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The Benefits of Risk Factor Allocation

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The importance of diversification is mentioned centuries before the birth of Christ (Ecclesiastes 11:2, 935 B.C.: "Invest in seven ventures, yes, in eight; you do not know what disaster may come upon the land") and is a well understood and appreciated concept in asset allocation. Most investors, however, focus on asset diversification, which is not always equivalent to risk diversification. In this paper we show how a better risk factor allocation and, therefore, a higher diversification of risks can improve the risk-adjusted return and, more importantly, reduce the drawdown of a multi-asset portfolio, with substantial benefits for the final investors.

In a previous article[1] we introduced the concept of risk budgeting and explained why this conveys more information about the nature of risk in a portfolio than using asset weights to define the capital allocated to each investment. We defined a risk factor as an economic or financial source of risk from which each asset class derives its risk/reward characteristics, and introduced the general idea that assets are more accurately viewed as being only the instruments used to access the risks for which an investor hopes to be rewarded. We showed how movements in the price of asset classes can be explained by three main risk factors: Inflation, Interest Rate and Economic Growth, and highlighted how significantly capital and risk budgeting may differ in the context of risk rated portfolios. While the allocation between equities and bonds, as well as the overall portfolio volatility, generally increases in a linear fashion through the risk profiles, the risk allocation is, on the other hand, quickly dominated by the economic growth factor as soon as a certain level of volatility is reached. The analysis suggested that portfolios commonly characterised as "balanced" in their asset exposure are in fact not balanced in their true risk exposure.

In this article we present how risk budgeting with risk factors (so called *risk factor allocation*) is used to improve the risk-adjusted return of a portfolio through a better diversification of the underlying risk factors. The better risk-adjusted returns are not only achieved with a higher return per level of risk (generally measured as volatility), but also with a significant reduction in of the portfolio drawdowns, a feature that makes the results particularly attractive.

[1] Laurent A. (2020), "Risk Budgeting for Multi-Asset Portfolios", www.lyskammcapital.com/research

INTRODUCTION

Table 1 shows the set of risk rated portfolios used to represent the offering of a generic UK asset or wealth manager. The transition from a Defensive to an Adventurous portfolio happens gradually, generally through a linear reallocation from bonds to equities. A balanced mandate sits normally in the middle of the risk spectrum, with typically an equal allocation between equities and fixed income securities. The overall volatility of the different mandates also increases in a linear way, from around 5% to 7% annualised volatility[2] for a Defensive mandate up to roughly 13% to 14% for an Adventurous portfolio.

	Defensive	Conservative	Balanced	Growth	Adventurous
Domestic Equities		9.0%	18.0%	26.0%	34.0%
Foreign Equites		14.0%	28.0%	42.0%	57.0%
EM Equities		2.0%	4.0%	7.0%	9.0%
Gov'n Bonds	30.0%	24.0%	16.0%	9.0%	
Corp. Bonds	40.0%	33.0%	24.0%	13.0%	
IL Bonds	30.0%	18.0%	10.0%	3.0%	
Equities	0.0%	25.0%	50.0%	75.0%	100.0%
Bonds	100.0%	75.0%	50.0%	25.0%	0.0%
Volatility	6.6%	7.4%	8.2%	10.8%	13.9%

Table 1. Example of the range of risk rated offering of a typical UK asset/wealth manager.

[2] The volatilities are calculated using long-term factor exposures (they are therefore not conditional on the actual market conditions, hence not a prediction of short-term future portfolio volatilities)

As previously suggested though, the linear transition through the different risk profiles is not apparent when analysing the risk budgeting of these portfolios using inflation, interest rates and economic growth as risk factors.

Figure 1 shows the risk contribution from the three risk factors for each of the different mandates. As soon as the volatility level goes above a Conservative mandate, the risk is dominated by the economic growth factor. The main reason for this is the linear increment of the equity allocation, which not only dominates the overall portfolio risk but is also directly linked to economic growth.

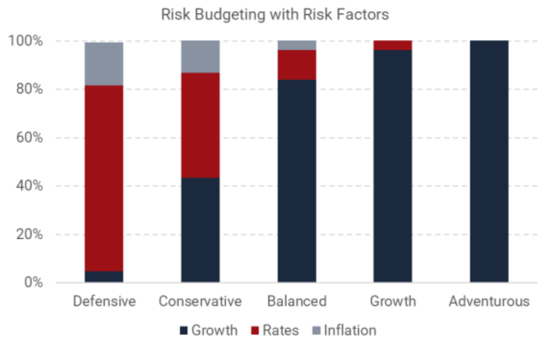

Figure 1. Risk budgeting between inflation, interest rates and growth risk across different risk profiles of a typical UK asset/wealth manager.

In the transition from a defensive to an adventurous portfolio, gradually increasing the allocation to equities and therefore to economic growth risk is the simplest way to increase the overall portfolio volatility. However, simply replacing the allocation of fixed income securities with equities is not the most efficient way to move up the volatility scale because the increase in the overall level of risk comes at the cost of a reduced risk diversification.

A BETTER DIVERSIFICATION OF RISKS

We can however reduce the trade-off between the overall risk level and risk diversification by explicitly targeting a more diversified portfolio exposure to the three risk factors while at the same time controlling for overall portfolio risk.

Figure 2 tries to give the intuition in a familiar mean-variance framework. Linearly increasing the allocation to equities is like moving along the straight line from the Defensive Portfolio to the Adventurous Portfolio. It is not necessarily similar, however, to moving along the curved line which denotes the most efficient combination of risks, the one that produces the highest expected return for a given level of risk. Note that the advantage of the curved line over the straight line is zero for the Adventurous Portfolio because, to achieve the volatility level of an adventurous portfolio, which generally has a 100% allocation to equities, there is no other way than allocating the entire risk budget to economic growth risk. For all other portfolios with a lower risk profile, however, we should be able to achieve the same level of volatility with a higher level of diversification among risk factors. In a similar way to asset class diversification in a mean-variance framework, a higher level of diversification among risk factors will have beneficial effects on the long-term risk adjusted portfolio returns, reducing at the same time the risk of significant drawdowns.

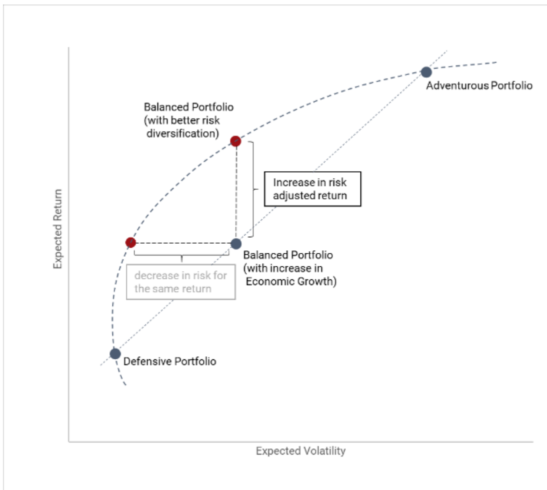

Figure 2. Risk budgeting representation in a mean-variance framework.

In order to move along the curved line, rather than linearly increasing the allocation to equities it is more effective to target a linear increase in the economic growth factor allocation, which is the primary driver of the performance of equities. In other words, by changing the focus from asset to risk factor allocation we shift the question from "how much equity exposure do I need to reach a certain level of risk" to "how can I better diversify my risk exposure given a certain level of overall portfolio risk".

Consider for instance the balanced portfolio in Table 1. More than 80% of its risk contribution is explained by the exposure to economic growth. Figures 3a and 3b show the allocation of the generic balanced portfolio used for this analysis (expanded to include each foreign equity allocation), as well as the contribution to volatility of its risk factor exposure.

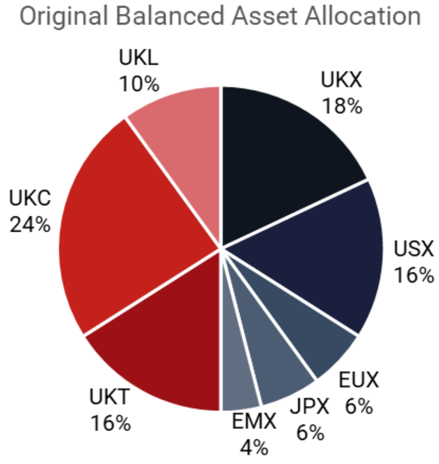

Figure 3a. Asset allocation of a generic balance portfolio UKX: UK Equity, USX: US Equity, EUX: EU Equity, JPX: Japan Equity, UKT: Gilts, UKC: UK Corporate Bonds, UKL: UK Inflation Linked Bonds.

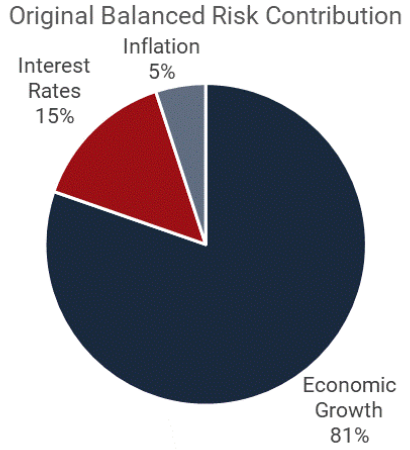

Figure 3b. Volatility risk contribution of a generic balance portfolio.

The return and risk characteristics of the portfolio computed using its long-term risk-factor exposures[3] are reported on in Table 2.

Annualised Expected Return	9.22%
Annualised Expected Volatility	8.24%
Expected Value-at-Risk (monthly 5% prob.)	3.69%
Expected Shortfall or CVaR (monthly 5% prob.)	5.39%

Table 2. Portfolio return and risk characteristics of the original balanced portfolio.

To increase the risk diversification of the portfolio we can now target a different risk budget for each of the three risk factors. We can for instance target a lower volatility risk contribution from economic growth and aim to increase the risk budget to interest rates and inflation, so as to obtain a more linear increment of the risk factor exposure throughout the different risk profiles. In this example, we target a contribution to volatility of 10%, 35% and 55% from inflation, interest rates and economic growth, respectively under the constraint that the overall expected long-term portfolio volatility remains equal to 8.24%. We can then optimise the portfolio allocation such that the risk budget is as closed as possible to our targets and all the constraints are satisfied.

Figures 4a and 4b shows the resulting portfolio allocation and risk factor contribution to volatility. Note first that the new risk budgeting optimised portfolio has no allocation to European (ex-UK) and Japanese equities, but an increased allocation to UK, US, and EM Equities. As a result, the overall equity allocation is reduced by less than 4%. Despite only a small reduction to equity we were still able to reduce the exposure to economic growth from 81% to 56%. This was also achieved thanks to the reduction in the allocation to UK corporate bonds, which were largely replaced by UK Gilts and inflation linked bonds.

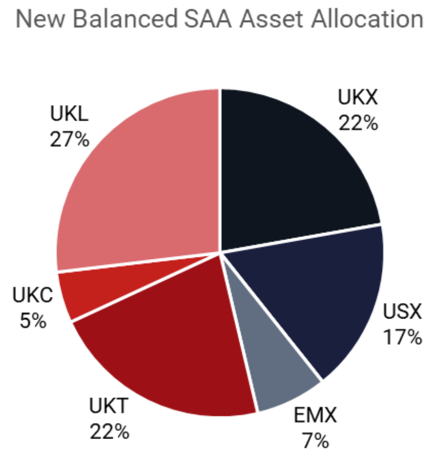

Figure 4a. Asset allocation of a risk budgeting optimised balance portfolio UKX: UK Equity, USX: US Equity, EUX: EU Equity, JPX: Japan Equity, UKT: Gilts, UKC: UK Corporate Bonds, UKL: UK Inflation Linked Bonds.

[3] These should therefore not be interpreted as any sort of prediction, which are conditional to the actual market conditions, but as long-term, unconditional characteristics of a portfolio with similar risk exposures.

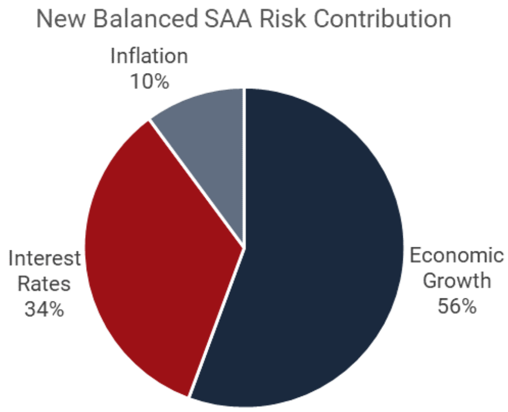

Figure 4b. Volatility risk contribution of a risk budgeting optimised balance portfolio.

While government and inflation linked bonds primarily load to interest rates risk, corporate bonds are, from a risk perspective, a hybrid between a stock and a government bond. Moving from corporate to government and inflation linked bonds therefore reduces the overall exposure to economic growth and increases the volatility risk budget to the interest rate risk factor.

Table 3 presents the return and risk characteristics of the optimised portfolio.

Annualised Expected Return	9.72%
Annualised Expected Volatility	8.24%
Expected Value-at-Risk (monthly 5% prob.)	3.58%
Expected Shortfall or CVaR (monthly 5% prob.)	5.08%

Table 3. Portfolio return and risk characteristics of the new optimised balanced portfolio.

Not only does the new risk budgeting portfolio achieve a higher expected long-term return for the same level of volatility, but at the same time both measures of tail risk, VaR and CVaR (or expected shortfall) are lower, suggesting a better performance during drawdowns.

The results are confirmed when looking at the simulated performance of the two portfolios over the last 20 years (January 2000 to May 2020). Each portfolio is rebalanced yearly (in January) back to its original weights[4]. Table 4 shows the realised return, volatility, and Information Ratio (i.e. return/volatility ratio) for the two simulated portfolios over the full 20 year period.

	Original Balanced Portfolio	New Balanced Portfolio
Annualised Return	5.06%	5.32%
Annualised Volatility	7.27%	7.08%
Information Ratio	0.70	0.75

Table 4. Portfolio return, volatility and Information Ratio of the simulated portfolios using the original and new optimised balanced portfolio weights (Jan 2000 – May 2020)

The new optimised balanced portfolio achieved an average annualised performance of 5.32% vs. 5.06% of the original balanced portfolio with a lower volatility (7.08% vs. 7.27%), for an Information Ratio of 0.75 and 0.70, respectively.

More importantly though, the new balanced portfolio outperformed in each of the major drawdown of the last 20 years. Figure 5 shows the drawdowns of the two simulations, while Table 5 reports the performance during all the major drawdowns of the past 20 years[5].

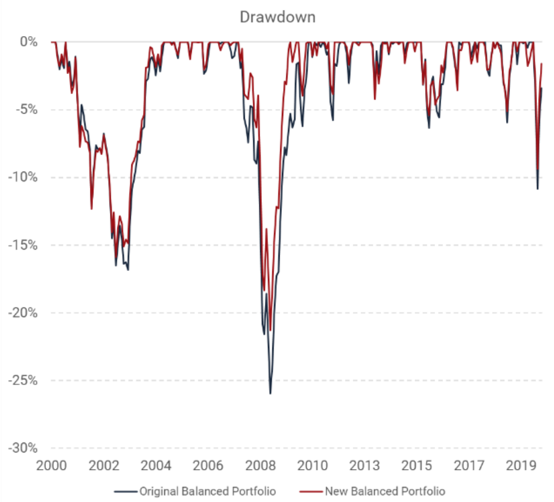

Figure 5. Drawdowns of the simulated portfolios using the original and new optimised balanced portfolio weights (Jan 2000 – May 2020)

[4] Semi-annual or quarterly rebalancing as well as changing the rebalancing month do not have a significant impact on the performance. No transaction costs are included in the simulation.

[5] We define as major every drawdown over 5%.

	Original Balanced Portfolio	New Balanced Portfolio
Aug 2000 - Aug 2004	-16.82%	-15.87%
Nov 2007 - Aug 2010	-25.95%	-21.29%
May 2011 - Dec 2011	-5.80%	-3.85%
Jun 2015 - May 2016	-6.35%	-5.43%
Aug 2018 - Feb 2019	-5.93%	-5.12%
Feb 2020 - May 2020	-10.85%	-9.38%

Table 5. Performance of the simulated portfolios using the original and new optimised balanced portfolio weights during major drawdowns (Jan 2000 – May 2020)

A better risk diversification would have allowed us not only to achieve a higher return with less volatility, but also to perform better in every single major drawdown.

LONG-TERM ROBUSTNESS CHECK

While the results of the simulations fully confirm our theoretical expectations, we are well aware of the statistical and economical limitations of our analysis. First of all, the model is calibrated over the same period used to run the simulation. To use statistical terminology, we are therefore running our test *in-sample* rather than *out- of-sample* with all the consequences to the robustness of our results. Second, running asset allocation tests using the past several decades of data introduces the problem of representativeness. Because of the extraordinary rally in bond prices over this period, every solution that increases the allocation to fixed income securities will most likely obtain better risk adjusted returns and lower drawdowns.

To overcome these critiques and improve the robustness of our analysis, we run a similar study using the SBBI data set originally produced by Roger G. Ibbotson and Rex A., which record monthly total returns for the major US asset classes from 1928[6]. For our analysis we use the following four assets: US large stocks, US government bonds, US corporate bonds and US High Yield bonds.

Like the previous analysis, we use the March 1982 to June 2020 period to calculate the risk-factor exposures and optimise the portfolio. We will then simulate the performance of the benchmark portfolio and the optimised portfolio over the full 1928-2020 period and compare the results.

In Table 6 we report the historical realised returns and volatilities over the calibration period. Note that the equity volatility is significantly higher than for the other three asset classes. More surprisingly, however, is the low volatility of the high yield bonds series in the database over that period, in particular when compared to corporate and government bonds.

	return	volatility
US large stocks	12.31%	15.01%
US government bonds	10.00%	10.53%
US corporate bonds	9.96%	9.03%
US High Yield bonds	9.66%	8.56%

Table 6. historical realised returns and volatilities (March 1982 – June 2020)

As a starting benchmark portfolio, we use a 40% Equity, 22% government, 22% corporate and 16% high yield bond portfolio. The reason for using 40% equities rather than 50% as in the previous example in to reduce the overall volatility of the benchmark portfolio. Because of the big difference in volatility between equities and the other asset classes, starting from a lower equity allocation gives the optimiser a higher leeway when finding the desired risk factor exposure. This allows the final portfolio to diverge more from the starting one, magnifying the results of an increased risk diversification. Similar outcomes, but with lower magnitude are found when starting with a 50% equity allocation. The inclusion of high-yield bonds in the starting portfolio may look unusual but given the limited number of assets in our opportunity set we decided to include a small allocation.

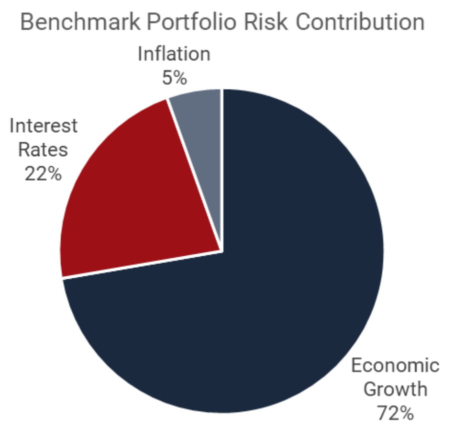

Figure 6. Risk allocation of the benchmark portfolio with 40% invested in equity, 22% in government, 22% in corporate and 16% in high yield bonds

[6]The data can be found on the CFA institute website https://www.cfainstitute.org/en/research/foundation/sbbi

The risk allocation of the benchmark portfolio is shown in Figure 6. Once again, the risk is highly dominated by economic growth.

As in the previous example we decided to target the same risk factor exposure, namely 55% economic growth, 35% interest rate and 10% inflation risk. The optimised asset allocation and the resulting risk factor exposure are reported in figures 7a and 7b.

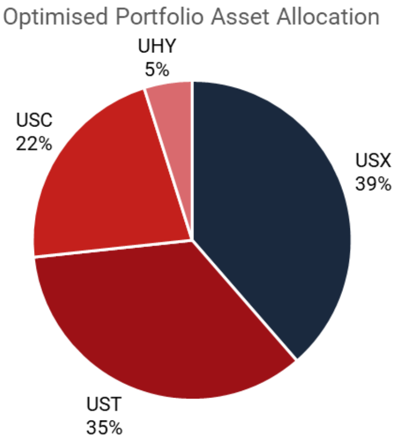

Figure 7a. Asset allocation of the risk budgeting optimised portfolio USX: US Equity, UST: US Treasury, USC: US Corporate Bonds, UHY: US High Yield Bonds.

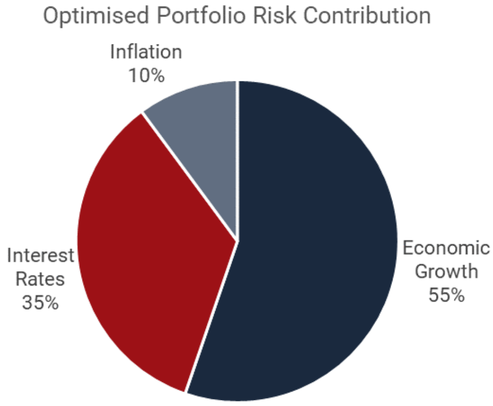

Figure 7b. Volatility risk contribution of the risk budgeting optimised portfolio.

Having obtained the optimal asset weights for a portfolio with the desired risk factor exposures we can run a similar back-test as before. Once again, each of the two portfolios is rebalanced yearly, every January, from 1928 to 2020. The results of the two simulations are reported in table 7. We divided the sample into two periods, the pre and post gold-standard era.

Jan 1926 - Jun 2020	Benchmark Portfolio	New Optimised Portfolio
Annualised Return	8.44%	8.23%
Annualised Volatility	9.59%	9.03%
Information Ratio	0.88	0.91

Jan 1926 - Aug 1971	Benchmark Portfolio	New Optimised Portfolio
Annualised Return	7.02%	6.63%
Annualised Volatility	10.28%	9.17%
Information Ratio	0.68	0.72

Aug 1971 - Jun 2020	Benchmark Portfolio	New Optimised Portfolio
Annualised Return	9.76%	9.72%
Annualised Volatility	8.88%	8.87%
Information Ratio	1.10	1.10

Table 7. Back-test results of the two simulated portfolios (Jan 1928 – June 2020)

For each of the three analysed periods the Information Ratio of the optimised portfolio is either higher or equivalent to that of the benchmark portfolio, which suggests that the portfolio with a higher risk distribution achieves better risk adjusted returns in the long-term.

Once again, though, it is when comparing the drawdowns that the advantages of a better risk distribution stand out. Figure 8 shows the rolling drawdown difference between the simulated benchmark and the optimised portfolio.

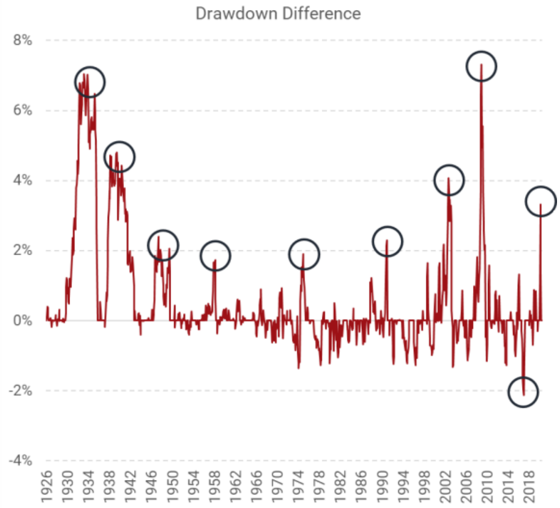

Figure 8. Rolling drawdown difference between the simulated benchmark and the optimised portfolio.

A positive (negative) value means that the benchmark portfolio experienced a bigger (smaller) drawdown than the optimised portfolio. Apart from one episode (January 2017) where the optimised portfolio had a relative drawdown about 2% worse that the original portfolio, in all other significant drawdown periods the portfolio with the better risk diversification outperformed significantly. Table 8 reinforces this conclusion by reporting the performance of the two portfolios during major drawdowns characterised by losses of more than 10%.

	Benchmark Portfolio	Optimised Portfolio	Difference
Aug 1929 - Oct 1935	-51.30%	-44.51%	6.79%
Mar 1937 - Oct 1942	-27.40%	-22.68%	4.72%
Jun 1946 - Aug 1949	-11.92%	-10.15%	1.77%
Dec 1968 - Dec 1970	-17.51%	-16.86%	0.65%
Jan 1973 - Nov1975	-24.14%	-22.62%	1.52%
Sep 1979 - Apr 1980	-12.85%	-13.68%	-0.83%
Dec 1980 - Jul 1982	-9.82%	-10.72%	-0.90%
Oct 1987 - Sep 1988	-14.09%	-13.18%	0.91%
Feb 2001 - Oct 2003	-10.36%	-7.43%	2.93%
Nov 2007 - Sep 2009	-22.92%	-17.95%	4.97%
Average	-20.23%	-17.98%	2.25%

Table 8. Simulated performance of the benchmark and optimised portfolio during major drawdowns (Jan 1928 – June 2020)

On only two occasions (20% of cases), during the period of double-digit inflation in the US, the new optimised portfolio underperformed the benchmark portfolio slightly. In all other significant drawdowns (80% of cases) the better risk-factor diversified portfolio outperformed significantly.

CONCLUSIONS

Asset diversification does not always imply risk diversification. In particular, during periods of market stress, hidden risk concentrations might emerge, with unintended effects on the performance of a portfolio. Focusing on risk diversification, by targeting a better risk factor allocation rather than asset allocation, can alleviate the likelihood of such hidden risks. This results in a better portfolio risk-adjusted return and, more importantly, a significant reduction in drawdown during adverse market conditions.

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