First Quarter 2022

Looking forward with historical carbon data

Executive summary

Increasingly many allocators are interested in computing their portfolio's carbon footprint. The usual way to do so relies on data on historical greenhouse gas emissions, which are typically 1-2 years lagged relative to when investment portfolios are built. We show that historical emissions data are useful despite this substantial lag. First, we use point-in-time data to show that the relative greenness of portfolio companies is very stable over time: Not surprisingly perhaps, companies that were historically green (or brown) remain green (or brown) today and for a number of years into the future, overall and compared to same-sector peers. Second, and more surprisingly, we show that portfolio carbon footprint measured using historical data is remarkably informative about the current portfolio carbon footprint (using current, or same-fiscal-year emissions that the portfolio finances). We believe this observation should give allocators comfort that historical carbon data still provides important insights about their portfolio's current, or even future, climate exposure.

Steffen Bixby
Vice President

Alfie Brixton
Vice President

Lukasz Pomorski
Managing Director

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Introduction

Climate-aware investing is one of the most important recent trends in asset management. In a survey of institutional investors, Krueger et al. (2019) found that 93% of respondents had incorporated climate risk into their investment process. Asset owners who publicly committed to net zero targets jointly manage over $10 trillion as of the end of 2021,[1] and many more have at least partial commitments to decarbonization, even if not net zero *per se*. These investors face a major challenge, and frequently complain, of lack of relevant climate data to help position their portfolios. The investor community generally agrees that the key variable is the carbon emissions of portfolio companies (and perhaps also countries), but unfortunately these data are only available to investors with a substantial lag. An investor building a low carbon portfolio today is likely using data that reflects emissions as of a year or two earlier, leading to an understandable concern that such staleness limits the usefulness of such data in a portfolio context.[2] Using historical data would only make sense if such data are informative about their portfolio companies' present, or even future emissions. We take this important concern to the data to gauge if "standard" data on emissions, historical in nature, still can be useful for investors. Our answer is a resounding "yes!"

Our first set of tests uses point-in-time data, meaning that we utilize the exact observations that are actually available to an investor on a given date. We ask a simple question: how often investors would change their mind about which companies are relatively greener, and which are relatively browner. Not surprisingly, we show that historical data is very persistent and thus informative about companies' relative emissions for many years after it is released. While this finding will be consistent with many investors' priors, the specific magnitudes we document will likely be novel to many: for example, we show that over 90% of companies in the brownest decile (i.e., the 10% of companies with the highest emissions) remain in the brownest decile for at least the next three years; the vast majority of those companies that move categories, only move to an adjacent decile.

Our second set of findings is based on a more challenging test, looking at a portfolio's absolute carbon footprint,[3] rather than the relative emissions of portfolio companies. We ask whether portfolios built using stale carbon data, available at the time, preserve their carbon characteristics when assessed using contemporaneous carbon data, only available ex-post. For example, we ask whether portfolios that target reductions in historical carbon footprint still show a similar reduction in their current carbon footprint (i.e., same fiscal year emissions they finance). This is a crystal ball-type exercise because such contemporaneous emissions data will not be available to investors

1 As reported by the United Nations Environment Programme Finance Initiative in "The Net-Zero Asset Owner Alliance New Year Countdown: A Review of 2021 and a Vision for 2022".

2 This view is increasingly often voiced by climate scientists, investors, and regulators alike. For example, Markwat (2021) notes that the backward-looking nature of carbon footprint data is a "fundamental problem"; Bocquet at al. (2021) state that these lagging indicators "provide limited insights for the future"; and a technical document from the Network for Greening the Financial System (NGFS, 2021) points out that such metrics "only provide a snapshot of an evolving problem."

3 Portfolio carbon footprint, or financed emissions, refers to the quantity of emissions 'financed' by allocating the emissions of underlying companies to a portfolio based on the percentage ownership of the companies' capital. We focus on this metric here acknowledging that there are other ways of measuring climate exposure e.g., carbon intensity or NLP measures for example as in Brixton et al. (2021), Engle et al. (2020).

for perhaps two years after portfolio formation. We find that a portfolio built to a carbon reduction target using historical data shows a similar reduction when measured using data contemporaneous with portfolio formation. The portfolios we investigate (a broad market index and a hypothetical low carbon portfolio) have realized financed emissions that are within 5% of the estimates based on historical data. We believe this is an important message for many allocators. While the experiment we conduct to show this is intuitive and straightforward, remarkably, we do not believe this simple exercise has been conducted by earlier studies on this topic.[4]

Empirically at least, historical data are a powerful predictor of future emissions in the short term. Is this reasonable from first principles? We think so, because, as shown below, companies that have been heavy polluters historically remain so going forward, even within sector. We do see examples of specific companies that dramatically lower their emissions, usually as a result of a corporate action. However, such companies are outliers and their impact on a diversified portfolio tends to be limited over a horizon of a few years. So, relative brownness can be expected to be persistent. Of course, portfolio-level emissions could still fall if the market as a whole decarbonizes – which is the real aim of global initiatives such as the Paris Agreement. Unfortunately, our results suggest this trend is not material over short horizons. We realize this is not a comforting insight, but it is consistent with macro-level data. Even a massive COVID-related intervention only decreased economy-wide greenhouse gas emissions by 6-7% from 2019 to 2020 (Le Quéré et al., 2020; IEA, 2021). Thus, it should not be surprising that historical data are informative about current and possibly even future emissions in a diversified portfolio.

Of course, the usefulness of emissions data, historical or not, for reporting and even portfolio construction does not mean that such data is flawless. It clearly is not, and in our discussion below we point out the noise and outliers in the data. While the issue may be greater for third-party estimates, even company reported emissions are by no means perfect. There is no common or binding accounting standard: e.g., the Centre for Audit Quality (CAQ) found that just over half of S&P 500 companies had some form of assurance or verification over ESG metrics, with just 6% receiving assurance from a public company auditing firm (CAQ, 2021). Despite these limitations, such data are our best estimate of actual company emissions.

Our article also contributes to the heated debate about "forward-looking carbon data," or data measuring a company's emission trajectory over longer, potentially decades-long, future horizon. We show that historical data is a good proxy for emissions today or even in the near future. Forecasts longer than a few years out are potentially interesting and useful, even if there are obvious challenges inherent in them.[5] A 2021 consultation of financial firms carried out by the Task Force on Climate Related Disclosures (TCFD, 2021) found that three-quarters of respondents admit to using some form of forward-looking metrics – for example, implied temperature rise, climate

4 There are of course many relevant studies that use carbon data, for example Kalesnik et al. (2020), who find that emissions data is very persistent at a 1-year horizon. However, we are not aware of studies that would gauge whether portfolios based on historical data meet their carbon targets when assessed with emissions data contemporaneous with portfolio construction.

5 Predicting a firm's emissions 10, 20, or 30 years from now is extremely challenging – for example, few analysts would be comfortable predicting company earnings over such horizons. Moreover, there is no discounting of carbon emissions, so estimated 2050 emissions count as much as actual emissions today. This can greatly amplify the noise in the data – in contrast, company earnings 30 years from now would typically be discounted, which would attenuate any data errors and their impact on say the implied enterprise value.

value-at-risk, and portfolio alignment estimates – but around 80% of respondents had concerns around the reliance on assumptions required.

In our view, the forward-looking data is not a replacement for the obvious question about the emissions an investment portfolio finances ***today***. For this question, historical emissions data provide quite a precise answer, and while some analysts may be able to incrementally improve the estimate, our evidence here shows that even the simplest direct approach is surprisingly worthwhile.

Data

For our discussion below, we use data obtained from Trucost, one of the leading providers of greenhouse gas emissions data for asset owners and managers, consultants, and academia. In our empirical tests we use scope 1+2 emissions data, because such data is most often used in investment practice, unlike scope 3 where a lack of consistency in measuring the broad scope of related indirect emissions leads to lower availability and quality of data. We would expect similar results using data from alternative providers because, as shown by Busch et al. (2020), scope 1+2 emissions data is very consistent across providers. For scope 3 data they find very low levels of consistency for both reported and estimated data.

We focus on large cap stocks in developed markets, generally similar to the MSCI World universe. This allows us to sidestep another concern about climate data: coverage. Our chosen universe has coverage throughout time that exceeds 95%.

The key data in our study are firms' greenhouse gas emissions, expressed in tons of CO_2-equivalents. We use this data to compute portfolio carbon footprint (financed emissions). In addition to emissions data, we leverage Trucost descriptions to identify the source of the emission data (reported by the company or estimated by Trucost). Trucost also provides a data field, effective date, indicating when the data became available to their clients. We use this variable before 2017; from 2017 onward, the data we use is collected on the point-in-time basis. Finally, to identify the period in which the emissions occurred, we use the companies' fiscal year, or the fiscal year end, as reported by Trucost.

How stale is historical carbon data?

To assess how stale carbon data may be, it is useful to review how providers of carbon emissions data obtain it in the first place. At a very high level, such data comes from two sources: from portfolio companies themselves (we loosely refer to this as "reported data") and from data vendors' and/or third-party models ("estimated data"). Between reported and estimated data, the former is likely to be more reliable. Using the data descriptors available from Trucost, we assess that reported data accounts for roughly two-thirds of large cap developed market issuers, but only for one-third of large cap emerging markets firms. But even for emerging markets company reports are going to be a very important source, and the availability of such reports will determine how stale historical data is and when it is updated.

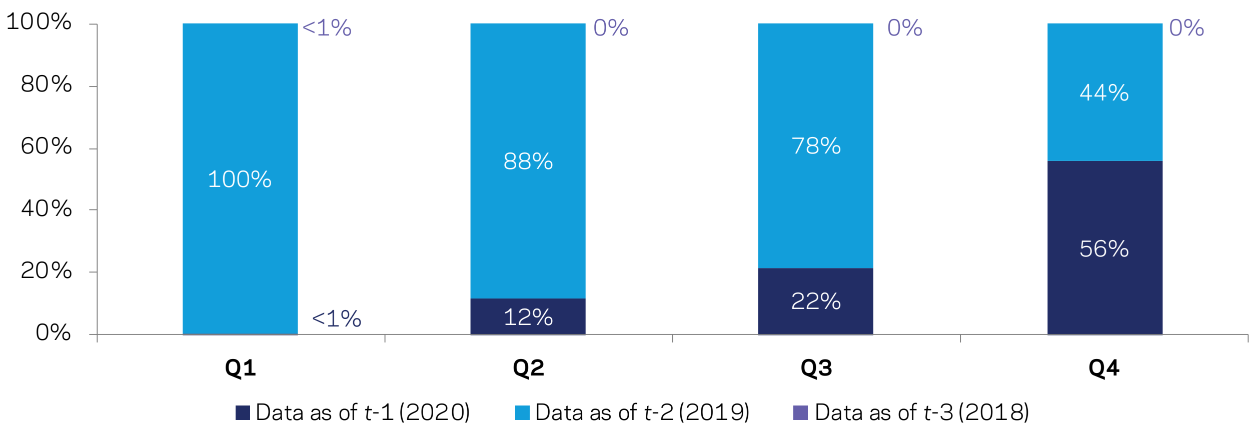
When do companies report their carbon emissions? There are two important channels: one is company-issued documents such as CSR (Corporate Social Responsibility) reports, the other is data aggregators such as CDP (formerly known as Carbon Disclosure Project). CSR reports are released on a company-determined schedule with many companies doing so at some point in the 2nd or 3rd quarter. CDP aggregates the questionnaires it receives back from the companies and releases the data to its clients and supporting organizations, usually in the 4th quarter. Importantly, in both cases, the reporting period is the prior fiscal year – for example, CSR or CDP data released in late 2021 generally covers the emissions reporting companies had in their fiscal year 2020.

When reported data is not available, many data vendors provide their own estimates instead. Such estimates could in principle be released and revised throughout the year, but they are generally provided on a fixed schedule for a given company, and often aligned with when data reported by other companies is released. This is not surprising given that peer groups usually play a central role in the estimation models.

All in all, this means that historical data, both reported and estimated, will be 1-2 years stale, meaning it describes the greenhouse gases emitted one to two years before the data is available to investors. Figure 1 shows how this lag evolves over time, taking four snapshots of Trucost data, as of the end of each quarter 2021, and assessing what fraction of the data refers to emissions portfolio companies had in their 2020, 2019, and 2018 fiscal years.

Figure 1: Lag in carbon emissions data

As of 2021 quarter ends



Source: Trucost, MSCI. The chart shows, for MSCI World index constituents and as of each quarter end in 2021, the fraction of carbon data corresponding to the emissions firms had in the prior year (2020), two years earlier (2019), or three years earlier (2018).

It is clear from **Figure 1** that carbon data is indeed stale. This is most directly visible from the leftmost bar in the chart. On March 31, 2021, only a tiny fraction of the data reflects 2020 emissions (i.e., the immediately preceding year). The vast majority of the data refers to companies' 2019 fiscal year; data earlier than that (2018 and before) are only a rounding error. It is worth noting that while for some companies the 2019 fiscal year-end may be December 31, for others it may be at any other point in the 2019 calendar year, meaning that this data could be as much as 2 years lagged relative to March 31, 2021. The average delay is 1.5 years while 10% of the data is delayed by 2 years or more. The coverage of fiscal year 2020 emissions gradually increases over time, jumping to about 20% at the end of Q3 and over 50% at the end of 2021, corresponding to the reporting milestones we mentioned above.

Are historically brown firms getting greener? Might green firms become browner?

How useful is historical carbon data for understanding today's or even future emissions? This is an empirical question, and we turn to the data to address it.

We start by checking how often the relative greenness, or brownness, of companies in a developed equity portfolio changes. We do this using point-in-time data, meaning we capture the actual numbers investors saw at each point in time, and gauge how often these numbers change. It is natural to expect persistence in emissions, if only driven by industry membership: an Oil and Gas company last year is likely to still be an Oil and Gas company today or going forward, and as such can be expected to have meaningfully higher emissions than, say, an IT Services firm. Nonetheless, there is at least a theoretical possibility that firms within a given industry may meaningfully change their emissions versus peers – to test this theory we ran the same analysis for sector-adjusted emissions and found comparable results which we present in **Figure 3**. In **Figure 2** below we present results for emissions without controlling for industry membership because most investors measure their overall portfolio emissions and do not neutralize the impact of industry exposure on their portfolio's carbon footprint or intensity.

Figures 2 and 3 quantify changes in relative greenness by looking at how often firms in different emissions bins jump to other bins over time. Such "transition matrices" are an intuitive way of describing how stocks move between categories. In **Figure 2** we show how much firms transition from one year to the next, comparing emissions using the data that was available to investors at the end of 2020 and 2021, respectively.

Figure 2: Carbon transition matrix (2020-2021)

	Low Emitters in 2021									High Emitters in 2021
Low Emitters in 2020	89%	10%	0%	0%	1%	0%	0%	0%	0%	0%
	6%	77%	12%	2%	1%	1%	0%	1%	0%	0%
	1%	10%	75%	12%	1%	0%	0%	0%	0%	1%
	1%	1%	9%	76%	12%	1%	0%	0%	0%	0%
	1%	1%	3%	8%	77%	9%	0%	0%	0%	1%
	0%	1%	1%	1%	6%	85%	6%	0%	0%	0%
	0%	0%	0%	0%	3%	4%	87%	4%	1%	1%
	1%	0%	0%	0%	0%	0%	7%	87%	6%	0%
	0%	0%	0%	0%	0%	0%	1%	6%	91%	2%
High Emitters in 2020	0%	0%	0%	0%	0%	0%	1%	0%	4%	96%

Source: Trucost, MSCI. MSCI World stocks are sorted into deciles by carbon emissions using data available to investors at the end of 2020 (with 10% of firms with the lowest emissions in the top row; 10% of highest emitters in the bottom row) and again using data available to investors at the end of 2021 (with 10% of lowest emitters in the leftmost column; 10% of the highest emitters in the rightmost column). Each cell depicts the fraction of firms in the corresponding row and column.

Figure 2 gives striking evidence of persistence in emissions. The color code in the figure indicates the importance of the diagonal in our transition matrix, meaning that by far the most usual outcome is for firms not to change their emissions decile. For example, the bottom right corner of the figure shows that almost all firms in the highest emissions decile (i.e., the 10% of firms with the highest emissions) in 2020 are again in the highest emissions decile in 2021. Only 4% of such firms "migrate" to the adjacent cell, meaning that only a small minority of top-decile emitters in 2020 ended up in the 2nd highest decile in 2021 and virtually no firms became any greener than that.

This remarkable persistence of the brownest companies is practically relevant for investors. These companies account for the vast majority of emissions in the investible universe: the emissions of the brownest decile of companies (10% of the largest emitters) adds up to 82% of MSCI World emissions in 2021.

Similarly, there is a strong persistence in the green firms: the top left corner indicates that 89% of firms in the lowest emissions decile in 2020 are again in the greenest decile in 2021. As we noted above, this pattern persists even when bucketing within industries. For example, 97% of companies in the brownest decile of sector-adjusted emissions in 2020 remain in the same or the second-highest decile a year later.

To illustrate this persistence even more forcefully, we present an extremely conservative analysis in **Figure 3**. First, we assume the exceptional lag of 3 years. As we saw in **Figure 1**, investors can be expected to have data less stale than 3 years. Second, we perform the analysis within sector to look at the persistence of company greenness relative to their sector peers. This is more stringent than what most investors would do: ultimately, we care about overall emissions by portfolio companies and the resulting portfolio carbon footprint, and not necessarily about sector-adjusted emissions.

Figure 3: Carbon transition matrix (2018-2021)

	Low Emitters in 2021									High Emitters in 2021
Low Emitters in 2018	71%	19%	7%	1%	2%	0%	0%	0%	0%	1%
	18%	47%	19%	8%	2%	2%	1%	2%	0%	2%
	4%	18%	38%	29%	6%	2%	2%	1%	0%	0%
	1%	9%	19%	39%	20%	8%	4%	0%	0%	0%
	2%	3%	7%	15%	45%	21%	5%	2%	0%	0%
	0%	3%	5%	3%	19%	41%	20%	7%	1%	2%
	2%	2%	1%	3%	4%	19%	47%	22%	2%	0%
	0%	0%	2%	1%	0%	4%	16%	54%	22%	1%
	0%	0%	0%	1%	2%	2%	4%	12%	64%	17%
High Emitters in 2018	0%	1%	0%	0%	1%	0%	1%	2%	14%	81%

Source: Trucost, MSCI. The chart is built similarly to Figure 2, except decile groupings are formed within sector, and groupings in rows are based on emissions data available at the end of 2018 (in Figure 2, decile groupings were formed using the whole universe and rows were based on data available at the end of 2020).

Figure 3 demonstrates that even if carbon data is lagged by three years relative to when a portfolio decision is made, and even if it is adjusted by sector, it is still a valuable indicator of which companies are greener or browner within their sector. 81% of companies in the brownest decile in their sector in 2018 remain in the highest emissions decile in 2021; most of the remaining firms only move to the second-brownest decile. Without sector adjustment, the persistence is even higher: 92% of firms in the brownest decile in 2018 are still in the same decile in 2020; 99% of such firms are in the brownest or the second-brownest decile.

There are a few outliers, some of which are modelling issues, such as for a company for which the emissions data was derived from firm disclosures in 2018 but modeled in 2021, leading to a difference of about three orders of magnitude. In other cases, a dramatic change may be driven by a corporate action. For example, we have observed cases of acquisitions that increased a company's emissions dramatically. Interestingly, the impact of M&A activity tends to be more muted for carbon intensity rather than raw carbon emissions, as acquisitions tend to change both emissions and revenue in the same direction. In results not shown herein we found similar levels of persistence for carbon intensity and other complementary measures of greenhouse gas emissions. If we sort firms on their carbon intensity, over 90% of firms in either the greenest or the brownest decile remain there in the following year; those firms that move, tend to move to the adjacent deciles only.

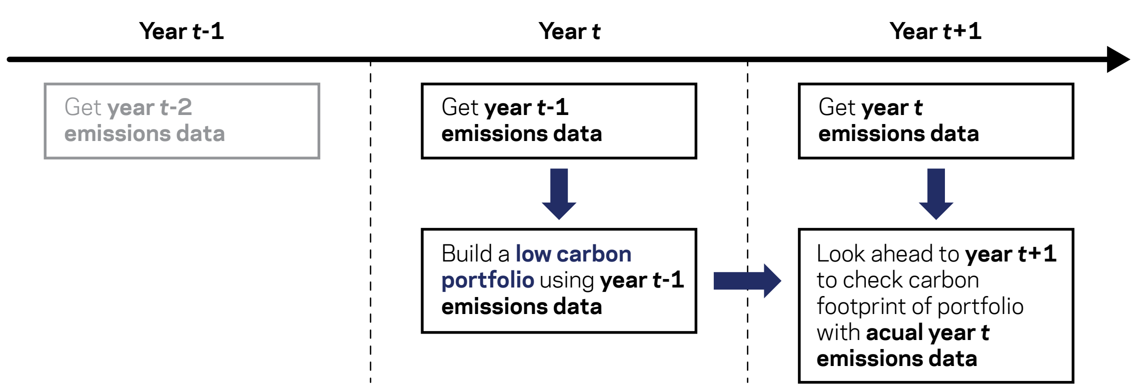
Nowcasting financed emissions using historical data

Having established strong persistence in relative carbon emissions, we now ask a more challenging question: can we describe a portfolio's financed emissions (carbon footprint) today, if all we have is historical data?

In principle, one could build a regression model to address this question, formally modelling how past financed emissions may predict today's or future financed emissions in a portfolio. But even so, the intuitive first step would be to simply compare a portfolio's carbon footprint computed using historical data to what the carbon footprint actually is using the data on emissions contemporaneous with when the portfolio is built. Remarkably, this very simple approach gets us most of the way there.

We used terms "historical," "current," and "future" somewhat loosely above, but the timeline in **Figure 4** makes them precise for our subsequent empirical tests. The timeline is meant to illustrate the quandary low-carbon investors are in. Consider such an investor today (at the "year *t*" point on the timeline). As we discussed, such investors only have access to data that is 1-2 years lagged relative to when they make portfolio decisions (in the timeline, we label that historical period "year *t*-1"). The investor builds a low carbon portfolio at time *t*. This portfolio, by construction, will meet its carbon target when assessed using year *t*-1 data. The question we ask is whether this portfolio is still low carbon, and whether its carbon characteristics are similar, when assessed using data on emissions from year *t*, i.e., contemporaneous with the investor's decision. Such data will not be known until 1-2 years into the future ("year *t*+1" in the timeline), so obviously cannot be used for portfolio construction – but can be used for a portfolio assessment ex post. We believe this simple experiment will be informative and of interest to many allocators interested in low carbon investing. Remarkably, we do not believe this simple exercise has been conducted by earlier studies on this topic.

Figure 4: Stylized description of how to assess the usefulness of historical data for portfolios with climate targets



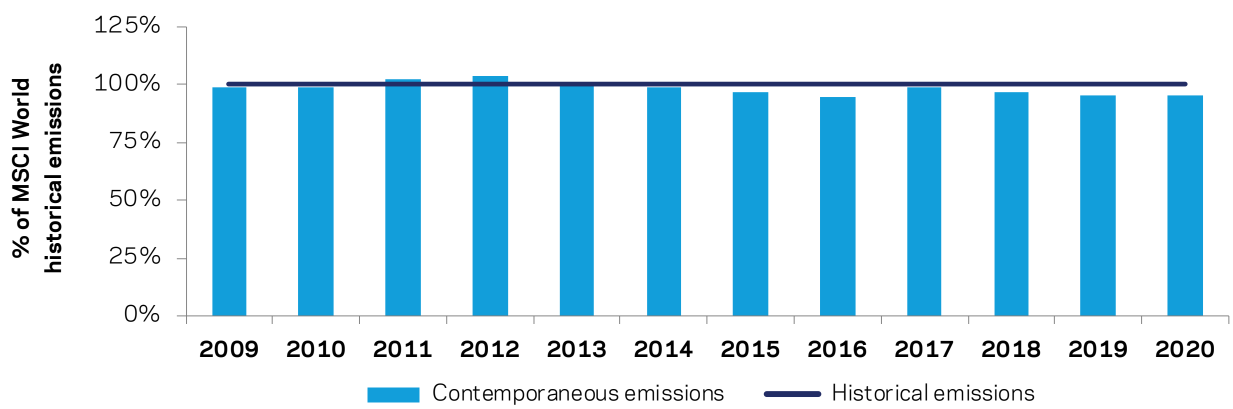
Such portfolios are necessarily built using historical data, but can still be evaluated ex post, using data on emissions in the year contemporaneous with when the portfolio was built.

Figure 5, the key exhibit in our study, takes the timeline from **Figure 4** to the data. For the ease of presentation, the bar charts in **Figure 5** show the carbon footprint using the actual emissions data covering a given year (e.g., using firms' emissions in fiscal year 2018 to compute a portfolio's carbon footprint as of 12/31/2018), as a fraction of the carbon footprint assessed using the latest historical data that were available to investors at that time (as of year *t*-1). For example, if the carbon footprint is identical in both cases, we record this as a value of 100%; if actual emissions are 20% higher than those estimated using historical data, the value is 120%, etc.

In the two panels of Figure 5, we consider two realistic portfolios. In Panel A, we look at one of the most important benchmark indexes, MSCI World. While not designed with climate investing in mind, this broad benchmark is a good approximation of many investors' equity portfolios. These investors in turn may, for a variety of reasons, produce climate reporting, and may be naturally curious as to whether their portfolio companies are low carbon not just in the past but also on an ongoing basis. In Panel B we consider a hypothetical portfolio, annually rebalanced, that minimizes the tracking error versus MSCI World while at the same time seeking to deliver a carbon footprint that is at most half of that of MSCI World. While the data coverage in Figure 5 is excellent for most years, we note that the 2020 fiscal year emissions are only partially reported as of December 31, 2021 (as Figure 1 shows, we know 2020 emissions only for about half of the MSCI World constituents, which translates to about 2/3 of the index by weight).

Figure 5: Assessing the usefulness of historical data for portfolios with climate objectives

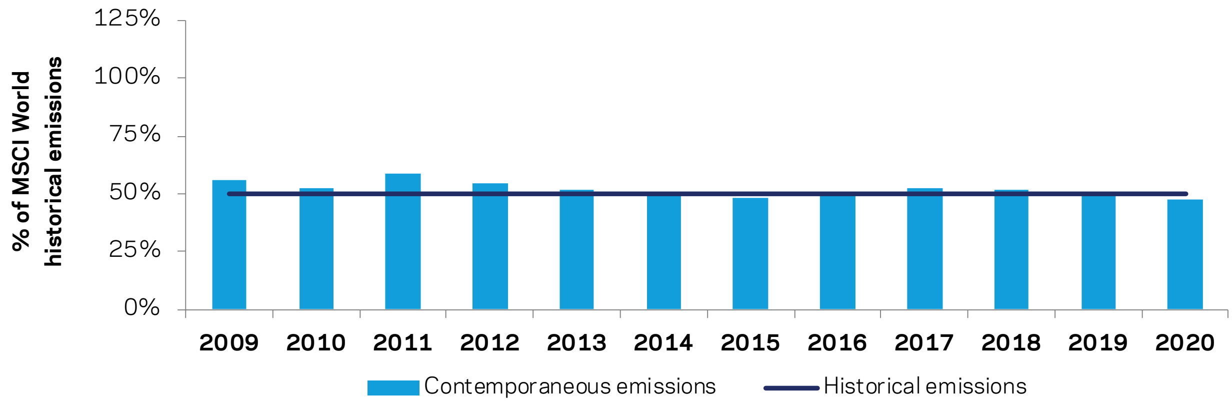
Panel A: MSCI World Index



Source: Trucost, MSCI. The chart shows the carbon footprint in tons of CO2e per $M investment assessed two different ways: using historical data (the snapshot available at portfolio construction) and using data on emissions portfolio companies produced in the year of portfolio construction (only available at a lag). Panel A shows the MSCI World index.

Figure 5: Assessing the usefulness of historical data for portfolios with climate objectives

Panel B: Hypothetical Low Carbon Strategy



Source: Trucost, MSCI. The chart shows the carbon footprint in tons of CO2e per $M investment assessed two different ways: using historical data (the snapshot available at portfolio construction) and using data on emissions portfolio companies produced in the year of portfolio construction (only available at a lag). Panel B shows a Low Carbon portfolio based on the MSCI World Index targeting a 50% reduction in carbon emissions while maintaining a low tracking error. This hypothetical Low Carbon portfolio is composed of MSCI World stocks and built to minimize tracking error versus MSCI World while targeting a 50% reduction in carbon footprint. The portfolio is optimized using the Global Equity Barra risk model and is rebalanced monthly from January 2009 – December 2020. In constructing the low carbon portfolio backtest we estimate missing carbon emissions data based on sector characteristics, but the reported numbers in the chart use only data provided by Trucost (scaled to account for the missing data).

Panel A shows that the carbon footprint of the MSCI World Index, assessed using actual emissions data for a given year, is remarkably close to the carbon footprint assessed using historical data. In some years such as 2012, the actual emissions were a bit higher than those implied by historical data; in other years such as 2016, the actual emissions were a bit lower. Overall, in the average year, the actual emissions are only 1.2% lower than historical, which as we explain below is remarkably close for this type of an exercise.

In **Figure 5**, Panel B we again see a similar pattern as in Panel A: the actual carbon footprint of the low carbon portfolio (assessed using emissions in the same fiscal year as construction) is very similar to that assessed using historical data. The portfolio's historical carbon footprint is only 4.1% higher than the contemporaneous carbon footprint on average.

These patterns are striking, for three reasons. First, while our analysis in **Figures 2 and 3** only dealt with firms' relative emissions, **Figure 5** is also affected by the overall emissions in the market. For example, if all firms produce exactly twice as much emissions as they did last year, the patterns in **Figures 2 and 3** would not change: they only reflect a firm's greenness relative to peers. But such doubling of emissions would double the carbon footprint of the portfolio, relative to what historical data would have said, which would clearly affect **Figure 5**. For example, historical emissions overstate the actual carbon footprint in 2020, when COVID-related policies reduced global energy demand and hence emissions by 6-7% (Le Quéré et al., 2020; IEA, 2021). Thus, if (or when) the world economy de-carbonizes, we can expect that the actual carbon footprint will be consistently lower than that assessed using historical data. This may be good news for allocators, in that historical data will tend to give them a conservative view of their financed emissions.

The second reason why **Figure 5** is striking relates to Panel B, showing a portfolio managed to deliver a low carbon footprint.

When optimizing any portfolio for a characteristic of choice, there is always a concern that a human analyst or a quantitative optimizer will fall prey to some mistakes in the data, overweighting those stocks for which the historical data may be overly rosy and avoiding stocks for which historical data is overly pessimistic. Put formally, a portfolio optimized for emissions may overweight stocks with the most egregious negative data errors (understating true emissions) and underweight stocks with most egregious positive data errors (overstating true emissions). If such data errors are resolved in the future (for example, corrected by the data provider) we can expect a meaningful difference between the carbon footprint assessed using historical data and the carbon footprint of the same stocks in the contemporaneous fiscal year.[6]

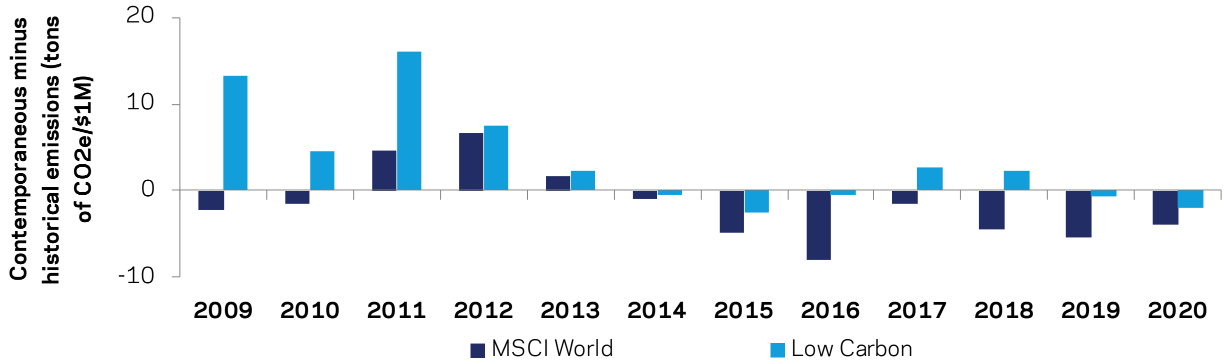
Surprisingly, we do not see much evidence for such outlying observations in Panel B. A potential reason is that our hypothetical strategy is very well diversified, given its objective to minimize the tracking error. Consequently, a few outliers may not influence its carbon footprint very dramatically. We saw in **Figures 2 and 3** that such outliers do occur – some firms meaningfully change their emissions category year to year – but this happens in a minority of the data. Thus, we conjecture that a well-diversified portfolio is unlikely to be so concentrated in such companies to see meaningful changes in its carbon footprint. With this diversification caveat, we expect the broad result to hold for other strategies as well.

Finally, **Figure 5** is interesting in that it uses the simplest possible forecast (or "nowcast") of emissions: it implicitly assumes that current fiscal year emissions will be equal to those historical ones. It is remarkable that such a simple approach delivers predictions that are as close to actual emissions as **Figure 5** documents. It is of course possible for investors to come up with more intricate forecasting tools, or perhaps with corrections to historical data, that will further improve the alignment of their portfolios with actual same-year or future-year emissions – but the evidence we present here suggests that just a straightforward use of historical data as-is is already very informative.

In our last exhibit, **Figure 6**, we present the distribution of "forecast errors" implied by **Figure 5**, showing the difference in the carbon footprint based on same-year emissions compared to that based on historical emissions. This is simply to provide another perspective: while **Figure 5** scaled emissions in each year to the historical estimate (showing current emissions as a percentage of what we thought they would be using data available at the time), **Figure 6** shows these differences in terms of overall tons of CO_2-equivalents per $M invested.

6 To the extent changes are driven by updates in emissions estimated by the data provider, the issue might be less that of historical data being stale and more of the precision of the estimates in the first place. This is because seemingly small changes in estimation methodology may lead to dramatic changes in the final estimate.

Figure 6. Assessing the usefulness of historical data for portfolios with climate objectives



Source: Trucost, MSCI. The chart shows the difference in the portfolio carbon footprint based on same-year emissions and based on historical emissions in terms of overall tons of CO2-equivalents per $M invested. The left bars show the MSCI World Index and the right bars show the hypothetical Low Carbon portfolio described in Figure 5.

Conclusions

We have presented evidence that historical carbon data is a valuable predictor of how green a stock may be today or in the future, or of what a portfolio's current financed emissions may be. This evidence suggests that historical data can be very important for allocators, contrary to recent commentary about the (lack of) value of such data. Of course, historical data is not a panacea for all relevant questions. It is probably going to be meaningfully less useful in predicting emissions in, say, 2030 or 2040. Such long-term predictions present formidable research challenges and may call for a variety of additional data, for example company decarbonization targets (ideally suitably adjusted given that many such targets may have very low quality – reduction commitments are not audited, and some companies have set public goals with no clear plan on how to achieve them, see, e.g., Vincent, 2020). But, for most obvious applications such as carbon reporting, we conclude that historical carbon data are meaningful and actionable.

Could historical data become less informative going forward? It is possible: ironically, we will only find out after future emissions actually occur and are included in historical data. As of right now, the answer depends on an investor's prior. If you expect that next year's emissions will be meaningfully different than this year's, then you would probably be cautious about historical data. However, the economy may be unlikely to dramatically change its carbon emissions over one or two years, even if it eventually reaches net zero over the coming decades. In such a case, historical data may well remain very informative about a portfolio's financed emissions today or even in the near future.

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