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The Appraisal of Data Centres: Deconstructing the Cash Flow

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Abstract

This paper analyses the appraisal of a specialized form of real estate - data centres - that has a unique blend of locational, physical and technological characteristics that differentiate it from conventional real estate assets. Market immaturity, limited trading and a lack of pricing signals enhance levels of appraisal uncertainty and disagreement relative to conventional real estate assets. Given the problems of applying standard discounted cash flow, an approach to appraisal is proposed that uses pricing signals from traded cash flows that are similar to the cash flows generated from data centres. Based upon 'the law of one price', it is assumed that two assets that are expected to generate identical cash flows in the future must have the same value now. It is suggested that the expected cash flow of assets should be analysed over the life cycle of the building. Corporate bond yields are used to provide a proxy for the appropriate discount rates for lease income. Since liabilities are quite diverse, a number of proxies are suggested as discount and capitalisation rates including indexed-linked, fixed interest and zero-coupon bonds.

Introduction

In the late 1990s, the boom in the Telecommunications, Media and Technology (TMT) sectors raised the profile and supply of data centres¹. The surge in the TMT sectors was mirrored by an expansion in the supply of data centres, where operators of facilities leased cabinet, cage and floor space. As the TMT bubble burst, many data centre operators and providers went into liquidation resulting in an oversupply of space. The subsequent period has witnessed market recovery, associated with consolidation within the sector and an increased recognition of the importance of business continuity and security. A large proportion of data centres have some of the characteristics of conventional investment properties in that they generate rental income flows that are underpinned by occupational agreements. However, the buildings are specialized and require significantly more current and capital expenditure over their life cycle compared to conventional assets. This presents a number of appraisal problems which are the focus of this paper.

The remainder of this paper is organised as follows. Firstly, it provides an analysis of data centres as a specialised form of real estate and discusses its unique attributes as an asset class. The appraisal issues for specialized or limited market properties are discussed. Particular attention is paid to the information requirements of discounted cash flow methods and the problems of identifying defensible inputs from market activity and analysis. Identifying the shortcomings of conventional discounted cash flow methodologies, the paper examines the mixture and volatility of revenues and liabilities of data centre facilities. It proposes an alternative appraisal methodology based on the 'law of one price'. Focusing on the credit rating of individual occupiers, and matching liability and income streams with traded financial instruments; the paper concludes by proposing a method that utilises external pricing signals to appraise the various incomes and costs.

Data Centres as an Asset Class

The core business of a data centre facility operator is the letting of space in a highly controlled environment to accommodate Information Technology (IT) operational and support equipment, which can access bandwidth through public or private data networks. Whilst this précis describes the gamut of data centre facilities and operations, it fails to highlight diversity of infrastructure in

¹ These assets have are also referred to as telehouses, rack-farms, carrier hotels, colocation and hosting centres.

available facilities and in the business frameworks under which they are operated. The main attributes relative to conventional real estate are examined in detail below and compared and contrasted in Table 1.

Physical and Locational Attributes

In its simplest form, data centres are highly specified and configured buildings which integrate infrastructure to provide a secure, controlled and optimised environment to house and operate IT equipment. Although the size, design and specification of data centres vary, the assets can be divided into comparatively distinct physical categories outlined in Appendix 1. We use the term Technical Real Estate (TRE) to describe the range of data centre facilities in terms of their physical attributes.

The two key features of data centres are availability of power and proximity to fibre optic networks. Crucially, facilities must be connected to multiple backbone fibre and local loops to allow for connectivity with other hosting equipment and redundancy in case of disruption. This affects location choice significantly, as the cost of connecting remote facilities satisfactorily can be prohibitively high. Regulatory pressures also limit the distance between data centre back-up sites, as it requires for a multiple of data copies to be *in situ* at any point in time².

In order however to operate the equipment housed in these facilities and to maintain critical temperatures, high capacity power feeds must be continuously active. This is achieved by minimising the risk of down-time which is reduced by feeding the building with two power sources from different points on the National Grid. Where this is not possible, two feeds are taken from each half of a single sub-station.

Operational characteristics

Whilst conventional UK Full Repairing and Insuring (FRI) leases and service charge provisions minimise the management resources and expenditure required by the investor during the period of the letting, this is not the case with data centres where operators and owners are faced with a range of current and capital expenditures during the life-cycle of the asset.

² Currently the limit on distance from primary hubs for synchronous replication stands at 40 miles, which increases the need for data centres to be in close proximity to fibre networks and indeed to other facilities.

Current fixed and variable costs will include staff and operational costs, business rates for any operator areas required to operate the facility and standing charges for power (particularly electricity) that have to be reserved. Other current variable costs will include the renewal of existing equipment, and maintenance of the building fabric and services elements of the facility. In addition, there are likely to be major capital expenditures associated with upgrading and replacing infrastructure. This latter cost is typically unpredictable and will depend on the base design of the existing infrastructure and the building itself, together with future technological change and prevailing market dynamics.

Occupational structures

A key business decision for data centre operators is whether to focus purely on the provision of space and support infrastructure, or to also offer complementary services. Some providers offer a range of services which can include full management and technical support for equipment, whilst other focus on pure space and infrastructure provision. The space and services provided vary in terms of cost, bandwidth, carrier access, occupational terms, security, power back-up and redundancy, technical support services, and financial standing of the provider

In turn, the occupancy structure of each facility varies in order to complement and achieve the business decision of the operators. Broadly speaking occupational structures are divided into two main groups; conventional real estate leases (and licences) and leases with managed services.

Conventional leases are usually applicable for large scale requirements where the tenant requires a degree of certainty for the footprint they occupy. This may be as a direct consequence of the level of investment in setting up the necessary equipment, regulations regarding confidentiality, or the critical level of data stored and/or processed. Under a lease structure, the occupier has a larger degree of responsibility over the environment which they occupy. In some cases the landlord may be only responsible for providing power and cooling and have restricted access to the space. Given the probable level of capital outlay by the occupier, these leases tend to have a nominal duration of five to 10 years, usually with a break at or after the fifth year.

More typically a large number of occupancy agreements are in the form of short leases or licenses. These usually have a duration of one to three years, with the landlord providing a greater number of services than for larger requirements under lease agreements. Landlords, either in their own

Table 1: Characteristics of TRE and Conventional Assets (UK)

Characteristics	Conventional asset (UK)	Technical Real Estate
Tenant base	Variable covenant strength.	Variable covenant strength.
Typical (lease) contract duration	10 years	5 years
Rental change	Fixed and reviewed to market every five years.	Annual (CPI) Index-linked rents.
Non-performance penalty payments	None	Potential for substantial payments.
Construction cost	X	2x-6x ³
Building infrastructure cost	Low relative to shell and core	High relative to shell and core
Site value	High relative to construction costs.	Low relative to construction costs.
Depreciation risk		
- Capex on infrastructure	Low	High
- Capex on building	High	Low
- Locational	Low	Low
- Aesthetic	High	Low
- Technological	Low	High
Building flexibility	High	Low
Market characteristics		
Liquidity	High. Mainstream investment class.	Relatively low. New investment class.
Maturity	High. Long established market	Low. Relatively new sector.
Transparency	Well-researched and monitored market.	Limited market monitoring. Client base may seek confidentiality.
Demand/supply shocks	Has suffered major demand and supply shocks.	Has suffered major demand and supply shocks.

³ It is estimated that the cost of construction can often be three times more than conventional office buildings and six times more than industrial and distribution.

capacity as managed service providers or otherwise, supply a degree of additional services ranging from “hands and eyes” (basic servicing of equipment) to complete service provision (in some cases this may even extend to outsourcing). Similar to more conventional short term tenancies, a high proportion of occupiers tend to renew these on a rolling basis in line with their business requirements.

For both types of occupancy structures, occupiers have a wide range of options. However, the key variables tend to be that rents are annually indexed (usually to a measure of CPI), there are termination and renewal options, and repairing obligations (similar to dilapidations for conventional real estate assets). In terms of added services and/or charging for power, local taxes etc this tends to be in addition to the base rent, charged on an individual basis.

The appraisal framework

Given the relative newness and specialized nature of data centres, there is very little published material that discusses appraisal issues - this accounts for the limited bibliography. One issue that is clear is well-documented, in the absence of comparables for income producing assets in thinly traded markets, such as the data centre market, appraisers tend to rely mainly upon (or exclusively) use discounted cash flow methods. Essentially it becomes impractical to use comparison-based approaches. In the UK, this has been apparent for the appraisal of going concern-type assets such as serviced offices, hotels, nursing homes *inter alia* (see McAllister, 2001, and Borner, 1994). Additionally, when UK appraisers are dealing with non-standard income streams – percentage rents and flexible lease structures – they have tended to revert to explicit DCF techniques (McAllister, 1996, Crosby *at al*, 2006).

When estimating Market Value by DCF, USPAP Statement of Appraisal Standards No. 2 states that:

To avoid misuse or misunderstanding when DCF analysis is used in an appraisal assignment to develop an opinion of market value, it is the responsibility of the appraiser to ensure that the controlling input is consistent with market evidence and prevailing market attitudes. Market-value DCF analyses should be supported by market-derived data, and the assumptions should be both market- and property-specific. Market-value DCF analyses are intended to reflect the expectations and perceptions of market participants along with available factual data.

However, it is particularly germane to data centres that this implicitly assumes adequate market activity to generate sufficient market signals

Specialized or Limited Market?

Data centres exhibit a number of the characteristics of specialized properties, as they are designed to house a particular process and their structure has particular attributes that can add to their value to others in the data centre sector. The IVS definition of a specialised asset is:

“...property that is rarely, if ever, sold in the market, except by way of a sale of the business or entity of which it is part, due to their uniqueness arising from its specialised nature and design, its configuration, size, location or otherwise.

The IVS guidance acknowledges the increased complexity of the valuation process and discusses the importance of market knowledge in deciding whether “a market approach to appraisal” is appropriate, or whether a depreciated replacement cost (DRC) approach should be adopted. Whilst the IVS guidance states that all methods should be considered, it does not list DCF in the alternatives and points out that the DRC approach is commonly used.

The IVS also discusses the appraisal of ‘limited market property’, and defines it as:

Property that, because of market conditions, unique features, or other factors, attracts relatively few potential buyers at a particular time. The central distinguishing characteristic of *limited market properties* is not that they are incapable of being sold in the (open) market, but that the sale of such properties commonly requires a longer marketing period than is common for readily saleable properties.

However, the guidance assumes clear categories whereas in reality the key questions are ‘how limited is the market?’ and ‘how specialised is the asset?’ In practice, it is probably better to view such concepts in terms of a continuum rather than as clearly defined categories. Figure 1 illustrates the implications of limited market activity for the appraisal in terms of approach and appraiser input.

Where there is a large quantity of transactions involving assets with similar characteristics, the role of the appraiser is essentially to interpret market signals and apply them to the subject property. Data centre facilities which are let on institutional leases to operators on standard lease terms would

fall within this category. Their appraisal is unlikely to require significant additional expertise relative to mainstream investment assets. At the other extreme, purpose-built, specialist data centres owned and operated by major corporate entities can often be unique, customized buildings without any alternative use that does not involve major expenditure. For these types of assets, there will be little, if any, transaction activity and consequently, little, if any, market signals. As a result, the appraiser is often forced to take a cost-based, DRC approach.

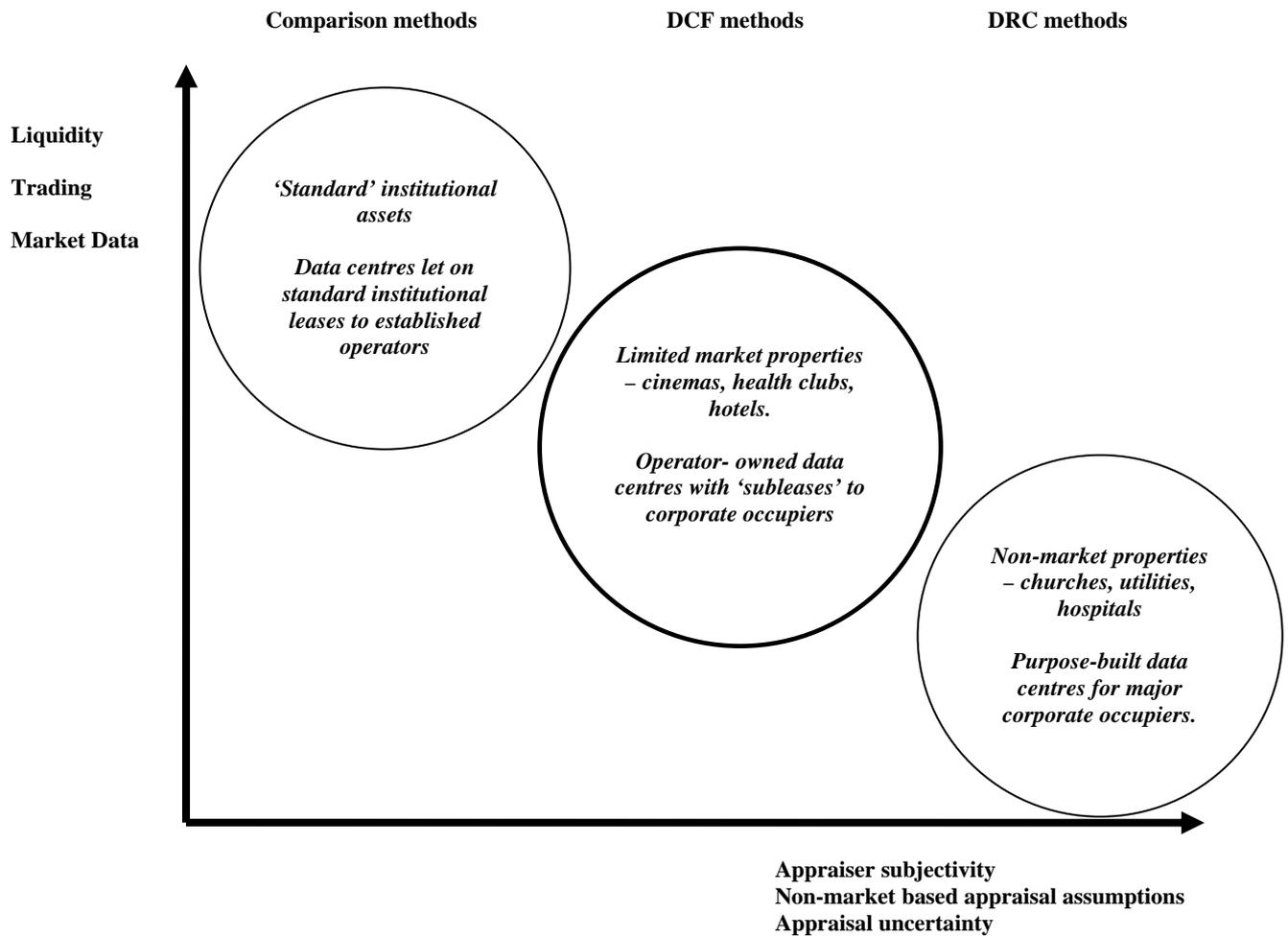
Operator-owned data centres facilities, especially those that offer private suites⁴, exhibit some of the characteristics of conventional investment properties in that they generate rental income flows that are underpinned by occupational agreements. However, the buildings are specialized and require significantly more current and capital expenditure over their life cycle compared to conventional assets. There tend to be shorter occupancy agreements than for conventional assets, and rents are annually indexed linked. Markets are immature and characterized by thin trading and poor information flows. All of the above increase the complexity of the appraisal process.

Appraisal Information Requirements

Due to their physical and operational characteristics, data centre assets could be classified as specialised properties for appraisal purposes. However, the fact that they produce income streams indicates that they can be appraised as investment rather than operational assets despite the absence of significant market trading. As such, they are in some ways similar to leisure property assets such as hotels that generate income streams and they lend themselves to appraisal on a DCF basis to account for the absence of market signals of capitalisation rates.

⁴ 'Private suites' are sections of a given data centre where the area occupied by a tenant has restricted access. This is achieved by either a divisive wall or a steel cage, with access to the suite controlled by an electronic card, finger-print or retina check.

Figure 1: Occupational Structures, Market Characteristics and Appraisal Methods



DCF appraisal methodology is forward-looking and requires a wide array of information about future incomes and expenditures. The variables influence the expected cash flows from the asset, and the individual value of these income streams. The key variables are:

- Market Rent,
- voids,
- rental and income growth,
- depreciation and capital expenditure,
- operational expenditure,
- exit capitalisation and
- target rate of return.

Market Rent

Estimating Market Rent can be prone to uncertainty even for conventional assets. However, added heterogeneity, confidentiality and reduced transaction levels in the data centre sector make the process prone to additional uncertainty. Data centre facilities have added heterogeneity as they can have quite different specifications of infrastructure. This probably explains the use of indexed-linked rents. In the absence of comparable transactions to 'prove' rental values at rent review, investors often opt to use index-linked review provisions.

Void Periods and Operational Costs

For conventional assets, data on market and sector averages of incidence and costs of voids are now produced by the Investment Property Databank (IPD) in their annual *Lease Events* survey. Although individual operators of data centre facilities monitor these variables privately, there are no published data. In the event of a rental void, the operator will have a number of fixed and variable costs.

- *Fixed costs* will include mainly the running costs and marketing and legal fees associated with finding a new occupier. These may be relatively high for data centre facilities due to the costs of maintaining and operating the building's infrastructure.

- *Variable costs* will include a combination of non-receipts and costs. For non-receipts, the operator no longer receives a rental income during the void period and may have to grant incentives to a new tenant. The level of these variable costs is largely a function of the length of the void period. Additionally, the operator is responsible for costs normally recovered from occupiers, e.g. business rates, insurance, power supply, etc.

Rental Value Growth

For conventional property sectors, it is possible to obtain forecasts from specialist consultancy firms where these are undertaken at a national, regional and local level. Since there is no comparable body of expertise and data available for the data centre sector, it is difficult to generate robust and defensible models and forecasts of rental growth.

Depreciation

Depreciation can affect cash flows in three main ways:

1. Income growth in the asset may be lower than in the location. However, for data centres the critical depreciation issue is of the infrastructure rather than the building, as the main source of depreciation is likely to be technological rather than aesthetic obsolescence.
2. Capital expenditure may be incurred on the asset in order to counter the effects of depreciation and obsolescence. For data centre facilities, we need to account for capital expenditure on the building and infrastructure which is likely to be substantially higher overall and biased towards the infrastructure. However, as many data centre facilities are relatively new it is difficult to find evidence of the level and timing of major capital outlays.
3. Capital values will be affected as depreciation is 'priced' by investors. This would affect the exit capitalisation rate applied to the asset, as it would be adjusted to account for the lower expected achievable rents and the higher expenditure required.

Exit Value

The shorter the cash flow, the more important the accuracy of the sale price becomes to the reliability of the appraisal. For conventional commercial property assets a five year period of

analysis is typical. A key issue is the forecasting of the exit capitalisation rate. For conventional office assets, the current capitalisation rate often serves as a starting point. Although most major property advisory practices provide capitalisation rate forecasts, there is considerable doubt amongst forecasters about the reliability of their models. Further, for conventional assets, individual analysts have to incorporate building specific issues into the estimation of the capitalisation rate, e.g. the effects of depreciation and obsolescence, potential lease structure changes. This process is rendered even more problematic for data centre facilities, where the absence of market trading provides little indication of current capitalisation rates let alone future capitalisation rates.

Target Rate of Return

For data centres, there are no well developed mechanisms for calculating risk premia, as the market has not developed mechanisms for determining the amount of adjustment to the discount rate to reflect variations to the risk profile of different properties. For conventional property investments there are, in practice, reasonably robust approaches to discount rate selection. Typically, the discount rate will be a product of:

- Investment management agreement mandates,
- (Consensus) Forecasts for the appropriate index or sub-index, or
- Government bond (risk free) rates plus a risk premium.

As a result, it is likely that similar investors will apply similar discount rates to similar assets. Estimating the discount rate for data centre facilities is more problematic due to the immaturity of the market; there are no indexes of projected returns and quantifying risk premia is difficult in the absence of market signals.

Liabilities

Data centre operators will incur a diverse range of costs, including operational, maintenance, and capital expenditure on both the building and infrastructure. Based on their variability, these outgoings can be classified into four categories.

- The first category comprises the most certain and least volatile liabilities. These are mainly fixed⁵ and consist of key staff and operational costs that will be incurred even if the building is vacant (unless it is mothballed).
- The second category consists of periodic costs which are reasonably predictable. These relate to the replacement of existing equipment in the facility and may form part of a rolling renewal program. Although these liabilities are more volatile and the timing is less certain relative to those in the first category, they are fairly predictable, i.e. because they are necessary to the continuing operation of the building, they will need to be incurred at certain points in time.
- The third category comprises of costs which are dependently variable on the level of operations within the facility. Elements of this group may have either a positive or a negative correlation with occupancy rates and can be divided into two broad categories. Positive costs are outgoings that are incurred as occupancy increases. Negative costs are additional costs that are incurred when occupancy decreases. These may involve payment of business rates, power supply and other service charges.

Additional complications may arise as to the individual behaviour and timing of these costs. For example, as occupancy increases it is likely that the operator will experience economies of scale and thus the cost per unit of space occupied will decrease. Conversely, as the occupancy rate rises the operator will require additional staff (technical and security) to provide the same range and level of services to each client.

Overall however, although an element of these costs will be stepped and may behave in a counterintuitive manner, these costs will, in their majority, be linearly related to the occupancy rate.

- The fourth category will be large scale upgrades to and replacement of the building infrastructure to counter-act technological obsolescence. These ‘lumpy’ expenditures tend to be uncertain both in terms of quantity and timing.

⁵ We use the term ‘fixed cost’ to refer to any cost of production which does not vary significantly with the volume of output or with any other factor external to the economic environment at the time of the appraisal.

Clearly, applying conventional DCF approaches to data centres requires a substantial degree of subjectivity on the part of the appraiser with its consequences for appraisal uncertainty and variation.

An Alternative Approach to Data Centre Appraisal

The market for data centres can be described as incomplete, characterised by a lack of trading and illiquidity. An alternative approach to appraisal is to use information contained in the prices of traded financial instruments to value cash flows that are neither actively traded nor can be replicated. In essence, this appraisal approach uses market pricing signals from similar traded assets to *approximately* complete an otherwise incomplete market. Such an approach uses “what we know” to find out “what we don’t know” and is based upon ‘the law of one price’.

In its formal sense, this ‘law’ states that two assets that are expected to generate identical cash flows in the future must have the same value now. Otherwise, market participants would identify an arbitrage opportunity and buy the under-priced asset. However, in reality there are rarely assets that have identical cash flows and some approximation is necessary. The basis of the approach is to try to ‘strip out’ the various components of the asset’s expected cash flow, appraise them individually and aggregate them. The essential insight is that different components of a property’s cash flow have different risks and different pricing processes. In DCF appraisals of conventional assets, investors normally apply a risk-adjusted discount rate which is (implicitly) a weighted average of a number of separate risk-adjusted discount rates for different components of the cash flow.. However, an alternative is to appraise the various individual cash flows using appropriate individual risk-adjusted discount rates.

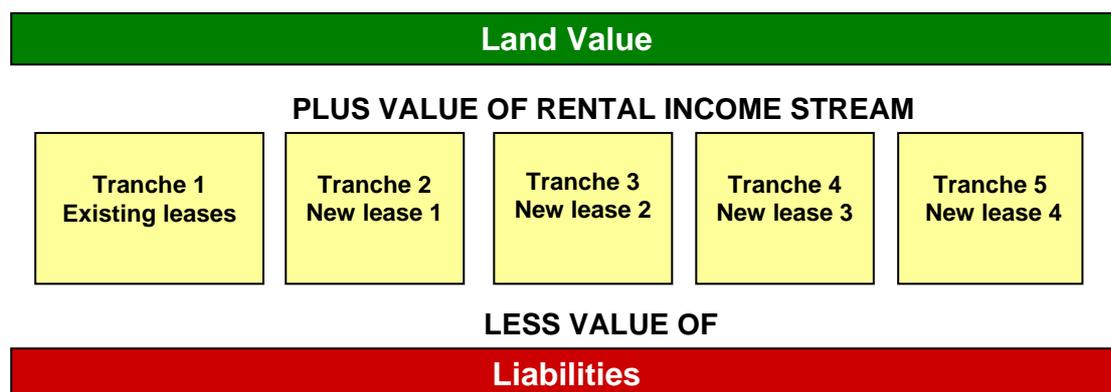
We can identify a number of different elements of a data centre asset and its associated income flows:

- the current contractual rental income over the period of the existing contracts;
- income from future rental contracts;
- land value;
- value of building (without infrastructure);
- value of building infrastructure;
- revenue from support services; and

- fixed and variable expenditures producing both current and non-current liabilities.

We incorporate these variables into a model which focuses on the three main components of the expected cash flow over the life cycle of the building. Illustrated in Figure 3, the basic approach is that the appraisal of a data centre is a function of the present value of the future rental income stream for the life cycle of the building plus land value less the present value of future outgoings.

Figure 3: Appraisal of Technical Real Estate: A Schematic Representation



Projected Rental Income

An important financial asset of the data centre facility owner is the right to receive current contractual rent for the remainder of the lease. This is similar to a CPI-linked corporate bond. Depending on the specific terms of each individual lease, the key insight is the argument that the main financial risk does not lie in the property but in the tenant. Hence, the focus is on the risk of tenant default. It is then argued that the corporate debt yield of the tenant (or comparable companies) provides us with an approximate discount rate. In reality, they have slightly different risk profiles for two reasons. Firstly, as discussed in depth below, bond default and tenant default do not necessarily have the same financial consequences. Secondly, the differential liquidity between ownership of rental streams and an ownership of bond repayments increases the illiquidity risk premium for data centre rents.

As noted above, a weakness of this approach is the implicit assumption that the risk lies solely in the tenant rather than the property and should be priced accordingly. Reality can often be more messy and complex. Whilst in many cases this will be reasonable, there will be situations where the

nature of the property is such that even if a tenant defaults on the rent, there will be no problem in replacing the tenant. Consequently, in some circumstances (especially where there is an excellent building let to a weak covenant) there is potential to mis-price the income stream. Further, in data centres, where providers of managed services constitute a substantial element of the rental income, it is not necessarily the case that income will not be received in the event of insolvency. Their clients may act like sub-tenants and choose to take new leases.

An additional difference is that leases do not offer a guaranteed return of principal at expiry in the same ways as bonds. As a result, they have a different duration than leases with similar time periods. This may be a relevant issue when there is a significant gradient in the yield curve e.g. 10 year bonds are trading a different redemption yields than five year bonds. At the time of writing, the yield curve is relatively flat and there is no reason to adjust for differences in the effective duration of a seven year bond relative to a seven year lease.

Where data facilities offer secure income streams from investment grade tenants, it should be possible to price this income accordingly.

- The current rents paid have the financial characteristics of a corporate index-linked bond. Depending on the covenant strength, this will be low risk.
- A proportion of these existing rents paid will renew at a new Market Rent which will set the base level for another set of corporate index-linked bonds.
- Following expected void periods, new leases (length needs to be specified) will generate new corporate CPI-linked bonds.

The right to receive future uplifts in rental value⁶ is probably the most complex element of the appraisal. We can logically state that the value of the *option* to receive future uplifts is a function of the:

- Expected rate of rental growth,
- Period to rental increase,
- Discount rate, and

⁶ Rental income growth will be driven by inflation since rents are indexed. However, at lease expiry, rents will revert to market level. This will be influenced by supply and demand conditions in the market at the date of lease expiry.

- Volatility in rental growth rates.

Simulation is attractive where volatility is a key driver of the possible cash flows. However, given that there is substantial uncertainty associated with a number of the variables and the lack of any robust indicators of growth and volatility, there are major impediments to the application of simulation in this context. Further, future rental growth is often a relatively insignificant element of the total value and it is likely that any potential benefits in terms of accuracy from applying simulation would be spurious given the uncertainties in the necessary inputs.

Given the similarities of rental liabilities to debt liabilities, a surrogate discount rate for estimated future rental income is the corporate bond rate for the existing tenants or, in the event that no corporate bond rate is available, the corporate bond yield for companies with similar credit ratings.

Residual (land) value

There is a great deal of uncertainty concerning the asset at the end of the period of analysis. Residual values are a growing area of interest in their own right as investors attempt to use insurance products to improve the range of alternatives in gearing structures. The value will be a function of a wide range of interrelated and uncertain variables such as:

- capitalisation rate at end of cash flow (exit yield);
- rental growth in the period to end of cash flow;
- state of the occupier demand at end of cash flow;
- building and infrastructure depreciation to end of cash flow;
- changes in highest and best use;
- probability of tenant renewal; and
- rebuild or refurbishment costs.

The approach adopted here is to reduce the significance of this variable by applying a cash flow for the expected life of the building and to assume that it reverts to land value.

Working on the assumption that the current value is an efficient indicator of the present value of future receipts, our suggested approach is to use the market pricing signal of current land values as a

surrogate for the present value of the right to receive the future land value. Intuitively this seems reasonable since the investor owns the land as well as the income stream from the data centre facility.

The key issue is whether the current land value is an efficient signal of the current value of the future revenues from the land including future optionality. More theoretically, it implies that the target rate of return and the nominal growth rate for the (right to receive) future land values are the same. As it is not possible to identify any risk premia for future land values, current market trading prices seem to provide the best available proxy⁷.

Liabilities and expenditure

A distinctive feature of data centre facilities is the high proportion of running costs and capital expenditure relative to conventional assets. The area of liability appraisal is widely analysed in the insurance and pension sectors. In the literature there is a consensus on basic principles for estimating the market or fair value of a liability (see, for example Babbel and Merrill, 1998; Reitano, 1997) Essentially the value of a liability should reflect the amount that the liability holder would need to be pay a third party to assume the liability. In the pensions context, it is referred to as a cash equivalent transfer value. As on the asset side, a commonly recommended technique is to estimate the expected cash flows of liabilities and apply an appropriate discount rate. The key problems in terms of application are estimating both the expected cash flows and the discount rate.

Similar to the asset side, the proposed solution is to identify, where possible, similar traded assets that provide a hedge against the future liability. Consequently, the identifiable value of the hedging asset should equal the value of the liability. Practical problems in implementing this type of approach include the non-existence, or thin trading, of comparable cash flows. This is especially the case where there are embedded options in the liabilities. For instance, issuers of mortgage backed securities may include prepayment options in their bonds.

⁷ Changes in land values can vary dramatically between sectors and regions. Between 1983 and 2005, according to Valuation Office data, industrial land values, industrial land values in the South-East increased by approximately⁷ 4% per annum in nominal terms. Over the same period, residential land values increased by approximately 12% per annum for the same region.

Table 2: An Alternative Appraisal Approach

Item	Method	Approach	Information needs and key assumptions
Site	Comparison	Analyse and apply comparable land sales to subject site.	<ul style="list-style-type: none"> • Transactions involving comparable land sales
Life cycle revenues	Discounted cash flow	<p>Project expected cash flows and discount at corporate bond yields of tenants.</p> <p>Adjust cash flow for effects of voids.</p>	<ul style="list-style-type: none"> • Corporate bond yields • Inflation and rental value growth • Depreciation • Incidence and length of voids • Rollover rates • Lease structures of new lettings
Life cycle liabilities	<p>Discounted cash flow</p> <p>Capitalisation</p>	<p>Identify discount rates applied to similar cash flows.</p> <p>Identify capitalisation rates for comparable cash flows and apply to expected liabilities e.g. fixed interest securities, index-linked securities, zero-coupon bonds.</p>	<ul style="list-style-type: none"> • Current running costs. • Long-term fixed running and operating costs. • Long-term variable running and operating costs. • Timing and amount of major capital expenditures. • Appropriate discount and capitalisation rates.

The appraisal of embedded options in thinly traded assets tends to introduce higher levels of analytic complexity requiring data and market behaviour that does not exist. In practice, it is often not possible to find instruments that replicate the actual liabilities. There can be differences in liquidity, certainty of timing and certainty of income/outgoings between the different cash flows. However, these approaches are unavoidably a compromise between some subjective market judgement and objective market data. It would be a mistake to reject the good for (unattainable) perfection.

Data centre facility operators will incur a diverse range of costs, which were classified into four categories above.

- **Current and long term fixed running and operating costs** are likely to increase at a nominal rate related to consumer price inflation. Due to their low volatility and relative

certainty, they will command relatively low discount rates. Thus, they can be valued at fixed interest or an index-linked bond or a blend of the two.

- **Long term variable running and operating costs** are dependently variable on the level of operations within the facility, i.e. occupancy rates. Elements of this tranche may have either a positive or a negative correlation with occupancy rates and, since they are matched by the rental income streams, it would be appropriate to use the same rate discount rate.
- **Major capital expenditures** to upgrade buildings and infrastructure tend to be uncertain both in terms of quantity and timing. In many ways they are similar to a zero coupon index-linked callable bonds. This is a bond which generates a single (CPI indexed) capital repayment at a fixed future date which the issuer can redeem prior to the expiry date. As such bonds are not available, probably the most practical approach to the appraisal of future major capital expenditures is to estimate their likely timing and cost and identify the value or yield of a (simple) zero-coupon bond that will guarantee this capital sum.

Conclusion

Data centres have a unique blend of locational, physical and technological characteristics that differentiate them from conventional real estate assets. In terms of construction, they have specific structural requirements making them specialized assets. Compared to conventional assets, there is considerable expenditure on mechanical and engineering services. Several secure sources of electricity supplies are crucial to provide reliable cooling and power. Locational requirements are specific and driven by availability of connectivity and diverse sources of power supplies. As a result, the operation, maintenance and management of the assets requires specialist staffing and high levels of current and capital expenditure compared to conventional real estate assets.

Given its recent emergence, the market is immature and characterised by limited trading and poor information flows, which lead to a lack of market pricing signals. This enhances the levels of appraisal uncertainty and disagreement relative to conventional real estate assets. For income producing assets in thinly traded markets (such as data centres), appraisers tend to use discounted cash flow methods due to the absence of comparables. However, the application of conventional

discounted cash flow approaches to the appraisal of data centres requires information about a wide range of inputs that is difficult to derive from market signals or estimate analytically. In practice, discounted cash flow appraisals of data centre facilities are forced to incorporate non-market assumptions that are inevitably subjective. Due to the complex mix of incomes and expenditures that are involved in owning and operating a data centres facility, identifying a risk premium is particularly problematic.

Cash flows from data centres tend to be more complicated because of the high levels of current and capital expenditure compared to conventional assets. This requires an understanding of the appraisal of liabilities as well as income. Further, the different balance between building structure and infrastructure suggests that capital allowances also be important. Given the problems of applying conventional discounted cash flow, an approach to appraisal is proposed that uses pricing signals from traded cash flows that are similar to the cash flows generated from data centres. Based upon 'the law of one price', it is assumed that two assets that are expected to generate identical cash flows in the future must have the same value now. It is suggested that the expected cash flow of assets should be analysed over the life cycle of the building. Corporate bond yields are used to provide a proxy for the appropriate discount rates for lease income. Since liabilities are quite diverse, a number of proxies are suggested as discount and capitalisation rates including indexed-linked, fixed interest and zero-coupon bonds. However, there are rarely assets that have identical cash flows and some approximation is necessary.

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