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The Italian broadband market:
an economic analysis of the main FWA players

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Abstract

Nonostante il numero delle linee a banda larga e banda ultralarga in Italia stia aumentando, il paese risulta in ritardo nel raggiungimento del secondo e terzo obiettivo dell'Agenda Digitale Europea. Il mercato italiano della banda larga è stato da sempre caratterizzato da un forte divario digitale infrastrutturale (DDI), la cui causa principale è attribuibile alla grande presenza di aree rurali nel territorio italiano, in cui gli internet service provider non trovano profittevole investire. Per far fronte a questa problematica sono state introdotte due principali misure di Aiuto di Stato: il Piano Nazionale Banda larga (2011) e la Strategia Italiana Banda Ultralarga (Strategia BUL, 2015). L'architettura di rete Fixed Wireless Access (FWA) rappresenta una valida soluzione per offrire una copertura rapida ed economicamente sostenibile a queste aree marginali. Purtroppo, il tradizionale ruolo di riduzione del DDI attribuito all'FWA continua ad essere presente anche nella Strategia BUL, dimostrando un'incomprensione da parte del legislatore dell'effettivo potenziale di tale tecnologia. Attribuendo una maggiore rilevanza all'FWA, si riuscirebbe a completare il processo di copertura della BUL in minor tempo e ad un costo inferiore rispetto alle tradizionali architetture FTTx. Le evidenze infatti, dimostrano un dinamismo del segmento FWA considerando: a) un aumento di performance notevole, arrivando a raggiungere 1 Gbit/s; b) che esso rappresenterà una delle primarie applicazioni in ottica 5G; c) che i suoi principali

operatori sono riusciti a conquistarsi gradualmente quote di mercato, erodendo quell'ex-monopolista, Telecom; d) che alcuni operatori tradizionali hanno introdotto un'offerta FWA nel loro portafoglio prodotti, fatto che denota l'attrattività di questo segmento.

Obiettivo della tesi è sviluppare un'analisi economica dei principali FWA player, Eolo e Linkem, al fine di evidenziare quali azioni strategiche intraprese abbiano consentito a due relativamente nuovi entranti di imporsi gradualmente, sebbene con piccole quote, nel mercato italiano della banda larga, che di per sé ha una struttura concentrata e richiede ingenti investimenti con un ritorno dilazionato. L'analisi strategica (focus dell'elaborato) sarà accompagnata da un'analisi di bilancio per il periodo 2012 – 2018, in maniera tale da comprendere le maggiori implicazioni delle scelte strategiche sulla profittabilità, solidità patrimoniale e liquidità delle aziende.

I risultati ci dimostrano i notevoli investimenti sostenuti dai due operatori per realizzare un'infrastruttura di rete che copra l'intero territorio nazionale. Una strategia commerciale di supporto a questo processo di espansione si è resa necessaria in entrambi i casi per monetizzare gli investimenti infrastrutturali. Da un lato, Eolo è riuscito ad individuare un segmento premium nell'utenza residenziale, a cui ha applicato un livello di prezzo elevato. Ciò ha garantito ricavi elevati, al pari negli ultimi anni a quelli di Linkem, nonostante avesse un portafoglio clienti inferiore. La profittabilità di Eolo risulta beneficiare dalla politica di prezzo applicata. La liquidità, al contrario, mostra dei segni di debolezza, dal momento che

viene preferito il ricorso a flussi di cassa generati dalla gestione per coprire il fabbisogno finanziario. Linkem invece, sembra puntare ad un segmento standard di clientela residenziale (30 ≤ Mbit/s < 100) con un posizionamento di prezzo inferiore, particolarmente attrattivo per le grandi aree metropolitane in cui opera e che gli ha garantito il posizionamento come FWA leader. La profittabilità mostra alcuni segni di debolezza; al contrario si evidenzia una corretta e continua pianificazione finanziaria, realizzata grazie al continuo apporti di soci (anche importanti fondi d'investimento) di pari passo con l'accensione di finanziamenti bancari.

Introduction

The objective of the thesis is providing an economic analysis of the two main FWA (Fixed Wireless Access) Italian players: Eolo and Linkem. The focus of the study will be the two competitors' strategies, analysed considering the actions undertaken in the field of network deployment, commercial strategy and strategic partnerships. To complement the strategic analysis, a financial statement analysis referred to the period 2012 – 2018 will be conducted, in order to outline the main implications of the strategic choices adopted on the companies' profitability, financial solidity and liquidity. The intent behind is understanding which are the determinants of their recent increase in market share in terms of broadband and ultrabroadband (B&UB) lines, at the expense of the incumbent Telecom. The starting point is considering that they are (relatively) new entrants in a market (the Italian broadband market) that requires high investments, dominated by well-established operators and where acquiring new customers is limited by the quite high switching costs. The analysis will be preceded by a context analysis, focusing both in the wider broadband market and in the FWA architecture. FWA actually is a network architecture enabling B&UB connection, alternative with respect to the traditional FTTx architecture. The role traditional attributed to FWA is the one of reducing the infrastructural digital divide, as it emerges from the implementation of the Italian National Broadband Plan (2011). FWA actually is characterized by a strong capability of

reaching marginal areas at a limited cost and in a short time. This role unfortunately, continue to be stressed by the policy maker in the ambit of the more recent Italian Ultrabroadband Strategy (2015), demonstrating a not fully understating of the potential of this technology. The evidences actually, follow another direction: FWA service providers have managed to highly increase the performance of their offering, reaching ultrabroadband connection (up to 1 Gbit/s). In addition, FWA could exert a prominent role in 5G perspective, since it represents its main application. Moreover, traditional service providers (e.g. Telecom) have expanded their customer portfolio offering introducing a FWA solution, indicating that they consider it an attractive segment to compete in.

Chapter 1 will provide some brief evolutive remarks on the Italian telecommunication sector, in order to understand the past infrastructural dynamics and the role assumed by the incumbent Telecom. Besides, FWA architecture will be introduced, together with the other network infrastructures enabling B&UB connection.

Chapter 2 will deal with the infrastructural digital divide (IDD) issue and with the solutions implemented to solve it. Notwithstanding B&UB lines are increasing in absolute value, the IDD strongly affects the Italian context, that emerges to be in delay with the achievement of the Digital Agenda for Europe (DAE) objectives. The projects ideated by the policy maker for reaching these objectives (essentially,

Italian National Broadband Plan and Italian Ultrabroadband Strategy) will be presented.

Finally, chapter 3, that represents the core of the thesis, will introduce an economic analysis of the FWA service providers, and then will focus entirely on the comparative analysis of the two FWA main players: Eolo and Linkem.

1. Introduction to Fixed Wireless Access

1.1. Brief remarks on Italian telecommunication sector

In this chapter we will provide an overview of the Italian broadband market, focusing on some evolutive remarks and some infrastructural issues.

Broadband market falls within the wider telecommunication sector, known for being a high-investment sector as a result of: a) need of adapting the existing infrastructure to an overtime growing demand for capacity; b) continuous technological advancement (AGCOM, 2000). The term "broadband" strictly speaking refers to the upload and download of data at a speed connection 2 Mbit/s, but when we make reference to broadband market, we use it indistinctly to address also ultrabroadband connection, that must provide a speed at least equal to 30 Mbit/s.

The economic relevance of broadband has been widely studied by academic literature[1]. The basic concept is that economy can benefit from broadband deployment (and consequently its adoption) in terms of productivity and efficiency increases. This is made possible by a major exchange of information permitted by a higher band. OECD (2004) invites governments to stimulate private telecom operator's investment in broadband network infrastructure. Recent Covid-19 outbreak has highlighted the need for broadband connection for smart working and

[1] This topic will be deepened in the second chapter.

homeschooling applications. In this context, internet service providers (this is how broadband market players are identified) have successfully sustained the major broadband requirement (Telco per l'Italia 360 Summit, 2020)

Some of the internet service providers also deliver a voice service; they can operate: at the wholesale level, by making available their proprietary infrastructure to other operators; at the retail level, by directly selling the connection service to the final user; or at both levels.

Broadband connection can be provided through different access system, as consequence we can differentiate among:

- Wireline broadband access
- Fixed broadband wireless access (or briefly, Fixed Wireless Access, FWA)
- Mobile broadband access.

Each of them owns its peculiarities that make it more appropriate in certain conditions and less in others (Troisi, 2015). Along the thesis it will not made reference to mobile broadband, but the attention will be on fixed broadband, both wireline and wireless[2] (more appropriate to provide an ultrabroadband connection for residential and business user) with a focus on the latter in the third chapter.

In the next lines we will provide some brief evolutive remarks on Italian telecommunication industry from the Second war aftermath to the liberalization of

[2] Wireline technology adopts copper of optical fiber cables, while wireless adopts radio

the sector started in 1988. The choice of dealing with this theme replies to a will of providing a broader picture of the telecommunication industry, before moving on the more recent events, in order to understand the past infrastructural development dynamics on a side, and on the other side the reason why the FWA operators we will analyse in chapter 3 have so narrow market share (even if growing) compared to the incumbent Telecom. Italian broadband sector actually has always been signed by the incumbent Telecom, which still maintain a predominant position (although little change that we will comment in the next section).

Until the market deregulation, Telecom Italia S.p.A. (Telecom, hereinafter)[3] was the monopolist telecommunication operator in the fixed line services; it was vertically integrated, since it owned the copper network infrastructure and operated also at the retail level, with zero competition. The traces of its monopolistic past are still visible in today market dynamics, as it emerges from the market share it still gains in broadband sector (see table 13 for detailed data). For this reason, along the thesis we will refer to Telecom also as "the incumbent".

To understand its infrastructural development dynamics of the Second world aftermath, we need to make reference to: a) the industrial rise of the so-called "Third Italy", terms used to refer to North-East and Centre regions of Italy; and b) Italian urbanisation model of that period (Matteucci, 2019). On a side, third Italy

[3]Telecom initially denomination was *SIP - Società Italiana per l'esercizio telefonico*, then modified into *SIP - Società Italiana per l'Esercizio delle Telecomunicazioni S.p.A*. in 1985. To date it is also denominated TIM S.p.A.

experienced an industrial development characterized by: a) presence of small and medium sized enterprises (SMEs); b) industrial content of economic activities (prevalence of artisanal and machine tools sectors); c) formation of industrial districts, often located in marginal areas (Ron A. Boschma, 1988). On the other side, urbanisation model was in contrast with any attempt urban planning, being characterised by territorially dispersed constructions. This common element of territorial dispersion, traceable both in business activities and in urbanisation style, has create not a few issues to the deployment of Telecom's network, that being a public utility at that time, had to provide connectivity service also to those marginal areas, more costly to be reached.

Another infrastructure-related event is the so-called Socrate (*Sviluppo Ottico Coassiale Rete Accesso Telecom)* Project, initiated in 1955 and sharply interrupted in 1998. The project objective consisted in realizing a Hybrid Fibre Coaxial (HFC) network[4] able to reach a large portion of Italian territory with broadband connectivity. The dismission of the plan is a consequence of the imposition of ADSL technology, that could have upgraded the copper network similarly - in terms of performance - to what possible with the HFC.

Following a chronological order, the next theme to be treated is the process of liberalization of Italian telecommunication market, which is not an isolated

[4] This infrastructure envisages the combination of two technologies: fiber optic for the backbone and fibre-coaxial for the last mile.

phenomenon, since it has interested the whole European Union (EU), starting from the late 1990s, with the realization of an EU regulatory framework to be transposed into the national legislation of the member states. The intent was gradually passing from a regulated monopoly to competition, allowing the market entrance of new companies operating downstream (in the retail segment) by - at least initially - adopting the incumbent access network.

The definition of the modalities through which the new operators would have accede the essential facilities is one of the main issues to be addressed by national regulators[5]. At European level the main adopted solution needs to be reconducted to the imposition of the Unbundling Local Loop (ULL) that aims at promoting infrastructural competition. It derives from a theory by Martin Cave (2004), known as "ladder of investment" (LoI), that in turns is based on the economic concept that consumers can benefit from competition (in terms of variety, prices and innovation), only if competition is extended to the entire (or most of the) value chain. To reach this situation in telecommunication sector, operators should overtime "climb" the LoI, by expanding gradually their investments from the retail market (reselling the incumbent services) until the Local Loop, becoming in this way a competitor to the incumbent in each stage of the value chain and disposing of a own property network infrastructure. Stimulating investments in this sense is

[5] The Italian regulation authority is called *Autorità per le garanzie nelle comunicazioni* (AGCOM).

demanded to the regulator, that in the first stage for example, should regulate the access price to the incumbent network in order to attract new entrants.

Also at the Italian level the regulatory choice fell on the ULL, concretized by imposing to the incumbent a series of obligations for allowing new entrants to accede gradually its network infrastructure. This was the only viable starting point, considering that at that time no alternative access networks were present. Actually, some obligations in this sense were imposed by AGCOM previously with respect to the EU regulatory framework, with the resolution 2/00/CIR.

Telecommunication liberalisation, jointly with innovation on technological side (digital technology) at the end of 1990s, signed the beginning of a stagnation period for the universal service, being Telecom (now privatized), no more incentivized to invest according to the past dynamics (as the failure of Socrate projects attests). Italy has to wait until the publication of two projects, Broadband in Italian Rural areas (2009) and Italian National broadband Plan (2011) in order to give a boost to broadband situation (Matteucci, 2019). On ultrabroadband side, the Italian government has intervened with another public initiative known as Italian Ultrabroadband strategy[6] (2015). Numeric evidence of what commented are visible at Table 1, that provides and overview of the number of broadband and ultrabroadband (B&UB) lines in the period 2012 – 2019. DSL (Digital Subscriber

[6] These national plans, concretized through different State Aid measures, will be discussed in chapter 2.

Line) includes several technologies adopting analogue transmission of data on copper cables in the last mile segment (the one that goes from the telephone exchange to the final user). In this table only the sub-set of DSL technologies providing broadband connection is used. The voice "Other technologies" instead involves different network infrastructure (FTTC, FTTH, FWA mainly[7]) and, as it emerges by crossing these data with those of Table 2, they refer mainly to ultrabroadband connection.

(in million)	2012	2013	2014	2015	2016	2017	2018	2019
DSL	13.17	13.22	13.03	12.74	12.13	10.84	8.57	7.19
Other technologies	0.59	0.79	1.35	2.18	3.36	5.69	8.50	10.28
Total	**13.76**	**14.01**	**14.37**	**14.92**	**15.49**	**16.53**	**17.07**	**17.47**

TABLE 1: BROADBAND AND ULTRABROADBAND LINES, 2012-2019
SOURCE: OWN ELABORATION ON AGCOM DATASET

The trend of total B&UB lines is growing in the period analysed, but it is the result of a decrease of the broadband lines (DSL) and of an increase of ultrabroadband lines (the majority of other technologies) that more than compensate the drop in the first ones. This switch of focus is not only the result of private investments (i.e. those planned by operators), but more precisely it can be stated that the public intervention with the above-mentioned Italian Ultrabroadband Strategy has orientated the investments of telecommunication operators towards the right direction. What need to be remarked is the fact that the growth trend of B&UB lines

[7] See section xxx for further explanation.

is not enough to ensure to Italy a good positioning at the EU level, since it is relevant the infrastructural gap with the other countries[8]. The passage from broadband to ultrabroadband connection is a consequence of several factors, including, on residential users' side, the growth of online content offering (e.g. video content) that implies a growth in traffic volume.

As last, broadband market players will be presented in the third chapter, where we will assess the relevance of FWA players within the whole sector.

1.2 Introduction to FWA

1.2.1 Alternative network infrastructures

To introduce the FWA technology, it is useful presenting an overview of the existing network infrastructure alternatives. To be precise, FWA is a network architecture, but along the thesis we will refer to it also as a technology or alternatively, as a platform and is able to provide broadband and ultrabroadband connections[9].

First, we make reference to AGCOM data[10], that allow us to appreciate numerically the degree of presence of the different network infrastructure at the Italian level.

[8] This topic will be expanded in chapter 2.

[9] (Basic) broadband connection must provide a speed ≥ 2 Mbit/s, while ultrabroadband connection ≥ 30 Mbit/s.

[10] AGCOM, *Osservatorio sulle comunicazioni*, various years. Retrieved from: https://www.agcom.it/osservatorio-sulle-comunicazioni

Infrastructure type	2014	2015	2016	2017	2018	2019
Copper	19.27	18.14	16.90	14.90	11.75	9.22
FWA	0.53	0.74	0.85	1.05	1.23	1.32
FTTC	0.44	1.06	2.05	4.06	6.38	7.76
FTTH	0.31	0.32	0.41	0.55	0.85	1.22
Totale *(Total)*	**20.54**	**20.25**	**20.22**	**20.57**	**20.21**	**19.52**

TABLE 2: LINES BY INFRASTRUCTURE TYPE, 2014 - 2019 **(MILLIONS)**
SOURCE: OWN ELABORATION ON AGCOM DATASET

Infrastructure type	2014	2015	2016	2017	2018	2019
Copper	93.8	89.6	83.6	72.4	58.2	47.2
FWA	2.6	3.6	4.2	5.1	6.1	6.8
FTTC	2.1	5.2	10.2	19.8	31.5	39.7
FTTH	1.5	1.6	2.0	2.7	4.2	6.2
Totale *(Total)*	**100**	**100**	**100**	**100**	**100**	**100**

TABLE 3: LINES BY INFRASTRUCTURE, 2014 – 2019 (DISTRIBUTION, %)
SOURCE: OWN ELABORATION ON AGCOM DATASET

Table 22 indicates the number of lines for each of the infrastructure type in the period 2014 – 2019. Table 3 represents the same concept by using percentage values. The main evidences emerging from the observation of the above tables are:

- Gradual decrease of copper technologies accelerated starting from 2017, in favour of the adoption of more innovative infrastructure type, especially FTTC. 2019 represents a crucial year, showing the lowest gap between copper access lines and FTTC access lines.

- Contextual increase in interest towards more performing connections – FWA and FTTH – in line with Government endeavours aiming at migrating from broadband to ultrabroadband network[11].
- FWA segment has registered an overall increase of 101.47% in the period considered, reaching a 6.8% of the access lines in 2019 (a bit higher than FTTH infrastructure). At December 2019, FWA lines reach 1.32 million, compared to 8.98 million lines considering jointly FTTC and FTTH.

In the next lines we provide an explanation of the alternative access network architectures, that are five according to AGCOM classification (2018, 2019); this implies a more refined classification than the one emerging from Table 2 and Table 3 (that envisages a merging of some sub-levels). The access network architectures are:

- FTTH (Fiber To The Home)
- FTTB (Fiber To The Building)
- FTTN (Fiber To The Node)
- FTTE (Fiber To The Exchange)
- FWA (Fixed Wireless Access)

The technical details are not useful for the purpose of this thesis, but a basic explanation must be provided. The first four, identifiable under the generic name

[11] See section 2.2.3 for further explanations.

"Fiber To The x" (FTTx) and differ according to the last point reached by the optic fiber. From that point forward, copper cables intervene and provide the connection to modem located inside the house/office. When compared to optical fiber, copper shows its weaknesses, in particular: copper cables experience a drop in performance (signal strength properly) that increases with the length of the cable itself, on the other side optical fiber cables exhibits their benefits in the long distance; copper cables have a lower capacity than the optical fiber cables that at the same time are easier and cheaper to be installed considering their reduced dimensions (Unger and Gough, 2008). Moreover, the Italian copper network is at the end of its useful life-cycle, with relevant implication from the performance perspective and the need of being subject to high maintenance costs or being replaced because obsolescent.

In the specific: FTTH implies the rolling out of fiber cables through the whole last mile segment (i.e. the one from the telephone exchange, to the final user); FTTB differs from FTTH only for the fact that fiber reaches the base of the final user's building, while inside the building the infrastructure is copper-based; with FTTN, the fiber segment reaches an intermediate node along the last mile, from this node forward the technology adopted switches to copper. When the intermediate node coincides with the cabinet, we talk about Fiber To The Cabinet (FTTC).

FTTE finally, can be reconducted mainly to ADSL (Asymmetric Digital Subscriber Line) - representative of copper technologies[12] - that envisages the deployment of fiber only in the backhaul segment (i.e. the one reaching the telephone exchange), while the last mile segment is totally covered with copper cables. As consequence, for the above-mentioned limits of copper, ADSL is only able to provide a broadband connection. Hence, despite still representing a wide portion of telecommunication infrastructure, FTTE architecture are destined to be surpassed, considering the objectives of the currently in force Italian Ultrabroadband Strategy[13] that aims to provide ultrabroadband connection to the whole population. FWA finally is a network architecture that presents some elements of the fixed connectivity and some of the wireless one.

[12] To be precise, copper technologies involves many different technologies, including ADSL, that provides a broadband connection and other technologies that do not reach a broadband connection. This is the reason why we can notice a gap between the total of lines by infrastructure type (table 2) and B&UB lines (table 1).
[13] See section 2.2.3 for the detailed explanation.

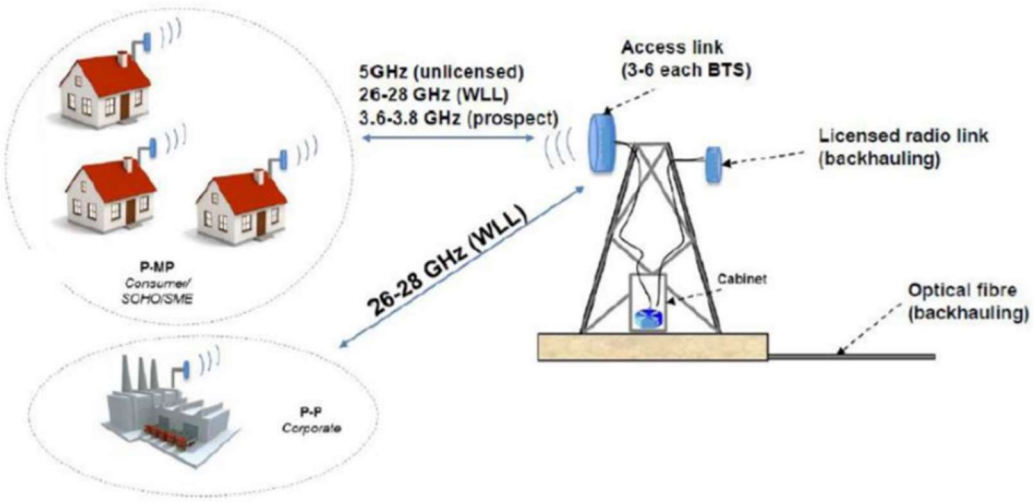


Figure 1: Functioning of FWA technology

Source: CFWA

depicts its functioning. Briefly, the backhauling (optical fiber essentially) reaches a base transceiver station (BTS), where an access link sends the radio signal to a customer premise equipment (CPE) located within the site (house/office) of the final user. The CPE then communicate with the user's devices through Wi-Fi connection or alternatively wired connection. In other words, FWA exploits radio technology to provide connection in the last mile. It creates a radio link between two fixed infrastructures: the BTS of the service provider and the CPE of the customer. The frequency bands involved are the 3.4 GHz – 28 GHz. A first consideration to be done is the fact that FWA expansion depends on radio spectrum frequencies' availability. Radio links can be of two different modalities:

- Point-to-point (more suitable for corporate use, since it offers a guaranteed bandwidth, not shared with external users).

- Point-to-multipoint (typically used with residential customer and SMEs, it envisages that the transmission capacity offered by the BTS is shared by the users falling within a certain area.

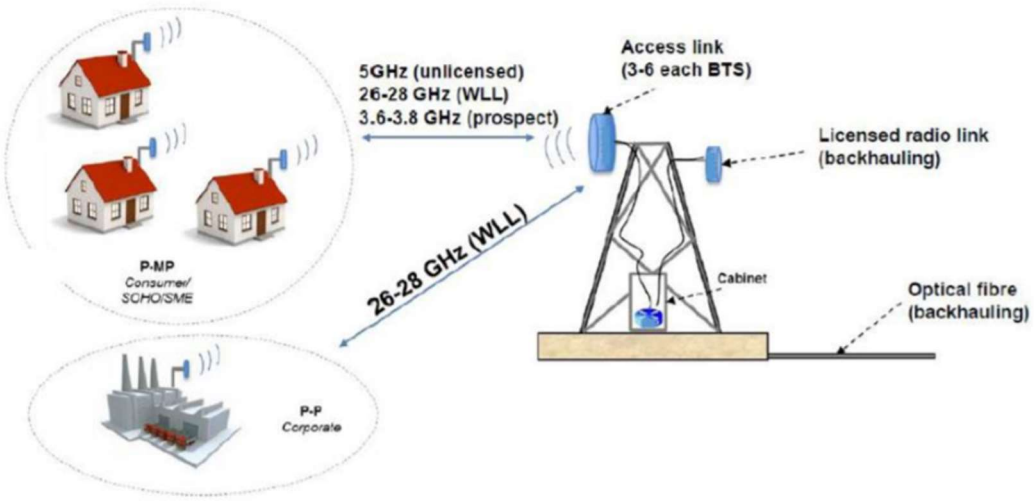


FIGURE 1: FUNCTIONING OF FWA TECHNOLOGY
SOURCE: CFWA

Some technical features of FWA network can be appreciated when comparing it to mobile broadband access[14] (Troisi, 2015). In the specific:

- FWA grants a higher SNR (Signal to Noise Ratio), factor that, bandwidth being equal, determines a higher transmission capacity (vs mobile connection). This is linked to the presence of the CPE that effectively catch the radio signal deriving from the BTS and, as consequence, allows a reduction of interference, higher speed connection and lower latency.

[14] The differences with the wireline broadband access (optical fibre essentially) will be object of the next section, because they are functional for some reasonings explained there.

- Better signal strength and quality of the signal, considering the relative inefficiency of mobile devices' antenna, less performing in receiving the signal.
- Greater control over the quality of the signal induced by the opportunity to decide the number of users per BTS, hence the number of users sharing the transmission capacity of the BTS. This is not possible with mobile service, because the number of users per BTS is variable.

All type of infrastructure above mentioned, with the exception of FTTE, are able to provide an ultrabroadband connection. For this reason, they all fall within the panel of choice for Next Generation Access Network (NGAN)[15] deployment within the ambit of Italian Ultrabroadband Strategy. Each of them involves a different level of financial burden and in the specific of FWA, it represents a relatively economic infrastructure, as we will comment in the next section.

1.2.2 Focus on FWA

In this section the main features of FWA infrastructure technology will be exposed, in terms of benefits, fields of application and obstacles it encounters for the development of its full potential.

[15] Next Generation Access Network are those able to provide ultrabroadband connection, also identified as Second Generation broadband.

To remark AGCOM (2018) definition, *"With FWA (Fixed Wireless Access) access network, we mean the access network where the optic fiber and/or other backhauling mean reaches a radio base station, to which the user terminals are linked through the use of a determined radio frequency band"*. The functioning of FWA architecture is based on exploiting radio spectrum frequencies in order to provide broadband and ultrabroadband connectivity services.

Several are the standards on which FWA infrastructure can be based, they include:

- WiMAX (Worldwide Interoperability for Microwave Access
- HiperLAN (High Performance Radio Local Area Network)
- 4G LTE (Long Term Evolution)
- LTE Advanced

As we will see with Linkem case, LTE represents a more advanced technology with respect to WiMAX (and HiperLAN, initially adopted by Eolo instead), able to grant better performance to the final user and to sustain the growth in traffic. WiMAX and HIPERLAN can be assimilated to ADSL in terms or performance, while LTE[16] to ultrabroadband. In this respect, AGCOM makes a clarification: FWA acronym is adopted for non-ultrabroadband connection (speed < 30 Mbps); FWA+ refers instead to ultrabroadband connection (speed in download ≥ 30 Mbps).

[16] LTE Advanced is the most used transmission technology by operators at the moment.

Besides the technology (i.e. standard), another element defining the FWA infrastructure is the frequency band adopted (3.4 GHz – 28 GHz).

The main advantages granted by this technology[17] - with respect to fiber optic - needs to be reconducted to (Troisi, 2015):

- fast deployment;
- low cost of deployment (being not so invasive and not requiring a capillary deployment of fiber optic as in the case of FTTx architecture);
- low maintenance costs;
- fast activation time (for the final user)
- scalability[18].

All these aspects make FWA a flexible solution that particularly fits well for rural areas, where serving the last mile with optic fiber would be too high to be sustained by operators on their own (because return on investment there is negative). Despite now FWA is appreciated also for other uses, the more traditional field of application for FWA architecture is precisely rural areas and it was the only one attributed to it until few years ago, at least in Italy. During the implementation of Italian National Broadband Plan (2011)[19] FWA served as a complement or substitute to other technologies to provide basic broadband coverage. The evidences attesting this are

[17] These advantages actually refers to the Point-to-multipoint accesses adopted in FWA network.
[18] Scalability is the property of a system to handle a growing amount of work by adding resources to the system. (Source: Wikipedia)
[19] See section 2.2.2 for further details.

given by Eolo[20] winning five out of the twenty auctions within the framework of model of intervention B. The technology used by Eolo for upgrading last mile access is WiMAX. Moving forward, as it will be outlined in section 2.2.5, the same role of digital divide gap-filler will be hypothesized within the ambit of Italian Ultrabroadband Strategy (2015), but only for 30 Mbps connections. In the specific, FWA is believed as a viable and valid solution for reaching 30 Mbps broadband coverage in low density areas (first point of second Digital Agenda for Europe (DAE) objective); its effectiveness it's not recognized instead when we deal with 100 Mbps connections (second point of second DAE Objective).

When we move to the implementation of the Italian Ultrabroadband Strategy it is clearly visible the marginal role attributed to this technology by the policy maker: again, a solution through which reaching residential units located in rural areas, with few space devoted to urban areas. The evidence is given by table 10 (chapter 2), outlining that the majority of the residential units planned to be reached by FWA are located low population density areas (South and the islands).

The framework presented until now depicts the role attributed to FWA by the policy maker, that is very marginal and confined to solving digital divide situations in rural areas, both in Italian National Broadband Plan and in Italian Ultrabroadband Strategy. Besides this nevertheless, there are the evidences related to

[20] FWA operator (see chapter 3).

telecommunication operators that have privately invested millions of euro to build their own FWA network able to reach more than 100 Mbps connectivity. In particular, the two most relevant operators are Eolo and Linkem (that will be analysed in chapter 3). The technological advancements steps taken along their growth path are resumed in table 20 and table 22, chapter 3. Currently, the protocols they are using are EoloWAVE G for Eolo and LTE for Linkem. The outcomes are not negligible in terms of technological innovation: Eolo for example manages to gain an excellent positioning in terms of Netflix Speed Index (see section 3.2.2) and has deserved a (relatively) important market share in 100 Mbps segment connection; Linkem instead has ideated a FWA offering capable of reaching 1 Gbps. Also, the entrance of big players within FWA market is a sign for a market destined to grow.

At 30/05/2018, the FWA coverage situation of the Italian territory was the one of

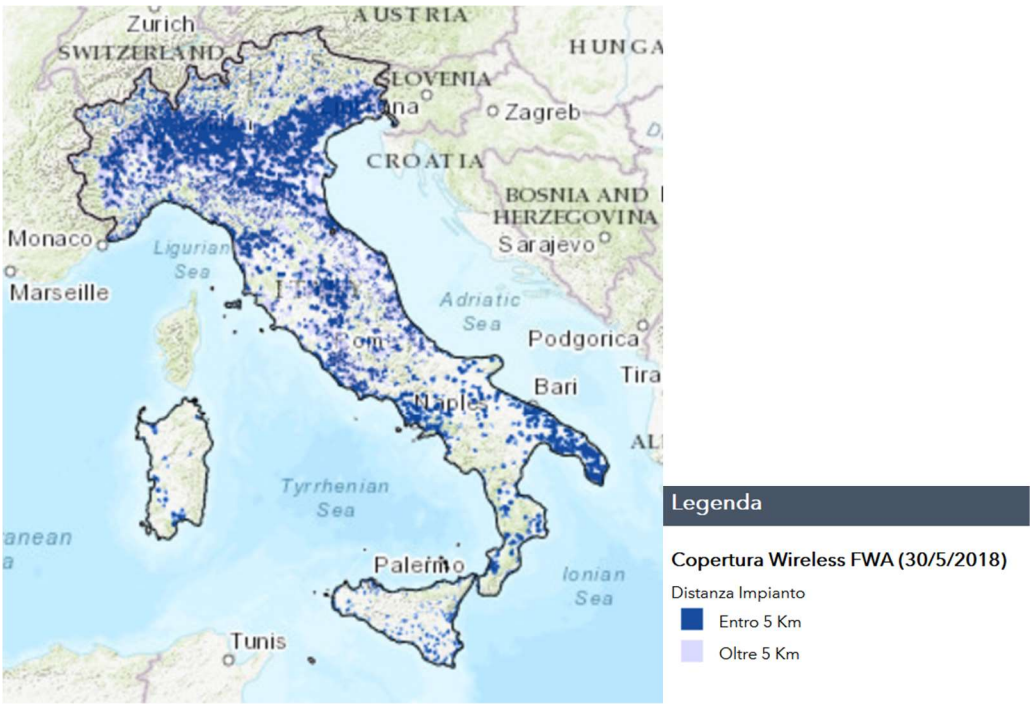


Figure 2: FWA coverage, Italy (30/05/2018)

Source: https://maps.agcom.it/.

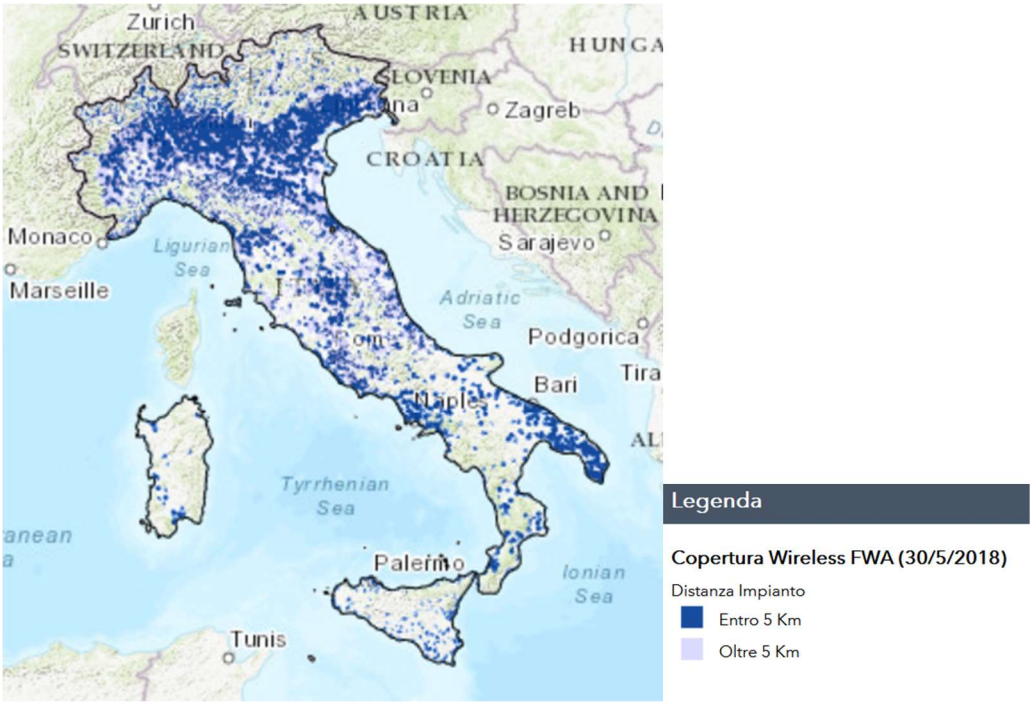


FIGURE 2: FWA COVERAGE, ITALY (30/05/2018)
SOURCE: HTTPS://MAPS.AGCOM.IT/

Despite the lack of the provincial level data, that could have permit us some interesting considerations, what is relevant to notice is that operators have invested in all the Italian territory, with a lot of BTSs concentrated in the Northern areas and, at general level, it is visible that the coverage goes far beyond the marginal areas. In particular, Linkem has located its access network in 19/20 metropolitan cities, becoming a direct competitor of the incumber and of the other big players there. In brief, Eolo and Linkem have tried to make their space among broadband lines and ultrabroadband lines.

These evidences have prompted the regulator to devote a relatively considerable space to FWA within the Resolution 292/18/CONS and to stress on the fact that it can deliver ultrabroadband connection, as above mentioned. A specific concerns the different FWA enabling technologies: LTE is the most adopted to date and allows operators to add to their portfolio an ultrabroadband commercial offer, able to reach 100 Mbps; while WiMAX and HyperLAN, near to be definitively overcome, can only deliver broadband connection.

In addition, future perspective for FWA must be underlined; it represents the main application of 5G, *"the fifth generation of cellular technology. It is designed to increase speed, reduce latency, and improve flexibility of wireless services"* (Cisco website).

5G could represents a great opportunity for FWA operators, since they dispose of the right assets, i.e. the frequency bands necessary for developing 5G network architecture, the so-called "pioneer bands" for 5G. Radio Spectrum Policy Group, RSPG (2016) identifies three bands that could support the introduction of 5G in Europe. In the specific, the pioneer bands are:

- 700 MHz
- 3.4 - 3.8 GHz
- 24.25 - 27.5 GHz

In the next lines we will briefly introduce how Eolo and Linkem are approaching in this respect[21]. Eolo has recently (2018) realized its own property network called EOLOwave G, based on 5G frequencies (27.5 GHz) acquired by the company at the end of 2016 at a price of € 10 million[22]. Thanks to this move, Eolo can rely on 112 MHz of radio spectrum in exclusive right of use, whose adoption, mixed to the company's R&S abilities, have led to the ideation of EOLOwave G access network, a 5G ready solution able to provide connections up to 100 Mbp/s in download and 50 Mbps in upload. The first field of application of EOLOwave G is given by the launch in April 2018 of a commercial offer dedicated to residential users (EOLO Super) able to reach indeed 100 Mbps in download[23].

Linkem's FWA network instead is based on frequencies of Linkem's network is based on licensed frequencies 3.5 GHz, for which the company owns the rights of use, assume a great relevance in future perspective, since they form part of the frequency bands pioneers for 5G applications. In 2017 furthermore, Linkem acquired 112 MHz of spectrum in the portion of spectrum 24.25 – 27.5 GHz in all the Italian regions (with some exceptions, see table 23, chapter 3). Therefore, Linkem holds portions of spectrum in two out of the three pioneer bands for 5G. As last, it is interesting to note the attempt made by Linkem of developing strategic partnerships with other telecoms operators in 5G perspective (e.g. Open Fiber and

[21] See 3.2 for further details.
[22] Source: https://www.eolo.it/eolonews/2017/04/17/eolo-in-campo-per-portare-il-5g-fisso/
[23] See section 3.2.2 for further details.

Go Internet)[24]. Sharing costs and risks for investments 5G related can represents a strategic move, considering the great halo of uncertainty that characterizes the 5G world.

The last aspect that we want to present concerns a radio spectrum consideration. Wireless services really rely upon the frequency availability, but the tendency of the regulator has always been making available new frequency bands for mobile connections and devoting few resources to fixed wireless services. In this context of scarcity, FWA operators have over the years developed a capacity for adaptation by exploiting the unlicensed frequency bands and showing hence, efficiency in the spectrum usage (Troisi, 2015). Starting from the end of 2016 something has changed, considering the purchase of right of use by Eolo and Linkem of licensed bands that allowed them to expand their coverage.

[24] See 3.2.3 for further details.

2. Infrastructural Digital divide

2.1 Infrastructural digital divide: basic concepts

2.1.1 Economic relevance of broadband deployment

In October 2003, a document[25] elaborated from the Directorate for Science, Technology and Innovation outlined the importance of broadband for economic and social development and contemporaneously, introduced some policy principles that OECD countries should use in order to develop broadband connectivity. Now, with the most recent technological advancements, the attention has shifted towards ultrabroadband connectivity, but the idea behind remains the same: investing in the deployment of the most advanced telecommunication networks is a way to give a boost to the impact of Information and Communication Technologies (ICT) on the other sectors, in terms of economic growth. Productivity and efficiency experience an increase, thanks to a major exchange of information permitted by a higher band. Not only the private sectors are benefitting from this situation - with new market opportunities arising and existing businesses experiencing an increase in performance - but also public sector and consumers can have access to the value created.

[25] The document in question is *Broadband Driving Growth: Policy Responses*, DSTI/ICCP(2003)13/FINAL. Retrieved from: https://www.oecd.org/sti/ieconomy/16234106.pdf

To reach the above benefits, the Directorate for Science, Technology and Innovation highlights the existence of two areas of action: on the supply side and on the demand side. The supply side implies that countries should find ways to invest in the infrastructure development: this refers mainly to the necessity of creating a competitive environment between telecommunication operators, such that investments in the networks' deployment are stimulated; public funds could be used (in addition), if compatible with the regulation framework. In parallel, telecommunication market should be liberalized. On the demand side, the document makes reference to the need of increasing the availability of digital content and online services, together with the not-negligible necessity of creating a trusted and secure network, where consumer privacy is ensured.

Acknowledged the above content, in February 2004, the OECD Council published a document titled: *"Recommendation of the OECD council on broadband development"*, where it invites governments to seriously stimulate telecommunication operators in investing for the development of broadband networks in their country. In doing this it emerges the importance attributed to the government, that should create appropriate policies for increasing investments and provide improved regulatory frameworks where different broadband technologies can coexist.

Many are the literature evidences and empirical findings supporting the idea that economy can benefit from broadband deployment (and consequently its adoption);

the majority of them considers the impact on the overall economy (GDP as dependent variable, basically), but also interesting studies have been conducted to evaluate the impact at the firm level (assessing the contribute to productivity growth).

Table 4 resumes some empirical findings on this theme.

Authors	Data and period	Main results	Methodology
Rohman, Bohlin (2012)	33 OECD countries, 2008 - 2010	Doubling the broadband speed level envisages a 0.3% growth in GDP with respect to the base year (2008)	Linear regression
Akerman, Gaarder, Mogstad (2013)	Norwegian non-financial joint stock firms, 2001 - 2007	Skilled workers (especially STEM and business graduates) see their relative productivity increasing with broadband adoption; by contrast, workers without a high school diploma suffer from a decrease in marginal productivity (broadband as a substitute)	OLS, IV and LP on a Cobb-Douglas production function
Gruber, Hätönen, Koutroumpis (2014)	27 OECD countries, 2005 - 2011	Deploying broadband in order to reach DAE objectives by 2020 would lead on average to 1.32% of net economic benefits in the base case scenario.	Cost-benefit analysis; 3LSL on aggregate production function
Koutroumpis (2019)	35 OECD countries, 2002 - 2016	Increase in broadband adoption and speed leads to increase in GDP, but with diminishing return to scale, up to a saturation point.	3LSL on aggregate production function
Hallera, Lyons (2019)	27,926 Ireland firms from 9 sub-sectors (services and distribution), 2006 - 2012	DSL availability does not offer the same productivity benefits to all firms; Information & Communication and Administration & Support services are the sectors gaining most.	Linear regression

TABLE 4: EMPIRICAL FINDINGS ON BROADBAND IMPACT ON ECONOMY
SOURCE: OWN ELABORATION

At a general level, Rohman, Bohlin (2012) assess the relationship between broadband speed (function of several variables, including broadband penetration) and the ratio GDP per capita at time t over the GDP per capita in 2008 (base year). They conclude that doubling the broadband speed determines a GDP per capita growth of 0.3% relatively to the base year. Gruber, Hätönen and Koutroumpis (2014) perform a cost-benefit analysis on the deployment of a broadband infrastructure within the ambit of the Digital Agenda for Europe (DAE). Net economic benefits are equivalent to the ratio *Net cumulative gains/infrastructure costs*. The numerator is estimated starting from an aggregate production function including also broadband factor, as follows:

$$GDP_{it} = f(K_{it}, L_{it}, BB\_Lines_{it})$$

GDP of a country i at time t is a function of the stock of capital (K), labor (L) and the stock of broadband infrastructure (fixed and mobile) (BB_Lines). The latter is considered in terms of penetration rate and quality of connection (measured through the broadband speed). Infrastructure costs are estimated in three different scenarios: a) base case scenario; b) recessionary scenario (high unemployment); c) recessionary scenario (pulling out investments); d) adoption boom scenario. In all four cases, cumulative gains more than outweigh the cost of broadband deployment, meaning that it will be remunerative for countries reaching DAE objectives on time. In particular, in base case scenario the benefits are 32% above the costs on average

in the sample. At national level this percentage varies a lot, but a positive outcome is observed in the great majority of countries. Koutroumpis (2019) adopts the same aggregate production function of Gruber et al. (2014) and, starting from it, performs two 3LSL econometric analysis. The first one only considers BB_Lines variable in terms of broadband adoption and finds that increasing of 10-lines per 100 people reflects into a GDP augment but with diminishing returns to scale. More important, these positive effects vanish when a saturation point is reached, from which network improvements (i.e. higher speed, Mbps) must be made in order to catch again broadband benefits. Consequently, the authors perform a new 3SLS analysis to investigate the effect of an increase in speed (accounted into BB_Lines variable) in GDP. The results are similar to the previous ones: on average, an increase by 0.08% annual is observed when broadband speed rises from 1 Mbps to 10 Mbps. Also, in the augment happens according to diminishing returns to scale and a saturation point exists. This threshold is not fixed but moves up, according to improvements in the readiness of the economy that overtime learns how to make a more efficient use of existing networks. The upper threshold of speed related gains is moving higher as a result of the "readiness" of the economy (individuals or firms) to make productive use of improved infrastructures through the availability of services that demand more bandwidth. Some researchers also concentrate on the link between broadband adoption and firm productivity. Akerman, Gaarder and Mogstad (2013) in trying to assess the effects of broadband adoption on the firm production

function, they found that the TFP of a firm is differently impacted according to the "skill-level" of the workers. They conduce different econometric analysis (OLS, IV and LP) using a Cobb-Douglas production function that take into account also broadband adoption variable. The related findings are those exposed in Table 4. Essentially, skilled workers result to "win" from broadband adoption in terms of productivity, while unskilled workers (i.e. without a high school diploma) "lose" in this circumstance. The explanation lies in the so-called "skill biased technology change"[26]. Finally, Hallera and Lyons (2019) investigated the effect of broadband introduction on Ireland firms, considering 9-sub sectors of the wider services and distribution sectors. Total factor productivity (TFP) is estimated considering several variables, including the most relevant one: broadband, proxied by DSL[27] local availability (area-based). To disentangle from possible adoption delays once that availability is granted to the firm, the outcomes of the model have been compared to those of one and two years lagged adoption since the date of availability. The main conclusion is that not all sub-sectors suffer from a significant increase in total factor productivity with broadband adoption, but the positive outcomes are limited essentially to two sub-sectors: Information & Communication and Administration & Support services, where an increase of FTP respectively by

[26] *Skill-Biased Technical Change is a shift in the production technology that favors skilled over unskilled labor by increasing its relative productivity and, therefore, its relative demand*. (Source: Violante, 2016)
[27] Acronym for Digital Subscriber Line. See chapter 1 for the definition.

32,75% and 30.97%, all other things equal are registered. The effects are still more marked considering the sub-set of small firms. ICT small firms are those gaining most in this scenario, with an explanation that could be reconducted to the fact that ICT sector *"contains most of the activities defined by Eurostat as High-tech knowledge intensive services"*. Some control variables are included in the TFP equation regression, such as firm size and domestic ownership.

2.1.2 Infrastructural digital divide: definition, determinants and measurement

As always, passing from the theory to the practice is not a one-day event, but it requires a lot of coordinating endeavours between the public and the private sectors. Moreover, we have to consider an unpleasant fact: what happens if a part of the population remains excluded from broadband access? We call this phenomenon "digital divide". To start, a definition of digital divide is required:

The term "digital divide" refers to the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to their opportunities to access information and communication technologies[28].

As evident from the framework we will explain in the next lines, digital divide either can derive from the lack of adequate infrastructure granting the access to ICT

[28] OECD definition, available at: https://www.oecd-ilibrary.org/science-and-technology/understanding-the-digital-divide_236405667766

(i.e. infrastructural digital divide), either from the poor use of ICT (descending in turn from poor ICT skills, lack of appropriate devices to access it, etc.). However, for the purpose of this thesis, we will narrow the field of analysis to a sub-set of digital divide, the infrastructural digital divide, IDD hereinafter. To remark OECD definition regarding digital divide, we could define the IDD as the gap between countries and among areas of the same country characterized by different roll-out level and quality of telecommunication infrastructure.

The International Telecommunication Union (ITU), in providing a measurement of digital divide country-based[29], presents a general framework summarizing a three stage-model that explains the evolutive path of a country to become an information society (ITU 2017).

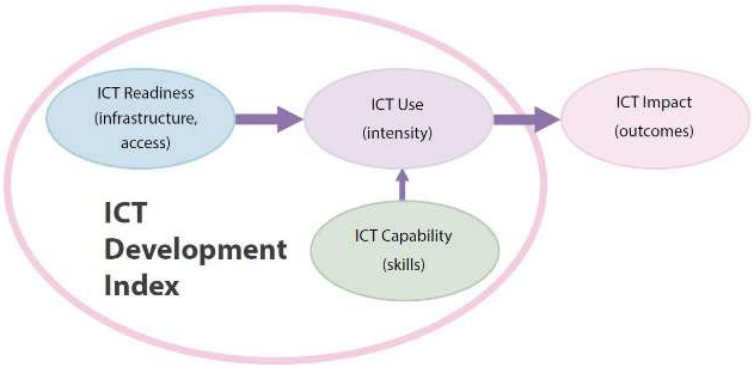


FIGURE 3: THREE STAGES IN THE EVOLUTION TOWARDS AN INFORMATION SOCIETY
SOURCE: ITU, 2019

[29] The corresponding index is the so-called *ICT Development Index* (IDI), a composite index aggregating 11 indicators catching various dimensions of digital divide. Source: *Measuring the Information Society Report 2017* (ITU). Retrieved from: https://www.itu.int/en/ITUD/Statistics/Documents/publications/misr2017/MISR2017_Volume1.pdf

The picture depicts the path for a country to become an information society.[30] This happens through a three-stages process, as the model exemplifies:

- Stage 1: ICT Readiness, which is related to the level of infrastructure present in a country to access the ICTs;
- Stage 2: ITC Use, standing for how much telecommunication infrastructure are used by the citizens of a country, the so-called "intensity". Advancing through the second stage depends on the level of ICT capability, in turn a consequence of ICT skills.
- Stage 3: ICT Impact, the final stage, that represents the outcomes a country has given an optimal ICT use.

If a country wants to become an information society, it has to pass through these three stages: making available telecommunication infrastructure that people can use, so as to improve economic growth. The last step is not automatic but depends on people ICT skills. Better skills owned by a higher portion of the population can lead to a more spread and aware ICT use, that in turn will allow the country to perform better in terms of ICT results. Behind the model there is a wider concept that interests policy maker, that is the possibility of leveraging on two sides for exploiting the benefits introduced by ICT: a supply side, with the construction of an appropriate network infrastructure; and a demand side, with the need of giving

[30] Information society is a society where economy primary information-based, rather than good-based (Bell, 1973)

the citizens the right "arms" for using them, that means developing people ICT skills.

At this point, the determinants of IDD will be object of the analysis. As first, we will propose the determinants of IDD in the Italian situation as investigated within a study by Servizio Economico Statistico on behalf of AGCOM. The study in question is titled *"Le determinanti degli investimenti privati in infrastrutture di telecomunicazione"*[31] (2016) and it must be quoted because of its innovative contribute with respect to the traditional literature of explaining the relationship between demographic and socio-economic conditions and investments by private operators. The study has been conducted through a quantitative analysis, both statistic and econometric (probit model), to take into account respectively the territorial dimension and the temporal dimension. The years of reference are 2001, 2007, 2011 and 2014, since they represent fundamental milestone in defining the current market structure in terms of economic and regulatory events.

The analysis starts with the description of the evolutive path of telecoms infrastructure from a geographical point of view. The variable that is investigated is the number of Telecom centrals that are opened to unbundling (ULL) [32]. In the reference period the number gradually pass from 1.065 (2001) to 1.748 (2014)

[31] English translation: *"The determinants of private investments in telecommunication infrastructures"*

[32] This choice depends on the fact that when an operator has access to Telecom centrals, then need to deploy its own network infrastructure to connect Telecom central to the single house/cabinet, hence, to deploy the so-called last mile.

following a proximity to the incumbent central logic and a demand-based decision-making: initially investments were located in urban areas more densely populated (with a population > 100.000 inhabitants), then they expanded towards three areas poorly served (Adriatic area, Apennines and Piemonte Region) and finally, the investments tried to spread in a way so as to cover the whole Italian territory. This last stage, started from 2010, is the consequence of policy measures implemented by Italian government for the digital divide reduction.

An increase in the competition within the same central has been found in parallel with the increase of ULL; 6.747 are the presence of the operators in centrals opened to ULL registered in 2014, versus a value of 2.130 in 2001. But the most interesting fact is that the share of ULL centrals with more than 4 competing operators is 27,9% at the national level. This increase in competition seems to reply to two correlated explanations: on offer side, ULL allows operators to reach higher density economies and scale economies (so ULL services appears to stimulate competition); on demand side, network effect plays a key role by increasing the broadband lines demand and, consequently, stimulating operators to invest.

The second part of the analysis aims to investigate the effects of socio-demographic and economic determinants over the investment decisions, that has been assumed as dependent variable and has been proxied by the probability that a Telecom central open to the ULL. This variable has been linked to several independent variables, that essentially can be reconducted to:

- Environmental factors (altitude)
- Technological factors (line density)
- Demographic factors (population age 15-64, number of households, study title)
- Economic factors (employment, income, firms)
- Regulatory policies (cost of unbundling service)

Fattori esplicativi	Significativo				Non significativo			
	2001	2007	2011	2014	2001	2007	2011	2014
Fattori ambientali								
- altitudine	√		√	√		√		
Fattori tecnologici								
- densità di linea	√	√	√	√				
Fattori demografici								
- età	√	√	√	√				
- numero di famiglie	√	√	√	√				
- titolo di studio					√	√	√	√
Fattori economici								
- occupazione	√					√	√	√
- reddito	√	√					√	√
- imprese			√	√	√	√		
Politiche regolamentari								
- costo del servizio di ULL	√	√	√	√				

TABLE 5: INVESTMENT DECISIONS: EMPIRICAL FINDINGS OF THE DETERMINANTS IN THE ITALIAN CONTEXT
SOURCE: AGCOM, 2016

The table above shows the main findings of the econometric part that can be summarized as follows:

- population aged 15-64, number of households and density line positively impact the probability that a Telecom central is opened to unbundling in all the years of reference;

- the cost of unbundling service exerts a negative influence on the same dependent variable in all the years
- Employment and income factors start to gradually lose their significance in the explanation of the dependent variable, as consequence of the diminution in price level, outcome of the market liberalization.
- The topography of the area (measured through the altitude) is a significant variable in explaining investment choices in all the years examined, except from 2007. Higher altitudes diminish the probability that a Telecom central is opened to ULL, given the greater difficulties and monetary expenses needed to build a network infrastructure.
- On firm presence side, the variable (measured as number of firms) is statistically significant only for the years 2011 and 2014, phenomenon that could be explained by the predominant function of data provider that ULL services started to assume during those years.

At a general level, what pushes from moment zero an operator to enter the telecommunication market, is a general economic principle (that applies to all market anyway): a firm enters the market when it is profitable. In other terms, a firm decides to enter if the difference between expected profits and entry costs is positive. Entry costs are considered as both fixed and sunk. Since telecommunication industry is characterized by high entry costs and consistent

economies of scale[33], it is understandable its concentrated market structure (Ford, Koutsky, Spiwak, 2005).

Several can be the determinants of infrastructural divide: demographic, regulation, environmental and economic factors can affect tlc investment choices (AGCOM, 2016). Paleologosa and Polemis (2013) for example, try to assess the impact of regulatory framework on private investments. They examine a panel of thirty OECD countries in the period 1988 – 2010. Performing and econometric analysis (static and dynamic models), they found that better regulatory environment in telecommunications industry are associated with higher investments by the sector players.

In Italy the infrastructural divide is particularly marked because of the peculiarity of the geographic territory, as pointed out from the situation analysis introducing the various Italian plans for broadband/ultrabroadband deployment[34]. Operators investments, as mentioned, are concentrated where the population density grants to them a reasonable economic return. A consequence of this profit-driven logic is that marginal areas, with low-population density, are left behind and in many cases market failure emerges[35], leaving these areas without connection (worst case) or without an appropriate one. The particular morphology of Italian country acts in a

[33] *Economies of scale refers to the phenomenon where the average costs per unit of output decrease with the increase in the scale or magnitude of the output being produced by a firm* (OECD, 2002).
[34] According to the year taken into consideration.
[35] See next sections for further explanations.

way that in some areas, because of the location altitude, not only less people live there, but it would be also more costly rolling-out telecommunication infrastructure there.

The last domain that we will introduce regarding IDD concerns its measurement, in order to provide numerical evidence attesting its relevance. An interesting index digital divide-related is the Digital Economy and Society Index (DESI)[36], that is computed at EU level as means to understand how member states are performing in terms of digital competitiveness. The DESI is a composite index that includes indicators explaining digital performance of European countries considering simultaneously 5 dimensions:

1. Connectivity
2. Human capital/digital skills
3. Use of Internet services by citizens
4. Integration of digital technologies by businesses
5. Digital public services

For the purpose of this thesis it is more interesting narrowing the attention on the first one of these dimensions: connectivity, that indicates the level deployment of broadband infrastructure and its quality. DESI Connectivity dimension in other terms, reflects the IDD of a country.

[36] Retrieved from: https://ec.europa.eu/digital-single-market/en/connectivity

Connectivity in turn, is a composite indicator including several sub-dimensions:

1. Fixed broadband (in terms of coverage and take-up)
2. Mobile broadband (including 4G coverage, mobile broadband take-up and 5G readiness. The latter was introduced in the last report)
3. Fast broadband (coverage and take-up)
4. Ultrafast broadband (coverage and take-up, as in the other cases)
5. Broadband price index

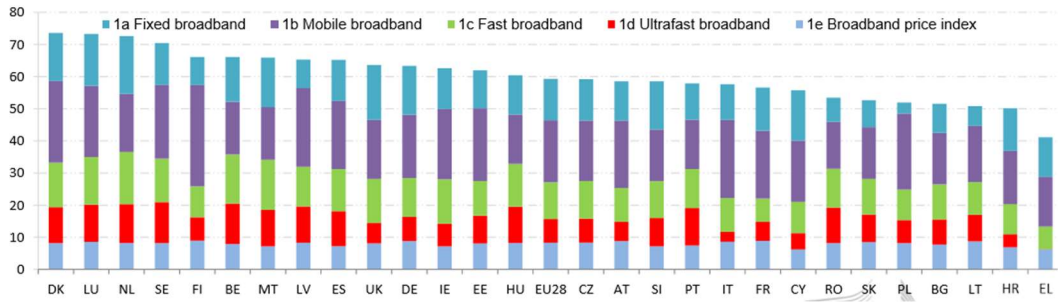


FIGURE 4: DIGITAL ECONOMY AND SOCIETY INDEX (DESI) 2019 – CONNECTIVITY
SOURCE: DESI 2019, EUROPEAN COMMISSION

Errore. L'origine riferimento non è stata trovata. shows DESI results for 2019 report[37], for EU member states. It highlights the contribution of each sub-dimension to the final value of DESI. As it emerges, Nordic countries are the best performing, with Denmark on the top. Italy instead, has a DESI value below the EU average and the most critic sub-dimension is the ultrafast broadband, the one in red. DESI Report proposes a more in-depth analysis of ultrafast broadband.

The table below shows a summary of the evidences that interest us.

[37] DESI 2019 refers to 2018 data.

	2016	2017	2018	UE Average 2018	DAE objective (by 2020)
NGA coverage (% of families)	72%	87%	90%	83%	100% households reached by NGA
Ultrafast broadband coverage (% of families)	n.a.	22%	24%	60%	
Ultrafast broadband take-up (% of families)	1%	5%	9%	20%	50% households' subscriptions to ultrafast broadband

TABLE 6: OWN ELABORATION FROM DESI REPORT 2019 AND DIGITAL AGENDA FOR EUROPE

The last column regards a topic that will be central is the next sections. Digital Agenda for Europe (DAE) set some general objectives at EU levels and it is under the responsibility of the member states reaching them by the deadline. These objectives regard in this case the coverage and penetration of fast broadband (NGA) and ultrafast broadband connectivity. The first three columns, with data coming from DESI, show how Italy is behaving with respect to DAE goals and with respect to the EU average. What is clear is that on NGA coverage side the Italian situation is favourable and above the EU average. Moving to ultrafast broadband coverage[38] instead, Italy appears to be in the lowest positions; the value evidences a clear gap with EU average, to be reconducted almost entirely to non-rural areas. On take-up side, the situation appears to be not less encouraging: the percentage of households

[38] Coverage value in this statistic considers Fiber to the Premises (FTTP) and Cable Docsis 3.0 coverage.

with an ultrafast broadband (at least 100 Mbps) subscriptions in 2018 is very far from the objective set in this regard by the DAE.

In section 2.2.3 we will address the thematic of ultrabroadband coverage (including NGA and ultrafast broadband), to expose the policy maker's endeavours mainly focused until now on the supply side (network infrastructure deployment).

The evolutive path of connectivity in the Italian country – according to DESI index – is shown in Chart 1, where it is visible how the six sub-dimensions of connectivity have evolved over the years 2014 – 2019. An element that must be noticed is the increment of fast broadband dimension starting from year 2016. This is consistent with what commented in section 2.2.3

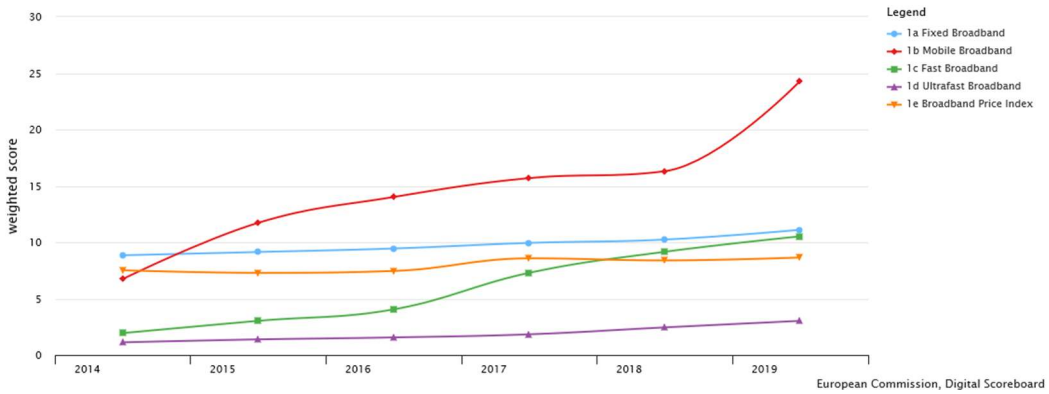


CHART 1: INDEX DESI – CONNECTIVITY BY SUB-DIMENSIONS, ITALY, 2014 – 2019
SOURCE: HTTPS://DIGITAL-AGENDA-DATA.EU/DATASETS/DESI/VISUALIZATIONS

2.2 Italian public interventions to reduce infrastructure digital divide

The next sections, although mainly descriptive, are fundamental for understanding the recent evolution of broadband an ultrabroadband connection in Italy. The purpose is giving a better awareness of the sea to swim for FWA operators: a scenario made of tight EU deadlines to be met by 2020 - reflected within Digital Agenda for Europe objectives – and obvious difficulties encountered by Italy in reaching them. The sole contribute by tlc operators was not enough; fact that required State intervention, in terms of budget and overall organization, in order to address the tlc operators' work towards the right destination. In this general framework, we will make some consideration regarding the role of FWA in this context

2.2.1 Europe 2020 Strategy and a Digital Agenda for Italy

To presents the attempt of solutions implemented at the Italian level to close or better, to reduce the IDD, we must take a step backwards the publishing of Europe 2020 Strategy (EC, 2010)[39]. The strategy was ideated in a critic moment for EU, shacked by the recent global economic crisis and the need for adapting to an environment that was changing always more rapidly (globalisation is an example).

[39] Retrieved from: https://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

In this scenario, it is relevant for EU to define its vision to be reached by 2020. A model of growth is thought, that is simultaneously smart[40], sustainable and inclusive.

Europe 2020 strategy, EU2020 hereinafter, is translated into seven pillars to allow a more agile implementation. For the purpose of the thesis we will focus just on the third one, that concerns digitalisation. In particularly EU2020 envisages the creation of "*a digital agenda for Europe to speed up the roll-out of high-speed internet and reap the benefits of a digital single market for households and firms"* (EC, 2010). The Digital Agenda for Europe (DAE) (EC, 2010)[41] seeks to exploit the benefits of Information and Communication Technologies (ICT) in an optic of reaching the growth objectives set in the above-mentioned Europe 2020 Strategy. The main aim within DAE is the establishments of a single and dynamic digital market for Europe, in order to overcome the actual fragmentation that deprive citizens and firms of many benefits[42]. Creating a single digital market require a network infrastructure able to sustain it; this is the reason why one of the action areas of DAE is providing access to fast broadband and ultrafast broadband to EU member states population. Three are the objectives set by DAE to this respect:

[40]Although the tree dimensions are intercorrelated, smart growth is the most interesting dimension for the purpose of our thesis. With the term the EC refers to leveraging on knowledge and innovation to gain economic benefits.

[41] Retrieved from: https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=celex:52010DC0245

[42] The document was published in 2010, when still online invoicing and payments (to make an example) were lacking and need to be stimulated. Online and accessible contents by EU citizens and firms is a pre-requisite for stimulating the demand.

1. Universal coverage of basic broadband (i.e. ≥ 2 Mbit/s) by 2013[43]
2. Universal coverage of NGA networks (i.e. ≥ 30 Mbit/s) by 2020
3. At least 50% of subscriptions to ultrafast broadband (i.e. ultrabroadband with connection ≥ 100 Mbit/s).

The pursuing goals has been possible thanks to the resort to European funds in particular, ERDF[44] and EAFRD[45].

As envisaged by EC, these three targets are shaped by member states in order to adapt them to the peculiarity of the country. At the Italian level the strategic documents that assume a relevance role in translating EU targets into national targets are: National Broadband Plan (2011) and Italian Ultrabroadband Strategy (2015), that we will discuss respectively in section 2.2.2 and in section 2.2.3.

2.2.2 First DAE objective: Italian National Broadband Plan (2011)

As a matter of fact, The Italian National Broadband Plan[46] (Italian Plan, hereinafter) (October 2011) is not the first state aid (SA) measure introduced by Italian Government to address the infrastructural digital divide regarding First Generation

[43] This first objective is not properly introduced by DAE, but DAE remarks the willingness to pursue it. European Economic Recovery Plan (EC, December 2008) had already fixed a 100% broadband coverage objective for EU Member States by 2010. Postponing the deadline implicitly means the previous one had not been respected.
[44] European regional development fund (ERDF), promotes balanced development in the different regions of the EU. (Source: EC website)
[45] European agricultural fund for rural development (EAFRD), focuses on resolving the particular challenges facing EU's rural areas. (Source: EC website)
[46] The National Broadband Plan definition is under the responsibility of Communication Department for the Ministry of Economic Development. Retrieved from: https://ec.europa.eu/digital-single-market/en/news/piana-nazionale-banda-larga-national-broadband-plan-italy

Broadband (FGB)[47]. Previous attempts include some not-centralized measures, planned and implemented at regional level by regional Governments and a multilevel governance attempt codified into Law n. 69/2009, from which two SA measures were born: SA N 649/2009 (cleared: 04/2010)[48] and SA.33807 (cleared: 05/2012) (Matteucci, 2019).

The former refers to the National project "Broadband in Italian Rural areas" that modifies the National Strategic Plan of Rural Development 2007 - 2013[49], making available European Agricultural Fund for Rural Development (EAFRD) funds that member states can devote to expand FGB to rural areas[50]. The targeted areas were white areas (see later in the section for a complete definition), for a total of 2.877 municipalities, where broadband was either lacking at all either inadequate.

SA.3307 refers to Italian National Broadband Plan (Italian Plan, hereinafter) (2011), successively object of extension resulting in SA.38025 (cleared: 12/2014)[51].

All the above-mentioned SA measured were judged compatible with EU legislation by EC, in the specific with article 107 (3) (c) of The Treaty on the Functioning of the European Union (TFEU), that envisages:

[47] FGB is the equivalent of basic broadband. Second Generation Broadband (SGB) instead, refers to NGA network.
[48] Retrieved from: www.reterurale.it › pages › ServeAttachment.php
[49] Retrieved from: https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/4961
[50] The National Plan 2007 – 2013, following EC definition, identifies "rural areas" as those with a population density below 150 inhabitants/sq.
[51] Retrieved from: https://ec.europa.eu/competition/state_aid/cases/254380/254380_1623783_85_2.pdf

1. Save as otherwise provided in the Treaties, any aid granted by a Member State or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the internal market […]

3. The following may be considered to be compatible with the internal market […]

(c) aid to facilitate the development of certain economic activities or of certain economic areas, where such aid does not adversely affect trading conditions to an extent contrary to the common interest;

The relevant aspect is that EU interest is avoiding SA measures implemented by Member State to distort competition in the internal market.

The Italian Plan implemented by Infratel Italia[52] responds to the need of reaching the first one of DAE objective (i.e. universal coverage of basic broadband by 2013). The budget allocated is about 1.471 billion received from different sources: EAFRD, ERDF, FAS[53] and private financing.

The measure aims at reducing digital divide in those marginal areas, with low-density population, that lack from telecommunication network infrastructure because operators, as we have commented in the previous section, do not find

[52] Infratel Italia (Infrastrutture e Telecomunicazioni per l'Italia S.p.A.) is an in-house company of MISE and it is in charge of implementing Italian broadband and ultrabroadband plan.

[53] *Fondo per la aree sottoutilizzate* (translated, Underutilized Areas Fund), now become *Fondo per lo Sviluppo e la Coesione* (FSC), (translated: Development and Cohesion Fund)

attractive investing there, either the coverage is not sufficient, either the quality of the connection is below the threshold for being defined basic broadband. In the latter case an upgrade of the current network infrastructure is needed. Providing these areas with adequate infrastructure means allowing population and firms living there, to exploit the benefits broadband-related described in section 2.2.1. In the rest of the section we will expose the Italian situation pre-plan and the state aids (and models of intervention) stemming from it.

In *"Orientamenti comunitari relativi all'applicazione delle norme in materia di aiuti di Stato in relazione allo sviluppo rapido di reti a banda larga"* (EC, 2009/C 235/04)[54], a distinction among three areas has been introduced, on the basis of the available connectivity level. The same distinction is applied in the framework of the Italian Plan. The areas are divided into:

- White areas, i.e. those areas completely unserved by infrastructure network or poorly served and further, there is no plan that it will be deployed in the medium term (3 years). White areas are subject to market failure and the EC recognizes the public intervention (state aid) as needed and desirable to correct the market failure and allow those territories to take part to economic development.

[54] Retrieved from: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2009:235:0007:0025:IT:PDF

- Grey areas, i.e. areas served by only one operator providing broadband infrastructure (monopolistic operator) but, despite this fact, market failure issue is not excluded a priori. On a side the monopolistic operator could feel entitled to practise higher prices and/or lower quality; on the other side, the public intervention could distort the competitive dynamics. As consequence, public intervention in grey areas must be subject to a case by case basis in-depth analysis.
- Black areas, i.e. areas where at least two operators are present, and the connection provision follows competition dynamics. These areas are not considered areas of market failure; hence the state intervention is banned.

Given the above drawn differentiation, the Italian Plan aims at intervening in white areas and in some of the grey areas respecting specific requirements. The areas have been identified through public consultation started by Infratel. For these areas have been envisaged different models of intervention that can be synthetically summarized in the table below:

Model of intervention	Description
A	Public investment to deploy backhaul-middle mile infrastructures
B	Contributions to telecom operators to invest in last mile infrastructures

C	Financial support to users for purchasing access terminals

TABLE 7: MODELS OF INTERVENTION IN ITALIAN NATIONAL BROADBAND PLAN
SOURCE: OUR ELABORATION BASED ON ITALIAN NATIONAL BROADBAND PLAN DOCUMENT

The first two intervention models act on the supply side. Model A implies launching a call for tenders to identifying the subjects which have to physically built the backhaul network[55] that, on a second stage, will be made available to the operators interested (upon payment of a licence fee). Model B too adopts the instrument of public procurement and envisages the opening of call for tenders divided into lots. The winner of each lot will have to grant the access to its property network to the other telecom operators showing an interest. Finally, Model C is a demand-side measure, to allow citizens of the most rural areas to have an access terminal for broadband services.

The completion of Italian Plan has been reached through the recourse to a new SA measure, SA.38025, translating into an extension of the original plan and into a delayed achievement of the first DAE objective (that had to be accomplished by the end of 2013). The reason on paper is the difficulty of Italian Government to attract the financial resources required, but actually an implementation delay cannot be neglected (Matteucci, 2019). Meanwhile, new EU guidance regarding application

[55] The winning bidder corresponds to the company who has presented either the most economically convenient either maximum downward (art. 81 and 83, Legislative Decree n. 163/2006) and also emerges in other evaluation criteria, such as the use of technologies with a low environmental impact.

of SA measures for a rapid broadband network deployment became valid (EC, 2013/C 25/01)[56]. This imposed a so-called "step change", that in the Italian case has been transposed by imposing the constrain of upgrading the existing network in grey areas with a connection of at least 30 Mbps (compared to the pre-existing obligation of a connection between 2 and 20 Mbps).

What is relevant to underline is the application in model A and B of the principle of technological neutrality, allowing respectively to all the operators[57] to require the access to the backhaul infrastructure once completed; and allowing any operator to take part to the call for tenders.

This provision, nonetheless, is not enough to ensure a heterogeneous outcome of the call for auctions. Fifteen out of the twenty auctions launched within the framework of Model of intervention B (one tender for each Italian region) for FGB deployment have been won by Telecom, the Italian operator who could rely on the most expanded proprietary network at the end of its useful life-cycle (Matteucci, 2019). The incumbent burden is a fact that is investigated also in the situation pre-Italian Ultrabroadband Strategy - so without considering State intervention – when the other network operators investment plans were highlighting a great dependence on Telecom as first mover for pursuing DAE objectives (Caio et. al, 2014).

[56] Retrieved from: https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/10570
[57] Whatever the connection technology to reach the final user: ADSL, HSDPA, LTE, WiMAX, satellite…

The remaining auctions have been won by Eolo[58], more precisely in the regions: Liguria, Marche, Emilia Romagna, Umbria and Abruzzo, starting from year 2014. The technology used by Eolo for upgrading last mile access is WiMAX, that have granted a connection up to 30 Mbp/s, in line with the new EU guidance, as commented above. The last municipalities to be reached by broadband services thanks to Eolo intervention are located in Abruzzo region, that need to wait until the first quarter of 2018[59]. These winnings are not negligible, considering that Eolo, being a relatively new entrant, was in a disadvantageous position in those years, with a narrow market share compared to the traditional tcl operators (Matteucci, 2019).

2.2.3 Second DAE objective: Italian Ultrabroadband Strategy (2015)

Before discussing about Ultrabroadband Strategy, it is useful offering some comments regarding the moment of transition, that offer interesting inspirations for understanding the future decisions taken by Italian Government.

A fundamental document in this respect is the well-known "Rapporto Caio"[60], released on January 30, 2014. A team of expert, guided by Francesco Caio (see note

[58] Eolo is an FWA operator, whose business name was NGI S.p.A. until the fiscal year ended in 31/03/2015; then it became Eolo S.p.A.

[59] Retrieved from: https://www.eolo.it/home/chi-siamo/informazioni-legali/bandi_infratel.html

[60] Rapporto Caio takes the name from the Government Commissioner Francesco Caio for the implementation of the DAE, leader of the expert advisory team appointed by Italian President Enrico Letta. The aim of the report is investigating whether the investment plans set up by the telecom operators at that time, would have allowed Italy to reach DAE objectives on time.

60), in trying to assess whether the investment plans of the telecommunication operators for next years were appropriate to reach DAE objectives by 2020, made some interesting findings that are resumed in Table 8.

As emerges from the table below, while the situation on first DAE objective side was optimistic (basic broadband coverage above the EU average), if we consider the second objective, it was fully of elements to be concerned. In particular, the report suggests to complete the FGB coverage using: a) mobile broadband to ensure connectivity up to 30 Mbp/s in rural areas (mobile broadband as a substitute for rural areas vs mobile broadband as a complement in urban/sub urban areas); b) consider FWA as powerful mean to reach the scope; c) resort to satellite only when other options are not viable.

DAE Objective	Key findings	Solution
1 - Basic broadband Coverage	98.4% of basic broadband coverage at end 2012	Use of complementary/ substitute technologies
2 - NGA Coverage	Telecom operators' investment plan not enough to reach the target: only 50% of households will have access to 30 Mbp/s connection by end 2017	- State intervention (public subsidy) - Public-Private Partnerships (PPs)
3 - Ultrafast broadband Penetration	Very poor demand of ultrabroadband: limited consumption of high-bandwidth contents, high mean age, poor use of PCs	Stimulate demand (e-public services, audio-visual contents…)

TABLE 8: SUMMARY OF MAIN FINDINGS REGARDING THE STATE OF ITALY IN REACHING DAE OBJECTIVES AND SOLUTION PROPOSED
SOURCE: OUR ELABORATION ON RAPPORTO CAIO, 2014

For the purpose of the thesis it is interesting devoting a little space to the role of FWA technology. The experts' team is highly optimistic with the role that Fixed Wireless Broadband will assume - as complement or substitute in certain areas -not only for the remaining coverage of broadband, but also in NGA perspective. The aspects that brings this enthusiasm are in particular the expected improvements in connectivity speed, in performance and the efficient use of spectrum FWA-related. Despite this, EU policy makers seem to neglect its potential.

With regard to NGA coverage, what need to be remarked is that, almost anyone of the network operators had drawn a credible investment plan for the near future, demonstrating an excessive "trust" towards the incumbent, Telecom Italia to act as first mover, as usual. The only one operator that seemed to deviate from this behaviour was Metroweb, but in the end had to take a step back and lock its invested capital, not to deploy ultrafast broadband networks in the same areas in which Telecom and Fastweb were investing in years 2012 – 2013. The other operators planned to expand their network in the same high-density areas, fact that would result in a waste of financial resources and would be unprofitable.

The same unpleasant fact is encountered within the framework of a survey by AGCOM (2014)[61]. Despite the decreasing revenues faced by network operators in

[61] The survey in question is: "Indagine conoscitiva sulla concorrenza statica e dinamica nel mercato dei servizi di accesso e sulle prospettive di investimento nelle reti di telecomunicazioni a banda larga e ultra-larga". In English it corresponds to: "Survey on static and dynamic competition in access

the previous years, an augment in the investments for expanding network infrastructure was registered. This increas nevertheless, could not have been considered enough to achieve DAE objectives, above all if the final destination of those investments is taken into account: FTTC networks in urban areas (again the unprofitable overlapping networks). This does not imply that a certain degree of infrastructure-based competition should not exist anyway: on the contrary, it would ensure a higher independence from the incumbent, with the related benefit of autonomously deciding the quality of the connection to be offered to the final user. Moreover, a stronger independence from Telecom could be created with the building of a FTTC network scalable towards FTTB/FFTH (*full infrastructure-based competition*). What is concluded has relevant implications for the next future (Ultrabroadband Strategy): a State intervention is considered as necessary in 2020 perspective, given that the private sector is showing is investment gaps. A public measure could be relevant in canalizing the private endeavours, speeding up the fibre deployment process, with upgrading directly to FTTB/H architectures in the highly density areas.

The demand side should assume a central role, with the need of spreading a digital culture, starting from digitalising the Public Administration.

facilities market and on the investment perspective in broadband and ultrabroadband networks". It was published on November 8, 2014.

The focus of this section from this point forward, is the attempts made by Italy towards the achievement of the second DAE objective. A first attempt in this direction dates back to 2011, with the Ultrabroadband Strategic Digital Plan (hereinafter, BUL Plan), deriving from art. 30, Decree-Law No 98/2011, then converted into Law 111/2011. The plan has been notified to EC and cleared on December 18, 2012, through state aid measure n. SA.34199 (2012/N). The BUL Plan born in a moment when still the Italian Broadband Plan was in force, but this doesn't imply an overlapping in the action areas. Actually, differently from the former, focused in the most marginal areas, the project in question targets the most strategic areas from the point of view of the economic development. The implementation is divided in several interventions, starting from the first one, called "Mezzogiorno", focused only on NGAN white areas[62], that at the time represented the 81% of the whole Italian territory. These areas will be beneficiaries of public financing, compatibly art. 107 (3) (c), TFEU (see previous section), and the intervention will follow a relevance logic, meaning that not all NGAN white areas can be object of state intervention, considering the huge amount of resources that such a plan would envisage, but only those that – on the basis of a public consultation – can be considered more "precious" in terms of economic development. Among the white areas, the areas selected are those hosting, in order

[62] Remarking the previously exposed definition, NGAN white areas are areas where currently no operator has invested in NGAN infrastructure either planned to invest within the next three years.

of importance: *new generation data centre sites, major population density, schools, strategic industrial areas and logistic hubs (airports, ports, interports); universities, research centres, technological hubs; health facilities, courts* (MISE, 2011). What happens as a consequence from investing in the South Italy first is that the North Italy would be taken into consideration only when ultrabroadband divide will exacerbate. Matteucci (2014) outlined the risk of leaving behind a North-East above all in the ultrabroadband deployment infrastructure process, since "*a large part of these areas hosts crucial and export-intensive aggregations of SME and industrial districts."* (Matteucci, 2014).

Meanwhile BUL Plan was still in force, another more important plan involving all Italian country was made public: *Italian Ultrabroadband Strategy* (hereinafter, BUL Strategy; official name: *Strategia Italiana per la Banda Ultralarga*), approved by Italian Government on March 3, 2015, jointly with another document, Digital Growth Strategy 2014 – 2020, to which we will devote the next few lines. While BUL Strategy is focused on the second DAE objective, Digital Growth Strategy (Digital Strategy, hereinafter) aims at pursuing the third DAE objective. Digital Strategy acts on the demand side of ultrabroadband service connectivity, trying to stimulate its adoption by Italian citizens and firms, actually showing a huge delay

in the use of network services with respect to the EU average. The actions of the plan in question can be synthetized as follows[63]:

1. building an adequate ultrabroadband infrastructure that covers above all the most frequented public places (e.g. recurring to hot spot Wi-Fi localized in strategic places)
2. realizing enabling platforms (e.g. for e-payments, for e-invoicing, etc.)
3. once that point 1 and 2 have been implemented, acceleration programs will be introduced (e.g. for increasing digital skills).

From now on, the focus will be on the BUL Strategy. It is implemented through the Investment Plan for Ultrabroadband Diffusion (PCM, 2015). With respect to the previous announced plan (BUL Plan), this one needs to be considered as integrative. Differently from the it moreover, where the focus was on the backhauling segment; here it is assumed that most of the backhauling infrastructure is "in step with the times", hence, priority is given to the deployment of NGA network (Matteucci, 2014). The infrastructure built must be "future proof", meaning that should be able to allow ultrabroadband users to benefit from the evolution of the online content offering (considering for example the growing traffic volume in the next years).

[63] The official document can be consulted at: https://www.agid.gov.it/sites/default/files/repository_files/documentazione/strat_crescita_digit_3marzo_0.pdf

Obviously rolling out fibre optic[64] in the FTTH architecture would be the most satisfying choice in this direction[65], but financial constrains must be taken into account. Hence, the solution is making a trade-off among the several communication technologies that grant the proper broadband connection, while not depleting community and national funds and private investments.

BUL strategy, all of them will prioritise the reuse of existing infrastructure[66] and, in line with the Italian Plan, the aim is deploying an infrastructure technologically neutral in order to strengthen competition on the retail market.

The models of public intervention that will be adopted are four:

- Model I: Direct intervention;
- Model II: Public- Private Partnership (PPP);
- Model III: Incentive model;
- Model IV: Intervention for demand aggregation[67].

The choice of the model of intervention depends on the cluster we are taking into consideration. Four are the clusters to which the 94.645 sub-areas[68] composing the

[64] Optic fiber – as outlined by the BUL Strategy - is more suitable for ultrabroadband network with respect to copper. The latter had played a key role in the roll-out of broadband network but is well-know also for its tendency to lose its efficacy as the years go by.

[65] The order of priority established in BUL strategy is: 1) FTTH; 2) FTTB; 3) FTTdp; 4) FTTC.

[66] This is one of the qualitative criteria adopted to select the winning bidder in the public tender procedure that we will comment further in the thesis.

[67] For in-depth explanation of the related functioning, review the official MISE document.

[68] The identification of sub-areas mostly reflects the outcomes of a public consultation kept by Infratel and concluded on July 2014, then refined using ISTAT areas data. The public consultation is updated yearly. It must be highlight that these sub-areas do not coincide with Italian municipalities, but actually is common that the same municipality is decomposed into one or more clusters of intervention.

Italian territory can be reconducted (A, B, C and D)[69]. The classification into clusters is a more refined version of the one adopted with Italian Broadband Plan (White, Grey and Black Areas); starting from a current NGAN coverage level and quality, and considering population density, and socio-economic characteristics, new targets regarding planned coverage are set for each cluster and different model of public intervention are though for each cluster. This is a way to optimize the use of the financial resources and also the time constrain (2020 as official deadline).

BUL Strategy aims at reaching more ambitious objectives to those fixed within DAE framework, in the specific they are:

- providing access to connection of at least 100 Mbps to up to 85% of the population;
- providing access to connection of at least 30 Mbps to the remaining portion of the population;
- providing access to connection above 100 Mbps to public administration of the greatest areas of focus, schools, health care facilities, industrial parks, high demographic density areas.

In order to allow a constant aligning between the above objectives and the strategy advancement, and in order to do this while making an efficient use of the resources at stake, a fundamental phase has been introduced: the monitoring, object of

[69] See official document "Italian Ultrabroadband Strategy" for an in-depth explanation of the four clusters.

particular attentions. The activities to be monitored are essentially coverage and penetration; various entities have been appointed to be active players in this phase, including: COBUL[70] (mainly coordinates the strategy implementation), Infratel (coordinates and monitors the coverage situation, through the so-called *Catasto delle infrastrutture del sotto e sopra suolo*[71], SINFI), AGCOM (responsible for controlling the adoption of ultrabroadband services).

The BUL Strategy implementation is divided into distinct phases, starting from the so called *"Piano Aree Bianche"*, White Areas Plan[72], notified to EC though state aid measure n. SA.41647 (2016/N)[73] and cleared on June 30, 2016.

The following scheme represents a synthesis of White Areas Plan.

Objective	Deployment of a NGAN, publicly owned, in order to smooth the social and demographic gaps within Italian territory
Target areas	White NGA areas: - cluster C (providing 70% of r.u.[74] with 100 Mbps) - cluster D (providing all r.u. with 30 Mbps at least)
Model of intervention	Direct intervention model. One or two public tenders for selecting the concessionary responsible for 1. the deployment of the passive infrastructure 2. *the maintenance, management and commercial exploitation of the network.*

[70] Comitato per la diffusione della Banda Ultralarga.
[71] The corresponding name in English is *Cadaster of below and above ground.*
[72] The white areas in question are the NGAN white areas of section XXX. See note 62 for a definition.
[73] Retrieved from:
https://ec.europa.eu/competition/state_aid/cases/264095/264095_1764969_101_2.pdf
[74] r.u. stands for "residential unit"

	Winning bidder: firm presenting the most economically advantageous offer[75].
Aid measure	Funds: FSC (1.6 bln), ERDF and EARFD (1.4 bln). The aid covers all the costs incurred in deploying the passive network.

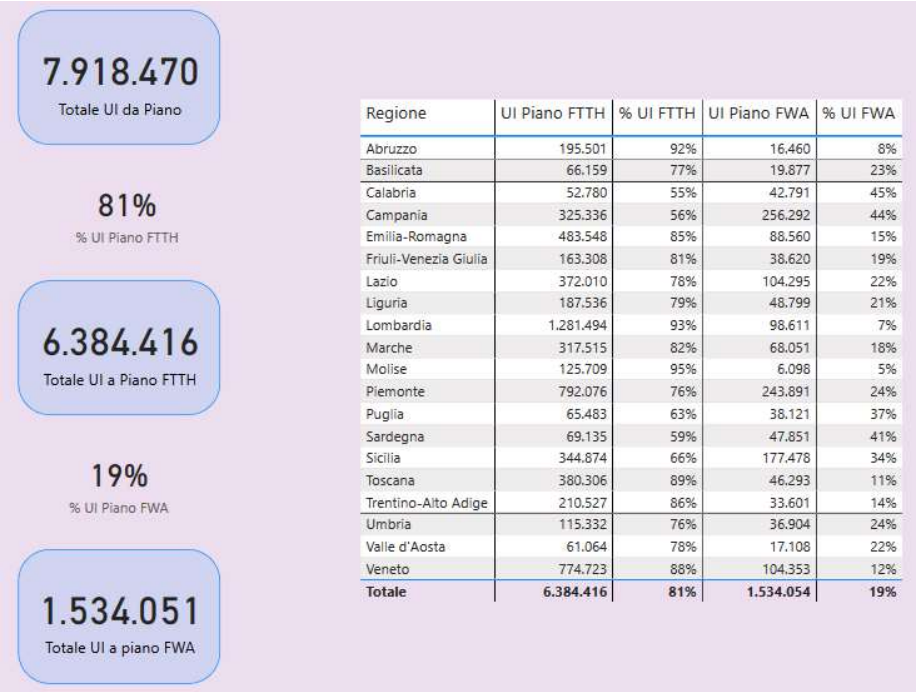
TABLE 9: MAIN ELEMENTS CHARACTERISING WHITE AREA PLAN
SOURCE: OUR ELABORATION ON EC AND MISE OFFICIAL DOCUMENTS

White NGAN areas are identified through public consultation, that is repeated once a year to eventually up-date the localities that can be beneficiaries of public intervention. Both cluster C and D fall under white areas, since are market failure areas; their most evident difference is the broadband connection target set as shown in the table above. Market failure areas will be addressed only with the direct intervention model (MISE, 2016). This model envisages the building of a publicly owned NGA network, from the winning bidder of the first public tender and, successively, the operators required could use the infrastructure (upon the payment of rights of use). In order for operators to utilize it, the access network must be connected to the backhaul network; *the subsidized network will be made available for interconnection with the backhaul networks of existing operators at neutral interconnection points*[76] (EC, 2016).

[75] The regulatory framework concerning selection criteria corresponds to art. 83, Legislative Decree 163/2006 – (Italian) Public Contract Code.
[76] See official EC document for a more concise explanation. The underneath logic is avoiding a huge imbalance in favour of the incumbent.

2.2.5 FWA contribute to Italian Ultrabroadband Strategy

In assessing the role had by FWA operators within the BUL Strategy, we will realize that is quite consistent with the one foreshadowed by the strategy itself, since it stated that *"Fixed access technology is playing an important role in achieving the first goal of the European Digital Agenda […] The performance provided to active customers can be better than with mobile because the radio link is not dependent on the mobility of terminal equipment. […] Fixed broadband wireless technology will be important in achieving 30 Mbps broadband service, Objective 2 of the European Digital Agenda, in low density areas in addition to mobile networks, while are not expected to be effective in achieving 100 Mbps service, objective 3 of the European Digital Agenda"* (page 107, Italian Ultrabroadband Strategy). By considering this statement together with the BUL strategy provision of building future proof infrastructure, it is easily understandable why so much priority is given to FTTH architecture.



Regione	UI Piano FTTH	% UI FTTH	UI Piano FWA	% UI FWA
Abruzzo	195.501	92%	16.460	8%
Basilicata	66.159	77%	19.877	23%
Calabria	52.780	55%	42.791	45%
Campania	325.336	56%	256.292	44%
Emilia-Romagna	483.548	85%	88.560	15%
Friuli-Venezia Giulia	163.308	81%	38.620	19%
Lazio	372.010	78%	104.295	22%
Liguria	187.536	79%	48.799	21%
Lombardia	1.281.494	93%	98.611	7%
Marche	317.515	82%	68.051	18%
Molise	125.709	95%	6.098	5%
Piemonte	792.076	76%	243.891	24%
Puglia	65.483	63%	38.121	37%
Sardegna	69.135	59%	47.851	41%
Sicilia	344.874	66%	177.478	34%
Toscana	380.306	89%	46.293	11%
Trentino-Alto Adige	210.527	86%	33.601	14%
Umbria	115.332	76%	36.904	24%
Valle d'Aosta	61.064	78%	17.108	22%
Veneto	774.723	88%	104.353	12%
Totale	**6.384.416**	**81%**	**1.534.054**	**19%**

TABLE 10: PLAN FOR RESIDENTIAL UNITS FTTH/FWA, ITALY, UPDATED AT 12/05/2020
SOURCE: INFRATEL OFFICIAL WEBSITE)

As shown in table 10, 19% of residential units of Italian country are planned to be reached by FWA technology. The majority of them is localized in South and in the islands, since, apart from some exceptions of big cities (e.g. Naples), these areas are rural areas, with low population density and, as already outlined, FWA technologies fits well with this condition. In cluster C and cluster D, *fixed wireless access (FWA) constitutes the only definitive and long-term solution* (CFWA, 2017). Hence, FWA technology, despite being considered a staple for rural areas, is not considered by MISE a technology to exploit for urban areas (see Lombardia and Veneto for example). In the policy maker perspective, FWA has application limited

rural areas and has not a great potential for accommodating the growing online content offering, otherwise, he would have given FWA a wider space (considering its less invasive intrinsic nature in terms of time and costs).

Finally, by investigating the auctions' outcomes in Infratel database, those won by FWA operators are negligible. The great majority of public tenders have been awarded by Open Fiber[77]. This is not a great issue, considering that FWA operators actually have not even applied to auctions in the majority of the occasions. Only Eolo is findable among those who "tried". In May 2017, Eolo S.p.A., together with E-via S.p.A. and EDS Infrastrutture S.p.A. formed a *Raggruppamento temporaneo di imprese* (RTI)[78] for participating to the public tender, lot number 2 – Friuli Venezia Giulia, Autonomous Province of Trento[79] with the aim of becoming concessionary for the building, maintenance and management of a public-owned BUL passive network in that area. Nevertheless, the lot was awarded by Open Fiber.

[77] Open Fiber is a wholesale only operator controlled by Enel S.p.A. and Cdp Equity S.p.A. It has been founded in 2015 appositely to realize a FTTH BUL infrastructure to cover a great portion of Italian territory.

[78] Temporary Grouping of Enterprises, with E-via S.p.A as parent company. RTI is an authorized form of taking part to public tenders, according to Public Procurement Code.

[79] Retrieved from: https://www.infratelitalia.it/archivio-documenti/documenti/candidati-ammessi-procedura-ristretta-per-affidamento-rete-banda-ultralarga-in-piemonte-valle-daosta-liguria-friuli-venezia-giulia-provincia-autonoma-di-trento-marche-umbria-lazio-c

3. Strategic analysis of FWA service providers: Eolo and Linkem

3.1 FWA relevance within broadband market

As already mentioned in chapter 1, FWA is a particular sub-set of the wider broadband market, defined by a peculiar network architecture.

To understand the relevance of FWA service providers within broadband market, it is essential making reference to AGCOM dataset[80], that highlights several aspects of broadband market players.

For what concerns the number of lines available in FWA technology, we refer to table XXX and table XX, indicating the lines by infrastructure type (chapter 1). In this section we synthetically report the main findings: gradual decrease of copper technologies accelerated starting from 2017, in favour of the adoption of more innovative infrastructure type. This result is in line with BUL Strategy, that envisages the migration towards ultrabroadband connections. In this context FWA is gaining interest, as attested by its absolute growth. In relative terms, FWA segment has registered an overall increase of 101.47% in the period considered, reaching a 6.8% of the access lines in 2019.

[80] AGCOM, *Osservatorio sulle comunicazioni*, various years. Retrieved from: https://www.agcom.it/osservatorio-sulle-comunicazioni

In terms of usage of FWA technology, few are the big operators that have "traditionally" operated in the market. Most of the FWA market players are small[81] and are focused on specific areas of the country. Despite this, during the current year something very interesting has happened.

Operator	Comments
Linkem	FWA-mainly operator
Eolo	FWA-mainly operator
Tiscali	FWA and fiber[82]
Go Internet	FWA and fiber
Mandarin	FWA-only operator
Other small operators	They are alternatively: Wireless Internet Service Provider (WISP), vendors. Often specialized in specific areas of the Italian territory
TIM	In 2020 TIM has introduced the offering *TIM Internet FWA* within its portfolio
Vodafone	In 2020 Vodafone has introduced the offering GigaNetwork™ FWA within its portfolio
Fastweb	It manages an FWA network in some digital divide areas though its subsidiary *Fastweb Air.* In Milan in February 2020 is started 5G FWA trial

TABLE 11: FWA SERVICE PROVIDERS

As it clearly appears from the above table, beside the traditional FWA operators (Linkem, Eolo and Go-Internet), and besides other small players, some of the traditional fixed line operators have introduced a FWA solution to complement

[81] We have not official data regarding the number of these small operators. The Fixed Wireless Access Coalition (https://cfwa.it/) includes 60 memberships representative of the whole FWA Italian industry, but besides WISP and vendors it also makes reference to system integrators, that are not classifiable as service providers.

[82] FWA product solutions added to its product portfolio thanks to the commercial agreement signed with Linkem in July 2019.

their internet offering portfolio. This could be seen as a strategic move by these operators, that have recognized in the past few years the growing relevance of FWA market, as highlighted by *Osservatorio sulle comunicazioni* data (AGCOM, various years). Another element that could have led these operators to expand towards FWA market is the particular suitability of FWA technology for 5G applications (see section 1.2.2).

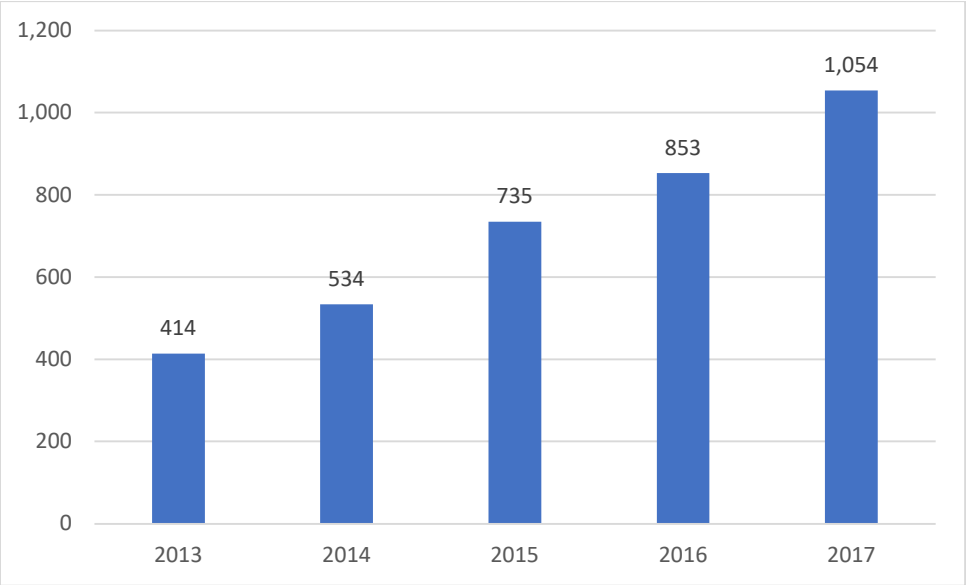


CHART 2: FWA MARKET SUBSCRIPTIONS (MILLION)

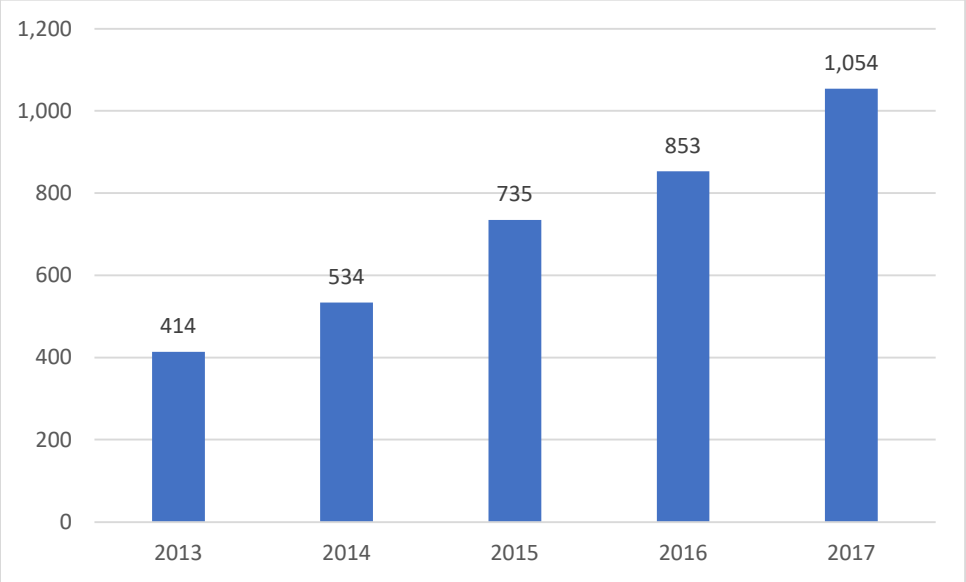


Chart 2 offers an overview of the increasing trend in subscriptions (i.e. lines) to FWA operators in the period 2013-2017, that are more than doubled.

Operator	2015	2016	2017
Linkem	42.5	47.3	47.5
Eolo	n.a	25.7	26.4
Others	n.a	27	26.1
Total	**100**	**100**	**100**

TABLE 12: MARKET SHARES – FWA MARKET

A decomposition of FWA market share is offered by Table 12, that presents the situation only for the 2015-2017 period. Linkem positions itself as FWA market leader, followed by Eolo.

Operator	2011	2012	2013	2014	2015	2016	2017	2018	2019
Tim	52.9	51.4	49.8	48.1	46.9	45.9	45.6	43.9	43.5
Wind Tre	15.9	16.3	15.9	15.4	15.4	14.5	14.5	14.4	13.8
Fastweb	11.8	12.9	14.0	14.4	14.8	15.1	14.8	14.9	15.1
Vodafone	12.5	11.9	12.0	12.3	12.9	13.6	14.5	15.8	16.4

Tiscali	3.7	3.6	3.7	3.4	3.1	3.4	3.2	2.8	2.6
Linkem	-	-	-	-	-	2.6	3.0	3.5	3.7
Eolo	-	-	0.8	1.0	1.2	1.4	1.7	2.2	2.6
Others	3.2	3.9	3.9	5.3	5.7	3.4	2.7	2.7	2.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

TABLE 13: MARKET SHARE (%) - BROADBAND AND ULTRABROADBAND LINES, 2011 – 2019

SOURCE: OWN ELABORATION ON AGCOM DATASET AND COMPANY SOURCES

For a wider perspective on B&UB market, we can make reference to Table 13, that shows the evolution of market shares, in percentage values, of operators offering broadband and ultrabroadband connections (B&UB) to their users. We have to underline the fact that we are dealing with the retail market. Wholesale market dynamics are excluded from these data. The main evidences arising from the table observation are the following:

- The market structure is highly concentrated
- Three clusters of aggregation can be identified: a) The incumbent, TIM, has always maintained a leadership position in the period considered, keeping a considerable share of the overall broadband and ultrabroadband lines; b) Wind-Tre, Fastweb and Vodafone occupy a second number position in the market share-rank. They are three traditional telecom and internet provider operators, with an established presence in the telecommunication sector; c) the last cluster of aggregation involves Tiscali, Linkem, Eolo and other smaller operators, with smaller market share compared to the two previous

clusters. Jointly, these smaller operators have gradually experienced an increase in relevance attributable mainly to FWA accesses.

- TIM has undergone an overall market share decrease by 17.68% in the period taken into consideration. The companies that have contributed to shrink its market share (because have experienced an overall increase in their market share) are: Fastweb, Vodafone, Linkem and Eolo. In other terms, some operators have seen their B&UB lines increasing between 2011 and 2019, at the expense of the incumbent, which, despite maintaining a predominance position, has suffered a gradual decrease in total B&UB lines.

For the purpose of our thesis, a focus on Linkem and Eolo is needed. Before - respectively - 2016 and 2013, their market shares aren't visible, but they are included within the voice "Others". Linkem has experienced an overall increase in market share (2016-2019) by 41.71%; Eolo has more than doubled his initial value (in 2013), increasing it by approximately 219%. Alone, their market share seems negligible, but actually the concentrated market context in which they operate needs to be taken into consideration (please refer to section 3.2.1 for a detailed explanation of the context).

Operator	Residential customers	Business customers
Tim	43.3	44.6
Vodafone	16.6	15.6
Wind Tre	14.3	11.6
Fastweb	14.7	17.1

Linkem	4.3	n.a
Tiscali	2.8	1.3
Eolo	2.7	2.0
BT Italia	n.a	2.1
Others	1.3	5.7
Total	**100**	**100**

TABLE 14: BROADBAND AND ULTRABROADBAND LINES BY CUSTOMER TYPE (%), 2019
SOURCE: OWN ELABORATION ON AGCOM DATASET

To have a more in-depth view of the customer typology, we can make reference to Table 14, which shows, for the year 2019, the composition of operators' customers' portfolio, distinguishing between residential customers (i.e. households with a broadband or ultrabroadband lines) and business customers (i.e. companies and offices).

To underline previous evidence on market share, the incumbent TIM holds the majority of both customer typologies, followed by Vodafone, in the case of residential customers and Fastweb in the other case. Considering FWA operators, it can be pointed out how Linkem is performing well in terms of residential customer, better than Eolo. Actually, Linkem positions after the four consolidated

operators, gaining a 4.3% of B&UB lines in the last year. On business customer side instead, Eolo is quite well-positioned, managing to obtain a 2% share of the business lines. Unfortunately, the same data is missing for Linkem (n.a., not available) and this fact limit us in providing some interesting conclusions based on numerical evidence. Neverthless, we will try to fix this constrain by adopting qualitative evidences to support the final conclusions. In both two-years periods, 2016-2017 and 2018-2019, Linkem has obtained a good share of contracted lines in the second speed range - respectively, 10 ≤ Mbit/s < 30 and ≥ 30 Mbit/s <100 Mbit/s - that is particularly suitable for residential customers, not so "high speed-oriented". When it comes to the third and highest speed connection range instead - respectively, ≥ 30 Mbit/s and ≥ 100 Mbit/s[83] – again the data of Linkem is missing. We can only make some hypothesis: considering that the voice *"Others"* measures 0.4% (in 2018) and 0.5% (in 2019), surely Linkem detains a market share in this segment inferior to these values. Eolo that in the same period has a 0.2% (2018) and 0.5% (2019) share in this premium segment.

[83] The speed range ≥ 100 Mbit/s is denominated *ultrafast broadband* according to DAE terminology.

	< 10Mbit/s		10 ≤ Mbit/s < 30		≥ 30 Mbit/s	
Operator	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Tim	58.9	65.2	30.4	27.9	42.4	48.0
Wind Tre	12.2	15.6	22.3	19.5	2.7	5.7
Fastweb	9.8	0.0	17.1	23.1	27.5	20.3
Vodafone	10.9	11.5	13.7	12.6	22.2	20.7
Tiscali	2.6	1.8	5.6	7.5	0.4	0.6
Linkem	0.1	0.1	6.9	6.2	0.0	0.0
Eolo	n.a	n.a	n.a	n.a	n.a	n.a
Others	5.4	5.8	4.0	3.2	4.7	4.6
Totale	**100**	**100**	**100**	**100**	**100**	**100**

TABLE 15: DISTRIBUTION (%) CONTRACTED LINES BY OPERATOR/ADVERTISED SPEED, 2016-2017

SOURCE: OWN ELABORATION ON AGCOM DATASET

	< 30 Mbit/s		30 ≤ Mbit/s < 100		≥ 100 Mbit/s	
Operator	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
Tim	46.2	50.6	41.7	33.6	40.7	39.4
Wind Tre	18.4	15.0	6.6	13.4	11.3	12.7
Fastweb	13.5	14.1	n.a	n.a	25.2	21.8
Vodafone	13.1	12.7	15.4	12.2	20.8	22.1
Tiscali	3.6	3.0	2.1	0.1	1.4	2.9
Linkem	n.a	n.a	22.2	24.4	n.a	n.a
Eolo	0.9	0.5	10.2	14.0	0.2	0.5
Others	4.3	4.1	1.7	2.2	0.4	0.5
Total	100	100	100	100	100	100

TABLE 16: DISTRIBUTION (%) CONTRACTED LINES BY OPERATOR/ADVERTISED SPEED, 2018-2019

SOURCE: OWN ELABORATION ON AGCOM DATASET

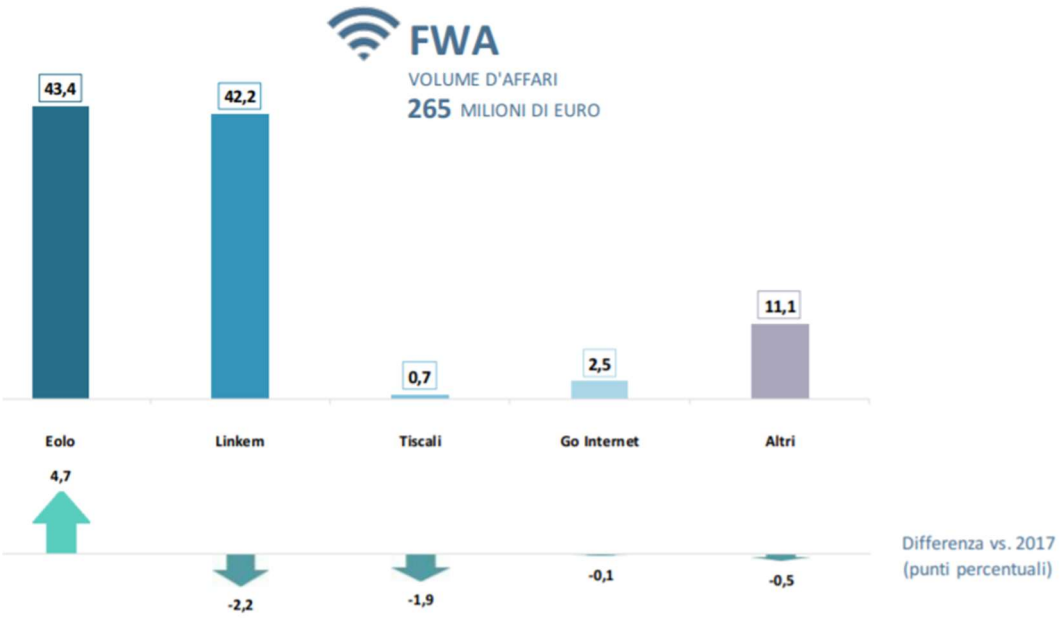


FIGURE 5: EXPENDITURE ON FWA SERVICE, 2018
SOURCE: AGCOM, ANNUAL REPORT, 2019

The last interesting aspect FWA-related is the business volume that, as visible in Figure 5, reached 265 million of euro in 2018, thanks to a 16.5% increase in revenues with respect to the previous year. About 85% of the total revenues are attributable to Eolo and Linkem.

3.2 Eolo and Linkem: strategy analysis

After this general framework, we can start with the comparative analysis of the two main FWA players: Eolo S.p.A. (hereinafter, Eolo) and Linkem Group (hereinafter, Linkem). The reason why they have been chosen for the study is essentially the relevance they play within FWA segment and the fact that they are similar in terms

of offering: both operate at the retail level by selling (for the great majority) connectivity services provided through their proprietary FWA network.

3.2.1 Research methodology

First, the methodology used to in the analysis must be defined. The objective is conducting a comparative study on the two competitors' strategies, in order to identify which kind of actions implemented and strategic choices have allowed them to experience, recently, an increase in market share in terms of B&UB lines. For this purpose, the majority of the information has been found within company sources: financial statements and website. Subsequently, a financial statement analysis will be performed. Not all aspects will be taken into account, since the financial statement analysis serves as complementary work in order to appreciate the main implications that the two competitors' strategies have had in terms of profitability, financial solidity, liquidity. The period taken into consideration is the seven years-period 2012-2018, for which we have availability of financial statements, but some references to the two last years in the case of the business model analysis have been done.

The analysis perspective on which we have based for conducing our work is presented in the rest of the section. As emerges from AGCOM data previously analyzed, the two FWA competitors have recently experienced a high relative growth in market share. Taken in isolation, their market share value (%) seem negligible; what instead need to be noted is the context in which these two operators

are playing: a) a sector (the wider B&UB service sector) with well-established operators, in terms of commercial presence, brand awareness, reliability of the network, etc. In this context, Linkem and Eolo can be considered small and relatively new entrants; b) a high-investment sector, implying the need of raising adequate financing, not so easy for "new entrants"; c) a context with quite high switching costs: once you have acquired a new customer, it is rare that he will move towards a competitor, at least for some years, considering the activation costs, the time it takes to enable the connection in the customer's house/office[84] and the early termination costs.

Given this framework, we can understand how it was difficult for Linkem and Eolo, at least in the past years, to expand their customer base.

In a nutshell, our aim is understanding what is behind Eolo's and Linkem gradual establishment in telecommunication sector in terms of strategic choices and in terms of repercussions of the same strategic choices on the companies' profitability, financial solidity and liquidity.

3.2.2 Eolo's strategy

[84] FWA operators have tried to overcome this fact, by decreasing the activation time. Obviously, it is not the same of mobile telecommunication sector, where the switching from one competitor to another can happen within 48 hours.

Eolo is an internet service provider founded in 1999, but whose relevance within the Italian broadband market has established only in the last decade. Eolo's core business is the wireless connectivity (i.e. FWA technology) one, represented by the so-called "EOLO" service, launched in February 2007 and that Eolo provides through a totally owned infrastructure to residential and business user. EOLO service was born in 2006, from a business idea of Luca Spada - president and CEO of the company – who's intent whose finding a solving the digital divide problem of the area he was living in (near Varese), that at that time was not reach by ADSL. Through Hiperlan2 technology (see Table 20) he was able to deliver an FWA connection, after some months of testing on some Varese inhabitants. The entrepreneurial mark characterizing the launch of FWA service will affect the future path of the company, that will expand gradually in the Italian territory, region by region, as we will see along the section. The company's offering portfolio involves other several marginal services, including a wireline service (known as "Formula") comprehensive of FTTH and xDSL services (sold relying on others operators' infrastructure); and other not-connectivity services (Hosting[85] and VAS[86]). As emerges from **Errore. L'origine riferimento non è stata trovata.**, their contribute to the company's income is very negligible.

[85] Hosting is a service that consists in hosting, in fact, on a web server the data of a web site, in order to make it visible to internet users.
[86] VAS is the acronym of Value-Added Service, indicating all those services external from the connectivity ones (e.g. games, weather forecast…).

Source of revenues	2012	2013	2014	2015	2016	2017	2018
Wireless access (EOLO)	18,975	26,219	37,478	52,022	71,636	96,161	123,728
Wireline access (Formula)	8,108	6,749	5,638	4,579	3,415	2,461	1,676
Hosting/VAS (Virtuo, Squillo)	639	649	560	331	0*	0	0
Other revenues	417	0	0	261	431	1,587	1,417
Total	28,139	33,617	43,676	57,193	75,482	100,209	126,821

TABLE 17: EOLO'S REVENUE STREAM, 2012-2018
***STARTING FROM 2016, VAS SHARE MERGES INTO "OTHER REVENUES"**

The society is 51% subsidiary of Cometa S.p.a. and 49% subsidiary of Searchlight Capital Partners EPC UK Limited, that entered the shareholder structure on December 2017. This fact represents a strategic move in order to provide financial sustain to the company, as we will see in section 3.3.

After this brief introduction to the operator, we will proceed with its strategy analysis. Eolo's ultimate goal over the period considered has been increasing its customer base, in other terms, increasing its market share and at the same time increasing the marginality. AGCOM data demonstrate that the expansion of the market share has effectively happened, as already established. The more relevant fields of intervention affected by top management decisions in order to reach the ultimate goal are:

- Network deployment
- Commercial strategy
- Human resources

To be more precise, it can be stated that, in order to increase the odds for a network deployment investment to be successful, other sustaining measures have been planned and implemented over the years. This fact too has implied a series of investments that have expanded the asset side of the balance sheet, with several consequences for the need of financing, the profitability and so on.

Network deployment is the first aspect of the strategy that will be object of evaluation. From the analysis of their official documents (financial statements essentially), it emerges that both Eolo and Linkem have implemented a network expansion strategy aiming at covering gradually the majority of the national territory.

Even if only graphically, Eolo offers coverage map for its network, at regional level. It would have been interesting disposing of provincial level data, nevertheless some considerations can be done basing on the available data.

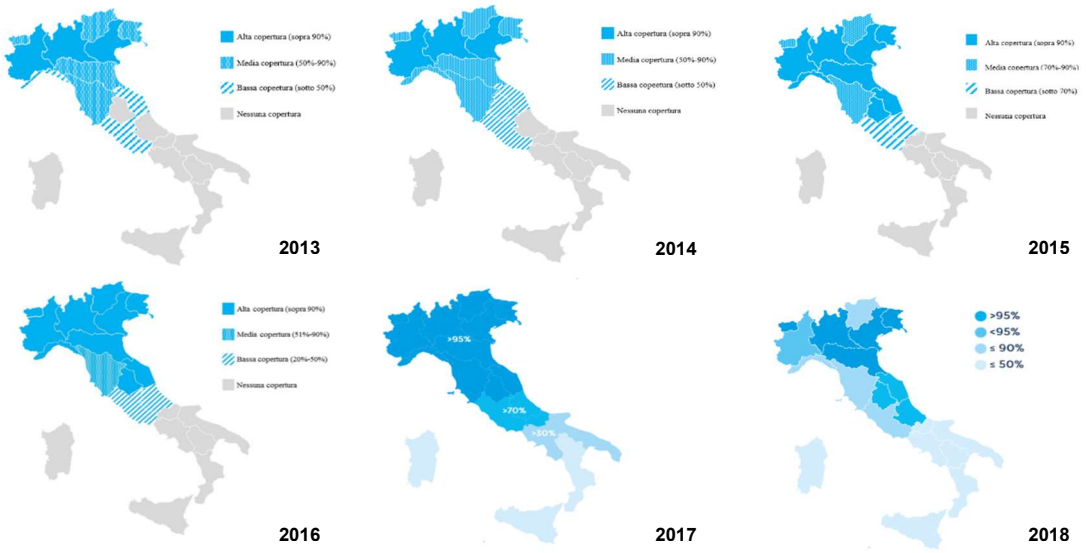


FIGURE 6: COVERAGE MAP EOLO NETWORK, 2013-2018
SOURCE: COMPANY'S BALANCE SHEET, VARIOUS YEARS

The coverage pattern that clearly emerges from the maps is the tendency towards following a geographical criterium (from North to South), with the long-term goal of covering the majority of the national territory. We could try to explain this gradual expansion either with a cautious approach of the CEO, either with the difficulty in attracting external capital (see section 3.4). By the way, it is useful to remember that some "forced" coverage steps have been implemented by the company, as consequence of the four call for tenders won by Eolo in 2014, within the domain of the Italian National Broadband Plan for reducing digital divide; in the specific the call for tenders have interested the regions Liguria, Marche, Emilia Romagna and Umbria (al already specified in chapter 2).

	2013	2014	2015	2016	2017	2018
Municipalities	n.a.	n.a.	5100	5100	5900	5900
Regions	11	12	13	13	20	20
BTS	n.a.	n.a.	n.a.	2200	2500	2600

TABLE 18: SOME COVERAGE DATA
SOURCE: OWN ELABORATION ON COMPANY'S FINANCIAL STATEMENTS

Table 18 offers an idea of how the network expansion took place, arriving to involve, at 31/03/2019, 5900 municipalities from the whole country, for a total of 2600 BTS. We will see further in this section that this number is intended to increase for effect of a project digital divide-related. In the two-year period 2017-2018, Eolo's network starts to expand towards the South of Italy, but initially the coverage is very limited.

To go more in depth regarding the characteristics of the area where Eolo is used to invest in, we present some data and facts.

What is peculiar in the case of FWA technology, is the relative cost-effectiveness of the last-mile deployment, that makes operators more willing to invest in less favoured areas. In this direction, we have to cite some facts. The first one is an interesting data regarding the coverage of white areas through ultrabroadband connectivity, that amounts to 78%[87] in May 2020. This does not imply actually that they do not invest in grey and black areas indeed, the second fact concerns their vocation of connecting the areas out of the big cities, in particular peripheral areas,

[87] Source: https://www.eolo.it/eolonews/2020/05/12/eolo-18-mesi-azzerare-digital-divide-nelle-aree-bianche-del-paese-connettere-7-500-comuni-fwa/

that notably are characterized by the presence of industrial districts (interesting for the the potential customer base that could be developed there). Another fact regards instead Eolo's initiative called "EOLO Missione Comune"[88], thanks to which the company commit itself to donating 1 million euro to be spent in projects in the field of digitalization, safeguard and valorisation of small Italian villages afflicted by the depopulation issue. Morever, the case happened during Covid-19 emergency and interesting the municipality of Fobello (VC) is a clear example of the commitment of the society in reducing digital divide[89]. As last, a relevant investment plan has been announced in May 2020[90]: reaching a total of 7.500 municipalities with FWA ultrabroadband connection, with an investment of € 150 million (considering the remaining 1500 municipalities to cover). This is in line with the connectivity necessities induced by Covid-19.

[88] Information regarding this initiative are available at: https://missionecomune.eolo.it/
[89] For the complete article, see: https://www.eolo.it/eolonews/2020/07/17/fobello-eolo-risponde-alla-richiesta-del-comune-difficolta-connette-le-frazioni-santa-maria-boco/)
[90] Source: see note 89

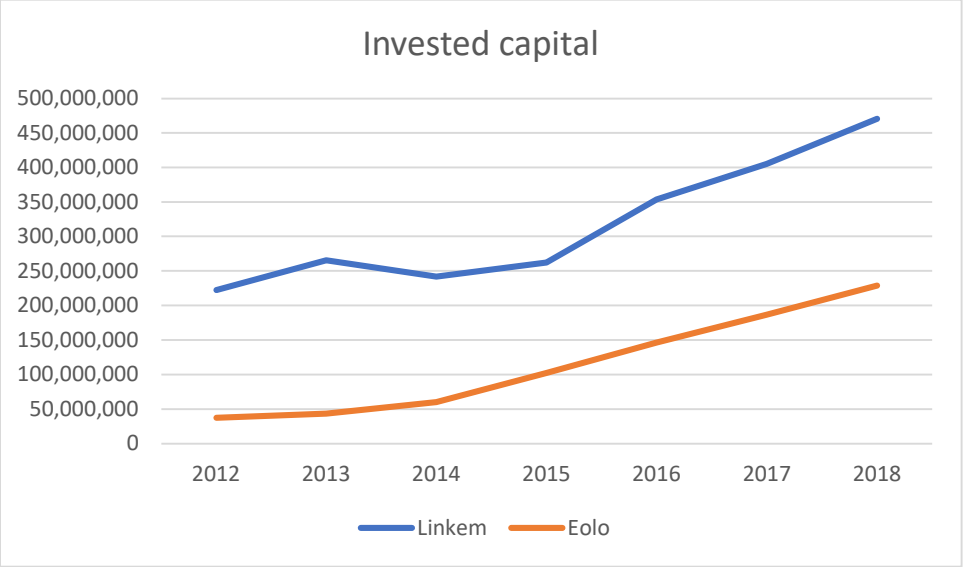


CHART 3: INVESTED CAPITAL, LINKEM AND EOLO, 2012-2018
SOURCE: COMPANIES BALANCE SHEETS

Invested capital growth	2013	2014	2015	2016	2017	2018
Linkem	19.23%	-8.84%	8.51%	34.70%	14.66%	16.21%
Eolo	15.00%	38.51%	70.24%	43.13%	27.61%	22.73%

TABLE 19: INVESTED CAPITAL GROWTH (RATE OF CHANGE INVESTED CAPITAL VS PREVIOUS YEARS), 2013-2018
SOURCE: OWN ELABORATION ON COMPANIES' BALANCE SHEETS

Chart 3 and Table 19 provide an overview of the invested capital development, in other terms, they exhibit the evolution of assets side of Eolo and Linkem. In absolute terms, Linkem has the highest investment. In relative terms (rate of change of invested capital), Eolo is the one which has grown more in the past years. In the rest of the section, the network expansion process of Eolo will be introduced, together with the sustaining measures (i.e. the appropriate investments) to make this

enlargement effective and credible. The same work will be exposed in the case of Linkem.

Telecommunication industry is a field where innovation is fundamental to retain and attract customers hence, when we are talking about network deployment, not only the geographical expansions (i.e. new BTS in FWA case) but also in terms of improving the current performance level and the network capacity. In this regard, Eolo's main steps are summarized in Table 20.

Year	Technological advancement	Benefits
2006	Hiperlan2 technology	-
2010	The upgrade process of BTSs to 802.16e technology (WiMAX) starts	Cells bandwidth capacity triples
2013	EOLOwave is introduced: an internally developed access technology	Twice better performance than WiMAX. Latency drops to 5-8 ms. 30 Mb/s in downlink; 10 Mb/s in uplink
2015	Maestrale project: connecting 70% of existing BTS to fiber optic in the next five years	Considerably improving the first mile connectivity
2018	Launch of "EOLO 100 Mega" based on the EOLOwave G network (upgrade of EOLOwave) developed starting from 27.5 GHz frequency	First worldwide commercial offer based on 5G frequencies. 100 Mb/s services extended to residential customers

TABLE 20: STEPS OF EOLO NETWORK TECHNOLOGICAL ADVANCEMENT
SOURCE: OWN ELABORATION ON COMPANIES' FINANCIAL STATEMENTS

From the investment point of view, what is relevant to underline in the above table is:

- EOLOwave access network (now substituted from EOLOwave G), together with other technologies (e.g. the network architecture BLU and the network support system EOLIA) were totally internally developed.
- The choice of internalising the R&D activity is a strategic choice and makes R&D a crucial department on which investments burden so as to keep Eolo's offerings competitive and appreciated by customers.
- EOLOwave G is the evolution of EOLOwave and it is based on 5G frequencies acquired by the company at the end of 2016. EOLOwave G is fundamental for introducing in the market the first world offering based on FWA 27.5 GHz frequency (EOLO Super, see along this section) that allows residential customers to benefit from a 100 Mbp/s in downlink (until that moment reserved only to business customers). The investment in this field regards the more than 220 MHz of radio spectrum acquired with exclusive right of use.

With respect to the second point, data regarding R&S investment are not useful for our analysis, being constrained by accounting limitations. Besides, the notes to the financial statements do not provide a separation of the components inside "Costs of development" item, which includes both innovation in the network field and internal innovation in terms of information systems.

The investment related to the third point instead are recorded within the item B) I 4) of the asset side of the balance sheet, *Concessions, licenses, trademarks and*

similar rights that, starting from 2016, mainly includes expenses related to the acquisition of the radio frequencies' rights of use and the passage licenses for passive infrastructure.

(in million)	2012	2013	2014	2015	2016	2017	2018
Concessions, licenses	34	190	6,137	11,403	19,598	24,817	23,953
Marketing&Sales	612	527	645	3,009	5,337	8,583	12,872

TABLE 21: CONCESSIONS, LICENCES/MARKETING AND SALES EXPENSE, 2012-2018
SOURCE: OWN ELABORATION ON COMPANIES' FINANCIAL STATEMENTS

By looking at the above table, it is clear how this expense items have impacted on the asset side of the balance sheet, resulting into an abundant financing need.

The second domain of strategic analysis regards the commercial strategy. The results obtained in terms of market share are the consequence of an overtime improved commercial strategy, that has accompanied the network expansion process. A network expansion actually, does not necessarily lead to an increase in the customer base but requires an adequate "infrastructure" behind that sustains and make possible the process of monetization of the investments. In this perspective, the main leverage adopted by Eolo is the implementation of an adequate commercial strategy.

In the period analysed we can distinguish between two phases, with the year 2015 signing a turning point:

1. years 2012-2014: basic commercial strategy, based on the enlargement of the indirect sales network, remodelling of the commercial offering

(proposing to the potential users a higher connectivity speed at the same price level);

2. years 2015-present: more structured commercial strategy aiming at gaining market share. The main pillars have regarded:
   a) Revision of the commercial offering and of its market positioning, with the identification of three customers segments: 1) residential customers, 2) professionals and SMEs, 3) companies. For each one of these segments, customized solutions were ideated and updated when needed.
   b) Sale channels, both direct and indirect. The indirect sales network involves a series of commercial partners spread across the country, with an intensity in line with the network presence[91]. The choice of the independent partners, instead of owned property point of sales or of a franchising network, allows Eolo to maintain a greater flexibility in starting or interrupting new collaborations and exerts less burden on the company's financial resources. The direct sales network is to be reconducted to the Eolo website, together with other digital initiatives, that have experienced a renovation process starting from 2015. Digital channels offer the benefit of a lower CAC (Costumer Acquisition Cost).

[91] Partners localization map isat: https://www.eolo.it/home/assistenza/non-sei-cliente/trova-partner.html

c) Communication and brand positioning: in the process of enlargement of the customer base, the brand EOLO has assumed a key role, in the view of reinforcing the corporate identity. In this sense, initially radio campaigns have been set up, both al national level and at local level (considering the coverage areas). Starting from August 2018, the communication strategy has expanded towards TV channels, with the broadcast of the first commercial[92]. TV campaigns activities have been intensified during the Covid-19 period. The elements that act as a guideline are the presence of the Eolo robot (functional for the corporate image) and the mission *"Internet dove gli altri non arrivano"*, that particularly fits the period we are living (think at smart workers' needs or at SMEs, located in disadvantaged areas, that want to exploit the digital wave…). TV spots represent a high costly investment, that has been done in a period where the coverage was present – even if at different intensity – at the whole Italian level (see Figure 6). Furthermore, working on the brand awareness once you are sure about the technology you are offering is a way not to fail to meet the customers' expectations (in line with what discussed in terms of analysis perspective, section 3.2.1). In this way, the probability to obtain a higher

[92] Article retrieved from: https://www.eolo.it/eolonews/2018/08/28/eolo-lo-spot-tv-air/

return on the marketing investment increases or, in other terms, investments are not wasted.

A specification needs to be done with regard to point a). The solutions portfolio ideated for the consumers segment (i.e. residential) has been revisited twice in the last years and what emerges as common thread is the willingness to propose high speed connections able to accommodate the present needs of the users.

In April 2018, *EOLO Super* was launched, at the promotional price of € 29,90 (that has been subject to several revision along the year, implying a lower promotional price). The download speed of 100 Mbit/s is an answer to the growing preference of users for online video content. The offering includes also 6/9 free months of two platforms among Dazn, Now TV, Amazon Prime, Chili and Xbox Live Gold. What is peculiar to this offer is that it represents the first worldwide offer developed from FWA technology based on 27.5 GHz frequency and that it has implied the need for establishing commercial agreements with the above-mentioned digital operators.

In July 2020 finally, *EOLO più*[93] was introduced within the offering portfolio mix, at the promotional price of € 27,90. The key word in this case is "customization", since the customer, by adding an additional cost to the basic offering, can create a personalized package, choosing among the three options: *+Intrattenimento (€ 5/month), +Studio e Lavoro (€ 5/month), +Sicurezza (€ 3/month),* with the benefit

[93] Information related to this offering can be viewed at: https://www.eolo.it/internet-casa/eolo-piu.html

of an ultrafast broadband connection (instead of a fast broadband one) in the first two options[94]. In the specific, the speed granted are: either up to 100 Mb/s in download and 10 Mb/s in upload either up to 1 Gb/s in download and 300 Mb/s in upload, according to the infrastructure type of the area where the activation takes place. The additional cost could be seen as a premium price that customers are willing to spend in order to benefit from higher connection and for the opportunity to personalize the offer.

A numeric evidence of the growing relevance attributed to the commercial strategy is retrievable from financial statement data, as emerges from **Errore. L'origine riferimento non è stata trovata.**. In the specific, the values refer to Eolo's reclassification of the income statement, according to the model EBITDA, EBIT.

The strategy implemented over the years has given rise to several outcomes, that partly have been either exposed either introduced. In a nutshell, the outcomes are the following:

a) Gradual increase in the customer base, leading to an increase in the market share
b) Increase in the average revenue per unit (ARPU)
c) Considerable evidences of the establishment of a technological leadership

The increase in the customer base is visible in Chart 4.

[94] Customers can benefit from additional free services during the first months: DAZN with *+Intrattenimento* and Microsoft with *+Studio e Lavoro.*

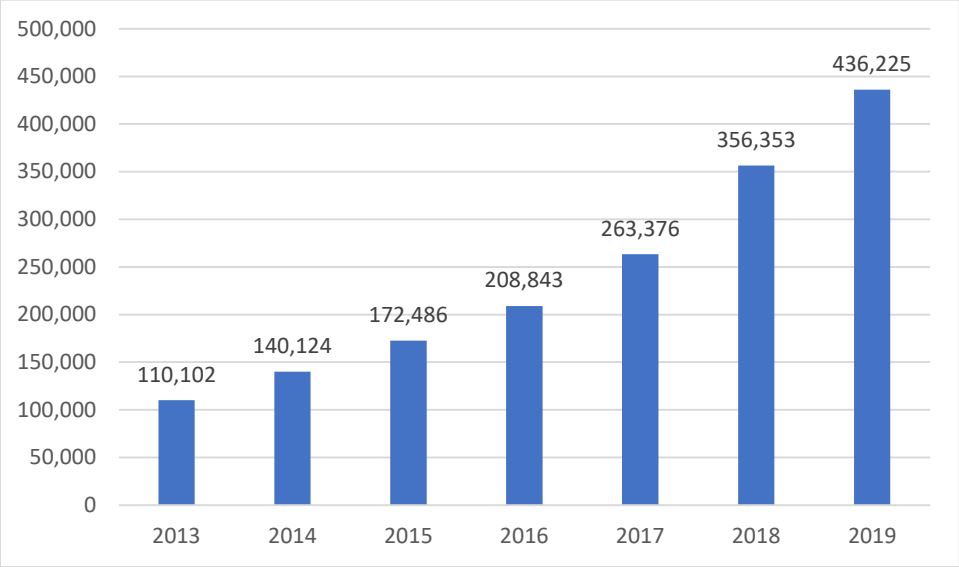


CHART 4: CUSTOMER BASE EOLO, 2013-2019
SOURCE: OWN ELABORATION ON AGCOM DATASET)

The company gives a significant credit for the recent customer base increase to the introduction of Eolo Super, and this could be true in so far as it replies to a specific need of the residential customer: enjoying an always more traffic consuming online content (video content especially). With regard to the increase in market share, we refer to section 3.1.

Point b), gradual increase in ARPU is visible at

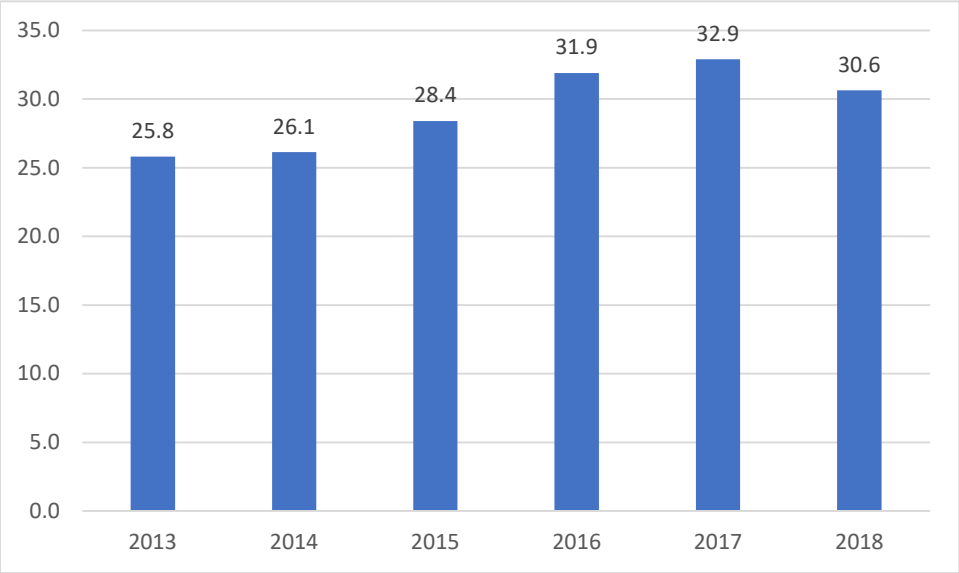


Chart 5. Although a slight decline in (monthly) ARPU in 2018, the trend has been increasing and probably linked to the pricing policy of residential users offering, that can rely on a premium price. Obviously, other typologies of users must be taken into account for commenting this value, but the choice of focusing on residential users depends on the fact that it represents the great majority of Eolo customer portfolio.

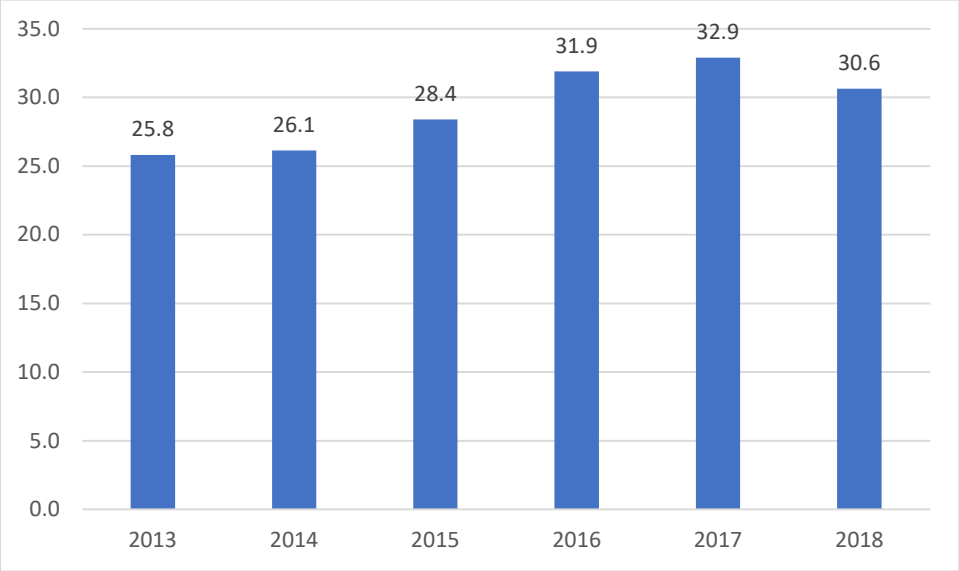


CHART 5: ARPU, EOLO (2013-2018)
SOURCE: OWN ELABORATION ON AGCOM DATASET AND COMPANY FINANCIAL STATEMENTS

Point c), regarding the establishment of a technological leadership, requires further comments. Several are the evidences in this respect. An evidence of the establishment of technological leadership is found in AGCOM data regarding contracted lines by advertised speed (see Table 15 and 16). In the premium segment (≥ 30 Mbit/s in the period 2016-2017; ≥ 100 Mbit/s in the period 2018-2019), Eolo had a not negligible market share. This fact could represent a sign that customers favourably consider and appreciate Eolo's premium offering[95]. Another evidence is given by the excellent positioning in terms of Netflix Speed Index[96], where Eolo

[95] EOLO Super once, now substituted from EOLO più.
[96] The Netflix Speed Index is and index through which Netflix measures the internet service providers' performance during the prime time. It is only Netflix-related, hence the performance computed cannot be taken as valid for other services.

obtains the top position worldwide among FWA operators. At the Italian level, the last rank provided is displayed in . Since January 2018, the primacy has been always contested by Eolo, Fastweb and Telecom Italia. Starting from July 2019, Eolo acquired the first place, maintained until February 2020, where is has been surpassed by Vodafone Italy.

Linkem on the contrary, occupies always the last position, with a considerable gap with the other operators.

ERRORE. L'ORIGINE RIFERIMENTO NON È STATA TROVATA.
The last evidence supporting the technological positioning concerns the fact that, as already commented, EOLOwaveG has allowed the company to introduce the first worldwide commercial offering based on 5G frequencies. This great achievement is the result of a three-years period of internal R&D, sign of the huge vocation for innovation of the company.

3.2.3 Linkem's strategy

Linkem was founded in 2001. It initially started as a Wi-Fi[97] operator, but now is core business is represented by FWA service, realized through point-to-multipoint links (for residential users mainly) and point-to-point links (ideated for big companies). Its FWA connectivity service was launched in 2011 and it is based on

[97] "*Wi-Fi is a wireless networking technology that allows devices such as computers (laptops and desktops), mobile devices (smart phones and wearables), and other equipment (printers and video cameras) to interface with the Internet. It allows these devices - and many more -to exchange information with one another, creating a network*." Source: Cisco website

a proprietary infrastructure (evolved during the years along with the new technological advancements) that the company also make available to third operators (i.e. in wholesale modality). It covers about 70% of the Italian territory (Source: Linkem website). Nowadays Linkem is the national FWA leader and it is highly committed in the rush towards 5G.

At the 31/12/2018 the Linkem Group (rif: Financial analysis is referred to Linkem Group) is constituted by: Linkem S.p.A. (parent company), Linkem Services S.r.l., Antea S.r.l., Live Protection S.r.L., Go Internet S.p.A., Project Group S.r.l. A peculiar event is Linkem's ability to attract foreign capital, as attested by the 2017 entrance of the US investment fund (BlackRock) within the shareholder structure, as we will see in the next section.

Also in this case the strategy analysis starts with a focus on network deployment. At the end of 2018, Linkem access network covered the 65% of Italian population with the 4th generation technology LTE. The investment plan envisages the willingness to cover the whole Italian territory, as we will see in **Errore. L'origine riferimento non è stata trovata.**. As Eolo, Linkem Group too has a fully-property FWA network, that gives the opportunity to have an end-to-end control on it. The frequencies of Linkem's network is based on (licensed frequencies 3.5 GHz), and for which the company owns the rights of use, assume a great relevance in future perspective, since they form part of the frequency bands pioneers for 5G applications.

Year	Technological advancement	Benefits
2011	Launch of FWA connectivity service based on WiMAX platform	
2014	Implementation of LTE technology starts, implying a gradual switch off from WiMAX to LTE	LTE is a more advanced technology allowing an improvement in the performance granted to customers and has the capacity to sustain the growth in traffic
2017	The process of switch off to LTE platform is concluded	LTE maximises the usage of the 84 MHz frequency band, for which Linkem has the exclusive right of use

TABLE 22: STEPS OF LINKEM NETWORK TECHNOLOGICAL ADVANCEMENT

The passage from WiMAX platform to LTE platform is part of an industrial development plan aiming at keeping Linkem a competitive internet provider operator, considering the evolving demand side: growth in traffic demand induced by a different internet usage. For this purpose, a more performing network is needed.

The industrial development plan concentrated in the South of Italy at the beginning, as envisaged by the *Development Agreement* with Invitalia, in accordance with D.Lgs 24/09/2010 issued by the Ministry of Economic Development. On the basis of the agreement, upon the concession of grants and soft loans, Linkem commits in the deployment of a wireless broadband network in some specific regions

(Campania, Puglia, Calabria and Sicily). The reason underneath is digital divide-related.

Year	Event	Comments
2008	Linkem Group wins - following a public acution – the concessions for WiMAX frequencies for 13 Italian regions ((Lombardia, Piemonte, Veneto, Umbria, Lazio, Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia, Sardegna).	-
2011	- Acquisition of entire shareholding in Maxi-Com, then merged into Linkem Group (operating in Toscana, Liguria and Province of Trento) - Agreement with Retelit for the rent of its business segment (E-via), owning WiMAX licenses - Purchase two frequency bands: Sicily (21 MHz) and Friuli Venezia Giulia (42 MHz)	These choices are the consequence of a well-structured investment plan aiming at covering the whole Italian territory: agreements to obtain at least one frequency spectrum in each region were executed
2012	Multiple acquisitions of some target telecommunication societies operating in unlicensed bands: Antes S.r.l., Florence (entire shareholding), Viterbo (business unit), Omniwave S.r.l., Sardinia (entire shareholding), Molisecom S.p.A., Molise (controlling interest of 90%)	This allows Linkem group to enter new target areas or to complete the coverage in specific territories avoiding network duplication and saving time
2013	Outright purchase of frequencies from Retelit (tlc operator)	-
2017	Purchase rights of use of 112 MHz of spectrum in the portion of spectrum 24.25 – 27.5 GHz in all	Two benefit from this new portion of spectrum: a) increasing the radio access

	the Italian regions (with the exception of Veneto, Marche and Umbria)	capacity in high density areas and where costumers concentrate b) from a 5G perspective, these bands – together with 3.5 GHz and 700 MHz – are the pioneer bands
2018	Purchase of shareholding of 21.22% in Go Internet, local tlc operator: mainly Marche and Emilia Romagna areas, where it owns rights of use for 3.5 GHz frequency band. March 24: Frequency sharing agreement with Go Internet to share the frequencies in the 3.5 GHz band in Marche and Emilia Romagna Regions	-

TABLE 23: COVERAGE STEPS, LINKEM

By observing the above table, it is clear that the process of network expansion is completely different from the one undertaken by Eolo. The modalities adopted involves:

- purchase of frequency (through public auctions) in all the regions, to obtain a widespread coverage in the whole Italian territory;
- purchase of shareholding or directly acquiring target companies to enter new target areas or to complete the coverage in specific territories avoiding network duplication and saving time
- frequency sharing agreement, as in the recent case of Go Internet[98].

[98] Along the section will be provided further specifications.

What emerges from official documents furthermore, is that Linkem access network is located in 19/20 Italian metropolitan cities. This fact is not negligible, since metropolitan areas, although a higher degree of competition, have a high density of population, hence - potentially - higher odds to increase the strategic KPI of average coverage (users/BTS), which overtime evolution is visible at Table 24, together with the number of BTS installed year by year. Furthermore, Linkem has a slight major coverage in the South of Italy, because it is where they started from (Bari is the first historically covered city); the first one city in terms of coverage instead, is Rome (Davide Rota, Telco per l'Italia 360 Summit, 2020).

	2012	2013	2014	2015	2016	2017	2018
BTS	1001	1120	Above 1000	1400	Above 2000	Above 2300	2437
Average coverage (users/BTS)	100	140	216	230	Stably above 200	Stably above 200	Stably above 200

TABLE 24: LINKEM COVERAGE: SOME DATA

The next topic that will be object of study concerns the commercial strategy. The same considerations made about the role assumed by Eolo's commercial strategy applies to Linkem case, meaning that it acts as a support structure to the network expansion process and has envisaged an increase in the market share. In this sense, what is peculiar in Linkem case is the great relevance attributed to customer care,

attested by the strategic decision of keeping this function internal and by the gradual year by year increase in customer care staff, in line with the expectations of customer portfolio expansion. The period considered is signed by growth programs which implementation envisages the construction of an adequate support structure behind.

With regard to the real core of the commercial strategy, some specifications need to be done. The customer segments are three: a) residential customer; b) business customer[99]; c) wholesale customer[100]. For the first two segments, two different offering solutions have been ideated: subscription and prepaid service. With reference to the installation modalities, the alternatives are: an indoor model, consisting of CPE positioned within the house in order to catch the radio signal and destinated to customers living near the BTS; and an outdoor model, with a CPE external to the house so that can easier catch the radio signal (suitable for those living more far from the BTS. Recently has been registered a prevalence of subscription over prepaid service and a prevalence of outdoor over indoor customers.

[99] The solutions thought for this segment are differentiated on the basis of three clusters: professionals, SMEs and big companies.

[100] This business line consists of Linkem offering access services and transportation services to telecommunication operators.

The actions implemented within the ambit of the commercial strategy over the years have contributed to the growth in the customer base. They can be summarised as follows:

- From the sales network point of view, Linkem elaborates growth plans specific for each of its for its selected commercial partners on the basis of their location. In this sense, a relevant KPI is the performance of each BTS by province. Near this indirect sales channel, also a direct one is present, represented by Linkem website.
- Regarding the product portfolio, a focus on outdoor subscriptions has been set, since it provides a higher ARPU and a lower churn rate, with respect to the prepaid service. Another way to lower the churn rate consists of the introduction of direct debit on the customer's bank account (SDD and credit cards), fact that also grants positive implications in terms of liquidity, in the sense that it ensures a constant cash flow. ARPU improvement has been also recently registered in the wholesale market, thanks to the highly customized solutions offered.
- A great relevance in terms of budget and frequency has been attributed to TV campaigns, a constant in the period analysed. Spots with famous testimonials are broadcasted on all the most followed TV channels. The marketing and communication leverage is particularly effective,

considering the increase in the customer base registered during the periods in which the spots are broadcasted.

- Since 2017 as last, several partnerships with Seria A clubs have been signed, introducing also specific promotions for their customers in the football field.

A specification needs to be done with reference to Linkem Group's product portfolio in order to make it comparable with Eolo's one. 100 Mbp/s speed connections results to be available only for big companies, whereas for residential customers, professionals and SMEs, the ultrabroadband connection assumes a maximum of 30 Mbp/s. This fact could have implications in the positioning in the ranking of contracted lines by speed, in the premium segment (see Table 15 and Table 16), but it cannot be proved because the data referred to Linkem in this segmemt (≥ 30 Mbit/s in 2016-2017; ≥ 100 Mbit/s in 2018-2019) are missing (not available). An interesting fact nevertheless, is that for big companies there is a dedicated offering (*Linkem Turbo*) that provides connection up to 1 Gbps (symmetric) in guaranteed bandwidth using FWA point-to-point modality.

Finally, analysing the pricing policies applied to residential customers offering, we have noted that the current subscription offering (*Linkem Senza Limiti*), has a price level notably lower than the same offer proposed by Eolo: € 19,90 for Linkem (promo price for the first months; normal price is € 26,90)[101], versus € 26,90 for its

[101] The price applied to offering has not been the same for all the time. But by analysing previous prices it can be confirmed that the gap with Eolo prices for residential users is relevant.

competitor (promo price for the first months; normal price is € 34,90). The gap is quite relevant, some considerations about will be done in section 3.4.

	2012	2013	2014	2015	2016	2017	2018
Advs&Promos	5,239	6,446	4,836	4,633	5,370	12,260	10,822
Commissions to intermediaries	930	2,208	1,436	1,533	1,927	1,825	2,752
Other commercial costs	305	338	1,208	2,045	4,161	580	426
Total commercial costs	**8,486**	**11,005**	**9,494**	**10,226**	**13,474**	**16,682**	**16,018**

TABLE 25: COMMERCIAL EXPENSES, 2012-2018

A numeric evidence of the growing relevance attributed to the commercial strategy is retrievable from financial statement data, as emerges from Table 25. The gradual increase in the voice item *"Commission to intermediaries"* is linked to the expansion of the indirect sales network. With reference to the voice *"Other commercial costs"* instead, from the income statement of the various years we note a change in the measurement criteria over the years, hence we cannot make significant considerations on this data.

As last, in the case of Linkem it is necessary devoting some lines to the strategic partnerships' topic. In the last two-years period, several are the relevant agreements signed by Linkem with others telecommunication operators, above all in 5G perspective. In other terms, what Linkem is trying to do is surrounding by strategic partners in order to lay the foundation for 5G market opportunity. In a nutshell, the intent consists in accelerating the deployment of a 5G Ready network by means of

sharing assets with each of the partners. The main features of the agreements are summarized in the Table below.

Company, date	Typology of agreement	Notes
Go Internet, July 2018	Frequency sharing agreement	Object: sharing the frequencies in the 3.5 GHz band in Marche and Emilia Romagna Regions. Aim: transforming the network in those Regions in a commercial network 5G Ready.
Tiscali, July 2019	Commercial agreement	Aim: Tiscali portfolio expansion towards FWA-based offerings.
Fastweb, December 2019	Network deployment agreement	Aim: reaching within 2023 the 30% of Italian population (i.e. grey areas) with ultrabroadband FWA-based networks.
Open Fiber, March 2020	Trial agreement	Object: trials on FWA technology in 3.5 GHz frequency band, also in 5G optic Aim: reducing the digital divide in low density areas

TABLE 26: STRATEGIC PARTNERSHIPS

In the following lines some comments more regarding the agreements will be briefly exposed:

- Go Internet: in other terms, the goal consists of building a network that will allow an easier migration to 5G. A collateral effect of the agreement is the improvement in LTE-based network performance, considering the greater spectrum availability.
- Tiscali: on Linkem side, the idea behind this partnership is the willingness to dispose of an open network also in 5G perspective.
- Fastweb: the agreement allows the acceleration of the network deployment by means of leveraging on the advantages granted by FWA technology and by means of sharing both companies assets: Fastweb, through its subsisdiary Fastweb Air, has acquired knowledge in the deployment of FWA-based network in intense digital divide areas; Linkem is market leader in FWA market with its extended LTE FWA network and its working on the upgrade to 5G.
- Open Fiber: the areas interested are those involved within Infratel calls for bids won by Open Fiber, in order to provide them more performing connections. The sharing of both companies' asset is fundamental also in this case, with Open Fiber making available To Linkem its backhauling fiber optic network.

Moreover, always within its 5G strategy, Linkem has funded a society, 3PItalia, together with Easygov Solutions S.r.l.[102]that has the objective to provide public services with the right resources in order to face the digitalization process, by means of public-private partnerships (PPPs).

The strategy implemented over the years has given rise to several outcomes, that partly have been either exposed either introduced. In a nutshell, the outcomes are the following:

a) Gradual increase in the customer base, leading to an increase in the market share
b) Establishment as market leader within FWA market
c) Relevant market share in ≥ 30 Mbit/s - <100 Mbit/s market segment
d) High level of technological innovation
e) Gradual increase in the strategic KPI of average coverage (users/BTS)

Point a) and b) has been widely commented in section 3.1. This result has been made possible also because of the network expansion towards big cities. An interesting fact to remark is the 16.36% increase in overall market share in 2017 that it is reasonable to be partly attributed to the huge advertising investments in

[102] Easygov Solutions is a business consulting society. For 3PItalia foundation, it has contributed a business branch with expertise in PA innovation projects.

that year. At end 2017 Linkem was the leading operator in FWA market, reaching a 47.5% of the total subscriptions.

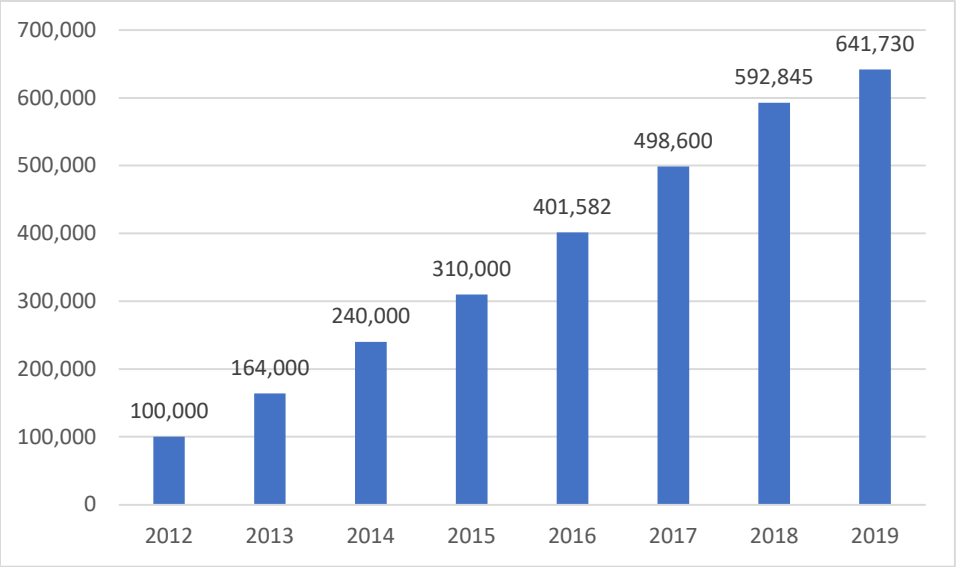


CHART 6: CUSTOMER BASE LINKEM, 2012 – 2018
SOURCE: OWN ELABORATION ON AGCOM DATASET AND COMPANY FINANCIAL STATEMENTS

Chart 6 provides a numerical evidence of the increase in customer base.

Point c) can be interpreted as the result of an appropriate pricing policy aiming at reaching a standard residential customer base, that is more price-driven. Considerations regarding the speed of installing the internet service cannot be neglected when commenting these evidences, since they can be a driver of choice for the potential customer. In this respect, Linkem offers a very rapid installation time.

Point d), high level of technological innovation refers to the Linkem's ability to provide advance services. For example, Linkem is now offering a 1 Gbps

connection to business users (typically, big companies) through its FWA network. Unfortunately, we cannot prove numerically the percentage of users of this technology, but it is likely that this premium service has a small customer portfolio. This statement comes from the joint observation of its market share in the premium segment, that is surely inferior to 0.5% (for the reason previously exposed) and of its incomes that seems more the result of a residential customer base focus.

For what concerns point e), gradual increase in average coverage, please make reference to what commented with regard to the network deployment.

3.3 Financial statement analysis

As already mentioned, the financial statement analysis serves as a complement to the core study on the two competitors' strategies. The period taken into consideration is the seven-years period 2012-2018. Some notes need to be made before initiating. The exercises of the two competitors end on different date, hence the balance sheets are referred to two different final dates. In the specific, Eolo's exercise ends on 31/03, while Linkem's exercise end on the traditional date, 31/12. To overcome this issue and allowing the comparability between the same years of the two companies, a simplification has been introduced: Eolo's exercise ending on 31/03/n is assumed to be referred to year n-1. To make an example, the balance sheet at 31/03/2019 is assumed to be referred to year 2018. This choice depends on the fact that the number of months included in 2018 is higher than those included

in 2019. In this way, Eolo's balance sheet at 31/03/2019 is made comparable to Linkem's balance sheet at 31/12/2018. Another specification regards the comparability between financial ratios of the two companies, considering that they apply different accounting policies: Eolo applies national accounting policies (OIC, from the association that issues them, *Organismo Italiano di Contabilità*); Linkem applies international accouting policies (IAS/IFRS, International Accounting Standards). In standard conditions, some precautions should be made in order to allow the comparability between balance sheet item, but in this case, we have adopted financial ratio downloaded from AIDA database[103], that proposes standardized and comparable data for all the companies that it contains. For any company, AIDA offers the detailed balance sheet, reclassified according to the scheme contained into the IV EEC directive. Some data were computed integrating the data already available with data included into the companies' balance sheets. For example, Linkem data for the two-years period 2012-2013 were missing from AIDA database, so they were computed following the same methodology. Moreover, the fact that this financial analysis serves as a complement to the business model analysis, make us state that differences in accounting policies do not undermine the validity of our conclusions. Another specification regards the fact that for Eolo the non-consolidated balance sheet has been used (the only one

[103] AIDA (Analisi Informatizzata Delle Aziende), a database realized and distributed from Bureau van Dijk, containing balance sheets, personal data, financial ratios, sectorial data of all italian limited companies. Link to the website: https://www.bvdinfo.com/en-gb/our-products/data/national/aida

available), while for Linkem, the decision has been adopting the consolidated balance sheet (referred to Linkem Group), since Linkem Group, besides Linkem S.p.A., includes companies that are functional to the survival and expansion of the business. Hence, their contribute to the formation of revenues and costs cannot be neglected. The last specification regards the components (revenues and costs) from accessory and extraordinary areas to the formation of the ordinary operating income: from our analysis of the companies' financial statements, their burden can be considered negligible; hence, from our analysis perspective, do not separating these components from the relative income and cost items does not distort again the results.

The main fields that will be investigated within the financial ratio analysis are:

- Profitability
- Financial solidity
- Liquidity

The first area considered is the profitability one. It will be useful in order to appreciate the profitability, the returns generated by the investments exposed in the precedent sections. The main indicators in this sense are those present in Table A1(for Eolo) and Table A2 (for Linkem). Table A3 provides some comments regarding the modality adopted by AIDA for building the indicators.

EBITDA comes from the difference between sales revenues and the so called *OPEX* (operating expenditure), including consumption of raw materials and services and

labour cost. In both cases an increasing trend in EBITDA can be noticed. Negative Linkem EBITDA until 2014 is a consequence of the start-up phase, characterised by huge investments in the network expansion. Positive EBITDA indicates that the increase in revenues associated to the expansion of customer base, more than compensate the operating costs incurred for reaching this result (those relative to the related network expansion in fact, mainly). From Linkem's income statements for example, the voices assuming great and increasing relevance over the years are strictly related to this fact: "Connectivity services", "Support and maintenance", "Hospitality equipment", "Plant, networks and infrastructure concessions", together with personnel cost and the burden of commercial costs (see previous section). Besides evident considerations regarding the positive impact of commercial strategy on customers growth, another element that must be considered is the improvement in the average coverage (users/BTS) value, highlighting a better exploiting of the existing assets (BTS). When it comes to ROI (Return On Investment), a discrepancy between the two competitors appears, with EOLO showing all positive returns on investments, while Linkem all negative. Since *ROI = Net Operating Margin/Total Assets*[104], a negative Net Operating Margin (NOM) in all years has a negative impact on the ratio (in the case of Linkem). The "fault" must be attributed to the cost items depreciation and amortization and partly to

[104] The formula is the one applied by AIDA. Net Operating Margin is assimilated to EBIT and proxied by (A – B), macro-categories of the income statement according to the civilistic setting.

writedowns. The gradual increase in the former over the years is a consequence of huge capital expenditure (CAPEX) for the network expansion and for the purchase of rights on new spectrum frequency bands. ROI improvement in 2018 can be attributed to an improvement in NOM thanks to a more than proportional growth of revenues with respect to OPEX; at the denominator, asset side expands in a lower percentage, thanks to, for example, the acquisition of 21.22 % shareholding in Go Internet. The ROI improvement could be interpreted as a peculiarity of telecommunication industry (but more in general, of utilities): the effect of today investments are not visible immediately but are delayed over time.

Eolo's ROI instead, has always maintained positive, even though it has significantly decreased in 2018, because of a deterioration in NOM (operating result) which causes are outlined in the next lines.

As regards ROS (Return On Sales) - computed, according to AIDA methodology, as *Net Operating Margin/Revenues* – for the same reason above mentioned Linkem has a constantly negative value. By the way, the exponential growth in sales envisages a year by year improvement in ROS value.

Eolo faces an always positive ROS, sign of a good operating efficiency. In this sense, it is useful citing solutions implemented by Eolo to reduce OPEX: this is the case of the adoption of Ceragon's FibeAir IP-20C multicore solution.[105]

[105] It is an an outdoor wireless backhaul solution developed by Ceragon in partnership with Eolo and, whose implementation within Eolo's network allows the reduction of operating expense

We can notice a peak upward (2014) and downward (2018). The latter has been generated by a huge augment in revenues, in line with the customer portfolio expansion and at the same time by a considerable reduction in NOM (vs 2017), in turns caused by increases in both OPEX and CAPEX, especially: depreciation and amortization, installation costs, marketing and sales costs. All these voices are the numerical evidence of what exposed with regard to network deployment and commercial strategy. In particular, the augment in depreciation and amortization is the result of the increase in invested capital for EOLO network development.

The last profitability ratio we are going to comment is the Return On Equity (ROE). It has always maintained positive, thanks to a positive net profit, in turn made possible by the fact that the financial, fiscal and extraordinary areas have not eroded the operating income. The gradual decrease starting from 2017, after a two-years period of upward peak, it's the consequence of the 2017 capital injection finalised to compensate the disproportion between debt and equity in the liabilities side of the balance sheet, as we will comment later in this section.

Linkem situation is opposite, with a persistent negative ROE, deriving from a persisting loss for the period. This is nothing strange if we consider that the operating income was negative. Despite this, shareholders continue to invest in the

company, as attested by the continuous capital injections, meaning that the credibility of the Linkem Group is safe.

The second aspect that will be investigated within the financial statement analysis framework is the financial solidity which main indicators again are exposed into Table A1 and Table A2. Jointly, also liquidity ratios will be commented.

The investments done by the companies (see Chart 3) have generated a financial need that, in turns, requires to be filled with different sources of financing traceable to a) internal source of financing: self-financing, b) debt; c) equity. One key point is that endeavours should be done in order to equilibrate the use of debt and equity. The ratio summarizing this aspect is the Debt-to-Equity ratio. We will use a reduced version of it, Financial debt/Equity, in order to appreciate the financial component of the liabilities. We have investigated this ratio together with the Equity-to-Asset ratio, expressing the degree of independence from debt capital.

In this sense, Table 27 provides a summary of the main sources of financing – besides autofinancing – adopted by Eolo to cover its investments.

Date	Source of financing	Notes
August 9, 2015	Loan agreement of € 43 million, 6 years length	Loan issued by a 5-banks pool. Destination: strengthening the existing broadband

		network; sustaining the network deployment in the regions interested by the calls won by Eolo
December 22, 2017	Paid off and renegotiated previous loan	A € 25 million budget line is envisaged for sustaining the current investments. Only two banks granted the loan: Monte dei Paschi and Unicredit
December 22, 2017	Increase in share capital of € 5 million (+ constitution of a € 25 million share premium reserve)	The capital injection is provided by Searchlight Capital Partners EPC UK, that enters the shareholder structure
2018	€ 10 million loan by BPM; € 5 million loan by Intesa Sanpaolo	-

TABLE 27: MAIN SOURCES OF FINANCING, EOLO 2012 - 2018

The two years period 2015-2016 was signed by an evident dependence from debt (with respect to equity). As a consequence, share capital increase was subscribed in 2017 to restore the excessive imbalance debt vs equity, with significant improvement in the Equity-To-Asset ratio. To remark is the entrance of Searchlight Capital Partners EPC UK within the shareholder structure, that has represented a fundamental step to provide financial and balance sheet strength to the company, in a moment where it is establishing more and more among the internet service providers. The tendency has been towards the reinvesting earnings, rather than distributing them to the shareholders. By the way, an evident fact is the preference

towards the resort to debt (rather than equity) as source of financing, as shown by the values of Financial debts/Equity ratio.

Financial expense shows an increasing trend, in line with the increasing resort to financial debts.

Liquidity can be investigated at this point, by looking at the quick ratio, current ratio and Net Financial Position (NFP). The first two in this case are basically equal, considering that the value of the inventory is near to zero. Their low value indicates liquidity issues caused by an excessive reliance on cash and cash equivalents and on the cash flow generated from operating activities as source of financing (i.e. autofinancing), instead of resorting to debt and equity capital. This fact on a side demonstrates Eolo's ability to generate cash flows able to cover investments, but on the other side erodes cash and cash equivalents, making them insufficient (together with current assets) to cover current liabilities. The same conclusions are reached by looking at the NFP, that is negative in all the years taken into consideration. Besides the liquidity issue, another aspect that should be considered is the financial leverage effect. With this term it is indicated the fact that the indebtedness represents a leverage that can be exploited to increase the remuneration for the company's shareholders, operating profitability being equal. The positive effect exerted by the debt nevertheless is counterbalanced by the fact that an increasing financial debt envisages a higher burden of financial expensed over the company revenues, inducing a shrinking in the operating income (Giunta

and Pisani, 2016). In numerical terms the financial leverage effect can be computed using the differences between ROI (Return on Investment), indicating the return on the capital invested by the company; and ROD (Return on Debt)[106], that indicates the cost of debt.

Until now, the spread (ROI – ROD) has always been positive, standing for a positive financial leverage, that exerts a (positive) multiplier effect on ROE. By increasing the amount of financial debt, and assuming a less than proportional growth of financial expense, the leverage effect could be amplified, in a way that shareholders could benefit from the ROE growth. Nevertheless, the fact that the resort to debt is not so exploited could derive from different considerations that will be exposed in the next section.

Regarding Linkem instead, Equity-to-Asset ratio has appeared quite good over all the period, thanks to Linkem's ability to raise capital from its shareholders when needed, demonstrated by the frequent resort to share capital increase. Autofinancing is less adopted than Eolo, since operating activities highly absorb cash flows, as attested by negative EBITDA in the first three years.

The trend in terms of Debt-To-Equity ratio is keeping it around 1, that mean having a sort of balance between the two sources of financing. Some years prevails debt, other year prevails equity, but the values appear more stable with respect to Eolo.

[106] ROD = Financial expense/Financial debt

Only considering financial debt, the trend is a prevalence of equity over the former, but again the variations along the years seem moderate. This is the result of a more dynamic and continuous financial planning, obtained through capital injections by shareholders and through external financing planned in advanced, according to cash requirement deriving from investment decisions and OPEX. Regarding equity, it is interesting to note that in almost all years considered a capital increase was subscribed and paid a capital increase, attesting a commitment of shareholders towards the company. A relevant fact is represented by the 2017 capital increase, consisting in a capital injection of € 100 million and the entrance of BlackRock[107] within the shareholder structure. Regarding debt, we simply list the financial institutions that have granted loans (of various typology) to Linkem Group during these years: Bank of China, Unicredit, BPM INTESA, BEI and also a non-financial institution, Invitalia (that have granted a subsidised loan in the ambit of the Development Agreement of section 3.2.3). As last, also shareholders have provided a financing of € 40 million in 2018 destined to renew the frequency bands 3.4 – 3.6 GHz, fact that demonstrates again their commitment and reliance in the company's industrial plan.

With regard to the financial leverage effect, the situation is different from the one of the competitor. (ROI – ROD) assumes a negative sign along all the period

[107] BlackRock is a US investment fund with a great worldwide relevance.

considered; this main cause is the negativity of ROI, that we have already commented. The suggestions in this case should be a limitation to the resort to debt, from the moment that it generates a negative multiplier effect on ROE. Nonetheless, not to be too generalist, we must take into consideration that we are dealing with telecommunication operators, for which the resort to debt is very common to finance the huge investments (see section 3.4 for what concerns Open Fiber).

The greater resort to debt, given the similarity with Eolo's income from sales, make the burden of financial expense of Linkem greater when compared to revenues. Moreover, EBITDA appears in some year unable to cover financial expense, while in other barely able to cover them, that is the opposite of what emerges from Eolo's analysis.

From this financial planning, liquidity risk is kept under control: current and quick ratio attest the capacity of the company to eventually repay the current liabilities with the current assets and cash and cash equivalents. By the way, if we introduce a longer horizon and we consider only the financial resources, the company shows its crisis signs, as highlighted by the NFP that is negative since 2013 and has really worsen in 2018.

3.4 Main results

In this section we will outline the main results arising from the combination of the strategy analysis and the financial statement analysis. The two competitors will be presented though a comparative approach.

As first; both have a proprietary network, that gives the advantage of an end-to-end control, independence from third parties and rapidity in installing the connectivity service in the customer house or office. The installation time for Linkem is less than one week for example.

In terms of network deployment, Linkem aims at reaching a basic coverage in the whole Italian territory in the initial phase, as attested by the 2011 frequency purchasing, and then gradually intensifying its presence within each region. The company is present in 19/20 metropolitan cities, with a slight greater coverage in the South, from where the expansion process has begun. Besides, its resort to purchase of shareholding, direct acquisition of target companies or business segments, grant to the company a faster process of expansion, since it can rely on an already existing and functioning network. Also, network duplications are avoided. coverage in specific territories avoiding network duplication and saving time. Contrarily, Eolo follows a more gradual expansion, following a geographical criterium, from North to South. It happens frequently that before investing in new regions, it intensifies the coverage within those already reached by Eolo FWA network. In this respect, it is important to remark that the company was born as an entrepreneurial reality and this fact surely conditions some strategic decisions.

In terms of technological innovation, we cannot adopt a strict positioning regarding who is the technological leader, but we can surely affirm that both present elements of high innovation. On a side Eolo has been the first to launch a commercial offering based on 5G frequencies, has a small (but notable for its condition) market share in ≥ 100 Mbit/s segment and ranked first for many months in terms of Netflix Speed Index. On the other side, Linkem has shown its technological abilities by realizing a FWA connection capable of reaching 1 Gbit/s.

Moving on to commercial strategy, the most aggressive one undertaken by Linkem has led to an increase in brand awareness overtime. A huge importance is attributed to TV campaigns, as attested by financial statement data. Eolo instead, has started only recently (2018) with TV advertising. The likely causes are: a) need of a national coverage in order to justify the huge investments. Actually, the expansion to South has started only in 2017; b) endeavours orientated towards increasing brand awareness must rely on a trusted technology, in order to be able to keep in step with customers' expectations; c) only eventually (as we will comment at the end of this section, this could be linked to a difficulty in rasing financing.

With regards to the customer segments, we have found that Linkem seems targeting a standard residential customer base (interested in connection up to 30 Mbit/s). The great market share obtained in the intermediate market segment (30 ≤ Mbit/s < 100)

is the result of its low-price positioning[108], particularly suitable for metropolitan cities. There, actually, the competition is high and the low-price results particularly attractive. Eolo instead, among residential users, seems to aim at a premium segment, with its personalized offering up to 100 Mbit/s. Besides, its intention of covering white areas, where the competition is absent, allows it to leverage on the price. Its higher price positioning translates into a higher ARPU.

Moving on to the 5G topic, considering the considerable investment costs associated to this technological advancement, developing strategic partnerships with other operators (either other players) could end up being an indispensable asset. This consideration could verify above all in optic of: a) cost savings (avoiding useless duplications); b) reduction in the risk associated to the investment (e.g. the trial with Open Fiber could be interpreted as a solution that offers the benefit of the risk sharing in the event that the trial would not work); c) fully exploiting the shared assets (assuming that 5G will imply a remarkable change in market dynamics). Under this point of view, Linkem denotes a fundamental advantage, while Eolo seems more "playing alone". This approach could not be in line with 5G evolutions.

The last aspect to compare regards the financial statement analysis. Both operators are growing, both are investing, but Linkem is investing more. This generates depreciation and amortization that are much higher than those of Eolo, fact that

[108] To affirm this, we have compared also the prices of other internet service providers using different technologies.

consumes Linkem's net marginality. Until now this has not been perceived as a problem by Linkem's investors, that still continues to invest in the company because they believe in the credibility of their industrial plan (as attested by the equity increase and the entrance of relevant investment fund within the shareholder structure). Moreover, a note must be made to the revenues side[109], that in the last three-years period have assumed quite similar values in both companies' income statement. This happens despite Linkem has a higher (overall) market share in terms of B&UB lines. We try to propose as explanatory fact the different pricing policies for residential customer (Eolo has a higher price positioning than Linkem).

On financial side, Eolo shows liquidity issues, attributable to the evident preference towards internally generated cash follows as financing source. Differently, debt and equity are not so exploited for reasons that we cannot ascertain. This by the way, does not limit this in doing some (opposite) hypothesis: a) this responds to a company choice, that is oriented towards a strong stock control policy. The intent could be growing gradually and avoiding losing the control policy by leaving enter external investors, b) this could alternatively be a forced choice, depending on difficulties encountered by the company in receiving soon financing (when necessary, as suggested by the discontinuity in the resort to debt and equity) and in attracting external investors. This happens despite a positive ROE and ROI.

[109] The amount of accessory and extraordinary incomes can be considered negligible with respect to the total amount of total revenues.

Linkem, differently from Eolo, despite profitability issues linked to a negative operating income (because of huge investments), has no problem raising financing, both debt and equity. This is attested also by the fact that it has recently attract the investment fund BlackRock within its shareholder structure. Its dynamic and continuous financial planning is in line with the fact that it has to give account to important shareholders.

A relevant fact to remark concerns the implication of adopting FWA technology in the capital requirement. This emerges by comparing Eolo and Linkem balance sheets to those of other broadband players providing different architectures infrastructure. In this respect, we have selected Open Fiber, since it is involved in the deploying of only one network architecture, FTTH, that notably requires a lot of investments. By observing Table 28 it is clear how different are the orders of magnitude with the FWA players. FWA requires investments are notably lower; this is due to its cost-effectiveness in the deployment. FTTH (and other wired technologies) instead, are really expensive: fiber cables deployment in the last mile segment is pervasive, digs for the laying of cables are needed and also require authorizations. This reflects into a much greater size of liabilities and equity.

Indexes	2015	2016	2017	2018
Total assets	5,008,341	1,012,786,150	1,414,992,000	2,210,817,000
Total liabilities	12,719	301,295,989	742,630,000	1,410,950,000
Financial liabilities	0	0	439,775,000	610,339,000
Equity	4,995,622	711,490,161	672,362,000	799,867,000

TABLE 28: OPEN FIBER: SOME BALANCE SHEET DATA, 2015 – 2018
SOURCE: AIDA

Conclusions

The Italian broadband market appears characterized by a strong infrastructural digital divide that make the country unable to fully grasps (on time) the economic benefit related to the adoption of broadband connection. Recent Covid-19 outbreaks have highlighted the need of speeding up the process of ultrabroadband deployment that, according to the second DAE objective should reach a 100% coverage by the current year. Italy is in delay with its achievement and more far from the achievement of the third DAE objective, involving ultrafast broadband adoption. At the date of 2018 actually, its deployment was only 24%, compared to the EU average of 60%. In this disadvantaged context, the policy maker should attribute to FWA technology a wider space in the light of: a) cost and time savings granted by FWA with respect to the other FTTx architectures; b) technological advancements pursued, thanks to which FWA has been capable of providing ultrabroadband connection (up to 1 Gbit/s).

In their little, the FWA service providers have managed to establish in a concentrated market, eroding the market share of the incumbent Telecom. The two main architects of this result are Eolo and Linkem, the subjects of the strategic analysis. The timeframe during which this happened is relatively short, from the moment that FWA service has been introduced recently in their offering portfolio (2006 for Eolo and 2011 for Linkem). The strategy implemented by Eolo has led it

to an increase in customer base, increase in ARPU and have allowed it to make great steps towards the establishment of a technological leadership. Linkem too has experienced an increase in customer base, above all in the intermediate segment 30 ≤ Mbit/s < 100, becoming the FWA market leader. Moreover, also in Linkem case, elements of high innovation orientation have been identified and its approach open to collaboration in 5G perspective could work in its favour. The two players dispose of the right assets for operating with 5G (frequency bands and technological capabilities) and should leverage on them to take advantage and impose in this new context.

The actions and the strategic choices they have undertaken have differently affected their profitability, financial solidity and liquidity. In a nutshell, both have experienced a huge growth in the invested capital over the period analysed, consequence of a network expansion process (that aims at a gradual national coverage), sustained by an appropriate commercial strategy in order to acquire new customer base. The increasing capital requirement has been differently handled by the two companies. Synthetically, Eolo's high price level for residential users have positively impacted on profitability. Its price positioning, inter alia, has made possible by its presence in white areas and by its premium offering. Liquidity issues instead arise as consequence to the wide resort to internally generated cash flows, instead of debt and equity. This could be interpreted either as a forced choice

(difficulty in attracting financing), either as a conscious decision for maintaining a stock control.

Linkem instead, denotes profitability issues, as consequence of huge investments for expanding the coverage, and increase the brand awareness. Its low-price level, within residential customer, in line with its presence in big cities where the competition is high, allows the company to become FWA leader and to reach a standard customer base. Nevertheless, the revenues expansion is not enough to grant positive operating income. Despite this, its industrial plan appears credible to the shareholders, that continues to invest in the company, supporting it with adequate financing, as well as investment banks. The financial planning is continuous and rigorous.

The last interesting result concerns the comparison with the investment size of a FTTH operator, Open Fiber. The huge order of magnitude of Open Fiber investments, compared to those of Eolo and Linkem, gives us a proof of the actual cost-effectiveness of FWA solution in opposition to FTTH.

Appendix

Indicators	2012	2013	2014	2015	2016	2017	2018
Profitability							
EBITDA	7,796,232	8,752,037	13,676,890	20,454,853	27,821,484	37,772,160	43,871,541
ROI	5.48	4.19	7.60	6.92	4.65	5.06	1.96
ROS	7.34	5.33	10.39	12.04	8.51	9.09	3.42
ROE	11.29	8.57	4.59	25.97	18.59	12.73	4.70
Financial solidity							
Debt-to-Equity	2.54	2.68	3.87	5.13	6.27	2.25	2.80
Financial debt/Equity	0.02	0.56	1.12	1.29	2.60	0.78	1.28
Financial expense/Sales	0.07	0.27	0.47	0.91	1.45	1.44	1.20
Equity-to-Asset	0.52	0.47	0.34	0.29	0.21	0.61	0.45
Net Financial Position	-57,570	-6,569,582	-13,344,935	-18,998,418	-52,051,291	-37,132,538	-64,570,736
ROD							
Liquidity							
Current ratio	0.46	0.26	0.17	0.59	0.45	0.55	0.43
Quick ratio	0.46	0.26	0.17	0.59	0.45	0.55	0.43
Other values							
Total Assets	37,695,960	43,350,897	60,043,705	102,218,231	146,302,087	186,702,988	229,134,833
Debt	27,051,636	31,575,833	47,702,786	85,547,356	126,164,985	129,251,997	168,848,621
Equity	10,644,324	11,775,064	12,340,919	16,670,875	20,137,102	57,450,991	60,286,212
ROI - ROD	-2.26	2.81	6.10	4.41	2.44	1.71	-0.09

TABLE A1: FINANCIAL STATEMENT INDICATORS, EOLO, (2012-2018)
SOURCE: AIDA AND OWN ELABORATION ON FINANCIAL STATEMENT DATA

Indicators	2012	2013	2014	2015	2016	2017	2018
Profitability							
EBITDA	-34,065,000	-28,513,000	-6,219,000	4,013,000	7,483,000	10,887,000	25,868,000
ROI	-21.82	-19.61	-16.02	-13.53	-13.41	-17.14	-8.49
ROS	-382.65	-182.25	-77.69	-56.01	-57.67	-68.77	-32.60
ROE	-29.26	-32.34	-36.55	-22.40	-21.29	-26.45	-19.37
Financial solidity							
Debt-to-Equity	0.83	1.17	1.69	0.54	0.94	0.82	1.51
Financial debt/Equity	0.24	0.68	0.30	0.22	0.29	0.21	0.50
Financial expense/Sales	14.43	8.00	8.96	8.79	2.54	3.29	5.13
Equity-To-Asset	0.55	0.46	0.37	0.65	0.52	0.55	0.40
Net Financial Position	2,146,000	-40,722,000	-7,921,000	-31,341,000	-43,405,000	-28,219,000	-80,658,000
ROD	6.15	2.73	16.49	14.91	3.96	6.95	6.69
Liquidity							
Current ratio	-	-	2.28	1.30	1.29	1.13	0.86
Quick ratio	-	-	2.31	1.31	1.29	1.13	0.87
Other values							
Total Assets	222,435,000	265,214,000	241,762,000	262,325,000	353,363,000	405,149,000	470,837,000
Debt	100,765,000	142,869,000	151,921,000	91,495,000	171,120,000	182,102,000	283,278,000
Equity	121,670,000	122,345,000	89,841,000	170,830,000	182,243,000	223,047,000	187,559,000
ROI - ROD	-27.97	-22.33	-32.51	-28.44	-17.37	-24.09	-15.18

TABLE A2: FINANCIAL STATEMENT INDICATORS, LINKEM (2012-2018)
SOURCE: AIDA AND OWN ELABORATION ON FINANCIAL STATEMENT DATA

Indicators	Method of calculation
EBITDA	(A - B, income statement) + Tot. Depreciation, Amortization and Write-downs
ROI	Net Operating Margin/Total assets; Net Operating margin = (A - B) from income statement
ROS	Net Operating Margin/Sales; Sales = A1) + A5) from income statement
ROE	Profit (or loss)/Equity
Net Financial Position	Financial debts - Cash and cash equivalents
ROD	Financial expense/Financial debt
Current ratio	(Current Assets + Cash and cash equivalents)/Current Liabilities
Quick ratio	(Current Assets + Cash and cash equivalents - Inventory)/Current Liabilities

TABLE A3: AIDA METHOD OF CALCULATION FOR FINANCIAL STATEMENT INDICATORS
SOURCE: OWN ELABORATION

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