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Structural Separation Models and the Provision of 'Dark Fibre' for Broadband Networks:
the case of CityLink

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Abstract

Fibre broadband networks are widely presumed to become the dominant form of fixed-line broadband access. However, the spectre of fibre firms gaining market power, such has been evidenced in legacy copper-based telecommunications networks, has led some policy-makers to suggest imposing separation mandates (either functional or structural) on the owners of fibre networks yet to be built, in order to militate against the creation of a new set of firms with market power. Whilst conceptually separation of the 'dark fibre' data transportation core from network intelligence and retail functions echoes the computer technology-centric view of the internet as a 'dumb core' and an 'intelligent fringe', and replicates the separation mandates currently proposed as a means of preventing integrated legacy copper-based providers from foreclosing retail competition, the ensuing structures likely exacerbate the chilling effect of access regulation on network investment observed in most markets where it has been applied.

The chilling effects arise because of an investment horizon mismatch (hold-up) between infrastructure operators with large fixed and sunk costs, and retailers (and arguably even end consumers) with freedom to switch between retailers and network infrastructures. The usual resolution to such problems requires customers to make a credible commitment to purchase services via relationship-specific investments or contractual commitments. Whereas access regulation precludes the contractual resolution of the hold-up problem, separation mandates preclude their resolution by consumer-owners vertically integrating upsteam into elements of infrastructure ownership. Consequently, it appears unlikely that the level of investment in separated fibre networks providing dark fibre connections will be optimal. Indeed, under competitive circumstances and high levels of demand uncertainty, there may be no private sector investment forthcoming for dark fibre infrastructures.

By examining the business model of CityLink, a firm that since 1995 has been successfully supplying dark fibre in a highly competitive broadband market segment, it is confirmed that long-term financial viability of dark fibre-producing firms is feasible when utilising a mix of both contractual and asset ownership mechanisms that bind end consumers into credible commitments sufficient to justify the firm's deployment of new network infrastructure capacity. The institutional arrangements that led to the development of this firm's successful business model draw their inspiration more from the flexible and collaborative commercial interaction of the information technology community rather than the adversarial and prescriptive regulatory environment of the telecommunications industry. It is concluded that if policy-makers wish to encourage the creation of a truly 'dark fibre-based' fixed line

broadband environment, then in the initial stages of network deployment at least, arrangements similar to those of CityLink are more likely to induce sufficient and timely private sector investments than the rigid and rigorous separation and access regulation arrangements common in the recent history of the telecommunications industry.

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Internet, broadband, fibre, dark fibre, access regulation, separation

1. Introduction

It is generally presumed that ultimately, due to their superior transmission speed characteristics, fibre-optic networks will become the dominant technology for the provision of fixed-line broadband access[1] (Ida & Sakahira, 2008; Van Gorp & Middleton, 2010). Whilst it is economically feasible for multiple fixed line infrastructure operators to compete in many geographic areas (Soria & Hernandez-Gil, 2010; Preissl & Whalley, 2008; Hellwig, 2008), undoubtedly there will be some locations (e.g. those with low population densities and challenging geography and topography) where fibre networks will face little or no competition (Atkinson, 2008). The spectre of fibre firms having some market power leads to an inevitable question of what the appropriate regulatory arrangements should be to govern the deployment and operation of these new networks (Lebourges, 2010; Amendola & Pupillo, 2008; Marcus & Elixmann, 2010).

There has been much debate about the 'appropriate' regulatory environment for fibre broadband markets (Gonçalves & Nascimento, 2010). The direction of the debate is shaped in large part by the historic regulatory instruments applied to the privatised former monopoly telecommunications networks in order to encourage the development of competition in liberalising markets (Howell, 2007; 2010). Whilst across most of the OECD access regulation[2] has been credited with facilitating the development of services-based competition (OECD, 2009; Hellwig, 2008), there is now a broad agreement that gains from services competition and (some, albeit limited) competitor investment on the incumbents' networks have come at some cost to the incentives for both incumbent firms and their competitors to invest in the core of new networks, given the very large fixed and sunk costs required for their deployment (Grajek & Roller, 2009; Huigen & Cave, 2008; Marcus & Elixmann, 2008; Crandall & Waverman, 2006). Even where some core investment has been forthcoming (for example, in the form of fibre-to-the-cabinet deployments), it is far from clear that the traditional access regulation tools will provide either the appropriate competitive remedies or sufficient incentives to ensure ongoing adequate and efficient investment occurs (Marcus & Elixmann, 2008; Gonçalves & Nascimento, 2010).

[1] For the purposes of this paper, 'access' is deemed to pertain to the provision of services over the 'last mile' between a local connection node (e.g. roadside cabinet or exchange) and end consumer premises. This is distinct from the 'core' of network provision that entails the transportation of digital information between local connection nodes (e,g.backhaul and international cables).

[2] For example, wholesale price controls and local loop unbundling.

1.1 Separated Structures as a Strategic and Regulatory Remedy

As the nascent fibre broadband networks will be based upon a very different set of network architectures from their telecommunications predecessors (internet protocol-based rather than circuit-based), it is likely that the institutional structures that best support the delivery of new fibre-based networks will differ substantially from those that either emerged, or were designed to encourage specific behaviours, in the legacy (and relatively mature) copper-based telecommunications markets (Gonçalves & Nascimento, 2010; Atkinson, 2008). Particular attention of late has focused upon the potential for some degree of network element separation to be employed as a structural means of constraining the acquisition and exertion of market power by network operators (Cave, 2006; de Bijl, 2005; Xavier & Ypsilanti, 2004)[3]. Although initially employed in the United Kingdom as a regulatory tool to constrain risks of market foreclosure in downstream retail operations by an integrated telecommunications network operator (as per Rey & Tirole, 2007) (Cadman, 2010), separated institutional structures are increasingly seen as a desirable means of giving commercial form to the "open systems architecture" on which the internet is considered to be based[4]. Thus, they have garnered broad support from both regulators seeking to constrain the exertion of telecommunications firms' market power and computer-centric internet users favouring networks where clear distinctions exist between the 'dumb' central data transportation component of digital networks and the 'intelligent fringe' where user-controlled applications transform raw data into meaningful information outputs.

Consequently, in some countries policy-makers are already mandating that fibre networks yet to be deployed must conform to rigorous ownership and/or functional separation obligations. For example, in Australia and New Zealand, substantial government subsidies will be applied only to networks where there are clear ownership delineations between retail operations and network infrastructure components. In particular, in New Zealand, any entity with a retail operation will be precluded from holding a controlling interest in government-subsidised local fibre companies. Thus, existing infrastructure owners with their own retail operations, including incumbent copper network provider Telecom and cable provider TelstraClear, would have to structurally separate their existing retail and infrastructure operations if they wish to expand into government-subsidised next-generation fibre provision (absent subsidy

[3] For example, the European Commission has mandated a form of functional separation of dominant operators as a regulatory remedy (European Commission, 2009).

[4] The "open systems architecture" concept has evolved over time. The "Open Systems Interconnection Reference Model" (Zimmerman, 1980) specified the seven-layer reference architecture used by the internet today. Its focus, however, was on standards that could be used to allow computers from different manufacturers to communicate. The standards were "open" in the sense that manufacturers could freely choose to adopt these standards, and if they did so, could expect their equipment to be capable of interconnection with other systems obeying the same standards. The early forerunners of the internet, ARPANET and NFSNet were strictly non-commercial and therefore not "open" in the sense that access was restricted. It was only with the Scientific and Advanced-Technology Act of 1992 (42 U.S.C. § 1862(g)) that commercial networks were permitted to interconnect with NFSNet, creating the basis for a single, global "open" internet.

funding they will be unable to compete by providing their own fibre networks as they will face an effectively higher outlay per connection then their government-subsidised rivals)[5].

1.2 Policy Questions for Separated Network Infrastructures

The imposition of regulated separation mandates on networks yet to be constructed poses two very important questions for policy-makers.

1.2.1 Competition Consequences

The first question relates to competition policy. What rationale supports the ex ante imposition of a costly, intrusive, irreversible structural remedy typically used to address a specific behaviour associated with firms with extant market power on firms which (Heatley & Howell, 2010):

(a) will be supplying an infrastructure that is yet to be even built;

(b) will initially be competing with other firms (often highly regulated because of their own market dominance) in the provision of highly substitutable broadband access services so will be unlikely to have any degree market power for a reasonable period of time; and

(c) given both the absence to date of compelling evidence that ultra-fast broadband will unconditionally dominate existing broadband products in the wider consumer market and the pace of industry technological change in competing technologies (wireless, mobile and increasing capacities of both copper and cable connections) may never acquire substantial market power?

Whilst in competition law the use of ownership controls to prevent the acquisition of market power is commonplace (e.g. merger applications) (Evans & Hahn, 2010), such remedies ought to be applied only following a detailed analysis of the costs and benefits of both the separated and merged entities where on balance the costs arising from increased market power are demonstrated to exceed the benefits of vertical integration (de Bijl, 2005) – an exercise which has been curiously absent from the policy analysis supporting the fibre network separation mandates in Australia and New Zealand and indeed the separation policy debate generally. Moreover, such analysis should also take into account the relative costs and benefits of utilising the range of other less-intrusive and more easily reversible contractual

[5] Whilst TelstraClear has signaled that it will not participate in the government-subsidiesd investment programme, Telecom has signaled an intention to structurally separate in the event that it is selected as a partner with the government for this project. http://www.telecom-media.co.nz/releases_detail.asp?id=3702&page=1&pagesize=10&filtertext=separation&m1=1&y1=1996&m2=8&y2=2010&filter=filter

instruments at the disposal of regulators (for example, price and access regulation) in order to militate against the exertion of market power should it be acquired at some future date (Howell, 2009).

1.2.2 Network Cost Structures and Business Case Viability Consequences

The second question, which gives rise to the principal focus of this paper, relates to the consequences of separation mandates on the development and viability assessment of the business case for both initial investment in, and ongoing maintenance and development of, network infrastructures. Such infrastructures are characterised by their long commercial life-spans, high levels of fixed and sunk costs, and the necessity for much of the investment to be committed long before a single network service can be sold to end consumers. Typically, the marginal cost of such service provision is very small compared to the fixed and sunk cost components. This characteristic cost structure leads to two significant investment problems for network operators. Scale economies in production mean such networks typically exhibit lower average production costs (are more productively efficient) the larger is the number of customers. Consequently, such networks operate in quite concentrated markets (no more than two or three operators is usual). However, as the sunk costs are large, an operator facing such a cost structure faces a substantial risk of asset stranding if insufficient connections can be sold at the prevailing market price. Under these circumstances, an investor considering deploying such a network will look for some assurances that the risk of asset standing can be either minimised or substantially compensated before committing to invest in the infrastructure.

In respect of legacy telecommunications networks deployed from the late nineteenth century, the first investors were generally insulated from asset stranding by government-mandated monopoly franchises protecting them from the consequences of competitive entry (Wallsten, 2006). Absent competition, the monopoly owner could set prices so as to recover all costs for any given level of demand. However, in the context of twenty-first century broadband infrastructure markets, liberalisation policies and technological innovation mean that in most circumstances, broadband network operators face some form of competition from alternative infrastructure operators. Whilst having some degree of market power (they tend to provide differentiated products in markets characterised by monopolistic competition), these firms are much more constrained in their ability to set prices than their monopoly predecessors (Carlton & Perloff, 2005: 200-20). In order to recover investment costs and avoid the risk of asset stranding under these circumstances, in the absence of any other mechanisms guaranteeing cost recovery (e.g. subsidies or long-term pre-purchase agreements) investors in new

networks will generally not enter the market (and indeed, it is economically inefficient for them to do so) unless:

(a) their production costs are truly lower than that of the competitors, so that in the event of asset stranding it is the competitors and not the entrant that bears the costs; or

(b) customer demand exists (or is reasonably anticipated to exist in the foreseeable future) to justify the production of the extra capacity that the new operator brings to the market.

Without such assurances, investors will (rationally) abstain from committing to the investment. Furthermore, existing infrastructure owners also facing similar uncertainties will (rationally) refrain from committing to capital-intensive network upgrades (including substituting more capable fibre networks for less capable copper or cable networks). Moreover, even, if there truly are potential consumer benefits exceeding the costs of asset stranding from network investment (e.g. substantial consumer welfare benefits from highly-valued capabilities of the new networks not available on the legacy ones), where there is only a small number of operators each exposed to very high unrecoverable costs in the case of failure, a 'prisoner's dilemma' emerges whereby nobody invests, each operator waiting for another to signal that they will take the risk and be the first to invest. The higher are the costs of network investment and the greater is the uncertainty about future financial viability (e.g. the less certain it is that consumers will value the benefits of the new technology highly), the more likely it is that such an investment 'stand-off' will emerge (Evans & Guthrie, 2006). The consequence is systemic under-investment and delay in the timing of investment in new network capacity – the phenomenon known as investment hold-up where the consumer is denied the use of a welfare-enhancing technology because the producer lacks sufficient certainty that the returns from the investment that leads to the technology being made available will be sufficient to justify its deployment (Coase, 1937; Williamson, 1985).

Assuming that there are substantial consumer benefits to be gained from the investment in new (or additional) network capacity, the classical resolution to the 'hold-up' problem is either a contractual arrangement that shares the risk of asset stranding across both the producer and consumers (e.g. the consumer makes an enforceable 'credible commitment' to purchase a quantity at a price that ensures adequate compensation to the producer) (Milgrom & Roberts, 1992) or an ownership arrangement – that is, vertical integration (Hansmann, 1996). In the specific case of telecommunications networks, consumer(s) who would benefit from the technology being made available may 'internalise the hold-up risk' by owning the infrastructure themselves under the aegis of a consumer-owned entity (e.g. a consumer co-operative) (Howell & Sangekar, 2009). However, if the consumer benefits are low or

uncertain, it is unlikely that individual consumers will commit to contracts that lock them in to costly long-term arrangements, due to the risk of wasting the committed resources. Likewise, if only a small number of consumers value the benefits of the new networks highly enough, the funds that they are prepared to contribute (up to their own individual benefits from having network access) will be insufficient to deploy the desired network infrastructure. The consumer ownership solution will not emerge endogenously either, as even under these arrangements where consumer demand uncertainty is largely internalised, the risks of asset stranding are too high.

1.2.3 Regulatory Risks and Asset Stranding

It has already been demonstrated both theoretically and empirically[6] that widespread application of access regulation as a means of increasing competitive pressure on former monopoly infrastructure owners has resulted in increased uncertainty for investors committing funds to the construction of new and upgraded broadband infrastructure. This occurs because regulators cannot easily 'look forward' to accurately assess the risks of asset stranding when setting cost-based access prices, so regulated access prices are extremely unlikely to induce the efficient level of investment, even in the cases where regulators have overtly considered possibility of stranding in their price-setting practice (Hausman & Sidak, 2005; Guthrie, 2006). Regulatory arrangements that result in an allocation of hold-up risk between producers and consumers that interferes with the incentives to invest, whilst simultaneously limiting the options available to the parties to come to mutually acceptable agreements that reassign the risks in a manner more conducive to addressing the investment hold-up problem risks, therefore exacerbate the likelihood that investors will abstain from building new networks. To the extent that separation regulations impose an additional layer of ownership and contractual restrictions on infrastructure owners over and above the restrictions imposed by access regulation, it must be questioned whether the additional separation obligations ameliorate or exacerbate the investment holdup problems already identified as problematic as a consequence of the widespread application of access regulation.

1.3 The Business Case Consequences of Separation Mandates

To that end, the balance of this paper examines the implications of separation mandates upon investment incentives for nascent fibre broadband infrastructures. Section 2 explores the architecture of fibre broadband networks and the ways in which generic separation models map the technological features of network provision onto the (separate) institutions investing

[6] For a literature review, see Grajek & Roller (2009).

in each component of network service delivery. Section 3 then identifies how the investment hold-up risks are allocated across the various (separated) institutions. Drawing extensively upon Howell, Meade & O'Connor (2010), this section finds that separation mandates actively militate against optimal sharing of the costs and risks of asset stranding across all market participants. In addition to the restrictions on contractual resolution imposed by access regulation, separation mandates also lock out the possibility of the utilising ownership solutions (e.g. infrastructure owners integrating downstream into retail operations or end consumers integrating upstream into infrastructure ownership) to address the question of hold-up risk allocation.

Given the problems for the generation of optimal investment incentives posed by separation, Section 4 then poses the question of whether it might ever be possible for a business case to be developed that supports the commercially viable provision of an institutionally separate 'dumb' ('dark fibre') internet core by any single institution. This section utilises the theory explored in the preceding sections via an illustrative case study of the New Zealand firm CityLink, which has been commercially successful as a supplier of dark fibre in Wellington since 1995. The case study shows that CityLink has been supplying its services in direct competition with both copper and cable broadband suppliers since 1999, and has increased the range of its network coverage substantially even in the face of aggressive competition from alternative suppliers. CityLink only lays fibre when it has established that there is an end customer who is willing to buy dark fibre services from the firm for a period of time that enables the recovery of fixed and sunk costs. CityLink's successful business model relies upon the credible commitment made by end consumers who vertically integrate upstream into elements of infrastructure ownership, and intermediaries who make credible commitments by investing in their own infrastructure, and bind their customers into longer-term contracts that reduce the likelihood of asset stranding occurring. The key mechanism employed is a relationship-specific customer investment (either in assets or contracts) whereby the customer shares in the costs of asset stranding should a decision be made subsequently to defect to a rival infrastructure provider. With this alignment of incentives, CityLink is reasonably assured of being able to price its services so as to recover its fixed and sunk costs, so is shielded from the risks of asset stranding.

The paper concludes with the observation that by failing to address the risks of asset stranding inherent in the construction of new fibre broadband networks, structural separation mandates on fibre network providers will likely exacerbate the chilling of investment incentives observed under access regulation. However, by adopting an approach that encourages end consumers individually making some credible commitments to purchase services from

specific providers (e.g. investments in specific assets or engaging in extended contractual commitments to purchase services for an extended period of time), some serious limitations upon the ability for network investors to recover their costs under structural separation mandates will be addressed.

2. Institutional Separation Mandates and an 'Open Internet'

Generic separation models for 'open end-to-end' internet infrastructures identify three 'layers' within the supply and distribution of fibre (and other data communications) networks: Layer 1, or the 'physical layer', which provides the dark fibre connection between the customer premises and a local aggregation node (akin to copper connections under local loop unbundling); Layer 2, or the 'data link layer', whereby dark fibre links are converted into bitstream connections over which internet traffic can be passed (akin to wholesale services offered by incumbent telecommunications companies, and by unbundling entrants using their own equipment in incumbents' facilities); and Layer 3 or 'network layer' services whereby retailers (for example, internet service providers - ISPs) offer cross-network communication and data access plans to consumers.

As typically over 90 percent of the fixed costs of network provision attend to the supply of Layer 1 and 2 components (of which at least 70 percent pertain to Layer 1 costs), it is in their provision that issues of market power as a consequence of cost structure are likely to arise. To enable the development of competition in the provision of Layer 3, and to a lesser extent Layer 2, services, separation proponents advocate either the prohibition of common ownership of the firms supplying services at each of the three different layers (structural separation) or the less rigorous 'functional separation', where the same firm may supply services at multiple layers, but with the services crossing the boundaries between layers being supplied to all customers (including the proprietary downstream firm(s)) at identical 'equivalence of inputs' terms (Heatley & Howell, 2010).

Under structural or functional separation arrangements, two impediments to the creation of competitive Layer 3 markets ('services competition') – denial of access to 'bottleneck' essential infrastructures (or monopoly pricing for such acquisition); and the risk of strategic foreclosure in Layer 3 markets by Layer 1 and Layer 2 operators with market power – are simultaneously resolved. Furthermore, if separation is mandated between Layers 1 and 2, then the tool in effect replicates the effects of local loop unbundling, by introducing competition into the provision of those components of network infrastructure provision (i.e. Layer 2) which, although themselves embodying some scale economies, are more conducive to

efficient duplication than the underlying Layer 1 infrastructures. In these respects, separation can be viewed as a substitute for historic access regulation (Xavier & Ypsilanti, 2004).

Moreover, the concept of 'open', 'non-discriminatory' access under equal terms to all access seekers, and in particular the separate provision of Layer 1 'dark fibre' services, conforms to the aspirational principles espoused by the internet's originators of a 'dumb' core transportation utility (Layer 1), with 'intelligent' processing capabilities turning transported bits into useful information operating at the 'edges' (Economides, 2008). As core information transportation capabilities provided by legacy telecommunications firms become more internet protocol-centric, it has become both more feasible and more popular for the commercial models for the provision of mass market core internet infrastructure services to be equated with the provision of ethernet-based 'dark fibre' services within firms or contractually-aligned entities (private networks). On one level, the supply of copper can be viewed as a functional equivalent to the supply of connections to an ethernet segment. The supply of the physical infrastructure can be separated from all 'intelligent processing' of the information transported on that infrastructure. Structural and/or functional separation of the copper loops from all processing echoes the within-network separation of the provision of core network services from the provision and maintenance of applications on that network. As network provision services are typically institutionally separate from application management within a given firm or collaborative network, the separation models currently attracting interest within the telecommunications regulation policy environment are already very familiar in a structural sense within the computer-centric user environment.

A clear distinction, however, exists between the business models supporting the operation of each infrastructure type. Within a single firm or collaborative network, there is usually some degree of ownership internalisation linking end users and the core network. The deployment of additional core capacity is driven directly by information derived from 'internal' end users of their likely anticipated future use. Future demand is thus reasonably certain, reducing the risks of asset stranding. Furthermore, internal corporate requirements can specify which networks must be used by specific end users for a given task, limiting the risks that users will defect to the use of services provided by a competing firm[7]. This is a very different institutional arrangement from that of a 'public network' provider, who faces the vaguaries of both future demand for services and competition from alternative network providers. Whereas the common ownership and internal usage edicts result in the risks of asset standing

[7] For example, the initial internet arrangements in New Zealand were predicated upon a collaborative model amongst a number of universities. One university (Waikato) took the lead buy investing in core network infrastructure, but supported by a pre-agreed charging arrangement whereby all other universities agreed to contribute towards the costs, regardless of the amount of use each may have made of the infrastructure (Brownlee, 1998).

and hold-up being minimised by their 'internalisation' within the institution, for a public network faced with separation mandates, the possibility of reducing the size of these risks by either ownership or functional integration is negated. The structural similarities thus do not translate neatly into equivalent viable business models, as the different allocation of hold-up risks alters their respective financial viability.

3. 'Hold-Up' Risk in 'Separated' Network Models

Howell, Meade & O'Connor (2010), drawing upon Meade & O'Connor (2009), Meade (2010) and Howell (2009), demonstrate that the requirement for separation of Layer 1 and 2 network infrastructures from Layer 3 retail operations leads to increased risks of investment hold-up, relative to the counterfactual of an integrated firm. The higher risks result from two factors – risk of bypass by a competing infrastructure, and loss of information to co-ordinate investment and usage plans.

3.1 Risks from Infrastructure Bypass Increased by Separation

The risks arising from separation increase the greater is the likelihood that a bypass technology could be deployed. It is noted that one of the purposes of separation was to preclude foreclosure by an integrated firm of Layer 3 competitive entry. Separation increases the likelihood of increased competition at Layer 3 relative to the case of vertical integration, even in the presence of access regulation. Many contractual relationships, each of which is subject to a risk of hold-up, now replace the single, internalised transaction within the integrated firm. Each Layer 3 retailer can now make independent decisions regarding the purchase of infrastructure services, increasing the uncertainty that the infrastructure owner faces regarding future demand.

A separate Layer 3 retailer buying underlying network services period-by-period at averaged (e.g. regulated LRIC) prices faces negligible fixed and sunk costs, so can therefore enter and exit from the industry relatively costlessly. Indeed, the entire purpose of access regulation (and by derivation, separation) is to make entry for these competitors as low-cost as possible by freeing them from the obligation to sink any costs in the first place, as it is the sinking of the costs that leads to the problem of market power. However, the infrastructure operator faces exit costs in respect of any unrecovered fixed and sunk costs. This leads to an investment horizon mismatch between the (short-term focused) Layer 3 retailers and the (long-term focused) infrastructure operator. In order to justify investing in the infrastructure, the infrastructure operator requires some assurances that Layer 3 retailers will purchase

services over a sufficiently long period of time to enable fixed and sunk costs to be recovered. In effect, the infrastructure owner requires the same form of 'credible commitment' that the retailers will continue to purchase services for the lifetime of the investment that its own retail arm would have provided had it been allowed to own one (as per Williamson, 1985).

Whilst in principle any Layer 3 retailer could enter into a long term contract with the infrastructure operator for the supply of services, the likelihood that such an agreement would be entered into willingly decreases the more likely it is that either another competing Layer 3 operator can subsequently obtain a more advantageous deal from the infrastructure operator thereby leading to a loss of customers by the first operator, or that a competing infrastructure provider will offer services to the Layer 3 operator at more advantageous terms than offered by the original network operator. Although the consequences of the first scenario are neutral for a monopoly infrastructure operator, insofar as the end consumer remains a customer of the same network, albeit serviced by a different retailer, the consequences of the second scenario threaten the financial viability of the investment in the core network. Without any reasonable certainty that the Layer 3 retailers will continue to purchase services (i.e. they are not 'locked in' to the original network – there is no 'credible commitment' to purchase), the infrastructure operator faces greater risks to its ability to recover its costs than under full integration where it manages its own retail customer contracts (including minimum connection periods). Network investment under the separation scenario is thus more costly (risky), leading to either delayed or foregone network construction. The 'natural' resolution to the increased contractual uncertainties in a separated environment would be for the network operator to reduce risks by vertically integrating downstream into retail operations – the very 'solution' that is precluded by separation mandates.

Howell, Meade & O'Connor (2010) also note that mandatory separation is likely to induce investment in bypass technologies earlier than would be socially efficient, simply because the separate Layer 3 retailers can defect costlessly to the new network, whereas an incumbent (vertically integrated) operator can use retail contracts to lock in its end customers until the relevant fixed and sunk costs have been recovered, thereby ensuring more efficient application of scarce investment capital. Whilst on the one hand, contracts locking retail customers in for extended periods of time might be perceived to be an anti-competitive practice, on the other hand they are desirable if they avoid the socially wasteful costs of asset duplication and stranding. Indeed, the purpose of regulatory protection from competition for networks with high fixed and sunk costs (as occurred in the early days of deployment of telecommunications networks) was specifically in order to provide sufficient incentives to

induce investment in the infrastructure in the first place by reducing the risks of both asset stranding and socially wasteful duplication of infrastructure.

3.2 Separation Exacerbates Information Quality Uncertainty Risks

Howell, Meade & O'Connor (2010) also demonstrate that, under conditions of monopolistic competition, the investment horizon mismatch will lead to 'too much' competition occurring in the Layer 3 retail market. As each entrant will likely fail to take account of the effect of their own entry on the residual demand curve when making their entry decision, more operators than is efficient will enter. Over-entry results in systemic overestimation of the likely demand for underlying network services. Furthermore, as none of the entrants faces any of the costs of sunk and stranded assets arising from their demand overestimates, and in order to receive favourable regulated access prices, they face strong incentives to even further exaggerate likely future demands. If the separated infrastructure operator is bound to invest to deliver according to Layer 3 demand projections, then if the infrastructure investor does not anticipate this consequence, there is a possibility that separation may also lead to inefficient over-investment and even higher risks of asset stranding if demand does not materialize. If the investor does anticipate the consequence, then it becomes even more likely that no investor will build the network, leading to the classic 'missing market' for investment. In either case, the outcome deviates from the optimal investment strategy, and likely an inferior outcome to the counterfactual of investment by an integrated, (e.g. rate-of-return) regulated firm.

Once again, the 'natural' economic resolution to the information quality problem is to require that the (separated) Layer 3 retailer be made to carry some of the risks associated with exaggerated forecasts. This can be achieved by 'locking in' the retailer to a long-term contract – for example, binding the retailer to purchase the demanded services for an extended period of time, thereby sharing some of the risks of ownership that the forecasts engender. However, the more rigid are such contractual requirement the more like an ownership arrangement they become, and the less likely it is that the optimal level of competition in the provision of Layer 3 services develops. The tautology of using regulation to preclude the utilisation of 'natural' ownership solutions deriving from the specific cost structures in the industry concerned, and then imposing further regulatory obligations in order to recreate the effects of ownership to restore investment incentives becomes immediately obvious[8].

[8] It also begs the question of whether, when there is competition from underlying infrastructures, a 'second best' outcome might be achieved by allowing competition directly between fully vertically integrated infrastructure firms – as is common in mobile telephony markets where different integrated network operators compete at the retail level with virtual operators purchasing their upstream network services under wholesale arrangements.

3.3 Consequences and Cautions

This line of thinking leads directly to the conclusion that mandating separation is likely to be most costly (and problematic) the greater is the extent of competition (both in infrastructure and services). Whilst any instrument aimed at increasing retail competition increases the risks of investment hold-up from bypass and lower information quality outcomes, the most prescient risk for separated fibre networks arises when the separated network infrastructure owner faces real or impending competition from both existing copper and cable networks and (in some markets at least) ongoing improvements to the capabilities of cellular and wireless networks. Under these circumstances, Layer 3 operators will be least likely to be willing to enter into long term contracts today, lest either they or their competitors can get a better deal tomorrow from an alternate infrastructure provider.

De Bijl (2005) cautions strongly against the use of separation in legacy networks where there is any possibility of infrastructure competition emerging. However, the Howell, Meade & O'Connor (2010) findings suggest that separation is also inconsistent with the alignment of investment interests in the case of new networks. By definition, absent any other industry distortions (such as the proposal in Australia where the government has negotiated to buy Telstra copper assets to preclude competition with the new government-funded fibre network – Heatley & Howell, 2010), new fibre broadband networks will be deployed into markets where they face extant infrastructure competition from at the very least incumbent copper networks, but also quite possibly also from cable broadband providers.

Absent both a range of compelling applications that cannot operate satisfactorily on any other technology and any clear evidence that consumers are willing to pay substantial price premiums for fibre connections in order to access these applications (Howell & Grimes, 2010), from the perspective of end consumers there may be a very large degree of substitutability between fibre and legacy broadband connections (Ida & Sakahira, 2008). Without its own retail operation, the infrastructure operator cannot manage the substitution of end customers from their existing infrastructure to fibre. There is always a risk that even when a Layer 3 retailer has connected its customers to the fibre network, the operator will get a 'better deal' from another infrastructure provider to switch technology-agnostic end consumers away again. Under these circumstances, imposing separation mandates even before there is any investment in fibre infrastructure will automatically raise risks and costs, thereby increasing the likelihood of fibre investment being delayed or held up, relative to the counterfactual of a vertically integrated fibre operator.

4. Dark Fibre Provision by CityLink

Taken to its conclusion, the reasoning of the preceding section leads to the question of why separation – a structural remedy used to militate against existing market power – should ever be applied in the case of a network infrastructure that yet to exhibit a market presence, let alone a position of market power. Whilst there may be some merit in its use in mature networks, to require separation of a network where there is yet to be any investment would appear to invoke the near certain result of a 'missing market for investment' in the Layer 1 and 2 infrastructures, unless there was such a large pent-up demand for the new technology that the risks of asset stranding were negligible.

Specifically, the findings suggest that, absent any other form of intervention (e.g. government subsidies), it would be extremely unlikely that investment in Layer 1 'dark fibre' networks providing underlying services for 'public' broadband access would emerge endogenously. The likelihood of such a network emerging in a highly technologically volatile environment where existing infrastructure providers were supplying competing (close substitute) services seems even lower. Yet it appears that this is precisely what has occurred in Wellington, New Zealand, where CityLink has been providing dark fibre services since 1995.

4.1 CityLink - Background

CityLink was formed in 1995 as a consequence of a Wellington City Council policy initiative to deploy an advanced, low-cost communications network to local business and government enterprises[9]. The firm had its origins in an internal Wellington City Council information network linking various council departments around the city. When Council bylaws were changed in 1995 to enable the use of the council-owned trolley bus wires and power poles for the provision of public-access infrastructures, the council's information technology manager and sixteen other shareholders contributing capital of only $85,000 formed CityLink, with the objective of providing a 'neutral' "open access infrastructure available to service providers and users alike"[10]. The firm provides a simple 'dark fibre' (Layer 1) service. Partner firms provide Layer 2 and 3 services[11]. End customers (predominantly businesses, although there is a small base of residential consumers) can choose to either provide the Layer 2 services themselves or buy services at either Layer 2 or above from the partner firms.

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[9] For further information, see CityLink's Digital Revolutionaries – available on http://www.citylink.co.nz/about/FibreCITY.pdf
[10] http://www.citylink.co.nz/about/background.html
[11] For a list of partner firms, see http://citylink.co.nz/channel-partners/isp-list.html .

The desire to provide an open access network was in part to differentiate the firm's services (derived from its computer service infrastructure origins) from the traditional 'telephony-based' leased line services offered by rivals Telecom and Clear (subsequently TelstraClear). At the time, the company was aided in part by the prevailing central government's 'light-handed' competition law-based governance of the telecommunications industry, which placed no regulatory barriers in the way of firms entering the market to compete with the incumbent (Howell, 2007). In the past fifteen years, the firm has grown from a small capital city CBD-based provider to one supplying services in Auckland in addition to inner-city suburbs and some at much further distances in the Wellington region. Its customers include some of New Zealand's most information–intensive businesses and government departments (including Victoria University, the Bank of New Zealand, the country's dominant internet trading platform TradeMe and the film industry's Oscar-winning Weta Workshop). It has also expanded out into the provision of server hosting, public and private LAN services, backhaul provision, security services and WiFi connections. In many of these, it competes directly with its partner firms. However, the core of the business remains the provision of its dark fibre connections.

4.2 The 'Exception that Proves the Rule'?

The startling feature of CityLink's growth is that it has been funded entirely from private investment and has been achieved in New Zealand's most intensely competitive geographical markets for such service provision. In the Wellington market, CityLink has faced traditional telecommunications-based broadband competition from Telecom and TelstraClear, cable broadband competition from Saturn (subsequently acquired by TelstraClear), internal service provision by large, integrated government departments and state-owned enterprises, and increasingly competition from wireless provider Woosh and mobile operators Telecom Mobile, Vodafone and 2 Degrees.

From the preceding discussion, the odds against CityLink succeeding commercially from the provision of dark fibre (leaving to one side the Layer 2 and higher services provided, as they contribute a proportionately smaller share of revenue streams) are substantial. Yet succeed it has. On closer examination, however, it becomes clear that, despite its objectives of open network provision, the reasons for CityLink's success rely very strongly upon a business model derived much more closely from the collaborative contractual relationships (and their attendant ethos of partnership and long-term, commitment) that have characterised the investment in and deployment of proprietary computer networks than the principles of

regulated open access (and attendant reduction in the costs of (residential and commercial) customer commitment and lock-in) that have characterised the liberalisation of former monopoly telecommunications networks.

4.2.1 CityLink's Business Model Specifically Addresses Hold-Up Risk

The first significant observation is that CityLink, unlike regulated telecommunications providers, is not obligated to provide services to all potential customers who might seek to buy from it. It is free to 'pick and choose' with whom it deals. Second, it does not have to provide a standardised' one size fits all' regulated, homogeneous product to all of its customers. It is free to customise services for each customer, whether that customer is one of its partner firms or an end user. Thus, unlike a separate, dark fibre firm as envisaged under telecommunications regulatory regimes, there is an ability to integrate downstream into services required for one customer at terms that can be agreed uniquely with that customer, without facing the obligation to supply the same services on identical terms to any other customer who might subsequently seek access to that service.

There are also substantial differences in CityLink's business model that enable it to address the risks of hold-up and asset stranding that attend the classic telecommunications separation models for dark fibre firms. Specifically, CityLink has minimised its risk of asset stranding by undertaking its investment in new network capacity (for example, a spur into a new suburb, such as the recent expansion into the distant Wellington suburbs of Miramar and Petone) only when it has located an 'anchor customer' from whom it has received reasonable (credible) assurances that a defection to a competing infrastructure provider will not occur until CityLink has been able to recover in revenues the fixed and sunk costs of deploying the infrastructure.

In the case of an end consumer purchasing dark fibre services, the assurance usually takes the form of investment by that consumer in relationship-specific assets (housing and electrical facilities, plus the specific technology required to transform the dark fibre services into useful information services that the customer can then utilise). As the customer's assets are 'co-partnered' (in economic terms 'specific') to the provision of CityLink's dark fibre service, they will become stranded if the customer defects to another infrastructure provider. The larger is the size of the investment the customer makes in the relationship, the greater is the assurance to Citylink that the customer will not defect to another infrastructure provider before the costs of Citylink's investment have been recovered. The customer and CityLink now share the risks of CityLink's assets becoming stranded, to the extent that CityLink now finds it worthwhile making the Layer 1 investment. Likewise, CityLink's investment in the

fibre to the premises and the need to recover a return on it provides mutual assurance to the Layer 2 investor that CityLink will not withdraw dark fibre services leaving the Layer 2 investor with stranded assets. In essence, the credible commitment has been achieved by the end consumer 'vertically integrating' (either by ownership or contractual alliance) upstream into the ownership of Layer 2 infrastructure, and assuming some risks of asset stranding that better align its investment horizon with that of the Layer 1 operator.

By comparison, under three-way separation mandates, the end consumer faces negligible costs of fibre asset stranding at all from the choice to switch infrastructures. The losses to the Layer 3 retailer from consumer defection are also very small. Under such arrangements, the Layer 1 dark fibre provider contracts with a Layer 2 provider, who also bears a risk of asset stranding if Layer 3 retailers defect to alternative infrastructure providers. In the CityLink case, the Layer 2 partner (and to a lesser extent, Layer 3 partner) providers must address the risks of being left with their own stranded assets in relation to Layer 1 fibre laid by CityLink to an end consumer's premises. The ultimate contractual relationship becomes one of 'partnership' between all of the end consumer, Layer 3 and 2 providers, and CityLink. Whilst CityLink receives assurances that defection will not occur from the Layer 2 provider due to the sunk investment commitment at that layer, the Layer 2 provider must also have some credible assurances from the Layer 3 provider, and the Layer 3 provider from the end consumer, that defection will not occur. As there is little capital required at the Layer 3-consumer and Layer 3-Layer 2 levels, these assurances are typically in the form of agreed fixed-term commitments to purchase services. For example, a building owner (Layer 3 equivalent) may contractually agree with a Layer 2 provider to purchase services for a defined period. The building owner then makes the services available downstream to tenants via a bundled fixed-term lease agreement for building space. The Layer 3 building owner has sufficient certainty to enter into the contractual commitment with the Layer 2 provider, who now has sufficient assurances to invest in infrastructure, and consequently CityLink has the necessary certainty of cost recovery to lay the fibre to the building. By a combination of relationship-specific investments and contractual commitments, the risks of asset stranding have been reduced to the extent that dark fibre provision is financially viable.

4.2.2 Using a 19th Century Business Model for Network Expansion

It is noted that the mix of contractual and relationship-specific investment arrangements under which CityLink has expanded its networks bears a remarkable similarity to the manner in which Post Office telephony services were deployed widely across New Zealand in the period from 1880 to around 1920 (Howell & Sangekar, 2009). Apart from those services deemed essential to service government and some business needs, new services were deployed in the

predominantly rural New Zealand of the time using a 'political petitioning' process. To acquire a telephone connection, groups of at least five 'reputable people' had to receive permission from the Governor in Council (a political process) to be allowed to pay the Post Office the full costs of laying wires and other ancillary equipment (including exchanges in some cases) to connect them to the telephony network (credible customer commitment by way of investment in relationship-specific assets). Moreover, successful petitioners were also required to enter into agreements with the Post Office to pay the full costs of providing ongoing services on those assets for an extended period of time. Failure to make the government-mandated monthly payments as agreed resulted in the customer-funded infrastructure assets being confiscated by the Post Office (equivalent of 'stranding' if the customer failed to continue purchasing a month-by-month connection service – i.e. 'defected').

The same model also applied to the deployment of electricity lines networks. An electricity connection to a house (akin to Layer 1 dark fibre provision) would generate the lines firm an ongoing income only if the customer had made relationship-specific investments in appliances (e.g. lights, cooker, water heater) that used the electricity (akin to Layer 2 investments). Relatively, these assets were very large household investments at the time. If the customer ceased purchasing services (connection) from the lines company (e.g. reverted to using candles or the coal range), the expensive appliance investments were 'stranded'. Hence purchase of appliances provided a credible signal of the consumer's intention to purchase electricity lines services (and indeed, the Layer 2-equivalent electricity from a generator/retail firm) for a meaningful period. Such credible consumer commitments gave sufficient assurances to both lines companies and generators of the likelihood of recovering costs to make their large fixed and sunk cost investments (indeed, in the typical model at the time, there was full vertical integration by providers in to all of appliance retail, electricity retail, generation and lines provision – Evans & Meade, 2009).

The 'problem' with such historic business models in a 21st century broadband world is that technological convergence means that it has become much harder to bind end consumers to the ongoing purchase of services by their own potential investments in assets that become stranded by defection to alternative network providers. The same computer/smartphone and attendant applications will work identically regardless of whether the broadband message comes via an ADSL modem, a cable modem, a Wi-Fi signal or a mobile 'dongle'. The technology-specific modems and dongles are very low-cost, and every computer and smartphone now comes with an embedded WiFi capability. Indeed, intense competition amongst infrastructure providers means that in most instances, the modem or dongle is

effectively given away by the Layer 3 retailer (who may even have received it at no cost from the Layer 2 infrastructure provider) in order to induce consumer switching to a different network (albeit with sometimes an attendant commitment to purchase the service for a minimum period – often 12 months). Indeed, such practices have been heralded as one of the innovation 'successes' of opening up competition in the telecommunications markets. But the consequence has been to raise the risks for separated Layer 1 and 2 investors, leading to the investment hold-up problems evidenced earlier in this paper.

4.3 Generalisability of the CityLink Model

The CityLink business model addresses the shortcomings of an access-regulated and mandatorially-separated broadband network infrastructure market model by utilising a 'partnership' model that replicates a vertically integrated production chain by the judicious use of contracts and relationship-specific investments. However, the partnership chain does not stop at the point of the Layer 3 retailer, as presumed by regulated telecommunications market models. In the CityLink model, the end customer is embedded into the partnership as surely as any Layer 2 or 3 operator. Whilst the customer could defect, it is in the interests of his Layer 2 or 3 provider to use contractual instruments to prevent this from happening ('lock in the customer'). The Layer 2 provider is 'locked in' by relationship-specific investments. In essence, this model reflects the 'partnership' approach that characterises within-firm or within-partnership provision of computer technology services. The 'end consumer' is bound to use the 'in-house' services (i.e. not defect) by virtue of membership of the firm/partnership. Indeed, there may be institutional provisions that prevent external purchase. These arrangements align the incentives for all concerned to justify the investments, because of either common ownership of the investing entity (the end consumer is a part of the institution) or common overarching objective functions aligning the interests of all parties.

Whilst successful amongst the customer market that has been targeted by the CityLink partnership, it is debatable whether the CityLink business model can be translated easily into mass-market public utility dark fibre broadband infrastructure provision under explicit separation mandates. Without the ability to lock end consumers into a meaningful or credible commitment to purchase fibre broadband services and not defect to other infrastructures, it seems likely that risks of asset stranding will militate against the provision of private sector funds for dark fibre network deployment. To replicate the alignment of interests that arguably still attends separated electricity infrastructure provision, in the absence of appliances or other relationship-specific assets that lock the end consumer into the purchase of a specific form of broadband provision, the end consumer must be locked in by some other instrument, such as

contracts that guarantee the recovery of investments or ownership of a key component of the network (e.g. the by the capital outlay for the connection of a premise to the network passing down the street).

In the first instance, commitments in the form of customer ownership of key network components will likely be made only if the benefit to the consumer from both the capital expenditure and the use of fibre broadband exceeds the capital sum expended. In the face of competition from alternative networks which do not necessitate customers committing large sums in advance for access to services, it would appear that fibre broadband network providers face substantial hurdles in the pursuit of customers, especially in the residential mass market. For example, even though CityLink provides substantial quantities of fibre around suburban Wellington (notably to Newtown, Kelburn and Miramar), and although the company is open to the possibility of connecting residential consumers whose properties the fibre passes, there is negligible interest in such services, given that under the CityLink model, such consumers would be bound to either invest in assets or enter into a long-term purchase commitment. This finding is unsurprising, given that an alternate provider (specifically TelstraClear cable) offers very high speed broadband services (DOCSIS 3.0) in the same streets Citylink also passes, with no substantial up-front investment required, and even gives away the modem in order to attract custom. Citylink's offer would appeal only to a very small number of current broadband consumers with specific requirements for product characteristics only available using dark fibre. Most of these (typically business customers) have already purchased services from the firm.

5. Conclusion

In summary, therefore, the CityLink case study serves as a warning to policy-makers seeking to encourage the deployment of dark fibre based public broadband networks to carefully consider the implications of both access regulations and separation mandates before imposing them on nascent networks. Without flexibility to adapt to the different investment requirements of new networks, such legacy instruments may chill investment incentives before the networks have even been deployed. If the desire is to truly encourage the creation of a 'dumb core', 'smart fringe' environment as espoused by the computer-centric internet community, then the institutions – the contracts and structures – which have been successfully deployed by firms emerging from that environment may offer a better model than those whose legacy derives from the models more familiar to those who have historically been charged with telecommunications regulation and policy-making.

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