WHQA market definition and analysis in Ireland

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Final Report

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Introduction

The 2014 EC Recommendation defines Market 4 as Wholesale High Quality Access ('WHQA') provided at a fixed location. This market includes the wholesale terminating segments of the leased line market (as set out in the 2007 European Commission Recommendation).

ComReg, in accordance with its regulatory framework, is undertaking a review of the WHQA market to determine which products/services belong in the market, and has asked Oxera to assist in defining the WHQA market, to analyse if any one operator has significant market power (SMP) in the relevant market, and to advise on regulatory remedies, as and if required. This analysis is based on a review of the available market evidence collected by ComReg from various stakeholders.

Leased lines are high-quality permanent connections used by businesses and other authorised operators (OAOs) to deliver dedicated transmission capacity between fixed locations, often with symmetric upload and download speeds. Dedicated capacity means that the service is not impeded by the activity of other users. Leased lines serve many different purposes and there is a large range of bandwidth available (around 64kbps to 10Gbps).

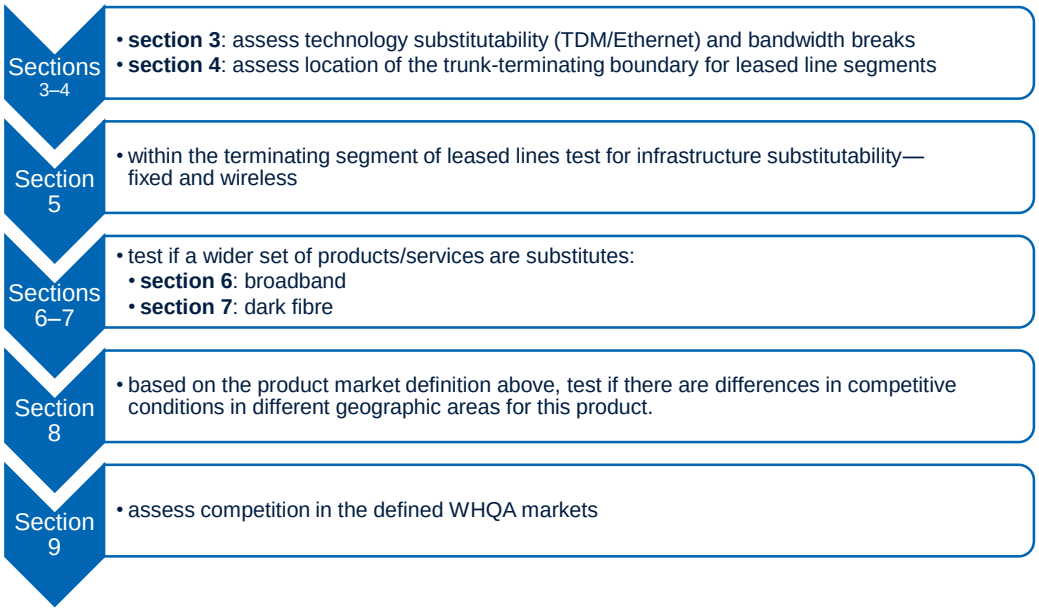
As recommended by the European Commission, the retail market for terminating segments (of leased lines) is not regulated in Ireland at present. Nonetheless, the interaction between retail and wholesale markets is taken into account because the demand for wholesale products is derived from associated retail services. Hence, although the main focus of this review is competition in the provision of wholesale leased line terminating segments in Ireland (which is included in the European Commission's WHQA market), the wholesale leased lines market definition is informed by the retail market.

Following this, various retail market developments are considered when analysing the wholesale market, and the interaction between retail and wholesale markets is taken into account in the framework of analysis. Oxera uses both wholesale and retail market evidence (as available) to determine which products/services belong in the WHQA market in Ireland. This includes evidence on:

- **demand-side substitutability such as**: technical/qualitative assessment of service characteristics, relative pricing, and evidence from a retail business survey commission by ComReg on switching and differences in end-user applications and service perceptions;
- **supply-side substitutability such as**: the extent to which existing products/services can be reconfigured, the requirement and availability of upstream or other inputs to provide services (and hence additional investment that may be required), and migration and market share differences (e.g. between TDM- and Ethernet-based technologies);
- **other evidence, as relevant**: For example, market structure and trends in volumes (used to define the product market), service availability and contestability (used to consider whether wireless services should be included in the market), supply chain relationships (used to consider whether dark fibre should be included in the market), and OAO network presence (to consider differences across geographic areas).

Based on the available evidence, Oxera first defines the product market, and then assesses geographic market definition for this product. Our analysis in this draft is structured as shown below.

Overview of analysis



Oxera notes that the ultimate purpose of the relevant product (and geographic) market assessment is to identify whether the WHQA market in Ireland is characterised by effective competition or should be subject to ex ante regulation. The market definition sets the boundaries within which to analyse such competitive dynamics. Thus, market definition is a useful tool and not an end in itself. Identifying the product/geographic market also involves an element of judgement, particularly given that the analysis is conducted on a forward-looking basis.

Our approach also follows the 'modified greenfield approach'. In the WHQA market review, this requires national regulatory authorities (NRAs) to assume that there are no ex ante SMP remedies in the leased line markets, but that ex ante remedies in other markets continue to apply.

Oxera's recommended WHQA market definition proposes some changes to the current market definition. These changes are motivated by market developments in the leased lines and related markets in Ireland since the last leased lines market review by ComReg in 2008, and based on analysis of data and information collected by ComReg.

Market developments motivating changes in the current definition

Oxera's proposed changes to the existing market definition are based on a consideration of several market developments since the last market review in 2008. These developments are discussed throughout the draft and include:

- migration from legacy TDM (time division multiplexing) based circuits to Ethernet and xWDM-based leased lines, and the increasing demand for higher-speed circuits;
- OAOs are now less reliant on eircom for network coverage. Evidence for this includes the increasing use of partial private circuits (PPCs) instead of

wholesale leased lines, expanding OAO network coverage, and a substantial increase in OAO market share for Ethernet-based leased lines;

- an increase in the availability and use of wireless leased lines in Ireland, helped by technological developments and complimentary access to OAO fibre networks such as enet and rail infrastructure, has also resulted in more competition and options for both retail and wholesale users.

Data and information used in the analysis

Oxera's analysis is based on data and information collected by ComReg as part of the WHQA market review. The data collected includes: leased lines (including wireless) circuit volumes and revenue data; OAO and eircom network information; pricing data; survey data (retail business survey and operator responses to qualitative survey); and business location data. Due to different commercial and circuit recording practices between the respondents, the raw data is not necessarily comparable. Details of these features and the way in which ComReg has adjusted for them are discussed in detail in Appendix A5.

Furthermore, as discussed in section 2.4, this data is limited in the availability of certain features and variables. While this limits the ability to undertake some types of analysis, Oxera has used alternative analyses based on the data available to draw robust conclusions.

Based on these market developments and analysis of the evidence available, Oxera proposes the following WHQA product and geographic market definitions for the Irish market.

1. A national wholesale Traditional Interface (TI) market

As discussed in section 3, the focus of any regulation, if required should be on analogue and digital TDM circuits with speeds up to and including 2Mbps. These low-speed circuits cover 98% of TDM circuits (see section 3.1.5 and Table 2.2). TDM circuit volumes with speeds over 2Mbps are very low and declining (Eir sold ✂[ ] new high-speed TDM line in 2015, and there were ✂[ ] fewer lines in operation in 2014 compared with 2013). Hence, the costs of imposing regulation on suppliers of 'high'-speed TDM circuits are unlikely to outweigh the benefits of imposing regulation.

Following this we propose that the national wholesale terminating TI market should be regulated. We define this market to include all analogue and digital TDM circuits (with speeds up to and including 2Mbps) and include the entire circuit i.e. the end-to-end link in this definition. This is because as discussed in section 9 we find that the competitive conditions for different TI circuit segments are similar, and that eircom has significant market power in the end-to-end circuit which includes links from an end-user premises to the nearest serving PPC interconnection exchange, and links that extend between PPC interconnect points.

This TI terminating market definition is similar to the current terminating market definition which defines the entire length of all low-speed (<155Mbps) circuits as terminating segments. Though we note that when ComReg proposed this definition in 2007, Ethernet circuits were generally not supplied in the market. The migration from legacy TDM (time division multiplexing)-based circuits to Ethernet and xWDM-based leased lines since 2008 has been one of the main market developments as discussed in this paper.

2. A national wholesale Modern Interface (MI) market

This includes all Ethernet-based services including EFM (Ethernet in First Mile], WDM and Ethernet wireless leased lines. Terminating segments are defined as links from an end-user premises that remains within a next generation network (NGN) aggregation area, as defined by eircom's hierarchy. Trunk segments are defined as links that pass between NGN areas.

As noted in section 3.4.4 the majority of MI circuits (for example 94% of on-net circuits, see Table 2.3) currently in use are above 2Mbps and the current stock of sub 10Mbps Ethernet circuits are legacy connections that are declining in number, and expected to fall into disuse as end-users demand higher-bandwidth lines. In this case, again, the costs of imposing regulation on suppliers of low-speed Ethernet circuits are likely to outweigh any benefits of imposing regulation. Hence, the he focus of regulation, if required, should be on high-speed MI circuits (above 2Mbps).

We note that the market analysis in section 9 suggests that eircom does not have SMP in the MI market.

Next, we discuss each aspect of the WHQA market definition as presented above.

Technology (TDM/Ethernet) and bandwidth segmentation (section 3)

A number of factors suggest that TDM and Ethernet services are not always substitutable (see section 3.1.6). Some end-users are likely to be captive TDM users given switching costs and their particular service requirements, which may not require the higher bandwidths offered by Ethernet services. OAOs are unlikely to expand capacity and supply the declining market for TDM circuits in response to an increase in TDM service prices, as demonstrated by ✂[redacted]. Functional analysis also appears to support differences between TDM and Ethernet, with few TDM circuits being used for data centre, platform or cloud use and few Ethernet circuits being used for infrastructure control or monitoring.

Supply-side evidence also suggests that TDM and Ethernet are serving different parts of the bandwidth spectrum, and that conditions of supply within these parts differ, with eircom having a relatively higher market share in TDM compared with Ethernet. Moreover, given the general migration to Ethernet services in the market, OAOs are unlikely to expand capacity to supply a declining TDM market. Evidence for this includes the relatively higher OAO market shares and relatively lower reliance of OAOs on eircom inputs in the Ethernet market.

As discussed earlier, TDM bandwidths above 2Mbps are available, although volumes have declined such that only a ✂[redacted] such products have been sold by eircom since the last review. It is most likely that demand for these speeds is now met by Ethernet products. Similarly, there remain a low number of Ethernet circuits below 2Mbps, which typically relate to legacy Ethernet products.

Considered together, the evidence supports separate market definitions for TDM and Ethernet products as described below. This is also consistent with and supported by our analysis of the trunk terminating boundary for Ethernet and TDM circuits in section 4 and the market assessment in section 9. This shows that differences between the TDM and Ethernet networks in Ireland mean that separate trunk-terminating boundary definitions are appropriate for TDM and Ethernet circuits.

Technology segmentation (wireless) (section 5)

Functional analysis and case-study evidence presented in section 5 show a strong overlap between wireless and fixed leased lines solutions. While there may be technical differences, such as line-of-sight requirements, these do not appear to play a limiting factor in wireless deployment for leased line services in Ireland. A significant portion of bandwidth demand up to circa 400Mbps can be served by wireless, on a national basis. The assessment of end-users also does not find clear differences between fixed and wireless end-users, relative to Ethernet services. Marketing material and evidence from HEAnet (see section 5.3) suggesting pricing parity (or advantage) also indicates that fixed and wireless leased lines are demand-side substitutes.

We find that, while some wireless links could be better suited in some areas (and could be complementary in some cases) of Ireland, wireless leased lines are a good demand-side substitute for fixed leased lines. Given the way the wireless market has developed in Ireland, with significant take-up, and that wireless leased lines are currently included in the market, Oxera proposes that wireless leases lines should be included in the MI market. This is because the majority of wireless leased lines supplied are over 2Mbps, and the majority of wireless leased lines use the Ethernet interface in Ireland. (✂[ ] supplied about ✂[ ] (≤2Mbps) wholesale lines in 2014, all of which are Ethernet).

Broadband substitution (section 6)

The available evidence suggests that broadband services are not part of the WHQA market, for the following reasons:

- a product gap remains between NGA broadband and leased lines, which relates to attributes that are important to leased line users, such as symmetry, service availability, resilience and low latency/jitter;
- NGA-based broadband is generally not marketed as an alternative to leased lines;
- a considerable price differential exists between NGA broadband and leased lines. Despite this, there is limited consumer switching from leased lines to broadband.

With regard to eircom's proposed Virtual Ethernet Access (VEA) service, while this product offers higher service-level specifications than Virtual Unbundled Access (VUA), it is still not equivalent to leased line-based services, as discussed in section 6.1. Ethernet in the First Mile is likely to be considered by consumers as a close substitute for leased lines, and should be included in the MI market, as discussed in section 6.3.

Dark fibre substitution (section 7)

The demand- and supply-side analysis shows that there are barriers to switching from dark fibre to active products and vice versa. Dark fibre volumes are also relatively low, which may suggest that it has limited appeal for most users, relative to active products. This evidence suggests that dark fibre should not be included in the WHQA market—i.e. either the TI or MI markets as defined previously.

Geographic market definition (section 8)

Geographic variations in competitive conditions—MI

The available evidence indicates that there are some variations in competition by region. However, there is insufficient evidence to indicate that conditions of competition are sufficiently heterogeneous within well-defined and stable geographic areas that it would be appropriate to define separate geographic markets for MI services.

Business parks and data centres contain a significantly higher density of demand than other locations. The practice of making some of these locations 'carrier-neutral' may also mean that the supply of leased lines to these locations is more competitive compared with other areas.

However, for retail MI services, there appear to be few differences in market share measures within and outside business parks and data centres. Concentration measures are comparable, and the main difference appears to be that eircom has a somewhat higher share in the absence of regulation.

For wholesale MI services, there are some differences in eircom market shares within and outside business parks, and, generally, eircom has a higher market share outside business parks. These differences in eircom's wholesale market shares within and outside business parks and data centres may suggest that there are some differences in OAO competitive supply in these areas. However, eircom's wholesale market share may not be an accurate measure of OAO competitive supply. This is because the majority OAOs do not depend on eircom's wholesale inputs to supply Ethernet circuits, as discussed in section 8.4.

This analysis suggests that competitive conditions in these business parks and data centres is not sufficiently different to define separate geographic markets.

Moreover, it is possible that a geographic boundary definition based on business park/data centre does not accurately capture differences in supply conditions – for example, it is possible that other areas outside business parks and data centres have similar conditions of supply as business parks (e.g. business districts within urban centres) that are not explicitly captured and combined in the business park/data centre group. Furthermore, a boundary based on the location of a business park may lack delineation from nearby areas, if, for example, areas adjacent to a business park experience similar conditions of supply.

Evidence on wireless coverage also does not allow further precision to be made in geographic markets definition.

Geographic variations in competitive conditions—TI

The supply of TI services to business parks and carrier-neutral data centres could be competitive if these sites contain a greater density of end-users.

However, unlike MI services, low-speed TI supply is more concentrated, with eircom and BT supplying most services. It is not clear that high-demand business parks are concentrated sources of TI-specific demand. Low-speed TI services are not suited to centralised connections for cloud computing, high-volume data processing or storage. While it is possible that low-speed TI is required at some of these locations, it is not clear that OAOs are competing to provide these services. For this reason, it is unlikely that there is competitive supply of TI services to these sites.

In addition, on-net and off-net market shares in section 8.4 show that, overall, OAOs are reliant on eircom for wholesale inputs to supply TI services, unlike MI services. As discussed in section 2.2, recent trends show a migration away from

TI, while new networks have been developed to serve mainly Ethernet-based MI services. This further suggests that there are no differences in the competitive supply of TI services within and outside business parks.

Legacy networks also tend to be tied to eircom local exchanges, which are ubiquitous. Applications that are geographically distributed, such as traffic control and infrastructure monitoring (as discussed in section 3), may mean that TDM networks are also more dispersed, and thus more difficult for OAOs to replicate on a national basis.

Conclusion

One of the main drivers of competition in terminating segments of leased lines is the presence of OAO infrastructure at a local level. All else equal, greater OAO presence in a particular area is likely to be associated with lower prices, lower switching costs and more choice for retail and wholesale customers. There are some observable differences in competitive supply in business parks and carrier-neutral data centres relative to areas outside these locations. However, the analysis does not identify clear and stable geographic boundaries more generally.

The available evidence suggests that national market definition is appropriate for both the MI and TI services.

Market analysis and assessment (section 9)

Based on the available market data, where possible, Oxera considers the following factors when assessing market power:

- alternative infrastructure: Alternative infrastructure (other than eircom's) to deliver WHQA services, when present, is an important driver of competition in WHQA markets;
- market shares: Operator market shares in the TI and MI markets (including circuits provided on-net) are an important measure of market power;
- other factors: We also discuss entry barriers, prospects for competition, ability to leverage economies of scale and scope, and countervailing buyer power in the market power assessment.

Market assessment for national wholesale TI services—eircom has SMP in terminating segments defined to include the entire end-to-end circuit

The Irish market has limited rival infrastructure directed at TI services. Potential competition is limited, with high barriers to entry, largely predicated on eircom's ubiquitous copper network and a backdrop of declining volumes.

In general, trunk networks face different conditions of competitive supply, as higher densities of traffic along certain routes make it easier for OAOs to overcome barriers to entry such as scale economies. In principle, these aggregation opportunities could also apply to TI services in Ireland.

However, any separate notional market for TI trunk lines is still unlikely to be competitive. This is because eircom has a ubiquitous copper network, which it can use to supply TDM services, and it is not commercially viable for OAOs to transmit TI circuits over Ethernet networks given the costs involved in doing so and the fact that the TI market is a declining market with users increasingly migrating to Ethernet-based services.

The barriers to entry in the TI market are also reflected by the fact that there is only one alternative wholesale operator to eircom, BT, active in the wholesale market. And even BT is expected to transfer around ✂[ ] of its 2Mbps circuits to Ethernet in the near future.

Hence, there are high barriers to entry in the TI market, and, given, the declining nature of the market, it is unlikely that the market will tend towards competition in the near future. eircom currently has a near monopoly position in this market, and ✂[ ]. Anti-competitive actions by eircom are unlikely to be remedied through ex post competition law in this context. Hence the TI terminating market (defined to include the entire end-to-end circuit) meets the European Commission's three criteria, and should be regulated in Ireland.

The available evidence on market shares also suggests that eircom has a high and persistent market shares in wholesale terminating TI services, and one that meets standard criteria for designating SMP.

Market assessment for national wholesale MI services—eircom does not have SMP

The wholesale MI market is characterised by the following.

- low eircom retail and wholesale market shares, which have been declining in recent years. The market volume and market share data shows that:
  - OAOs supply a large share (above ✂[ ]%) of both the wholesale and retail markets, regardless of how these are measured;
  - reliance on eircom for MI off-net tails is low (see Table 8.3 and Table 8.4, and the discussion in section 8.4). We note that this MI operator data is supplied on a national basis and, therefore, this data suggests that OAOs also supply the trunk segments using on-net inputs not dependent on eircom.
  - retail MI providers such as BT, VM, Colt and Airspeed also have a significant presence (✂[ ]% volumes) in the wholesale market, with the vast majority of their retail supply being on-net.
- Considerable presence of rival infrastructure.
  - As mentioned above, evidence from on-net/off-net ratios suggests that OAOs can deliver circuits using their own infrastructure. Where OAOs do not have infrastructure, they appear to have a limited reliance on eircom.
  - In addition, as discussed in section 5, in Ireland, wireless leased lines are a good demand-side substitute for fixed leased lines. This is reflected in the development of the wireless market, which has seen a significant take-up of these services.
  - Enet's position in the wholesale market is significant, and it is an important provider of alternative infrastructure in Ireland. Enet operates metropolitan area networks in 94 towns and cities on behalf of the Irish state. Its wholesale operation is open-access, meaning that all licensed operators can access the infrastructure. Once an OAO has connected to an enet metropolitan area network, it is able to serve customers throughout this local footprint.

- At the same time, prospects for competition are relatively favourable in the Irish context.
    - There are limited barriers to entry, as demonstrated by the presence of multiple operators that offer WHQA services via their own physical infrastructure.
    - Migration of services to Ethernet is underway, and Ethernet volumes exhibit double-digit year-on-year growth in volumes. Downstream drivers of demand are likely to increase with further developments, such as the National Broadband Plan extending broadband coverage as well as mobile network expansions, infill or upgrades. OAOs could use further investments to deliver these MI services.
    - The SIRO joint venture between ESB and Vodafone will bring fibre-to-the-home connectivity to areas mainly outside Dublin within the period of the market review. To the extent that this infrastructure could be used to deliver high-quality symmetrical services consistent with the MI market definition, this is likely to boost competition.

These various factors, and the market share evidence (which shows low eircom market shares), suggest that eircom (or any other individual operator) is unlikely to have SMP in the MI market—in either the terminating or trunk segments, however defined.

1 Introduction

1.1 Background

The 2014 European Commission Recommendation defines Market 4 as wholesale high-quality access ('WHQA') provided at a fixed location.[1] This market includes the wholesale terminating segments of the leased line market (as set out in the 2007 European Commission Recommendation).[2]

Leased lines are high-quality permanent connections used by businesses and other authorised operators (OAOs) to deliver dedicated transmission capacity between fixed locations, often with symmetric upload and download speeds. Dedicated capacity means that the service is not impeded by the activity of other users. Leased lines serve many different purposes and there is a large range of bandwidth available (around 64kbps to 10Gbps).

The 2014 Recommendation also notes that most EU member states have defined terminating segments of leased lines as the part between end-users' premises and the closest exchange of the service provider. A clear distinction between the terminating and trunk segment (the part of the leased line not included in the terminating segment) is important, as the market for wholesale trunk segments was removed from the list of markets susceptible to ex ante regulation in the 2007 Recommendation (and this continues to be the case in the 2014 Recommendation). However we note that several NRAs in the EU have chosen to regulate at least some trunk circuits. Two examples are France and Portugal, where ICP-Anacom and Arcep, respectively, found trunk segments connecting the mainland with island territories uncompetitive and therefore subject to regulation.

In accordance with its regulatory framework, the Commission for Communications Regulation (ComReg) is undertaking a review of the WHQA market to determine which products/services belong in the market, and has asked Oxera to assist in defining the WHQA market; analyse if any one operator has significant market power (SMP) in the relevant market; and advise on regulatory remedies as and if required. Our analysis is based on a review of the available market evidence collected by ComReg from various stakeholders.

1.2 Structure of report

The remainder of the report is structured as follows:

- section 2 presents an introduction to leased line services in Ireland; market developments since ComReg's previous leased lines market review; an overview of Oxera's methodology to define the WHQA market in Ireland; and the data available to undertake the analysis;
- section 3 assesses whether the terminating leased line market should be segmented by interface technology, and whether sub-markets at different bandwidths exist;

[1] European Commission (2014), 'COMMISSION RECOMMENDATION of 9 October 2014 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services', Recommendation, 9 October.
[2] European Commission (2007), 'COMMISSION RECOMMENDATION of 17 December 2007 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services', Recommendation, 17 December.

- section 4 defines the trunk and terminating segments for Ethernet and TDM circuits;
- section 5 considers whether wireless leased lines are in the same market as terminating segments of fixed leased lines;
- section 6 reviews the use of broadband products and assesses whether these are substitutes for terminating segments of leased lines;
- section 7 discusses the position of dark fibre and whether it falls into the same market as active products;
- section 8 defines the relevant geographic markets;
- section 9 assesses whether any single operator has market power in the WHQA markets defined in sections 3–8.

Appendices A1 to A4 provide supporting evidence, and Appendix A5 provides a summary description of data collected for the leased lines consultation.

2 Background, methodology, and data overview

The section is structured as follows:

- section 2.1 describes typical (wholesale and retail) leased line services, which are the main focus of this market review, and lists the main wholesale and retail service providers in Ireland;
- section 2.2 presents the key market developments and trends since the previous leased lines market review by ComReg in Ireland;
- section 2.3 provides an overview of the methodology followed to define the WHQA market. This includes a discussion on the interaction between retail and wholesale markets as well as the importance of indirect constraints and self-supply. We note that indirect constraints and self-supply may influence market definition and/or the analysis of market power;
- section 2.4 provides an overview of the types of data used to inform Oxera's analysis. Appendix A5 contains a detailed discussion of these datasets.

2.1 The leased lines market in Ireland

Leased lines can be provided using:

- legacy platforms, including time-division-multiplexing (TDM)-based technology (or interface), which includes both synchronous digital hierarchy (SDH) and plesiochronous digital hierarchy (PDH) services,[3] and can be provided over fibre, copper or wireless infrastructures. These legacy services may also include low-bandwidth analogue and digital lines—i.e. circuits that provide 2Mbps or lower speed connectivity;
- Ethernet-based technologies, which include access over fibre, copper or wireless, and services provided over multi-protocol label switched (MPLS) and internet protocol (IP) routed core networks;
- xWDM and other equivalent high-bandwidth fibre-based technologies.[4]

Although these services may be point-to-point or point-to-multipoint, we understand that, in Ireland:

- the majority of leased lines (either Ethernet or TDM) are used to connect each customer premises to a data platform or service (MPLS, Internet access, etc.);
- TDM- and Ethernet-based networks are used to provide broadly similar services (an issue we consider in section 3);
- in many cases, leased lines form part of a wider package of (retail) business data services (especially for Ethernet leased lines). For example, these circuits may be purchased in a bundled contract containing voice services, Internet connectivity, and cloud computing services. Thus, leased lines access is just one element of the bundled sales price.

The leased lines market consists of a retail market that provides services or facilities directly to end-users, and a wholesale market that provides upstream

[3] 'Plesiochronous' networks are TDM networks that preceded SDH, where individual elements are not quite synchronised with each other.
[4] CWDM and DWDM (coarse and dense wavelength division multiplexing) multiple wavelengths (typically 2.5Gb/s) are carried on a single fibre.

access to facilities or networks to operators so that they can compete to provide services to end-users.[5] In the next section, we discuss these two related markets and the main operators offering retail and wholesale services in Ireland.

2.1.1 Retail market

The retail leased lines market supplies bespoke connectivity requirements for large businesses and institutional users as well as supplying services to firms with specialised data requirements. ComReg asked a sample of business users[6] to report the applications they use leased lines for; the most favoured options were:

- email and Internet;
- data services such as cloud computing and other software services;
- connectivity between business premises;
- employee remote access to the business network;
- disaster recovery services;
- voice—VoIP\voice over broadband;
- card machines.

Other typical leased line applications include industrial plant control, traffic monitoring and control, rail signalling, CCTV backhaul, scientific research, medical imaging, television multiplex connectivity, disaster recovery and transaction processing.

These retail leased lines can be provided as either point-to-point or point-to-multipoint configurations. As mentioned above, we understand that the majority of leased lines (Ethernet or TDM) provided in Ireland are point-to-multipoint.

- Point-to-point circuits are usually described as having an A-end and a B-end. From a retail perspective, the A- and B-end locations could be two separate offices that a customer wishes to connect.
- Point-to-multipoint configurations are slightly different, as a common solution is to provide any-to-any connectivity between sites with a virtual private network (VPN) solution. This means that a leased line that acts as an input to this service has only a single end, compared with a 'double-end' in the point-to-point example above.

Table 2.1 below lists Irish operators active in the retail leased lines market in Ireland. These operators provide services using:

- **on-net infrastructure**. On-net means that the access portion of the leased line is delivered entirely and exclusively based on the OAO's own local access infrastructure (e.g. OAO fixed wire or wireless media to connect the customer premises) or the OAO's use of upstream physical infrastructure

[5] See European Commission (2014), 'Explanatory note Accompanying the document Commission Recommendation on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services', staff working document, 9 October, section 2.
[6] ComReg business user survey.

inputs such as dark fibre or local loop unbundling (LLU) connected between an OAO's active equipment;

and/or

- **off-net infrastructure**. This is where OAOs buy wholesale access to a leased line provided by another operator to connect between the customer premises and the OAO network. OAOs can rent wholesale leased lines from both eircom and each other.

Table 2.1 Leased line operators in the Irish market

Operator	Technology (on-net)	Infrastructure (on-net)	Wholesale
Airspeed	Ethernet	Wireless	Yes
AT&T	n/a	Fixed	No
BT	Ethernet and xWDM/TDM	Fixed	Yes
Colt	Ethernet and xWDM/TDM	Fixed	Yes
Digiweb	Ethernet and xWDM	Fixed and wireless	Yes
eircom	Ethernet and xWDM/TDM	Fixed	Yes
enet	Ethernet and xWDM	Fixed	Yes
EU Networks	Ethernet	Fixed	Yes
Fullnet/Strencom	n/a	None (reseller only)	No
Magnet	Ethernet and xWDM	Fixed	Yes
Three	Ethernet	Wireless	Yes
VM	Ethernet and xWDM/TDM	Fixed	Yes
Verizon	Ethernet and xWDM/TDM	Fixed	Yes
Vodafone	Ethernet and xWDM/TDM	Fixed and wireless	Yes

Source: Oxera analysis of operator circuit volumes.

As can be seen from Table 2.1, many (but not all) operators active in the retail market in Ireland are also active in the wholesale market. In addition, there are two wholesale-only operators in Ireland—Aurora Telecoms and ESB Telecoms. Both provide dark fibre access. We discuss the wholesale market next.

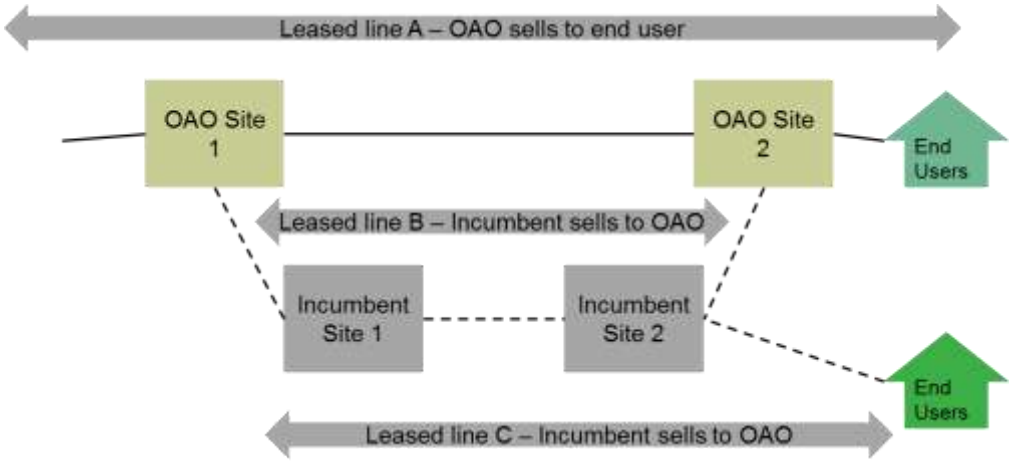
Enet's position in the wholesale market is significant. It operates metropolitan area networks in 94 towns and cities on behalf of the Irish government. Its wholesale operation is open access, meaning that all licensed operators can access the infrastructure. Once an OAO has connected to an enet metropolitan area network, it is able to serve customers throughout this local footprint.

2.1.2 Wholesale market

Wholesale leased lines are mainly used by OAOs and mobile network operators (MNOs). OAOs may purchase a circuit from A to B to serve a retail customer with connectivity requirements at those locations. They may also use wholesale leased lines (partial private circuits) to build and extend their own networks, for example to provide backhaul. In this case, the A-end typically refers to the end-user location, while the B-end location refers to the point of interconnect of the supplier.[7] Figure 2.1 illustrates OAOs' typical use of leased lines.

[7] In the case of international leased lines, a 'B-end circuit' refers to the situation where the commercial relationship with the customer is held in a foreign territory, and the service is paid for outside of Ireland. This could occur if, for example, Verizon's US arm sells a leased line to Microsoft (US), for connectivity to a branch office in Dublin.

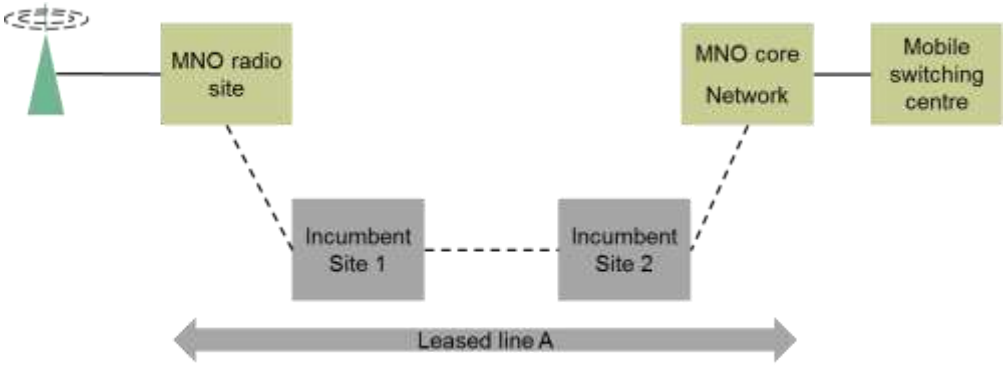
Figure 2.1 Typical fixed OAO uses of leased lines



Source: Oxera.

Mobile networks typically use leased lines to convey traffic from a dispersed set of radio access nodes to a centralised location where calls and data can be routed to their destination. Leased lines provide a high-quality connection in terms of availability and other essential characteristics for call and data routing such as the ability to synchronise timing across base stations and low jitter. Figure 2.2 illustrates MNOs' typical use of leased lines.

Figure 2.2 Typical MNO use of leased lines



Source: Oxera.

2.2 Market developments since the previous review

Since ComReg's last market review in 2008, we have observed several trends in the leased lines market in Ireland, as follows.

- Migration from legacy to Ethernet. In 2013, there were about 5,026 wholesale TDM circuits and 4,178 wholesale Ethernet circuits; in 2014, there were 4,022 TDM and 4,939 Ethernet circuits; and in 2015, there were 2,225 TDM and 6,356 Ethernet circuits.[8] This compares with about 9,000 TDM circuits and about 30 Ethernet circuits in 2008.
- Increasing demand for higher-speed circuits. Demand for low-speed circuits has fallen, while the volume of higher-speed circuits is increasing,

[8] This is based on a circuit count using method 2 (see Appendix A5.1), and includes both on-net and off-net, circuits.

particularly for Ethernet circuits. We note that most TDM lines are low-speed (below 2Mbps), but almost all Ethernet lines are above 2Mbps.

- OAOs are now less reliant on eircom for network coverage. Evidence for this includes the increasing use of partial private circuits (PPCs) instead of wholesale leased lines, expanding OAO network coverage, and a substantial increase in OAO market share for Ethernet-based leased lines (see Table 3.4 and Table 3.5).
    - The increasing use of PPCs rather than wholesale leased line inputs shows expanding OAO network coverage. This is because PPCs require increased OAO interconnection with eircom, which means that OAOs need to self-supply (using their own infrastructure) parts of the leased line circuit.[9] Circuit inventory data collected by ComReg shows that, since 2008, OAOs have been migrating from wholesale leased lines to PPCs.[10] As of 2014, eircom had around ✂[ ] live wholesale leased line circuits, compared with more than ✂[ ]PPCs, excluding international, analogue and high-bandwidth circuits. This compares with a split of approximately 60% PPCs, 40% wholesale leased lines in January 2008,[11] a period when eircom had approximately 95% share of a wholesale TDM market of around 9000 circuits.[12]
    - OAOs have expanded their network footprints (as per the supplied mapping files—Appendix A1.1 presents detailed analysis of the growth in OAO footprints).
- Finally, we note an increase in the availability and use of wireless leased lines in Ireland. This has been helped by technological developments and complimentary access to OAO fibre networks such as enet and rail infrastructures. The increased availability of wireless has also resulted in more competition and options for both retail and wholesale users.

Table 2.2 and Table 2.3 below present data on retail leased line circuit volumes between 2013 and 2015, separated by bandwidth and technology. We observe that:

- compared with 2013, the total number of TDM circuits fell in 2014 and then again in 2015, while Ethernet volumes have risen;
- there is increasing demand for higher bandwidth circuits. For example eircom introduced 1Gpbs and 10Gpbs Ethernet products in January 2016.[13] ✂[ ] has also noted the demand for higher-bandwidth circuits, with the possible demand for 100Gbps circuits in the future.[14]

[9] Wholesale leased lines are equivalent to reselling eircom's leased line product and do not require specific OAO presence at either end of a circuit, and connect directly to the end-user A-end and B-end locations. A partial private circuit requires the OAO to interconnect at one end of the eircom service.
[10] See ComReg (2015), 'Terminating Segment Remedies', internal note, 15 May.
[11] ComReg (2010), 'Further specification of the price control obligation, the transparency obligation and the access obligation in relation to the market for wholesale terminating segment of leased lines', ComReg document 10/70, 10 September, figure 15.
[12] ✂[ ] Operator data provided by ComReg.
[13] http://www.openeir.ie/Products/Data/Next_Generation_Ethernet/
[14] See ✂[ ] response to ComReg's qualitative survey, Q3b.

Table 2.2 On-net retail circuit volumes, 2013–15, TDM

	Circuit volume			Share of total TDM		
	2013	2014	2015	2013	2014	2015
≤2M TDM	4,752	4,315	3,883	98%	98%	98%
>2M TDM	94	95	98	2%	2%	2%
Total	**4,846**	**4,410**	**3,981**			

Note: This data are based on total market TDM retail circuit volumes, using count method 2.

Source: Oxera analysis of ComReg operator data.

Table 2.3 On-net retail circuit volumes, 2013–15, Ethernet only

	Circuit volume			Share of total Ethernet		
	2013	2014	2015	2013	2014	2015
≤2M Ethernet	431	375	438	7%	5%	6%
>2M Ethernet	5,344	6,935	7,330	93%	95%	94%
>2–20M Ethernet	2,215	3,205	2,958	38%	44%	38%
20–100M Ethernet	766	989	1,035	13%	14%	13%
100M Ethernet	1,333	1,854	1,705	23%	25%	22%
100M–1Gb Ethernet	308	386	542	5%	5%	7%
1Gb Ethernet	443	475	1,032	8%	6%	13%
>1Gb Ethernet	57	26	58	1%	0%	1%
Other unspecified	222	0	0	4%	0%	0%
Total	**5,775**	**7,310**	**7,768**			

Note: This data are based on total market Ethernet (xDWM not included) retail circuit volumes, using count method 1.

Source: Oxera analysis of ComReg operator data.

2.3 Overview of the methodology used to define the WHQA market

The European Commission 2014 Recommendation states that:[15]

> the objective of any ex-ante regulatory intervention is ultimately to produce benefits for end-users by making retail markets effectively competitive on a sustainable basis
>
> and recommends that:
>
> the starting point for the identification of wholesale markets susceptible to ex ante regulation is the analysis of corresponding retail markets.

Hence, although the main focus of this review is competition in the provision of wholesale leased line terminating segments in Ireland (which is included in the European Commission's WHQA market), the definition of the wholesale leased lines market is informed by the retail market. This is also appropriate because the demand for wholesale products is mainly derived from associated retail

[15] European Commission (2014), 'Commission Recommendation of 9.10.2014 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services', section 2.

services. Thus, when services are perceived as substitutes in the retail market, they are likely to be substitutes in the wholesale market. Where this is not the case, it is probable that the services are not substitutable at the wholesale level either.

In light of this, we have considered various retail market developments when analysing the wholesale market, and taken into account the interaction between retail and wholesale markets in our framework of analysis. We have used both wholesale and retail market evidence (as available) to determine which products/services belong in the WHQA market in Ireland, including evidence on:

- demand-side substitutability;
- supply-side substitutability;
- other evidence, as relevant.

2.3.1 Demand-side substitutability

Demand-side substitutability is used to determine the extent to which consumers are prepared to substitute other services or products for the service or product in question.[16] It is not necessary for all consumers to switch to establish substitution; rather that a sufficient proportion of consumers would switch in response to a small but significant price rise (usually assumed to be around 10%) to make the price increase unprofitable.

The demand-side evidence we have considered includes the following (depending on relevance and availability of data):

- technical/qualitative assessment of service characteristics. This is because the service characteristics of potential alternatives will need to meet the connectivity requirements of the end-user in order to be considered a substitute;
- relative pricing. Similar pricing may indicate that end-users perceive the product as interchangeable, whereas disparate prices could mean that they are considered as different;
- evidence from the ComReg's retail business survey on switching, differences in end-user applications and service perceptions.

2.3.2 Supply-side substitutability

Supply-side substitutability measures the extent to which suppliers offering services other than the product in question would switch to supplying the focal product (leased lines in the current case) in response to a small but significant price rise (usually assumed to be around 10%). For an alternative product to act as a supply-side constraint (and potentially to be included in the relevant market), such switching must occur in a relatively short period (within a year), without significant additional costs.

The supply-side evidence we have considered includes the following (depending on relevance and availability of data):

[16] European Commission, (2002), 'Commission guidelines on market analysis and the assessment of significant market power under the Community regulatory framework for electronic communications networks and services', Commission guidelines, 7 July.

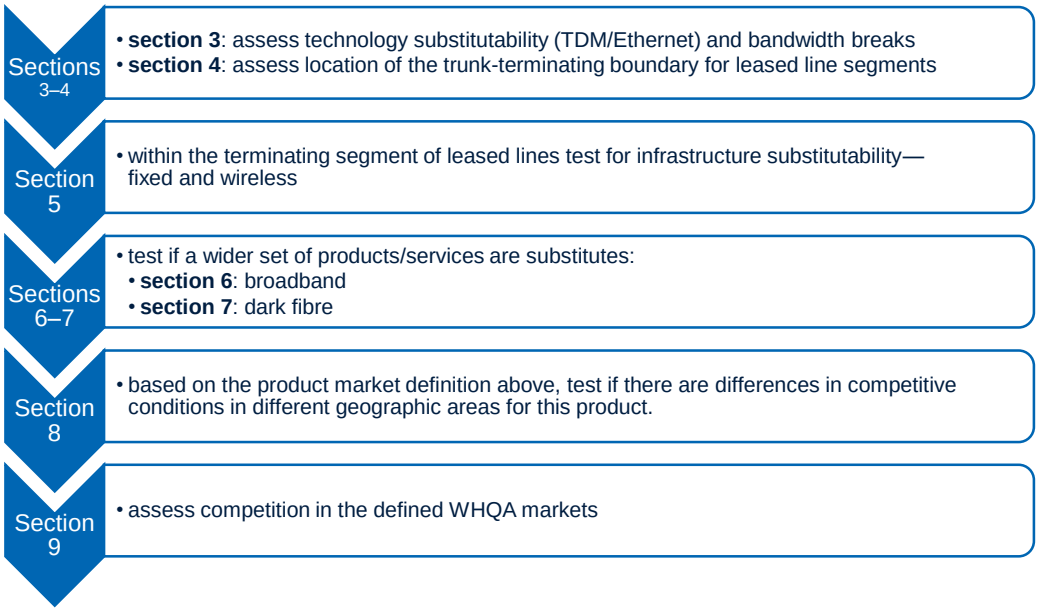
- technical characteristics, such as the extent to which existing products/ services can be reconfigured;
- the requirement and availability of upstream or other inputs to provide services (and hence additional investment that may be required). These may include additional electronic equipment such as Ethernet switches, duct, fibre or spectrum;
- migration and the evolution of market shares (e.g. TDM and Ethernet market shares). This evidence may help inform the likelihood that OAOs are likely (or unlikely) to expand capacity for certain services and/or start offering a particular service.

2.3.3 Other evidence considered

We have also considered the following evidence in assessing market definition (depending on relevance and availability of data):

- market structure and volume trends (used to consider product market definition);
- service availability and contestability (used to consider whether wireless is in the same market);
- position and relationship of product to other wholesale inputs (used to consider whether dark fibre is in the market);
- OAO network presence and eircom market shares within and outside business parks.

Based on the available evidence we first define the product market, assess geographic market definition for this product, and then analyse if any operator has SMP in the relevant market. Our analysis is structured as follows:



We note that the ultimate purpose of the relevant product (and geographic) market assessment is to identify whether the WHQA market in Ireland is characterised by effective competition or should be subject to ex ante regulation. The market definition sets the boundaries within which to analyse such

competitive dynamics. Thus, market definition is a useful tool and not an end in itself.

Identifying the product/geographic market also involves an element of judgement, particularly given that the analysis is conducted on a forward-looking basis, which may be influenced by a number of factors such as the level of indirect constraints and self-supply in the relevant market. We discuss these issues briefly below as well as the modified greenfield approach followed by the European Commission in its recommendations.

2.3.4 'Modified greenfield' approach

The modified greenfield approach is included in the European Commission Recommendation on relevant markets and SMP analysis.[17] In the WHQA market review, this requires national regulatory authorities (NRAs) to assume that there are no ex ante SMP remedies in the leased line markets but that ex ante remedies in other markets continue to apply. We have followed this approach, and therefore assumed that remedies exist in neighbouring markets such as Markets 3a and 3b.[18] This means that when assessing broadband products, we have assumed that OAOs can provide relevant connectivity services based on regulated local and central access wholesale inputs.

We also note that as of July 2016, the EU Civil Infrastructure Directive[19] will require all utility networks to meet reasonable requests for access to their infrastructure from public communications network operators, made with a view to deploying high-speed electronic communications networks. However, we understand that the Civil Infrastructure Directive does not require the provision of dark fibre access, and thus is not directly relevant to the WHQA market review. This is because access to passive infrastructure such as trenches and ducts alone is not sufficient to provide leased line type services. An operator would also require time and investments to roll out fibre and set up various exchanges and electronic switches before it could start offering active services.

Separately, we consider whether dark fibre is a substitute for leased lines in section 7.

2.3.5 Indirect constraints

The presence of indirect constraints via retail markets may have an impact on the assessment of wholesale markets, and we take these effects into account. For example, while eircom will be 'directly' constrained by other wholesale supplier of leased lines, it may also be constrained by retail operators offering products and services which may or may not fall within the WHQA market definition. For example, say NGA broadband is not considered as a substitute for terminating segments of leased lines at the wholesale level and thus not included in the WHQA market, it may still impose competitive constraints on the WHQA market if there is competition between these services at the retail level.

[17] See European Commission (2014), 'Explanatory note Accompanying the document Commission Recommendation on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services', staff working document, 9 October, section 2.2.

[18] These are the markets for wholesale local access provided at a fixed location (3a) and wholesale central access provided at a fixed location for mass-market products (3b).

[19] European Commission (2014), 'DIRECTIVE 2014/61/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks', Directive, 23 May.

This is because a wholesale leased line price increase (to the extent that it is passed on to the retail market) may result in end-users switching to NGA broadband services. This loss of retail leased line consumers, if sufficiently numerous, may decrease demand for wholesale leased lines and make the wholesale price increase unprofitable. The indirect constraint therefore arises where consumers switch to alternative services.

2.3.6 Self-supply

The European Commission recognises that the issue of how to take into account the self-provision of wholesale inputs arises frequently for both market definition and market analysis. It states:[20]

> The issue of how to take into account the self-provision of wholesale inputs arises frequently in both defining and analysing wholesale markets. In some cases, what is under consideration is the self-supply of the incumbent operators. In others, it is the self-supply of alternative operators.
>
> In many cases the incumbent is the only undertaking that is in a position to provide a potential wholesale service. It is likely that there is no merchant market as this is often not in the interest of the incumbent operator. Where there is no merchant market and where there is consumer harm at retail level, it is justifiable to construct a notional market when potential demand exists. Here the implicit self-supply of this input by the incumbent to itself should be taken into account.

Thus, the level of self-supply—i.e. the wholesale supply by vertically integrated firms to their own retail arm—is useful in understanding the competitive dynamics of the market. This is related to the issue of whether the presence of self-supply exerts a direct constraint on a wholesale operator's price—i.e. by potentially diverting this self-supply to the wholesale merchant market. This is likely to depend on the availability of self-supply, and whether this supply is captive with respect to the retail arm. Indirect constraints may also exist, as described above. In summary, the relevance of self-supply depends on the strength of direct and indirect competitive constraints exerted by vertically integrated operators.

The Body of European Regulators for Electronic Communications (BEREC) describes how and under what circumstances individual NRAs include self-supply in the analysis of wholesale markets (with a focus on Market 3a, the wholesale broadband market).[21] BEREC finds that: most NRAs analyse self-supply on the basis of direct and indirect constraints described above; some take into account the incumbent's self-supply while others also consider OAO self-supply; and, in general, when self-supply is included in the market it is also included when analysing market shares.

We note that OAOs in Ireland generally provide wholesale leased lines to each other on a commercial basis. eircom supplies regulated wholesale access services as well as some wholesale leased line services on a commercial basis (e.g. it supplies WDM-based wholesale uncontended connections on a reasonable request/non-discrimination basis). Thus, unlike other wholesale markets (such as 3a and 3b), there is an active wholesale or merchant market for leased line services even in the absence of regulation. There is no need to construct a 'notional market'. There is demand for wholesale leased lines and

[20] See European Commission (2014), 'Explanatory note Accompanying the document Commission Recommendation on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services', p. 18.
[21] See BEREC (2010), 'BEREC Report on self-supply', March.

multiple operators supply this demand in the wholesale market in addition to self-supplying the same or similar services.

In this context, we discuss whether it is appropriate to include eircom, MNO and OAO self-supply based on a consideration of whether this self-supply may be available on the merchant market.

2.3.7 eircom's self-supply

Eircom's ubiquitous network coverage and scale of operations suggest that its self-supply could be made available to the merchant market. At the same time, the scope of downstream operations (i.e. covering all fixed telecommunications services) suggest that the wholesale arm is not captive. For this reason, eircom's self-supply should be included in the market, with the exception of lines supplied to Meteor and Tetra, as these are captive sales (this supply is unlikely to be made available on the merchant market).

This is consistent with ComReg's position in its last market review, which was that an operator's self-supply should be considered part of the market assessment where an operator has spare capacity that could be offered in the wholesale market in a reasonable timeframe and that a customer could easily switch to.[22] This condition would clearly apply to the incumbent, eircom.

2.3.8 OAO's self-supply

As noted above there is an active merchant (wholesale) market for leased lines in Ireland with both eircom and OAOs supplying the market. This suggests that, in general, OAO self-supply should be included in the wholesale market assessment, as this supply is already available in the merchant market. Other evidence also suggests that OAO self-supply could be made available on the merchant market and hence should be included in the wholesale market. For example:

1. Fixed network OAOs have a significant infrastructure presence in business parks and data centres, and in other areas of high-demand density (discussed further in section 8). This spare capacity can be offered in the merchant market.

2. Market operator data shows that OAOs supply most of their volumes on-net (including the terminating segment), suggesting that they predominantly use their own infrastructure (see Table 8.3 and Table 8.4). This suggests a strategic approach to OAO build-out serving the majority of business customers in all locations, rather than a case-by-case build-out based on services supplied by third-party tails.

3. The off-net data also shows that OAOs supply segments to each other (rather than just buying from eircom), consistent with making spare capacity available on the merchant market.

This evidence suggests that OAO self-supply should be included in the relevant market in Ireland.

We also note that, unlike other markets—such as 3a and 3b, where there are significant differences between wholesale and retail services—for leased lines, the underlying inputs to supply the wholesale and retail markets are similar.

[22] ComReg (2008), 'Market Analysis – Leased Line Market Review, Response to Consultation on draft Decision Instrument', consultation document 08/103, 22 December.

For instance, serving a 1Gbps retail Ethernet leased line terminating segment is likely to use the same underlying physical infrastructure, routing and logical devices as a 1Gbps wholesale terminating segment. Both will require infrastructure at the local level. The type of differences that exist (e.g. resilience options, lead time or service level agreement) may be relatively easy to overcome or reflect commercial rather than economic supply factors. This suggests that a retail supplier should be able to make available its self-supply inputs on the wholesale market and vice versa. Indeed, we observe that many OAOs are active in both the wholesale and retail markets (Table 2.1).

For operators active only in the wholesale market (ESBT and Aurora Telecoms), the question of whether to include self-supply in the merchant market is not relevant because all of their supply is made available in the wholesale market in any case.

A recent market development is Vodafone's joint venture with ESB, called SIRO, which will extend fibre-to-the-building coverage to 50 towns in Ireland by the end of 2018. We understand that wholesale access will be open to all operators. While this venture is expected to pass 500,000 premises, it is not clear what the impact will be on business users.[23] We note that to the extent that SIRO is a wholesale only supplier, like other wholesale operators, the consideration of self-supply does not apply because this supply is made available in the wholesale market in any case.

Similar conditions also apply to wireless leased lines suppliers, as discussed further in section 4.

2.3.9 MNOs' self-supply

Where MNOs supply leased line connectivity to a downstream mobile operation, this is often for backhaul from base stations. This may be delivered to specific (and even remote) locations which could limit the availability of that supply to a more general market for connectivity services. Wireless links in these areas are likely to be bespoke, in that they are engineered to suit the local terrain, using available high sites. Diverting these inputs to the merchant market could be difficult. Capacity may be adjusted to suit the specific needs of a mobile network (i.e. by use of bandwidth-limited radio links), which suggests that supply in these locations is captive. This would suggest that MNO's self-supply should be excluded from the market. Thus, we have excluded eircom's self-supply to Meteor and Tetra.

We discuss MNO use of leased lines for mobile backhaul further in section 5.3.2.

2.4 Data and information used

Our analysis is based on data and information collected by ComReg as part of the WHQA market review, and includes:

- leased lines (including wireless) circuit volume and revenue data;
- OAO and eircom network information;
- wholesale pricing data;
- survey data;

[23] The SIRO plan appears to target areas outside Dublin (e.g. Cavan, Dundalk, Westport, Castlebar, Sligo, Carrigaline, Tralee, Navan, Letterkenny and Wexford). It will offer business services, however it is not clear how much priority these will take.

- business location data.

Due to different commercial and circuit recording practices between the respondents, the raw data is not necessarily comparable.

Details of these features and the way in which ComReg has adjusted for them are discussed in detail in Appendix A5. A summary of certain features of the data collected in terms of availability is provided below.

2.4.1 Quantitative data prior to 2013

Quantitative data prior to 2013 is generally unavailable. However, this has little impact on the analyses of historical trends relevant to understanding technology migration and substitution from TDM to Ethernet and the increased use of wireless services. This is because more recent data (2013 to 2015) is available and can be used to understand emerging trends and features relevant to the upcoming regulatory period.

In addition, there is other evidence available that can be used to study these trends, from sources such as customer/contract lifespans and qualitative survey results. In addition, some market data is available for 2008, when ComReg last reviewed the leased lines market. This data does not have the same level of granularity as more recent data, but it still allows us to compare different points in time (2008, 2013, 2014 and 2015) and to understand how the market has changed and is changing.

2.4.2 Data for 2013–15 incomplete for some OAOs

We understand that not all the data requested by ComReg for 2013–15 was initially returned by operators in a complete and consistent format. In some cases, this may be because operators do not in their normal course of business keep records of the type of data requested by ComReg. ComReg (assisted by Oxera) undertook an extensive data-cleansing exercise and, where possible, clarified data submitted with operators. This process of data cleansing and clarification helped us to extract additional data and has enhanced the reliability of our analysis.

2.4.3 Market share data

Market share data is derived from the circuit inventory data that ComReg gathered from operators. Importantly, these inventories do not distinguish between (the D06/08 definition of) terminating and trunk segments of leased lines, as operators do not record this information.

However, as the circuit inventories separate on-net and off-net data, it is still possible to infer market positions for different types of leased lines services. In particular, we understand that if a circuit is reported as on-net, this means that the access portion of the line was either delivered entirely and exclusively based on the OAO's own local access infrastructure (e.g. OAO fixed wire or wireless media to connect the customer premises) or OAO's use of upstream physical infrastructure inputs such as dark fibre or LLU connected between an OAO's active equipment. This implies that the entire leased line circuit (including the terminating segment, however defined) is supplied using non-eircom inputs or potentially eircom wholesale inputs outside the WHQA market.

The circuit inventory data also captures bandwidth, technology (TDM, Ethernet, xDWM), local access media (fixed, wireless), which generally allows market shares to be delineated by these attributes.

The circuit inventory data does not contain geographic location (i.e. X-Y co-ordinates) of circuit end-points; instead, ComReg requested (and received for the majority of relevant circuits) A-end and B-end location and end-user address. This is sufficient to enable an address-based geographic analysis (as explained in section 8) and inform the definition of wholesale geographic market.

2.4.4 Mapping data and network locations

ComReg requested mapping files to detail operators' network locations. The data received from operators is sufficient to locate most major trunk routes and operator points of presence where traffic is aggregated. Data gathered on the locations of business parks and data centres shows the presence of operators at these locations, to the extent that operators control infrastructure at these points. While many operators have provided complete network location data (e.g. the cable routing between interconnection points), others provided less granular information.[24] This limits proximity analysis in the context of geographic market definition, although cable location itself is likely to be a sufficiently strong indicator of network presence (see section 8 and Appendix A5.2 for further details).

We have used this data to assess the trunk-terminating boundary, and, given the high level of coverage of trunk routes and points of presence, this is sufficient. We have also used data on business park and data centre locations in the geographic assessment of terminating segments which are prospectively competitive. As these locations and the supply conditions therein are available, this data is sufficient for this assessment.

In addition, ComReg purchased data on business locations from the Bill Moss Database. The business location data is geographic data and consists of a sample of businesses in Ireland. It has good coverage of Irish businesses, and appears to locate premises with strong precision. This data, in combination with the other mapping data, is useful in establishing that leased line network roll-out and provision follows businesses in general.

2.4.5 Price data

In general, leased line services are sold on a price-on-application basis in the retail and wholesale market. Retail and wholesale prices are generally not publicly available; the only exception to this is the wholesale price lists that eircom is obliged to publish. This price data is used in the analysis on technology and bandwidth segmentation. We note that this comparison of relative wholesale prices for different Ethernet and TDM services should be a good proxy for substitution in retail markets, given that wholesale and retail leased line services have similar functionality and service characteristics.

We note that ComReg also gathered value-based information from operators (e.g. circuit rental revenue), but this information is not always complete. In addition, practices such as bundling with other services make rental revenues a less reliable measure, as it is not always possible to separate out circuit rental revenue from revenues for other services. This also means that it is not possible to compare retail prices for different leased lines services.

[24] For example, one operator has provided fibre connectivity data at a high level, listing the nodes that are connected, but not the precise routing of a cable between these points. There is also no data or information that specifies how far an OAO would extend its network to connect a customer. This is complicated by civil planning guidelines mandated at a local authority level, which can differ from street to street or even within a street.

2.4.6 Retail survey data

The retail survey data sampled more than 1,000 retail business users, including leased line end-users. This covered small, medium and large users across a range of sectors. The questions sought consumer views on the importance of service features, applications and potential switching. We note that the sample size for different segments of leased lines users (e.g. Ethernet versus TDM users or users of different bandwidths) is small, meaning that the survey results may not be fully representative of all leased line users. This data is still useful in order to understand how retail businesses use leased lines and the service characteristics valued by retail business users.

2.4.7 Qualitative survey data of wholesale users

The qualitative questionnaire conducted by ComReg asked for service providers' (wholesale users) views on a range of topics intended to inform the market review process. This covered retail and wholesale markets for leased lines and related business broadband services. The topics covered were:

- developments and trends affecting wholesale and retail markets;
- substitution between leased line products, broadband services and wireless services;
- barriers to switching;
- end-user cost awareness;
- geographic variation in pricing and conditions of competitive supply;
- the position of self-supply in market assessment;
- wireless service costs.

Operators provided varying levels of depth in their responses, and did not always substantiate their answers with evidence. For instance, some listed which products they considered to be substitutes without providing further justification. In other cases, where multiple operators provided well-reasoned responses to a question, it is has been possible to use this information to complement our analysis.

3 Are TDM and Ethernet in the same market?

In this section we consider whether terminating segments of wholesale leased lines with Ethernet interfaces and those with TDM interfaces are in the same product market, and also whether analogue leased lines are in the same product market.

The increased take-up of Ethernet, particularly at higher speeds may indicate that TDM and Ethernet product market definition could be dependent on bandwidth. Therefore, Oxera also assesses the presence of bandwidth breaks, or whether there are sub-markets defined by circuit speed. This section is structured as follows:

- Section 3.1 considers technology segmentation for TDM and Ethernet. We also consider whether analogue leased lines are part of the leased line market or a separate product. The analysis of the evidence supports separate market definitions for TDM and Ethernet products, as explained in section 3.1.6.
- Section 3.2 assesses whether bandwidth breaks occur in the TDM product market.
- Section 3.3 assesses whether bandwidth breaks occur in the Ethernet product market.
- Section 3.4 concludes and presents the proposed market definition based on the analysis of TDM and Ethernet services currently provided in Ireland.

3.1 TDM–Ethernet technology segmentation

In this section we consider whether terminating segments of TDM and Ethernet circuits are in the same or different markets. We do so by considering a variety of demand, supply and other market evidence, including:

- demand-side evidence, such as:
  - service characteristics (section 3.1.1);
  - retail business survey evidence on switching, differences in end-user applications and service perceptions (section 3.1.2);
  - relative (wholesale) pricing of TDM digital and Ethernet services at the same bandwidths. This is based on eircom's wholesale reference offer for leased lines (section 3.1.3);
- supply-side substitution between TDM and Ethernet (section 3.1.4), including market trends such as migration from Ethernet to TDM and market share differences in TDM and Ethernet (section 3.1.5).

While the analysis focuses on defining wholesale markets (WHQA), evidence is also considered from the retail market. In general, demand derived from the retail market will influence wholesale markets, although some exceptions may occur.[25]

Finally, section 3.1.6 concludes and also considers if analogue leased lines should be in the same market as TDM circuits.

[25] For instance, OAOs do not always purchase inputs for direct resale, but also to complement core network topology.

3.1.1 TDM and Ethernet service characteristics

TDM allocates dedicated capacity to each user based on a specific time slot on a link. This network resource is not contestable by other network users.[26] Precise alignment of timing throughout TDM networks means that data is transported with low jitter, or minimal variation in arrival time.

Ethernet is a frame switched data link technology that evolved from linking computers in local area networks. Small fragments of data are forwarded over shared network resources as and when they are received. This allows statistical multiplexing, or sharing of the network resources based on the statistics of demand such that core links can be over-booked.[27] This feature means that Ethernet makes more efficient use of resources, but can potentially result in network congestion depending on utilisation rates.[28]

However, developments in core Ethernet networking such as multi-protocol label switching (MPLS) address this with fast switching of traffic, taking into account the desired class-of-service of a given traffic stream (e.g. voice). This has enabled Ethernet to become increasingly similar to TDM in terms of service characteristics. Contention in managed MPLS Ethernet services can be engineered, and eircom states that congestion will not occur under normal conditions, with core links being upgraded when they reach 80% utilisation.[29] Ethernet latency and jitter standards have also further developed (i.e. ITU-T Recommendations. G.8261, G.8262 and G.8264 for Sync E) and now provide similar synchronisation functionalities to TDM.

Hence technological developments mean that Ethernet is increasingly similar to TDM in terms of service characteristics. However there may be a small minority of users that face high switching costs and which don't require the higher speeds that Ethernet can supply (e.g. customers using TDM for telemetry purposes) and hence may be hesitant to migrate to Ethernet. But for the large majority of end-users, TDM and Ethernet provide similar service characteristics and should be substitutable on this basis.

A detailed comparison of other service attributes based on eircom's TDM and NGN platform is included in Appendix A2.1.

3.1.2 Retail business survey data

The general substitutability in terms of service characteristics discussed above is also reflected in survey data evidence on end-user applications and service attributes for TDM and Ethernet services.

Oxera notes that these observations based on the retail business survey data are subject to the data limitations and caveats associated with the survey data as explained in Appendix A5.4.

TDM and Ethernet end-user applications and importance attached by users to different service attributes

[26] This would mean that four users at 100Mbs could share a link of capacity only equal to or greater than 400Mbps.
[27] In this way, a single 100Mbs link could be shared by four users who each subscribe at 100Mbs, at a 4:1 contention ratio.
[28] The effects of congestion, such as delay or dropped data can adversely affect some applications such as voice calls or video streaming.
[29] eircom (2015), 'Technical Handbook Wholesale NGN Ethernet Products, product manual v 1.8, 5 June, p. 32.

In the business survey, a sample of business users were asked to report the applications they use their service for—a summary set of results is shown in Table 3.1.

Table 3.1 Leased line end-user applications

	Primary access modes			
	Other incl. wavelength (58)	**Digital leased lines (55)**	**Ethernet leased lines (46)**	**Analogue leased lines (35)**
Email and Internet	90%	72%	94%	82%
Data services such as cloud computing and other software services	67%	43%	54%	18%
Connectivity between business premises	59%	60%	45%	43%
Employee remote access to the business network	52%	50%	46%	49%
Disaster recovery services	18%	37%	27%	34%
Voice—VoIP\voice over broadband	49%	32%	31%	60%
Card machines	–	–	–	–
Other	2%	7%	–	–

Note: The numbers in brackets refer to the sample size for the relevant survey question. As noted in Appendix A5.4 the small sample size for many questions, including on potential switching between products, means that robust conclusions cannot be drawn from responses to these questions. This problem is accentuated for leased line users, and when looking at sub-segments of users (e.g. TDM users or high-bandwidth users).

Source: Oxera based on ComReg/REDC (2015), 'Market Analysis – Business Market Draft'.

This shows that Ethernet and TDM products tend to have similar uses, although TDM users are less likely to use their service for email and internet than Ethernet users.

The survey also asked business users to indicate whether certain service attributes were important. The survey results are summarised in Table 3.2 below. These results appear to show that Ethernet users may place a higher value on low latency compared with TDM users. Given that Ethernet is not technically superior in terms of latency compared with TDM, we interpret these results as suggesting that there is no specific perceived advantage for TDM or Ethernet services with regard to latency.

In summary, the evidence from the retail business survey suggests that TDM and Ethernet serve similar functions and their users indicate that a similar range of attributes are important.

Separately, the TDM functional analysis (section 3.2.1) and Ethernet functional analysis (section 3.3.1) appear to support differences between TDM and Ethernet, with few TDM circuits being used for data centre, platform or cloud use and few Ethernet circuits being used for infrastructure control or monitoring. Details of this functional analysis are presented in Appendix A2.4.

Table 3.2 Leased line user attribute importance

	Other incl. wavelength (58)	Digital leased lines (55)	Ethernet leased lines (46)	Analogue leased lines (35)
Degree of availability (% time service is working)	90%	86%	96%	79%
Bandwidth—download speed	97%	80%	94%	69%
Bandwidth—upload speed	93%	72%	75%	79%
Connection	91%	74%	88%	62%
Jitter	75%	62%	79%	64%
Latency	80%	70%	96%	90%
Resilience	88%	75%	89%	73%
Symmetry	82%	65%	67%	77%
Range	51%	34%	59%	56%
Synchronisation	55%	57%	50%	44%

Source: Oxera based on ComReg/REDC (2015), 'Market Analysis – Business Market Draft'.
Note: The numbers in brackets refer to the sample size for the relevant survey question. As noted in Appendix A5.4 the small sample size for many questions, including on potential switching between products, means that robust conclusions cannot be drawn from responses to these questions. This problem is accentuated for leased line users, and when looking at sub-segments of users (e.g. TDM users or high-bandwidth users).

Switching evidence

The survey results also suggest that few end-users switch from Ethernet to TDM (3%), but a larger percentage of users switch from TDM to Ethernet (21%).[30] This evidence suggests that there is *asymmetric switching* from TDM to Ethernet. Combining this evidence with the overall migration trend to Ethernet circuits (section 3.1.5) reflecting technological developments suggests that Ethernet may act as competitive constraint on some TDM users, but that the opposite may not be true.

3.1.3 Relative wholesale pricing—TDM and Ethernet

We assess demand substitution based on comparing changes in wholesale pricing within a 'small, significant, non-transitory increase in price' (SSNIP) framework. That is, we analyse if prices of Ethernet increase by 10%, would sufficient significant switching to TDM occur to constrain a hypothetical monopolist or vice versa?

This comparison is based on eircom's wholesale pricing list (see section 2.4). In principle, these price comparisons could be made for a wide range of bandwidths. However, market volume data shows that TDM demand is effectively limited to certain (low) bandwidths below or at 2Mbps (Table 2.2). In addition, current generation Ethernet products offered by eircom are only offered at speeds above 10Mbps.[31]

The pricing analysis below compares 2Mbps TDM pricing with 10Mbps Ethernet pricing, reflecting circuits currently available in the market and those that are likely to be supplied during the market review period.

[30] ComReg retail business user survey.
[31] Operator volumes from other OAOs also show very low volumes for sub 2Mbs Ethernet circuits.

Relative wholesale pricing—approach

Oxera's approach is to compare pricing of TDM and Ethernet for a single leg of a leased line from an OAO handover to an end-user (A-end), containing all of the required wholesale inputs. This allows us to compare equivalent TDM and Ethernet services as far as possible. A detailed description of TDM and Ethernet wholesale input pricing and the modelling assumptions is covered in Appendix A2.2, and the analysis below follows that approach.

For terminating segments of TDM circuits, Oxera's analysis assumes:

- single circuit, no resilience;
- 0.5km end-user link distance;
- 0, 15 km or 30km main link distance;
- transport link of 0.5km, speed of STM-1 (155Mbps), no resilience.

For terminating segments of Ethernet circuits, the structure is slightly different, as the core conveyance depends on regions traversed, rather than explicit distance. Oxera considers the following Ethernet circuit in its comparison:

- NGN Ethernet product;
- single circuit, no resilience;
- 0.5km local access distance;
- same node, same region and inter-region (urban to rural) connections;
- traffic-based management, class of service option 1;[32]
- Ethernet interconnect distance of 0.5km, speed of 10Gbps.

Based on these product dimensions, Table 3.3 presents the relevant TDM-Ethernet relative price comparison.

Table 3.3 TDM–Ethernet relative price comparison

	TDM, 2Mbps, annual rental (€)	Ethernet, 10Mbps, annual rental (€)
Local node/no main link (TDM), local node (Ethernet)	2,330	3,242
15km main link (TDM), same region (Ethernet)	6,315	3,492
30km main link (TDM), urban to rural region (Ethernet)	8,995	4,556

Source: Oxera analysis of eircom wholesale leased line pricing.

The results show that a 10Mbps Ethernet circuit is significantly cheaper than a 2Mbps TDM circuit for distances that require core conveyance. A 10% price change is unlikely to substantially alter Ethernet's relative pricing advantage (compared with the current pricing) over TDM, and lead to subscribers switching from TDM to Ethernet or vice versa.

[32] This is the most basic class of service for traffic options; there is no guaranteed level of traffic that can be placed into the 'expedited' or 'assured' forwarding classes. The end-user is guaranteed a certain level of traffic in the 'standard' queue.

Furthermore, as the bandwidths do not match, users requiring more than 2Mbps at any distance are unlikely to choose to combine multiple TDM services when a single 10Mbps Ethernet circuit is cheaper. Users requiring smaller bandwidths are able to choose cheaper TDM products (i.e. in 64kb increments down to 64kb), but smaller (cheaper) current generation Ethernet leased line are generally not available.

This suggests that the substitutability between these services is not driven by pricing but by other factors such as the adoption of newer Ethernet technologies. As noted above, the retail business survey also presents evidence for this asymmetric substitution, and this is also reflected in the market migration from TDM to Ethernet services (section 3.1.5).

However, there are likely to remain a sub-set of TDM users for whom switching to Ethernet services is not an attractive option, given the costs of doing so and their service requirements (which may be met by low-bandwidth speeds), as we discuss below.

Switching costs and service requirements

The pricing analysis above does not explicitly consider switching costs that users face when considering changing services. These could include the costs of acquiring new equipment (in most cases the legacy equipment that these users have cannot be used for Ethernet services) and the costs of running two services in parallel during a migration phase. These switching costs are a barrier to these remaining low-speed TDM users migrating to Ethernet-based services.

Moreover, higher bandwidths may not be required for the kinds of services that remaining legacy TDM lines are used for such as infrastructure monitoring. This further reduces the incentives for these users to switch to Ethernet services. In addition, users may be tied into long-term contracts which could limit switching. These factors could delay switching such that it occurs when a contract expires or other related end-user equipment becomes obsolete.

3.1.4 Supply-side substitution

Supply-side substitution between TDM and Ethernet will depend on the ease with which operators can reorganise their networks to switch technologies. Both Ethernet and TDM networks use some of the same upstream inputs, such as fibre, duct and network colocation space. However, low-speed TDM services supplied to end-users generally tend to use copper access inputs in Ireland, whereas wholesale Ethernet leased lines services use fibre to the end-user. This is a potential barrier, particularly for a low-speed TDM-based operator using copper intending to serve high-speed Ethernet services based on fibre.

Even if upstream inputs are available, there remain other barriers to supply-side substitution, such as electronic equipment. Changing from TDM to Ethernet equipment is likely to require significant upfront investment, as all devices in the circuit path would need to be replaced.[33] Network support, engineering and vendor support would also add fixed costs to such a move.

BT and eircom are the main suppliers of TDM services in Ireland at present). In its response to the qualitative survey, ✂[■] stated that for ‘reasons of efficiency and cost TDM is slowly being replaced by Ethernet’. This may suggest that it is

[33] Oxera is aware of the ability to encapsulate Ethernet traffic over TDM networks with the use of media converters. These add cost and complexity, without necessarily providing the full benefit of the native network. For these reasons, they are unlikely to enable supply-side substitution.

inefficient for Ethernet operators to begin supplying TDM services, a further barrier to supply substitution.

Finally, we note that even if some level of supply-side substitution may be possible, market trends and market share data (as discussed in section 3.1.5) suggest that OAOs are unlikely to expand capacity to supply TDM circuits as we discuss next. Oxera is not aware of any OAO that is planning to begin providing TDM services.

3.1.5 Market trends and market share data

Migration from TDM to Ethernet

A major development in leased line markets since the last review is the migration to Ethernet interfaces. In 2013, there were about 5,026 wholesale TDM circuits and 4,178 wholesale Ethernet circuits; in 2014, there were 4,022 TDM and 4,939 Ethernet circuits; and in 2015, there were 2,225 TDM and 6,356 Ethernet circuits.[34]

This compares with about 30 Ethernet and about 9,000 TDM circuits in 2008. A similar pattern is evident in retail leased line volumes (see Table 2.2 and Table 2.3).

Within this shift to Ethernet services, most new circuits being sold are high-speed Ethernet circuits. As shown in Table 2.2, most of the remaining demand for TDM circuits is for low-speed circuits.

Moreover low-speed circuit additions are declining rapidly. A small number of new low-speed circuits are still being added to eircom's TDM platform with approximately ✂[ ] sub 2Mbps added over the 2014 calendar year.[35] For 2015, the total number of TDM wholesale sub 2Mbps services fell by 1,776 circuits, or 46%. However these are off-set by migration to higher-speed Ethernet circuits, which means there is a net reduction in low-speed TDM circuits. Almost no low-speed Ethernet circuits are being added. Only✂ [ ] sub 2Mbps Ethernet have been added since 2011 and these may be wireless or legacy Ethernet products.[36]

ComReg internal analysis also shows a similar pattern of slowing TDM orders, and increasing Ethernet orders.[37] It is likely that this pattern of sales indicates that for some users (e.g. at specific speeds), the dynamic of migration to Ethernet is effectively complete and that the remaining TDM users are unable or unwilling to switch given their bandwidth requirements and barriers to switching, as discussed above.[38]

Market share data

There is a significant difference in eircom's market share for TDM circuits relative to Ethernet circuits. As of 2015, eircom had a ✂[ ] (✂[in the absence of wholesale regulation) wholesale market share for TDM circuits compared with

[34] This is based on a circuit count using method 2 (see Appendix A5.1), and includes both on-net and off-net circuits.
[35] While this is based on data on eircom circuits, the size of eircom's TDM market share, as shown in section 9, suggests that this is a good refection of the scale of total market additions.
[36] ✂[ ] Operator data supplied by ComReg.
[37] ✂[ ] Operator data supplied by ComReg.
[38] Some users may have legacy equipment of their own which only operates on TDM interfaces.

a ✂[ ] (✂[ ] absent wholesale regulation) market share across all bandwidths in the Ethernet segment.[39]

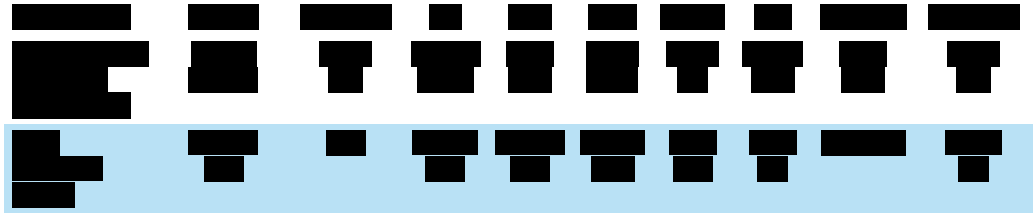
This suggests some differences in competitive conditions and differences in the supply side with OAO networks mainly serving Ethernet demand.

TDM

Market shares segmented at 2Mbps are summarised in Table 3.4.

Table 3.4 Wholesale market shares of TDM services, segmented at 2Mbps, 2015

✂ [REDACTED]



Note: The wholesale market shares are based on circuit volumes (presented in brackets) based on count method 2 under the assumption that existing regulation remains in place.

Source: Oxera analysis of ComReg market share summary data.

Oxera notes that when reviewing operator inventories at TDM speeds of below 1Mbs, OAO wholesale supply is insignificant: BT and others have around ✂[ ] circuits, while eircom has over✂ [ ].[40] In addition, as of 2014, there are approximately 30 wholesale analogue leased lines (see section 3.1.6). As stated previously, the volume of TDM services of bandwidth greater than 2Mbps is very small (Table 2.2).

Ethernet

Market shares for wholesale Ethernet leased lines in 2013 are shown in Table 3.5 below.

This market share data shows a clear difference between TDM and Ethernet supply and competitive conditions:

- first, OAOs are active in the supply of Ethernet circuits but generally do not offer TDM circuits;
- second, different sets of OAOs compete with eircom for the supply of TDM and Ethernet circuits. For TDM, eircom's main rivals are BT and Colt (although the volume of TDM circuits supplied by these operators is very small). For Ethernet, eircom's main competitors are enet, BT, Airspeed and Magnet at lower bandwidths and BT, enet and ESBT at higher speeds, with Colt competing across the spectrum.

In addition, as discussed in section 8.4, operator circuit inventory data (Table 8.3 and Table 8.4) show that OAOs have relatively low reliance on eircom for Ethernet circuits. For Ethernet circuits above 2Mbps in speed (the majority of retail Ethernet circuits), OAOs are not reliant on eircom. The circuit inventories show that for the main OAO suppliers, around only ✂[ ] of circuits rely on eircom's wholesale leased line inputs. This shows that the majority of Ethernet

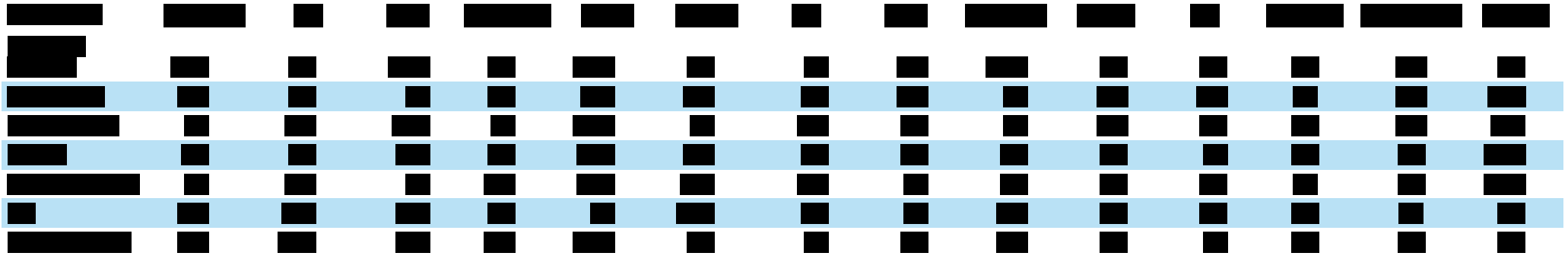
[39] Source: Oxera analysis of ComReg market share summary data. These data show that Eircom's market share with or without regulation is over 60% for TDM circuits and under 40% for Ethernet circuits.
[40] This is based on count method 2, not adjusting for self-supply.

circuits supplied by OAOs are on-net circuits. This provides further evidence to suggest that the focus of expansion and supply from OAOs is the Ethernet market and not the TDM market.

The market share and supply data, the general migration from TDM to Ethernet services (given technological developments), and the increasing share of OAO on-net supply of Ethernet circuits suggests that OAOs are unlikely to expand capacity to supply the declining TDM market.

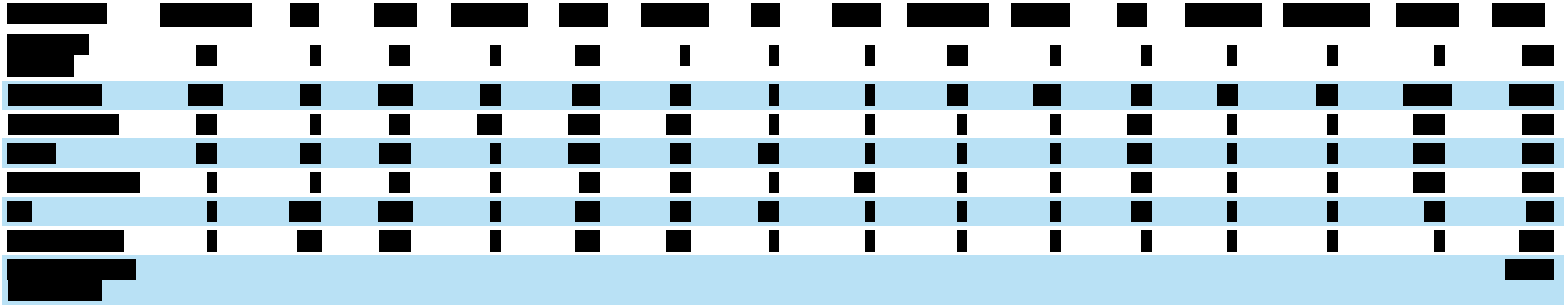
Table 3.5 Wholesale market shares of Ethernet services, segmented at various bandwidths, 2015

✂ [REDACTED]



These wholesale market shares are based on the wholesale Ethernet circuit volumes below, 2015

✂ [REDACTED]



Note: The circuit volume for each operator is based on wholesale on-net counts as per method 1.

Source: Oxera analysis of ComReg market share summary data.

3.1.6 Conclusion

Separate TDM and Ethernet product markets

While a comparison of service characteristics, end-user applications and the relative importance of different service attributes for end-users is similar for TDM and Ethernet services, a number of factors suggest that these services are not substitutable (for some end-users), and that OAOs are unlikely to expand capacity and supply TDM circuits in response to an increase in TDM service prices. Functional analysis also appears to support differences between TDM and Ethernet, with few TDM circuits being used for data centre, platform or cloud use and few Ethernet circuits being used for infrastructure control or monitoring.

The market volume and consumer switching evidence suggests a migration to Ethernet is underway, and that a group of remaining TDM users may be unwilling to switch even if similar product characteristics are available on Ethernet given switching costs and their particular service requirements which may not require higher bandwidths. This also suggests that for some TDM end-users Ethernet is not a substitute. These end-users are captive TDM users.

Supply-side evidence also suggests that TDM and Ethernet are serving different parts of the bandwidth spectrum, and that conditions of supply within these parts differ, with eircom having a relatively higher market share in TDM compared with Ethernet. Moreover, given the general migration to Ethernet services in the market, OAOs are unlikely to expand capacity to supply a declining TDM market. Evidence for this includes the relatively higher OAO market shares and relatively lower reliance of OAOs on eircom inputs in the Ethernet market. We also note that eircom recently increased its TDM prices but, to date, none of the OAOs have entered (or plan to enter) the TDM market in response to the price increase.

Considered together, the evidence supports defining separate markets for TDM and Ethernet circuits.

Analogue leased lines should be included in the TDM market

Analogue leased lines are dedicated direct connections linking two sites over the same platform as ≤2M TDM leased lines, using standard copper lines. These can natively support voice, and may be used as a permanent voice connection between business locations. This is a very small and declining market with only ✂[wholesale analogue leased lines being supplied by eircom.[41]

For data transmission, modems are connected to an exchange using dedicated 2- or 4-wire copper pairs. As the data is modulated at narrow band like a voice signal, it can be switched over the network of voice exchanges to remote locations.[42] The bandwidth provides ranges from 1,200 bits per second up to 56kbps. Due to the low-speed and legacy nature of the standards, these services are most likely to compare with low-speed TDM rather than Ethernet circuits and a review of demand- and supply-side substitution supports the inclusion of analogue leased lines in the TDM market.

[41] Operator 2015 data.
[42] For an incumbent network provider it is similar to providing an additional analogue voice line to a premises.

Demand-side substitution

In terms of functionality, analogue leased lines may be similar to low-speed TDM services. In the UK, Ofcom found that analogue leased lines and low-speed TDM circuits were in the same market, based on:[43]

- equivalent functionality;
- both are legacy services, with the same functionality since the last review period;
- analogue and low-bandwidth TDM services run on the same network, and hence cost changes will equally affect the competitive price of both.

These factors are likely to apply in Ireland as well, since the technology and functionality of the services are likely to depend on global standards and therefore be identical. TDM and analogue services also use the same infrastructure (i.e. in local access) in Ireland and so supply costs are similarly affected.

Eircom's wholesale prices for analogue leased lines also support the inclusion of these services in the TDM market. Oxera finds that an analogue leased line end-user link at 64kbps (1.5km, zero main link distance) is priced at €698, which is similar to the price of a local exchange only 2-wire (copper pair) leased line at €615.

Supply-side substitution

Analogue leased lines rely on upstream inputs of copper access lines (e.g. LLU products), network of PSTN telephone exchanges, and the TDM platform. Traditionally, such telephone exchanges have been connected using TDM bearers and digital cross-connects to transport voice traffic. A TDM operator that also has a network of exchanges (i.e. for serving a calls market) may be able to use LLU inputs to serve demand for analogue leased lines as well. Similarly, an analogue leased lines provider is likely to use its exchanges and cross-connects, and it seems plausible that operators could switch supply between these two products.

Next, following on from evidence that supports separate market definitions for terminating segments of TDM and Ethernet leased lines:

- section 3.2 assesses whether bandwidth breaks occur in the TDM product market;
- section 3.3 assesses whether bandwidth breaks occur in the Ethernet product market.

3.2 TDM bandwidth segmentation

Leased line users tend to require circuit connectivity up to a certain bandwidth, even if not all of this bandwidth is utilised all of the time. If products of higher or lower bandwidths are not able to meet this demand or face differing supply conditions then it is appropriate to define separate markets delineated by bandwidth.

Another possibility is that products of adjacent bandwidths are substitutable for one another, and that price rises at one bandwidth induce switching to higher

[43] Ofcom (2015), 'Business Connectivity Market Review – Review of competition in the provision of leased lines', consultation document, 15 May, Annex A10.6.

speeds or combinations of lower-bandwidth products. If this occurs across a spectrum of bandwidths then chains of substitution exist, linking many bandwidths. In this case, it is appropriate to define a product market that includes the different bandwidths.

In this section, we investigate potential bandwidth breaks between 64 Kbps and speeds in the region of 2Mbps for TDM services via:

- demand-side evidence such as differences in retail applications of different bandwidths (section 3.2.1), and relative (wholesale) pricing of existing TDM services at different bandwidths (section 3.2.2);
- supply-side substitutability (section 3.2.3).

3.2.1 TDM functional analysis

Oxera has reviewed the end-users who purchase the majority of eircom's retail leased lines, segmented by specific circuit bandwidths based on eircom's circuit inventory reported to ComReg. This data indicates the end-user and, in some cases, the application that the link is used for (e.g. wide area network, control or remote monitoring).

By analysing this data we can see if users or applications vary by speed. Oxera notes that as the data generally indicates the name (but additional information on use is incomplete), this evidence is not conclusive but can be considered alongside other demand-side evidence.

This functional or end-user analysis supports a single market for TDM across speeds, as similar end-users appear in the circuit inventory. Major users of low-speed TDM appear to be utility network operators and government institutions. These users could have distinct demand features, such as control applications that are suited to supply over TDM but not Ethernet circuits.

Details of this functional analysis are presented in Appendix A2.4.

3.2.2 TDM wholesale pricing comparison

As with the product segmentation in section 3.1, bandwidth substitution can be assessed via a SSNIP framework. That is, if prices of a bandwidth (e.g. 10Mbps) increase by 10%, would a significant number of subscribers switch to another bandwidth (e.g. to 20Mbps) to constrain a hypothetical monopolist supplying 10Mbps? If so, this suggests a wider market—i.e. a market including multiple bandwidths is appropriate. Furthermore if there is substitution across a wider spectrum of bandwidths, then chains of substitution exist, linking many bandwidths and it is appropriate to include these in the same market.

Oxera's analysis includes comparable elements from the entire cost stack as faced by a wholesale OAO, purchasing a single leased line segment or leg from eircom. For TDM products, the relevant components are PPC products, which consist of an end-user link, main link access, main link distance, and a transport link (see Appendix A2.2 for details).

In constructing the bandwidth price comparison, a range of scenarios are constructed to test the bandwidth price relationship at different distances. Oxera assesses the four TDM variations presented in Table 3.6.

Table 3.6 TDM bandwidth break analysis

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Bandwidth range	64kbps–2048kbps	64kbps–2048kbps	64kbps–2048kbps	64kbps–2048kbps
End-user link distance (km)	0.5	5	0.5	5
Main link type	Type 1[1]	Type 1	Type 2[2]	Type 2
Main link distance	15	15	0	0
Transport link capacity (Mbps)—up to 2Mbps	155	155	155	155
Transport link capacity (Mbps)—above 2Mbps	622	622	622	622
Transport link distance (km)	0.5	5	0.5	5

Note: [1] PPC circuits where the end-user link and OAO interconnect are located at different exchanges. [2] End-user links that terminate at the OAO at the same exchange as the customer link is connected to. There is no main link distance (or charge) for Type 2 connections.

Source: Oxera analysis of eircom wholesale leased line pricing.

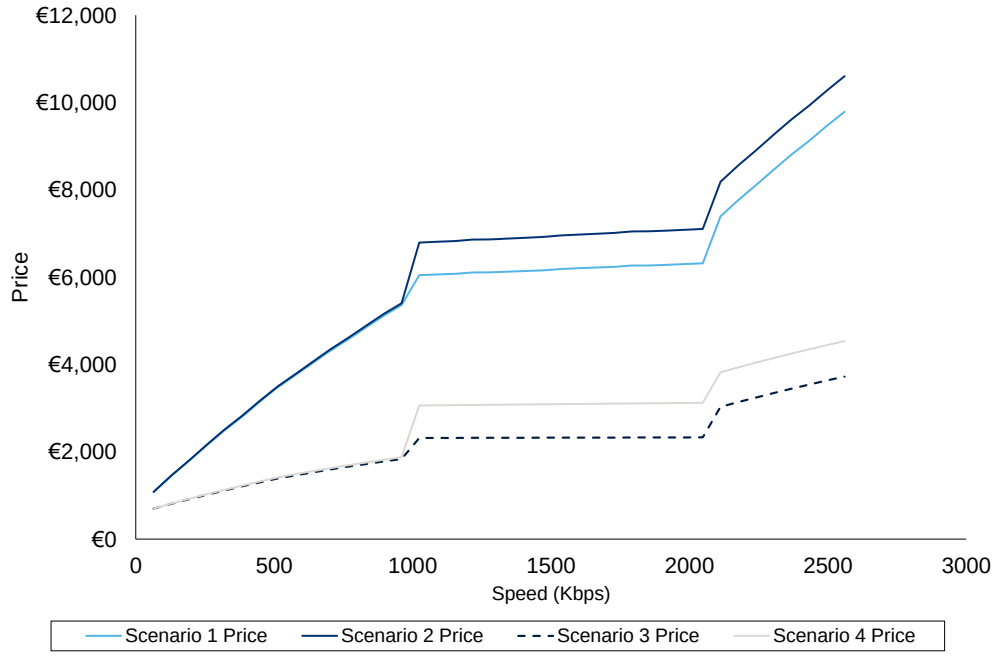
Figure 3.1 below plots the price of buying the required wholesale inputs for the four different circuit configurations presented in Table 3.6.

First, the plot shows that, regardless of how circuits are configured, a price discontinuity occurs at 1Mbps, with prices flattening out up to 2Mbps. This is a feature of the end-user link price structure, which has a flat rate for 64–960kbps and then a step up at 1,024kbps, as well as the fact that a ≥1Mbps circuit requires two copper pairs whereas a <1Mbps requires a single pair. In all scenarios, the price increase at 1024kbp corresponds to a 13% increase on the 960kbps price. This is significant in nominal terms and could indicate a break in conditions.

However, in terms of price per unit of bandwidth, this corresponds to an increase of 6%. Importantly, with low-speed TDM services it is possible to augment (or reduce) bandwidth in service, without additional connection fees or downtime. Thus for TDM services, the demand-side evidence of relative pricing indicates a possible break at 1Mbps, however the price discontinuity is relatively small.

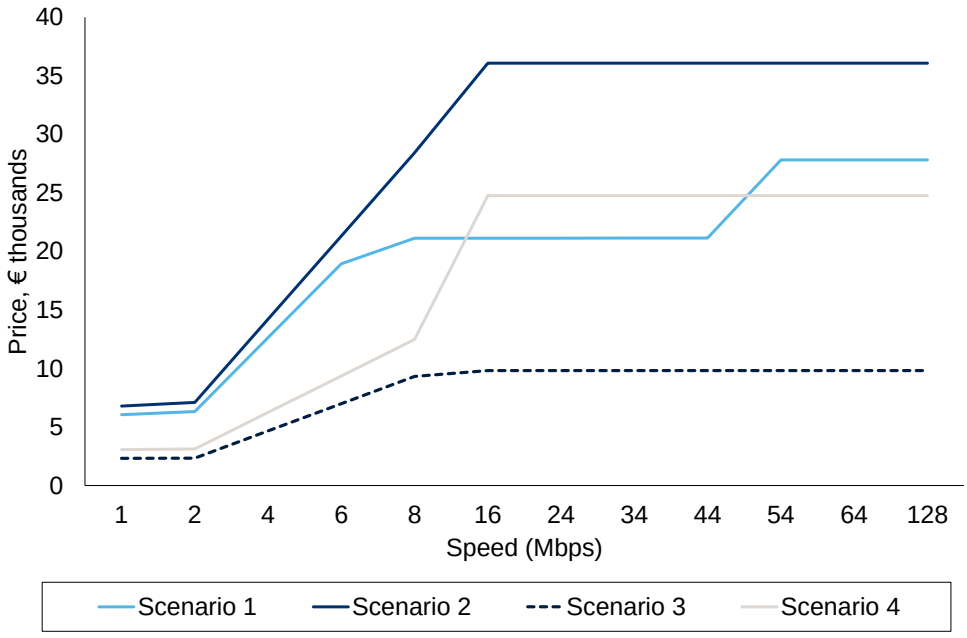
Considering bandwidths above 2Mbps confirms a significant pricing break in this region, as shown in Figure 3.2 below. Price increases rapidly above 2Mbps, and it is never cost-effective for 1Mbps users to avail services above 2Mbps. In addition, a 4Mbps user would always be better off using 2Mbps service increments rather than 1Mbps.

Figure 3.1 TDM bandwidth price analysis (up to around 2Mbps)



Source: Oxera analysis of eircom wholesale leased line pricing.

Figure 3.2 TDM bandwidth price analysis (above 1Mbps)



Source: Oxera analysis of eircom wholesale leased line pricing.

3.2.3 TDM supply-side substitutability

Low-speed TDM services (64–1,984kbps) are typically delivered to end-users by eircom over high-bit-rate digital subscriber loop (HDSL) technology operating at a line rate of 2048kbps.[44] These allow configuration of any bandwidth within this range by selecting the number of channels available within this link. Other operators that provide low-speed TDM services may have a different service

[44] eircom (2009), 'Partial Private Circuit Product Description', Issue 2.3, 7 September, Annex D, Section 7.

delivery, such as SDH or PDH, but providing the bandwidth over a channelised 2Mbs bearer is a common approach. These features suggest that supply substitution is possible within this range.[45] For TDM services above 2Mbps, fibre is often required to deliver the service. Unlike in other countries, 8Mbps (E2 - copper based) TDM services are not offered in Ireland. This division limits substitutability above and below 2Mbps.

As discussed in section 3.1.3, users requiring more than 2Mbps at any distance are unlikely to choose to combine multiple TDM services when a single 10Mbps Ethernet circuit is cheaper. This is reflected in the migration of users requiring high-bandwidth services to Ethernet circuits and in the market data. As discussed in section 3.1.5, 98% of TDM circuits are ≤2Mbps, and there have been no new retail additions of greater than 2Mbps TDM lines recently.[46]

3.3 Ethernet bandwidth segmentation

As noted in section 3.1.5, the majority of Ethernet circuits currently in use are above 2Mbps and the current stock of sub 10Mbps Ethernet circuits are legacy connections, which are declining in number and expected to fall into disuse as end-users demand higher bandwidth lines. Hence in this section, we focus our analysis on Ethernet circuits with speed over 10Mbps.

Oxera analyses whether there are bandwidth breaks for the Ethernet product set separately via:

- demand-side evidence such as Ethernet functional analysis (section 3.3.1), and relative (wholesale) pricing of existing Ethernet services at different bandwidths (section 3.3.2);
- supply-side substitutability (section3.3.3);
- an analysis of dense-wavelength-division-multiplexing (DWDM) and very high-speed services (section 3.3.4).

3.3.1 Ethernet functional analysis

As with the TDM functional analysis (section 3.2.1), a common pattern is also apparent among users and applications by speed for Ethernet circuits and it is clear that wide-area network links are a common requirement across bandwidths. Details of this functional analysis are presented in Appendix A2.4.

3.3.2 Ethernet wholesale pricing comparison

Like eircom's TDM product set, eircom's Ethernet product has access, core and interconnection components, although it is structured differently. The relevant components are wholesale symmetrical Ethernet access (WSEA) physical; WSEA logical; and wholesale Ethernet interconnection link (WEIL). Details of these Ethernet wholesale components in Appendix A2.2.

As with TDM, a range of scenarios are constructed to test for bandwidth breaks in Ethernet pricing. These include different bandwidth ranges, WSEA physical distance, WSEA area density (urban and rural) terminating circuit destination (same node, same region and different region), class of service, type (circuit or traffic based), and WSEA physical circuit and WEIL lengths.

[45] In general, there may be limits to the ability of supply substitution to constrain a hypothetical monopolist. For instance, wireless OAOs may have a limitation in their ability to supply beyond limits in radio technology and spectrum allocations.
[46] ComReg (2015), 'Terminating Segment Remedies', internal note, 15 May.

The complexity of the Ethernet product structure means that there are a wider set of possibilities to examine. In each scenario, Oxera aims to assess whether products of adjacent bandwidths are possible substitutes, holding other attributes constant. The set of scenarios enables the analysis to test whether the pricing relationships are valid as the link becomes longer (i.e. different regions) or has a different quality.

Oxera's analysis is based on NGN Ethernet products only. While service delivery of high-speed services (i.e. above 1Gbps) may be via DWDM, prices for these services are not available.[47]

NGN Ethernet services can be configured in ways for handling class of service: circuit-based and traffic-based. We discuss the relative wholesale pricing analysis for each of these options below. The details of this analysis are presented in Appendix A2.3.

Circuit-based class of service

For circuit-based configurations, *all* of a customer's traffic is placed into one of three traffic management queues on eircom's NGN core. A circuit mapped to the 'standard' queue will have its traffic placed in the same queue as all of eircom's customers' standard traffic in the event of congestion.

The circuit-based Ethernet pricing analysis suggests that, for Ethernet circuits terminating on:

- the same NGN node, the range of bandwidths from 10Mbs to 5Gbps are in the same market. The pattern is the same for longer WSEA and WEIL distance specifications;
- different nodes (in particular, different classes of service) or regions, a possible break appears at around 1Gbps. Oxera also notes that equipment cost differences between 1G and 10G cards could contribute to this.[48]

Oxera points out that where such price differences are due only to differences in the cost of electronic equipment rather than control of bottleneck infrastructure, they may be transient. Electronic equipment used in backhaul and core networks responds to technological progress, where unit costs (i.e. cost per GB transmitted) fall over time.[49] In its 2015 consultation of the business connectivity market in the UK, Ofcom found that BT's costs to serve high-speed circuits in particular had fallen over time.[50] Oxera notes that the decrease in costs due to technological progress in network equipment is also likely to apply in Ireland (to the extent that this is passed on to customers).

Traffic-based class of service

Traffic-based class of service means that customer traffic entering the network is inspected for 'class of service marking' as indicated by the end-user. The NGN network will then place individual packets of traffic into a queue based on the type of marking it sees. This can be done at a granular level, such that voice,

[47] eircom's wholesale uncontended data product is not covered by an obligation to provide a reference offer, and therefore prices are not available.
[48] See eircom (2015), 'eircom Network Price List', reference offer, service schedule 13, v6.7, 30 June. A 1Gbps WEIL with customer site handover costs €2,100 per year while a 10Gbps connection costs €2,315 per year. Connection costs also differ: a 1Gbps in-span handover costs €1,450, while a similar connection at 10Gbps costs €3,950.
[49] See plum consulting (2014), 'The evolving business services market and the review of the EC Recommendation on relevant markets', report for ETNO, 27 March.
[50] Ofcom (2015), 'Business Connectivity Market Review – Review of competition in the provision of leased lines', consultation document, 15 May, paras 4.55 to 4.59.

video and emails within one leased line circuit are all treated differently. This is complex, but widens the scope for handling congestion, and thus may be more efficient. This distinction applies to Ethernet circuits only; all TDM products are fully circuit-oriented and do not experience congestion. Oxera has modelled the traffic-based scenarios based on the assumptions shown in Table 3.7.

Table 3.7 Ethernet bandwidth break analysis—traffic-based

	Scenarios 15–16	Scenarios 17–20	Scenarios 21–24
Bandwidth range	10Mbps–5Gbps	10Mbps–5Gbps	10Mbps–5Gbps
WSEA physical distance (km)	0.5–1.5	0.5–1.5	0.5–1.5
WSEA area density	Urban	Urban	Rural
Destination	Same node	Same region	Different region
Class of service	n/a	Options 1 and 6	Options 1 and 6
WEIL area density	Urban	Urban	Urban
WEIL capacity (Gbps)	10	10	10
WEIL distance (km)	0.5–1.5	0.5–1.5	0.5–1.5

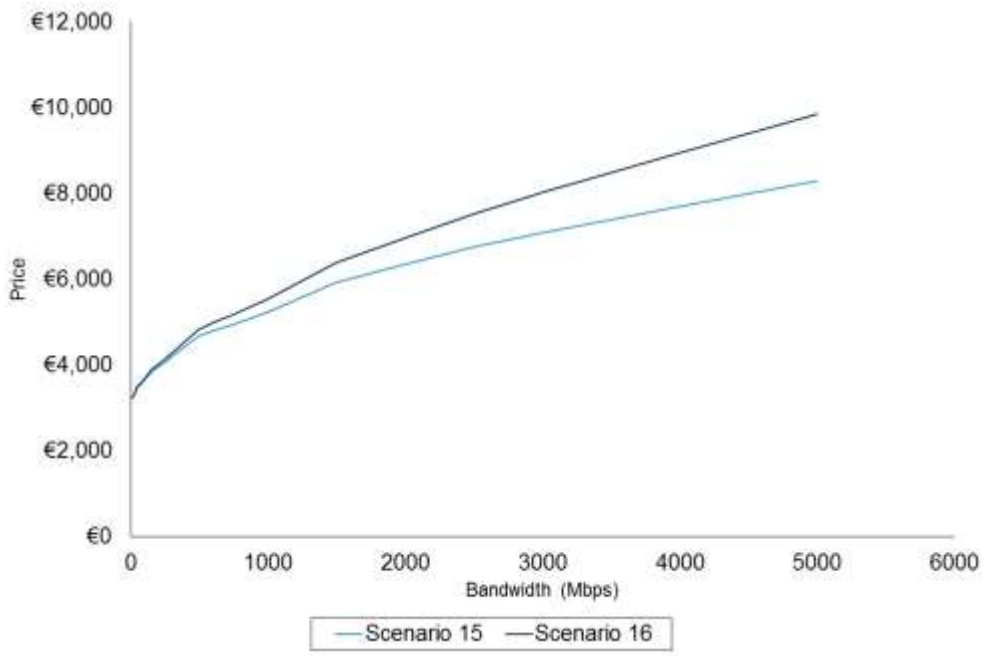
Note: Variations within the scenario grouping are via the WSEA/WEIL link distances and class of service types. Scenarios 5–14 are all 'circuit-based' while scenarios 15–24 are all 'traffic based'. See Appendix A2.3 for more details.

Source: Oxera analysis of eircom wholesale leased line pricing.

Oxera understands that the majority of NGN Ethernet circuits sold are configured on a traffic class of service configuration rather than circuit-based. And for traffic-based Ethernet leased lines, there is no apparent discontinuity in prices at a specific bandwidth. Altering circuit length, core conveyance (region) or class of service introduces a level shift but does not shift relative pricing across bandwidths.

An example of this type of analysis is shown in Figure 3.3 below, which compares traffic-based Ethernet prices in the same node (further examples and analysis are presented in Appendix A2.3).

Figure 3.3 Traffic-based Ethernet prices, same node



Note: These scenarios are explained in detail in Appendix A2.3.

Source: Oxera analysis of eircom wholesale leased line pricing.

3.3.3 Ethernet supply-side substitutability

Oxera notes that Ethernet technology is generally flexible in meeting the demands of different bandwidths, especially when provided over fibre optic networks. Ethernet switching equipment, such as that used to deliver eircom's WSEA, tends to support a range of physical interface specifications concurrently, such as 10Mbps, 100Mbps and 1Gbps.[51] Between these speeds—e.g. providing a circuit at 50Mbps—bandwidth on the WSEA physical link is determined by configuring a software rate limit on the equipment, rather than any explicit limit on the equipment or fibre link.

Conveyance of higher bandwidths on the core will displace more network resources, but in general these could be expected to support a range of end-user bandwidths due to the aggregation of many different users. These features suggest that a provider of a 10Mbit/s Ethernet leased line could provide 100Mbit/s using similar technology and therefore at a similar cost. This could act as a competitive constraint on the provider of the 100Mbit/s service.

3.3.4 DWDM and very high-speed services

DWDM and high-speed services (over 1 Gbps) may be delivered using DWDM technology over fibre. Similar speeds over 1 Gbps may also be delivered using Ethernet services, suggesting a chain of substitutability between DWDM and Ethernet services. This is also supported by the fact that there is increasing similarity in the service features and costs of providing these services, as discussed further below.

An example is eircom's wholesale Ethernet uncontended product. Oxera notes that in 2014, the volume of >1 Gbps circuits was low, with approximately 71 circuits in the wholesale market and 27 circuits in the retail market.[52] In 2015, there were approximately 224 wholesale xWDM (and related) circuits and 273 retail circuits. Nonetheless, these types of circuit tend to be high-value connections, which are used for critical applications such as storage area networking or connectivity to data centres.

Limited market evidence is available for these services. DWDM products pricing is not published. Survey evidence is also limited, but indicates similar user perceptions as Ethernet leased lines generally. It is possible that DWDM users value bandwidth and symmetry more than Ethernet users, as shown in Table 3.2.

Oxera notes that, in the UK, Ofcom found a break in the chain of substitution at 1Gbps in its 2013 review, mainly due to differences in costs of DWDM and Ethernet equipment.[53] However, more recently, Ofcom has found that OAOs are using various technologies to compete, resulting in greater interaction between Ethernet- and DWDM-based services.[54] Ofcom also found that some features that previously separated DWDM and Ethernet (support of niche interfaces, ability to scale bandwidth) were no longer distinct, and that BT's new 10G Ethernet-based product filled a gap in the product range. Importantly, Ofcom

[51] See eircom (2015), 'Technical Handbook Wholesale NGN Ethernet Products, product manual v 1.8, 5 June, p. 36.
[52] Based on operator volumes provided by ComReg.
[53] Ofcom (2013), 'Business Connectivity Market Review, Review of retail leased lines, wholesale symmetric broadband origination and wholesale trunk segments', final statement, 28 March.
[54] Ofcom (2015), 'Business Connectivity Market Review – Review of competition in the provision of leased lines', consultation document, 15 May, para. 4.44.

noted that WDM costs and prices had fallen. Following this, Ofcom now includes WDM-based services along with Ethernet above 1Gbps in the same multiple interface symmetrical broadband origination (MISBO) in the UK.

Some of these factors are related to generic equipment developments that should be available in the Irish context. Some changes could be specific to particular operators in the UK. Evidence from eircom's pricing list indicates that the NGN Ethernet product has expanded with the addition of 10Gbps WSEA logical connections in May 2014.[55] This may indicate a similar interaction with WDM as the UK.

The limited evidence suggests greater supply and demand substitution since the previous review for serving very high-speed links. In light of this, including WDM this product within the market for Ethernet leased lines would seem reasonable.

3.4 Conclusion

As discussed in section 3.1.6, a number of factors suggest that TDM and Ethernet services are not substitutable. Some end-users are likely to be captive TDM users given switching costs and their particular service requirements, which may not require the higher bandwidths offered by Ethernet services. OAOs are unlikely to expand capacity and supply the declining market for TDM circuits in response to an increase in TDM service prices, as demonstrated by eircom's ✂[ ].[56] Functional analysis also appears to support differences between TDM and Ethernet, with few TDM circuits being used for data centre, platform or cloud use and few Ethernet circuits being used for infrastructure control or monitoring.

Supply-side evidence also suggests that TDM and Ethernet are serving different parts of the bandwidth spectrum, and that conditions of supply within these parts differ, with eircom having a relatively higher market share in TDM compared with Ethernet. Moreover, given the general migration to Ethernet services in the market, OAOs are unlikely to expand capacity to supply a declining TDM market. Evidence for this includes the relatively higher OAO market shares and relatively lower reliance of OAOs on eircom inputs in the Ethernet market.

As discussed earlier, TDM bandwidths above 2Mbps are available, although volumes have declined such that only a ✂[ ] such products have been sold by eircom since the last review. It is most likely that demand for these speeds is now met by Ethernet products. Similarly, there remain a low number of Ethernet circuits below 2Mbps, which typically relate to legacy Ethernet products. Conditions of supply within these technology and bandwidth breaks also differ, with eircom having a higher market share in TDM compared with Ethernet.

Considered together, the evidence supports separate market definitions for TDM and Ethernet products, as described below. This is also consistent with and supported by our analysis of the trunk terminating boundary for Ethernet and TDM circuits in section 4. This shows that differences between the TDM and Ethernet networks in Ireland mean that separate trunk terminating boundary definitions are appropriate for TDM and Ethernet circuits.

[55] eircom (2015), 'eircom Network Price List', reference offer, v6.7, 30 June.
[56] Eircom ✂[ ]

3.4.1 TDM services up to 2Mbps—the wholesale Traditional Interface market

Demand-side evidence of relative pricing indicates a possible break at 1Mbps; however, the price discontinuity is relatively small. A much larger break in pricing occurs just above 2Mbps. Supply-side substitution and end-user analysis do not indicate differences across bandwidths. For this reason, the evidence supports a single Traditional Interface (TI) market containing all bandwidths up to 2Mbps, including analogue leased lines.

3.4.2 Traditional Interface services above 2Mbps

As discussed in section 4.1.5 and as shown in Table 3.2, 98% of TDM circuits are ≤ 2Mbps (which means that only 2% TDM circuits are >2Mbps). In addition, there are very few high-speed TDM circuits sold in Ireland. In 2015, 134 high-speed wholesale TDM lines were in use in the whole country, compared with around 2,091 low-speed lines.[57] Demand for these circuits is also decreasing: Eir sold ✂[ ] in 2015, and there were ✂[ ] fewer lines in operation in 2015 compared with 2014 (section 4.1.5). Eircom also has less than 30% wholesale market share for TI services above 2Mbps (as of 2015 this market share was ✂[ ]). This means that no single operator has SMP in for TI services above 2Mbps.

Volumes are low and declining in this market, and therefore the costs of imposing regulation on suppliers of high-speed TDM circuits is unlikely to outweigh the benefits of imposing regulation. Oxera proposes not imposing regulation on high-speed TDM circuits on these grounds. This approach was considered by Ofcom with reference to high-bandwidth TDM circuits in its recent decision on the business connectivity market.[58] In this case, Ofcom argued that Ethernet was an adequate and cheaper substitute for the small volume of high-speed TI services. Given the expected decline in volumes, Ofcom considered that imposing regulation would be disproportionate and unnecessary, and thus would not fulfil the European Commission's three criteria test.[59]

Oxera understands that ComReg is obliged to act in a proportionate fashion and impose regulatory remedies when appropriate and proportionate to the competition problems identified. In this case, ComReg may consider whether such a small volume of circuits is material, and hence justifies the cost of regulation for both the industry and ComReg.

Finally, given the market trend of migration to Ethernet, it is possible that remaining TDM circuits above 2Mbps also migrate to Ethernet at some point. Oxera also notes that relevant competition authorities could review wholesale provision of these circuits on a case-by-case basis if a complaint is initiated by a wholesale access seeker.

3.4.3 Ethernet services over 2Mbps—the wholesale Modern Interface market

The relative pricing analysis indicates a possible break in pricing conditions at 1Gbps, although this is only for a subset of services that attract limited demand. Oxera understands that the majority of NGN Ethernet circuits sold are configured on a traffic class of service configuration. For these circuits, there is no apparent

[57] Based on count method 3, on-net and off net combined and no adjustment for self-supply.
[58] Ofcom (2016), 'Business Connectivity Market Review – Volume I Review of competition in the provision of leased lines', final statement, 28 April, para. 5.48.
[59] Ofcom (2016), 'Business Connectivity Market Review – Volume I Review of competition in the provision of leased lines', final statement, 28 April.

discontinuity in prices at a specific bandwidth. Altering circuit length, core conveyance (region) or class of service introduces a level shift but does not shift relative pricing across bandwidths.

Supply-side evidence also suggests that a wide selection of bandwidths can be served at similar cost, and functional analysis does not reveal obvious differences in users across the speeds.

Based on this evidence, Oxera recommends a single Modern Interface (MI) market for all Ethernet speeds above 2Mbps, including services provided using xWDM, fibre distributed data interface (FDDI), fibre connection (FICON) and other alternative service types. This is likely to be a more forward-looking market definition, capturing the expected development and adoption of high-speed Ethernet services in general.

3.4.4 Modern Interface services under 2Mbps

As noted in section 4.1.5, the majority of Ethernet circuits (for example 94% of on-net circuits, see Table 2.3) currently in use are above 2Mbps and the current stock of sub 10Mbps Ethernet circuits are legacy connections that are declining in number and expected to fall into disuse as end-users demand higher-bandwidth lines. In this case, again, the costs of imposing regulation on suppliers of low-speed Ethernet circuits is likely to outweigh the benefits of imposing regulation.

Moreover, as we discuss in section 9 eircom does not have SMP in this market. Therefore, Oxera proposes that ComReg deregulates these circuits as with TI circuits above 2Mbps.

4 Trunk-terminating boundary in Ireland

Trunk networks may face different conditions of competitive supply, as higher densities of traffic along certain routes make it easier for OAOs to overcome barriers to entry such as scale economies. In addition, scope economies may exist for operators that are present in multiple downstream markets and rely on trunk connectivity such as broadband, voice conveyance or cloud computing. A trunk-terminating boundary captures these differences in competitive conditions based on (traffic) aggregation switches in the prevalent network.

The trunk market is adjacent to the terminating market in that leased line suppliers require trunk and terminating segments to complete an end-to-end link (if separate trunk and terminating segments are defined). For this reason, the definition of the trunk market affects the terminating market definition (and vice versa). The boundary between these markets therefore determines the scope of the terminating segment market (product and geographic), and has implications for market assessment and remedy design.

Table 4.1 summarises the current definition of trunk terminating segments in Ireland. This definition implies that low-speed (<155Mbps) circuits that traverse high-traffic urban areas are considered the 'terminating' segment for the entire length.

Table 4.1 Current trunk-terminating boundary definition

Definition	Competitive supply criterion	Reference architecture	Implications
Trunk defined as tandem connectivity between areas of high traffic density—i.e. via STM-1 (155Mbps) capacity or above (see Appendix A1.4)	Two or more OAOs present in exchange or nearby (definition of nearby in previous consultation based on case-by-case analysis given limited data availability)	Based on TDM network architecture; applies to TDM and NGN circuits	Trunk definition unlikely to capture market changes, such as the shift to Ethernet and increased OAO network presence The 155 Mbps speed criteria may no longer be appropriate

Source: Oxera based on information provided by ComReg.

Market developments described in section 2.2 suggest significant changes to the leased lines market, which mean that a change to the existing trunk terminating boundary definition may be appropriate. In this section we define appropriate trunk-terminating boundaries for TDM and Ethernet circuits in Ireland based on the available evidence and expected market developments. The section is structured as follows.

- Section 4.1 discusses differences in TDM and NGN architecture which (in addition to market developments) mean that it is appropriate to define separate trunk-terminating boundaries for TDM and Ethernet circuits in Ireland.
- Section 4.2 sets out our proposed trunk and terminating segments definition for TDM circuits in Ireland.
- Section 4.3 sets out our proposed trunk and terminating segments definition for Ethernet circuits in Ireland.

4.1 Different trunk-terminating boundaries for TDM and Ethernet circuits

Given the two networks in use in Ireland (TDM and Ethernet), there are two potential trunk-terminating boundary definitions that could be used:

1. a common trunk-terminating boundary for TDM and Ethernet technology; or
2. separate trunk-terminating boundary definitions for TDM and Ethernet technology.

Divergent competitive conditions (and architectures) may suggest a separate definition, while more pragmatic, forward-looking considerations might consider Ethernet as the focal network and product of the future. Crucially, a common trunk-terminating boundary definition based on, say, the Ethernet network would also require that the aggregation opportunities in Ethernet and TDM networks overlap so as to potentially capture replicable (by both eircom and OAOs) segments (i.e. trunk segments) of leased line circuits.

Oxera has analysed the overlap between eircom's TDM and Ethernet networks, as detailed in Appendix A1.2. In summary:

- there is some overlap between the two networks; however, at certain critical points in aggregation (i.e. edge nodes for the Ethernet network and PPC interconnection sites for the TDM network) there are differences. Additionally, there are differences in the way both TDM and Ethernet networks are organised. TDM networks were designed with digitised voice traffic in mind, and tend to map onto existing copper-based PSTN network exchanges. Ethernet networks evolved from the local area network environment and were designed to link workstations with a packet-based connection protocol in a 'connectionless' manner;
- Oxera also notes that differences in the networks of eircom and OAOs such as technology and topology are also important in that the definition should capture aggregation opportunities for the incumbent and access seekers. In this context we note that:
    - market evolution suggests that TDM demand has fallen and demand for Ethernet services has increased. This is likely to affect the conditions of supply on TDM and Ethernet networks differently and could lead to divergent aggregation/competitive opportunities for OAOs;
    - the NGN boundary reference should also be forward-looking, as it needs to capture OAO aggregation opportunities and potential OAO network roll-out (as OAO mainly supply Ethernet services and increasingly interconnect with Ethernet). In contrast, as far as Oxera is aware, there is no recent or planned eircom or OAO TDM network expansion.

Given the evidence on hierarchical differences, overlap analysis as well as market and historical evolution, separate TDM and Ethernet trunk-terminating boundaries are appropriate for the Irish context. These separate boundary definitions can reflect the variations in supply conditions by platform. Furthermore, this is consistent with the finding in section 3 that TDM and Ethernet circuits are in different product markets.

4.2 What delineates the TDM trunk-terminating boundary?

Oxera considers the following options to analyse if there are differences in competitive conditions between different TI circuit segments to define a TDM-trunk terminating network boundary:[60]

- a boundary based on re-assessing the competitive supply to discrete TDM exchanges—i.e. 'urban nodes' as previously defined by ComReg;[61]
- a boundary in terms of a specific hierarchy (or type of TDM site) that broadly reflects OAO supply conditions—e.g. PPC interconnections points.

Both the first and second options start by defining a notional trunk market first. The terminating segment market then naturally follows from this definition. The main difference between them is the choice of node or network point that may form the boundary. In both these cases, notional trunk segments would be defined as segments that connect between different boundary locations. Terminating segments are the remaining portion of circuits—i.e. those that connect the boundary location to the end-user.

Based on our analysis, we find that:

- a revised set of 'urban nodes' may not fully capture OAO presence and may require the specification of a distance that operators are prepared to dig in order to connect to eircom. Such a distance is likely to vary greatly across geography. In addition, a general node list approach may require regular revision, at the expense of additional regulatory resources;
- a definition based on PPC interconnection points has conceptual merit in that it reflects actual OAO presence. Problems in more dense urban areas could arise whereby some OAOs possess the equivalent of trunk links, although these could be solved by rationalising and updating the set of active PPC sites.

Conclusion

Given the available evidence, a TDM trunk boundary based on a clear, revised set of PPC interconnect sites would balance the requirement to capture the presence of potential breaks in competition in the market (if these exist). However, as discussed in section 9 we find that the competitive conditions for different TI circuit segments are similar, and that eircom has significant market power in end-to-end TI circuits which include segments from an end-user premises to the nearest serving PPC interconnection exchange, and for links that extend between PPC interconnect points.

Given the absence of current (and prospective) breaks in competition in different TI segments, we propose that the national wholesale terminating TI market be defined to include the entire circuit i.e. the end-to-end TI circuit. We note that this TI terminating market definition is similar to the current terminating market definition but with a lower speed threshold. The current terminating market definition defines the entire length of all circuits with speed less than155Mbps as terminating segments.

[60] Oxera notes that approaches across member states vary—the UK, Austria, Estonia and France take a hierarchical approach and identify the trunk network via OAO points of interconnection. Spain and Portugal define terminating segments beginning from the terminating segment.
[61] ComReg (2010), 'Leased Line Markets: Review of urban centres, Response to Consultation 09/86 and Final Decision', ComReg document 10/12, 15 February.

The proposed definition limits the implementation complexity within the context of a declining TI market (see section 2.2), and reduces the regulatory complexity for both operators and ComReg as existing regulations could be continued for this segment of the market as appropriate.

4.3 What delineates the NGN trunk-terminating boundary?

Ethernet supply has changed considerably since the previous leased lines market review. At the time of the previous review, Ethernet was still an emerging product, with NGN network deployment still in early roll-out phase.

As with TDM networks, the trunk-terminating boundary could be based on network hierarchy (delineating trunk and terminating networks by type of site) or a discrete exchange approach. Oxera considers two options to delineate the Ethernet trunk-terminating boundary:

1. define the boundary based on NGN Edge and Core nodes. This would mean:
    a. defining trunk segments as circuit segments that pass between NGN Edge and Core nodes;
    b. defining terminating segments as traffic subtending NGN Edge and Core nodes to an end-user and not traversing to another Edge or Core site.
2. define the boundary based on existing NGN aggregation areas. This is conceptually similar to the approach above, but is less specific in where the points of aggregation or boundary exists. In this case:
    a. trunk segments would be defined as circuit segments that pass between NGN areas. This may reflect that OAOs can aggregate traffic between regions, albeit from slightly different locations;
    b. terminating segments would be defined as segments from an end-user that remain within an aggregation area as defined by eircom's hierarchy.

Another option would be to define the boundary with reference to existing NGN aggregation nodes. This is a more granular approach, defining the boundary at a subset of eircom's 141 aggregation nodes as the lowest point of Ethernet aggregation in the network. Based on analysis of the different options, we find that:

- the 'NGN Edge and Core nodes' and 'aggregation' approaches are conceptually similar, and mainly differ on where OAO aggregation equipment is located;
- OAOs have extensive fibre routes at the regional level. This facilitates alternative interconnections between regions. Circuit inventories show that OAOs are generally not dependent on eircom inputs to serve end-users. Together, these points suggest that to the extent that OAOs are reliant on eircom, this is to supply terminating segment for Ethernet services in some instances;
- there is a lack of evidence to support a stable, consistent trunk boundary at the aggregation node level. This definition is based on assessing OAO locations in proximity to eircom's NGN nodes. There are significant practical issues in undertaking this analysis, given the lack of an objective distance measure to determine the constraint imposed by OAO locations near to (but not co-located with) eircom NGN nodes.

4.4 Conclusion

The available evidence suggests that OAOs are able to aggregate Ethernet traffic between regions in Ireland. At a granular level, the evidence shows variations in supply that would make a node-based approach unworkable. The NGN area approach also allows for flexibility with regard to the location of OAO infrastructure, and hence captures not only eircom but also OAO aggregation opportunities. Therefore, Oxera recommends the aggregation area approach to define the Ethernet trunk-terminating boundary.

This means that all MI circuit segments between different NGN aggregation areas are defined as trunk circuits. Circuit segments entirely within an aggregation area are defined as terminating segments.[62]

[62] This would include segments served by APT Reach nodes or any other Ethernet extension product, where these devices would be associated with the nearest (logical) NGN aggregation node.

5 Are wireless leased lines in the same market?

In this section Oxera considers whether wireless leased lines are in the same market as fixed leased lines.

Since ComReg's last review of the leased line market, there has been an increase in the prevalence of wireless leased line provision in Ireland, with a number of operators specialising in wireless leased line/network solutions at both the wholesale and retail level. There are now several operators in Ireland that offer or use wholesale wireless connectivity. These include operators such as Airspeed, Host Ireland and Digiweb, which offer wireless solutions in the wholesale (and retail) market, as well as mobile network operators (MNOs) such as Vodafone and H3G. In addition, we understand that BT and VM also provide wireless solutions in the retail market.

Some wireless operators have also gained access to OAO fibre networks such as those of enet and rail infrastructure to complement their networks and provide national services. At the same time, the demand for fixed circuits in Ireland is mainly for services below 100Mbps. Market data presented in Table 3.5 shows that ✂[ ] Ethernet circuits provide speeds of 100Mbps or below. This may enable a significant portion of leased lines to be served by wireless, even if fixed networks are capable of higher bandwidths.

The situation Ireland is thus likely to be different from other member states (e.g. the UK and France) where NRAs have found that wireless services are not substitutes for fibre or copper-based leased lines.[63] Various factors in these other countries may limit the substitution between fixed and wireless services. For instance, topographical or geographic features may mean that line-of-sight requirements limit radio link deployments. End-user density and the demand for high bandwidths may make it more difficult for wireless (relative to fixed solutions) to serve some markets. Oxera considers the evidence on wireless substitution specific to Ireland and whether such issues are also applicable in this context.

To assess substitution between wireless and fixed leased lines in Ireland, we consider:

- demand-side evidence such as service characteristics and marketing material (section 5.1);
- supply-side substitutability, including the geographic availability of wireless services (section 5.2);
- end-user analysis, including purchases by MNOs (section 5.3).

5.1 Demand-side evidence

5.1.1 Service characteristics

Oxera notes that many features of wireless and fixed leased lines are similar for bandwidths up to around 200Mbps, and that speeds of up to 1Gbps are possible to provide over wireless leased lines.[64]

[63] The Italian regulator, AGCOM, found that leased line connectivity where supplied to a mobile base station was in a different market to those supplied to other end-users, and noted that base station supply was characterised by wireless supply in addition to fixed infrastructures.
[64] Analysys Mason (2013), 'Competitiveness of the leased-line market in Ireland', report for eircom, 30 August.

Hence, the bandwidth limitations posed by wireless links may currently only apply to a small segment of services in Ireland, given the relatively low volume of services above 200Mbps (see Table 5.1). Approximately three-quarters of on-net wholesale Ethernet circuit volumes are less than 100Mbps. Around 80% of on-net circuits are less than 200Mbps. This suggests that the structure of demand is focused on bandwidths that wireless can deliver, and that OAOs are not reliant on the incumbent to deliver services above this level.

Table 5.1 Bandwidth distribution of wholesale On-net Ethernet circuits, 2015

Bandwidth	Number of circuits	Share of market	Cumulative share of market
Less than 2MBit/s	199	4%	4%
2–20Mbit/s	2,339	43%	47%
20–100Mbit/s	548	10%	57%
100Bit	953	17%	74%
100Mbit/s–1Gbit/s	377	7%	81%
1G	797	15%	96%
Above 1Gbit/s	239	4%	100%
Total for all bandwidths	5,452		

Note: Based on count method 1, for on-net volumes not adjusted for self-supply.

Source: Oxera analysis of ComReg market share summary data.

There are also some differences between fixed and wireless products. The main distinction between wireless and fixed services are that the operation of wireless leased lines requires a line of sight between the service end-points and that licenced spectrum is required for the types of services aimed at businesses. The requirement to have a direct line of sight between wireless end-points may make wireless better suited to certain locations generally.[65] However in Ireland this does not appear to limit wireless services. Evidence from HEAnet, which purchases a large number of leased lines on behalf of education institutions, shows that wireless bids did not lose out to fixed services on the basis of line of sight. HEAnet evidence is discussed further in Box 5.2.

A wireless link must have licensed access to radio spectrum (or frequencies). Spectrum is limited, as only certain microwave bands have desirable propagation characteristics and are available for commercial use. In Ireland, approximately 20 bands from 1.3GHz to 80GHz are available for the deployment of fixed links.[66] Scarcity of spectrum within these bands could also limit the constraint that wireless could impose on fixed solutions. Analysis conducted by ComReg's spectrum team indicates that there is some congestion in spectrum capacity in the Dublin area, and for this reason a specific band (13–15GHz) has been closed to new licensees.

However operators have responded by utilising available capacity in higher-frequency bands,[67] and Oxera understands that ComReg's upcoming Radio Spectrum Management Strategy may identify further bands (in cooperation with

[65] Oxera is aware that some wireless transmission technologies may offer non-line-of-sight operation, however the commercial deployments are currently limited. See Hansry, J., Edstam, J., Olsson, B.-E. and C. Larsson, (2013), 'Non-line-of-sight microwave backhaul for small cells,' Ericsson Review, edition 3, 22 February; and GSMA (2014), 'Wireless Backhaul Spectrum Policy Recommendations & Analysis', white paper, 2 December.
[66] See ComReg (2013), 'Guidelines to Applicants for Radio Links Licences' document 09/89R1, 11 December.
[67] It is possible that these bands better meet users' bandwidth requirements.

international bodies such as CEPT) that could be added to the licensing regime to increase capacity for fixed wireless links. It may also consider sharing mechanisms that could more efficiently use existing bands. The migration to higher bands may indicate that capacity is available, albeit in different bands and contingent on the propagation properties of such bands. As such, it is difficult to predict both the nature of future bandwidth demand and the ability of wireless technologies to deliver further capacity increases.

For instance, over the years, ComReg has modified licence conditions to accommodate new modulation schemes that can increase the capacity of a unit of spectrum.[68] Changes such as these and interference mitigation schemes have allowed link capacities to increase up to 1Gbps. Future developments such as Multiple Input Multiple Output (MIMO) may further increase link capacity. ESBT marketing material shows that speeds 'up to 300Mbps' are currently possible; information supplied by Digiweb states that 400Mbps is possible on a single link.

Another difference between fixed and wireless leased lines is supply lead times. For some installations (e.g. in areas where fibre has not been deployed in the access network), wireless services provisioning is likely to take a shorter time.

Overall, wireless radio links and fixed leased lines seem to have similar service characteristics, although there are also some differences between fixed and wireless radio link products. We also note that in some cases wireless links may be complementary to fixed—e.g. radio links could be used as back-up for resiliency, as they are not dependent on the same fibre infrastructure as fixed links.

Operator responses to the qualitative questionnaire also suggest that wireless can be both a complement and substitute. For example, ✂[] states that ✂[] uses such wireless technology where fibre delivery is not practicable. This view—that wireless is a complement/substitute and used when fixed solutions are not available—is shared by ✂[]. Another common view is that wireless is effective on a case-by-case basis. For example, ✂[] states that wireless radio is an effective solution up to approximately 300Mb but over that it becomes less credible, and that it is effective on a case-by-case basis because it requires line of site.

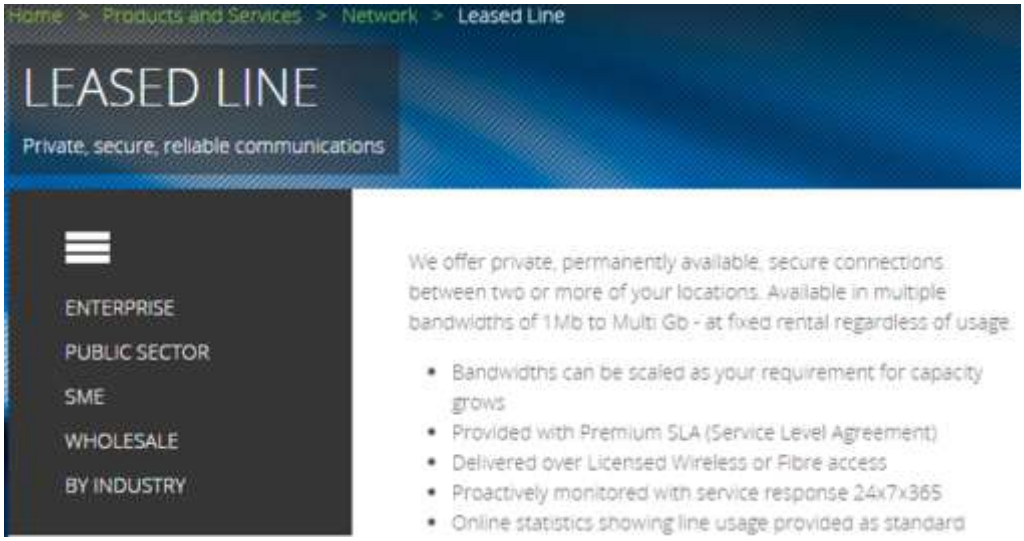
5.1.2 Marketing material

Oxera has reviewed Airspeed marketing material (an excerpt of which is shown in Figure 5.1). This suggests that Airspeed's wireless services are positioned as a leased line, equivalent to fixed solutions.

Oxera also notes that Host Ireland has recently started offering a 50Mbps symmetric service for approximately €200 per month. While this is for a contended service, it is a similar price to low-speed Ethernet circuits (at the same node), as per Figure 3.3.

[68] See ComReg (2009), 'Use of Adaptive Coding and Modulation in terrestrial fixed link bands', technical paper, 18 November.

Figure 5.1 Airspeed marketing material



Source: Airspeed website, http://airspeed.ie/.

5.2 Supply-side substitution

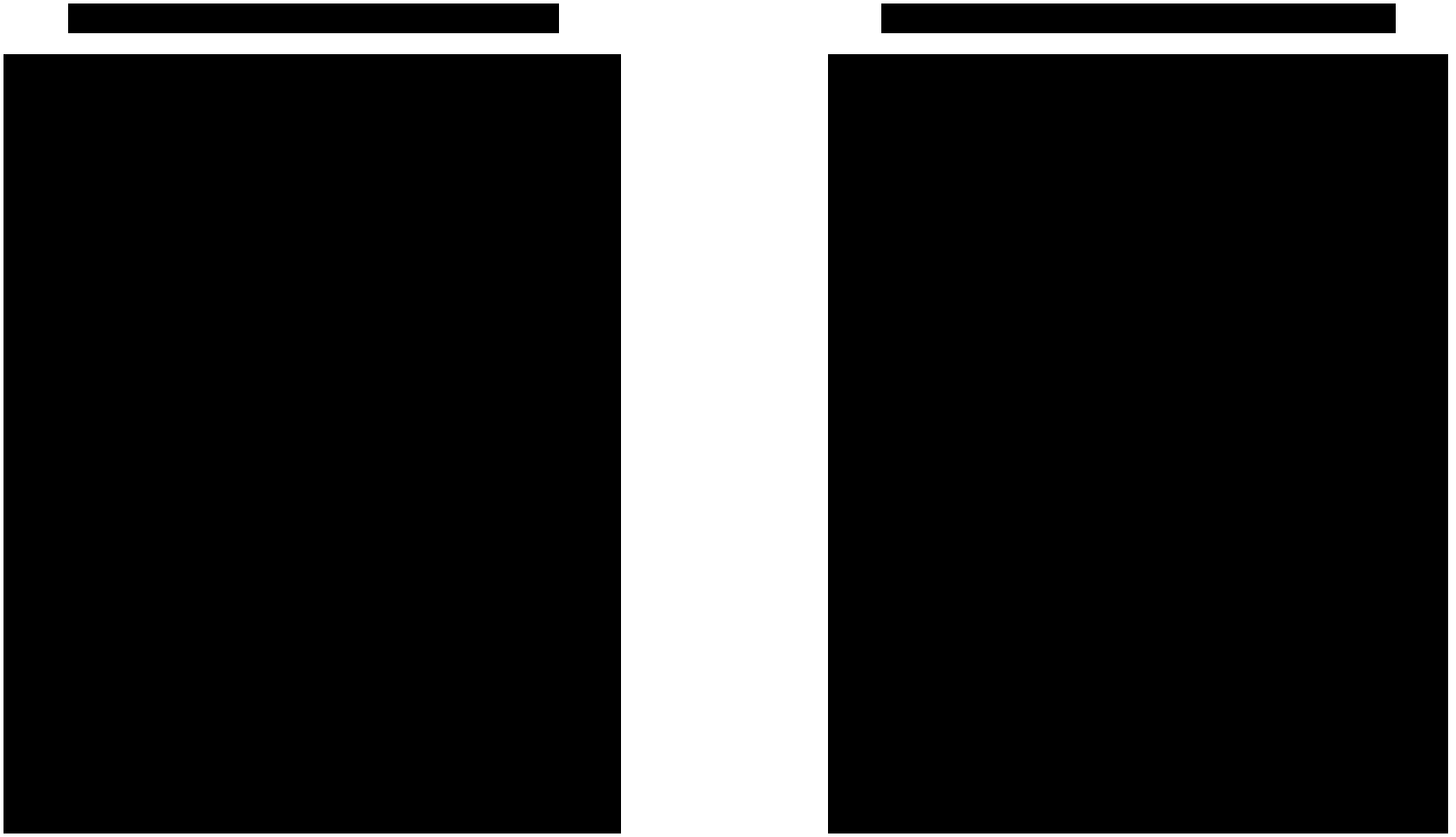
In this section we consider:

- the geographic availability of wireless leased lines—i.e. are wireless leased line solutions available nationally? (section 5.2.1)
- the ability of wireless service providers to expand and offer fixed leased line services (section 5.2.2).

5.2.1 Geographic coverage

Wireless networks serve end-users from a network of masts or high-site locations. ✂[ ] has a similar number—see Figure 5.2 below.

Figure 5.2 Locations in Ireland: Digiweb and Airspeed✂ [REDACTED]



Source: Oxera analysis of ComReg operator location data.

As can be seen from Figure 5.2 ✂[ ] high sites show relative clustering in urban areas such as Dublin and Cork, although ✂[ ] network is perhaps more dispersed in the west of Ireland. Based on this site clustering, both network operators are likely to have good coverage in urban locations, although local conditions (obstructions) could still limit availability. At the same time, wireless may be more appropriate in less dense areas that are not economic for fibre to serve.[69] For example, ✂[ ] stated that wireless was faster to deploy in less dense areas, and that spectrum limitations in urban areas make it difficult to deploy.[70]

However, evidence from HEAnet (see Box 5.1) and analysis by ComReg suggests that wireless operators can serve customers nationally and win business in these more dense areas as well.

5.2.2 Ability of wireless leased line operators to offer fixed leased line services and vice versa

This section considers the extent to which providers of wireless leased lines services could utilise their infrastructure to provide fixed leased line services if there was a SSNIP for the latter product.

There are different upstream inputs required for radio links relative to fixed leased lines. Wireless operators require access to spectrum, radio equipment and high sites to locate their antennae. Fixed operators need access to ducts (or wholesale dark fibre access) as well as aggregation sites to connect and switch traffic. This difference suggests that supply-side substitution between fixed and wireless operators is unlikely. However, as discussed above from a demand side perspective, in Ireland, fixed and wireless leased lines are substitutable.

5.3 Wireless end-user analysis

5.3.1 Retail end-users

Oxera has analysed ✂[ ] customers to see what type of user buys wireless leased line solutions. ✂[ ] clients by revenue are shown in Table 5.2.

[69] ✂[ ] stated that wireless is a second choice or redundancy service option in their response to the qualitative survey, Q8. This may suggest that it is used in locations where fixed solutions are not feasible, economically or otherwise.
[70] See ✂[ ] response to the qualitative survey, Q8.

Table 5.2 Top retail clients by revenue, ✂[ ], 2014 ✂ [REDACTED]

Note: ✂[ ].

Source: Oxera analysis of operator circuit inventories provided to ComReg.

Of ✂[ ] top 50 client revenue, only 36% comes from the private sector. However, excluding one institutional contract (HEAnet), the ratio of private sector revenue is 61%, thus it appears that the large share is driven by one particularly important contract (this is discussed further in Box 5.1).

This mix of ✂[ ] customer base is similar to that of fixed leased lines that also serve a similar mix of customers including private sector, government, local authorities and utilities.

Box 5.2 HEAnet as a purchaser of fixed and wireless inputs

HEAnet is a systems integrator (SI) of information and communications services, focused on servicing the needs of the Irish education sector. SIs combine inputs from a variety of suppliers to deliver bespoke, bundled IT solutions, rather than re-sell leased line products. For this reason they are neither a retail nor wholesale leased line operator from the perspective of this market review, but rather a retail customer. As a large purchaser of fixed and wireless leased line products with over 750 circuits under management, they provide an insight to demand substitution.

HEAnet provides 100Mbps circuits for post-primary schools, 1Gbps lines for Higher Education Institutions (HEI) and 10Gbpslines for large HEAs and Universities. The provision of circuits is spread across the geography of the State from islands off the Western seaboard to urban high tech campuses.

For campuses where HEAnet is the prime contracting authority (e.g. post-primary), it specifies the award conditions for leased line providers. For the framework period from 2009 to 2013, HEAnet applied technology neutral criteria and high SLAs in its award design, With over 8 fixed and wireless providers on the panel. The out-turn split between wireless and fixed solutions was 2:1. This split also applies to urban areas such as Dublin, where civil infrastructure access can be difficult to obtain.

Based on this procurement HEAnet report that wireless service performance was good and that tight roll-out deadlines were achieved. In some cases roof-top access on an end-users' site was difficult to access.

Under a revised framework for link upgrades, HEAnet have specified a fibre preference in the criteria, on the basis that it is more scalable for future bandwidth upgrades. A ✂[ ] award

premium applies to fibre based solutions. While some fixed operators have been able to increase their share of the services to campuses, HEAnet observe that some existing fixed solutions were replaced with wireless services. In general HEAnet has been impressed with the in-service performance of wireless services during this procurement process.

For hub site services (or third-level connectivity), bandwidth demands are high (1G and 10G). In these cases, HEAnet prefers fibre based solutions. It has found that no-bid situations occur where these sites are located in areas with no fibre infrastructure. Wireless leased lines are able to provide a solution in these cases.

Source: HEAnet interview with ComReg, 9 February 2016.

5.3.2 MNO purchases of fixed and wireless inputs

Mobile networks are large consumers of both wireless and fixed leased lines. The majority of point-to-point wireless licenses are licenced to MNOs and serve this end use.[71] A significant driver for this demand is the need to provide backhaul connectivity from mobile base stations back to collector sites.

It is common for MNOs to self-supply radio links to deliver this connectivity, and this is supported by licence data. These links are generally used exclusively for 2G, 3G or 4G mobile backhaul, to connect dispersed base stations to a central switching and interconnection facility. The single critical backhaul requirement these lines serve for MNOs means that supply to base stations is likely to be captive at many locations. Since this supply cannot be easily diverted to the merchant market, it is not plausible for self-supply from MNOs to constrain fixed leased line markets. For this reason, MNO self-supply should be excluded from the market.[72]

In locations where MNO backhaul and fixed leased line users overlap, the requirements for this connectivity are not particularly dissimilar to the demands made by other users of leased lines. Connections to mobile networks tend to require the following.

- **High availability**. Any disruption to the service will interrupt mobile network availability, which can affect revenue. MNOs tend to require tightly specified service-level agreements.
- **Dedicated connection**. Contention of the backhaul link could adversely affect the mobile end-user experience, so MNOs often manage link capacity themselves.
- **Low jitter**. A voice transport requirement means that excessive jitter can affect voice quality.
- **Synchronisation**. MNOs may have a specific requirement to provide precise synchronisation to base stations, so that mobile users can move freely between areas of network coverage without their service disconnecting.
- **Remote site connectivity**. MNOs may need to locate base station sites away from main business centres to serve some areas such as motorways or for rural coverage, or in areas that suit engineering requirements (i.e. coverage).

[71] Analysis of the licensees of point-to-point spectrum allocations shows that most are for MNOs. Oxera understands that the end-user is generally listed as the licensee, even under outsourced or turnkey network contracts.
[72] Note, however, that the circuit inventory data only allows identification of eircom's self-supply to Meteor, but not for other operators. eircom is the only wireless supplier where self-supply can be accounted for.

The first three characteristics are general to leased lines, regardless of whether the line is fixed. Synchronisation is a more telecoms-carrier-specific requirement, but one met by both wireless and fixed solutions.

The geographic aspect of backhaul demand is perhaps one where wireless and fixed solutions differ. If connectivity is required in a remote location, far from cable routes, then wireless may be a preferred solution as it will require less civil engineering. The fact that MNOs tend to require national coverage could mean that demand for backhaul is more geographically dispersed relative to other users of leased lines, and thus more likely to rely on wireless inputs.

Note that this does not mean that wireless is always a preferred product for MNOs. Increased smartphone data usage means that bandwidth demand for MNOs is growing, translating into higher loads on backhaul networks. 4G/5G mobile roll-out may also increase reliance on high-capacity backhaul in high-traffic density areas.

Oxera notes that there is evidence that MNOs use both fixed and wireless leased lines to meet their own connectivity needs (see Appendix A3.2). These wireless leased lines are usually self-supplied. The data shows that MNOs ✂[([redacted]] make significant purchases of fixed leased lines and continue to use wireless links, indicating potentially significant overlap in how MNOs view the two products.[73]

5.4 Conclusion

Functional analysis and case-study evidence show a strong overlap between wireless and fixed leased lines solutions. While there may be technical differences such as line-of-sight requirements, these do not appear to play a limiting factor in wireless deployment for leased line services in Ireland. A significant portion of lower bandwidth demand can be served by wireless, on a national basis. The assessment of end-users also does not find clear differences between fixed and wireless end-users, relative to Ethernet services. Marketing material and evidence from HEAnet experience suggesting pricing parity (or advantage) also indicates that fixed and wireless leased lines are demand-side substitutes.

In conclusion, while some wireless links could be better suited to some areas of Ireland (and could be complementary in some cases), wireless leased lines are a good demand-side substitute for fixed leased lines. Given the way the wireless market has developed in Ireland, with significant take-up, and that wireless leased lines are currently included in the market, Oxera proposes that wireless leases lines should be included in the MI market. This is because the majority of wireless leased lines supplied are over 2Mbps, and the majority of wireless leased lines use the Ethernet interface in Ireland. (✂[[redacted]] supplied about ✂[[redacted]] (≤2Mbps) wholesale lines in 2014, all of which were Ethernet).[74]

[73] Vodafone's lower purchases may be explained by its use of dark fibre (own or purchased) to self-supply mobile backhaul.
[74] See 2014 Wholesale operator volumes from ComReg. Note that Airspeed had around 144 retail Ethernet services in 2014, with no TDM.

6 Is broadband in the same market?

In this section, Oxera considers whether broadband services in Ireland could be considered a close substitute of leased lines, and thus part of the WHQA market.

We note that broadband services are not a homogeneous product, but rather offer a wide range of bandwidth speeds (generally asymmetric—i.e. lower upload than download speeds), quality of service and prices. Such variety of product characteristics is partly driven by technology. In Ireland, broadband is delivered over three distinct fixed platforms:[75]

- the current generation DSL network, which is based on eircom's copper network;
- the NGA network (including VUA[76] and the recently launched Virtual Ethernet Access, VEA,[77] service). This is available in areas where eircom has deployed fibre deeper into the access network (usually to the cabinet) and offers higher speeds than ADSL (with up to 20Mbps upload speeds possible), as well as potentially higher service levels;[78]
- VM's cable network.

Oxera notes that current generation DSL-based services as offered by eircom are only used by ✂[ ] to provide ✂[ ] services.[79] An existing wholesale product aimed at business users (Bitstream Ethernet Access) has not been taken up by OAOs. The main user of these CGA-based business products is likely to be ✂[ ]. For this reason, Oxera would expect limited competitive constraint from these services on WHQA services.

Of the remaining services, NGA-based broadband offers the closest functionality to leased lines. This is based on a number of attributes that are important for leased line customers—e.g. upload speed, latency/jitter and contention (see section 6.1.1).

Another potential substitute to leased lines is Ethernet in the First Mile (EFM) launched by BT Ireland in 2014. This service relies on eircom's LLU service and allows a range of speeds by the bonding of copper lines. We note that EFM is currently included in the leased lines market.

To assess whether broadband services in Ireland are a close substitute to leased lines, we consider:

[75] Broadband can also be provided over fixed wireless access (FWA) and mobile networks (using 3G and 4G). However, mobile broadband over 3G and 4G is primarily a service for nomadic users and has very different service characteristics to leased line services. Similarly, services provided over FWA are not comparable to leased line services and the use of FWA in Ireland is decreasing.
[76] VUA is a virtual local loop wholesale service that allows OAOs to access a customer's premises from eircom's local aggregation nodes.
[77] VEA builds Ethernet services on top of an NGA connection to allow OAOs to access a customer's premises from eircom's regional aggregation nodes in a similar fashion to bitstream services. This service has not as yet gained significant volumes.
[78] Unlike legacy DSL products, NGA-based products are designed to ensure that the backhaul network does not normally experience congestion. Furthermore, the product has the support of traffic-based class of service via the 802.1p VLAN marking feature. This allows certain types of traffic (i.e. voice) to be treated with priority on the NGN core network, a feature not supported by some legacy DSL products. Another feature of VUA products is that OAOs can choose to build multiple WEILs to service the same end-user connections. This provides a level of redundancy in the event that the OAO–eircom interconnect fails. Oxera understands that this feature is not available on legacy DSL services.
[79] The operator data supplied by ✂[ ] also indicated some low-speed DSL-based services, although, based on its submission, Oxera understands that all business services provided b✂[ ] use LLU y, fibre or wireless inputs rather than eircom DSL inputs.

- demand-side evidence, such as:
- service characteristics and marketing material (section 6.1.1);
- evidence from the retail business survey on end-user applications, service attributes importance and switching (section 6.1.2);
- relative pricing of NGA-based broadband and leased line services (section 6.1.3);
- supply-side substitutability (section 6.2).

Finally, section 6.3 considers whether EFM services are a substitute for leased line services.

6.1 Demand-side evidence

6.1.1 Service characteristics and marketing material

Looking at service characteristics is useful to assess the extent to which consumers consider different services as substitutes. The more similar the characteristics of two services, the more likely consumers are to consider them as close substitutes. We consider the service characteristics of eircom's NGA broadband and leased lines by focusing on wholesale services, as these determine the minimum characteristics of the operators' retail offering.

For NGA broadband, we analyse the characteristics of eircom's VUA service, including its FTTC and FTTH versions; while for leased lines, we consider eircom's TDM (below 2Mb) and Ethernet wholesale services.

Based on desk-based research, we find that VUA allows for speeds comparable to low-bandwidth leased lines as, in principle, VUA is capable of delivering symmetric speeds of up to 20Mbps (which is the maximum upload speed offered by VUA). However, our research also identified service gaps between NGA broadband and leased lines. These are:

- symmetric speeds are not guaranteed and symmetric connectivity cannot be provided at higher speeds based on VUA;
- lack of bandwidth guarantee—these services are provided on an up-to basis;
- absence of business class SLA;
- service availability: VUA offers up to 1.8 days (per year) of service downtime, while basic leased line services offer (at most) four hours—this is a material difference for businesses that consider connectivity a critical input for their day-to-day operations;
- latency/jitter: VUA cannot guarantee (100%) low and stable latency and jitter levels given that it uses shared capacity from the cabinet to the first aggregation node. Leased line services offer low and stable latency/jitter levels at all times;
- resilience: VUA does not provide end-to-end redundancy as it relies on a single local access loop at both ends of the connection. Leased lines offer end-to-end redundancy.

For a detailed comparison of NGA and leased line service characteristics, see Appendix A4.1.

eircom's VEA service

eircom recently launched a new NGA-based service known as VEA. This product offers higher service-level specifications than VUA but we find that this service is still not equivalent to leased-line-based services. ✂[ ] response to the Qualitative Survey also suggests the same:[80]

> [VEA] has similar attributes to a Leased Line but there are fundamental differences which prevent the VEA product from being a complete proxy for a Leased Line.✂ [ ] […] It is an 'up to' service and not all premises will be able to achieve the highest speed profile (100Mbps)

✂[ ] response suggests further gaps, including the inability to migrate larger leased line systems to VEA and limited availability of the service.[81]

Therefore, a service gap between VEA and leased lines is likely to exist in terms of service availability, contention and latency/jitter levels—all of which are important attributes to leased line users.

Marketing material

Marketing material (used by operators for advertising purposes) can provide further indication of the characteristics and potential uses of the relevant services.

We have analysed the marketing material of eircom's VUA service, which suggests that VUA is not marketed as an alternative service to leased lines—but rather as a broadband solution for residential consumers and small businesses to add TV and/or VoIP to their broadband service.[82] Furthermore, eircom's wholesale website advertises VUA and leased lines in different sections—in fact, leased lines are advertised with 'other data and facility services'.[83]

This suggests that VUA may be targeted at businesses that have different needs from those of leased lines users—e.g. businesses that may not attach a high value to quality factors such as service availability, low latency/jitter and end-to-end resilience.

This is in line with BT's response to the Qualitative Questionnaire, suggesting that broadband may appeal to a niche selection of businesses that do not value high levels of service reliability, and refers to examples of customers wanting to connect home workers or branch offices, as well as ATM machines.[84]

6.1.2 Retail business survey

The discussion in this section is based on evidence on the uses of broadband and leased lines from the retail business survey.

End-user applications and importance attached to different service attributes

The survey results suggest that broadband and leased lines are used differently by consumers. In particular, broadband is mostly used for email and Internet access; while leased lines are often used for multiple purposes, including email

[80] ✂[ ] 'Response to Annex 1 to the Request for Information dated 15/05/2015', pp. 85–6.
[81] ✂[ ] Response to ComReg's Qualitative Leased Lines Information Request', A.28.
[82] eircom wholesale, 'Next Generation Access (NGA)', Marketing brochure.
[83] eircom wholesale website, accessed June 2015.
[84] BT (2015), 'BT Response to ComReg's Qualitative Leased Lines Information Request', A.45.

and Internet, data services, connectivity between premises and VoIP services (see Table 6.1).

Table 6.1 Use of primary service (Q: What does your business use your service for?)

	Broadband		Leased lines	
	%	*ranking*	%	*ranking*
Email and Internet	97	1	85	1
Connectivity between premises	19	3	53	2
Employee remote access	18	4	49	3
Data services	25	2	47	4
Voice—VoIP	9	6	41	5
Disaster recovery services	11	5	34	6

Note: As noted in Appendix A5.4, the small sample size for many questions, including on potential switching between products, means that robust conclusions cannot be drawn from responses to these questions. This problem is accentuated for leased line users, and when looking at sub-segments of users (e.g. TDM users or high-bandwidth users).

Source: Oxera based on ComReg/REDC (2015), 'Market Analysis – Business Market Draft'.

This difference in use suggests that leased line users are likely to place a higher value on quality aspects that are important for multi-site connectivity, VoIP and data services such as contention, latency/jitter, symmetry and resilience. This is consistent with the survey results. The data suggests that leased line users tend to attach a higher value to quality aspects such as resilience and contention; while broadband users tend to attach a higher value to speed of connection (see Table 6.2 below).

In particular, the top three attributes (considered as 'very important') for lease line users are service availability, resilience and contention; while for broadband users these are service availability, download speed and upload speed.

Table 6.2 Aspects considered as 'very important' when selecting a supplier (Q: Thinking about your primary service, how important are each of the following aspects when selecting a service supplier?)

	Broadband		Leased lines	
	%	*ranking*	%	*ranking*
Availability	73	1	82	1
Resilience	51	4	61	2
Contention	39	5	53	3
Download speed	59	2	53	3
Upload speed	54	3	47	4
Latency	39	5	46	5
Jitter	38	6	44	6
Symmetry	39	5	37	7

Note: As noted in Appendix A5.4, the small sample size for many questions, including on potential switching between products, means that robust conclusions cannot be drawn from

responses to these questions. This problem is accentuated for leased line users, and when looking at sub-segments of users (for example TDM users or high bandwidth users).

Source: Oxera based on ComReg/REDC (2015), 'Market Analysis – Business Market Draft'.

Evidence on consumer switching

The business survey also provides information on the level of consumer switching between leased lines and broadband services. This indicates that switching between these two services occurs but to a limited extent: 8% of broadband switchers claim to have previously used leased lines as their primary access (mostly analogue leased lines).[85]

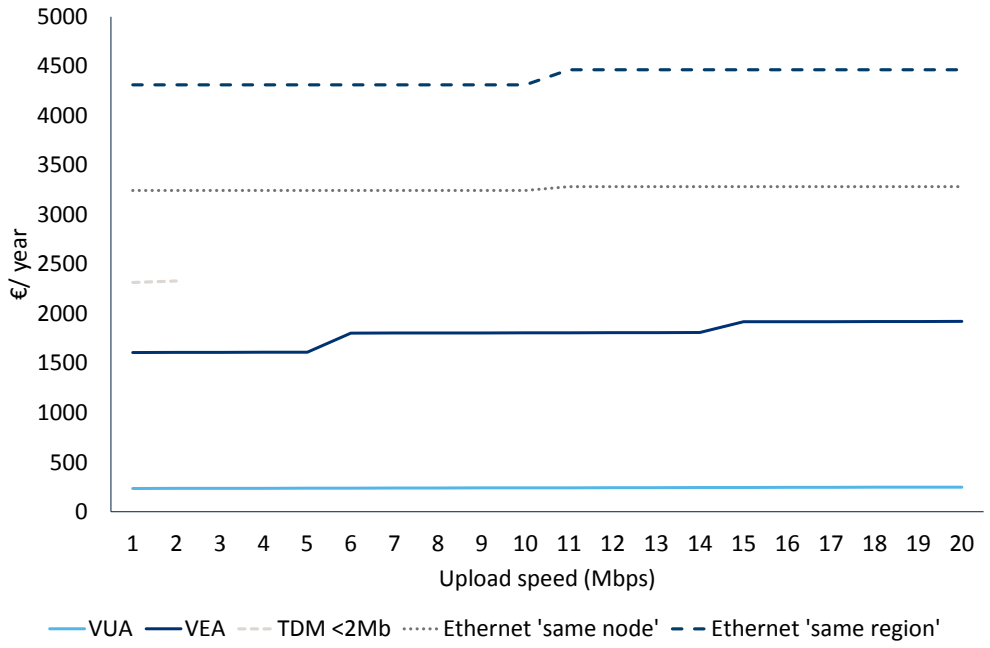
This is despite broadband services being priced considerably below leased line prices, as discussed below. This suggests that leased line users may not be willing to trade off lower service quality for lower prices.

6.1.3 Relative wholesale prices

Relative pricing could be indicative of differences in the underlying characteristics between services, and large price differentials could suggest that the relevant services have different attributes, and hence that consumers are unlikely to consider these services as close substitutes.

To inform our analysis we consider wholesale prices of NGA broadband (VUA and VEA) and leased line services for comparable upload speeds (i.e. under 20Mbps). These are compared in Figure 6.1 below.

Figure 6.1 Estimated annual costs of VUA, VEA and low bandwidth leased line services



Note: Upload speeds for the 50Mbps and 20Mbps VEA products were not available. Oxera has assumed that these follow the same download/upload speed ratio as the 70Mbps product, which is 70/20.

Source: Oxera based on eircom's price list.

Oxera's findings are summarised below.

[85] ComReg/REDC (2015), 'Market Analysis – Business Market Draft', Q.43 /Q.101, p. 66.

- Leased line prices are significantly higher than VUA prices (more than ten times higher). Despite this, we do not observe significant switching of leased line users to broadband services (see, for example, the retail business survey evidence in section 6.1.2). In addition, leased line volumes have not decreased in recent years (although there has been significant migration from TDM to Ethernet services, as discussed in section 3.1). This suggests that consumers may not see broadband and leased lines as close substitutes, as leased line users could switch to broadband and pay considerably less.

- Proposed VEA prices are seven to eight times higher than VUA prices. This price difference may reflect the higher service levels proposed for the VEA service (see section 6.1.1).

- VEA is cheaper than leased lines for all upload speeds—the price gap varies from leased lines being priced 40% higher (for speeds below 2Mb) to three times higher (for speeds above 2Mb). Our analysis of service characteristics in section 6.1.1 suggests such a price differential is likely to reflect different quality attributes.

6.2 Supply-side substitution

From a supply side, substitutability from broadband to leased lines is likely to be limited.

In Ireland, most DSL-based broadband providers are reliant on the incumbent for local access (LLU or current and next generation bitstream, including VUA). For bitstream, they do not have physical infrastructure at the local level to switch to providing leased lines, and may lack trunk connectivity. In order to switch, broadband operators would need to incur significant investments to build out local fibre or duct networks, as well as any backhaul or aggregation devices required to deliver uncontended services. These differences are likely to be reflected in the large price differential between NGA broadband and leased lines (see Figure 6.1).

Vertically integrated cable operators like Virgin Media are not reliant on the incumbent for local access in broadband markets, within their own footprint. However, cable networks are generally not engineered to deliver symmetrical services, and as a fundamentally shared local access medium they can be difficult to manage contention on. Nevertheless cable operators can offer leased line services off their fibre-based aggregation networks, and thus could supply leased line services. However, this is likely to be within a subset (aggregation/core) of their networks, which are generally deployed in residential areas. This suggests that some supply side substitution from cable broadband networks is possible but likely to be limited to certain areas.

Hence in general broadband operators may not be able to switch their production in the short term (within a year) to start supplying leased lines in response to a price increase by a hypothetical leased line monopolist.

6.3 Ethernet First Mile

Another potential substitute to leased lines is BT's EFM service, launched in 2014. This service relies on ✂[redacted] and allows a range of speeds by the bonding of copper lines. This service is currently included in the leased lines market, and EFM circuits are included in the leased line circuit count as the local access is symmetrical and backhaul can be engineered to be uncontended or uncongested.

The specifications of BT's EFM are quite similar to eircom's low bandwidth leased lines (Appendix A4.1). It offers:

- symmetric local access combined with backhaul which can be engineered to be uncontended or uncongested;
- business-grade service availability standards;
- uncontended bandwidths;
- resilience at the local access level.

Furthermore, ✂[ ] response to the Qualitative Questionnaire suggests that it has plans to ✂[ ] technology.[86]

Based on this, EFM is likely to be considered by consumers as a close substitute for leased lines, and thus part of the WHQA market. However, we understand that this service is only offered by ✂[ ] and ✂[ ], and that there is ✂[ ].[87] Thus, its impact on the assessment of market power (and therefore on remedy considerations) is not likely to be material. This will also be the case given the low existing and expected take-up of LLU in Ireland, which limits the current and prospective availability of EFM.

6.4 Conclusion

The evidence examined suggests that broadband services are not part of the WHQA market, for the following reasons.

- A product gap remains between NGA broadband and leased lines, relating to attributes that are important to leased line users, such as symmetry, service availability, resilience and low latency/jitter.
- NGA-based broadband is generally not marketed as an alternative to leased lines.
- A considerable price differential exists between NGA broadband and leased lines. Despite this, there is limited consumer switching from leased lines to broadband.

With regard to eircom's proposed VEA service, while this product offers higher service-level specifications than VUA, it is still not equivalent to lease-line-based services, as discussed in section 6.1.

Finally, as noted above, EFM is likely to be considered by consumers as a close substitute for leased lines and should be included in the MI market as it is based on Ethernet technology.

[86] ✂[ ] Response to ComReg's Qualitative Leased Lines Information Request', A.20.
[87] ✂[ ] EFM lines out of its ✂[ ] LLU connections. ✂[ ] also has a very small number of EFM connections. This volume would not affect any market assessment, but this could be relevant if eircom launches such a product.

7 Is dark fibre in the same market?

In this section, Oxera considers whether dark fibre is in the market for leased lines, either in the low-speed TDM market or the Ethernet product market. Dark fibre refers to wholesale rental of fibre optic cables (or pairs of fibre within a cable) owned by a network operator to a third party. This is a passive, physical infrastructure product that requires the end-user to provide the electronic equipment (switches, multiplexers, repeaters) to transmit data over the cable. In contrast, 'active' products are provided to end-users with the electronics and management to enable an end-to-end connection between locations.

In principle, dark fibre services can be availed by an end-user or an OAO seeking network extension. As OAO end use may be more common in Ireland, Oxera assesses demand- and supply-side substitutability of dark fibre from the wholesale perspective, although the retail market is also considered. In detail we consider:

- demand-side evidence such as:
  - a comparison of dark fibre to active, Ethernet leased line products service characteristics (section 7.1.1);
  - a review of current users and applications of dark fibre in Ireland to understand the potential end-user demand for dark fibre and the potential for substitution with active products (section 7.1.2);
- supply-side substitutability (section 7.2).

7.1 Demand-side evidence

7.1.1 Service characteristics

In this section we compare the features of dark fibre to active, Ethernet leased line products. We note that, given the unlimited bandwidth of dark fibre, it is likely to be a closer match to high-speed Ethernet services.

The product characteristics of dark fibre and Ethernet leased lines are presented in Table 7.1.

Table 7.1 Characteristics of dark fibre

	Ethernet leased line	Dark fibre
Interface	Ethernet, electrical or optical	Any optical interface
Download speed	2Mbps to 10Gbps	Unlimited
Upload speed	As above	Unlimited
Bandwidth/distance limitations	None	End-user must ensure link budget met—may need repeaters
Service availability	99.95% or better	High availability, but end-user must report faults
Resilience	Resilience options available	Managed by end-user
Quality of service/ traffic management	Circuit-oriented or traffic-based management	Defined by end-user
Contention	None	None
Latency/jitter	Specific levels can be guaranteed	Specific levels can be guaranteed
Synchronisation	Supported	Supported
Security	Secure link	Secure link
Geographic availability	National availability	May depend on local capacity limits, duct routes
Install lead times	May be restricted by wayleaves access	May require duct survey
Equipment needed by end-user	None	End-user requires terminal equipment

Source: Oxera analysis of operator and vendor technical data.

These service features show that dark fibre can enable high-quality connections, with high bandwidth, low jitter and latency. However, to enable this, end-users need to provide additional inputs, such as terminal equipment and switching locations. Dark fibre requires additional operational resources, in commissioning, acceptance testing, and administering a physical infrastructure. As the service is generally provided as unmanaged, the end-user must place additional resources into monitoring and fault reporting of the link. For end-users with a small number of links, these may be difficult or costly to provide, relative to managed, active products.

Oxera notes that preliminary pricing data on implied dark fibre prices, derived from a separate market 3a access pricing model is available. While it may be possible to compare these prices with wholesale active products, it is difficult to make valid comparisons. This is because, as noted above, users will require additional capital and operational investments before being able to use dark fibre to deliver active services. And this level of investment will vary depending on the types of active services delivered over the network. We examine this below using end-user analysis.

7.1.2 End-user analysis

Oxera has reviewed the inventory of dark fibre purchases between OAOs. These have some circuit descriptions, span lengths and location and, in some cases, a name of an end-user. This information can reveal the approximate use of dark fibre, which may help in indicating its position in the market. Oxera's assessment of the purchasers' requirements is shown below in Table 7.2.

Table 7.2 Dark fibre purchases, 2014✂ [REDACTED]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Source: Oxera analysis of operator infrastructure purchases.

Similarly, the ComReg operator data shows details on dark fibre sales by operators. This is shown below in Table 7.3.

Table 7.3 Dark fibre sales, 2014✂ [REDACTED]

Source: Oxera analysis of operator infrastructure purchases.

We note that:

- in addition to the services above, there are large corporate and institutional buyers such as HEAnet, Google, Amazon and Government Agencies that purchase dark fibre on a retail basis;
- the take-up of dark fibre in terms of volumes is low, with several hundred lines relative to the several thousand leased line circuits currently in use. In terms of value, this could be higher given the type of uses it is put to—most use is for backbone connectivity, with some use for connections to data centres and serving high-usage customers;
- using dark fibre for core connectivity is likely to be relevant for the market for trunk markets, rather than a terminating segment market. This would suggest that actual use in the terminating segment is quite low. Importantly, self-supply—or OAOs using their own fibre to serve customers with active products—is not revealed in the data;[88]
- the analysis shows that sales to end-users are very low, suggesting that dark fibre would only be suitable for very large, sophisticated users. This suggests that inclusion of dark fibre in the retail market would not affect a retail market assessment, given the low volumes.

The circuit inventory evidence of limited end-user uptake supports the findings from the service characteristics, in that dark fibre requires additional inputs and

[88] In this context, if eircom self-supply (of fibre-based NGN Ethernet services) is included in this market, eircom is likely to have a volume market share of around 30%, compared with market shares in the high 20s without this adjustment.

management by end-users. These two factors suggest that retail substitution is unlikely.

Wholesale purchasers of dark fibre may be better equipped to manage wholesale dark fibre, but limited use in the terminating segment suggests that dark fibre is not a demand substitute for active products.

7.2 Supply-side substitution

The following operators are known to supply dark fibre, based on the quantitative data supplied to ComReg on infrastructure sales: Aurora Telecom; ✂[redacted]; ✂[redacted]; enet; ESB Telecoms; EU Networks; and ✂[redacted].

Many operators supplied details of the A-end and B-end location of the wholesale dark fibre sales. ✂[redacted] sales mainly serve the 'T50' infrastructure that follows Dublin's orbital motorway. ✂[redacted] dark fibre connections are almost entirely to business parks. Enet's dark fibre sales are all rings sold on its metro area networks, with some connections to OAO interconnection points within these footprints. ✂[redacted]

Oxera notes that dark fibre is an upstream input to active leased line services, along with other passive inputs such as ducts and wayleaves (these upstream inputs are also used as inputs to serve adjacent downstream wholesale local access and broadband markets). Following this, dark fibre suppliers cannot easily expand capacity and start offering active leased line circuits in response to a potential price rise for active products. This is because, in addition to the requirement to combine inputs at various layers of the value chain, dark fibre suppliers face additional costs:

- **large fixed costs of offering active services**—to move from a pure dark fibre operator to an active product supplier, an operator would need a network of switched electronic (i.e. Ethernet equipment) in locations appropriate for aggregating customer traffic. Additional ongoing costs of network operations (e.g. maintenance, fault monitoring and repair, vendor support) would also be associated with moving to an active product delivery;
- **adjustment of business model**—some dark fibre suppliers leverage spare capacity that is in place as part of a control and monitoring network for other infrastructure (e.g. electricity grid, rail infrastructure). Dark fibre provision in this case can be structured as wholesale-only business, with few additional resources, dealing with a small number of retail partners. Switching to a business model that aims to deliver high-quality managed services to many different end-users could be challenging.

As such, supply substitution across the value chain is unlikely, as other inputs (i.e. electronic equipment, co-location) are required in addition to passive inputs to deliver secure, reliable symmetric connectivity.[89]

7.3 Conclusion

The demand- and supply-side analysis shows that there are barriers to switching from dark fibre to active products and vice versa. Dark fibre volumes are also relatively low, which may suggest that it has limited appeal for most users,

[89] This problem also exists in the demand-side substitution, in that inputs the supplier does not provide in delivering dark fibre need to be provided by the end-user.

relative to active products. This evidence suggests that dark fibre should not be included in the WHQA market—i.e. either the TI or MI markets as defined above.

8 Geographic market definition

In this section we review whether the available evidence suggests a national or sub-national geographic market definition for the WHQA product markets defined in the preceding sections. These are the MI market, which includes wireless leased lines (section 5), and the TI market. As discussed in section 6, broadband services are not included in the MI or TI markets (with the exception of EFM). Nor is dark fibre included in the MI or TI markets, as discussed in section 7.

The section is structured as follows:

- section 8.1 describes our approach to geographic market definition and discusses the data available for the analysis;
- section 8.2 presents the geographic market analysis for the MI terminating segments market;
- section 8.3 presents the geographic market analysis for the TI terminating segments market;
- section 8.4 presents on-net and off-net market shares to analyse the extent to which OAOs are dependent on eircom infrastructure to provide leased line services; and
- section 8.5 concludes.

8.1 Approach

Different geographic areas can form a single market if supply and demand conditions are similar. However, the SSNIP framework used to define product markets is generally not useful for defining geographic markets in the context of supply of access at a fixed location. End-user locations such as business premises are fixed. This means that it is not generally feasible for end-users to move location to avail alternative services in response to a price increase. A SSNIP framework would thus suggest artificially small markets, with potentially each fixed location being defined as a separate market. A standard analytical framework to use in this context is the homogeneous competitive conditions (HCC) approach, which aims to identify geographic areas with competitive conditions that are distinct from the surrounding areas.

In delineating geographic areas, analysis can consider similar factors as in the product market definition—product features, availability, consumer preferences, etc. Differences in service offerings (e.g. in bandwidth, technology or SLAs) across regions may indicate differences in demand or supply. In this context we note that all operators' leased line offerings in Ireland are marketed uniformly on a national basis, subject to availability.[90] This national menu of leased line services offered and purchased in Ireland suggests a national market.

The other main driver of competition in terminating segments of leased lines is the presence of OAO infrastructure at a local level. Disaggregated geographic-level data (say at the level of exchanges) on the extent of OAO infrastructure within the terminating segment would be useful in this context. Analysis of this data would show if there are differences in competitive conditions across geographic areas in Ireland, and whether it would be appropriate to define sub-national markets.

[90] Differences can occur depending on the use of on-net and off-net services.

In Ireland, business parks and data centres are geographic groupings that could delineate different geographic WHQA markets. Business parks and data centres contain a significantly higher density of demand than other locations. The practice of making some of these locations 'carrier-neutral' may also mean that the supply of leased lines to these locations is more competitive compared with other areas.

We use market share estimates in section 8.2 to test (based on the data available) whether competitive conditions in these business parks and data centres is sufficiently different to define separate geographic markets. We find that this is not the case.

8.1.1 Data available

The following datasets are useful in testing if there are separate geographic markets for MI and TI or if there is one national MI and one national TI market:

- circuit inventories;
- OAO network location data;
- fibre route location data;
- business park and data centre location data;
- business location data. This is a sample of 16,589 small, medium and large businesses in Ireland. It is segmented into five categories, based on the number of employees.[91]

This datasets are discussed in detail in Appendix A5.

Oxera notes that business location and fibre route location data is likely to be the most important, as this could link the source of leased line demand to local OAO availability.[92] A geographic 'reach' analysis could identify how many different OAO networks each business location would be able to connect to within a specific distance. By grouping business locations into areas (streets, counties, regions), it may be possible to summarise and compare competitive supply across areas. While some data is available, it does not permit a geographic 'reach' analysis, as discussed in section 8.1.2. However, the data does suggest some geographic variation in competitive conditions.

We study these geographic variations in competitive conditions further based on address data on terminating segments of leased lines. We use these addresses to assess market shares within and outside business parks and data centres. This is based on a list of 209 business parks and data centres [see Appendix 5 of the accompanying ComReg consultation]. We consider business parks and data centres where two or more OAOs supply services using their own infrastructure.

8.1.2 Data analysis

Limited ability to implement a reachability analysis

A 'reachability' analysis would compare the ability of businesses in different geographic areas to easily reach alternative infrastructure, such as a fibre cable

[91] These are 11–20; 21–50; 51–100; 101–250; and greater than 250.
[92] Oxera understands that the fibre route information is supplied by ComReg on an as-complete-as-supplied basis from the OAO. Oxera interprets the supplied fibre route data to represent OAOs' fibre in the terminating and trunk segments, and that, specifically, it includes fibre at the deepest level (closest to the end-user) that each OAO has. However, it is possible that some fibre route information is missing.

or network access point.[93] This assumes that network operators could connect an end-user within a specific distance from their network footprint.

However, limitations in the data available means that this type of detailed geographic analysis is not feasible. For instance, some fibre routes for some operators are 'logical', explaining connected nodes rather than physical routes.[94]

Identification of competitive conditions in an area based on reach from a network to an end-user also requires a reliable estimate of how far an operator would extend its network in order to connect a customer.[95] Again, it is not practicable to undertake this analysis, as this would need to take into account:

- differences in local authority planning rules, which affect deployment costs (per metre) and lead times of civil infrastructure. These vary widely across areas. Oxera notes that these differences are not fully delineated by a specific local authority (i.e. county), nor by whether an area is urban or rural, commercial or residential. For example, Oxera understands that in some areas, such as Dublin, wide differences in planning rules apply to certain roads (i.e. strategic transport routes vs local access roads) and can even vary within a single road. The implication is that economic dig distance could vary at a granular level;
- planning rules, which may mean that it takes a few months to apply and receive planning permission. The implication is that using passive access (such as ducts) as a substitute for active leased lines may not be feasible in the context of bidding for specific contracts where new build is required.

As a result, a reachability analysis sufficiently reliable to identify clear, sustainable differences in competitive conditions is not feasible with the data available.

But the data available suggests some geographic variations in competitive conditions

Although the data does not allow for a detailed reachability analysis, it does suggests that there are some geographic variations in competitive conditions. These data include:

- locations of business parks/carrier-neutral data centres and OAO presence at these parks;
- network maps;
- business location data.

In sections 8.2 and 8.3 we discuss whether this geographic variation in competition conditions in the MI and TI product markets means that it is appropriate to define sub-national markets or whether it is appropriate to define national markets for each of these products.

[93] This type of analysis has been conducted on leased line market reviews in the UK context. See Ofcom (2015), 'Business Connectivity Market Review – Review of competition in the provision of leased lines', consultation document, 15 May.
[94] A misrepresentation of actual cable routes would add measurement error to such an analysis.
[95] Connecting a new customer to a network requires provision of cable route (fibre) into the premises, which requires either new ducts to be dug and laid or access to existing facilities. The large fixed and sunk costs of this mean that distances that are economical to connect are within a relatively short distance (possibly less than one kilometre) for most contracts.

8.2 Geographic variations in competitive conditions—Modern Interface

8.2.3 OAO presence at business parks and carrier-neutral data centres

Business parks are sites that contain clusters of typically commercial businesses. They tend to be located in suburban areas and near to main roads. As these tend to group similar types of end-user demand (i.e. corporate or IT-specific firms) in one location, the costs for OAOs connecting to these sites are lower.

Data centres are specific buildings (or sections of buildings) designed to host computer and telecommunications equipment. These may be used to serve telecommunications, data storage, processing and cloud computing needs. They usually require a secure site with specific power supplies, air conditioning and layout to permit easy interconnection. Carrier-neutral data centres are not controlled by a single network operator, and therefore their owners have an incentive to host multiple operators to enable them to offer advantageous connectivity terms to end-users.[96]

ComReg has reviewed connectivity to various business parks, third-level campuses and data centres and analysed if an OAO has site or cables (or third-party access to a cable) connected to it.[97] ComReg found that at 209 of these business parks and data centres two or more OAOs were connected.

This evidence suggests that these sites may have different conditions of competitive supply directly to an end-user location compared with areas outside business parks and carrier-neutral data centres. However, we note that this evidence is not sufficient to clearly delineate these areas because the areas adjacent to business parks may or may not have multiple OAOs serving them.

To test whether competitive conditions differ at business parks and data centres, Oxera assisted ComReg in assessing market shares for Ethernet services delineated by the list of 209 business parks and carrier-neutral data centres with two or more OAOs present.

8.2.4 Market shares in business parks and data centres

If competitive conditions differ at business parks and data centres, these differences should be reflected in market shares within and outside business parks and data centres. In this section, we present the results of the market share analysis for Ethernet services within and outside business parks and data centres.

For the purpose of assessing wholesale and retail market shares for these areas, Oxera notes that there are data limitations, such as the lack of precise geographic co-ordinates information on circuit or network termination points. This means that precise allocation between these two areas (and hence market share assessment) is difficult. The primary method of market share assessment has been a circuit-level assessment of the inventories provided by stakeholders, with the aim of identifying the circuit A-end and B-end locations as either business park/carrier-neutral data centres or outside these locations.

[96] Some data centres may be controlled by network operators, effectively leasing spare space within their exchange or node to end-users or other providers in the ICT value chain. Network operators of data centres may have an incentive to restrict OAO leased line access to these sites, in order to direct end-users to their own products.

[97] OAOs with nearby cables would still need further investment to connect and therefore exert limited competitive constraint.

Appendix A5 outlines further details of the data available and the limitations inherent in using this data, and the cross-checks of circuit inventory counts within and outside business parks/data centres by ComReg undertaken by Oxera.

Based on this analysis, the market shares for retail and wholesale Ethernet services above 2Mbps are presented in Table 8.1 and Table 8.2 below.

For retail MI services, there appear to be few differences in market share measures between the two groupings. Concentration measures are comparable, and the main difference appears to be that eircom has a somewhat higher share in the absence of regulation. There are some differences—e.g.✂[redacted] wireless appears to have somewhat higher market shares outside business parks, whereas✂ [redacted] has stronger presence within business parks. However, overall, the differences are not substantial, and eircom's retail market share inside and outside business parks is similar to its market share measured nationally.

The difference in market shares in the provision of wholesale MI services is greater than in the retail MI market. eircom has a higher market share outside business parks, more so in the absence of regulation.

These differences suggest that there are some differences in OAO competitive supply in these areas. However, eircom's wholesale market share may not be an accurate measure of OAO competitive supply. This is because, as discussed in section 8.4, the majority OAOs do not depend on eircom's wholesale leased line inputs to supply Ethernet circuits (which will be the majority of the circuits supplied to business parks and data centres).

Table 8.1 2014 MI retail market shares, within and outside business parks ✂ [REDACTED]

[redacted]

Note: Based on count method 3. Data excludes circuits below 2Mbps. (These MI circuits are declining in number and expected to fall into disuse as end-users demand higher-bandwidth lines as discussed in section 3.4.4). Figures in brackets are market shares assuming no regulation in the leased lines market. This means that off-net leased lines supplied by OAOs based on eircom inputs are assumed to revert back to eircom. Off-net leased lines supplied by

OAOs based on other OAO inputs which are not regulated are assumed to be continued to be supplied by the OAO.

Source: Oxera analysis of operator circuit inventory.

Table 8.2 2014 MI wholesale market shares, within and outside business parks ✂ [REDACTED]

Note: Based on count method 3. Data excludes circuits below 2Mbps (These MI circuits are declining in number and expected to fall into disuse as end-users demand higher-bandwidth lines as discussed in section 3.4.4). Figures in brackets are market shares assuming no regulation in the leased lines market. This means that off-net leased lines supplied by OAOs based on eircom inputs are assumed to revert back to eircom. Off-net leased lines supplied by OAOs based on other OAO inputs which are not regulated are assumed to be continued to be supplied by the OAO.

Source: Oxera analysis of operator circuit inventory.

8.2.5 Wireless coverage by geography

Wireless leased lines supply may vary based on the geographic location of their high sites, and this could drive a geographic break in conditions.

However, the available evidence is unlikely to be able to point to clear and stable boundaries. First, any wireless-based boundary would need to reflect actual areas serviceable by radio operators' high sites.[98] Wireless coverage areas are highly influenced by terrain, obstructions and other phenomena and are ultimately empirical in nature. Thus, definitive boundaries would not be possible without a large wireless coverage exercise.

Second, it is possible that a wireless-based boundary is not stable. Wireless availability may contribute to the state of competitive conditions, but may not be a sufficient condition to determine supply conditions. Also, the relatively short timescales in which wireless links can be delivered and reconfigured in some instances may imply that any such definition would not hold for the duration of the market review. This also suggests that that wireless's sub-national coverage is not instructive for the purposes of market definition.

Other available broad measures of geographic differences also do not appear sufficient to delineate separate geographic markets. Evidence from HEAnet's

[98] This would need to combine the radio mast, site and tower of all operators.

award of connectivity contracts to schools shows a similar ratio of fixed to wireless services' provision in urban areas and rural areas.[99] This suggests that wireless leased lines are equally likely to be supplied nationally and that wireless services are, at present, not constrained in offering services in any one geographic area, such as urban areas.

Finally, Oxera has assessed whether the market shares for within/outside business parks in Table 8.1 and Table 8.2 are driven by the presence of wireless operators.[100] This shows that that wireless supply only has a small impact on eircom's market shares within and outside business parks. eircom's market share in the absence of wireless circuits is similar to its market share with wireless supply within business parks. For areas outside business parks, removing wireless increases eircom's market share (with regulation) from ✂[ ]. This provides further evidence that wireless leased lines are not a major driver of differences in competitive conditions inside and outside business parks.

8.2.6 Business location data

Business location data on 16,569 small, medium and large enterprises in Ireland shows some clustering of end-user locations in urban centres such as Dublin, Cork and Galway, relative to rural locations.

Considered together with the network maps and wireless high-site locations, these business location data show that in general network supply overlaps with these end-user locations. This shows that network infrastructure, particularly alternative infrastructure, is likely to follow end-user locations. However, this data cannot be used to define where a break in competitive conditions might occur.

8.2.7 Conclusion

The available evidence indicates that there are some variations in competition by region. However, there is insufficient evidence to indicate that conditions of competition are sufficiently heterogeneous within well-defined and stable geographic areas that it would be appropriate to define a separate geographic market for MI services.

Business parks and data centres contain a significantly higher density of demand than other locations. The practice of making some of these locations carrier-neutral may also mean that the supply of leased lines to these locations is more competitive compared with other areas.

However, for retail MI services, there appear to be few differences in market share measures within and outside business parks and data centres. Concentration measures are comparable, and the main difference appears to be that eircom has a somewhat higher share in the absence of regulation.

For wholesale MI services, there are some differences in eircom market shares within and outside business parks, and generally eircom has a higher market share outside business parks. These differences in eircom's wholesale market shares within and outside business parks and data centres may suggest that there are some differences in OAO competitive supply in these areas; however, eircom's wholesale market share may not be an accurate measure of OAO competitive supply. This is because the majority OAOs do not depend on

[99] A reason cited for this was high civil infrastructure costs. HEAnet notes that areas such as Dun Laoghaire-Rathdown did not have fibre connectivity.
[100] Oxera's assessment from section 4 finds that wireless is included in the market for wholesale Ethernet services.

eircom's wholesale inputs to supply Ethernet circuits, as discussed in section 8.4.

This analysis suggests that competitive conditions in these business parks and data centres is not sufficiently different to define separate geographic markets.

Moreover it is possible that a geographic definition based only on a business park/data centre boundary results in heterogeneity within the groupings—that is, it is possible that other areas outside business parks and data centres have similar conditions of supply (e.g. business districts within urban centres) that are not explicitly captured and combined with this group. Furthermore, a boundary based on the location of a business park may lack delineation from nearby areas, if for example areas adjacent to a business park experience similar conditions of supply. Evidence relating to wireless coverage does not allow further precision to be made in geographic markets definition.

8.3 Geographic variations in competitive conditions—Traditional Interface

In principle, a similar type of approach to reachability analysis to that described in section 8.2 could be conducted for TI services. However, the same constraints on data and dig distance assumptions means that it is not possible to reliably assess TI network reachability.

Supply of TI services to business parks and carrier-neutral data centres could be competitive, in that these sites contain a greater density of end-users.

However, unlike MI services, TI supply is more concentrated, with eircom and BT supplying most services. It is not clear that high-demand business parks are concentrated sources of TI-specific demand. Low-speed TI services are not suited to centralised connections for cloud computing, high-volume data processing or storage. While it is possible that low-speed TI is required at some of these locations, it is not clear that OAOs are competing to provide these services. For this reason, it is unlikely that there is competitive supply of TI services to these sites.

In addition on-net and off-net market shares in section 8.4 show that, overall, OAOs are still reliant on eircom for wholesale inputs to supply TI services, unlike MI services. As discussed in section 2.2, recent trends show a migration away from TI, while new networks have been developed to serve mainly Ethernet-based MI services. Furthermore, this suggests that there are no differences in the competitive supply of TI services within and outside business parks.

Legacy networks also tend to be tied to eircom local exchanges, which are ubiquitous. Applications that are geographically distributed, such as traffic control and infrastructure monitoring (as discussed in section 3), may mean that TDM networks are also more dispersed, and thus more difficult for OAOs to replicate on a national basis.

8.4 On-net/off-net market share data

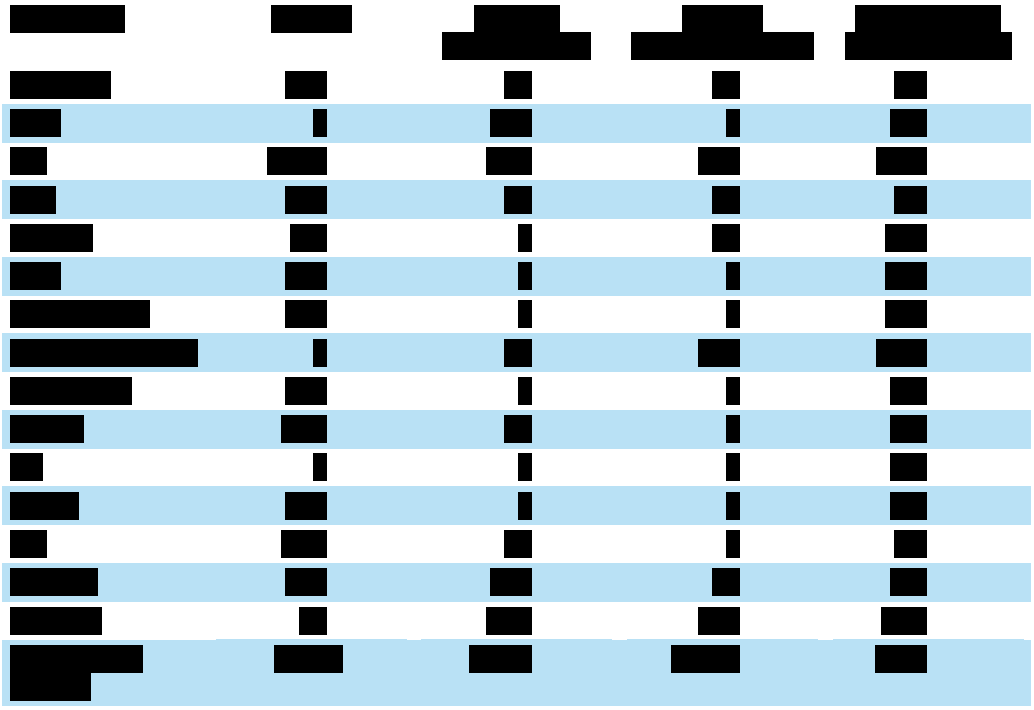
The split for of on-net and off net circuit types for retail and wholesale providers shows the extent to which operators are reliant on other providers, and particularly eircom.

With the exception of ✂[redacted] and ✂[redacted] (which has only core network infrastructure), reliance on eircom to deliver retail Ethernet-based MI services is low. Overall, only ✂[redacted] of retail MI services provided by OAOs

depend on inputs from eircom. In the wholesale market, the corresponding figure is ✂[ ] (see Table 8.3 and Table 8.4 below).

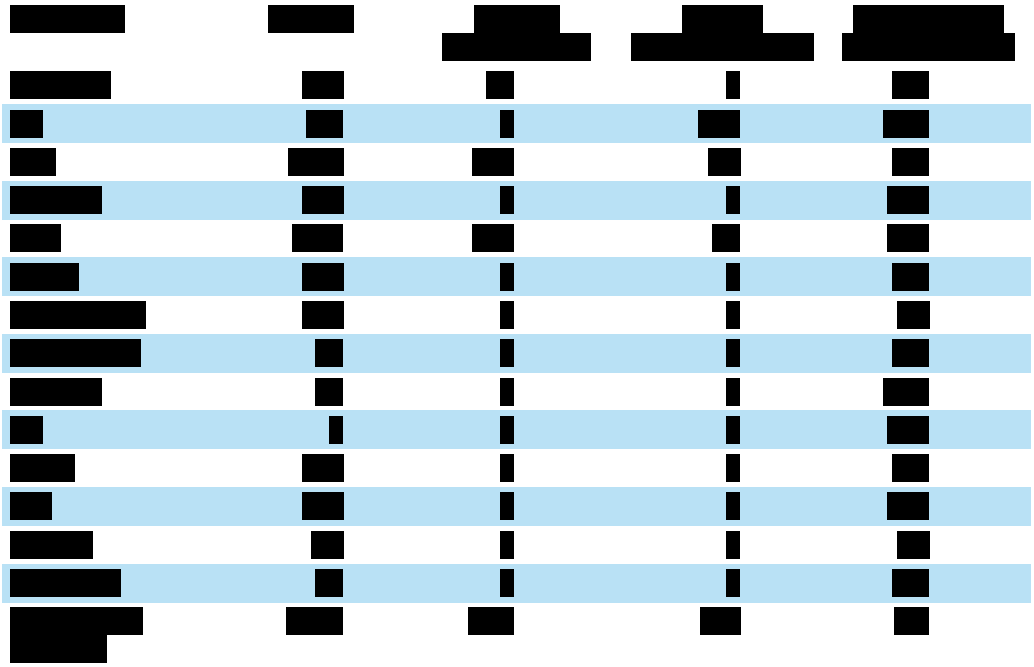
In general, OAOs are more reliant on eircom to provide TI services than MI services. Overall,✂ [ ] of retail TI services provided by OAOs depend on inputs from eircom. In the wholesale market, the corresponding figure is ✂[ ] (see Table 8.5 and Table 8.6 below). The fact that operators source a smaller fraction of wholesale connections from eircom may reflect that a significant proportion of wholesale inputs are used in serving retail users directly, rather than other wholesale users, and that the majority of TDM circuits are supplied by eircom as we discuss in section 9.1.

Table 8.3 Retail eircom off-net operator shares, MI, >2Mbps, 2015 ✂[REDACTED]



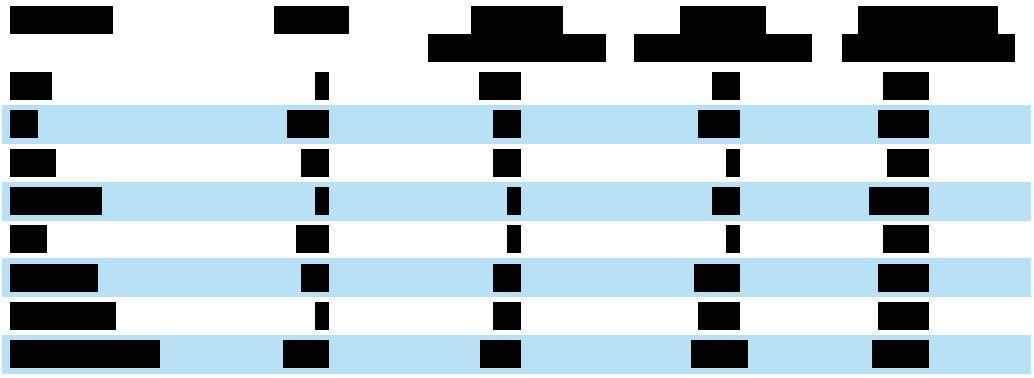
Source: Oxera analysis of operator circuit inventories, using count method 3.

Table 8.4 Wholesale eircom off-net operator shares, MI, >2Mbps, 2015✂ [REDACTED]



Source: Oxera analysis of operator circuit inventories, using count method 3.

Table 8.5 Retail eircom off-net operator shares, TI, ≤2Mbps, 2015 ✂ [REDACTED]



Source: Oxera analysis of operator circuit inventories, using count method 3.

Table 8.6 Wholesale eircom off-net operator shares, TI, ≤2Mbps, 2015 ✂ [REDACTED]

Source: Oxera analysis of operator circuit inventories, using count method 3.

8.5 Conclusion

One of the main drivers of competition in terminating segments of leased lines is the presence of OAO infrastructure at a local level. All else equal, greater OAO presence in a particular area is likely to be associated with lower prices, lower switching costs and more choice for retail and wholesale customers. There are some observable differences in competitive supply for business parks and carrier-neutral data centres relative to areas outside these locations. However, the analysis does not identify clear and stable geographic boundaries more generally.

This implies that a national market definition is appropriate for both the MI and TI services.

9 Market assessment

This section considers available market evidence to assess if eircom (or another operator) has SMP in the WHQA market as defined in sections 3 to 8. To summarise, Oxera proposes the following relevant product and geographic market definitions for the WHQA market.

A national wholesale Traditional Interface market

We define this market to include all analogue and digital TDM circuits (with speeds up to and including 2Mbps) and include the entire circuit i.e. the end-to-end link in the terminating segment following the market assessment evidence in section 9.1 which finds that the competitive conditions for different TI circuit segments are similar.

As discussed in section 3, the focus of any regulation, if required, should be on analogue and digital TDM circuits with speeds up to and including 2Mbps. These low-speed circuits cover 98% of TDM circuits (see section 3.1.5 and Table 2.2). TDM circuit volumes with speeds over 2Mbps are very low and declining (Eir sold ✂[ ] new high-speed TDM line in 2015, and there were ✂[ ] fewer lines in operation in 2014 compared with 2013). Hence, the costs of imposing regulation on suppliers of 'high'-speed TDM circuits are unlikely to outweigh the benefits of imposing regulation.

A national wholesale Modern Interface market

This includes all Ethernet-based services, including WDM and wireless leased lines. Terminating segments are defined as links from an end-user premises that remain within an NGN aggregation area as defined by eircom's hierarchy. Trunk segments are defined as links that pass between NGN areas.

As noted in section 3.4.4, the majority of MI circuits (for example 94% of on-net circuits, see Table 2.3) currently in use are above 2Mbps and the current stock of sub 10Mbps Ethernet circuits are legacy connections that are declining in number and expected to fall into disuse as end-users demand higher-bandwidth lines. In this case, again, the costs of imposing regulation on suppliers of low-speed Ethernet circuits are likely to be greater than the benefits of imposing regulation. Hence, the focus of any regulation, if required, should be on high-speed MI (above 2Mbps). We also note that the market analysis below suggests that eircom does not have SMP in the MI market generally.

The remainder of this section is structured as follows:

- section 9.1 assesses the market for wholesale TI services;
- section 9.2 assesses the market for wholesale MI services; and
- section 9.3 concludes.

In doing so Oxera considers the following factors when assessing market power where possible (based on the available market data):

- alternative infrastructure. Alternative infrastructure (other than eircom's) to deliver WHQA services, when present, is an important driver of competition in WHQA markets;
- market shares. Operator market shares in the TI and MI markets (including circuits provided on-net) are an important measure of market power;

- other factors. We also discuss entry barriers, prospects for competition, ability to leverage economies of scale and scope, and countervailing buyer power in the market power assessment. These factors are also likely to affect market power.

9.1 Market assessment for national wholesale TI services

9.1.1 Presence of rival infrastructure for wholesale TI services

Network coverage

Network presence mapping data presented in Appendix A1.1 shows that OAOs have a broad presence across Ireland. Fibre routes (see Appendix A1.2) show that OAOs are not dependent on eircom for connectivity between regional areas. As discussed in section 8, these measures are too broad to indicate presence at a local, terminating segment level. In addition, to measure market power for TI services, a measure should distinguish between OAOs that offer TI services as opposed to other WHQA services. Such detailed network data relevant to the terminating segment is not available.

Moreover as discussed in section 9.1.3, it is unlikely to be commercially viable for OAOs to use fibre networks to deliver TDM-based services, as the conversion equipment required for interconnection between TDM and Ethernet lines is costly. Hence, while there is evidence of extensive OAO fibre routes throughout Ireland, this does not suggest that OAOs can provide TI services based on their own inputs.

Reliance on other suppliers to complete circuits

Table 8.6 shows on-net and off-net volumes for the wholesale TI market. This shows that OAOs rely on eircom to supply around ✂[ ] of wholesale TI lines. This indicates a relatively low reliance; however, most of the market is supplied by eircom and BT. A large proportion (over ✂[ ]) of total off-net supply is provisioned by eircom, suggesting limited choice in alternative infrastructures.

Oxera understands that BT is expected to transfer around ✂[ ] of its 2Mbps circuits to Ethernet in the near future.[101] Following this, eircom will further solidify its primary position in supplying TI services nationally. Also, given the market migration to Ethernet-based MI services (section 2.2), the TI market is a declining and hence a forward-looking assessment of rival infrastructure suggests increasing reliance on eircom for the provision of TI services.

9.1.2 Market shares for wholesale TI services

Approach

Oxera has assessed the market share for national TI terminating segments using the operator circuit inventory data gathered by ComReg. In doing this, some methodological considerations and choices were made, as follows.

- In general, data gathered reflects circuits provisioned on a national basis, with no break-down for trunk or terminating segments. This is because OAOs are not obliged to distinguish between trunk and terminating

[101] ✂[ ] Operator data supplied by ComReg.

segments. For eircom, effectively all low-speed circuits will be classified as terminating segments, based on the previous market definition.

- Volume-based assessments. ComReg also gathered value-based information from operators (e.g. circuit rental revenue); however, this information is not always complete. In addition, practices such as bundling with other services make rental revenues a less reliable measure as it is not always possible to separate out circuit rental revenue from revenues for other services. This is why we use circuit volumes to estimate market shares.
- On-net and off-net. In general, Oxera considers market shares as the combination of on-net and off-net volumes.
- Modified greenfield approach. Where appropriate, Oxera also considers market shares in the absence of wholesale regulation. This implies that eircom is no longer obliged to offer regulated wholesale access to OAOs in the WHQA market. To calculate market shares under this assumption, Oxera assumes that all wholesale volumes of off-net circuits provided by eircom would revert to eircom's volume count.
- eircom and OAO self-supply is generally included as discussed in section 2.3.6.

In addition, features of the data required several further choices to be made, and this is discussed in Appendix A5.1.

Market shares

Table 9.1 presents market shares based on reported volumes sold by each retailer, and includes both off-net and on-net volumes.

Table 9.1 Wholesale TI market share with regulation (≤2Mbps) ✂ [REDACTED]

Note: These market shares are based on count method 2 and include both on-net and off-net circuit volumes sold by each operator.

Source: Oxera analysis of operator circuit volumes.

These market shares show that eircom and BT have the highest market shares, and that high retail market shares are persistent. Table 9.2 below shows the

corresponding market shares in the absence of wholesale regulation—i.e. attributing OAO sales based on eircom inputs to eircom rather than the OAOs.[102]

Table 9.2 Wholesale TI market share (≤2Mbps), absent regulation ✂ [REDACTED]

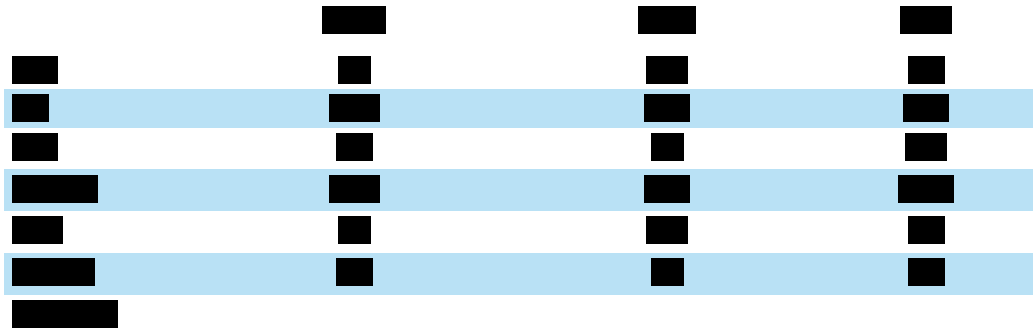
Note: Based on count method 3. These are market shares assuming no regulation in the leased lines market. This means that off-net leased lines supplied by OAOs based on eircom inputs are assumed to revert back to eircom. Off-net leased lines supplied by OAOs based on other OAO inputs which are not regulated are assumed to be continued to be supplied by the OAO.

Source: Oxera analysis of operator circuit volumes.

Removing regulation increases eircom's market share, particularly in retail services. This market share has been increasing in recent years, and in 2015 eircom's market share was ✂[ ] in the wholesale market and ✂[ ] in the retail market.

Table 9.3 presents market share estimates taking into account operators' self-supply.

Table 9.3 Wholesale TI market share (≤ 2Mbps), adjusted for self-supply ✂ [REDACTED]



Note: Based on count method 2. Self-supply is calculated as the sum of retail on-net and wholesale on-net. Self-supply for both eircom and OAOs is considered (see section 2.3.6).

Source: Oxera analysis of operator circuit volumes.

Taking into account self-supply further increases eircom's market share, reflecting eircom's very large footprint in the retail TI market and OAO

[102] We note that, currently, only eircom is obliged to provide a regulated set of wholesale leased line services. OAOs supply unregulated wholesale leased line products.

dependence on eircom inputs to supply TI services. This shows very limited (if any) constraint exerted by OAOs on eircom in the wholesale market.

Overall, eircom's market share is high, and suggests that eircom has SMP in the TI market. Effectively, there are only two national providers, with ✂[ ] largely concentrating on B-end business and ✂[ ] focusing on services within its metro fibre rings.

9.1.3 Other factors

Barriers to entry and prospects for competition

The TI terminating market is characterised by high barriers to entry:

- large fixed and sunk costs. Any entrant would require physical infrastructure such as duct or copper cabling to business user premises. Even for entrants in the adjacent MI market, further costs of TDM equipment would be required;
- declining market volumes. The decline and migration to Ethernet would hinder any recovery of new TDM investments;
- eircom's ubiquitous copper network. Given sufficient spare capacity, this enables eircom to serve new TI customers at very low incremental cost.
- the presence of economies of scale and scope. eircom (and potentially BT) may be able to leverage economies of scope by using the same TDM infrastructure to deliver services such as legacy voice or ISDN. An entrant is unlikely to be able to serve this kind of demand, as most new voice and data services are likely to be delivered over more modern platforms.

One way for alternative operators to transmit low-speed TDM circuits would be over Ethernet networks. However, this is unlikely to be commercially viable as the conversion equipment required for interconnection between TDM and Ethernet lines is costly. eircom estimates that OAO investment required to deliver TDM over Ethernet to 190 sites would be in over ✂[ ].[103] As discussed in section 3.1.4, replacing TDM equipment outright would also be costly. Such investments are not attractive given that they are likely to be stranded with the migration to Ethernet. Moreover, the direction of activity is likely to be towards a withdrawal of services (such as BT's migration plans), which may supress competition in TI services.

These factors suggest that there are limited prospects for competition (new entry or expansion by existing suppliers) in the TI terminating market, and that prospects for competition are unlikely to improve in the foreseeable future.

Countervailing buyer power

Countervailing buyer power (CBP) describes the constraint a large purchaser can have on the supply side of a market. Leveraging the buyer's market power and reducing demand can constrain the seller's market power.

For this to constrain eircom, there would need to be a buyer with a larger market share. Even large retail operators such as BT (approximately ✂[ ] TDM purchases from eircom in the retail segment and ✂[ ] in the wholesale market) reflect only ✂[ ] of TDM purchases volumes (excluding self-

[103] eircom (2016), ✂[ ]

supply).[104] Given that it already has an incentive to use its own TDM network where possible, BT is unlikely constrain eircom.

Moreover, the ability to exert CBP requires a credible threat to divert volumes to another TDM supplier. Given the lack of rival infrastructure and eircom's ubiquitous copper network, it is unlikely that CBP would constrain eircom in the wholesale TI market.

9.1.4 Any notional separate market for low-speed TI trunk lines is also likely to be uncompetitive

In general, trunk networks face different conditions of competitive supply, as higher densities of traffic along certain routes make it easier for OAOs to overcome barriers to entry such as scale economies. In principle, these aggregation opportunities also apply to low-speed TI services in Ireland.

However, any separate market for low-speed TI trunk lines is still unlikely to be competitive. This is because eircom has a ubiquitous copper network which it can use to supply low-speed TDM service. Given that there is significant (spare) capacity on the TDM trunk network, the incremental cost for eircom to connect multiple 2Mb circuits across its network is very low.

Moreover, as discussed above, it is not commercially viable for OAOs to transmit low-speed TI circuits over Ethernet networks given the costs involved in doing so and the fact that the TI market is a declining market with users increasingly migrating to Ethernet-based services. This would make it difficult for MI-based operators to carry this traffic, implying that eircom and BT are likely to supply the majority of any trunk volumes.

The barriers to entry are also reflected in the fact that there is only one alternative wholesale operator to eircom, BT, active in the wholesale market. And, as mentioned, even BT is expected to transfer around ✂[ ] of its 2Mbps circuits to Ethernet in the near future.[105]

9.2 Market assessment for national wholesale MI services

Oxera's approach and data treatment is the same for MI services as for TDM (see section 9.1.2).

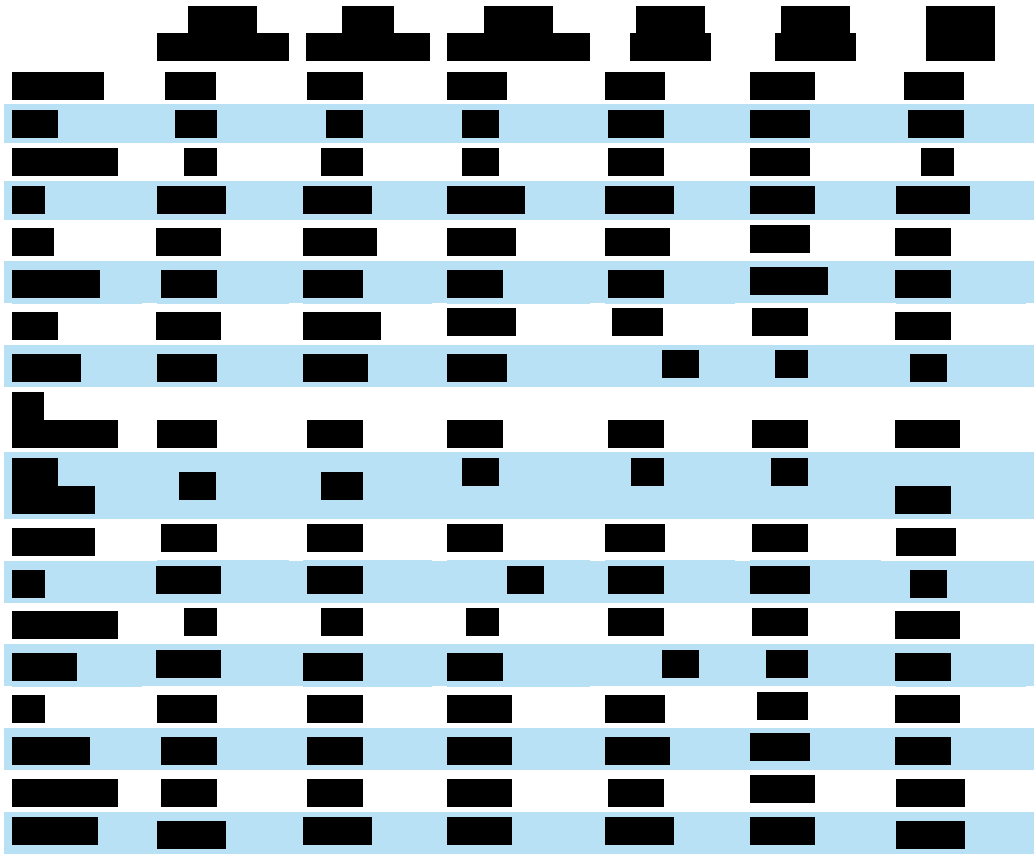
As mentioned in section 9.1.2, in general, data gathered reflects circuits provisioned on a national basis, with no break-down for trunk or terminating segments. This is because OAOs are not obliged to distinguish between trunk and terminating segments. For eircom, effectively all low-speed circuits will be classified as terminating segments, based on the previous market definition. This means that the market shares as presented should be interpreted as indicative of products at a combined trunk and terminating level.

9.2.1 Market shares and reliance on eircom infrastructure

Market shares for MI services, defined as on-net plus off-net volumes are presented in Table 9.4.

[104] This estimate is based on the total wholesale market for 2014 (4,823 circuits) and the retail off-net market (1,273 circuits).
[105] ✂[.] Operator data supplied by ComReg.

Table 9.4 MI market shares with regulation (>2Mbps) ✂ [REDACTED]



Source: Oxera analysis of operator circuit volumes, based on count method 3.

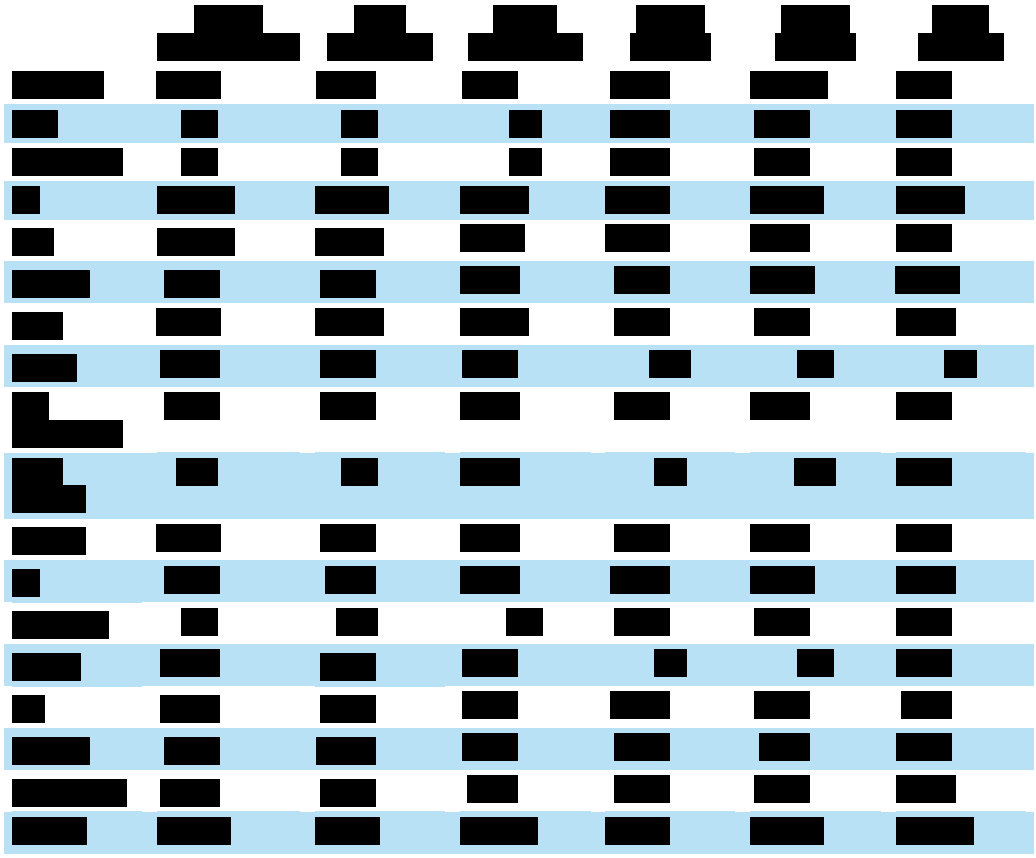
We note that:

- eircom, enet and BT supply almost ✂[ ] of the wholesale market;
- supply at the retail level is more dispersed, with smaller suppliers such as Vodafone, Digiweb and Airspeed collectively supplying ✂[ ] of the market;
- with the exception of ✂[ ][106] and ✂[ ] (which has only core network infrastructure), reliance on eircom to deliver retail Ethernet-based MI services is low. Overall, only ✂[ ] of retail MI services provided by OAOs depend on inputs from eircom. In the wholesale market, the corresponding figure is ✂[ ] (Table 8.3 and Table 8.4). This indicates that alternative infrastructure is a significant source of supply in the wholesale merchant market.

Adjusting for the presence of wholesale regulation increases eircom's market share further, as shown in Table 9.5, but is still relatively low around ✂[ ].(Even excluding wireless operators from the market only increases eircom's wholesale market share to around ✂[ ] for 2014. Although, as discussed in section 4, wireless leased lines are included in the MI market and hence impose a competitive constraint in the MI market).

[106] Oxera understand that✂ [ ] has a Dublin Metro Fibre network.

Table 9.5 MI market shares (>2Mbps), absent regulation ✂ [REDACTED]



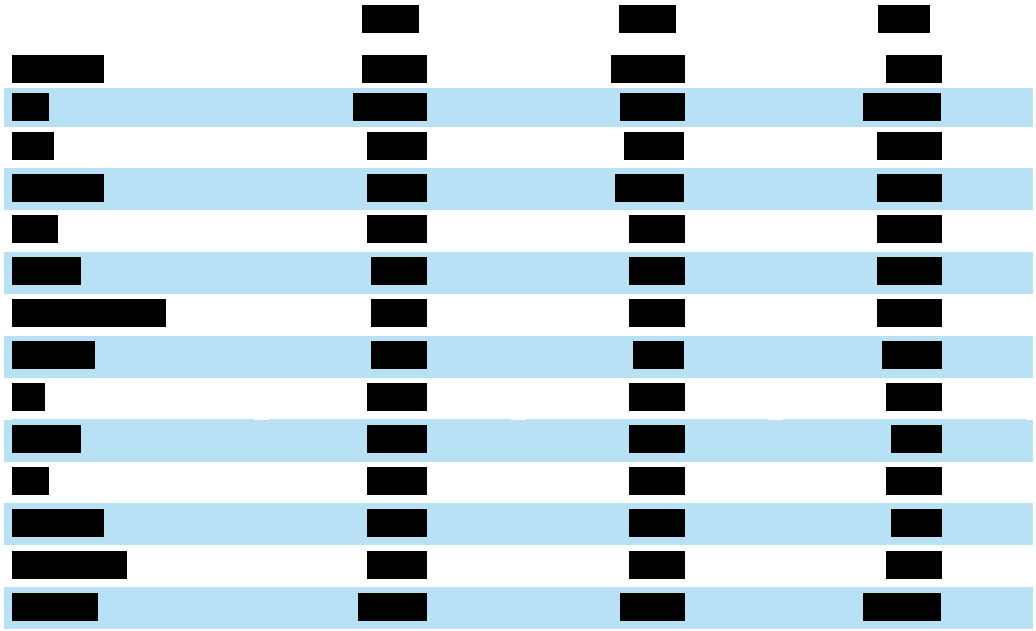
Note: Based on count method 3. These are market shares assuming no regulation in the leased lines market. This means that off-net leased lines supplied by OAOs based on eircom inputs are assumed to revert back to eircom. Off-net leased lines supplied by OAOs based on other OAO inputs which are not regulated are assumed to be continued to be supplied by the OAO.

Source: Oxera analysis of operator circuit volumes.

Note that the increase in eircom's market share under the modified greenfield approach (i.e. in the absence of wholesale regulation in the WHQA market) is larger for retail services than for wholesale services. This is due to the higher volumes of off-net circuits in the retail market.

Market shares including eircom and OAO self-supply are shown in Table 9.6. This adjustment decreases eircom's market share compared to its market share absent regulation as presented in Table 9.5. For example eircom's 2015 wholesale market share absent regulation decreases from ✂[ ] when adjusted for self-supply. This decrease in market share reflects the low reliance of OAOs on eircom inputs to supply MI services as discussed in section 8.4. We also note that eircom's MI wholesale market share adjusted for self-supply has been falling and has persistently been below 30%.

Table 9.6 MI wholesale market shares (>2Mbps), adjusted for self-supply ✂ [REDACTED]



Note: Based on count method 3. Self-supply is calculated as the sum of retail on-net and wholesale on-net. Self-supply for both eircom and OAOs is considered (see section 2.3.6).

Source: Oxera analysis of operator circuit volumes.

More broadly, the market volume and market share data shows that:

- OAOs supply a large share (above ✂[redacted]) of both the wholesale and retail markets, regardless of how these are measured;
- reliance on eircom for MI off-net tails is low (see Table 8.3 and Table 8.4, and the discussion in section 8.4). We note that this MI operator data is supplied on a national basis and, therefore, this data suggests that OAOs also supply the trunk segments using on-net inputs not dependent on eircom;
- retail MI providers such as BT, VM, Colt and Airspeed also have a significant presence (✂[redacted] volumes) in the wholesale market, with the vast majority of their retail supply being on-net.

9.2.2 Presence of alternative infrastructure

The market share data in the previous section and the discussion in section 8.4 strongly suggest that, in general, OAOs are not dependent on eircom to supply MI services—both for trunk and terminating segments. The majority of MI services supplied by OAOs are supplied on-net—i.e. based on their own infrastructure inputs.

As discussed in section 5, in Ireland, wireless leased lines are a good demand-side substitute for fixed leased lines. This is reflected in the development of the the wireless market, which has seen a significant take-up of these services.

Also, as mentioned earlier, enet's position in the wholesale market is significant, and it is an important provider of alternative infrastructure in Ireland. Enet operates metropolitan area networks in 94 towns and cities on behalf of the Irish government. Its wholesale operation is open-access, meaning that all licensed operators can access the infrastructure. Once an OAO has connected to an enet

metropolitan area network, it is able to serve customers throughout this local footprint.

9.2.3 Other factors

Limited barriers to entry

The Irish market is characterised by the presence of multiple operators that offer WHQA services via their own physical infrastructure. This suggests that entry barriers have to date been overcome, at least where OAOs have deployed networks.

The presence of enet as a major wholesale access supplier, as discussed in the previous section, also reduces potential barriers to entry. Furthermore, the trend for increased wireless provision in Ireland reduces the infrastructure access barrier to entry. Evidence in section 4 demonstrates that wireless links can be deployed on a roughly national basis, on very short lead times and on similar commercial and operational terms to fibre services. As these services require fewer sunk costs (e.g. civil infrastructure), this is a reduced barrier.

Good prospects for competition

There are several factors that suggest the state of competition could maintain its current level, or even intensify. Migration of services to Ethernet is underway, and Ethernet volumes exhibit double-digit year-on-year growth in volumes. Downstream drivers of demand are likely to increase with further developments such as the National Broadband Plan extending broadband coverage as well as mobile network expansions, infill or upgrades.

The SIRO joint venture between ESB and Vodafone will bring FTTH connectivity to areas mainly outside Dublin within the period of the market review. To the extent that this infrastructure could be used to deliver high-quality symmetrical services consistent with the MI market definition, this is likely to boost competition.

These factors suggest that there are reasonable prospects for competition to develop further in the MI terminating market.

Countervailing buyer power

For CBP to constrain market power in the MI market, a buyer with market power (or monopsony) would need to be able to make a credible threat to divert purchases to alternate suppliers. While there appears to be significant OAO network presence such that purchases may be diverted, in practice, network presence at a very granular level would be pivotal in determining whether a buyer can credibly switch to a rival.

Regarding purchasers with market power, some large retail end-users such as HEAnet or Bord Gáis are present in the MI market, as shown in Table A2.6 and Table A2.7. However, these still represent a small share of total services and would only exert an indirect effect on wholesale pricing.

Off-net purchases of MI services could be an area where a buyer could exert market power. The concentration of total retail and wholesale off-net purchases is relatively low, with no single buyer having more that 30% share of off-net purchases. Considering that off-net is a small fraction of total links, this would not be sufficient to exert CBP.

9.3 Conclusion

9.3.1 TI services—eircom has significant market power

The Irish market has limited rival infrastructure directed at TI services. Potential competition is limited, with high barriers to entry, largely predicated on eircom's ubiquitous copper network and a backdrop of declining volumes.

The available evidence on market shares suggests that eircom has a high and persistent market share in wholesale terminating TI services (defined to include the entire end-to-end circuit), and one that meets standard criteria for designating SMP.

9.3.2 MI services—eircom does not have significant market power

The wholesale MI market is characterised by:

- low eircom retail and wholesale market shares, which have been declining in recent years. OAOs supply a large share (above ✂[ ]) of both the wholesale and retail markets, regardless of how these are measured;
- there is considerable presence of rival infrastructure. Evidence from on-net/ off-net ratios suggests that OAOs can deliver circuits using their own infrastructure. Where they do not have infrastructure, they appear to have a limited reliance on eircom;
- alternative infrastructure is also provided by wireless operators and enet, which provides mandated open wholesale access to its metropolitan area networks in 94 towns and cities on behalf of the Irish government;
- at the same time, prospects for competition are relatively favourable in the Irish context, with increasing demand for MI circuits and further OAO investments that could be used to deliver MI services.

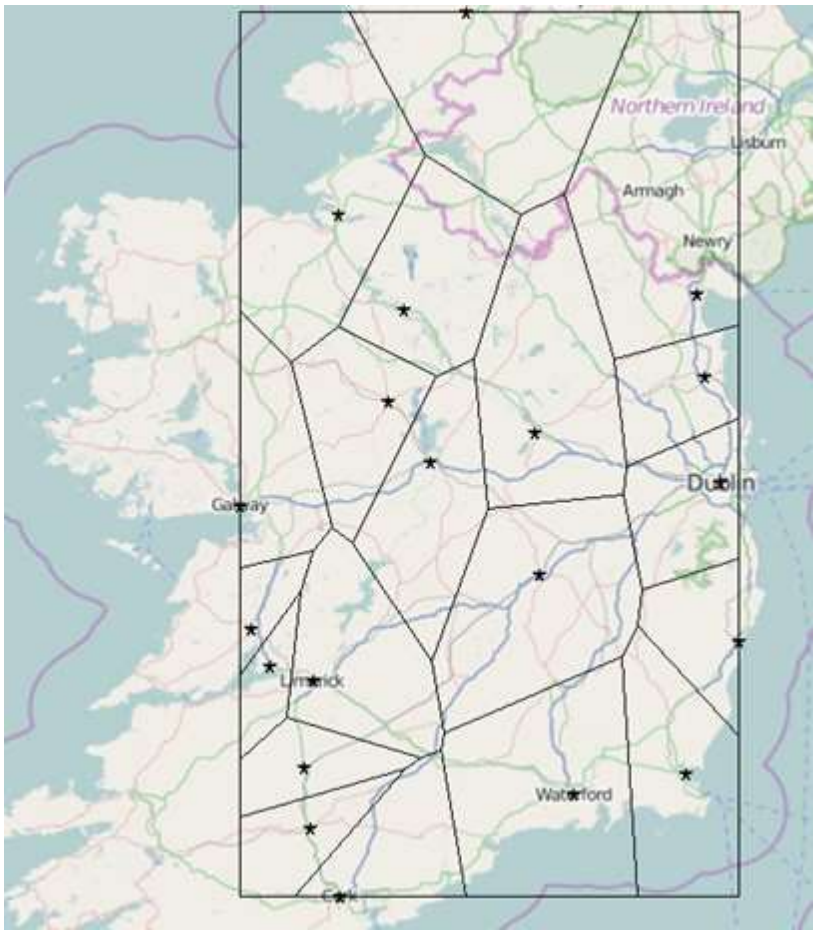
These factors and the market share evidence reviewed suggest that eircom (or any other individual operator) is unlikely to have SMP in the MI market—in either the terminating or trunk segments, however defined.

A1 Supporting evidence: market developments and differences between TDM and Ethernet networks in Ireland

A1.1 Expanding OAO coverage

In order to capture the expanding OAO coverage, Oxera has plotted current OAO presence (as per the supplied mapping files) in Ireland against the trunk sites identified in 2008.

Figure A1.1 Trunk sites in Ireland, as identified in the 2008 market review

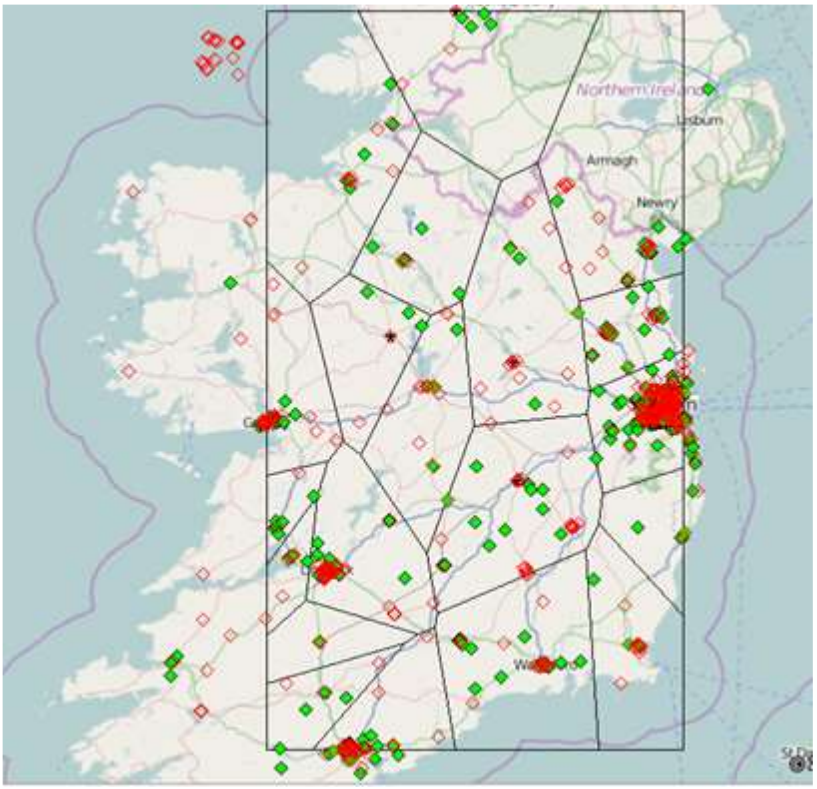


Note: Stars indicate the location of 2008 urban centres. The lines form regions separated by an equal distance from each other. This is a graphical technique to indicate a possible catchment area for each exchange.

Source: Oxera analysis of ComReg operator data.

When the locations of OAO points of presence are overlaid on this map, we see considerable dispersion of OAO presence, beyond these urban centres, as shown in Figure A1.2 below.

Figure A1.2 OAO network locations in Ireland



Note: Both green and red diamonds indicate OAO locations (a different symbol denotes a different data format). Oxera notes that several sites are plotted out of scope. These sites are all data centre locations. This is likely to be a data error (i.e. incorrect projection) for these sites.

Source: Oxera analysis of ComReg operator data.

A1.2 Extensive OAO fibre routes

The mapping evidence shows that OAO fibre routes are extensive, as shown in Figure A1.3 below. Each coloured line represents a different OAO's fibre network. This shows extensive core network coverage, and competitive connections between the 16 NGN aggregation areas.

The OAO fibre route mapping evidence and operator circuit inventory data supports the hypothesis that connectivity between broadly defined aggregation areas is competitive, but is too general to conclude on competitiveness at a more granular level.

Figure A1.3 Plot of OAO controlled fibre routes

Source: Oxera analysis of ComReg supplied mapping files.

A1.3 Differences in aggregation opportunities between the TDM and Ethernet networks

Aggregation on the TDM network—PPC interconnect points

Interconnection points (called PPC interconnections) to OAO networks are not explicitly defined by eircom as a specific point in the TDM network hierarchy for interconnection (see Appendix A1.4 for a description of eircom's TDM architecture).[107] However, these points where an OAO interconnects with eircom is a strong indication of its ability to aggregate circuit demand, and a potential break point in competitive conditions.

Aggregation on the Ethernet network

The first point at which traffic is aggregated on the NGN network is at one of the circa ✂[ ] aggregation nodes. Oxera understands that these switches apply policies to traffic (such as quality of service marking) and forward the traffic across uplink Ethernet/IP links.

[107] Oxera understands that eircom has not refused reasonable requests to interconnect, although interconnection at non-PPC local exchanges is unlikely. There are relatively low volumes of new TDM circuits being ordered, and a local exchange would offer limited traffic density from which to recover an OAO's fixed costs of connecting.

As with TDM, link capacities tend to increase through the network hierarchy. Additionally, the NGN network is also structured and organised by region. Appendix A1.4 provides a detailed description of eircom's Ethernet architecture.

Differences between TDM PPC interconnect and Ethernet aggregation points

Based on our analysis of network aggregation points on the TDM and Ethernet networks, we find that PPC sites are almost entirely co-located with an NGN aggregation node. However, at the Edge and Core nodes, there is significantly less overlap—just over half the total Edge sites are co-located with PPC sites.[108]

There are also important differences in the networks, such as the way NGN aggregation areas are organised (see Appendix A1.4). For example, the overlap analysis of urban and provincial NGN nodes and TDM legacy urban centres suggests that there are differences between eircom's NGN and TDM networks. Critically, there is a lack of overlap at PPC interconnection sites, from which OAOs can potentially aggregate traffic. This is one reason to consider separate TDM and Ethernet boundaries.

Another reason is the different evolution of TDM and Ethernet networks. TDM networks were designed with digitised voice traffic in mind, and tend to map onto existing copper-based PSTN network exchanges. Ethernet networks evolved from the local area network environment and were designed to link workstations using packet-based protocols or in 'connectionless' manner. This means that Ethernet may have different dimensioning and topology, and may be more suited to current and future leased line applications (i.e. connectivity between two sites) and less tied to legacy exchange locations. In addition, we note that some OAOs (e.g. enet, EU Networks, ESB Telecoms) do not offer voice services.

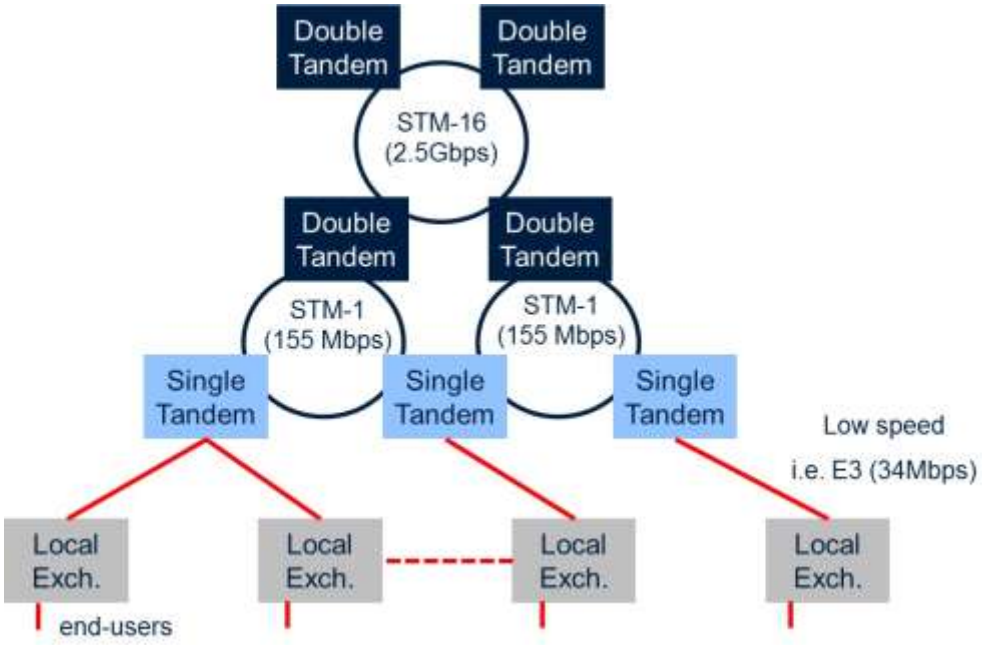
A1.4 eircom's TDM and NGN architecture

eircom's TDM network architecture

TDM networks of incumbents (such as eircom) tend to map onto the topology of legacy voice networks, as it was intended as a technology to transport voice traffic between exchanges. A typical hierarchy is shown below in Figure A1.4.

[108] Oxera notes that differences in network overlap closer to the end-user (i.e. at the local exchange or aggregation nodes) may be less influential in defining the boundary; rather, they are more likely to indicate geographic differences in supply of terminating segments.

Figure A1.4 Sample TDM network architecture



Source: Oxera.

End-users connect directly to a local exchange, which is the first point of aggregation. In eircom's case, there are approximately 1,024 MDFs or local exchanges/remote subscriber units. For traffic (and leased lines) that is destined for another exchange, routing is via a tandem exchange. These are defined as nodes that relay traffic purely between exchanges, and do not directly connect to end-users. Since an individual exchange may only serve a small number of users, the capacity of the serving links may be small. Higher-level tandem exchanges (double tandems) have higher-capacity links. The topology in the core (tandem exchanges) tends to be ring layout for diversity. Such rings may serve specific regional areas, although we understand that this is not explicit in the pricing of TDM-based wholesale products.

Note that interconnection points (called PPC interconnections) to OAO networks are not explicitly shown in the hierarchy in Figure A1.5. This is because eircom has not defined a specific point in the hierarchy for interconnection and allow interconnection at a variety of site types.

Oxera understands that eircom has not refused reasonable requests to interconnect, although interconnection at the local exchange is unlikely.

eircom's NGN network architecture

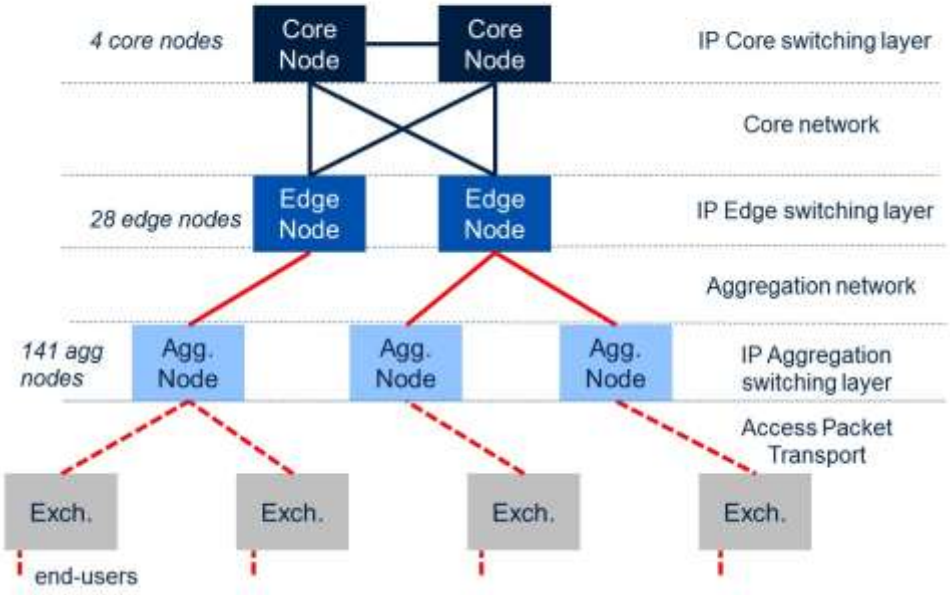
eircom's NGN is a packet/IP-based network designed to carry converged traffic (voice and data). The network architecture is shown below in Figure A1.5.

The NGN network will not reach all 1,200 local exchanges, however Oxera understands that it will be accessible to almost all via the Access Packet Transport network, which will effectively extend the NGN over existing (legacy) infrastructure. The first point at which traffic is aggregated on the NGN network is at one of the circa ✂[ ] aggregation nodes. Oxera understands that these switches apply policies to the traffic (such as quality of service marking) and forward the traffic across uplink Ethernet/IP links.

Edge nodes form the boundary to the MPLS network. These switches label traffic to allow the fastest possible transmission across the core, while maintaining the desired quality parameters. As with TDM, link capacities tend to increase through the network hierarchy.

Figure A1.5 eircom's NGN network hierarchy

Figure A1.5 eircom's NGN network hierarchy

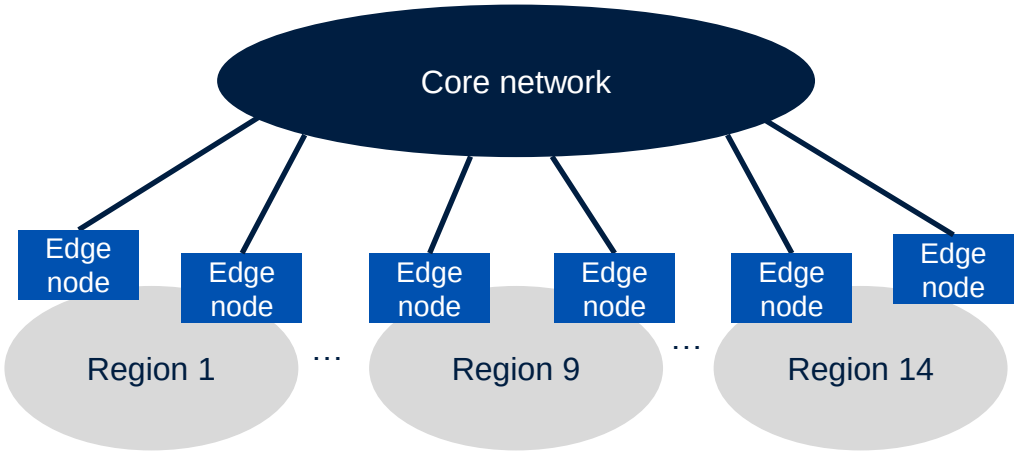


Note: Aggregation nodes are also local exchanges and facilitate interconnections. Access Packet Transport and Fibre Extension are deployed in the smaller MDFs/exchanges offering sub-1G services.

Source: Oxera, based on information provided by ComReg.

Additionally, the NGN is also structured and organised by region, as shown in Figure A1.6 below. eircom groups the✂ circa[ ] aggregation nodes into one of 16 aggregation areas throughout Ireland. Each aggregation area is served by two Edge nodes for resilience purposes. In addition, the regions are defined to capture homogeneous conditions within the area—i.e. there are separate aggregation areas defined for rural and provincial areas. This separation is also reflected in Ethernet product pricing.

Figure A1.6 eircom's NGN regional structure



Source: Oxera, based on information provided by ComReg.

A2 Supporting evidence: TDM and Ethernet products

A2.1 TDM and Ethernet service characteristics

	Low-speed TDM leased lines	High-speed TDM leased lines	Ethernet leased lines
Download speed	64kbps to 1984kbps	From 2Mbps to 25G	From 10Mbps to 1Gbps
Upload speed	64kbps to 1984kbps	From 2Mbps to 25G	From 10Mbps to 1Gbps
Distance limitations	None		
Service availability	99.95% uptime or four hours downtime per year		
Quality of service/traffic management	high QoS levels	high QoS levels	Circuit and traffic management options available
Contention/planning ratios	Uncontended		Uncontended in the access network, 'managed' such that contention does not occur in the core
Latency/Jitter	Specific levels guaranteed	Specific levels guaranteed	Sync E specifications (ITU-T G8261) comparable to SDH
Resilience	n/a	Route, local access resilience available	
Security	Secured, private connection		
Synchronisation	Not supported	Supported	Sync E specifications comparable to SDH
Geographic availability	National coverage	National coverage	National coverage Some limitations may exist depending on eircom NGN roll-out

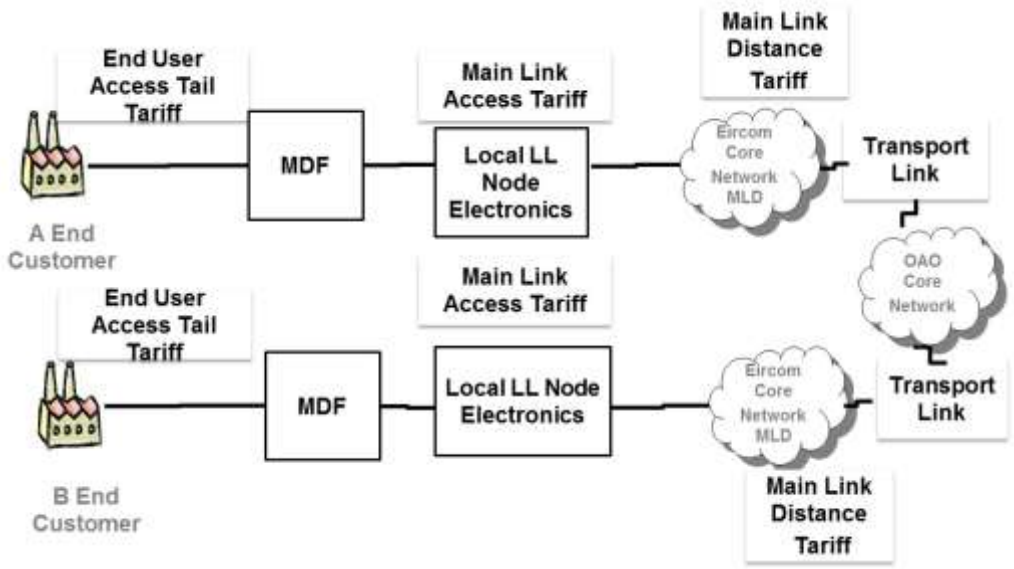
Source: Oxera analysis of eircom network features.

A2.2 TDM and Ethernet wholesale components

TDM wholesale components

Oxera's analysis includes comparable elements from the entire cost stack as faced by a wholesale OAO, purchasing a single leased line segment or leg from eircom. For TDM products, the relevant components are PPC products shown below.

Figure A2.1 TDM wholesale network components



Note: Oxera analysis considers a single leg (e.g. from the A-end to the OAO).

Source: ComReg.

A PPC circuit from OAO to end-customer has four components, as follows.

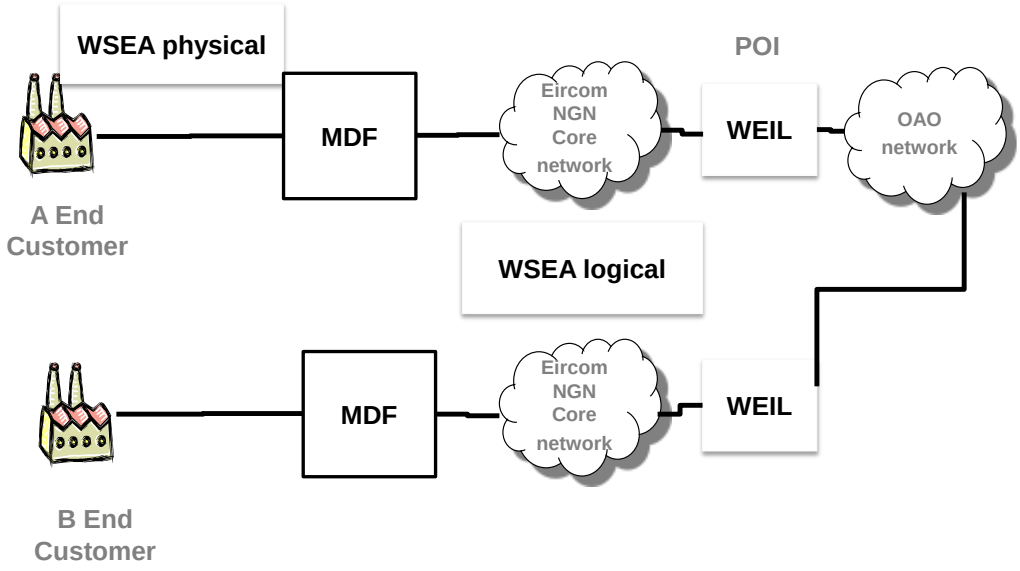
- **End-user link**—the access from the exchange to the end-user. Prices vary by bandwidth. Additional charges exist for distances beyond a certain length (1.5km for circuits less than or equal to 2Mbps, 0.5km for circuits above 2Mbps). Pricing also varies by handover type (e.g. in-building handover or customer site handover). Additional charges for diversity (not modelled).
- **Main link access**—the charge for accessing the TDM core network from the access link. Prices vary by bandwidth and also depend on whether traffic is local (same node), to a different exchange.[109]
- **Main link distance**—charges that apply for conveyance across the core. There are fixed and variable (distance) based charges at each bandwidth interval.
- **Transport link**—the physical interconnection to the OAO at the point of interconnect. There are fixed and variable (distance) based charges at each bandwidth. Different types of handover (in-span, in-building, customer site) also apply. As the transport link is shared across multiple OAO links, a loading factor is required. For TDM circuits we apply a loading factor of 70%, which is consistent with how ComReg assesses pricing in the context of margin squeeze.

Ethernet wholesale components

eircom's Ethernet product also has access, core and interconnection components, although it is structured differently (see Figure A2.2 below).

[109] At a minimum, a PPC be charged some main link access—i.e. in the case the PPC handover point is at the same node (type 2).

Figure A2.2 Ethernet wholesale network components



Note: Oxera analysis considers a single leg (e.g. from the A-end to the OAO).

Source: ComReg.

The relevant components are:

- **WSEA physical**—the physical fibre and port extending from the NGN Exchange to the customer premises. Prices vary by capacity (1Gbps or 10Gbps), distance and the density (urban, provincial or rural) of the area;
- **WSEA logical**—the configuration of the conveyance across the NGN core network. Prices vary by bandwidth, class of service, and whether conveyance is local, within the same region or to another region;
- **WEIL**—the interconnection from the OAO to eircom at a central interconnection point. Prices vary by capacity (1Gbps or 10Gbps), by area density of the WEIL link, and by the type of handover—i.e. whether the connection to eircom is in the OAO's site (customer site handover) or within eircom's exchange (in-building handover).[110] For Ethernet circuits we apply a loading factor of 50%, which is consistent with how ComReg assesses pricing in the context of margin squeeze.

A2.3 Ethernet wholesale pricing comparison

As with TDM, a range of scenarios were constructed to test for bandwidth breaks in Ethernet pricing. Oxera assesses the following groups of scenarios.

[110] An additional type of handover called Edge node handover is also possible. This requires greater investment from the OAO in return for lower incremental costs of interconnection. Due to the added complexity of this option, it has not been explicitly modelled in the pricing analysis.

Table A2.1 Ethernet bandwidth break analysis—circuit-based

	Scenarios 5–6	Scenarios 7–10	Scenarios 11–14
Bandwidth range	10Mbps–5Gbps	10Mbps–5Gbps	10Mbps–5Gbps
WSEA physical distance (km)	0.5–1.5	0.5–1.5	0.5–1.5
WSEA area density	Urban	Urban	Rural
Destination	Same node	Same region	Different region
Class of service	n/a	Options 4 and 5	Options 4 and 5
WEIL area density	Urban	Urban	Urban
WEIL capacity (Gbps)	10	10	10
WEIL distance (km)	0.5–1.5	0.5–1.5	0.5–1.5

Note: Variations within the scenario grouping are via the WSEA/WEIL link distances and class of service types. Scenarios 5–14 are all 'circuit-based' while scenarios 15–24 are all 'traffic-based'.

Source: Oxera analysis of eircom wholesale leased line pricing.

Table A2.2 Ethernet bandwidth break analysis—traffic-based

	Scenarios 15–16	Scenarios 17–20	Scenarios 21–24
Bandwidth range	10Mbps–5Gbps	10Mbps–5Gbps	10Mbps–5Gbps
WSEA physical distance (km)	0.5–1.5	0.5–1.5	0.5–1.5
WSEA area density	Urban	Urban	Rural
Destination	Same node	Same region	Different region
Class of service	n/a	Options 1 and 6	Options 1 and 6
WEIL area density	Urban	Urban	Urban
WEIL capacity (Gbps)	10	10	10
WEIL distance (km)	0.5–1.5	0.5–1.5	0.5–1.5

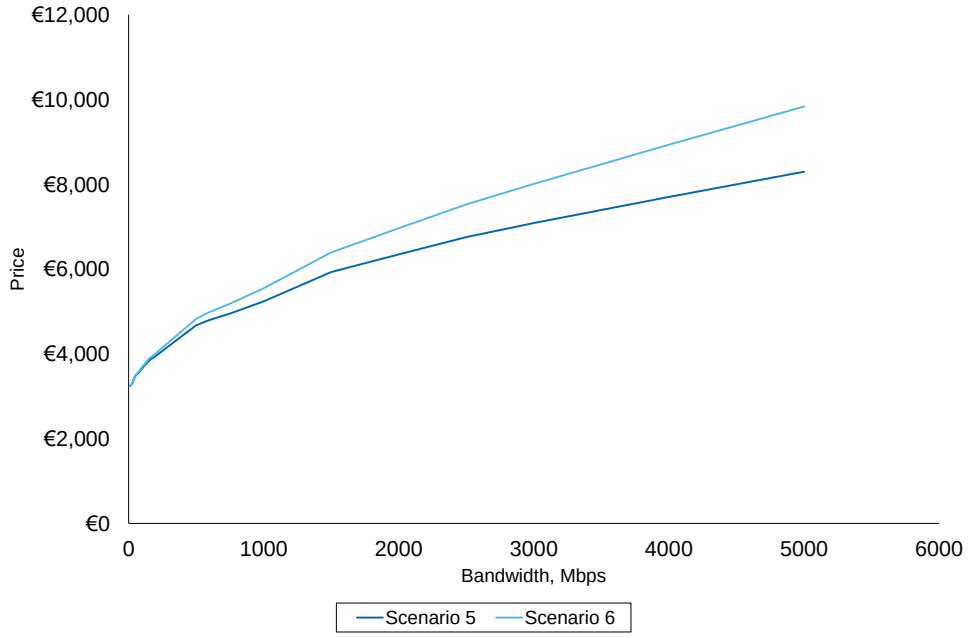
Note: Variations within the scenario grouping are via the WSEA/WEIL link distances and class of service types. Scenarios 5–14 are all 'circuit-based' while scenarios 15–24 are all 'traffic-based'.

Source: Oxera analysis of eircom wholesale leased line pricing.

Ethernet bandwidth prices—circuit-based

Figure A2.3 below shows a plot of circuit-based Ethernet prices for services that terminate on the same NGN node. The plot shows a continuous price without any breaks across the range of bandwidths from 10Mbs to 5Gbps. Although this is steeper at lower speeds, the incremental price increases are small. The pattern is the same for longer WSEA and WEIL distance specifications.

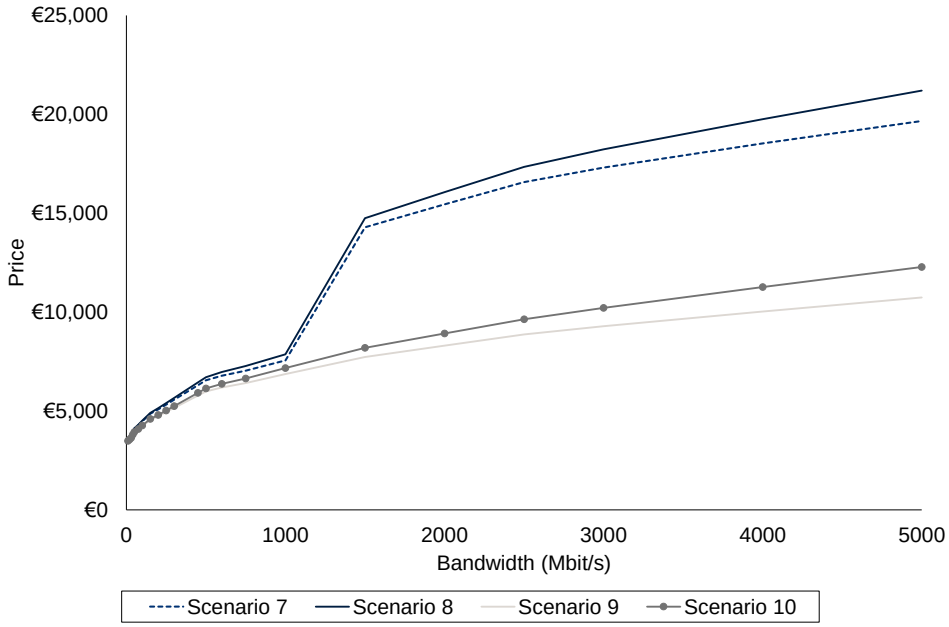
Figure A2.3 Circuit-based Ethernet prices, same node



Source: Oxera analysis of eircom wholesale leased line pricing.

When different nodes (and in particular different classes of service) are tested, a possible break appears at around 1Gbps, as shown in Figure A2.4.

Figure A2.4 Circuit-based Ethernet prices, same region



Source: Oxera analysis of eircom wholesale leased line pricing.

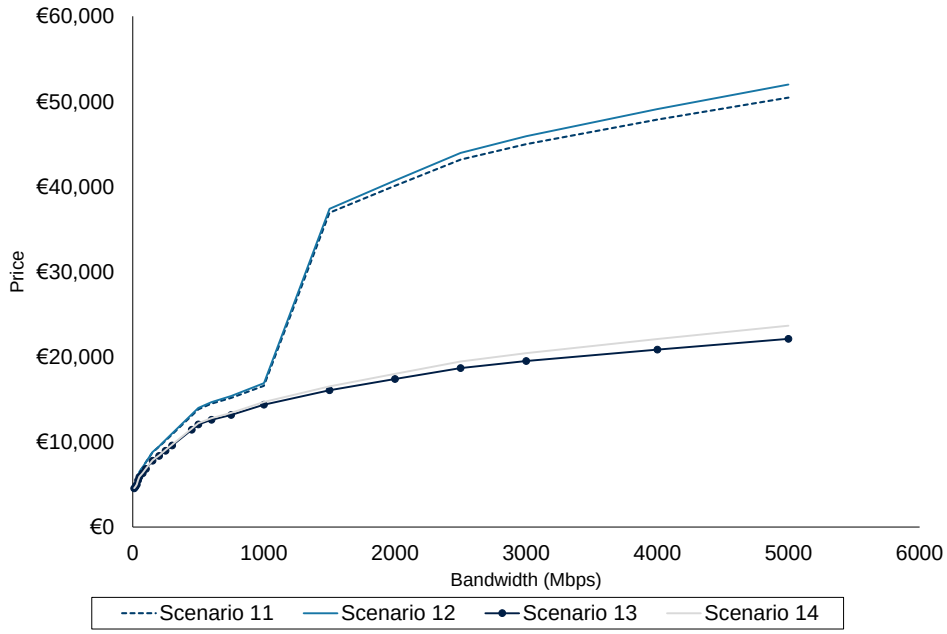
Scenarios 9 and 10 both have a class of service mapping to Option 5, whereas scenarios 7 and 8 are configured with Option 4. The main difference is that Option 5 maps all end-user traffic onto a standard queue, whereas Option 4 maps traffic onto an assured forwarding queue.[111] As this corresponds to a more sensitive traffic type, it may require more core network resources as bandwidth

[111] See eircom (2015), 'Technical Handbook Wholesale NGN Ethernet Products, product manual v 1.8', 5 June, p. 25.

increases. Otherwise, a similar smooth gradient in prices applies for standard services.

A similar pattern applies for circuit-based leased lines that are provisioned across a different region, as shown in Figure A2.5.

Figure A2.5 Circuit-based Ethernet prices, different region



Source: Oxera analysis of eircom wholesale leased line pricing.

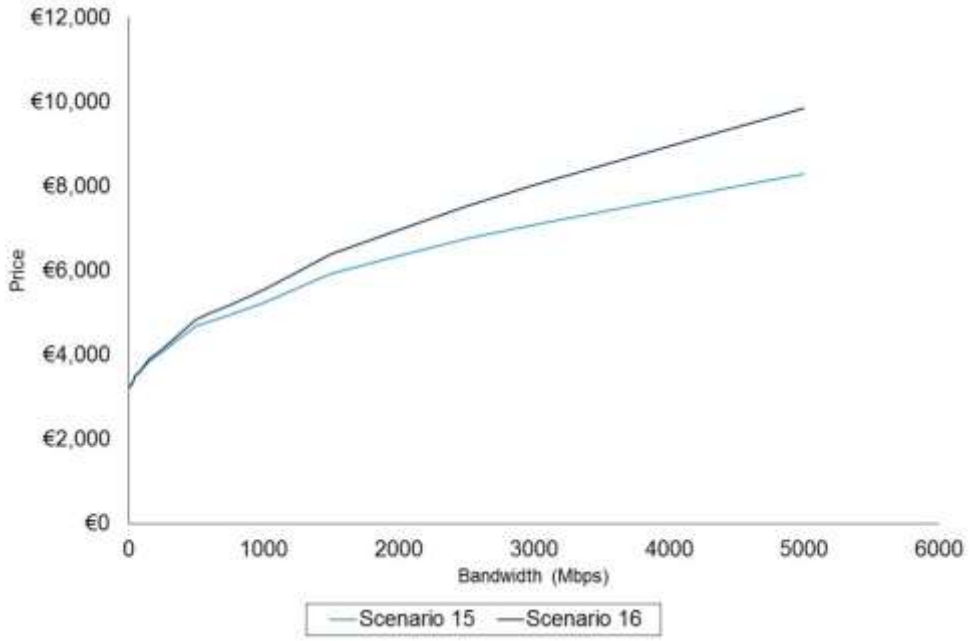
Again, the same pattern of price increase occurs at 1Gbps for circuits with higher class of service requirements. Given the scale of price increase, this could indicate a break at 1Gbps, although it only appears to apply to certain configurations.

Oxera understands that the majority of NGN Ethernet circuits sold are configured on a traffic class of service configuration rather than circuit-based. That only a subset of configurations exhibit a price discontinuity suggests that more evidence may be needed to conclude that a break exists.

Ethernet bandwidth prices—traffic-based

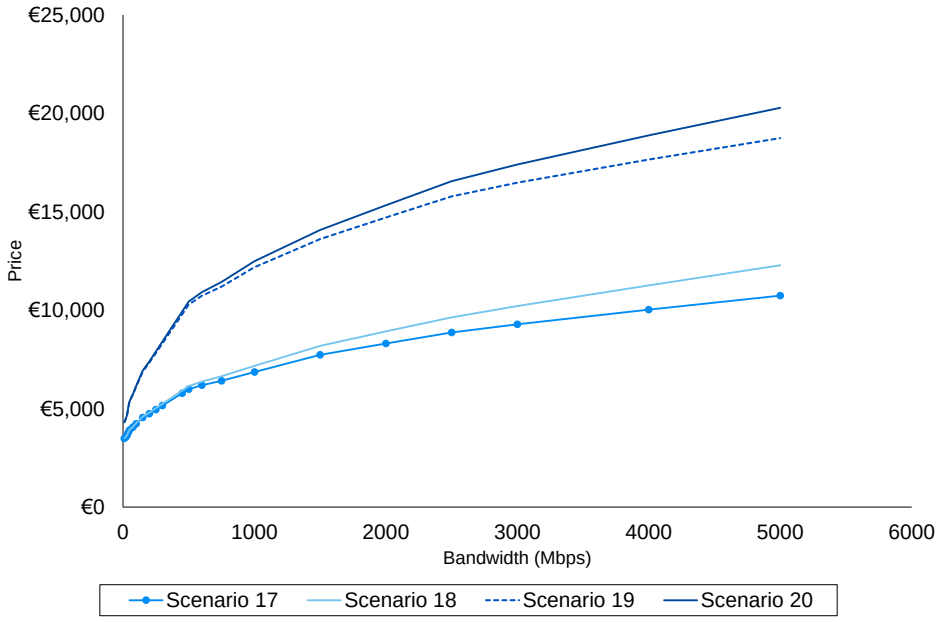
Oxera's analysis of traffic-based circuits shows a similar pattern of smooth price increases (without any breaks) over the bandwidth spectrum, as shown in Figure A2.6, Figure A2.7 and Figure A2.8.

Figure A2.6 Traffic-based Ethernet prices, same node



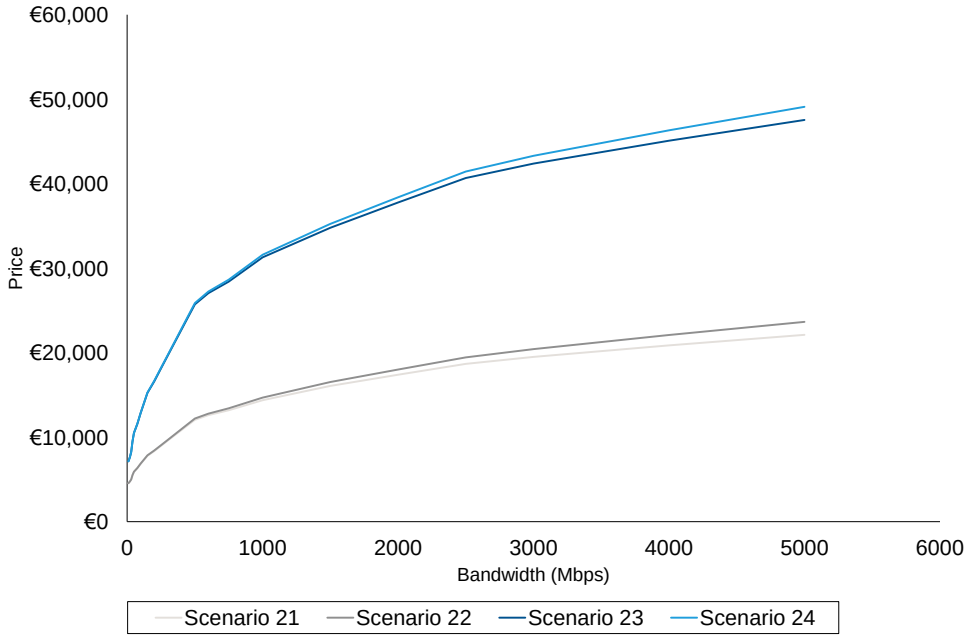
Source: Oxera analysis of eircom wholesale leased line pricing.

Figure A2.7 Traffic-based Ethernet prices, same region



Source: Oxera analysis of eircom wholesale leased line pricing.

Figure A2.8 Traffic-based Ethernet prices, different region



Source: Oxera analysis of eircom wholesale leased line pricing.

For traffic-based Ethernet leased lines, there is no apparent discontinuity in prices at a specific bandwidth. Altering circuit length, core conveyance (region) or class of service introduces a level shift but does not shift relative pricing across bandwidths. As traffic-based offering forms the majority of eircom's NGN leased line demand, evidence of a lack of a break should carry more weight relative to circuit-based pricing.

A2.4 TDM and Ethernet functional/end-user analysis, 2014

100bps/analogue leased lines

The highest-value, low-speed (100bps) retail analogue leased lines offered by eircom are shown below in Table A2.3.

Table A2.3 Highest-value eircom retail circuits, 100bps ✂ [REDACTED]

[redacted]

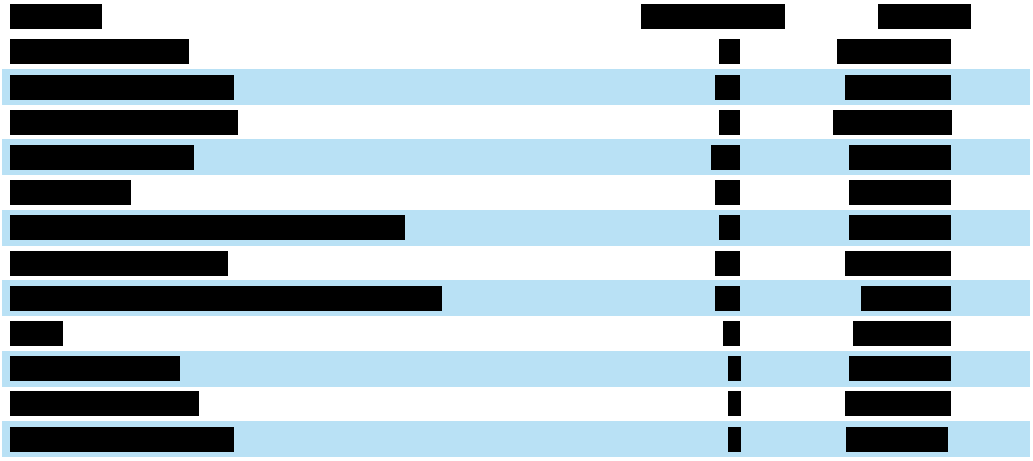
Source: Oxera analysis of eircom retail circuit inventory.

The largest users in this list are utility operators ✂[redacted], transport, financial and government institutions. Leased lines in these cases may be used in remote monitoring, critical system control and secure transactional applications. Such end-users could be using proprietary or legacy systems with specific features that do not require large bandwidth, but are not suited to modern (Ethernet) services.

The most prominent users of low-speed (64kbs) retail leased lines are shown in Table A2.4.

64kbps TDM

Table A2.4 Highest-value eircom retail circuits, 64kbps ✂ [REDACTED]



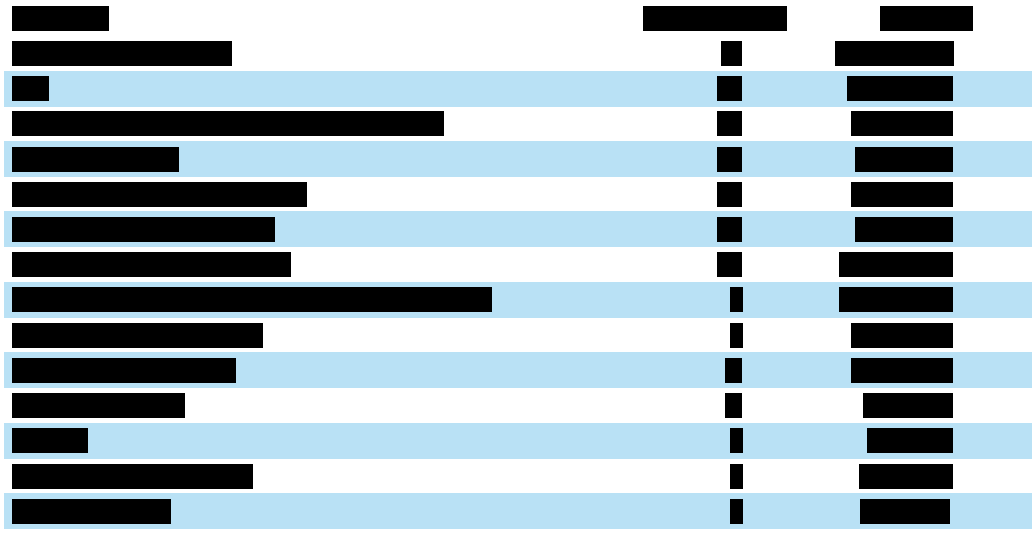
Source: Oxera analysis of eircom retail circuit inventory.

This set of end-users shows a similar pattern for 64Kbps services, with utility, government and transport the main users of such links. This could suggest that similar applications are found for analogue leased lines and low-speed TDM services.

2Mbps TDM

eircom's highest-value 2Mbps TDM retail leased line users are shown in Table A2.5.

Table A2.5 Highest value eircom retail circuits, 2Mbps ✂ [REDACTED]



Source: Oxera analysis of eircom retail circuit inventory.

Again, the end-users at this bandwidth comprise a large proportion of utility, government and transport users. However, there is some indication (✂[']) that these links form part of a generic inter-site connectivity rather than specialist control or transactional functions. There is also a long tail of private and corporate entities, suggesting that these have more general use.

10Mbps Ethernet

eircom's highest-value 10Mbps Ethernet retail leased line end-users are shown below in Table A2.6.

Table A2.6 Highest-value eircom retail circuits, 10Mbps✂ [REDACTED]

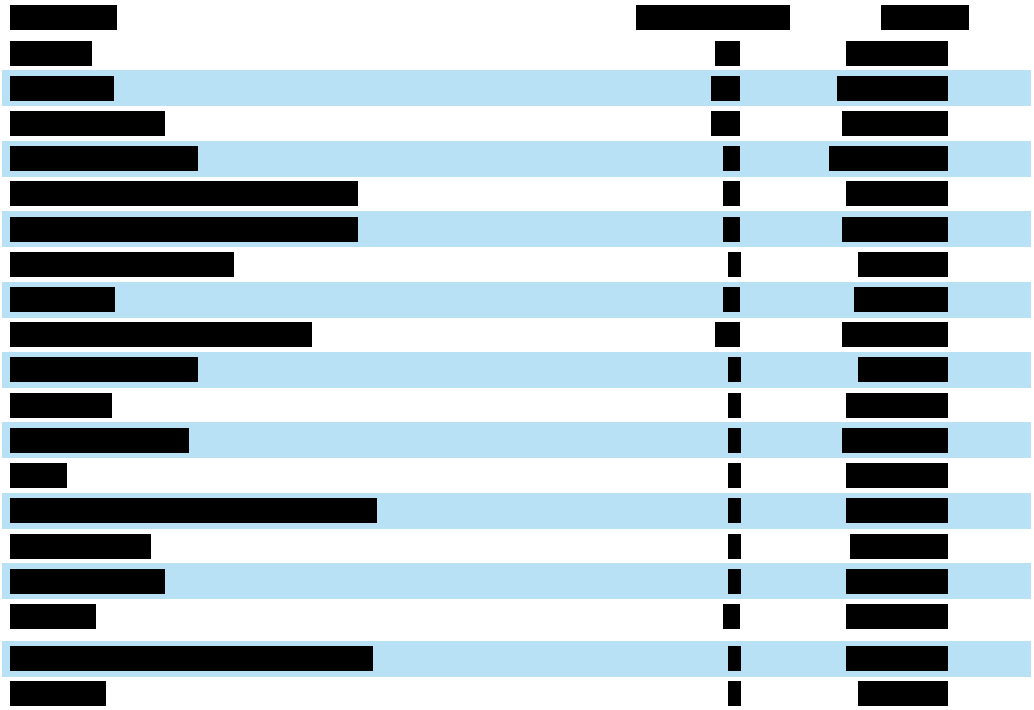
Source: Oxera analysis of eircom retail circuit inventory.

For Ethernet, eircom's customer base is comprised of large institutional and corporate customers. Utility operators are also significant purchasers, but they appear to be purchased for general data networking (i.e. labelled as Data or Wide Area Network). In addition, Oxera notes the presence of data centre or platform service operators (e.g. ✂[ ]).

100Mbps Ethernet

Table A2.7 shows eircom's top 100Mbps Ethernet retail leased lines end-users.

Table A2.7 Highest value eircom retail circuits, 100Mbps✂ [REDACTED]



Source: Oxera analysis of eircom retail circuit inventory.

The end-users appear to be similar in type to the 10Mbps users—institutional, government and corporate users. Note, also, the presence of platform, cloud and data centre type users.

A3 Supporting evidence: radio links

A3.1 Fixed and wireless leased line service characteristics

Table A3.1 Characteristics of wireless and fixed leased lines

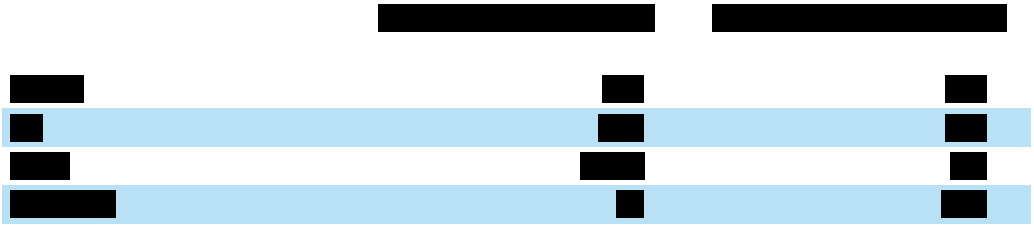
	Wireless leased line	Fixed leased line
Interface	TDM or Ethernet	TDM or Ethernet
Download speed	2Mbps to 1Gbps possible; although few circuits above several hundred Mbps	2Mbps to 10Gbps
Upload speed	As above	As above
Bandwidth/distance limitations	Engineered solution; requires line of sight	None
Service availability	Up to 99.999%, although can be affected by weather	99.95% or better
Resilience	Resilience options available	Resilience options available
Quality of service/ traffic management	Circuit-oriented or traffic-based management	Circuit-oriented or traffic-based management
Contention	None	None
Latency/jitter	Comparable to fixed leased lines	Specific levels can be guaranteed
Synchronisation	Possible on some microwave equipment	Supported
Security	Secure link	Secure link
Geographic availability	Requires line of sight and spectrum license	National availability
Install lead times	Short	May be restricted by wayleaves access

Source: Oxera analysis of operator and vendor technical data.

A3.2 MNO purchase of fixed and wireless inputs

Table A3.2 shows that, as at 2014, a significant volume of fixed circuits are purchased by OAOs.

Table A3.2 Fixed leased line circuit purchases by MNOs, 2014 – 2015 ✂ [REDACTED]

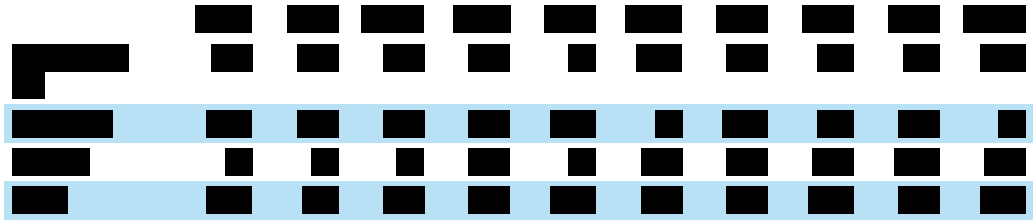


Source: Oxera analysis of operator data, S3.2.1 network input data.

Although ✂[ ] volumes may appear low, it has recently gained wholesale access to ✂[ ]. Oxera understand that, based on licencing data, ✂[ ] has moved traffic off wireless point to circuits and onto fibre based leased lines.

At the same time, MNOs still heavily rely on wireless links to transport calls and data back to central locations. Table A3.3 below shows the number of licences issued each year to MNOs for the last ten years.

Table A3.3 Point-to-point licences issued over the last ten years, by year of issue ✂ [REDACTED]



Source: Oxera analysis of operator data.

These refer to point-to-point licences, as separate to general spectrum licences to connect handsets to base stations. While the volume of licence additions fluctuates, clearly there is still a heavy reliance on this form of connectivity.

A note on relative pricing comparison between wireless and fixed leased lines

Oxera also attempted to compare relative pricing across different bandwidths for eircom and wireless leased line providers (where data was available) within a SSNIP framework. However in assessing the data, we noted that there is likely to be some heterogeneity in the circuit information provided by different wireless operators and differences in price levels due to a number of factors that cannot be controlled for in such a comparison. For example, differences in prices due to circuit length, location, install revenue, volume discounts, regulated/unregulated inputs and potentially customer type are not explained in the data.

Some wireless products are also priced on a bespoke basis, specific to the customer sites and requirements For example, pricing for wireless services could exhibit significant variability reflecting the case-by-case feasibility of wireless solutions (driven by line of sight and bandwidth requirements).[112] For these reasons it is difficult to be certain of the precise differences in price levels, and use relative pricing analysis to inform market definition.

[112] Fibre-based services can also have this variability. For the purposes of testing substitution, eircom's reference offers on fixed services allow prices to be compared.

A4 Supporting evidence: broadband product set

A4.1 Service characteristics of NGA broadband and leased line products

	Broadband—VUA FTTC	Broadband—VUA FTTP	EFM (BT)	LL Analogue + Sub 2M digital	LL Ethernet
Download speed	Up to 70Mbps	150Mbps	Up to 20Mbps	From 64kbps to 2Mbps	From 10Mbps to 1Gbps
Upload speed	Up to 20Mbps	30Mbps	Up to 20Mbps	From 64kbps to 2Mbps	From 10Mbps to 1Gbps
Bandwidth limitations	Line length dependent	No limitation	Line length dependent but may be overcome by extra copper bonding	No limitation	
Service availability	Lower than standard business grade performance (offers around 99.5% service availability or 1.8 days of service downtime over a year)		Similar to LL	99.95% service availability or four hours of service downtime over a year	
Contention/planning ratios	Managed backhaul—no contention cannot be 100% guaranteed		Uncontended		
Latency/Jitter	Variable—cannot be guaranteed			Specific levels guaranteed	
Resilience	Call resilience available		Local access resilience available	Route, local access + call resilience available	
Synchronisation	Not supported			Supported	
Geographic availability	Available in 660 exchanges	Limited geographic coverage	Available at 85 locations within BT's network	National coverage	Available in 660 exchanges

Note: Broadband products include ADSL, BEA, FTTC and FTTP; EFM service relies on eircom's LLU.

Source: Oxera based on eircom and BT offerings.

A5 Summary of data collected for the leased lines consultation

A5.1 National leased lines (including wireless) circuit volume and revenue data

The circuit inventory data contains a list of all the wholesale and retail leased lines that eircom and OAOs currently serve. Organised at an individual circuit layer, each observation indicates the bandwidth, technology and sales revenue of each circuit. For each table listed in this document that relies on circuit counts, the corresponding counting method used, whether or not off-net circuits were added and if self-supply was included or excluded is specified.

Data preparation and cleaning

ComReg supplied cleaned versions of operator circuit inventories to Oxera and corresponding summary circuit counts and the original data for reference purposes. Circuit counts were used by ComReg and Oxera to calculate market shares rather than revenue as revenue was considered less reliable to reasons discussed below. ComReg has taken 3 approaches to generating circuit counts for on-net Ethernet and xWDM circuits to be then used in calculating market shares:

- Method 1 Physical and logical circuits were counted. The logical count was that where the actual bandwidth delivered was recorded as a logical circuit. This is how BT and eircom (and EU Networks to a lesser extent) record its circuits for the majority of its Ethernet products. For such instances, access bearers were not included in the count to avoid double counting but the revenue was included for overall market valuation There were important exceptions to this where both BT & Eircom only record physical circuits for some product types and where this also reflects the actual bandwidth delivered to the end user. For these instances, the physical circuits were counted. The majority of operators do not count access bearers and designated the all circuits listed as physical as this reflects the manner in which they record and charge the end user, thus circuits were counted as physical. This method had the advantage that bandwidth trends could be observed. Otherwise, the number of 1 Gbps circuits would be over represented, the standard bandwidth of fibre access bearers

- Method 2 Physical single ended circuits were counted. Each recorded instance of a physical leased lines was counted ignoring whether or not the service was a single-ended interconnection based service or retail equivalent (e.g. connecting point of interconnection/handover or retail MPLS platform or equivalent) or end-to-end or double-ended service connecting 2 customer premises. The number of double-ended circuits was low according to the product type recorded and for some of these no B-end address was listed;

- Method 3 Each physical access were counted. In this approach the double-ended circuits contributed 2 instances to the overall count. This was the approach used for the calculation in the geographic analysis for market shared within and outside business parks.

For off-net circuit counts, method 2 was adopted as the majority of operators recorded circuits in this manner, as single instances of bandwidth purchases.

TDM Circuit Count

For the TDM circuit count, method 2 above was used and each listed instance of a TDM circuit was counted as one occurrence. TDM interconnection circuits (i.e. the connections between operators and eircom's network for the purposes of supplying PPC end User Links) have been excluded from the volume count, as these are not leased lines per-se but are merely the delivery mechanism to present PPC end user links. For revenue calculations, these are included, although revenues are reduced by 50% to reflect that significant interconnection volume is for voice interconnection which are outside the scope of this market review.

Revenue issues

Information supplied by operators relating to revenue was less reliable than circuit volume information. This was due to various issues: bundling of offers, which created difficulty for operators in disaggregating the value of the access portion of their services; similarly for international services where only the national portion was relevant; outliers, where some operators placed values of multiples the average and did not appear realistic. Other issues were related to long term and indefeasible rights of use (IRU) contracts. In some cases these were not reflected in the circuit count by the supplying operator and listed as a single item. For some of these, ComReg calculated the circuit volume by distributing the total assured and projected volume over the disclosed number of links, for the life of the contract.[113]

Oxera understand that in these cases, the cost of the international leased line was separated from that of the national leased line as sold to the end-user.[114]

ComReg found that some of the historical information on circuit volumes was missing. This included contradictions, omissions and incorrect inclusion of circuits. Via discussion with the operators ComReg was able to rectify most issues and ascertain that the circuit volumes are reliable. In a small number of cases where data gaps occurred, service revenues or bandwidths were inferred from a group of similar circuits. In addition, clear errors in ascribing technology were manually corrected.[115]

Data treatment

Oxera has assessed the data as supplied by ComReg. This means that data cleaning described in Appendix 3 of the accompanying ComReg consultation has already been applied:

- international circuits. In many cases, these have been identified and removed by ComReg. In certain cases (e.g. EU Networks and Colt), Oxera has manually identified and removed international circuits by inspecting the country field of the address or by reference to a known list of foreign circuits;
- double-ended circuits. In some cases an operator sells local access and core circuits separately. In some cases, a list of double-stacked circuits had been supplied by ComReg where the information was supplied by operators;

[113] This was done on a case-by-case basis following discussions with the submitting operator.
[114] Operators were requested to apportion a reasonable cost based on internal standards to national portions of international leased line circuits where the actual charge was not accessible by the operator.
[115] TDM multiplex rates such as 34Mb, 45Mb, 155Mb and 622Mbs are not used in Ethernet products, so it is in many cases possible to infer technology from the specific bandwidth.

- logical and physical. Some operators sell physical links (sometimes referred to as bearers or tails), as separate from logical services, that are provisioned over these links. Differences in practices across operators could under- or over-represent specific operators' counts. Most circuits are interpreted as physical. Oxera has removed circuits marked as logical from EU Networks and BT inventory lists for counts completed using methods 2 and 3, outlined above.

Regarding the data collected and used in this report, Oxera comments as follows.

- Inventories do not distinguish between the D06/08 definition of terminating and trunk segment of leased lines, as operators do not record this information. This means that market share information does not fully reflect terminating segment specific conditions.
- Distance, class of service and resilience options are not indicated. As these are drivers of cost, it makes price comparisons difficult. Oxera notes that in some cases, this reflects the fact that not all operators' service specifications are the same as eircom—e.g. we understand that only eircom charges by class of service.
- Data detailing the routing to upstream nodes was requested from the operators but was not supplied by all respondents. This is likely to be due to limitations in the data captured and stored by respondents. This detail of nearest node or areas may be possible for some eircom circuits, but it means that it is not generally feasible to obtain market shares by node or area.
- Operators were unable to provide precise customer premises location information such as geographic coordinates. In many cases, this reflects the fact that operators themselves do not have data available on their own customer locations. This could arise if operational data is locally stored and not linked to financial or customer relationship management systems.
- On-net/off-net circuits are reported by operators and are useful in isolating and calculating on-net market shares. On-net market shares are more indicative of an operator's control of infrastructure, and hence the ability to replicate eircom's products.

This data has been used to estimate market shares, split by bandwidths, and technology, as well as understand OAO use of their own network (i.e. on-net circuits) and their dependence on other networks (including eircom). Oxera has used the identity of the retail customer (when listed) for end-user analysis.

Oxera has also reviewed the inventory of dark fibre purchases between OAOs. These have some circuit descriptions, span lengths and location and, in some cases, the name of an end-user. This data is used to assess dark fibre applications.

Further details on ComReg's approach to data collection and treatment can be found in Appendix 3 of the accompanying ComReg consultation.

A5.2 OAO and eircom network information

The network information from OAOs and eircom is geographic mapping data, organised by grid reference. It consists of:

- existing network sites and points of presence for eircom, disaggregated by type of node (Aggregation/Edge/Core/APT Reach, PPC, exchange);
- additional information provided by eircom such as NGN aggregation area, uplink technology, capacity and presence of other network platforms;
- for OAOs, data is often more limited, sometimes only the name and location of a site. Where available, separate data has been provided for planned and future sites;
- fibre route information. For some OAOs this data is granular, and includes street-level features such as joints and cable flexibility points. For other OAOs, this is summary or schematic information consisting of major sites that they have fibre between, but no detail on the specific path of the cable.

Regarding the data collected and used in this report, Oxera comments as follows.

- We understand that ComReg's network mapping files are complete in terms of containing the available data from OAOs. However, detailed mapping data on announced roll-outs is not available—e.g. ESB's or Vodafone's network information does not capture details of the planned roll-out by SIRO (the joint venture between Vodafone and ESB). As a result, the details of SIRO's roll-out cannot be captured in mapping analysis. But, more generally, Oxera's forward-looking analysis recognises that SIRO will provide more competition in both the wholesale and retail markets.
- From a mapping perspective, Oxera has reviewed the publicly available data on the SIRO roll-out. This data is coarse, in that it names the towns that will be served but not precise network locations or terminating segment routes.[116] As we understand that this project will leverage electricity pole infrastructure to primarily serve residential users, it is not possible to presume that network locations will neatly overlap eircom's exchanges. From a trunk perspective, Oxera expects that as ESB (via ESB-Telecom) and Vodafone have trunk networks, minimal additional alternative trunk infrastructure will be built as part of this project.
- Some location data is likely to be inaccurate—e.g. some network sites' co-ordinates resolve to locations outside Ireland. However, to the extent that these instances are known, they are resolved and accounted for in the analysis.
- OAOs appear to have more concentrated networks, aggregating traffic to fewer nodes, serving larger catchment areas. Some operators were unable to provide information on where specific customers connect to their network.[117]

This data is used to plot OAO and eircom points of presence and fibre connectivity to analyse the trunk-terminating boundary.

Business location data

As discussed above, operators were unable to provide XY coordinates for their customers and detailed mapping data but ComReg collected information on operators' network locations. In addition, ComReg also collected information on

[116] Some of these may still be in the planning phase, as the SIRO website requests end-users to register their interest. This could be used to assess demand and direct roll-out accordingly.
[117] This, and the lack of customer co-ordinates limits the scope for geographic analysis.

business park/data centre locations and purchased data on business location data from the Bill Moss Database.

The business location data is geographic data for businesses with more than ten employees in Ireland.[118] The data is also segmented by business size in terms of employees. Oxera notes that this sample is a large proportion of the population (90–100% compared with government statistics on the total number of firms in Ireland).

The business location data has good coverage of Irish businesses, and appears to locate premises with strong precision. This is useful in establishing that leased line network roll-out and provision follows businesses in general.

Business park/data centre locations and circuit-level assessment of the inventories provided by stakeholders

The information on business parks details the locations of known business parks in Ireland. For each business park, ComReg has collated the known operators present at these sites with their own infrastructure (i.e. cable or mast).

Business park and data centre information, in combination with address information on where circuits terminate, is useful in identifying wholesale and retail market shares within and outside these areas.

Oxera notes that there are data limitations such as the lack of precise geographic co-ordinates information on circuit or network termination points. This means that precise allocation between these two areas (and hence market share assessment) is difficult. The primary method of market share assessment has been a circuit-level assessment of the inventories provided by stakeholders, with the aim of identifying the circuit A-end and B-end locations as either business park or non-business park locations. The underlying address information:

- is not consistent across suppliers (and lacks precise geographic identifiers or proxies such as postcodes);
- may be recorded on disparate systems due to differences in access/logical circuit provisioning or bundling, and is thus not easily accessible.

For this reason, the process has relied on an element of local knowledge in determining the correct allocation.

In order to provide a cross-check to this process, Oxera proposed an empirical or data-driven approach to allocation. The objective was to allocate circuits to either business-park or non-business park locations in a method informed by the available data as much as possible.

Approach to assessment

Oxera's approach to this cross-check assessment can be described as a word-search classification of each circuit in the inventories. This scans the address portions of each line in the inventory for a set of keywords that relate to business parks. Where a match is found, the terminating segment is classified as a business park.

If the address data were recorded in a consistent manner (exactly the same spelling, no shorthand names, no abbreviations or alternatives) then a simple list

[118] This is approximately 9% of all businesses in Ireland.

of the addresses of business parks could be matched to the addresses in the circuit inventory. However, this not the case, which means that the approach has had to consider several different approaches to word search allocation, as follows.

1. Generic matching. Circuits inside business parks are identified by keywords relating to names that describe generic business parks—e.g. bus pk, ind estate, technology park. This could over-allocate to business parks, especially if some business park addresses do not meet the competitive conditions criteria.

2. Strict matching. Circuits inside business parks are identified by complete business park name—e.g. IDA Cork Business and Technology Park, Willsborough Business Park, as per the list determined to meet the competitive conditions criteria. While this aims to be more precise, different ways of recording the same address could mean that some circuits that terminate in these locations are missed.

3. Two-part approach. This approach combines the generic approach (1) above and the strict approach (2). The word-search method uses a list of generic business park identifiers *and* a list of parts of names that are associated with competitive business parks. Circuits that contain both a generic business park term and part of a known business park location name are allocated to the business park geography. This ensures that there is targeting of the known locations, while allowing for some variation in recording.

These three options provide a range of strictness in allocating circuits to business parks. Given the data issues, Oxera considers that the two-part approach is most appropriate. This assessment was applied to wholesale and retail on-net circuit inventories. Where off-net circuit address information was available, it has been applied. Where off-net circuit address data was not available in the raw data, Oxera inferred the business park shares from the proportion calculated in the operator's on-net allocation between within and outside business parks.[119]

A5.3 Pricing data

The pricing data used by Oxera has been obtained from eircom's published wholesale prices. This pricing is split by separate wholesale products that are required to build a partial private type circuit (end-user link, interconnection, core conveyance) and is disaggregated by bandwidth and distance or region.

As noted previously, leased lines are generally bundled with a wider suite of connectivity services (e.g. call conveyance, mobile services and value-added data services) in the retail market. This means that it is not practicable to compare retail prices for these services.

Also, in general, leased line services are sold on a price-on-application basis in the retail and wholesale market, and retail prices are not publicly available. The only exception to this is the wholesale price lists that eircom is obliged to publish. In addition, in the wholesale market OAOs buy leased lines from each other

[119] Where there is no off-net circuit address information, an assumption is required to allocate between 'in business parks' and 'outside business parks'. Our approach is to assume the split implied by the purchasing OAO's in-out business park ratio for which address information is available. This is based on the idea that customers acquired off-net have a similar geographic distribution to the on-net split of the purchasing operator This inferred ratio applies to only 35 wholesale off-net circuits, which is unlikely to affect the overall result.

based on their particular connectivity requirements (e.g. A-end location, bandwidth, etc.). Thus, wholesale prices can be compared more easily.

Oxera also understands that eircom's regulated price set is based on a bottom-up long-run average incremental cost (BU-LRAIC) model. This should be a good proxy for competitive prices. This is a useful property when using this data to compare relative prices across bandwidths and technologies in order to test whether these are in the same market. Another option would be to consider OAO retail prices, which might be set competitively. As highlighted above, as this data mixes circuits of different distances or quality, comparisons based on these may be less useful in informing our analysis.

Oxera has also used implied wholesale prices (wholesale revenues divided by volumes) to compare patterns of pricing of wireless services to fixed.

A5.4 Retail business survey data

Oxera has used results from ComReg's retail business survey carried out by RED C between November and December of 2014, entitled: 'Market Analysis – Business Market (Draft)'.[120] This survey analysis contains the following information:

- the importance attached by consumers to different service features when selecting a supplier;
- uses of services;
- characteristics of services such as speed and SLAs;
- the extent to which consumers switch between services;
- bundling and contract features;
- SSNIP-related questions, eliciting the consumers' response to a 10% price increase.

However, there are a number of caveats associated with the business survey results, and thus with any inferences based on this data. For example:

- small sample size for many questions, including on potential switching between products. This means that robust conclusions cannot be drawn from responses to these questions;
- the small sample size problem is accentuated for leased line users, and when looking at sub-segments of users (e.g. TDM users or high-bandwidth users);
- respondents tend to overstate what they would actually do if facing a real situation, which means that survey results are usually indicative of the maximum extent to which consumers are willing to take a particular action.

Therefore, the business survey results, while indicative of end-user preferences, cannot be used to draw robust conclusions.

Oxera has therefore made limited use of this data in its analysis, and has done so in combination with other evidence. Oxera has used the survey results to

[120] ComReg/RED C (2015), 'ComReg: Market Analysis – Business Market (Draft)'.

draw some tentative conclusions on the substitutability of broadband and leased line services, as well TDM and Ethernet interfaces.

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