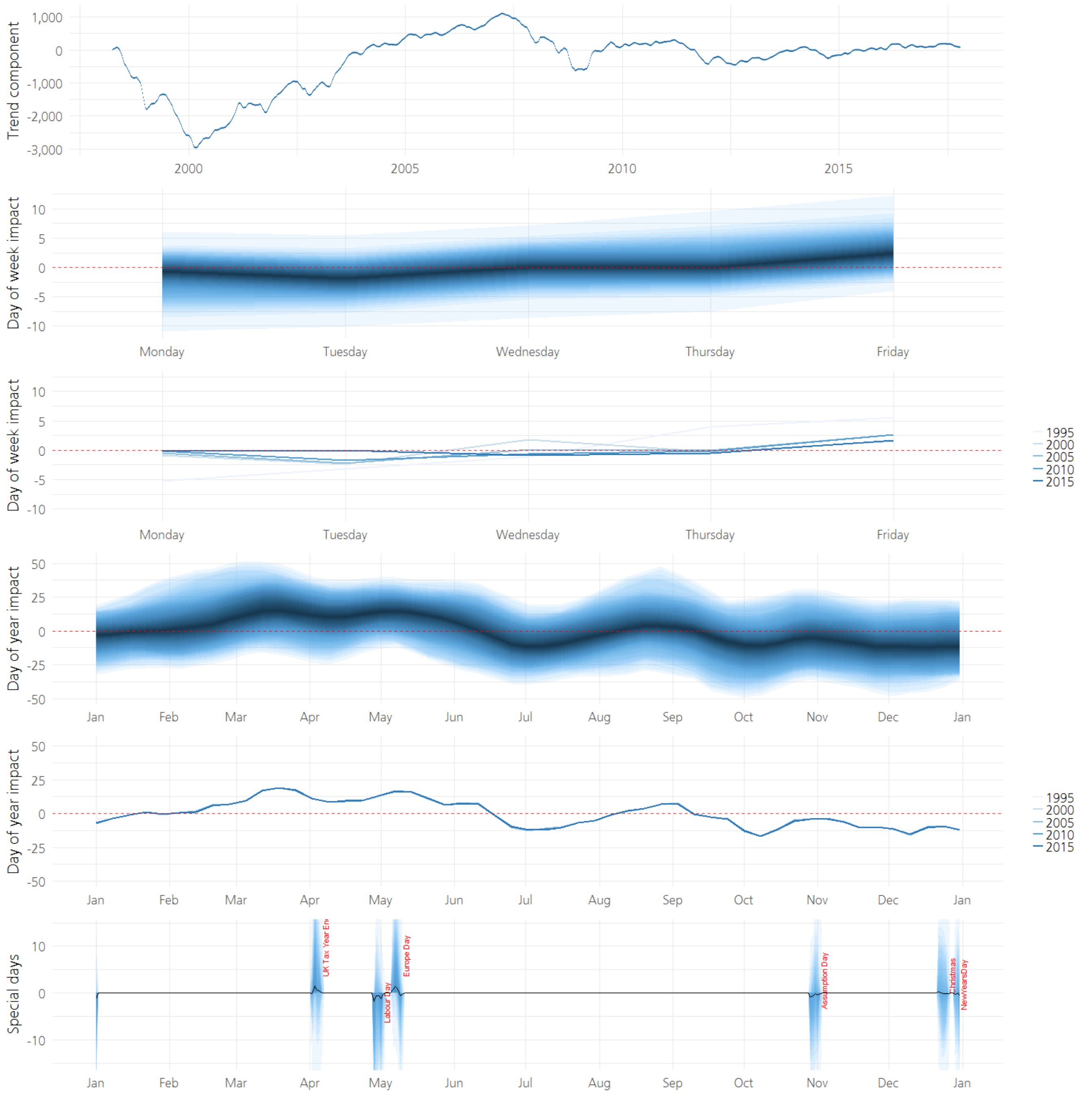
MSCI Europe: Size

MSCI Europe small versus large caps evidently have weak annual seasonal components; perhaps this is not surprising given the 15 distinct countries represented within this index. We might expect that all these seasonal patterns are more pronounced at the country level; different fiscal year-ends and taxation schemes, cultural drivers, weather patterns and economic cycles all tend to muddy the seasonal explanations offered in the literature.

Europe has weak seasonal components, perhaps due to the homogeneous index constituents

The weekday effect shows a familiar upward contribution on Friday and a negative contribution on Tuesday, which is common amongst the size factor throughout global markets, albeit very marginally.

Figure 21: MSCI Europe small caps vs large caps



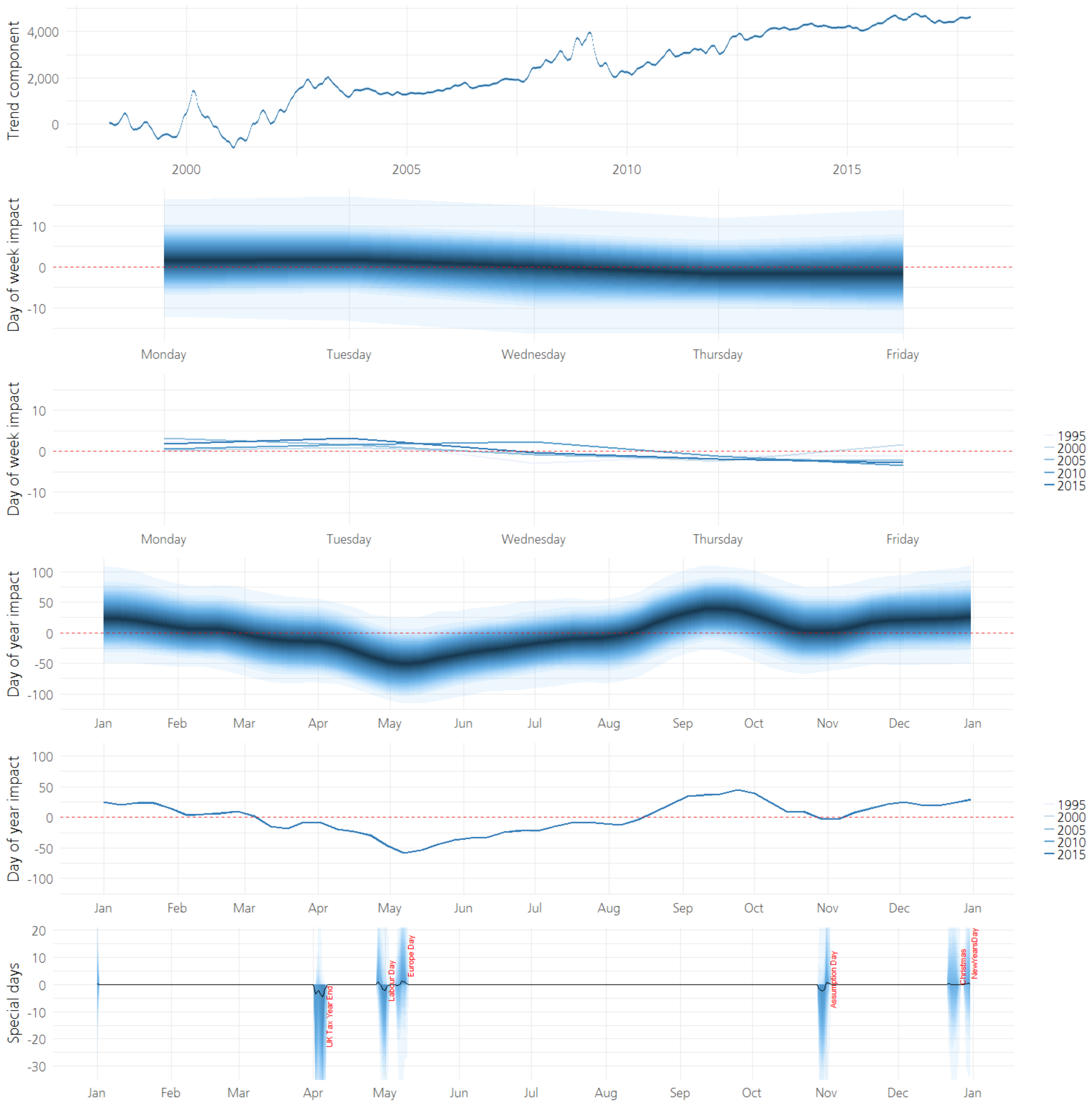
Source: MSCI, Factset, UBS Quant

MSCI Europe: Momentum

Pursuing a (long high)/(short low) momentum strategy in Europe has clearly performed well overall, with some modest bi-annual seasonal components evident. January and September indicate strong momentum outperformance; these peaks are largely coincident with the seasonal effect seen in MSCI Europe ROE, however (Figure 23). Given that momentum itself is essentially the shadow of another factor this may indicate that the 'purer' source of this seasonality is driven by a seasonal demand for highly profitable companies instead.

Momentum also appears weak; though it is coincident with the ROE seasonal effects

Figure 22: MSCI Europe high momentum vs low momentum



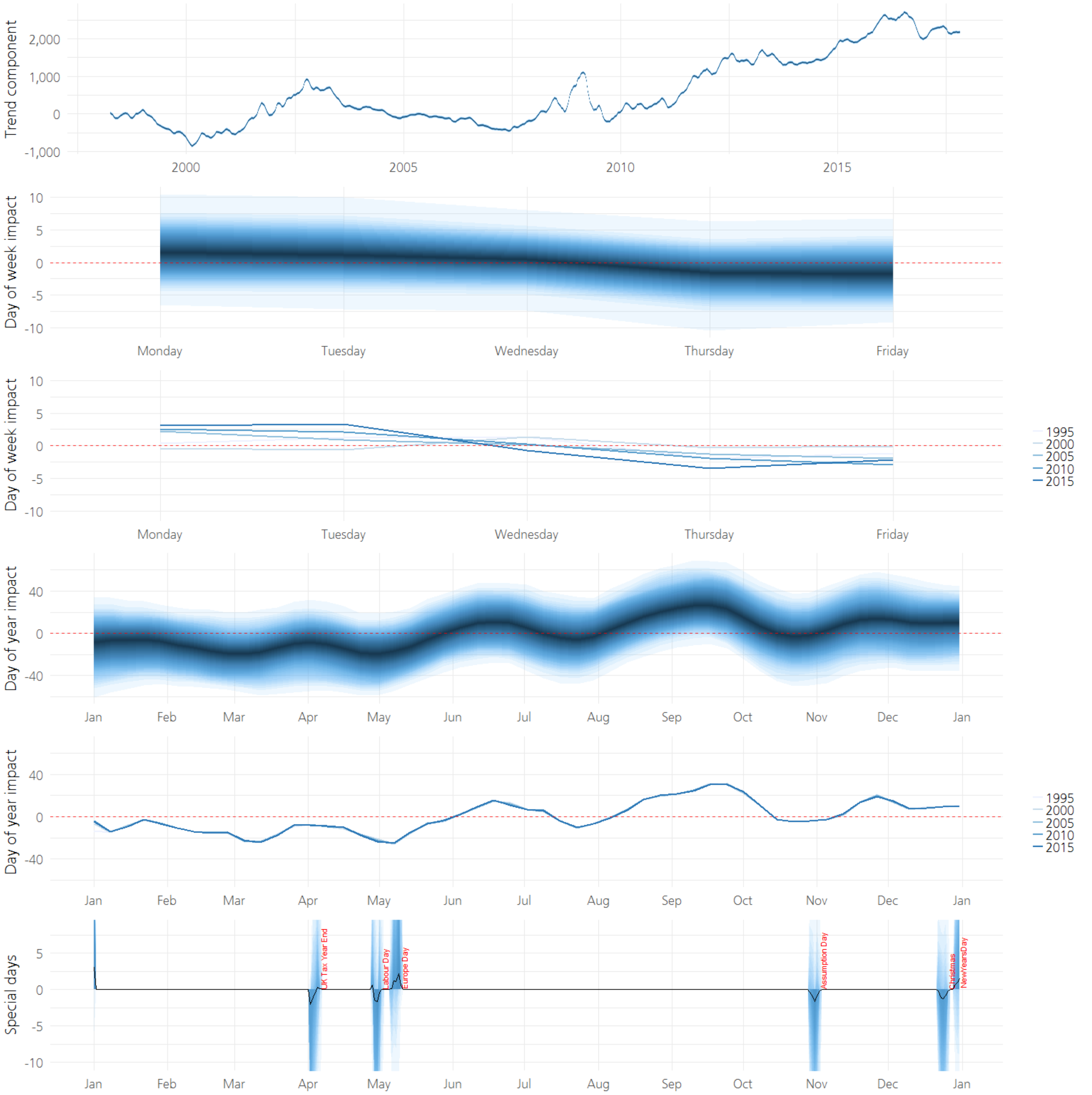
Source: MSCI, Factset, UBS Quant

MSCI Europe: ROE

The day-of-the-week effect here again seems consistent with the notion of risk aversion during the earlier part of the week; if we consider high ROE as a crude proxy for quality, this pattern is consistent with the premium to small caps, high volatility, and negative earnings revisions stocks globally near the end of the week.

A modest annual seasonal appears in Europe ROE; the weekday effect is consistent with global findings on risk aversion

Figure 23: MSCI Europe high ROE vs low ROE



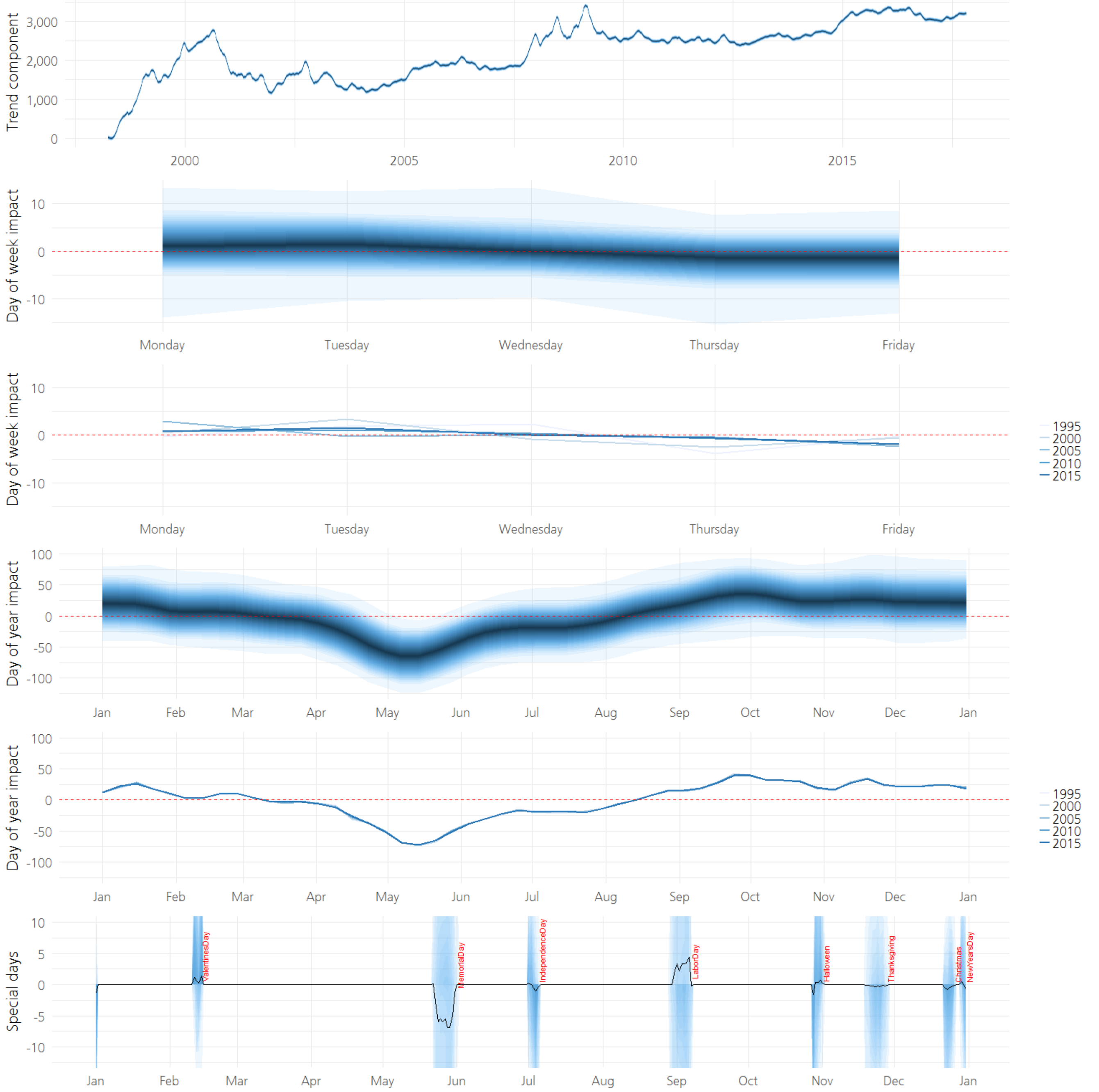
Source: MSCI, Factset, UBS Quant

MSCI US: Earnings revisions

Coincidentally, one of the strongest seasonal findings in our analysis exists in what is arguably the most widely studied and most efficient market globally, the US. Earnings revisions have trended very strongly in the early history of this data but are less effective now; however the seasonal component to this trend indicates almost a -100bps impact in May (-2.3% impact in the index ratios). We expect that there should be a strong seasonal component present from our earlier finding that analyst errors contained seasonal components (Figure 4).

MSCI US shows some of the most significant annual seasonal effects, surprisingly

Figure 24: MSCI US high earnings revisions vs low earnings revisions



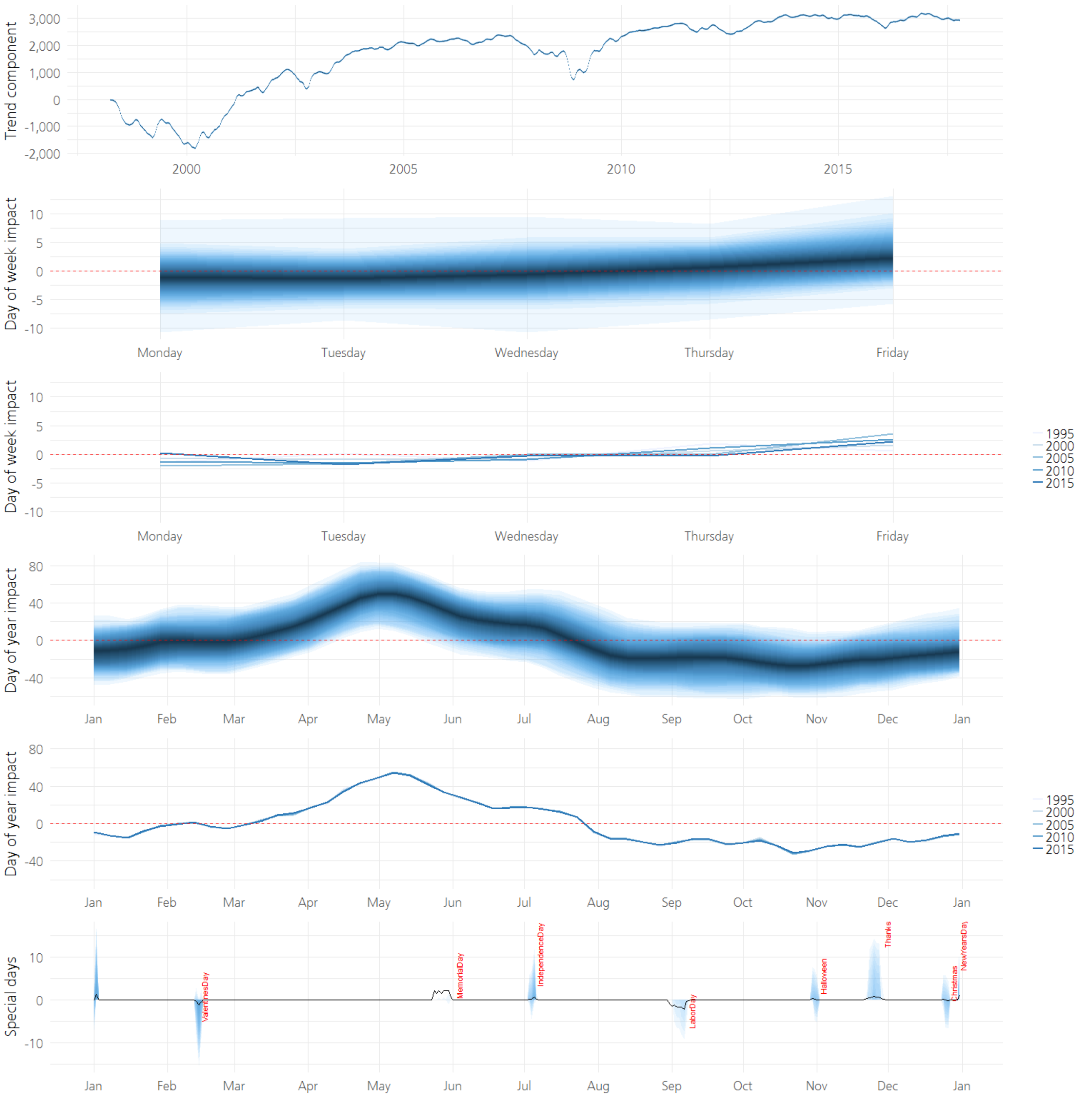
Source: MSCI, Factset, UBS Quant

MSCI US: Size

MSCI US is perhaps not the conventional index in the US, but it closely reflects the more common S&P 500 (about 85% of the total market cap, value-weighted, free float-adjusted). Consistent with the findings in the rest of the world, we observe a small cap weekday effect near the end of the week. However the small cap effect in May is significant, with an attributed 50bps of small cap outperformance around this month alone. The old adage "sell in May and go away" might have held up for the broad market index, but US investors would do well to tilt into small caps instead (rather, the small end of the relatively large-cap MSCI US).

Sell small caps into the end of the week; sell small caps into the start of May

Figure 25: MSCI US small caps vs large caps



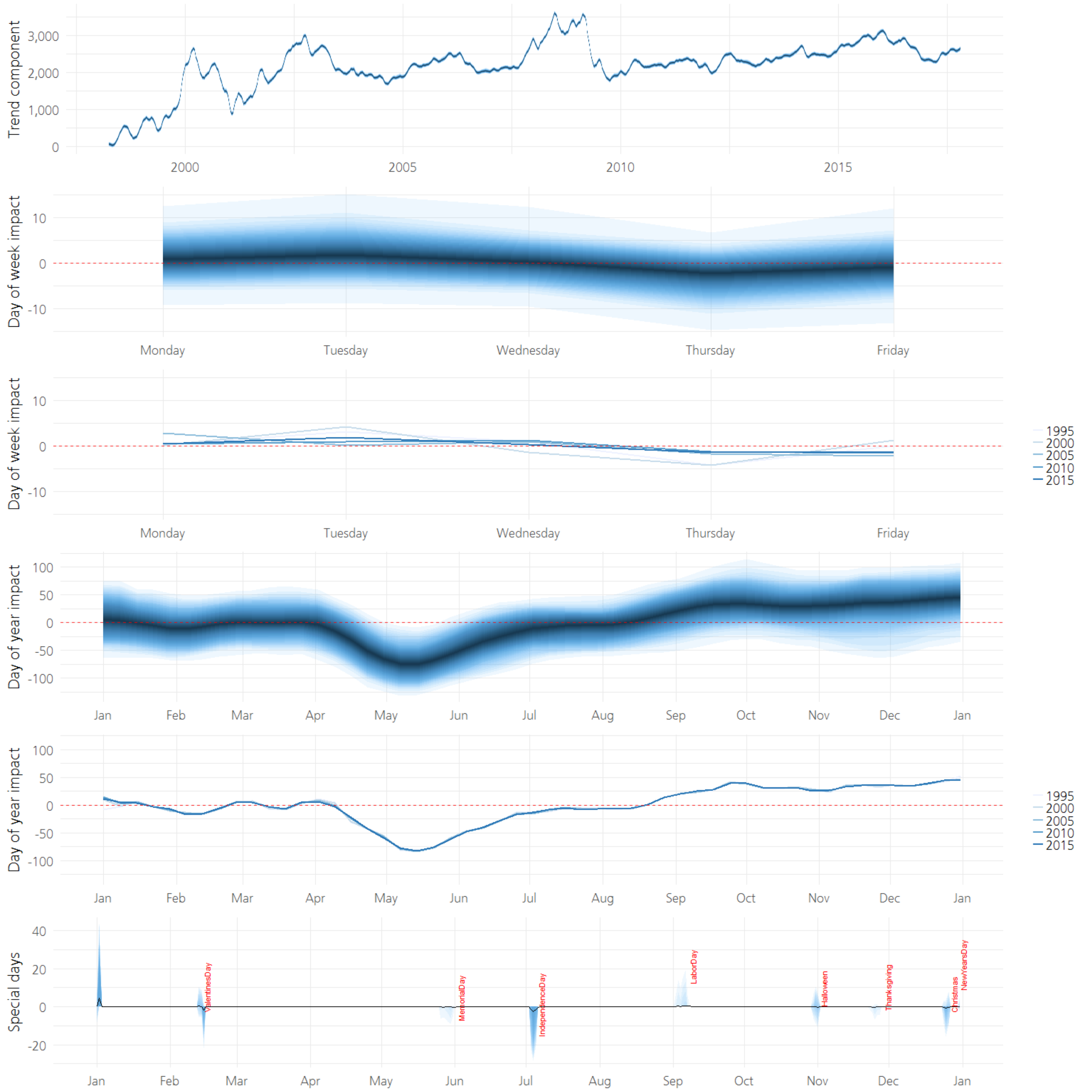
Source: MSCI, Factset, UBS Quant

MSCI US: Momentum

Another strong May seasonal emerges in the 12-month price momentum within MSCI US; this finding is one of the most significant results in our global analysis; perhaps -75bps of underperformance is attributable to the month of May alone. Thus "sell in May and go away" might be more aptly named "sell momentum and EPS revisions, and buy small caps in May, then go away". There is negligible impact to the weekday within this data set also.

Sell momentum and EPS revisions and buy small caps in May, and then go away

Figure 26: MSCI US high momentum vs low momentum



Source: MSCI, Factset, UBS Quant

Conclusion

Our results do not revolutionise the existing literature on seasonality, but this is the first application of a structural timeseries model to jointly estimate multiple seasonal components and holiday effects, to our knowledge.

The first application of a structural timeseries model to estimate seasonality, to our knowledge

The earliest work in this space (equal-weighted versus cap-weighted findings), could be considered as a crude proxy for the explicit style returns we consider in this report. Note that the academic literature in seasonality dates back almost 90 years; these effects and our results have persisted truly out-of-sample since this time.

There are many potential sources of seasonality that might arise inadvertently; we believe the lack of a rigorous theoretical model is neither possible nor necessary for investors to exploit these anomalies—analogous to price momentum. Our results and intuition suggest that seasonal influences are more pronounced at the country level: varying fiscal year-ends, taxation schemes, cultural drivers, weather patterns, economic cycles, etc, are all locally motivated explanations.

Robust empirical anomalies are sufficient for investors to exploit; they need not seek a higher truth

Trading costs are often cited as impediments to exploiting such effects in practice. We do not propose the implementation of a purely seasonal strategy; however the gains to successfully modelling seasonal effects are too significant for investors to ignore, in our opinion.

We do not propose implementing a purely seasonal strategy, of course

We believe the robustness of this technique and the statistical and economic significance of our findings *make a compelling case for the incorporation of seasonal tilts into a tactical style allocation*; we think investors can both lower turnover and enhance returns by expediting a buy trade that is depressed by a seasonal effect, or postponing selling a position if an upcoming seasonal uplift exists, for example.

Rather, the incorporation of seasonal tilts into to a tactical style allocation process

Statistical significance is a far lower hurdle than economic significance; we have intentionally avoided citing statistical tests as the litmus test of how meaningful these results are; our future work will likely extend this model to enrich a style allocation model with a seasonal overlay with trading costs. Nonetheless, our results indicate some useful takeaways for investors to consider immediately:

Statistical significance is a far lower hurdle than economic significance

1) Markets show a globally consistent pattern of risk aversion mid-week, and risk-seeking near the end of the week (Japan excluded). This seemingly exists across all conceivable proxies for risk: low ROE, small capitalisation, high volatility and low momentum strategies all exhibit this effect, albeit at marginal significance.

Sell risk into the end of the week

2) Annual seasonal effects are roughly an order of magnitude larger than the weekday effect, but vary significantly from region to region. Buy small caps, sell low momentum and negative revisions ahead of May in the US; buy Japanese low volatility in January, sell it following Golden Week; buy high EPS revisions after 1H earnings in Australia; sell low volatility ahead of 3Q in Asia ex Japan.

Annual seasonal effects are much larger but vary from country to country

If you would like to see our analysis of another style index or any of our in-house timeseries, please feel free to get in touch.

Appendix

Bayesian structural timeseries models

Turn to the back of most timeseries textbooks and you will likely see a chapter on structural timeseries models; essentially just an alternative representation to the ubiquitous autoregressive integrated moving average (ARIMA) models. Despite their difference in outward appearances, these are very closely related. All ARIMA models have a state space representation and if you actually estimate an ARIMA model using R, it will be represented in state space form internally.

The ARIMA approach has several fundamental weaknesses that make a structural representation more appealing, in our opinion. While ARIMA models are extremely flexible, this is their curse, as there are practically countless permutations of such models that can fit the (often very limited) data, well. State-space models do not suffer from the tortured ritual of differencing data until it becomes unintelligible, they can handle missing values cleverly, and adapt to changing dynamics of a data generating process rather than rigidly adopting a single parametrisation.

Most importantly, these models are transparent, modular and intuitive. The benefit of more sophisticated techniques is arguably lost if the intuition falls apart; these models provide a natural way to combine domain knowledge within a powerful framework.

There are many packages for implementing structural timeseries models in R; we adopt the excellent implementation in the Bayesian structural time series (BSTS) package. Many other techniques also exist for decomposing timeseries into their seasonal components, for example, the seasonal and trend decomposition using loess (STL) procedure[25] is very flexible and commonly used. However this technique cannot handle multiple seasonal components, missing values, holiday effects or trading day effects, which all arise in this setting. STL is a nonparametric, ie, model-free technique, meaning that essentially no domain knowledge can be applied so the modelling process is fundamentally less rich and insightful.

The model we estimate, eg, for our small/large cap daily indices is as follows:

$$y_t = log_{10}(small_t \,/ large_t) = \mu_t + \gamma_t^A + \gamma_t^W + \varepsilon_t \;\; , \varepsilon_t \sim N(0, \sigma^2)$$

$$\begin{aligned} \mu_{t+1} &= \mu_t + \delta_t + \zeta_\mu && \zeta_\mu \sim N(0, \tau_\mu^2) \\ \delta_{t+1} &= \kappa + \rho \cdot (\delta_t - \kappa) + \zeta_\delta && \zeta_\delta \sim N(0, \tau_\delta^2) \\ \gamma_t^A &= \sum_{j=1}^{52-1} \gamma_{[t\,/\,5]-j}^A + \eta_{[t\,/\,5]}^A && \eta_t^A \sim N(0, \tau_{\eta,A}^2) \\ \gamma_t^W &= \sum_{j=1}^{5-1} \gamma_{t-j}^W + \eta_t^W && \eta_t^W \sim N(0, \tau_{\eta,W}^2) \end{aligned}$$

Where μ_t denotes the level expressed as a random walk, δ_t denotes the trend, that varies as an AR(1) model centred on κ with the autoregressive parameter ρ; σ^2 is the variance of the observation error. The seasonal dummy variables γ_t^A and γ_t^W capture annual and weekday effects with corresponding variances $\tau_{\eta,A}^2$, and $\tau_{\eta,W}^2$, respectively.

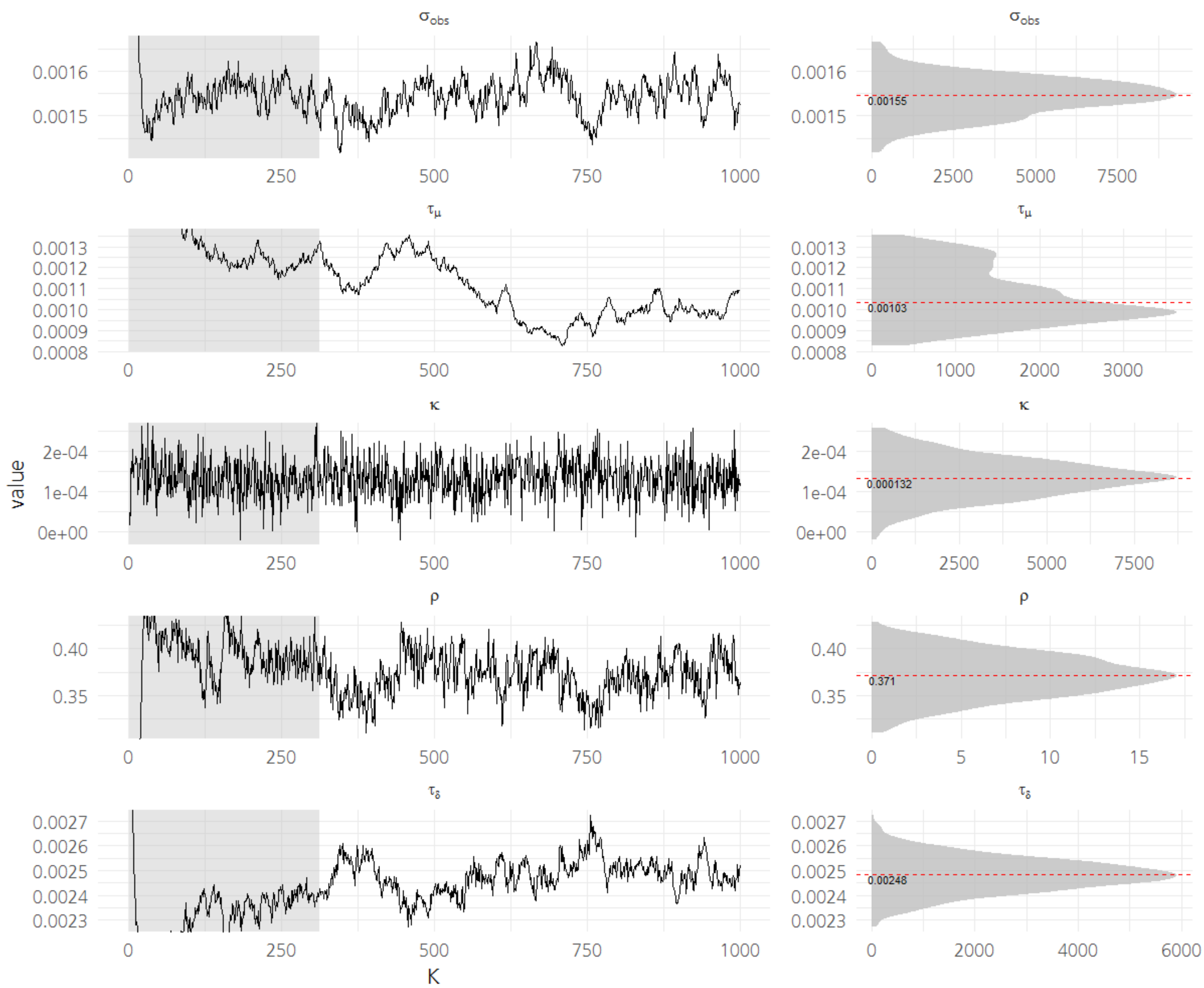
The parameters can be estimated using maximum-likelihood, as is implemented in many packages in R; however the BSTS package uses a Bayesian process (Markov

[25] Cleveland (1979)

chain Monte Carlo, or MCMC), by which we can observe the full posterior distribution of the parameters, as the figures show throughout the report. Philosophically we do not agree with the fixation on test statistics, rather than maintaining some intuition behind the estimation process.

Figure 27 below shows the successive draws from the MCMC process, which we think is a useful diagnostic for evaluating the appropriateness of the model and proper functioning of the sampler.

Figure 27: The parameter draws from the Markov chain typically show good mixing (here ASX 300 EPS revisions)



Source: UBS Quant

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Valuation Method and Risk Statement

Our quantitative models rely on reported financial statement information, consensus earnings forecasts and stock prices. Errors in these numbers are sometimes impossible to prevent (as when an item is misstated by a company). Also, the models employ historical data to estimate the efficacy of stock selection strategies and the relationships among strategies, which may change in the future. Additionally, unusual company-specific events could overwhelm the systematic influence of the strategies used to rank and score stocks.

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Buy	FSR is > 6% above the MRA.	45%	26%
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Sell	FSR is > 6% below the MRA.	16%	11%
Short-Term Rating	**Definition**	**Coverage[3]**	**IB Services[4]**
Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 30 September 2017.
1:Percentage of companies under coverage globally within the 12-month rating category.
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