



#02

2nd issue 2019

**A factor-based
approach to
diversifying oil
exposure**

China's lower-tier cities stepping up to fuel China's consumption upgrade

Patent data as a driver of equity returns

How can fixed income factors help investors with allocation decisions?

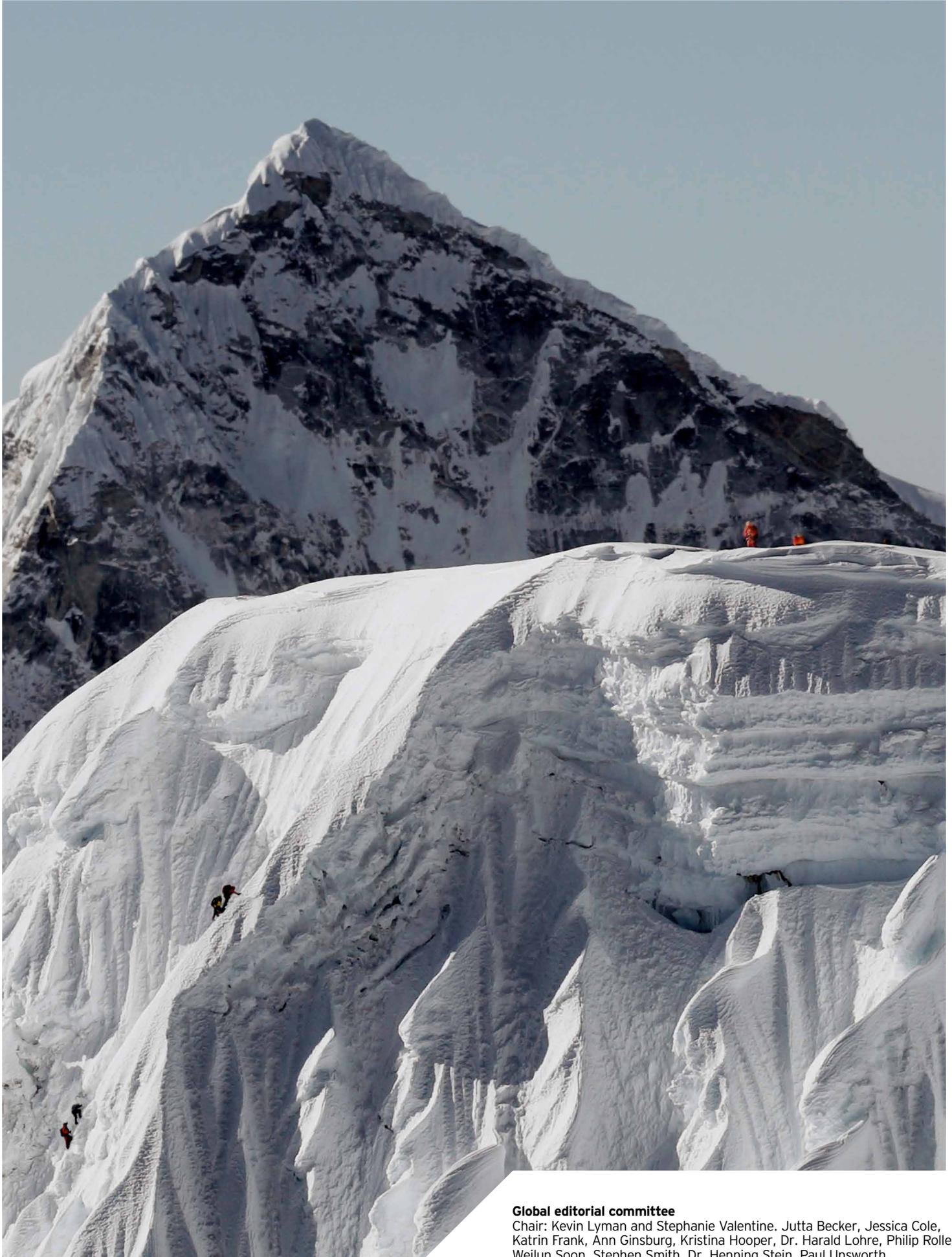
Risk & Reward

Research and investment strategies



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Sovereign wealth funds are important institutional investors with very specific needs. These funds are often set up by oil and other resource-rich countries who wish to hedge their exposure in case of commodity price declines.

Four of our top researchers have investigated the most effective ways to accomplish this and found that traditional price hedging is far from optimal. Advanced factor solutions may be a viable option. Within our multi-asset multi-factor model, quality and low volatility style factors play a crucial role in mitigating oil price exposure while increasing overall portfolio diversification.

We've also included another article focusing on China. This time, we examine China's consumption growth, which - despite some negative news of late - continues unabated. The interesting part for investors lies in the structural changes which are seeing smaller cities closing the gap on their tier-1 counterparts. Will they be the future drivers of China's transition to a consumption-based economy?

In our continuing series on alternative data sources, we turn our sights to patents. For innovative companies like biotech and semiconductor firms, patent data appears to be a useful source when it comes to forecasting equity returns. We took an in-depth look and came up with some promising results.

Finally, fixed income factors tell us much more than traditional bond characteristics such as credit rating, industry or duration. My colleagues show what this means in practice - and how factors can enhance bond allocations and improve the performance of balanced portfolios.

We hope you enjoy this latest issue of Risk & Reward.

Best regards,

Marty Flanagan
President and CEO of Invesco Ltd.

Contents

Feature



4 **A factor-based approach to diversifying oil exposure**

Dr. Harald Lohre, Erhard Radatz, Carsten Rother, and Mark Humphreys

The idea of a country establishing an investment portfolio with the proceeds of a temporary revenue stream is nothing new. There are, however, different ways in which the accumulated assets can be used by sovereign asset managers.

10 **Oil diversification with style** Interview with Mark Humphreys, Dr. Harald Lohre and Erhard Radatz

We spoke to the authors of the diversifying oil exposure study in this issue about the investment challenges of oil-rich countries and factor investing for sovereign wealth funds.

In focus

12

China's lower-tier cities stepping up to fuel China's consumption upgrade
Mike Shiao

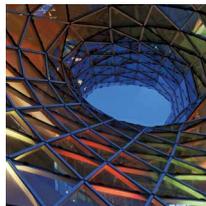
Observers are wondering about China's transition to a consumption-driven economic model. But we are convinced that consumption remains a reliable driver of growth - and that the time is ripe for lower-tier cities to play a greater role.



18

Patent data as a driver of equity returns
Michael Fraikin and Edward Leung, PhD

For firms focusing on innovation, patent data appears to be a promising proxy for future stock returns. We have analyzed this relationship for different segments of the stock market. This study continues our informal series on the use of "alternative data" for factor investing.



23

How can fixed income factors help investors with allocation decisions?
Jay Raol, PhD

How can fixed income factors enhance the credit rating, industry or duration view of portfolio construction? Can adding a factor element improve the risk-return profile? Do fixed income factors make sense in an equity-fixed income allocation? How can investors complement an allocation without disrupting the existing portfolio? We address these four important questions.

A factor-based approach to diversifying oil exposure

By Dr. Harald Lohre, Erhard Radatz, Carsten Rother and Mark Humphreys



In brief

Institutional investors who are highly sensitive to oil price changes are keen to reduce their risk exposure without explicitly engaging in oil price hedging. We investigate a viable alternative that considers diversifying oil exposure by employing adequate market and style factors. In particular, we present a multi-asset multi-factor solution in which quality and low volatility style factors play a crucial role in mitigating oil risk exposure while increasing overall portfolio diversification.

The idea of a country establishing an investment portfolio with the proceeds of a temporary revenue stream is nothing new. It is the model used by many sovereign asset managers around the world, such as those of Norway and the Gulf economies. In such economies, the revenue stream from extraction of natural resources (notably, oil and gas) is not expected to be permanent, so the intention is to build up a fund for when the resource revenue declines and, eventually, dries up. In Norway, for example, around half of oil reserves have been extracted over the last fifty years and, if extraction continues at the same pace, the reserves are expected to last only another fifty years.¹ There are, however, different ways in which the accumulated assets can be used by sovereign asset managers.

Sovereign asset managers can be seen as falling into one of five broad categories:² investment sovereigns (which do not have liabilities), liability sovereigns (which have liabilities either currently or in the future), liquidity sovereigns (normally commodity exporters which seek to manage assets to stimulate their economies during a commodity downturn), development sovereigns (which seek to drive local economic growth) and central banks (which have historically concentrated on the management of foreign exchange reserves but have taken on a greater role as sovereign asset managers in recent years).

The Norwegian sovereign wealth fund, for example, is currently both a liability sovereign (as it has future liabilities) and a liquidity sovereign (as short-term economic management is its secondary goal). In the early days of oil and gas extraction, however, the proceeds were used primarily to develop the economy: it was a development sovereign. In 1996, the Norwegian oil fund was established. On behalf of the Ministry of Finance, the fund is managed by Norges Bank (Norway's central bank), and it is now one of the largest sovereign wealth funds in the world, owning around 1% (by value) of listed global equities.

Diversifying oil with style

One important issue facing an oil (or other resource)-rich economy is that global economic growth and inflation, and hence developments in asset prices, are often closely correlated with the oil price. As a case in point, two recent oil shocks, both of which saw oil prices fall by 76%, have been accompanied by sharp falls in equity markets: in the second half of 2008, the peak-to-trough decline in oil prices was from USD 145.6 to USD 34.6, representing a -76% change. At the same time, the MSCI World index lost 34% of its value and the nominal yield of US 10-year Treasuries shrank by 175 bps to 2.19%. The second major oil price collapse lasted from 19 June 2014 to

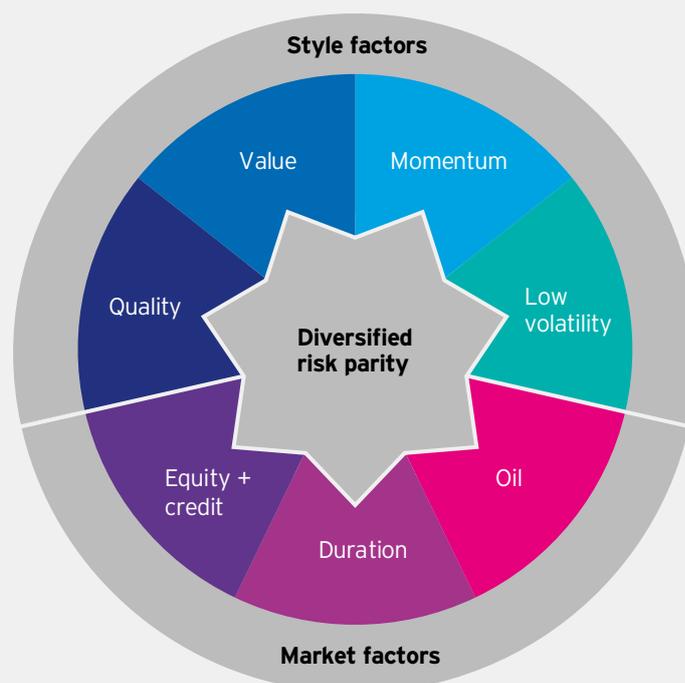
20 January 2016 with another -76% change (from USD 115.5 to USD 27.8). Over that period, the MSCI World index fell 14% and US 10-year nominal yields declined by 54 bps. This raises a concern that achieving diversification of oil exposure by investing in market factors such as equity and credit may be far from optimal. Of course, government bond investments are a natural candidate to diversify all of the above asset classes. Yet their associated absolute return proposition is weaker given the prevailing low yield environment.

To thoroughly address the question of diversifying exposure to oil, one needs to combine major sources of risk and return that permeate capital markets and determine the pricing of assets. In this vein, market factors related to equity and credit, duration or commodity risk are obvious contributors to any global multi-asset risk model. In complementing this set of factors, the literature has put forward the notion of style factors that help explain the cross-section of many asset classes. Figure 1 features four equity style factors, including quality, value, momentum and low volatility. By design, these style factors invest according to firm characteristics that are ultimately associated with distinct return patterns. All considered, style factors are long-short factors and thus do not carry significant equity market risk.

For instance, value investing looks to buy relatively cheap securities while selling more expensive ones, often leading to a pro-cyclical return profile. Conversely, momentum investing rests on the observation that past price trends tend to continue. Consequently, momentum strategies are far more active when seeking to capitalize the price differential between

Achieving diversification of oil exposure by investing in market factors such as equity and credit may be far from optimal.

Figure 1
Diversified risk parity: building blocks and stylized risk allocation



Source: Invesco. For illustrative purposes only.

winner and loser stocks. Given the return profiles of these two salient style factors (value and momentum), one may ask which other factors could act as more natural diversifiers with respect to significant equity or commodity risk exposure. In this regard, quality investing looks to invest in companies that excel in terms of a number of metrics associated with high balance sheet quality. A related, yet distinct, route is to directly enforce a defensive low risk profile by focusing on low volatility names. Additionally, shorting the broad market then allows capitalizing the low volatility effect, which relates to the empirical evidence of risk-adjusted outperformance of low volatility companies. Both defensive style factors, quality and low volatility, tend to be particularly strong when broad equity markets suffer.

Oil allocation through the factor lens

To investigate the extent to which oil exposure can be diversified by means of additional multi-asset and multi-factor exposures, we consider a simple benchmark with a constant allocation of 10% in oil,³ referred to as the 'oil benchmark'. For simplicity, we assume the remainder of the oil benchmark allocation to be invested in cash (as proxied by 3-month US Treasury bills). In evaluating the benchmark's risk exposure, we follow Dichtl, Drobetz, Lohre and Rother (2019) in building a risk model consisting of three market factors (equity, duration and oil risk) and four equity style factors (value, momentum, quality and low volatility), as shown in figure 1. Based on these seven factors, we x-ray and explain the oil benchmark's portfolio risk.⁴

Unsurprisingly, we find more than 80% of portfolio risk to be related to commodity or oil-specific risk (figure 2). Even so, we note that the oil benchmark also carries some equity and duration sensitivity throughout time. Moreover, there are even some style factor exposures to be observed. Given the negative performance of oil investments in the sample period, the 10% oil allocation leads to an overall return of the oil benchmark of 0.59% p.a. at

an annualized volatility of 3.2%, thus underperforming the risk-free rate. Despite the low volatility of the oil benchmark, one would have experienced a maximum loss of 16.8%.

Factor completion for oil benchmarks

In light of the above evidence, we examine whether one can alleviate the inherent downside risk of the oil allocation. Better diversification, in our view, can be achieved by combining exposure to equity style factors (value, momentum, quality and low volatility) with the above market factors. Dichtl et al. (2019) suggest different alternatives to tapping the diversification potential of style factors in an integrated portfolio optimization framework, including:

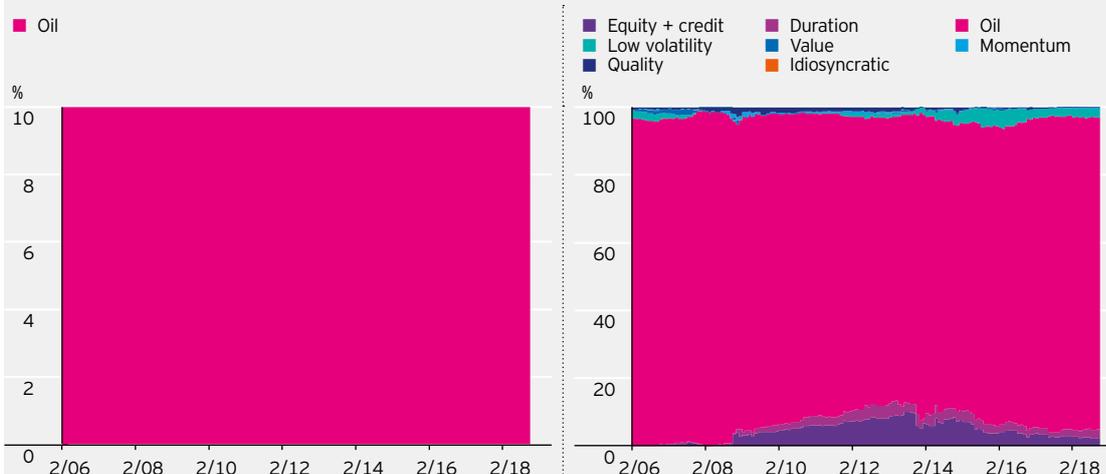
1. Factor-based tail hedging: adding style factor exposure in the pursuit of better risk management, particularly minimizing portfolio volatility
2. (Constrained) factor completion: using style factors to complete the risk allocation towards a fully diversified proposition while abiding by the benchmark constraints (i.e. holding the fixed 10% oil allocation)

In what follows, we utilize both approaches to diversification of the oil benchmark and shed light on the mechanics and nature of the ensuing portfolio allocation over time.

Tail hedging through equity style factors

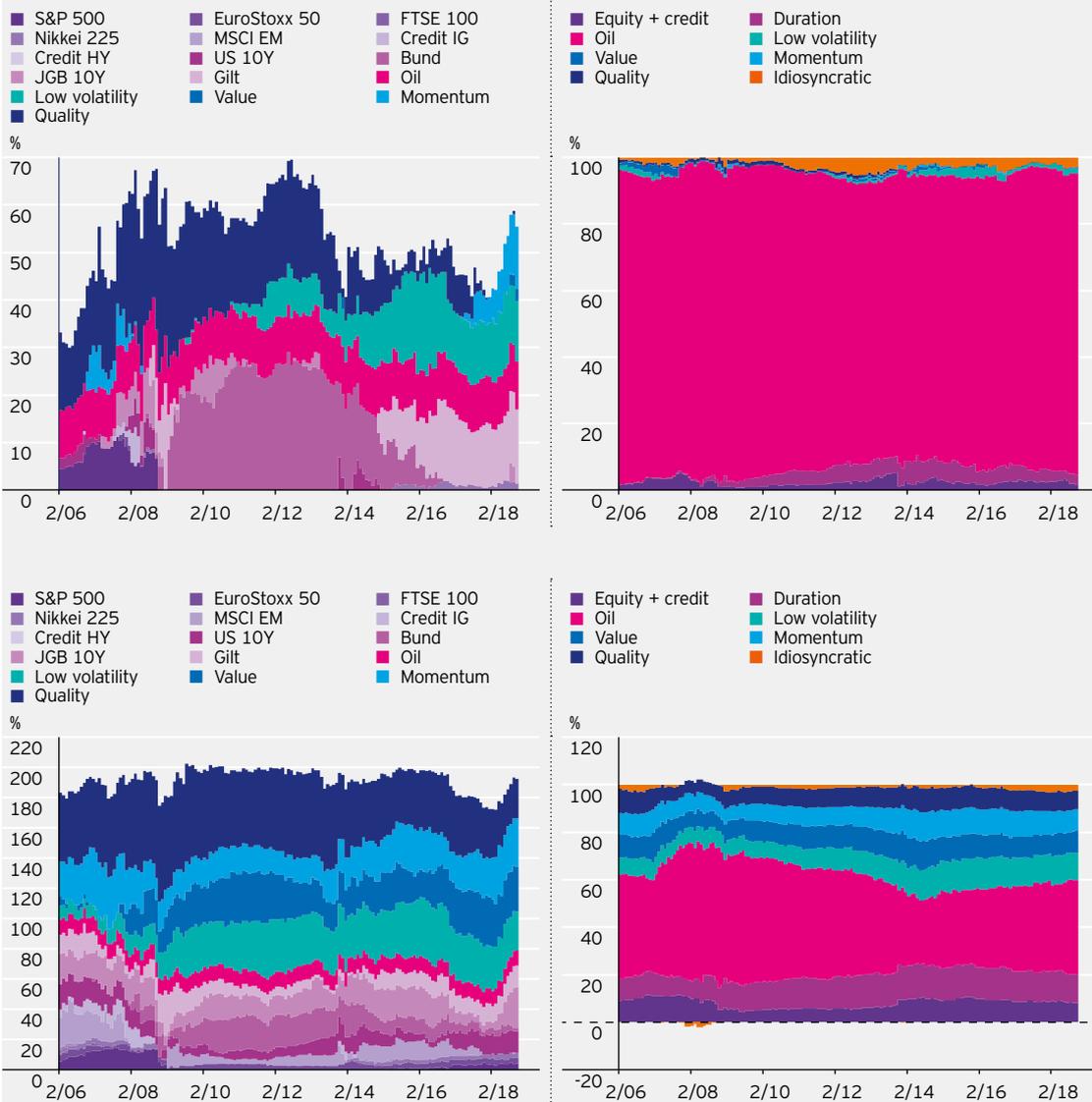
A major concern of holding the oil benchmark is the associated (tail) risk. Setting aside the upside potential of style factors, one may focus on their potential to minimize the volatility of the oil benchmark. Specifically, we run a minimum-variance portfolio allocation that is constrained to hold the oil benchmark but can dynamically add a factor completion portfolio to help reduce portfolio volatility. The resulting factor completion allocation is shown in figure 3.

Figure 2
Oil benchmark through the factor lens



The left chart plots the oil benchmark with a 10% allocation to oil. The right chart decomposes the volatility of this allocation by relevant market and style factors. Sources: Bloomberg, Invesco. Period: 31 January 2006 to 31 October 2018.

Figure 3
Factor completion for the oil benchmark: weights and risk allocation



The left chart plots the single factor and asset allocation of the factor-based tail hedge (upper row) and the constrained factor completion portfolio (lower row). Accordingly, the right chart decomposes the systematic volatility of these allocations by relevant market and style factors.
 Sources: Bloomberg, Invesco. Period: 31 January 2006 to 31 October 2018.

As expected, the factor completion portfolio hardly considers exposure to broad equity markets for hedging purposes given that these are prone to similar growth shocks as oil. We instead observe a decent allocation to government bonds that is complemented by investments in equity quality and equity low volatility. As expected, these defensive styles help counteract the oil exposure. Notably, the reduction in portfolio volatility is marginal, going from 3.2% for the oil benchmark to 3.1% for the tail-hedged portfolio. The benefits of the factor-based tail hedge are more apparent, however, when looking at the reduction in maximum drawdown by 5.5 percentage points down to -11.2%. In all, the tail-hedged portfolio experiences an increase in performance to 1.67% annualized return, corresponding to a Sharpe ratio of 0.10.

Constrained factor completion

The factor completion solutions of Dichtl et al. (2019) are centered around the notion of a diversified risk parity (DRP) anchor to complete the oil benchmark. At its heart, this allocation paradigm seeks to maximize diversification for a given set of assets and factors. It turns out that maximum diversification prevails when running a risk parity strategy using de-correlated variants of the three market and four style factors.⁵

Unlike the risk allocation of the oil benchmark, which is driven primarily by a single factor, the optimal diversified risk parity portfolio would, by design, exhibit equal risk contributions for all seven factors. While such a pure factor completion might not always be attainable, we are particularly interested in the extent to which a constrained factor completion can

Table 1
Diversifying oil - from benchmark to constrained factor completion

Performance statistics	Oil benchmark	Tail hedge	Factor completion	Pure DRP
Return p.a. (%)	0.60	1.67	3.34	4.28
Volatility p.a. (%)	3.20	3.10	4.30	4.00
Sharpe ratio	-0.24	0.10	0.46	0.73
Maximum drawdown (%)	-16.80	-11.20	-13.90	-6.50
Calmar ratio	0.04	0.15	0.24	0.66
Number of bets	1.53	1.47	5.42	6.77
Turnover (%)	0.00	5.60	12.50	7.80

The table provides simulated performance figures for different factor completion strategies from the perspective of a US-dollar investor. **There can be no assurance that the simulated results can be achieved in the future.** This model does not factor in all the economic and market conditions that can impact results. The hypothetical performance returns shown are from 31 January 2006 through 31 October 2018.
 Sources: Bloomberg, Invesco.

drive out the substantial oil exposure of the benchmark allocation.

To practically achieve the best possible factor completion overlay for a given asset allocation, Dichtl et al. (2019) simply translate the information embedded in the DRP allocation to a set of expected returns. Feeding these returns to a mean-variance optimizer, one would naturally recover the original DRP portfolio in the absence of investment constraints. However, in the presence of a fixed benchmark, the optimizer is tasked to trade off the diversification view relative to particular investment constraints, such as a fixed 10% allocation to oil.

Figure 3 (lower left chart) shows the ensuing factor completion overlay allocation. Unlike the fairly concentrated factor-based tail hedge portfolio, the factor completion overlay comprises a broad mix of market and style factors. Notably, the equity and credit market exposures are not overly dominant. As for equity style factors, the overall portfolio considers allocations to all four style categories, with quality and low volatility contributing the biggest stake - probably due to their genuine ability to diversify the (fixed) oil allocation.

As we aim at rounding out the risk allocation of the oil benchmark, we next investigate the risk decomposition in the lower right chart of figure 3. While oil risk is still the most prominent contributor to portfolio volatility, we note that the overall risk allocation is considerably less concentrated, with oil contributing at most around 50%. Interestingly, the remaining risk budget is almost equally shared among the other six factors. When measured in terms of number of bets,⁶ the strategy is seen to have 5.4 out of 7 maximum possible bets on average, operating in a range from 4 to 6.5 bets over time. Also, being more diversified would have been attractive from a risk-return perspective, as the constrained factor completion yielded 3.34% at 4.3% volatility, amounting to a Sharpe ratio of 0.46. Admittedly, one would have required some leverage to actually affect the 10% oil allocation, letting volatility rise by 1.1 percentage points relative to the oil benchmark (from 3.2% to 4.3%).

Conclusion

In the context of an economy aiming to diversify the risk of reliance on one particular commodity, such as oil, a case can be made for going beyond standard asset allocations. Traditional asset allocations tend still to be unbalanced across the key drivers of risk and return. Specifically, by augmenting market exposure (to equity and high yield markets, duration and commodities) with exposure to salient equity style factors (value, momentum, quality and low volatility), better diversification away from commodity-specific risk can be achieved. Notably, the presented framework is not restricted to commodity benchmarks but can be readily tailored to accommodate alternative strategic benchmark allocations in need of broad multi-asset and multi-factor diversification.

In the context of an economy aiming to diversify the risk of reliance on one particular commodity, such as oil, a case can be made for going beyond standard asset allocations.

References

- S. Bernardi, M. Leippold and H. Lohre (2018); Maximum diversification along commodity risk factors, *European Financial Management*, 24(1), 53-78.
- H. Dichtl, W. Drobetz, H. Lohre and C. Rother (2019); Active factor completion strategies, Working paper.
- R. Deguest, A. Meucci and A. Santangelo (2015); Risk budgeting and diversification based on optimized uncorrelated factors, *Risk*, 11, issue 29, 70-75.
- H. Lohre, H. Opfer and G. Ország (2014); Diversifying Risk Parity, *Journal of Risk*, 16, 53-79.
- A. Meucci, 2009, Managing diversification, *Risk*, 22, 74-79.

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Appendix

Here, we briefly describe the single asset and style factor indices underlying the article's empirical analyses. The global equity and bond markets are represented by equity index futures for S&P 500, Nikkei 225, FTSE 100, EuroStoxx 50, MSCI Emerging Markets and bond index futures for 10-year US Treasuries, German Bunds, 10-year JGBs and Gilts. The credit risk premium is captured by the Bloomberg Barclays US Corporate Investment Grade (Credit IG) and High Yield (Credit HY) indices (both duration-hedged to synthesize pure credit risk). To capture the investment in oil, we consider the total return index of S&P GSCI for crude oil.

All equity style factors are constructed in a long-short fashion. We utilize the definitions as laid out in Investing in a multi-asset multi-factor world, *Risk & Reward*, #3/2017. In particular, value, momentum and quality each follow a multi-factor approach that combines several metrics proxying for the respective style dimension. For low volatility, we build on a long-short approach that is long a minimum-volatility portfolio while shorting a beta-adjusted market portfolio.

Notes

- 1 <https://www.nbim.no/en/the-fund/about-the-fund/>
- 2 According to the Invesco Global Sovereign Asset Management Study (2017).
- 3 We believe this choice of benchmark to be representative of many oil-rich economies. In principle, the insights generated from this oil benchmark can be extrapolated for higher exposures to oil risk. Yet, there will be a natural upper limit to any factor-based diversification effort given the required leverage when approaching a 100% allocation to oil.
- 4 To flesh out the risk exposures of the oil benchmark over time, we linearly map the returns \mathbf{R} of the underlying 11 market assets and 4 style factors from the seven factors \mathbf{F} : $\mathbf{R} = \mathbf{B}'\mathbf{F}$, where \mathbf{B} is a 7×15 matrix containing the factor sensitivities. In turn, the variance-covariance matrix Σ of returns \mathbf{R} can be decomposed as: $\Sigma = \mathbf{B}'\Sigma_{\mathbf{F}}\mathbf{B} + \mathbf{u}$, where $\Sigma_{\mathbf{F}}$ is the global factor variance-covariance matrix and \mathbf{u} captures the idiosyncratic variance.
- 5 See Lohre, Opfer and Ország (2014) and Bernardi, Leippold and Lohre (2018) for operationalizing the concept of diversified risk parity across de-correlated (risk) factors, based either on principal portfolios or minimum torsion factors.
- 6 The effective number of bets relates to the number of uncorrelated risk sources represented by a given allocation through time. Mathematically, it is computed as

$$N_{Ent} = \exp\left(-\sum_{n=1}^N \ln p_n\right);$$

see Meucci (2009). For a completely concentrated portfolio, it holds that $N_{Ent} = 1$, whereas a fully diversified portfolio gives $N_{Ent} = 7$.

Oil diversification with style

Interview with Mark Humphreys, Dr. Harald Lohre and Erhard Radatz



Mark Humphreys, Head of EMEA Solutions, Invesco Investment Solutions



Dr. Harald Lohre, Senior Research Analyst, Invesco Quantitative Strategies



Erhard Radatz, Portfolio Manager, Invesco Quantitative Strategies

Risk & Reward spoke to Invesco's Mark Humphreys, Dr. Harald Lohre and Erhard Radatz, authors of the diversifying oil exposure study in this issue, about the investment challenges of oil-rich countries and factor investing for sovereign wealth funds.

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Economies with significant oil and gas reserves have been in the news recently: Norway, with the largest sovereign wealth fund in the world, has announced plans to divest from its oil and gas investments. At the other extreme, Venezuela, with the world's largest oil reserves, is gripped by chronic economic distress. Is there a lesson from these sharply diverging experiences?

Mark Humphreys

The lesson is that a country rich in natural resources can manage them either well or poorly. We have known for some time about the Dutch disease - the adverse side effects from the discovery, in the Netherlands' case, of natural gas: it pushed up the real exchange rate and led to a substantial increase in state spending and poor economic performance in the 1980s. These things took years to rectify.

Erhard Radatz

Venezuela's economic problems are, of course, far worse.

Mark Humphreys

Indeed they are. But, at the other extreme, there are many examples of countries establishing an investment fund with the proceeds of their oil revenues and using this fund to stabilize their economies over the short and long term. Norway and the Gulf economies provide several examples of oil and gas revenues being managed prudently.

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Is there a standard approach to properly managing such a sovereign fund? Is there a 'one-size-fits-all' solution?

Mark Humphreys

No, not at all. This is because the fund might serve different purposes and its objective may change and thus the way the fund is managed.

Erhard Radatz

The Norwegian sovereign wealth fund, for instance, is currently both a liability sovereign (as it has future liabilities) and a liquidity sovereign (as short-term economic management is its secondary goal). This was not the case in the early days of oil and gas extraction, when the proceeds were used primarily to develop the economy: it was a development sovereign.

Mark Humphreys

In addition, there are pure investment sovereigns, which do not have liabilities, and central banks, which have historically concentrated on the management of foreign exchange reserves but have taken on a greater role as sovereign asset managers in recent years.

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And how are the assets of such funds generally managed?

Harald Lohre

Again, there is no standard model although many sovereign wealth funds, given their typically long-term investment time horizon, will have significant exposure to international equities. This is typically based on the view that equities produce higher long-term returns than money market instruments and bonds.

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That sounds very prudent and sensible: is it?

Mark Humphreys

It does sound prudent, but one important issue which an oil (or other resource)-rich economy faces is that global economic growth and inflation, and hence developments in asset prices, are often closely correlated with the oil price. So, a falling oil price may well see global equities fall in value. The drop in the value of equity markets we have seen during oil shocks over the last decade or so can test the resolve of any supposedly very long-term investor. In the second half of 2008, and once again from 2014-2016, the oil price fell some 75% and equity markets around the world suffered severe losses.

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Surely fixed income securities do well in such periods, providing an offset to weaker equity markets?

Harald Lohre

Generally speaking, they can. But the picture is a more nuanced one. High yield corporate bonds typically behave like equities. Government and investment grade bonds, on the other hand, are pulled in two different directions by falling oil prices: lower inflation will support bond prices, but lower savings by oil-rich economies may raise real yields.

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So, does that mean investing in a standard diversified portfolio of equities and bonds is far from optimal for an oil-rich economy?

Erhard Radatz

We think it certainly does mean that. Better diversification, in our view, is achieved by combining exposure to equity factors (value, momentum, quality and low volatility) with traditional beta (duration, equity and credit risk and commodity exposure).

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Is that primarily with a view to avoiding extreme 'tail events' in a market downturn?

Harald Lohre

Adding sources of diversification in order to reduce tail risk is an important potential consideration, but it is not the only one. We could also look at adding a more complete exposure to equity style factors as well as market factors and then look at how to calibrate the risk of such a portfolio to match an appropriate benchmark exposure.

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Can you give a concrete example of that process?

Erhard Radatz

Sure. Let's take a simple benchmark portfolio consisting entirely of oil exposure. This can be expected to be an extremely volatile portfolio. To moderate that volatility, let us add exposure to cash - indeed a large allocation so that 90% of the benchmark is in 3-month US Treasury bills and 10% in oil.

Harald Lohre

We can then look at how different factor completion alternatives compare to our simple benchmark. Such factor completion consists entirely of a factor overlay allocation serving a special purpose. In the present

study of the oil benchmark, we focus on two objectives: first, a factor completion portfolio which has the intention of "tail hedging" - that is, adding style factor exposure in the pursuit of better downside risk management. Second, a factor completion portfolio which adds style factors to complete the risk allocation in line with diversified risk parity.

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How would you summarize your study's findings?

Harald Lohre

As you might expect, the tail hedging approach focuses on bringing in an allocation to defensive market and style factors; that is, government bonds as well as quality and low volatility. While this factor completion overlay has a limited effect when it comes to actually reducing volatility, we find it dampens tail risk to some extent.

Erhard Radatz

Unlike this fairly concentrated tail hedging allocation, the constrained factor completion is represented by a broad mix of the available assets. As a result, the corresponding portfolio simulations not only achieve higher portfolio diversification but also enjoy the associated enhancement of portfolio returns - an important feature in the current low yield environment.

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To be clear, that involves broad factor and market exposure, with leverage used to take the risk back up to that of the simple benchmark?

Harald Lohre

That is correct.

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Is this an approach with more general applicability, not just to oil-rich countries?

Mark Humphreys

We think it has broader utility. For example, it can be used for any economy with a particularly high exposure, not just to one commodity but to one particular industrial sector. The message is that diversification needs to be as extensive as possible using "all the tools in the toolkit," as we often say. It is not enough just to use a diversified portfolio of international equities.

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This approach is likely difficult for some asset owners and fund managers to accept. Are they ready for factor as well as market exposure and "using all the tools in the toolbox," as you say?

Erhard Radatz

There is naturally going to be reluctance on the part of some portfolio managers. This is always the case when new techniques are introduced. But we think the merit of this more broadly diversified approach is steadily becoming more accepted.

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Thank you very much for your time.

China's lower-tier cities stepping up to fuel China's consumption upgrade

By Mike Shiao

In brief

The outlook remains bright for Chinese consumption growth, with lower-tier cities becoming one of its key drivers. Favourable demographics, rapid income growth, improved accessibility and low penetration are releasing pent-up demand beyond China's main urban centres. Consumer goods companies are tapping into this trend to capture growth potential from consumption trade-up and experience seeking, thus ensuring the continued expansion of the country's consumer sector.

Recent economic data coming out of China has observers wondering about the momentum of the country's transition to a consumption-driven economic model. But we are convinced that consumption remains a reliable driver of growth for the world's second-largest economy - and that the time is ripe for lower-tier cities to play a greater role in driving consumption growth in China.

Our optimism about China's consumption growth is based on economic realities, and not just news headlines. Although retail sales have lately been lower, this was largely due to a sharp fall in car sales following the end of a tax break for new car buyers. Moreover, retail sales data does not capture services, which account for more than half of total consumption. For instance, household expenditure on healthcare is still on the rise; it was 15.1% higher in 2018 following a 9% increase in 2017.¹ In all, private consumption in China amounted to roughly USD 5 trillion at end 2017. This is more than 10% of the world's total and makes China's consumer market the world's second largest.

Yet, the market's potential is far from being fully exploited. Data shows that private consumption's share of China's GDP still lags other major economies. In 2017, the share of China's GDP attributable to domestic consumption was at 39.1%, below the 68% in the US, 62.2% in India and 55.8% in the European Union.² At the same time, real incomes are expected

Explaining China's city tiers

Chinese cities are usually divided into multiple tiers. There is no agreement on an exact definition of the tiers as there is no official list. Different organizations have their own definitions based on a number of factors that often reflect the following three main considerations:

- 1) GDP: China's cities range from major urban centres with USD 350 trillion in GDP to minor cities with GDP under USD 20 billion.
- 2) Politics: Refers to how the city is administered. Directly administered municipalities are generally in the top tier, followed by provincial capitals, prefecture capitals, then county-level administrations.
- 3) Population: Takes into account the core city and urban areas surrounding the core. Top-tier cities often have upwards of 15 million inhabitants.

Based on these criteria, the more well-known Chinese cities are assigned to the following tiers:

- Tier 1:** Beijing, Shanghai, Guangzhou and Shenzhen
- Tier 2:** Mainly provincial and sub-provincial capitals, such as Chengdu, Nanjing, Hangzhou, Xi'an, Wuhan, Harbin
- Tier 3:** Mainly prefecture capitals and county-level cities, such as Wenzhou, Guilin, Dongguan, Hohhot
- Tier 4:** Smaller county-level cities such as Jieyang, Yiwu, Ordos, etc

to continue rising thanks to sustained high economic growth and supportive government policies. Strong real income growth of Chinese workers has been a key factor behind the rapid growth of China's consumer sector over the past few years. What these trends highlight is that the forces - which have helped create one of the world's largest consumer markets - are set to continue.

What we think will be different, however, are the dynamics of expansion in China's consumer sector: lower-tier cities are fast emerging as another key dynamo in China's consumption engine.

Ever since China embarked on economic reforms four decades ago, its largest cities have led the country's economic development. These tier-1 cities, including Beijing and Shanghai, have grown to become centres of urbanization and development. Improvements in infrastructure in these cities support growing industries and in turn, nurture employment opportunities. The inhabitants of these cities have seen their incomes rise rapidly, which has propelled the consumer sector's growth. Now, salaries in these upper-tier cities have reached high-income status based on the World Bank's definition of USD 12,236 per capita.³

China's domestic consumption is likely to find additional much-needed momentum from the emergence of its lower-tier cities.

Today, China's domestic consumption is likely to find additional much-needed momentum from the emergence of its lower-tier cities. Defined as those in the second tier and below (prefecture and county-level urban centres), these cities are riding beneficial trends that are turning them into sources of fuel for China's next stage of consumption growth. There are already initial signs emerging of how consumption in lower-tier cities is poised to drive overall consumption growth in the country: consumption growth in lower-tier cities is outstripping that of tier-1 cities (figure 1). Take, for example, Chengdu - the capital of Sichuan province in southwestern China. It boasts a population of 16 million and its average retail sales growth reached 11.6% over the past five years (2013-2017). By comparison, Beijing has a population of 22 million but retail sales growth in the national capital averaged only 7.4% during the same period.

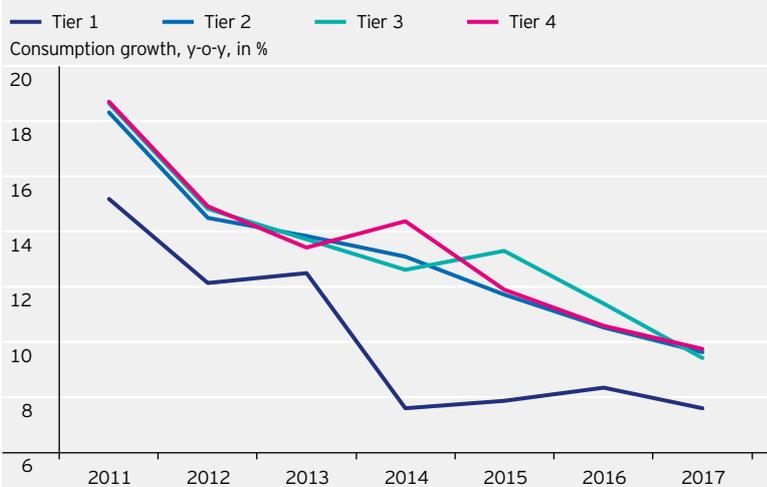
Lower-tier cities step up

Below, we detail the multiple reasons behind developments in lower-tier cities that will ultimately boost consumption in these markets.

Favourable demographics

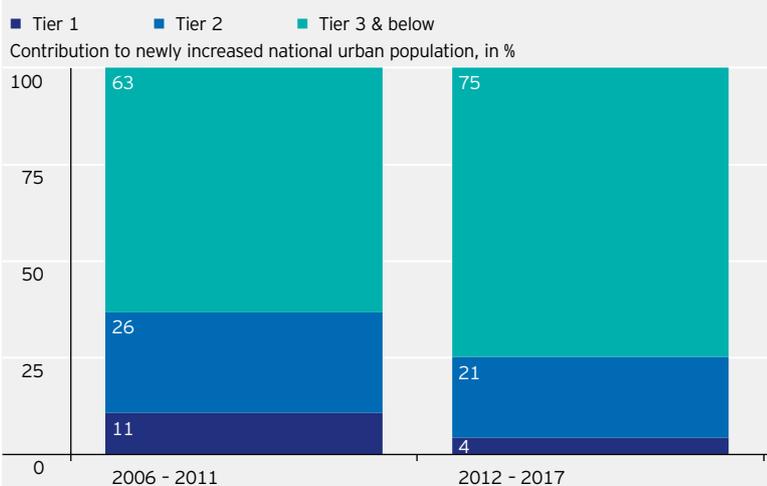
China is experiencing a gravitational shift in population growth. A majority of the Chinese population now lives in lower-tier cities, which account for most of China's newly increased urban population (figure 2). This change is allowing the consumer sector to flourish in lower-tier cities.

Figure 1
Spending growth in lower-tier cities outstrips tier-1 cities



Sources: CEIC, Wind, NBS, Goldman Sachs. Data as at August 2018.

Figure 2
Lower-tier cities account for most of China's newly increased urban population



Sources: NBS, Morgan Stanley Research. Calculation based on usual resident count.

Fertility rates tend to be higher in lower-tier cities as the relaxation of the one-child policy and affordable cost of living are increasing the willingness of people to have larger families, giving lower-tier cities needed momentum to expand their consumer base. Indeed, natural population growth in cities of tier-3 and below is higher than that of tier-1 cities.⁴

Policy initiatives such as more flexible hukou (household registration system) policies are also giving the consumer sector's expansion in lower-tier cities a further push. In fact, lower-tier cities are taking advantage of these policy tweaks in order to actively attract talent to reside there. For example, Nanjing, the capital of Jiangsu province in eastern China, introduced a policy in March 2018 to attract those holding a bachelor's degree and aged 40 and below to transfer their hukou to the city.⁵ The city

government also expanded its talent program so that the most desirable potential new residents can get a 3-million yuan housing subsidy to help them relocate, while all fresh university graduates who travel to Nanjing for job interviews can claim 1,000 yuan to cover costs.⁶

While the major cities of Beijing and Shanghai both chalked up a 6.6% rate of growth in 2018, smaller cities such as Chengdu and Xi'an recorded 8% and 8.2% respectively.

Rapid income growth

Economic growth tends to be faster in lower-tier cities. For example, while the major cities of Beijing and Shanghai both chalked up a 6.6% rate of growth in 2018, smaller cities such as Chengdu and Xi'an recorded 8% and 8.2% respectively. This is faster than the top-tier cities and above the national growth rate.⁷

The faster rate of growth in the less developed regions has also led to faster income growth. For the whole of 2018, growth in rural disposal income per capita was at 8.8%, while that for urban populations was at 7.8%.⁸

At the same time, the property sector's performance across lower-tier and upper-tier cities in relation to income growth also affects consumption. Even though higher property prices tend to correlate to higher consumption, high mortgage payments have the

potential to crowd out consumption. We think that a good balance of housing affordability and disposable income can be found in China's lower-tier cities.

Improved accessibility

There have been big improvements in accessibility and connectivity in China's smaller cities, which bode well for consumption. Plans for mega urban conurbations, better transport infrastructure and improved communications networks all allow goods and services to be delivered more efficiently to an eager consumer base in these smaller cities, thereby unlocking pent-up demand.

China's central government has planned for multiple city clusters, with three of them to become world-class metropolitan areas by 2020. These three are: The Greater Bay Area, centred on the Pearl River Delta with Hong Kong, Shenzhen, Guangzhou and Macao as its biggest cities; the Yangtze River Delta with key cities such as Shanghai, Suzhou and Hangzhou; and Jing-Jin-Ji, which comprises Beijing, Tianjin and Hebei province. These conurbations focus attention on regional economic and employment opportunities, and infrastructural projects are underway to speed up their development. The country's top leadership has stated that these city clusters will create "networks of cities and towns" and enable "coordinated development of cities of different sizes and small towns."⁹ We think that this underscores the political will to speed up the pace of urbanization in these mega city clusters, and lower-tier cities in these conurbations will benefit from rapid growth and development.

China's plans to improve its high-speed rail network will also contribute to lower-tier cities' growth. At the end of 2012, China had only 9,356 km of high-speed rail.¹⁰ Six years later, the high-speed rail network has reached 29,000 km.¹¹ With the rollout of the high-speed rail network, several of the lower-tier cities now also fall into the orbit of key cities, opening up new job opportunities and leisure options for inhabitants. In the Greater Bay Area, for example,



inhabitants of the smaller city Foshan will find it easy to reach Hong Kong or Shenzhen for work or leisure as these upper-tier cities are only a 70-minute high-speed train ride away. For Nanjing residents, what was once a five-hour rail journey to Shanghai is now just slightly over an hour on the high-speed rail.

Moreover, better communications infrastructure is making it easier for people in lower-tier cities to jump on the consumption bandwagon. For decades, lower-tier cities had their development held back due to poorer-quality and smaller-scale infrastructural networks compared to their top-tier counterparts. Today, faster internet and mobile data speeds, a proliferation of mobile phones and apps and the ease of online and mobile payments have unlocked latent demand, allowing lower-tier cities to overcome infrastructural limitations so that consumers there can participate in the market for attractive goods and services alongside their peers in the top-tier cities. Even though online penetration is still highest in tier-1 cities (at 73% in 2017), online penetration growth is shifting to lower-tier cities.¹² The proportion of e-payment users in lower-tier cities has increased as compared to those in upper-tier cities: in 2017, users in lower-tier cities accounted for 78.5% of all e-payments in China; a year later, this proportion increased to 84.3%.¹³

Low product penetration

Given their poor accessibility to goods and services, product-penetration rates in lower-tier cities have historically been low for major retailers and consumer companies (figure 3). But improved accessibility and connectivity are changing that: retailers and distributors can now find inroads to the vast consumer base and demand potential that China's lower-tier cities have to offer.

Retail chains that are new to lower-tier cities will likely find a receptive audience if they possess strong brands, good management and execution capabilities. A study on baby products found that 60% of China's infants younger than three years old live in lower-tier cities, whereas consumer spending on baby products in lower-tier cities is only two-thirds that of upper-tier cities. In the infant formula, disposable diaper and baby toiletry categories, for example, leading brands still don't command shares as big as they have achieved in upper-tier cities.¹⁴

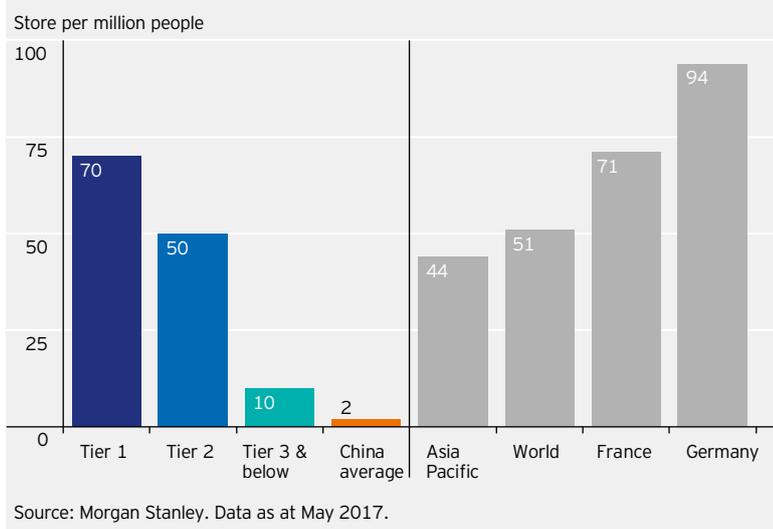
Trends that are driving consumption in China's lower-tier cities

With the above-mentioned driving factors in place, companies will find a ready consumer base for their products in lower-tier cities. We believe that the emergence of consumption in lower-tier cities will lead to two notable trends in spending patterns: a trade-up in consumption habits and a growing preference for seeking experiences.

Lower-tier city inhabitants are primed to buy more premium products

Wealth is rising in China's lower-tier cities. Consumers there are increasingly looking for better products and brands, which has spurred a growing number of consumer companies to position themselves in these markets. In addition to higher levels of wealth, these firms are also attracted by lower levels of product penetration and improved accessibility to the market in lower-tier cities.

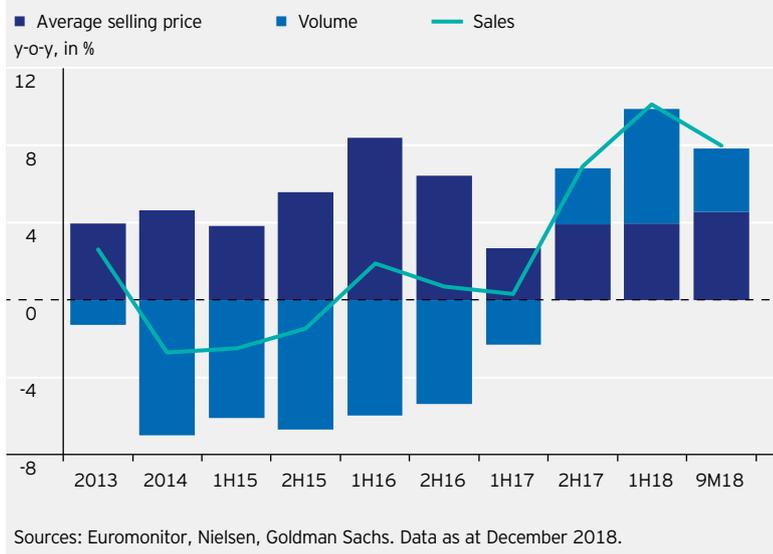
Figure 3
Penetration of fast-food chains remains low in China, particularly in lower-tier cities



We have seen a premiumization trend in several consumer segments. Consumer companies are responding to the demand for premium products by diversifying their product ranges through innovation and introducing higher-end products. In some cases, those that have already established a solid presence in China's top-tier cities are finding it easy to offer the same high-end products to consumers residing in lower-tier cities.

The instant noodle market is a mature consumer segment in China, and not one often associated with China's consumption upgrade. However, growth in instant noodle sales has been driven predominantly by price increases (figure 4). The premium segment for instant noodle makers has been outgrowing the mid-range and mainstream segments. The premium segment accounted for 12% of overall value in

Figure 4
Average selling price increases are driving growth in China's instant noodle market



China's instant noodle market in 2017, up from 7% in 2015 (figure 5).

We attribute the premiumization of instant noodles to companies' engagement in innovation and brand investment to shape public perception of their products in China so that consumers are increasingly viewing instant noodles as high-end snacks rather than low-end fast food. Instant noodle companies recognize that lifestyle habits are evolving and that living standards are improving. This has drastically changed consumers' expectations when it comes to food choices.

These changing consumer habits apply not only to consumers in the first-tier cities but also those from lower-tier ones, where consumers are eager for healthier and higher-quality products. We see major players in the segment focusing their efforts on research and promotion of premium instant noodles. For instance, one key maker has developed a way to separately package the noodles alongside stewed, imported beef. Separating the beef from the noodles provides consumers with a non-fried and nutritious ingredient to add to their noodles.

The hot pot restaurant segment is one example of how companies can benefit from the increasingly popular trend of dining out in lower-tier cities.

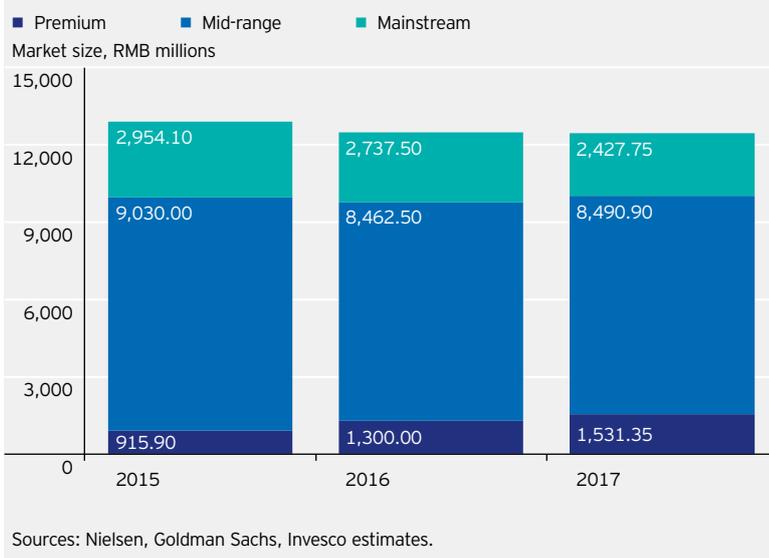
The hot pot restaurant segment is one example of how companies can benefit from the increasingly popular trend of dining out in lower-tier cities. Between 2017 to 2022, the market size of hot pot restaurants in tier-1 cities is expected to grow from 41.4 billion yuan to 68.5 billion yuan, while in lower-tier cities it is set to expand from 394.8 billion yuan to 639.2 billion yuan. The anticipated increase in market size in lower-tier cities is thus more than nine times what the tier-1 cities will experience.

Leading hot pot restaurant operators, attracted by strong expansion potential in lower-tier cities, are deepening penetration into these cities. This process is helped along by the niche they have carved out for good service quality and complimentary services, such as manicure and shoe-polishing services for waiting guests. Leading operators are also known to provide food and ingredients that are of high quality at affordable prices. This allays customers' concerns about food safety and generates a good overall dining experience. By leveraging on their expertise, experience and strong brands, these leading operators are quickly establishing themselves in lower-tier cities.

Lower-tier city consumers are seeking more experiences

Lower-tier city consumers are also looking for more intangible experiences when deciding where to spend their money.

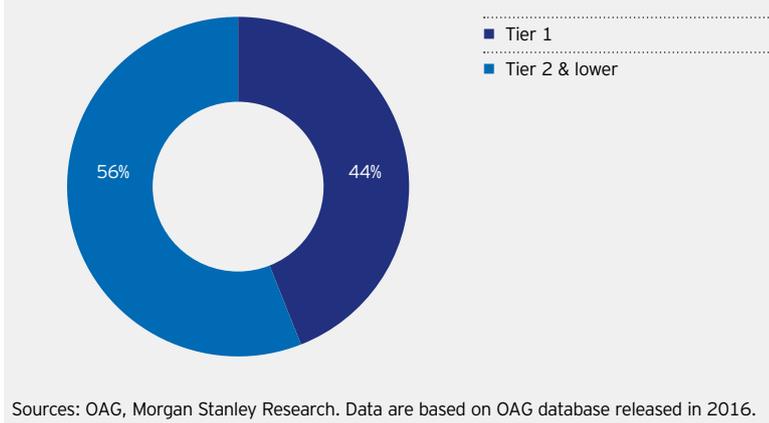
Figure 5
Growth in value of the premium instant noodle market outstrips other segments



Online travel agencies stand to gain from this trend. Penetration of outbound travel is still low in China, and we believe travellers from lower-tier cities will be driving much of the sector's future growth. Outbound travel penetration in China was only 8.8% in 2016, or 4% excluding trips to Hong Kong, Macao or Taiwan - very low compared to developed Asian countries. According to Ipsos (a global market research company), outbound travellers in China come mainly from its biggest cities, while inland provinces remain a relatively untapped market. This is because tier-1 cities such as Shanghai and Beijing are better connected, with more international routes at their airports and higher disposable income levels among their inhabitants. However, lower-tier cities are clearly ramping up their connections to international destinations. In 2016, they accounted for 56% of new international flights in China (figure 6).

Increasing mobile phone penetration and income levels in lower-tier cities are likely to drive the growth of online travel agencies' presence in these smaller urban centres. Mobile phone penetration as a share

Figure 6
Lower-tier cities account for a higher share of new international flights



Increasing mobile phone penetration and income levels in lower-tier cities are likely to drive the growth of online travel agencies' presence in these smaller urban centres.

of overall travel bookings in China is more than 16 times greater than levels seen in the United States (figure 7).¹⁵ Riding this trend, one major online travel service provider has been expanding aggressively into lower-tier cities, setting up numerous offline franchise stores in 2018. Of the 1,500 stores set up by this company, 80% are in lower-tier cities.

Conclusion

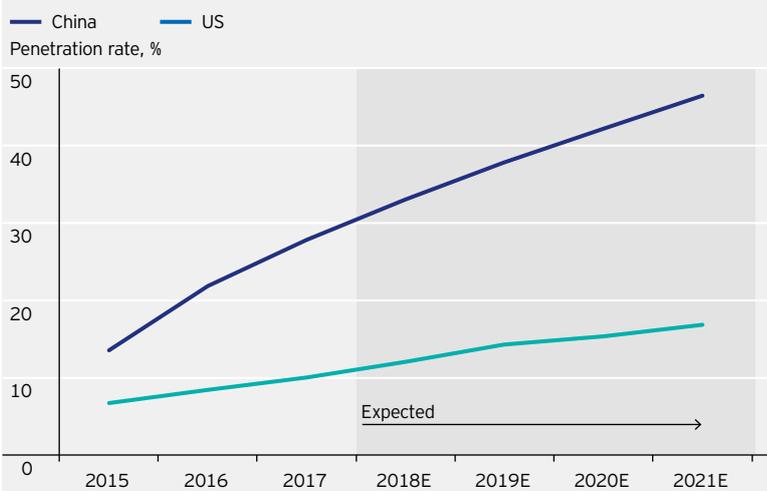
Like its economy, China's consumption landscape has been diversifying over the past few decades. The growth engine that once relied on China's largest cities for fuel now needs more input from other sources.

Lower-tier cities thus offer the consumer market vast potential to tap into.

Lower-tier cities thus offer the consumer market vast potential to tap into, and a confluence of developments, ranging from demographic trends, increasing wealth, a faster pace of urbanization, improved accessibility and connectivity and low product-penetration rates, is facilitating the market's growth in these smaller cities.

Similar to their top-tier peers, residents from lower-tier cities are also looking for premium products and exploring varied experiences on the strength of these favourable developments. We believe this trend will serve to attract astute consumer companies into China's smaller cities. Their efforts, together with the consumer market's steady growth in top-tier cities, will help maintain the momentum of the Chinese consumer sector as it leads China's economic growth.

Figure 7
Mobile phone travel bookings in China far higher than in the US



Source: McKinsey & Company.

About the author



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Mike Shiao joined Invesco in 2002 and serves as Chief Investment Officer, Asia ex-Japan. He has been the Lead Manager of the Greater China equity portfolios since 2008 and became Lead Manager of the Asia Opportunities equity portfolios in July 2014. Mike Shiao is also responsible for China Focus equity portfolios, Hong Kong & China portfolios and institutional portfolios investing in Hong Kong/China.

Notes

- 1 More and more signs point to slower spending in China. Analysts say not to worry," CNBC, 19 February 2019; accessed 13 March 2019.
- 2 Latest data for each country taken from CEIC as of January 2019.
- 3 "Unleashing China's Consumption Boom", Citi, 19 January 2018.
- 4 "Lower-tier Cities - Bigger, Richer, More Eager to Spend", Morgan Stanley, 25 May 2017.
- 5 "Immediate implementation of policy for talents and skilled labour holding bachelor degrees and above to reside and seek employment in Nanjing city", Nanjing Municipal Public Security Bureau, 1 March 2018; accessed 5 March 2019.
- 6 "Chinese city seeks young blood: how ageing Nanjing lures new talent", The Guardian, 30 January 2019; accessed 4 March 2019.
- 7 National Bureau of Statistics of China; accessed 4 March 2019.
- 8 "China's resident disposable income rises 6.5pct in 2018", Xinhua News Agency, 21 January 2019; accessed 4 March 2019.
- 9 "Secure a Decisive Victory in Building a Moderately Prosperous Society in All Respects and Strive for the Great Success of Socialism with Chinese Characteristics for a New Era", Xi Jinping, 18 October 2017; accessed 5 March 2019.
- 10 China Railway Yearbook 2013, Ministry of Railways of China, August 2014; accessed 4 March 2019.
- 11 "China's economy: China to invest in 6,800 km of new rail in 2019, a 5% increase from a year ago", Reuters (in Chinese), 2 January 2019; accessed 4 March 2019.
- 12 "As Shoppers Upgrade, Growth Returns", Bain & Company, 6 July 2018; accessed 5 March 2019.
- 13 Annual Survey of Mobile-Payment Users 2018, Payment and Clearing Association of China, 24 December 2018, accessed 4 March 2019.
- 14 "Growth potential of baby market in lower-tier cities", Kantar World Panel, 27 September 2018; accessed 4 March 2019.
- 15 "Chinese tourists: Dispelling the myths - An in-depth look at China's outbound tourist market", McKinsey & Company, September 2018; accessed 5 March 2019.

Patent data as a driver of equity returns

By Michael Fraikin and Edward Leung, PhD

In brief

For firms focusing on innovation, like biotechnology companies, patent data constitutes a useful proxy for intangible assets. Using sample patent data to construct factors that predict subsequent stock returns, we find that intellectual property (IP) quality and value factors can predict cumulative 6 and 12-month returns of certain industries in the US small cap universe. Furthermore, in the US large cap universe, the IP quality factor can predict cumulative 6 and 12-month returns of biotechnology stocks. However, more work is necessary to understand the potential relevance of these findings outside the US and the benefit of the data in a multi-factor context.

For firms focusing on innovation, patent data appears to be a promising proxy for intangible assets and, by extension, future stock returns. Within the framework of our multi-factor model, we have analyzed this relationship for different segments of the stock market - small and large caps, growth sectors with high R&D spending and specific industries such as biotechnology and semiconductors. This study continues our informal series on the use of "alternative data" for factor investing.¹

The patent search website of the United States Patent and Trademark Office (USPTO) provides records of all patents from 1976 to the present.² We used this data to construct patent-related factors. Converting the XML patent files into structured, analyzable data is a time-consuming and by no means trivial process,³ resulting in high barriers to entry for anyone attempting to use US patent data for investment purposes. In order to fairly quickly test the usefulness of patent data for predicting US stock market returns, we obtained annual trial data from two third-party data vendors, labelled "M" and "Q".

Patent data or R&D expenditure?

While it may seem logical to use research & development (R&D) expenditure as a proxy for innovation, we believe that this leads to the following issues:

- Under current US GAAP accounting rules, R&D expenditure is fully expensed and therefore not reflected as intangible assets on the balance sheet. Such treatment may distort the yardstick for valuation by investors.*
- In the US, firms only need to report R&D if the expenditures are "material".**
- Unlike patents, R&D expenditure is not broken down by product line or geography.
- Unlike patents, R&D expenditure is input for future innovation, and not output.
- Data on R&D expenditure is available in financial statements, and thus has a low barrier to entry.

We believe that patent data is likely a better option than R&D expenditure. In the US, patent data also has a much longer history and better coverage than other alternative data sets.

* For a more detailed discussion, see Wang, Luo, Alvarez, Jussa, Wang, Rohal, Elledge and Zhao (2016) and Chapter 15 of Damodaran (2010).

** For example, under US tax law, service firms are generally unable to take advantage of the R&D tax credit. As a result, these firms often report no R&D expenditures. See Lerner and Seru (2018) for further discussion.

Table 1
Patent factors and subsequent returns of US stocks

		Large caps				Small caps			
		IC1	IC3	IC6	IC12	IC1	IC3	IC6	IC12
IPQ	Mean	0.02	0.02	0.01	0.01	0.02	0.00	0.00	0.00
	T-stat	1.22	0.83	0.56	0.94	1.19	0.12	-0.03	-0.02
IPQ2	Mean	0.02	0.01	0.01	0.03	0.02	0.01	0.02	0.03
	T-stat	0.72	0.64	0.67	2.41	0.93	0.49	1.30	1.66
IPV	Mean	0.02	0.03	0.02	0.03	0.02	0.01	0.02	0.03
	T-stat	0.96	1.33	1.03	1.26	1.33	0.31	1.13	1.83

Source: Invesco calculations based on US patent data from 2010 to 2016.

From vendor M, we obtained annual trial data for 2010 to 2016, a relatively small sample. The data contains proprietary intellectual property factors such as IP value (IPV), which measures the average value of the patent portfolio, and IP quality (IPQ), which is an average of various patent-related metrics. We also constructed "IPQ2", which is IPQ minus the IPQ benchmark.⁴

The data coverage is reasonable: e.g. in December 2016, 68% of companies in the US large cap universe released patent data. The figure for small caps is 53%, which makes sense because patents are not relevant for all industries in our universe.

We first tested the relationship between patent factors and subsequent stock returns for the full US large cap and small cap universes. Later, we narrowed the focus to growth sectors with high R&D spending in both universes. Finally, we considered specific industries such as biotech and semiconductors.

Tests for US large and small caps

Using firm-level data for the US large cap and small cap universes, we evaluated the performance of the three IP factors. Each factor is industry neutralized so that companies from different industries can be compared. Table 1 shows the information coefficients (IC) for the three factors, defined as the correlation between current factor scores and subsequent (1, 3, 6 and 12-month) cumulative returns. As expected, we found no significant relationship between patent factors and subsequent stock returns at the 5% level (with the exception of IPQ2 in large caps), because technological innovations are not relevant for all industries.

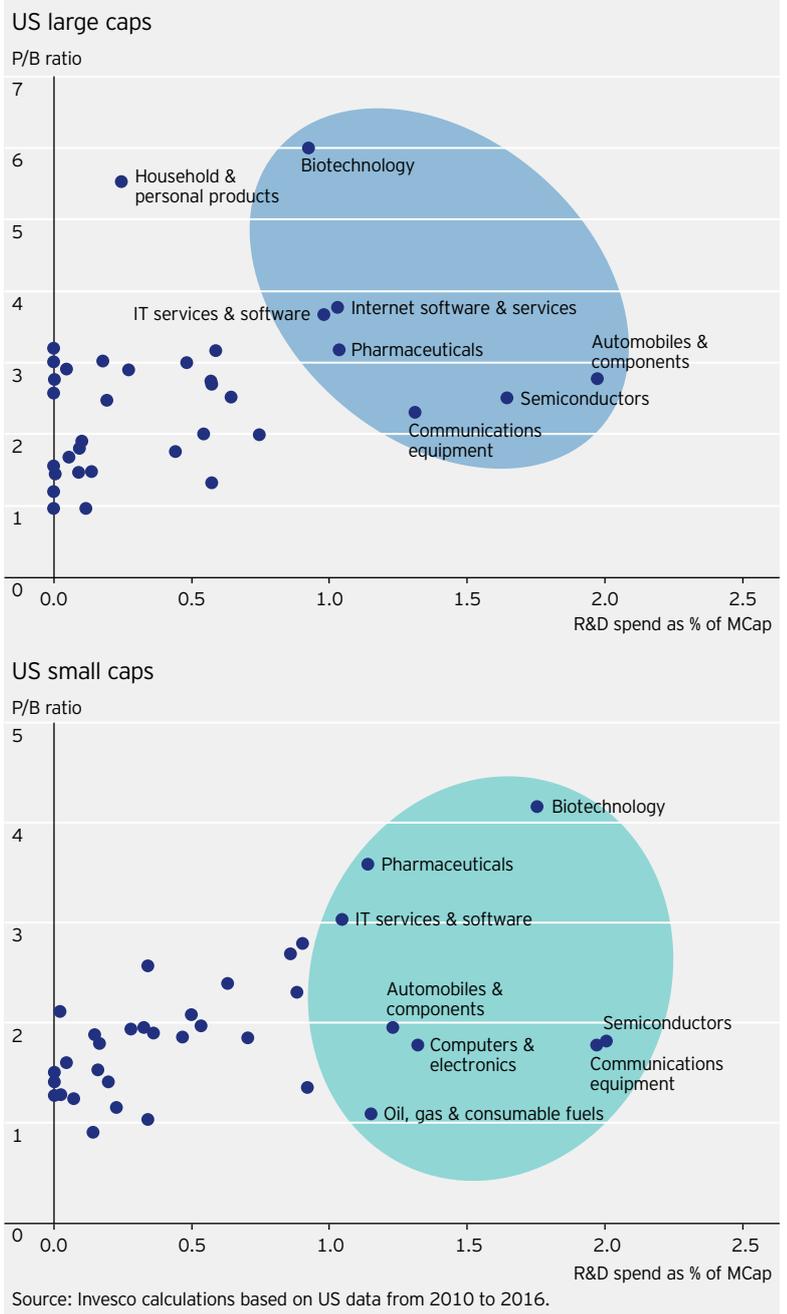
Technological innovations are not relevant for all industries.

Tests for US stocks from "IP-relevant industries"

Figure 1 shows the mean P/B ratio⁵ and mean R&D spending as a percentage of market capitalization for all industries in our US large cap and small cap universes (based on annual data for 2010 to 2016).

R&D expenditure is a measure of input, and the P/B ratio gives an indication of how much lasting value

Figure 1
R&D expenditure and P/B ratio of US large and small caps



Source: Invesco calculations based on US data from 2010 to 2016.



investors can expect from it. One should look at both indicators to estimate the importance of intellectual property for a given industry:⁶ based on figure 1, we believe that patent data should be relevant for these IP-relevant industries.

According to these charts, the following industries tend to have high P/B ratios and high R&D spending relative to market capitalization:

- **US large caps:** biotechnology; IT services & software; internet software & services; pharmaceuticals; communications equipment; semiconductors; automobiles & components
- **US small caps:** biotechnology; pharmaceuticals; semiconductors; communications equipment; IT services & software; automobiles & components; computers & electronics; oil, gas & consumable fuels

We define these industries as “IP-relevant”⁷ and aggregate their firm-level data. Each factor is industry neutralized so that cross-industry comparisons are possible.

For these IP-relevant industries, we expect firms with high IP quality and IP value to outperform firms with lower scores. This is due to the limited attention

hypothesis: information about factors such as quality, value or commercial success in innovation is difficult to process. It is difficult to forecast whether patents will turn into commercially successful products, not least because of the long time span involved. As a result, prices do not fully and immediately reflect the arrival of the relevant public information, which leads to under-reaction. Returns may therefore become predictable.⁸

Indeed, for US small caps in IP-relevant industries, we find a significant relationship between the IP factors and subsequent stock returns. The proprietary IP factors from vendor M are particularly strong: IP quality and IP value are able to predict 6 and 12-month returns with statistical significance at the 10% and 5% levels, as table 2 shows.

For US small caps in IP-relevant industries, we find a significant relationship between the IP factors and subsequent stock returns.

Table 2
Patent factors and subsequent returns of US stocks from IP-relevant industries

		Large caps				Small caps			
		IC1	IC3	IC6	IC12	IC1	IC3	IC6	IC12
IPQ	Mean	0.02	0.03	0.02	0.01	0.02	0.00	0.01	0.02
	T-stat	0.48	0.79	0.60	0.14	0.96	-0.16	0.63	2.00
IPQ2	Mean	0.04	0.01	0.02	0.04	0.04	0.02	0.05	0.03
	T-stat	1.74	0.26	0.69	0.66	1.61	1.60	3.04	1.66
IPV	Mean	0.03	0.04	0.03	0.04	0.03	0.02	0.04	0.06
	T-stat	0.65	1.03	1.07	0.95	1.71	0.69	1.62	4.23

Source: Invesco calculations based on US patent data from 2010 to 2016.

Table 3

Patent factors and subsequent returns of US biotechnology and semiconductor stocks

			Large caps				Small caps			
			IC1	IC3	IC6	IC12	IC1	IC3	IC6	IC12
Biotechnology	IPQ	Mean	0.00	0.11	0.20	0.21	0.04	0.04	0.11	0.08
		T-stat	-0.09	1.33	3.44	2.99	1.34	1.99	3.40	1.87
	IPQ2	Mean	0.05	0.15	0.22	0.23	0.03	0.05	0.09	0.08
		T-stat	1.04	1.55	2.59	1.79	1.20	2.14	3.21	2.25
	IPV	Mean	0.05	0.13	0.23	0.25	0.08	0.08	0.10	0.12
		T-stat	0.63	1.80	3.46	4.14	1.97	2.05	3.03	2.84
Semiconductor	IPQ	Mean	0.08	0.02	-0.07	-0.03	-0.03	-0.04	0.01	0.03
		T-stat	0.75	0.30	-1.10	-0.46	-0.70	-0.84	0.14	0.41
	IPQ2	Mean	0.10	0.03	0.03	0.04	0.12	0.11	0.14	0.11
		T-stat	3.17	0.52	0.43	0.55	2.25	1.63	2.35	2.00
	IPV	Mean	0.19	0.04	0.00	0.08	0.03	0.00	0.05	0.11
		T-stat	1.81	0.47	0.04	1.22	0.83	0.03	1.09	2.15

Source: Invesco calculations based on US patent data from 2010 to 2016.

One reason why these factors do not work as well for large caps may be that the IP-relevant industries are dominated by a handful of large firms.

Tests for biotech and semiconductor stocks

Consistent with previous studies as well as figure 1, we find that semiconductors and biotechnology have the highest average IP relevance scores⁹ for both US large and small caps. Thus, for these two industries, we expect the relationship between the IP factors and subsequent stock returns to be the most significant.

Table 3 indicates that IP quality and IP value can predict cumulative 6 and 12-month returns in biotechnology for both US large caps and small caps, with statistical significance at 10% and 5% levels. The results are not as strong for semiconductors.

IP quality and IP value can predict cumulative 6 and 12-month returns in biotechnology.

We believe this is due to the inherent differences between semiconductors and biotechnology companies. Figure 1 shows that semiconductor stocks have a moderate P/B ratio and very high R&D spending, whereas, in biotechnology, the P/B ratio is very high and R&D spending is relatively high for both US large and small caps. This difference reflects how investors see the importance of R&D spending in the two sectors.

Moreover, much of the value contained in the early stages of a pharmaceutical project lies in the promise of developing a successful drug. This is especially true for biotechnology, where many firms have significant valuations long before they earn profits from selling the drug. In contrast, the value of patents for semiconductors is more predictable, perhaps because the industry is less capital intensive and more cyclical. This makes it a lot easier to estimate the value of patents, so that the market for semiconductor stocks is more efficient with respect to patent data.

Additional checks

In addition, we tested another proprietary IP factor using monthly data from vendor Q. This IP factor is a composite of various signals. When we tested the more recent period from 2011 to 2017, the results were similar to what we found earlier: i.e. the IP factor can predict subsequent returns for a set of IP-relevant industries such as healthcare. But, contrary to the results based on data from vendor M, this IP factor does not work for biotechnology and semiconductors.

Conclusion

For firms focusing on innovation, like biotechnology companies, patent data may be used to predict subsequent stock returns. We found that, in the US small cap universe, IP quality and IP value can predict cumulative 6 and 12-month returns of certain industries. Furthermore, in the US large cap universe, IP quality can predict cumulative 6 and 12-month returns of biotechnology stocks. However, more work is necessary to understand the potential relevance of these findings outside the US and the benefit of the data in a multi-factor context.

References

- Cohen, L., Diether, K., and Malloy, C., "Misvaluing Innovations", *Review of Financial Studies* (2013).
- Damodaran, A. *The Dark Side of Valuation*, FT Press, New Jersey (2010).
- Gentzlow, M., Kelly, B.T., and Taddy, M., "Text as Data", *Journal of Economic Literature*, forthcoming (2018).
- Hirshleifer, D., Hsu, P-H, and Li, D., "Innovative Efficiency and Stock Returns", *Journal of Financial Economics* (2013).
- Kelly, B., Papanikolaou, D., Seru, A., and Taddy, M., "Measuring Technological Innovation over the Long Run", SSRN Working Paper (2018).
- Lerner, J. and Seru, A., "The Use and Misuse of Patent Data: Issues for Corporate Finance and Beyond", Harvard Business School Working Paper 18-042 (2018).
- Wang, A., Luo, Y., Alvarez, M-A., Jussa, J., Wang, S., Rohal, G., Elledge, D., and Zhao, G., "The Drug Business", *Signal Processing*, Deutsche Bank (2016).

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Notes

- 1 Earlier articles in this series are "ESG integration for equities: evolving our systematic investment process" and "What do corporate managers' words reveal about their firms' value?", both in *Risk & Reward* #4, 2018.
- 2 <https://www.uspto.gov/patents-application-process/search-patents>
- 3 For details, see the data construction appendix of Kelly, Papanikolaou, Seru and Taddy (2018). For an excellent discussion on the use and misuse of patent data, see Lerner and Seru (2018).
- 4 The IPQ benchmark is a proprietary composition of various metrics such as market attractiveness, coverage, technology value and legal value.
- 5 R&D spending is taken from Computat and the unit is stated in USD millions.
- 6 For example, an industry such as Household & Personal Products has a high price/book ratio, but that is typically a reflection of brand value or other strengths rather than R&D.
- 7 Note that some of these industries also have very high IP relevance scores provided by vendor M.
- 8 See Hirshleifer, Hsu and Li (2013) and Cohen, Diether and Malloy (2013).
- 9 Based on vendor M's IP relevance scores.

How can fixed income factors help investors with allocation decisions?

By Jay Raol, PhD

In brief

Factors can enhance a traditional approach to fixed income investing because they are not just a replication of traditional fixed income characteristics such as credit rating, industry or duration. To illustrate this, we walk through ways fixed income factors can decrease the risk of typical investment grade and multi-sector credit approaches, complement existing portfolios and improve balanced equity-fixed income portfolios, showing that fixed income factors are more than just equity factors in disguise.

How can fixed income factors enhance the more traditional credit rating, industry or duration view of portfolio construction? Can adding a factor element improve the risk-return profile of a multi-credit portfolio? Do fixed income factors make sense in a balanced equity-fixed income allocation? How can investors complement an existing allocation without significantly disrupting the existing portfolio? In this study, we address these four questions often faced by investors.

To answer each question, we build portfolios using traditional portfolio construction techniques (i.e. allocating along traditional lines such as maturity, industry and rating) and then construct new portfolios adding factors. We find that adding factors improves portfolio outcomes, whether we are constructing an investment grade portfolio, a multi-sector credit portfolio, a balanced equity-fixed income portfolio or complementing an existing portfolio. In other words, we find that factors reduce risk for given levels of return across a wide range of investment cases.

Box 1

How to interpret the efficient frontier plots

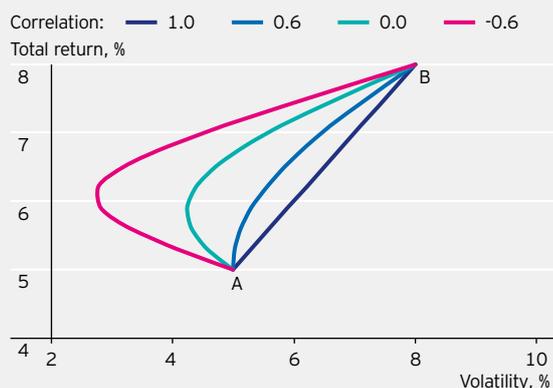
The use of portfolio optimization and construction of the efficient frontier allows us to understand portfolios that would have provided the highest level of return given a certain risk target, assuming a consistent, broadly diversified approach. For most of the analysis, we consider long-only portfolios without leverage since these are constraints most clients face. Let w be the weights associated with the assets in our portfolio, μ the average return of the asset over the sample period and Σ the covariance matrix computed across all assets. The efficient frontier is calculated by solving for the minimum variance portfolio ($w^T \Sigma w$) that satisfies the long-only ($w \geq 0$) and no-leverage ($\Sigma w = 1$) constraint at different return targets (α_i).

$$\begin{aligned} \min w^T \Sigma w \\ \text{s. t. } w \geq 0, \Sigma w = 1, \mu^T w = \alpha_i \end{aligned}$$

The result of this exercise yields a curve representing the portfolio that would have maximized the return at a given level of risk. When looking at the weights of assets at different points on the frontier, an investor can better understand how each asset contributes to the risk-adjusted return. Assets with high weights in the portfolio can meaningfully contribute to the efficient frontier through some combination of high returns and strong diversification.

The figure below illustrates a simple efficient frontier between two assets. It shows how the addition of an asset can change the risk and return profile of a portfolio. Assuming an investor starts with a portfolio labelled A and has the choice of adding an asset labelled B, the figure shows how correlations will impact the portfolio's risk and return. A more diversifying asset will cause the efficient frontier to move further to the left and reduce risk.

Efficient frontier shifts outward through diversification



Source: Invesco. For illustrative purposes only.

Box 2

Credit factor definitions

We believe factors help explain credit returns across asset classes and in different investment environments:

Carry	Quality	Value
The carry factor explains the excess risk and return associated with holding those bonds with the highest yields in the universe. These bonds typically have longer maturities, lower ratings and higher spreads. They tend to be the riskiest bonds in the universe.	The quality factor explains the higher risk-adjusted returns associated with holding low volatility bonds and is widely observed in the academic literature. ² These bonds typically have short maturities and low default risk as measured by their ratings. The quality factor is a characteristic of securities that tend to be good stores of value during times of market stress given their low volatilities.	The value factor explains the excess return obtained by holding assets priced at a discount relative to similar securities. Since a bond's price is a function of its default risk, a natural definition is to identify bonds priced at a discount relative to their implied default rates. These factor returns include transaction costs of 10-40 basis points, depending on the maturity and rating of the bond.

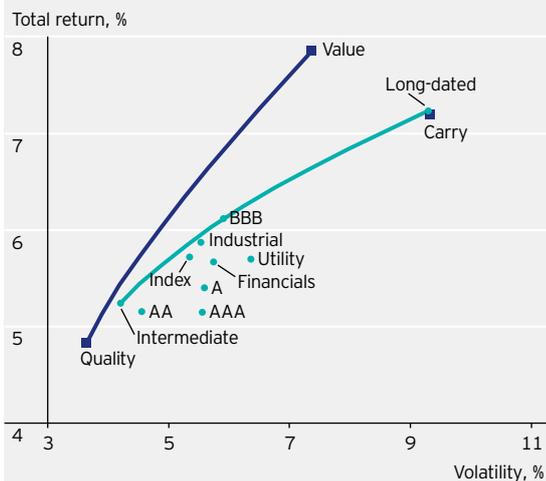
In adding factors to traditional portfolios, we focus on the value, quality and carry factors, based on the methodology from Raol and Pope (2018),¹ and apply them to the Bloomberg Barclays US Investment Grade Corporate Index, Bloomberg Barclays US High Yield Corporate Index and the Bloomberg Barclays Emerging Market Hard Currency Index over the period from 1 January 2000 to 31 December 2018. To construct portfolios, we use mean-variance optimization to identify portfolios that minimize risk at a given level of return (efficient frontier). This method highlights those combinations of assets that comprise optimal portfolios for different levels of risk. We find that factors are often present in optimal portfolios, meaning that adding factor allocations to portfolios improves investment outcomes, i.e. shifts the efficient frontier outward.

1. How do fixed income factors fit with the more traditional credit rating, industry or duration view of portfolio construction?

To answer this question, we narrow complex fixed income portfolio construction to a simple analysis of how to use factors within US investment grade credit. An investment grade credit portfolio must balance the wide ranges of risk and return across the bond universe. In order to represent different investment choices, we divide subsets of the universe into sectors according to rating, maturity and industry using the following market value weighted indices, hereafter referred to as traditional indices: the Bloomberg Barclays US Corporate Index, Intermediate Corporate Index, Long US Corporate Index, US Corporate Industrial Index, US Corporate

Utility Index, US Corporate Finance Index, US Corporate AAA Index, US Corporate AA Index, US Corporate A Index and the US Corporate BBB Index. We construct the efficient frontier as combinations of sectors and plot it as a dotted line throughout. Next, we include factors and recompute the efficient frontier as a solid line (figure 1).

Figure 1
How factors can improve the risk-return profile of US investment grade portfolios



Source: Bloomberg Barclays Indices, Invesco calculation from 1 January 2000 to 31 December 2018. **This is simulated performance and there is no guarantee that the simulated results will be realized in the future.** The figure shows the efficient frontier from constructing a long-only portfolio without leverage from a universe of investment grade quality, value and carry factors along with common market value weighted indices, including US investment grade, represented by the Bloomberg Barclays US Corporate index, Intermediate Corporate Index, Long US Corporate Index, US Corporate Industrial Index, US Corporate Utility Index, US Corporate Finance Index, US Corporate AAA Index, US Corporate AA Index, US Corporate A Index and US Corporate BBB Index. The efficient frontier is constructed by solving for the weights of different assets that maximize the Sharpe ratio of a portfolio for a given level of risk. The highest Sharpe ratio portfolios are shown for portfolios built with market value weighted indices only (green) and those including factors (blue).

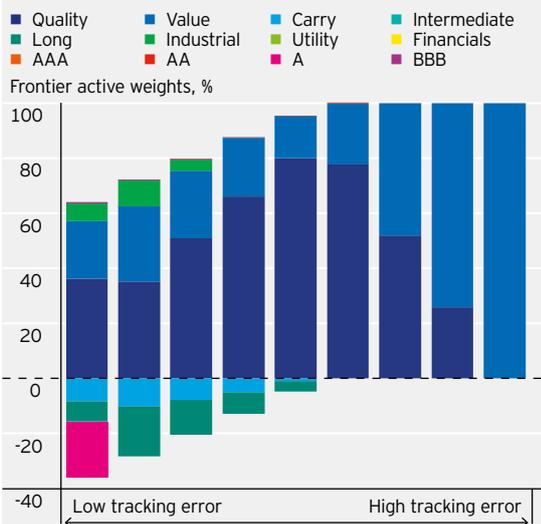
We narrow complex fixed income portfolio construction to a simple analysis of how to use factors within US investment grade credit.

Table 1
Descriptive statistics of US investment grade factors and sectors

	Information ratio	Active skew	Active expected shortfall	Active return
Quality	-0.35	0.05	-1.28%	-0.93%
Value	0.73	-0.08	-1.37%	2.09%
Carry	0.25	-0.14	-2.91%	1.30%
Intermediate	-0.30	0.04	-0.84%	-0.49%
Long-dated	0.34	-0.04	-2.12%	1.42%
Industrial	0.10	-0.04	-0.60%	0.14%
Utility	-0.01	-0.08	-1.57%	-0.07%
Financials	-0.02	0.04	-1.18%	-0.08%
AAA	-0.18	0.03	-1.65%	-0.63%
AA	-0.32	0.07	-0.84%	-0.58%
A	-0.33	0.03	-0.45%	-0.32%
BBB	0.21	0.01	-0.85%	0.37%

Source: Bloomberg Barclays Indices, Invesco calculation from 1 January 2000 to 31 December 2018. The table shows summary statistics of active return and risk of different market value weighted investment grade sub-indices and factors relative to the Bloomberg Barclays US Corporate Index. The information ratio is the active return per unit of tracking error. The active skew is a normalized number where zero represents a symmetric distribution, negative represents a small number of large losses and positive represents a small number of large gains. The active expected shortfall is the average of the worst 10 observations in the study. The active return is the annualized return over the benchmark. **Past performance is not a guide to future returns.**

Figure 2
Tracking error of different US investment grade portfolios



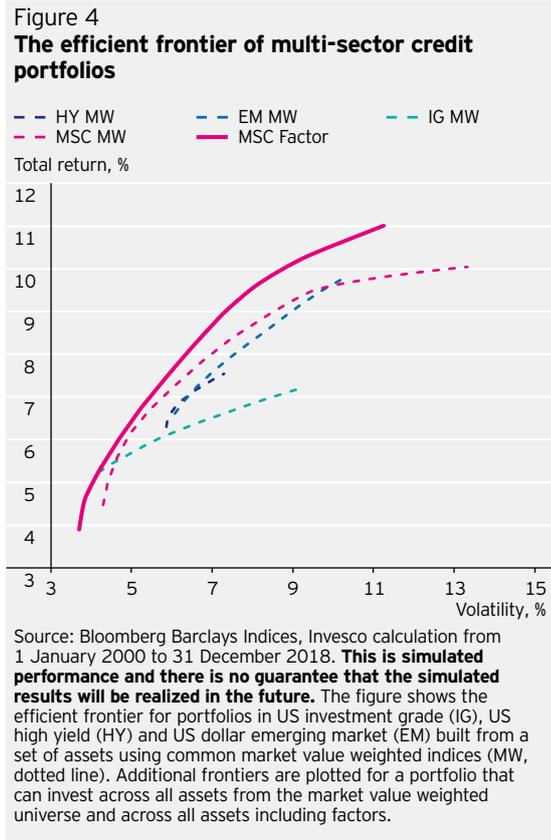
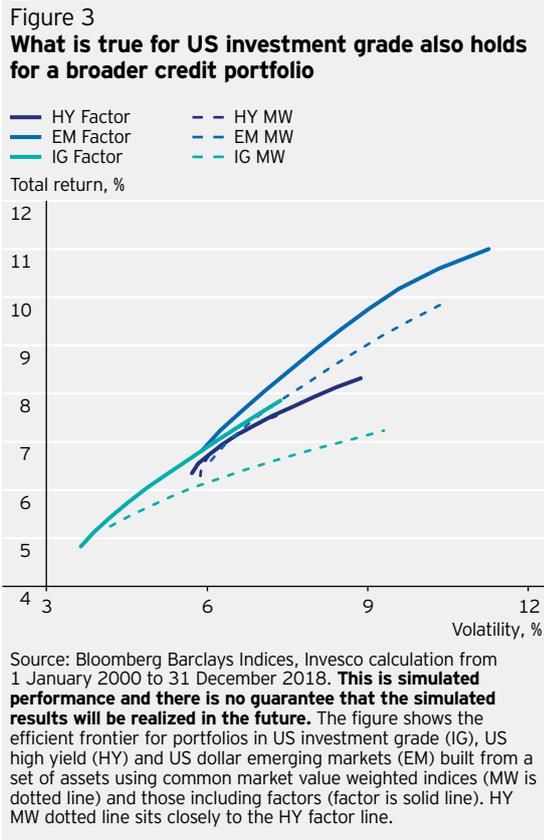
Source: Bloomberg Barclays Indices, Invesco calculation from 1 January 2000 to 31 December 2018. The figure shows the portfolio weights of the efficient frontier at different levels of tracking error. The efficient frontier was calculated relative to the Bloomberg Barclays US Corporate Index; negative values represent underweights to the benchmark and positive values represent overweights.

As can be seen, the addition of factors shifts the efficient frontier outward, meaning that factors reduce risk for a given level of return. In addition, factors significantly lower the volatility of the least risky portfolio (minimum variance portfolio). This means the addition of factors expands the universe of potential outcomes for investors.

We now take a closer look at a benchmark-centric approach. Table 1 shows the active returns, active risks (skew and expected shortfall) and the information ratio relative to the Bloomberg Barclays US Corporate Index (benchmark) for the factor and traditional portfolios. Figure 2 shows the active weights of the portfolios at the efficient frontier relative to the benchmark. First, we can see that factor weights dominate traditional metrics like maturity, rating and industry, in terms of minimizing risk at different levels of return. Even more surprising, the quality factor is selected for the efficient frontier at almost all levels of risk, except the riskiest. The reason can be found in table 1: while quality has a low expected return against the benchmark, it has positive skew - i.e. a small number of large gains which tend to coincide with large losses in value. This negative correlation to value makes quality generally very useful for investors with low risk budgets.

Factor weights dominate traditional metrics like maturity, rating and industry.

Figure 2 also shows some non-intuitive results when constructing lower risk portfolios: while value has a high risk-adjusted return, it also has high risk. To achieve relatively low levels of risk in a portfolio while including value, the mean-variance optimization suggests removing long-dated bonds and bonds with high carry exposure since they are riskier and offer only minor diversification benefits relative to their historical returns. Figure 2 shows



that value-tilted portfolios would maximize return for investors with large risk budgets.

Figure 3 shows the analogous efficient frontiers with and without factors in the US investment grade, US high yield and emerging markets (EM) hard currency universes. Like investment grade, we use traditional market value weighted indices broken down by maturity, rating and industry for each credit

sector. We see a similar pattern across all three sectors, where factor-based portfolios consistently lead to better outcomes at most levels of risk.

2. Can adding a factor element improve the risk-return profile of a multi-credit portfolio?

We now increase the level of complexity and consider multi-sector credit portfolios. Figure 4 shows the efficient frontier that can be achieved by looking

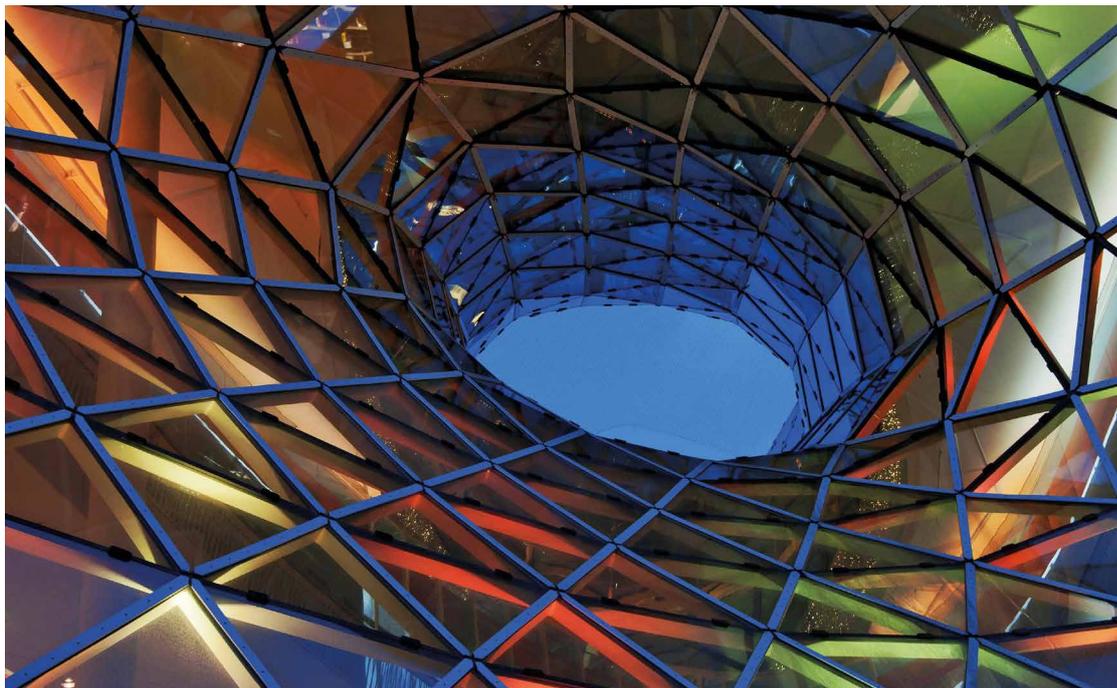
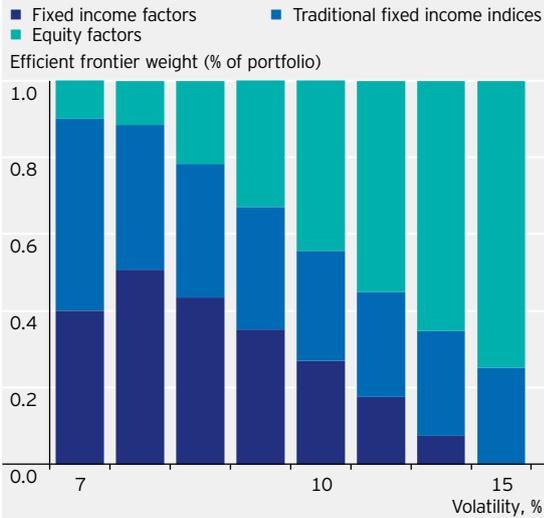


Figure 5

Efficient balanced portfolios



Source: Bloomberg Barclays Indices, Invesco calculation from 1 January 2000 to 31 December 2018. The figure shows the weights assigned to the fixed income factors, traditional FI indices from US Treasuries, US investment grade and US high yield and MSCI equity factor indices (see appendix) along the efficient frontier.

are more than just a “reshuffling” of traditional risk buckets (i.e. adding the investment grade value factor is not equivalent to adding high yield beta); they represent a separate and complementary asset allocation decision.

3. Do fixed income factors make sense in a balanced equity and fixed income allocation?

Finally, we look at how credit factors can complement a balanced portfolio of equities and bonds even when equities already benefit from a factor-based approach. We construct the equity portfolio from MSCI USA factor indices that include value, quality, size, momentum and minimum volatility. We then construct the efficient frontier and plot the associated weights for each asset, aggregating the fixed income factors, the traditional fixed income sectors (US Treasuries, US investment grade corporates and US high yield corporates) and the MSCI equity factor weights (figure 5).

At almost all levels of risk, the most efficient portfolio includes a significant allocation to fixed income factors. It is important to understand that fixed income factors are not subsumed by equity factors. While fixed income and equity factors have some correlation to each other, they are more often diversifying. In addition, it is not surprising that fixed income factors have their highest allocation around the 7% volatility level. This represents the level of risk at which factors can be harvested most efficiently across rating and geography since multiple credit sectors overlap at this risk level. This is another powerful data point suggesting the advantages of a multi-sector and multi-factor portfolio.

across credit sectors using the traditional asset class breakdowns found in typical multi-sector credit (MSC) portfolios.

Even in a multi-sector context, we can see that including factors can meaningfully improve performance. This shows that factor portfolios

4. How can factors complement an existing portfolio without significantly disrupting the existing portfolio?

We consider the case of an investor seeking to improve risk-adjusted returns without major disruption to an existing carry portfolio. As a proxy for a typical investor, we consider the portfolio of the median active bond manager whose active returns have been shown to be primarily driven by carry,³ (this proxy should reasonably approximate a true portfolio). We compute the efficient frontier given an existing, static 75% allocation to investment grade carry. Figure 6 shows that the pure carry portfolio can be improved by allocating along the spectrum to either quality or value with the overall risk varying between the minimum risk portfolio (carry + quality), with an allocation of 25% to quality, and the maximum return portfolio (carry + value), with an allocation of 25% to value.

Figure 6

The efficient frontier of a portfolio with 75% allocation to carry factor



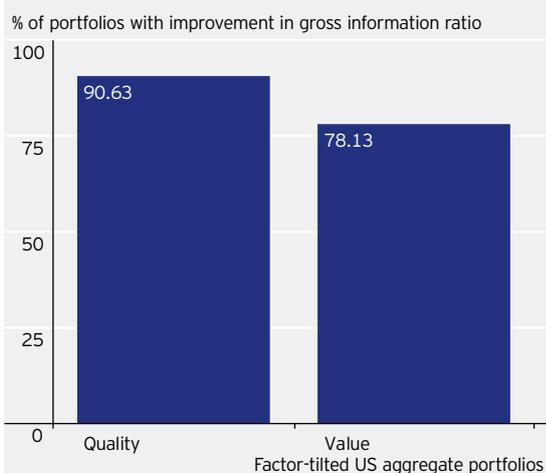
Source: Bloomberg Barclays Indices, Invesco calculation from 1 January 2000 to 31 December 2018. **This is simulated performance and there is no guarantee that the simulated results will be realized in the future.** The figure shows the efficient frontier for a portfolio that has a 75% allocation to carry. The risk and return characteristics of carry are shown. The minimum variance portfolio with a 25% allocation to quality (labelled Carry + Quality) and all the portfolios in between to a maximum return portfolio with an allocation of 25% to value (labelled Carry + Value) are shown. The risk and return characteristics can be improved by varying the allocation to quality and value.

Case study: US bond managers perform better with factors

While the previous example represented a theoretical problem, we use actual investment manager data here to show how quality and value factors can improve the risk-adjusted performance of carry portfolios.

We construct quality and value-tilted core bond funds which each own securitized and US Treasury allocations with similar weights to the Bloomberg Barclays US Aggregate Index. Credit factors are added at weights similar to credit in the aggregate index - one with most of the allocation to quality and the other with most of the allocation to value. We then create a new portfolio by combining 90% of an

Figure 7
How factor allocations can improve the risk-return profile



Source: Bloomberg Barclays Indices, Invesco calculation from 1 January 2000 to 31 December 2018. The figure shows the percentage of core plus bond funds whose information ratio improved when a 10% allocation to either a quality-tilted or value-tilted factor-based core bond portfolio was added. We look at active manager returns in excess of the benchmark in the core bond fund space from 1 January 2007 to 31 December 2018. We sampled 65 investment managers representing the largest managers in the Lipper Core Plus peer group. For each fund, we aggregated monthly total returns, i.e. price returns plus any dividends, and added back stated manager fees to approximate gross monthly returns. Each fund's returns were subtracted from the benchmark returns to calculate "active" returns for each month.

existing active manager portfolio with a 10% allocation to one of the factor portfolios. Figure 7 shows that the majority of existing managers' information ratios are improved with an allocation to one of the two factors, even at the low 10% weight. The result is consistent with figure 5 - i.e. the risk-adjusted returns of carry-based portfolios can be improved with a diverse factor allocation.

Conclusion

By analyzing the addition of factors to four common use cases in fixed income investing, including: (1) using factors to improve on a portfolio diversified across rating, maturity and industries, (2) adding factor exposure to a multi-sector credit allocation, (3) utilizing factors in a balanced stock and bond portfolio and (4) completing or risk-controlling an existing active approach, we show that managed factor exposure can potentially improve results across risk and return objectives. Both academic and practitioner research has shown that investors have a meaningful amount of factor exposure, whether they employ a factor investing strategy or not.⁴ We believe a natural conclusion is for investors to adopt a more explicit approach to the monitoring and managing of their fixed income factor exposures.

Investors have a meaningful amount of factor exposure, whether they employ a factor investing strategy or not.

Appendix

The following indices are used in this study:

- Bloomberg Barclays US Corporate Index
- Bloomberg Barclays US Intermediate Corporate Index
- Bloomberg Barclays US Long Corporate Index
- Bloomberg Barclays US Corporate Utility Index
- Bloomberg Barclays US Corporate Industrials Index
- Bloomberg Barclays US Corporate Financials Index
- Bloomberg Barclays US Corporate AAA Index
- Bloomberg Barclays US Corporate AA Index
- Bloomberg Barclays US Corporate A Index
- Bloomberg Barclays US Corporate BBB Index
- Bloomberg Barclays US High Yield Corporate Index
- Bloomberg Barclays US Intermediate High Yield Corporate Index
- Bloomberg Barclays US High Yield Corporate BB Index
- Bloomberg Barclays US High Yield Corporate B Index
- Bloomberg Barclays US High Yield Corporate CCC Index
- Bloomberg Barclays Emerging Market USD Aggregate Index
- Bloomberg Barclays Emerging Market Sovereign Index
- Bloomberg Barclays Emerging Market Corporate Index
- Bloomberg Barclays Emerging Markets USD Latin American Index
- Bloomberg Barclays Emerging Markets USD Asia Index
- Bloomberg Barclays Emerging Markets USD EMEA Index
- Bloomberg Barclays Emerging Markets USD Investment Grade Index
- Bloomberg Barclays Emerging Markets USD High Yield Index
- Bloomberg Barclays Emerging Markets Aggregate Intermediate Index

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Notes

- 1 Raol, J. and Pope, S. (2018), "Why should investors consider credit factors in fixed income?", AIAR Vol. 7(3)
- 2 For example: Frazzini, Andrea and Pedersen (2014), "Betting Against Beta", Journal of Financial Economics, 111, 1-25. Low volatility bonds are typically characterized as bonds with short maturities and low default risk.
- 3 Raol, J. and Quance, S. (2019), "Active bond funds - powered by factors", Risk & Reward #1/2019, pp. 4-8.
- 4 See also footnote 2 and Ang, Goetzman and Schaefer (2009), "Evaluation of Active Management of the Norwegian Government Pension Fund - Global".

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