September 2024

privateMetrics®

Asset Valuation Methodology

Executive Summary

The privateMetrics asset pricing model enables the fair market value of unlisted private equity investments to be estimated in a robust and dynamic manner. It solves the twin problems in private markets of smoothed reported NAVs, that are not convincingly marked-to-market or capture risk, and of the absence of a sufficient number of observable transaction prices. Traditional approaches in private equity valuation tend to rely on too few, often stale data points that do not capture all the information at the time of reporting or even replace these with multiples from completely different public markets.

In this document, we discuss:

- Issues with traditional approaches in private equity valuation that rely on multiples of poor quality (e.g., public market multiples or reported data) or quantity (e.g., a stale handful of not-so-recent transactions), highlighting the potential consequences of using the wrong data.
- The privateMetrics asset pricing model as a reliable approach to estimating the marked-to-market prices of unlisted companies, using private market transactions to distinguish between the market price signal and asset-specific noise, and how this approach is genuinely aligned with the IFRS 13 standard and industry guidelines.
- The robustness of this approach, including how well average predicted values track observed transactions in individual market segments, and capture market risk in a convincing manner.
- An application of such a model to build robust valuation ‘Anchors’ for private equity investments.

Introduction

Unlisted companies very seldom trade, leading to a dearth of market price data for a given asset and too few data points to build robust comparables from raw data. As a result, the ongoing valuation of unlisted equity investments must rely on an asset pricing model until it is next sold.

Following the IFRS 13 standard, the fair value of financial assets is unequivocally defined as the exit price on the date of valuation i.e., as if the asset was sold in the market on that date, whether it can be liquidated on that date or not. In other words, the model of the price multiple used to value private equity investments must reflect the latest market conditions given the information available.

Unfortunately, traditional private equity appraisals typically fail to meet this standard.

Due to the inherent uncertainty in future cash flows and the terminal horizon of private companies, market-based valuation methods (multiples) are typically preferred over income-based approaches (discounted cash flows) in private equity valuations. However, problems arise when implementing a market-based approach using a handful of recent transaction-based multiples. Recent transactions are sparse, noisy, and biased because few private companies transact regularly and each valuation is subject to idiosyncratic (or individual) effects.

We show in the appendix of this document that using raw reported data leads to using meaningless multiples because the reported data is:

1) mostly the result of appraisals, which are smooth, inconsistent and not representative; and
2) the remaining observable transactions, which represent about 10% of the reported data (Source MSCI/Burgiss) are too few to provide investors with a good proxy of market prices, let alone control for the sector, geography and risk profile of the company being valued.

This leads to various adjustments being made to comparables but the starting point of these (often subjective) departures from the market data is never robust enough to justify them. In effect, private valuations are built on sand.

We show in the Appendix that the valuation errors due to the use of raw market multiples are very large and that they these problems are not solved by using a listed proxy instead.

The privateMetrics asset pricing model was developed to address these issues and provide the best possible estimation of the market multiples required to calculate the fair value of private, unlisted equity investments. It is designed to reflect the principles of IFRS 13, which are also repeated in the IPEV valuation guidelines: to derive valuation inputs for individual private equity assets that genuinely reflect current market conditions and the risk exposure of each individual investment in the market for unlisted equity.

privateMetrics is used to estimate prices for hundreds of thousands of assets in the private equity universe. We show that, on average, at the market segment level, these predictions are very close to average exit prices (also at the segment level). It follows that infraMetrics can be used to produce market-level metrics of value, risk, and performance because in aggregate (on average), it predicts accurate market exit prices.

This is why the privateMetrics asset pricing model is used to create market indices, custom benchmarks, and investment and valuation comparables.

In the rest of this document, we describe the privateMetrics asset pricing model, its robustness, and how it can be applied to build robust, yet granular market price 'Anchors' or comparables.

The privateMetrics® Valuation Model

Our approach to the valuation of private companies is designed to maximise the available transaction and financial data in private markets and provide a standardised and systematic manner to update prices with every observed transaction.

First, we construct a multi-factor model of prices using a sample of observed transactions over time which can infer the unbiased and precise factor prices that investors pay for different characteristics of a private asset. Although every transaction is idiosyncratic or unique, in a large sample of transactions, the individual errors in each transaction price can be diversified away to discern the price attributable to each factor. Factor prices refer to the premium (or discount) that an investor is willing to pay to seek exposure to a specific factor of return in private companies. For example, observing the relationship between size and valuation among reported transactions, it can be inferred how much premium or discount an investor is willing to pay for purchasing a larger private company.

Second, an important and key application of this approach is that, with the estimated factor prices, say for size, it would then be possible to price unlisted private companies whose size information is available, irrespective of whether they are traded or not. This approach provides a more robust estimate for FV and enables the creation of representative indices of private companies.

Our approach's novelty is in calibrating the model to newly observed transactions obtaining the factor price evolution over time, which allows us to update the valuation for all tracked unlisted private companies.

Common risk factors

If investors trade unlisted private companies from each other in mutually negotiated transactions, there must be some common characteristics that at least partially explain prices. For example, private companies that have higher profits or growth opportunities may be more valuable to investors than those that are not.

To arrive at a potential list of factors, we follow simple criteria that there needs to be an economic rationale for the factor to affect valuation. The factor should also be statistically related to the valuation. Moreover, the factor should also be objectively observable or measurable. With a potential list of factors, our factor selection is the result of a statistical approach, where the factors that can satisfactorily explain the variation in observed transaction valuations are included in the final model while trading off being parsimonious with being able to explain a higher variance in valuation. The privateMetrics asset pricing model uses five key risk factors as below:

- Size: Larger companies may be more complex, have higher transaction costs, and be less liquid, all of which can make them trade at a lower valuation per USD of revenue.
- Growth: As traditional PE strategies rely on growing the entry multiple, that may involve both increasing its top and bottom lines, i.e., revenue and profits. Thus, companies that can grow faster can be more sought after, making them more valuable.
- Leverage: Leverage can make a company riskier as it increases the risk of default. However, there is also a signaling effect of leverage, as companies with stable consistent cash flows can support a higher leverage, and vice versa. Thus, leverage is expected to influence the valuation of a company.
- Profits: More profitable companies have more predictable (less risky) future payouts and hence attract a lower risk premium, making them more valuable.

- Maturity: Younger companies have fewer track records and face higher information uncertainty. Studies have shown that firms with high uncertainty tend to be overvalued and earn lower future returns. Thus, the maturity negatively affects valuation.
- Country risk: Investors may require a high return when investing in a high-risk country, thus depressing the current valuation. In other words, in countries with lower risk, investors may be willing to purchase assets at a higher valuation as government policies may be more predictable with lower macroeconomic risks.

Table 1: Key factors, their effect on valuation, & the economic rationale for including them in the model

Factor	Definition (Proxy)	Effect on price	Economic Rationale	References
Size	Revenues	Negative	Larger firms are more illiquid and trade a lower price	Fama & French (1993)
Growth	Change in Revenues	Positive	Companies with higher revenue growth trade at a higher price	Fama & French (1992), Petkova & Zhang (2005)
Leverage	Total debt / Revenues	Positive	Companies that can borrow more have a lower cost of capital and a higher value	Gomes & Schmid (2010), George & George & Chuan-Yang (2010)
Profits	Ebitda Margin	Positive	Companies that have higher profits have a higher value	Novy-Marx (2013), Hou et al. (2015)
Maturity	Years since incorporation	Negative	Companies that are mature exhibit less growth potential and trade a at a lower price	Jiang, Charles & Zhang (2005)
Country Risk	Term Spread	Negative	Companies in high-risk countries face more uncertain prospects	Chen & Tsang (2013)

Source: calculated using more than 10,000 deals from PitchBook, CapitalIQ, Factset, and other primary sources between 1999-2022

Our factors have been documented in prior academic studies to be associated with valuation. We also include factors that have been identified as key determinants of valuation from a survey of private equity practitioners that we conducted in 2023. Table 1 summarises the key factors that we use in the model, how they are measured, each factor's effect we document in the data on average, the economic rationale for their inclusion, and citations for the work that underpins their inclusion.

Empirical evidence supporting common risk factors

To illustrate the systematic effect these factors have on valuation, in Table 2 we summarise the average P/S ratio in each quartile of the transaction sample segmented by each of these factors. Even in this single-dimensional sorts, the trends as we move along the quartiles strongly indicate the presence of systematic effects in valuation. For example, viewing the size factor, we can observe that the smallest companies (those that belong to the bottom quartile) enjoy the highest valuation per USD of sales, and this keeps decreasing as we move up the quartiles one by one.

In Table 3 we summarise the average P/S ratio by each class in a PECCS® pillar. PECCS® is a private-asset focused multi-pillar taxonomy of private companies developed by EDHEC Infra and Private Assets. By focusing on independent pillars with exhaustive and non-overlapping classes within each pillar, PECCS® can capture several dimensions of risk factors that affect the valuation of private companies. Moreover, the PECCS® classification is objective and clearly defined to enable one to segment private companies even with the limited information that is a hallmark of private markets. Consistent with this, we find that the valuation in transactions varies systematically by PECCS® classes, with many of the classes having significantly different mean P/S compared to the other classes.

TABLE 2: KEY FACTORS, THEIR EFFECT ON VALUATION, & THE ECONOMIC RATIONALE TO INCLUDE THEM IN THE MODEL

Sample	Size	Growth	Profitability	Maturity	Leverage	Country Risk
Top Quartile	2.1x	3.0x	4.2x	2.1x	3.8x	2.3x
Second Quartile	2.5x	2.8x	2.5x	2.5x	2.7x	2.9x
Third Quartile	2.8x	2.6x	1.8x	3.1x	2. 5x	3.0x
Bottom Quartile	3.5x	2.5x	2.5x	3.2x	2.2x	2.8x

Source: Calculated using more than 10,000 deals from PitchBook, CapitalIQ, Factset, and other primary sources between 1999-2022

TABLE 3: DISTRIBUTION OF THE CALIBRATION DATASET BY PECCS® PILLARS

PECCS Pillar	PECCS Class	P/S	PECCS Class	P/S	PECCS Pillar
PECCS Activity	Education and public	1.9x	Startup	2.4x***	PECCS Lifecycle Phase
	Financials	2.4x***	Growth	2.1x	
	Health	2.1x	Mature	2.6x***	
	Hospitality and entertainment	1.9x***	Advertising	2.1x***	PECCS Revenue Model
	Information and communication	2.6x***	Reselling	1.4x***	
	Manufacturing	1.5x***	Production	1.6x***	
	Natural resources	1.9x	Subscription	2.9x***	
	Professional and other services	1.6x**	B2B	1.8x	PECCS Customer Model
	Real estate and construction	1.8x	B2C	1.7x***	
	Retail	0.9x***	Hybrid	2.4x	PECCS Value Chain
	Transportation	1.4x***	Products	1.5x***	
			Services	1.9x	

Source: Calculated using more than 10k deals from PitchBook, CapitalIQ, Factset, and other primary sources between 1999-2022.
**** & ** indicate a significant mean difference with the rest of the population at the 1% & 10% levels, respectively.*

In addition to these factors, we also include control variables that have statistical power in explaining the observed valuations. Table 4 summarises the control variables in our model, grouped into three categories, including the transaction characteristics (i.e., PE Deal Controls), PECCS® segments, and equity market controls.

TABLE 4: KEY CONTROL VARIABLES, THEIR EFFECT ON VALUATION, & THE ECONOMIC RATIONALE FOR INCLUDING THEM IN THE MODEL

Factor	Definition	Effect on price	Economic Rationale	References
PE Deal Controls	Deal Leverage	Positive	Companies that trade with deal leverage are considered better prospects and have a higher value	Jenskinson & Stucke (2011)
	Percentage Control	Negative	A higher control stake in an acquisition creates larger risks and decreases the price.	Renneboog and Simons (2005)
	Add-on	Negative	Add-on deals create new risks for investors including synergy risk.	Hammer et al. (2022)
PECCS Controls	Dummy variable for PECCS classes	Positive or Negative	Different segments of private markets exhibit different average level of price because of systematic difference in risk .	See PECCS documentation
Equity Market Controls	Listed Industry Valuations	Positive	Higher same-sector valuations in listed markets correlates with higher same-sector private market valuations.	Chan, Lakonishok & Swaminathan (2007)
	Residual Market Valuations	Positive	Higher listed market sentiment correlates with higher private market valuations	Bibo & Tian (2022)
	Fama French Value Factor Return	Positive or Negative	The returns of the value factor correlate with private market valuations: private company investments are also a Value play.	Fama & French (1992)

Source: Calculated using more than 10,000 deals from PitchBook, CapitalIQ, Factset, and other primary sources between 1999-2022.

Model set up

The privateMetrics asset pricing model uses the Price-to-Sales ratio of observable transactions (the entry price multiple) as the modeled variable. The model is estimated as the linear sum of the product of factor exposures and factor prices. The estimation can then separate the systematic part of the valuation while leaving out 'noise' in each valuation.

$$\frac{P}{S} = \alpha + \sum_{k=2}^{K} \beta_k \lambda_k + \varepsilon$$

Following standard asset pricing notation, the factor exposure or factor loading is called a beta (β), and the factor premium is called a lambda (λ) for the k factors in the model. α is the intercept and ε is the noise or idiosyncratic part of the valuation.

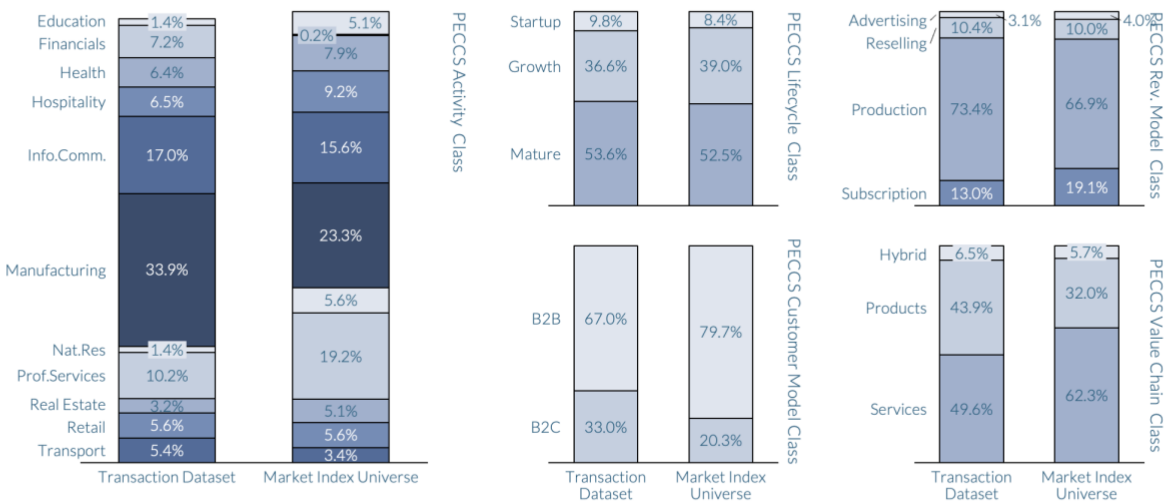
Model calibration

The privateMetrics model uses a carefully curated dataset of more than 10,000 unlisted private company investments going back two decades sourced from a wide variety of datasets including PitchBook, Factset, Capital IQ, fund manager reports, and other publicly available data sources.

We calibrate this model using new observations monthly to update its estimation of the price of risk of each factor. In other words, each transaction observed is then used to 'update' this model (i.e., obtain new λs) through a dynamic estimation (using a Kalman filter), which retains the memory of past λs while also allowing the new transaction to influence the relationship while keeping the average ε close to zero. More details on the implementation of the model are available in our online documentation and Selvam and Whittaker (2024). The dataset covers all key segments of the market as shown in Figure 1.

A good application of using the model to value unlisted private companies is to create a representative marked-to-market index of private companies that are regularly valued. The privateMetrics index universe in Figure 1 includes the constituents of the private2000® index constructed by Scientific Infra and Private Assets, which is developed on this shadow pricing idea and captures the performance of private companies in 30 countries globally that are important for private equity investors (read more about the index here).

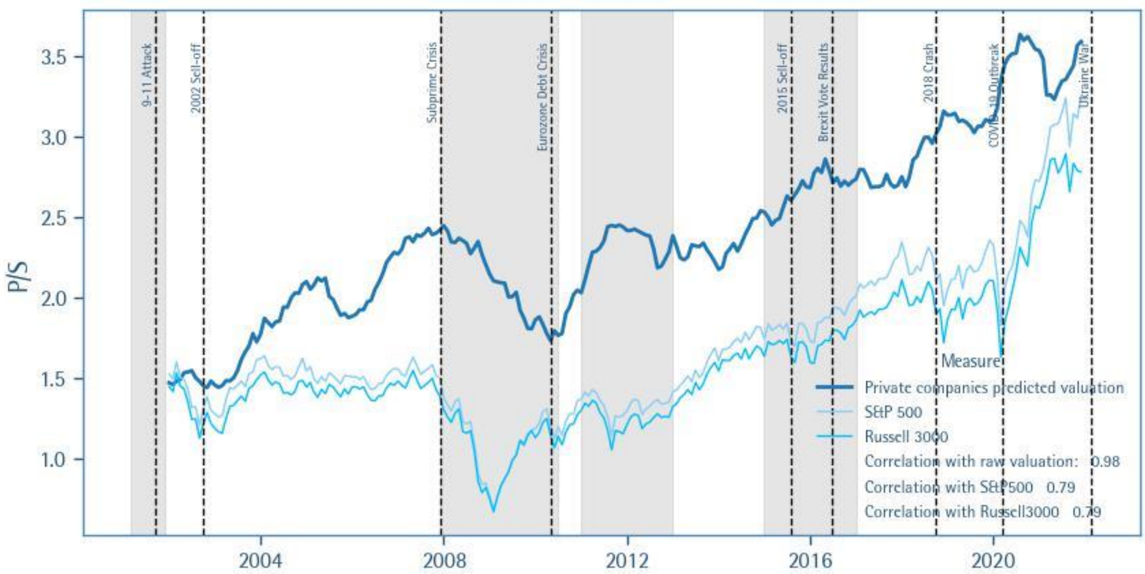
Figure 1: privateMetrics Transaction Dataset Compared to the privateMetrics index universe by PECCS Pillar & Class



Model output

The output of the asset pricing model is an estimated P/S ratio for each observed transaction such that on average the estimated and observed values converge. To examine how closely the predicted valuations track the raw modeled valuations in transactions, we compute the moving average P/S (using median values) of all the data over the previous 12 months and plot the predicted and the raw series. For context, we also include the monthly P/S of key public market benchmarks. Figure 2 presents the results, and we can see that the moving average of the predicted valuations from the model very closely tracks the raw valuations, with the two series having a correlation coefficient of 0.98. Moreover, we also see that the average transaction at any point in time is also highly correlated with public market valuations, as indicated by a correlation coefficient of 0.79. Thus, Figure 2 is reassuring that the modeling does not introduce any mechanical artifacts in predicted valuation and is very well aligned with raw data.

Figure 2: Moving Average Predicted vs Raw Valuation and Public Market Valuation



Source: Calculated using more than 10,000 deals from PitchBook, CapitalIQ, Factset, and other primary sources between 1999-2022.

Model Robustness

How precise are the predictions across PECCS® pillars?

To examine how closely the predicted valuations track the raw modeled valuations in transactions, we compute the average estimation errors of the full sample, and also by classes within each PECCS® pillar. What stands out is that although the model by design is expected to have lower estimation errors in the full sample, the within PECCS® class estimation errors are also very small. All the errors are within ±10%, reassuring that the model predictions on average even within each segment of PECCS® are reasonable. The errors are summarised in Table 5.

The most commonly used metric of valuation in private markets is EV/EBITDA, as PE owners have the flexibility to alter the capital structure of their holding company and hence are more interested in operational profitability without factoring interest costs. However, our model is based on P/S because P/S is statistically better, stable, and not affected by loss-making companies. Thus, it is worth investigating whether or not our predictions for EV/EBITDA might be biased.

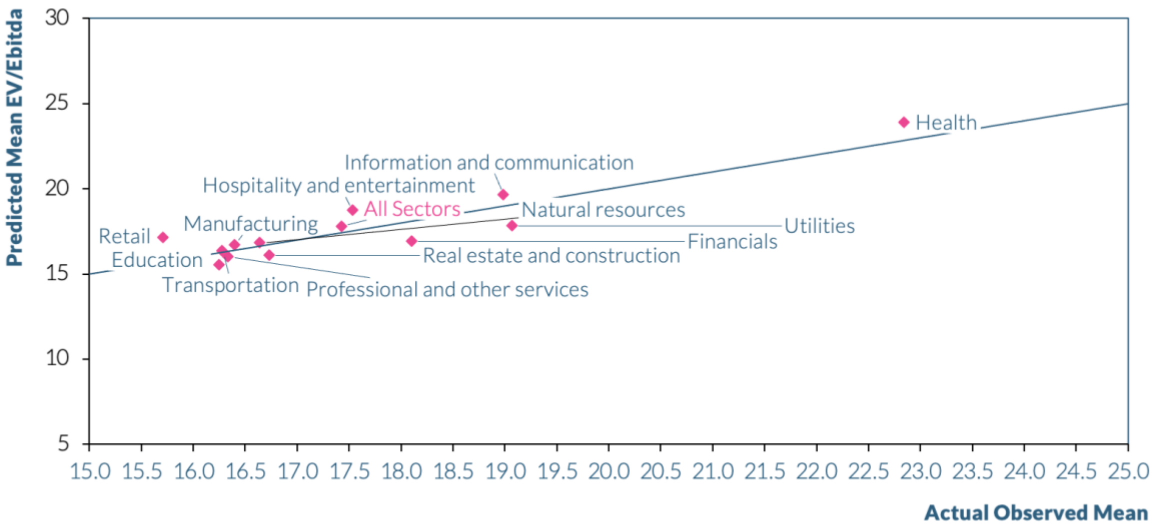
To ensure that is not the case, we compute the EV based on the book value of debt and predicted equity valuation and divide the sum by the EBITDA to get a predicted EV/EBITDA and compare it to transaction implied ratios. Figure 3 presents the average predicted and observed EV/EBITDA by PECCS® activity classes. We find that the predictions are very close to the observed values, thus mitigating this concern.

Table 5: Average estimation errors across PECCS® classes, based on the difference between transacted valuations and factor model predictions

PECCS Pillar	PECCS Class	Mean Estimation Error	PECCS Class	Mean Estimation Error	PECCS Pillar
PECCS Activity	Education and public	0.9%	Startup	0.1%	PECCS Lifecycle Phase
	Financials	1.8%	Growth	-1.7%	
	Health	2.6%	Mature	2.8%	
	Hospitality and entertainment	-1.1%	Advertising	1.2%	PECCS Revenue Model
	Information and communication	-4.4%	Reselling	4.6%	
	Manufacturing	2.5%	Production	2.9%	
	Natural resources	9.4%	Subscription	-6.9%	
	Professional and other services	3.3%	B2B	1.5%	PECCS Customer Model
	Real estate and construction	1.9%	B2C	0.9%	
	Retail	0.5%	Hybrid	0.6%	PECCS Value Chain
	Transportation	7.2%	Products	1.1%	
Full Sample		**1.1%**	Services	3.4%	

Source: Calculated using more than 10,000 deals from PitchBook, CapitalIQ, Factset, and other primary sources between 1999-2022.

Figure 3: Predicted versus actual EV/EBITDA ratios by PECCS® activity classes



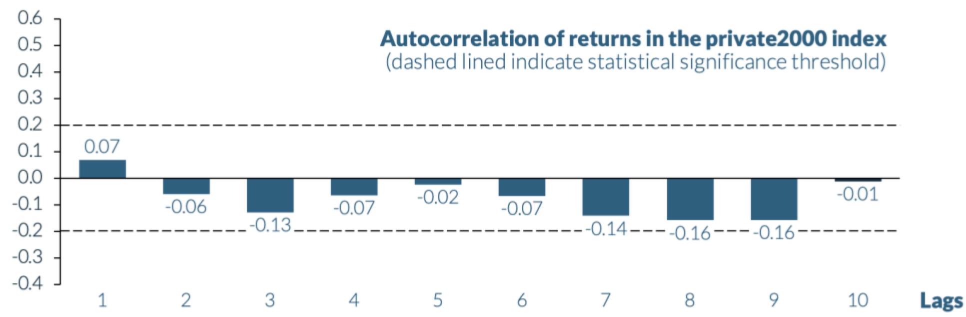
Source: Calculated using more than 10,000 deals from PitchBook, CapitalIQ, Factset, and other primary sources between 1999-2022.

How realistic are the results?

To assess how realistic the valuation from the shadow pricing exercise is, it would be useful to look at the return characteristics of an index constructed based on this methodology. Thus, we can look at the performance of the private2000® index constructed by Scientific Infra and Private Assets on these principles. A standard indication of 'smoothed' returns and the underestimation of volatility is the presence of autocorrelation in private asset return indices. In contrast, privateMetrics indices, such as the private2000®, exhibit no serial correlation, as shown in Figure 4. This demonstrates that they accurately capture the true risk of private markets.

Another way to look at the staleness is to compare the Sharpe ratio (excess returns per unit of risk) of different asset classes, based on appraised indices and the private2000® index. Indices with stale NAVs might show very low volatility and hence extremely high or even unrealistic Sharpe ratios.

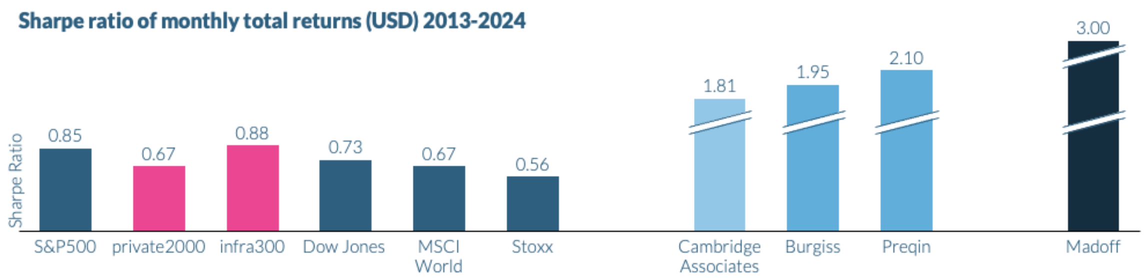
FIGURE 4: AUTOCORRELATION OF RETURNS IN THE PRIVATE2000 INDEX. THE DASHED LINES INDICATE STATISTICAL SIGNIFICANCE THRESHOLDS



Source: Scientific Infra and Private Assets' private2000 monthly index return data between 2013-2024.

In Figure 5, comparing the Sharpe ratios of public markets and different private market indices, this becomes evident. The Sharpe ratio of the private2000 index is 0.67, almost the same as that of the MSCI World Index. However, the appraisal-based private market indices (such as those of Cambridge Associates, Burgiss, or Preqin) have Sharpe ratios way over 1.5.

FIGURE 5: SHARPE RATIO OF MONTHLY TOTAL RETURNS (USD) 2013-2024 (RISK-FREE RATE = 1%)

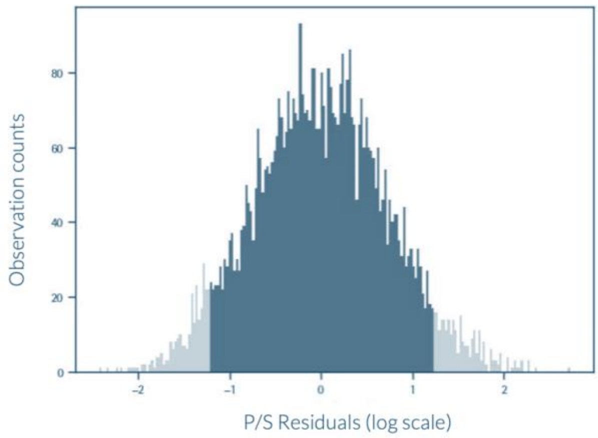


Source: Scientific Infra and Private Assets' private2000 & Infra300 monthly index return data between 2013-2024.

Model Residuals

Our factor model is constructed to capture the systematic effect of observable factors on valuation and leave out the idiosyncratic 'noise' in transactions. A diagnosis of residuals from the model can allow one to interpret whether or not that objective has been met. In Figure 6, we present the residuals from the model and can see that the average error in the model is centered around zero and, at least visually, the residuals look almost Gaussian, or in other words like 'white noise' – i.e. they have a zero mean, are symmetrical around the mean, and follow a normal distribution.

Figure 6: Distribution of model residuals based on a factor model of log(P/S) using transaction data



Source: Calculated using more than 10,000 deals from PitchBook, CapitalIQ, Factset, and other primary sources between 1999-2022

Application: Anchoring Market Comparables

Shadow pricing the universe

The most obvious application of the privateMetrics factor model is to transplant the factor prices to the characteristics (or factor loadings) of other unlisted private companies and compute their valuation as a linear sum of the product of the factor prices and their characteristics. And as the privateMetrics asset pricing model is updated monthly using the latest transaction data, this enables us to refresh the factor prices and thus compute updated valuations for a large sample of unlisted companies.

To illustrate how the monthly update process works, consider, for example, a large, profitable, and highly leveraged retailer that is taken private in an expensive transaction during the month. Then the factor prices update, specifically by allowing changes to the factor prices of size, profitability, leverage, and the retail sector to change in a manner that can explain the newly observed valuation while at the same time being path (current levels of factor prices) and time (explain the price now more than at any point in the past) consistent. Thus, when the updated factor prices are then applied to an unlisted private company, those that are similar to the retailer face similar valuation changes as compared to the valuation arrived at before this transaction.

The privateMetrics database includes PECCS® classifications and financial information for hundreds of thousands of private companies, all of which can be shadow-priced each month, using the latest calibration of market transactions. Table 6 shows the mean of the factor risk exposures or loadings in the privateMetrics database from June 2013 to May 2024.

Table 6: Average factor loadings for PECCS® activity for the period June 2013 to May 2024

PECCS Activity Class	Size (USD millions)	Growth (%)	Profit (%)	Leverage (ratio)	Maturity (years)	Country Risk (spread in bp)
Education and public	115.6	3.6%	10.5%	0.2	47.6	1.7
Financials	112.7	9.3%	29.1%	2.0	27.6	38.1
Health	40.7	4.9%	10.4%	0.2	33.3	30.7
Hospitality and entertainment	80.8	8.1%	14.9%	0.8	30.2	63.6
Information and communication	95.6	10.6%	29.4%	0.4	22.9	85.6
Manufacturing	77.5	9.5%	10.5%	0.4	32.2	113.5
Natural resources	176.8	9.7%	23.5%	0.7	23.1	90.1
Professional and other services	88.2	8.9%	16.2%	0.8	27.7	64.0
Real estate and construction	42.2	8.4%	9.6%	0.4	33.1	59.3
Retail	89.3	7.5%	6.7%	0.3	31.2	88.7
Transportation	75.5	6.7%	11.8%	0.5	31.6	87.9

Source: privateMetrics database of Scientific Infra & Private Assets in June 2024.

Using these factor loadings, a valuation multiple can be estimated for each asset each month using the factor model outputs, resulting in a multiple that can give the 'shadow price' for each asset every month, which corresponds to the systematic (driven by market forces) component of its price. While each shadow price represents the 'typical' or average price of an asset that exhibits the same characteristics (the same risk factors exposures), it does not integrate any idiosyncratic or asset-specific aspect of its value.

Still, we know that on average the privateMetrics model predicts prices accurately (see preceding chapter). Therefore, once averaged or aggregated, these shadow prices can be considered to represent the average price in a segment of the market accurately as well.

Table 7 shows the number of shadow prices that the privateMetrics asset pricing model allows us to compute, say for example, in May 2024. Also, if considered since June 2013, the start of the dataset, this gives a total of over 40 million monthly prices for more than 900,000 unique private companies.

TABLE 7: SHADOW PRICES FOR PECCS® ACTIVITIES IN MAY 2024

PECCS Activity Class	Number of Shadow Prices Computed for May 2024
Education and public	15,371
Financials	2,740
Health	19,385
Hospitality and entertainment	31,972
Information and communication	18,605
Manufacturing	132,457
Natural resources	37,755
Professional and other services	84,665
Real estate and construction	90,237
Retail	167,047
Transportation	18,614
Total	**618,848**

SOURCE: PRIVATEMETRICS DATABASE OF SCIENTIFIC INFRA & PRIVATE ASSETS IN JUNE 2024

With so much more data, it is now possible to build comparables that are 1/ robust: accurate on average and 2/ granular: that truly match the profile of the investment of interest.

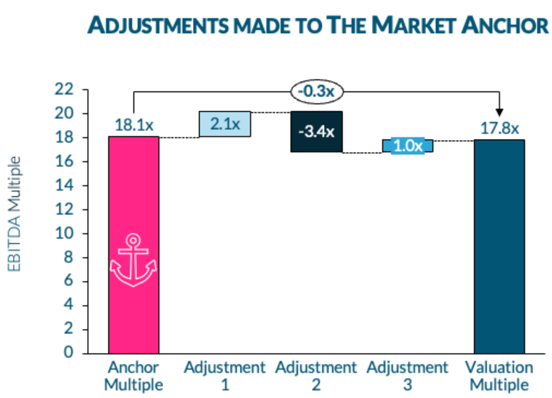
Anchoring price comparables

Once computed, shadow prices can be used to build genuine comparables for investment due diligence and asset valuation. The comparables method requires using assets with similar characteristics to those being evaluated, including market segments and risk profiles. The shadow prices produced by privateMetrics, which we know are accurate on average, are sufficiently numerous and updated to allow the creation of comparables that truly have the same characteristics and risk profile as any asset under consideration.

Figure 7 illustrates this point: after choosing a combination of market segments corresponding to a manufacturing company in the US in May 2024, it is possible to adjust the risk factor exposures of the asset in terms of size, growth, leverage, profitability, and its maturity to obtain the most relevant comparable or Anchor multiple. From there, any number of adjustments to the anchor can be made to reflect the idiosyncratic dimensions of the investment that are not captured by the average market multiple. For example, it could be for the quality of management, some specific supply chain disruption to the company, or some legal issues on its past products.

FIGURE 7: EXAMPLE OF MARKET MULTIPLE ANCHOR WHILE CONTROLLING FOR TIME, PECCS® PROFILE, GEOGRAPHY AND RISK FACTOR PROFILE

		May 2024	Data points
Global Market Ebitda Multiple		17.4x	75.6k
MARKET SEGMENTS			
	United States	17.3x	49.9k
	B2B		
	Manufacturing	18.8x	22.4k
RISK FACTOR PROFILE		within the segments	
Size	Med Exposure	18.1x	4.5k
Growth	High Exposure	16.4x	4.5k
Leverage	Neutral Exposure	18.7x	4.5k
Profitability	Med-High Exposure	18.6x	4.5k
Maturity	Low Exposure	18.9x	4.5k
	MVA Multiple	***18.1x***	



Source: privateMetrics database of Scientific Infra & Private Assets in June 2024

A quantitative, model-based approach to private asset valuation presents multiple advantages:

1. It is **robust**: the calculation is *customised* to reflect the segments and the risk factor profile of the assets of interest while relying on enough datapoints.
2. It is **transparent**: the factors contributing to the valuation are explicit and defined, based on an economic rationale e.g., higher profits equate to higher value (everything else held equal), and documented to be persistent.
3. It is **dynamic**: on each valuation date, a new market benchmark can be used (they can be calculated monthly), anchored to the asset's risk profile (which may have changed), and adjusted to reflect asset-specific elements. A major improvement on non-robust or traditional approaches is that **the NAV never becomes stale**: it is anchored to a continuously evolving private market benchmark.
4. Anchoring the valuation creates a **clear distinction between systematic (market-level) and idiosyncratic (asset-level) risks**: this approach dispenses the valuer from assuming the existence of an 'illiquidity premium' since the inputs do not come from listed markets, but instead from the same illiquid markets in which the assets are priced. All systematic or market elements are included in the Anchor and asset-specific adjustments can be clearly documented and justified.
5. Anchoring is consistent with investors' **prudential and fiduciary duties**: NAVs that are not stale or smoothed enable investors to measure and manage risk and ensure the fair reporting of valuations to final investors in pension plans, insurance, and wealth management products.

Appendix

privateMetrics & IFRS

IFRS 13 Fair Value Measurement provides specific guidance on using market data, particularly focusing on data from the principal market, to measure fair value. privateMetrics is designed to follow IFRS guidance closely in all its key aspects.

1. Principal Market

IFRS Guidance: The principal market is the market with the greatest volume and level of activity for the asset that can be accessed by an investor. IFRS 13 requires that the fair value measurement reflect the price in the principal market.

privateMetrics Approach: privateMetrics addresses the notion of the principal market through its coverage of the private asset market globally. In early 2024, that translates to covering transactions in private assets from over 100 countries globally involving more than 10,000 unique private companies. Using the factor prices gleaned from such transactions, we price unlisted private companies in more than 140 countries, including over 600,000 valuations in early 2024. Moreover, in the flagship indices, 30 of the most important private markets, determined independently, are covered.

2. Unit of Account

IFRS Guidance: IFRS 13 Fair Value Measurement highlights the importance of the notion of the unit of account in fair value measurement. The unit of account refers to the level at which an asset is aggregated or disaggregated for recognition purposes, which is determined by the applicable IFRS standards. While IFRS 13 does not dictate what the unit of account should be, it emphasises that fair value measurements must be consistent with the relevant unit of account. This approach ensures that the fair value measurement aligns with how the asset is recognised and reported in the financial statements.

privateMetrics Approach: privateMetrics is designed to measure the value of private equity investments made by institutional investors and asset managers and that may be accessed through different types of vehicles, from closed and open-ended funds to retail life insurance products. As a result, privateMetrics focuses on the *private company* as the unit of account and on the valuation of the equity shares of capital that may be owned in such firms. This focus on the company level is consistent with the PECCS® taxonomy of private companies.

3. Use of Market Data

IFRS Guidance: When measuring fair value, investors must use inputs that would be used by market participants in the principal market. These inputs need to represent what is customary in the particular market to which the asset belongs, considering the perspective of market participants who are independent, knowledgeable, and willing, but not compelled, to transact.

privateMetrics Approach: privateMetrics uses data from the principal market to derive Market Anchor Valuation metrics. These include private equity transactions (entry and exit transactions) to calibrate a valuation model that uses the characteristics of the asset, the interest rates at the time of valuation in the relevant country, and also inputs from public markets as factors. The characteristics include the financial and accounting data of the private companies and also their taxonomy according to the PECCS® framework. In other words, the model inputs closely mimic the key information that market participants are expected to rely on when transacting in the principal market.

4. Choice of Valuation Technique and Market-Based Inputs

IFRS Guidance: The standard requires that valuation techniques maximise the use of relevant observable inputs and minimise the use of unobservable inputs. Calibration is particularly important when market conditions change or when new markets develop, for instance in the event of large changes in the level of interest rates or macro-economic shocks like the Covid-19 pandemic. Inputs and valuation techniques need to be updated to ensure the reflection of current information from the principal market.

privateMetrics Approach: privateMetrics uses the *market method* to estimate the value of private companies and maximises the use of relevant and observable transaction data by using a parsimonious factor model to capture asset price dynamics and therefore ensures the reflection of current market information in the principal market.

The privateMetrics asset pricing model is re-calibrated monthly as new transaction information becomes available. privateMetrics also recomputes a yield curve using the latest treasury and interest rates on each valuation date along with considering the level of contemporaneous valuation in publicly listed markets. Thus, considering the latest transactions as well as changes in interest rates and public markets ensure the estimated fair value on the valuation date, reflects all current information from the principal market.

5. Consistent Calibration of Valuation Techniques

IFRS Guidance: Calibration involves adjusting the valuation technique to ensure that it reflects current market conditions. Under IFRS 13, when a valuation technique is used to measure fair value, it should be calibrated so that the outcome of the valuation technique matches the transaction price at the measurement date. Subsequent measurements should use a consistent methodology, recalibrating as necessary to ensure the valuation technique reflects changes in market conditions. The intention of IFRS13 is for fair value estimates to reflect market conditions and a potential exit price at the time of valuation (not at some other date in the future).

privateMetrics Approach: privateMetrics uses an asset pricing model calibrated with the most recent private equity transactions, interest rate data, and data from public markets that reflect and accurately match average observable transaction prices. Subsequent measurements or 'shadow prices' for the same private companies use a consistent valuation technique and an updated calibration on each valuation date.

6. Hierarchy of Inputs

IFRS Guidance: IFRS 13 prioritises the use of observable inputs (Levels 1 and 2) over unobservable inputs (Level 3). When observable inputs from the principal market are available, these should be used without modification. Calibration is more critical when using Level 2 and Level 3 inputs, which might require adjustments based on observable data to ensure they align with market participant assumptions. Level 3 inputs are unobservable inputs reflecting the assumptions that market participants would use in pricing the asset or liability, based on the best information available in the circumstances.

privateMetrics Approach: privateMetrics relies on Level 3 information to produce the best estimate of the Market Valuation Anchor (MVA) of a private company valuation. The MVA represents the value of a typical company with the same PECCS® and systematic risk exposure profile. Adjustments representing the company-specific aspects of the valuation are then added by individual users of privateMetrics.

Thus, IFRS 13 clearly establishes that the calibration of fair value estimates should be rooted in market data from the principal market, ensuring that the fair value measurement aligns with the conditions and expectations in that market. Calibration ensures that the fair value measurement remains accurate and relevant, reflecting current market conditions and practices. In turn, privateMetrics uses a highly consistent framework with a focus on measuring fair value in the principal market, re-calibrating results monthly to reflect the latest, most up-to-date information.

7. Adjustments

IFRS Guidance: Adjustments to the valuation techniques might be necessary to ensure that the fair value measurement reflects what knowledgeable, willing parties would exchange in a transaction at the measurement date, under current market conditions.

privateMetrics Approach: The creation of a Market Valuation Anchor that represents the systematic drivers of the valuation of a private company is specifically designed to allow adjustments to be made that are focused on asset-specific phenomena and characteristics. This approach allows a clear separation between systematic and asset-specific adjustments and benefits the objective of continuously updating the valuation to represent the state of the market but also to allow asset-specific adjustments transparently.

8. Disclosure

IFRS Guidance: Extensive disclosure is required for fair value measurements that use significant unobservable inputs (Level 3). These disclosures include the valuation processes, sensitivity of the fair value measurement to changes in unobservable inputs, and the effect of measurement uncertainty.

privateMetrics Approach: privateMetrics provides detailed information for the reporting of asset valuations including the loadings and returns of each one of the factors that affect the valuation multiple. Moreover, it also allows one to determine the range of values due to possible values due to changes in the factors, which is equivalent to measurement uncertainty. Such features enable stress testing to be carried out under different scenarios which is required by various regulations.

Issues with raw reported valuation data

Lack of recent transaction data

To illustrate the severity of the data paucity issues, in Table A1, we present the typical number of such data points available in the market at any given time. For example, from MSCI's private capital quarterly holdings data (erstwhile Burgiss), it is apparent that only about 150 recent transactions, or about 13% of what is reported is actually observed in a given quarter, and even then some sectors are hardly represented.

TABLE A1: UNDERLYING DATA THAT CAPTURES RECENT TRANSACTIONS

Median EBITDA Multiples from Burgiss Q2 2022						
Sector	**All Multiples**		**Entry Multiples**		**Exit Multiples**	
	Count	Median	Count	Median	Count	Median
All Sectors	1,209	12.4x	114	10.1x	43	12.2x
Comm. Services	62	13.8x	7	11.0x	2	N/A
Consumer Disc.	195	11.0x	14	7.6x	10	12.4x
Health Care	203	14.1x	22	12.1x	9	14.2x
Industrials	270	10.5x	29	9.1x	11	12.0x
Information Tech.	259	15.7x	23	11.1x	6	12.3x
Materials	62	10.6x	9	9.5x	1	N/A

Source: MSCI/BURGISS Q2, 2022 report.

Flaws in reported data

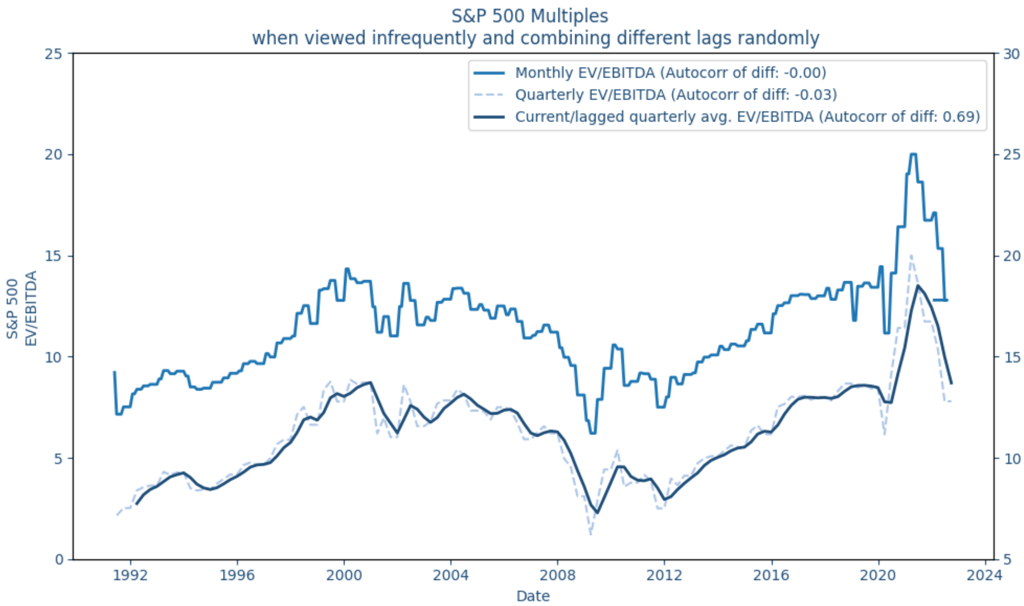
Reported data such as the first two columns in Table A1 provide aggregate multiples (All Multiples) that combine GP-appraised valuations and actual transactions, making the aggregate metric an amalgamation of various methods, assumptions, and individual decision-makers. But even when disentangling the two, and using only the reported valuation multiples, they are still problematic for several well-documented shortcomings, including but not limited to:

- **Not current**: Due to data collection, reporting, and aggregating timelines, these multiples are often stale, lagged, and asynchronous. Moreover, when GPs use static assumptions such as a fixed IRR as the discount rate and fail to reflect other changes in their valuation methods, the multiples can remain unchanged over several quarters.
- **Smoothness**: Due to the behavioral biases of GPs, the reported valuations are smooth and unrealistic and exhibit low volatility across quarters, effectively masking the risk of the asset class.
- **Not granular or robust**: Viewing multiples at a highly aggregated sector or region level makes it less useful to apply for a specific asset without ad-hoc adjustments. For example, there are large valuation differences between subsectors within a given sector. However, using an aggregated sector multiple can produce a very high error.
- **Combine disparate modeling approaches**: Reported data at the end uses only models, but these models are being applied by many individual GPs or analysts and hence risk using variable assumptions and methods, leading to a very noisy multiple. If in fact, every GP was valuing the same company, it is feasible for the noise in methods and assumptions to cancel out, but because every asset being valued is unique and different, the methods and assumptions can take a life of their own and introduce biases in reported data.

Smoothness can therefore creep into private valuations when valuations on different dates are combined, which happens when a data provider aggregates NAVs from different funds reporting on different month-end or quarter-end dates.

In Figure A1, we illustrate the timeliness and smoothness problem together. Specifically, we show how combining valuations of different lags can produce a smoothening effect on valuation. First, we plot the monthly EV/EBITDA multiples of all S&P 500 stocks over time, and the monthly differences in this series have an autocorrelation of 0. Second, on the right axis, we plot the same EV/EBITDA series but by using only quarterly measurements. We still see the same pattern but fewer changes and similar autocorrelation in quarterly differences. However, when we try to mimic how appraisal data is aggregated from different funds reporting asynchronously, we find a striking result. Specifically, we assign a random weight between 0% and 30% to each of the current and three lagged quarters and ensure the weights sum up to one. When we plot this weighted series, we find that the EV/EBITDA is very smooth, with a high autocorrelation of 0.69.

FIGURE A2: BIASES FROM COMBINING VALUATION OF DIFFERENT LAGS OF MULTIPLES



Source: calculated from Bloomberg data on the S&P500 Index

Using reported appraisals leads to large errors

To highlight the granularity and robustness problems in reported data, we apply them to transactions in private markets. Using the median value of EV/EBITDA values from Q2, 2022 MSCI/Burgiss multiples, we compute an implied price for over 120 deals from PitchBook. The absolute errors are then computed as the difference between the implied and actual deal price implied EVs. Table A2 presents these errors at each PECCS® activity and aggregate level. For sectors without estimates, we use the aggregate medians from MSCI/Burgiss. The errors are quite high and are over 50% in the majority of the activities, indicating the reported values are not robust.

We also perform this analysis with a few selected deals in the Healthcare sector. The granularity problem stands out here, as there are two distinct types of Healthcare companies in the deal sample, which also have significant differences in their valuation. For example, Health Care Equipment & Supplies enjoyed EV/EBITDA multiples that are consistently higher than Health Care Providers & Services. However, the lack of granularity in the aggregate Healthcare multiples in reported data produces systematically varying errors in the implied EV multiples across these two subactivities, no matter which quartile multiple is used.

The estimation errors in Table A3 clearly show the representativity issues of reported data, when they are directly used for the same activity companies, but which may operate with a distinct subactivity in the sector.

TABLE A2: VALUATION ERRORS BY SECTORS IN DEALS VALUED USING REPORTED MULTIPLES

Activity	Absolute Error in Deal EV minus Reported Data Implied EV
Information and communication	56%
Transportation	95%
Manufacturing	73%
Real estate and construction	81%
Hospitality and entertainment	113%
Retail	60%
Professional and other services	68%
Utilities	96%
Health	46%
Financials	55%
Natural resources	33%
Education and public	30%
All Deals	74%

Source: 120 PitchBook Deals in2022, and MSCI/BURGISS Q2, 2022 report.

TABLE A3: VALUATION ERRORS IN DEALS IN HEALTHCARE WHEN VALUED USING REPORTED MULTIPLES

2022 Healthcare Deal Data (PitchBook)					Reported Multiples Healthcare (Burgiss, 2022)			Estimation Error			
Co. Name	**Sector**	**Deal Date**	**Deal Multiple**	**EBITDA M$**	**Top Q**	**Med.**	**Bottom Q**	**Upper Bound**	**Med.**	**Lower Bound**	**Avg Abs. Error**
Natus Medical	Health Care Equipment & Supplies	7/5/22	22.8x	48.6				20%	38%	52%	37%
Artel		6/13/22	28.0x	5				35%	50%	61%	48%
IntriCon		5/24/22	51.2x	4.3				64%	72%	79%	72%
Hanger	Health Care Providers & Services	10/3/22	12.2x	100.74	18.3x	14.1x	10.9x	-50%	-16%	10%	26%
Probo Medical		3/8/22	15.0x	30				-22%	6%	27%	18%
Tivity Health		6/28/22	19.5x	157.7				6%	28%	44%	26%
							Avg Abs. Error	**33%**	**35%**	**46%**	**38%**

SOURCE: PITCHBOOK DEALS IN THE HEALTHCARE SECTOR IN 2022 AND MSCI/BURGISS Q2, 2022 REPORT

Public market proxies do not help

Private companies are inextricably linked to the economy as they must face market demand, obtain financing, withstand business cycle fluctuations, and access capital markets for investor exits, thus exposing them to the same factors as publicly listed companies. However, there are significant differences between the two types of assets, as summarised below, making public peers poor proxies for valuation.

- **Disappearing public companies**: Since the 1997 peak in public listings, the number of listed companies has been shrinking for several reasons and has been documented by several studies (Doidge et al., 2018). Thus, there is a selection effect to which companies publicly list and stay public, thereby making their valuation different from private companies.
- **Difference in characteristics**: A key way of value creation in private equity is through the use of leverage, and many studies have documented these differences (Chingono and Rasmussen, 2015). Thus, using public peers as proxies for valuation may fail to capture the effect of leverage on valuation correctly.
- **Diversification**: Most investors in private markets follow concentrated investment strategies, whereas in public markets the cost of diversifying the portfolio is very low, thereby making an asset that is perfectly diversifiable a poor proxy for the valuation of a less diversifiable asset.

Using the same set of deals from PitchBook in 2022, we compute an implied EV based on publicly listed companies' EV/EBITDA multiples. We use the most commonly used dataset from Damadoran (NYU) which provides the EV/EBITDA multiples for several sectors of US companies (91 sub-sectors of multiples are available). Mapping these sectors with the activities of PitchBook, we compute the implied EV of the over 120 deals. As can be seen in Table A4, the errors are even larger than those using the reported data. Moreover, half the sectors have valuation errors that exceed 100% indicating private market companies have transacted at far higher multiples than is indicated by their publicly listed peers in 2022.

Table A4: Valuation errors by sectors in deals valued using publicly listed multiples

Activity	**Absolute Error in Deal EV minus publicly listed peers' based Implied EV**
Information and communication	70%
Transportation	107%
Manufacturing	78%
Real estate and construction	143%
Hospitality and entertainment	179%
Retail	54%
Professional and other services	109%
Utilities	207%
Health	45%
Financials	355%
Natural resources	11%
Education and public	48%
All Deals	**103%**

Source: 120 PitchBook Deals in2022, and Damodaran NYU dataset for 2022.

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