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Regulated Retail Tariff Structures, Dial-Up Substitution and Broadband Diffusion:
Learning from New Zealand's Experience

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Abstract

Despite an apparent absence of supply side impediments to the uptake of broadband, New Zealand has persistently exhibited one of the lowest numbers of connections per capita in the OECD. Whilst geographic, demographic and economic factors may partially explain the disparity, they fail to explain the comparatively low uptake in a country that, in the early 2000s, ranked amongst the top OECD countries in the number of internet users per capita and average usage per account. Demand side factors, however, offer some insights. Using a combination of diffusion theory, two-part tariffs, price discrimination and bundling, this paper proposes that the historic flat-rate tariff for local voice telephony has resulted in substitution from legacy dial-up to frontier broadband internet access in New Zealand occurring at a higher user valuation of both internet connection and usage than if the telephony tariff was set at a level whereby the fixed component recovered fixed costs and the variable usage component was set at marginal cost – the tariff structure that prevails in most other OECD countries.

The New Zealand experience suggests that the extensive use of flat-rate tariffs for the current generation of broadband technologies (e.g. ADSL) may impose similar braking of the rate and timing of substitution to future internet access technologies (e.g. fibre to the home). These effects are exacerbated if the legacy connection is purchased as part of a bundle where customers predominantly value other elements more highly than the internet component. Substitution inertia created by the flat-rate tariff may only be overcome by the development of new applications which are both highly-valued by the majority of users and which can only be feasibly deployed using the frontier technology.

New Zealand's low level of per-capita broadband uptake relative to other OECD countries has been widely perceived as a significant problem, leading to substantial regulatory reform of the telecommunications sector in 2006 with the specific objective of increasing uptake, and projecting new Zealand into the top quartile of the OECD in broadband connections per capita (MED, 2006). Despite considerable international debate, and few firm conclusions about the relative importance of each of the factors which appear to be correlated to broadband uptake (e.g. Hausman & Sidak; Wallsten, 2005; Wallsten & Sacher, 2005; Ford, Koutsky & Spiwak, 2007; Crandall & Sidak, 2007), the New Zealand regulatory actions were prompted by an analysis (Network Strategies, 2006) that found the competitive environment the most plausible explanation for New Zealand's low ranking. The finding was deemed sufficient to justify wide-ranging regulatory reform, including full local loop and sub-loop unbundling and structural separation, principally because it was the only factor of those examined where New Zealand was found to be at the extreme when compared to the top eight countries in broadband connections per capita (Howell, 2006).

The New Zealand analysis is conspicuous for its near-complete focus upon supply-side factors in its attempt to attribute causation for New Zealand's perceived poor performance, thereby limiting the search for policies to remedy the perceived problem to supply-side interventions. Melody (2005) notes that such a focus is not uncommon, as the body of regulatory knowledge has developed as a consequence of regulating firms in mature markets of already widely-diffused technologies, where the principal objective was to constrain market power. In such markets, the presence of residual pent-up demand is typically taken for granted (Howell, 2008). Consequently, little attention has been given in the regulatory arena to developing models to assist in understanding how demand-side factors influence the already-regulated markets, let alone to understanding how demand and supply interact in emerging markets where new technologies are only in the early stages of their diffusion.

Limitations in the body of regulatory knowledge, therefore, may plausibly account for the lack of consideration given in the 2006 New Zealand analyses to a significant, regulatorily-imposed, demand-side difference between New Zealand and all other countries in the top quartile in the OECD broadband connections per capita rankings except Canada – the historic sale of residential telephone services at flat-rate tariffs. In part to address this lack of understanding, and to further explore the role of retail tariff structures in the diffusion of technologies, this paper explores both theory and the New Zealand case data to determine if this line of inquiry better explains the New Zealand broadband uptake pattern than the supply-side conclusions of the 2006 study.

Section 1 summarises the existing literature on the key drivers of broadband uptake. Section 2 then examines the New Zealand data, and narrows down the inquiry to tariff structure differences by eliminating all other possible explanations for the difference. The principal enigma emerging is that New Zealand's low uptake is especially puzzling given the apparently high levels of dial-up internet use evidenced. This leads to the implication that the New Zealand 'problem' is principally one of why the substitution from dial-up to broadband has not occurred as rapidly as elsewhere. Section 3 begins by constructing a model based upon diffusion theory to surface the ways in which different tariff structures will influence the point of substitution. The model is extended to take account of how different tariff structures and bundling effects result in different points of purchase and substitution for users with different valuations of the goods in the bundle, over the dimensions of both connection and usage of the network. The effects of flat-rate tariffs in particular are shown to bias upward the marginal valuations of both connection to and usage of the internet at which the substitution will occur. As use of the internet is a derived demand, the valuation of applications is paramount. Application to the New Zealand case data leads to the conclusion that the dial-up tariff structure offers the most cogent explanation for the New Zealand data. Section 4 concludes by extrapolating the lessons for other jurisdictions given the extensive use of flat-rate tariffs and bundling in the sale of broadband accounts.

1. What Drives Broadband Uptake?

The extent to which broadband technologies have penetrated different OECD member economies has generated much research over the past decade (see de Ridder (2007), Distasio, Lupi & Manenti (2006), Howell (2006; 2007) and Wallsten (2006) for recent reviews). The factors which determine both the number of broadband connections purchased and the rate at which purchase occurs are many and complex, and will invariably result in different outcomes in different countries. The diffusion of any technology will take place over an extended period of time, most likely following the typical S-curve pattern. At any point in time, due to different underlying economic, demographic, policy and other factors influencing when customers will purchase the technology, different countries will be at different points on the diffusion curve, and each national curve will have a different set of slopes.

Nonetheless, due to the perceived importance of broadband as an economic enabling technology, much attention has been paid to determining those characteristics which appear most significant in explaining cross-country differences, in order to enable countries seeking to accelerate their diffusion rates to alter, where feasible, any underlying factors that may have been impeding the rate of diffusion. Not surprisingly, much of the research effort has focused upon the OECD countries where broadband diffusion has occurred first and, apparently, fastest (for a commentary, see Ford, Koutsky & Spiwak (2007)).

To date, many factors on both the supply and demand sides of the broadband market have been posited as possible explanators of observed inter-country broadband penetration differences. These include income (individual and country), price, the addressable market size, education, population density, degree of urbanisation, population age, government policy, the extent and form (inter-platform or intra-platform) of competition present, the length of time and the extent to which the technology is available, and even weather[1]. Whilst statistically significant univariate correlations have been found between broadband penetration per capita and most of these factors in the many studies undertaken, in multivariate regressions the factors appearing most consistently as statistically significant are the size of the addressable market, income, price, and some combination of population density and urbanisation (de Ridder, 2006 Table 1). The findings in respect of competition and regulatory factors are more equivocal, with model specification being apparently a significant factor (e.g. in de Ridder's analysis of eight multivariate studies, in all but one case competition and local loop unbundling are either both statistically significant or neither is significant as a driver of broadband penetration).

2. The New Zealand Enigma

In light of these findings, New Zealand remains a persistent enigma in respect of its obdurately low broadband penetration per capita (16.5 in June 2007[2] compared to leader Denmark at 34.3, and 20th out of 30 OECD countries, having ranked as low as 23rd in 2005 and with a high of 17th in 2001). Whilst the country's GDP per capita ranks lowly (21st in the OECD 2003[3]), and population density is low by OECD standards (Network Strategies, 2006), New Zealand appears to exhibit few other barriers that appear to explain its absolute and relatively low uptake per capita.

2.1 Supply-Side

On the supply side, ethernet LAN broadband has been available commercially since 1996, and since 1999, up to five technologies (cable, ADSL satellite, wireless and mobile) have competed for customers in various localities (although cable is not widespread). Fast-

[1] These are in addition to the factors such as age, gender, household and individual income, highest level of education achieved and occupation which have been found to have some power in explaining diffusion patterns between households within a country (e.g. OECD, 2007; Rappoport, Kridel & Taylor, 2002; 2003)
[2] http://www.oecd.org/dataoecd/21/35/39574709.xls
[3] http://www.stats.govt.nz/products-and-services/nz-in-the-oecd/gdp-per-capita.htm

download ADSL was made available widely and early - 2Mbps ADSL has been the standard offering from the incumbent since January 1999 until speeds were upgraded in 2005 (NZ was third in the OECD to offer ADSL commercially – 128kbps and 256kbps services were introduced subsequently), the technology was widely available (85% of customers able to access it by 2003, by 2007 the reach was 95% - Howell, 2008) and adjusted for speed, prices have been comparatively low (3rd-lowest per kb/s in 2001 – OECD, 2001; and consistently in the lower half of the OECD between 2001 and 2007)[4].

Even in October 2007, New Zealand's supply-side position still compared very favourably with other OECD countries featuring very much higher in the numbers of broadband connections per capita. Low-end monthly subscription prices[5] and prices per megabit/second[6] were both 7th lowest in the OECD, and the country mid-ranked in the average monthly subscription prices per megabit/second[7], with a price (in US dollars PPP) very similar to that of the Netherlands, which at the time had the OECD's second-highest penetration per capita. Despite the presence of data caps in all packages[8], the average price per megabit/second after reaching the bit cap was one of the lowest recorded, at only one sixth of the OECD average price[9]. Neither does the speed of service available nationwide seem to be a particular supply-side impediment. In October 2007, New Zealand had the fifth-fasted advertised download speeds in the OECD[10], and the 8th-fastest speeds advertised by an incumbent operator[11].

2.2 Demand-Side

On the demand side, furthermore, New Zealand has one of the largest internet-using populations in the OECD (Howell, 2006). The adoption of dial-up internet occurred early, and the number of hours per user account per month was amongst the highest in the OECD in 2000 – attributed by the OECD to widespread flat-rate (unmetered) dial up telephony usage (OECD, 2000). At the peak in 2003, the country's more than 850,000 dial-up internet users were connected for more than 35 hours each per month (Figure 1), with internet traffic accounting for two thirds of local PSTN traffic (Figure 2) on a network where 'free' local calling means call minutes per account are two to three times higher than in OECD countries with metered calling (NZIER, 2005). These data suggest that New Zealand's dial-up internet

[4] For details of these statistics over time, see Howell (2007), Howell and Marriott (2004), Howell (2003), Howell and Obren (2003) and Boles de Boer, Evans and Howell (2000).
[5] http://www.oecd.org/dataoecd/22/42/39574970.xls
[6] http://www.oecd.org/dataoecd/22/43/39574979.xls
[7] http://www.oecd.org/dataoecd/22/45/39575011.xls
[8] http://www.oecd.org/dataoecd/11/38/39575261.xls
[9] http://www.oecd.org/dataoecd/10/49/39575048.xls
[10] http://www.oecd.org/dataoecd/10/53/39575086.xls
[11] http://www.oecd.org/dataoecd/10/55/39575114.xls

users were amongst the most prolific in the OECD as a consequence of cheap dial-up access, but have been slow to substitute to broadband, despite having access to some of the OECD's fastest, cheapest and most widely available ADSL services.

Whilst it might be that New Zealanders lack the technological sophistication to take advantage of broadband technologies, this contention is not supported by either educational achievement indicators or history. New Zealanders have historically been very early and avid adopters of new technologies of all kinds, and electronic technologies in particular. Uptake and use of electronic funds transfer and electronic banking were world-leading in 2000 (Boles de Boer, Evans and Howell, 2000), and in 2005, the consumer-to-consumer trading platform TradeMe became the most-visited website in the country, exceeding the traditional web portals such as MSN and Yahoo (Howell, 2006) – a position it still maintains in 2008. Furthermore, cellphone diffusion is also very high. In 2005, New Zealand at 101.9 connections per 100 population ranked 10th in the OECD, only slightly behind Finland at 102.7[12]. Moreover, at this time, over 20% of subscribers were connected to 3G networks – the 3rd-highest diffusion of this technology in the OECD after Korea and Japan, and substantially ahead of the nearest European rivals Austria and Italy (around 10% of subscribers) (OECD, 2007:99).

2.3 Regulatory Environment

The absence of mandatory local loop unbundling and low levels of competition have been offered as possible reasons for New Zealand's low broadband uptake (MED, 2006; Network Strategies, 2006). However, it is not at all clear that these are plausible explanations, given the equivocal support found for them as statistically significant factors in the multivariate regressions. Using Wallsten's (2006) multivariate equations, the presence of co-mingling c-location unbundling in New Zealand would have led to only a very small and not consistently statistically significant increase in the number of broadband connections per capita (between 2.8 and 4 connections per 100 population, depending upon the presence or absence of other regulatory instruments), and been insufficient to push it any further than one place up the OECD broadband per capita rankings as at the end of 2005. Indeed, New Zealand's actual broadband uptake per capita in 2005 was less than 2 per 100 lower than predicted by some of Wallsten's equations.

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[12] http://dx.doi.org/10.1787/011460012458

Furthermore, if the objective of access regulation is to induce competition which will put downward pressure on retail prices and thereby increase uptake, it is not clear that increased competition via access regulation will necessarily have any significant effect upon New Zealand uptake levels, given the already comparatively low retail prices. Since 2004, regulated bitstream access has been available to entrants at internationally benchmarked TSLRIC-based prices which it is claimed by entrants are too high to enable a viable entrant business case, given the incumbent's already-low retail prices. Regulated benchmarked TSLRIC prices of $NZ27.87 per month prevailed when the incumbent's entry level product had been priced at $NZ29.95 per month even prior to bitstream access being mandated, compared to previously-available regulated wholesale packages sold to entrants at retail, minus discounts in the order of 14% to 18% (Howell, 2007). Consequently, Figure 3 shows that, relative to the period when wholesale access prevailed, competition (measured as the market share of entrants) has *decreased* since bitstream access was made available in 2004, despite New Zealand exhibiting the OECD's fourth-fastest growth rate in connections per capita over the period 2005-6 – a scenario that is quite consistent with an absence of a supply-side pricing 'problem' in the form of monopoly pricing arising from exertion of dominance, and therefore one where access regulation would have negligible effect upon uptake via the pricing mechanism[13].

2.4 The Enigma Prevails

Rather, Wallsten's equations suggest that it is New Zealand's low GDP per capita, low population density and lower-than-average number of telephone lines per capita (possibly due to large average household size - see Ford, Koutsky and Spiwak (2007) for a discussion of this issue) that are primarily responsible for low broadband uptake. Given the size of the coefficients for these factors, and the limited ability to address any of these factors with policy instruments in the short-term, New Zealand's low broadband uptake per capita may not be a 'problem' at all, but simply an artefact reflecting underlying demographic, geographic and economic characteristics. However, this does not answer the question of why, despite an

[13] This does not discount the possibility of market power leading to the incumbent pricing below cost to strategically foreclose competitive entry. However, increased access regulation is impotent to address this eventuality (de Bijl, 2005). Whilst it is acknowledged that competition in downstream product quality variation on the back of bitstream access might have some effect upon the benefits derived by users and hence influence the uptake rate, if the core benefit from ADSL relative to broadband is simply the speed of the underlying network product, it is difficult to see that choice in downstream elements would have anything other than a marginal effect on the purchase decision. If the core product on its own as offered by the incumbent at low prices does not appeal sufficiently to dial-up users to induce broadband purchase, it seems implausible that a potential customer will eschew the incumbent's broadband offerings, even though broadband purchase per se might be beneficial, simply to wait to take advantage of an entrant's alternative marketing, billing system, email management services etc. The one area where downstream services may make a difference would be content bundling. However, to date, there have been no substantial content offerings bundled with either the incumbent's or entrants' offerings in New Zealand simply because the most popular pay-to-view content – SkyTV – is owned by a company with its own proprietary satellite-based broadcast infrastructure, and therefore has no need to partner with an infrastructure provider to reach its customers. However, it is noted that SkyTV is now offering premium pay-per-view content on 3G mobile phones, in conjunction with Vodafone. But given the different distribution channels that mobile telephony offers, this would be seen as complementary to, rather than competing with, SkyTV's existing offers.

absence of supply-side impediments and a highly sophisticated demand side already internet-experienced and inured to high levels of dial-up internet use, substitution to broadband by these experienced users has been so slow.

3. An Alternative Line of Inquiry

An area of potential inquiry which has so far not been well-explored in the literature, but which offers some insight into this question is the effect of retail tariff structures on the method of internet connection purchased, and especially their effect in determining the point at which an existing dial-up internet user will substitute to broadband access. The role of flat rate tariffs is well-documented as an inducement to use a technology once a connection has been purchased (Anania and Solomon, 1997; Odlyzko, 2004; 2001), but the literature is less clear on how such tariffs affect the decision to purchase a connection in the first place. Neither is the literature explicit about the effect of mixtures of tariff structures upon the decision to substitute from one connection type to another. The enigmatic New Zealand data may possibly be explained by the application of a combination of the theories relating to tariff structures (two-part tariffs, price discrimination) for a bundle of connection and usage of a service (internet access) and diffusion, whereby the service which undergoes a technological improvement resulting in the substitution over time of the legacy technology (dial-up) to a frontier technology (broadband).

3.1 The Diffusion of Legacy and Frontier Technologies

The technology diffusion literature suggests that for a General Purpose Technology (GPT) such as the internet (Helpman & Trajtenberg, 1996; Greenwood & Yorukoglu, 1997; Greenwood, Seshadri & Yoruloglu, 2000), where demand for the technology is derived from the value accrued by the use of a number of applications (Crawford, 1999), a user of the legacy technology will purchase the frontier only when the additional benefits from the applications used, less the switching and adjustment costs, exceed the additional costs of purchasing the frontier (Jovanovic & Stolyarov, 2000). Under diffusion theory, if the frontier technology diffuses rapidly and displaces the legacy from the market, then it is said to be unconditionally dominant. This occurs when the frontier is so much cheaper or delivers so many greater benefits to users given their existing application base that all new and potential users purchase it very soon after it becomes available, even though the legacy still exists. Initial diffusion of the frontier is rapid, due to extensive substitution by existing users (i.e. the S-curve is very steep initially).

However, if the additional benefits from purchasing the frontier are not large, or the costs of switching and adjustment are extensive, large numbers of existing users will persist with the legacy technology, delaying the point at which substitution will occur until the net benefits are positive, and slowing down the diffusion of the frontier relative to the case of it being dominant (i.e. the S-curve is flatter). New users who have not purchased the legacy technology do not face switching and adjustment costs, so will purchase the frontier technology as long as its benefits minus costs are positive and exceed those accrued when purchasing the legacy. If the legacy technology yields greater net benefits to a user, then despite the presence of the frontier technology in the market, the legacy will be purchased. If benefits conferred by the frontier technology are not large (or costs are large), or they are not highly valued by users (i.e. demand is elastic), then diffusion of the frontier will take longer to occur than if the benefits are larger (costs are smaller) and benefits are highly valued (less elastic demand).

3.1.1 A Simple Substitution Model

Howell (2008) develops a simple model to explain the substitution. Assuming that the principal benefit of broadband over dial-up pertains to time savings and the ability to use applications which are technologically infeasible on dial-up, diffusion theory thus suggests that substitution to broadband by an individual user *i* with valuation of time γ_i per minute will occur at the time *t* where the cost of acquiring the benefits $\Sigma_{j=1}^{n}\beta_{ij}$ from using a set of applications $j = 1,2, \ldots, n$ each requiring υ_j megabytes of bandwidth and T_{Bj} minutes of time using broadband sold at fixed price F_B and variable price per megabyte F_B exceeds the cost of acquiring those same benefits using dial-up at fixed cost F_D , variable price V_D per minute and takes T_{Dj} minutes to accrue[14]. That is:

$$(F_D - F_B) + \gamma_i \Sigma_{j=1}^{n}(T_{Dj} - T_{Bj}) + \Sigma_{j=1}^{n}\left(V_D T_{Dj} - V_B \upsilon_j\right) > 0\,. \qquad (1)$$

Equation (1) shows that substitution to broadband will be more likely to occur if the fixed costs for dial-up are large relative to the fixed cost of broadband, the value of time for the user is high (and/or broadband is significantly faster than dial-up – connection speed is implicitly captured in the user value of time), or the volume of information transfers (determined by application volume and bandwidth demands) is large. It is less likely to occur if the per-

[14] Whilst there may be some switching costs for the user in purchasing a broadband modem and scrapping the existing dial-up one, these costs are assumed to be trivial, and subsumed into the fixed costs. Learning effects are also ignored.

megabyte charge is large relative to the per-minute charge, the value of user time is low, or the relative speed difference is small.

3.1.2 Application to New Zealand

Figures 1, 4 and 5 interpreted together with equation 1 indicate that New Zealand's broadband uptake 'problem' is not necessarily one of extent, but one of timing. Figure 3 shows that, until mid 2003, dial-up internet connection and broadband connection numbers were positively correlated, even though the average number of hours connected per dial-up account was also increasing (i.e. existing dial-up users were increasing their dial-up usage, either by using more applications, or more extensively using existing applications rather than switching to broadband, and new internet users were continuing to buy dial-up connections). Despite its low prices, broadband was certainly not a dominant technology. However, in 2003, when average dial-up usage peaked at around 35 hours per account, a 'tipping point' was reached, and substitution to broadband accelerated. Figure 5 indicates that, consistent with equation (1), it is the predominantly the highest-using dial-up users that are substituting to broadband, leaving low users on the dial-up network, albeit with the rate of substitution accelerating post 2003.

Given the high average volume of usage at which the tipping point occurred relative to other countries that experienced earlier switching to broadband at much lower dial-up usage levels (OECD, 2007a), and the fact New Zealand's growth in broadband subscribers in 2005-6 was fourth-highest in the OECD, it appears that New Zealand's S-shaped broadband diffusion pattern has simply occurred later than in most other OECD countries (technically, the value of *t*, taken as the time since the invention of broadband at which an individual substitutes, is higher for the average New Zealander than the average user in many other OECD countries). Put another way, the already mature and highly-used dial-up internet markets in New Zealand continued to develop for much longer than they did in other OECD countries, with users persisting with dial-up connections for much higher volumes of usage, delaying the point at which substitution to DSL began to occur relative to these other countries.

From equation (1), this could have occurred because the average valuation of user time is very much lower in New Zealand than in other countries. Whilst this is plausible, individuals generally appear to value their internet use time lowly in other countries as well. Varian's (2002) Californian INDEX study found very low valuations, and surveys in both the United States and the European Union find that broadband users do not appear to be prepared to pay very much to receive faster broadband connections (Horrigan, 2006; EU, 2006). As the application range used by New Zealanders is unlikely to be significantly different from that of users in other countries, the only remaining explanation using equation (1) appears to be the relative prices of dial-up and broadband access and use. Whilst broadband is not expensive in New Zealand compared to other OECD countries, dial-up is extremely cheap.

3.2 The Role of Tariff Levels and Forms

De Ridder (2007) finds the relative price of broadband is a significant factor in determining broadband uptake levels in his regressions, and comments that of all the OECD countries in 2005, only five (Czech Republic, Mexico, Slovak Republic, Spain, Turkey) had higher relative values of broadband to dial-up prices than New Zealand. Indeed, his equations suggest that New Zealand's broadband uptake per 100 would be between 2 and 4 higher if New Zealand exhibited the OECD average relative prices – that is, relative price appears to be at least as important in De Ridder's equations as exchange co-location is in Wallsten's as an explanation for New Zealand's lower-than-expected uptake. Cheap dial-up is thus most likely implicated in the delay in New Zealand's rate of substitution to broadband. However, as the OECD identified in 2000, the extent of the benefits conferred from dial-up arise principally because both dial-up telephony and ISP charges are sold on a flat-rate (unmetered) basis. This leads to a tentative hypothesis that the New Zealand dial-up tariff structure is a factor in delaying New Zealand broadband uptake.

3.2.1 Historical Tariff Structures in New Zealand

Unmetered local PSTN calling has been a feature of the New Zealand telephony market since 1879, when the incumbent Superintendent of Telegraphs determined that it was too costly for government-employed telephonists at the new government-owned exchanges[15] to record the details of calls connected within a local exchange. Consequently residential telephony consumers have never paid any usage-based fees for local calls on the PSTN[16]. As exchanges merged and increased in size, 'free' local calling areas became subject to political, rather than technological determination (Howell, 2007, drawing upon Wilson, 1994). When Telecom New Zealand was privatised in 1990, a contractual deed in the company's constitution (known initially as the 'Kiwi Share' and subsequently the Telecommunications Service Order (TSO)) bound the company to always offer an unmetered local calling tariff[17]. Despite metered tariffs being offered in the late 1990s in response to competitive entry, very few customers took advantage of them, and they are no longer offered. Indeed, the size of the

[15] It was illegal for anyone other than the New Zealand Government to operate a telephone system without the permission of the Governor in Council (essentially political sanction) from the inception of the first service in 1879 until the passing of the Telecommunications Act in 1987 (Wilson, 1994).
[16] Per call charges for business users were introduced only following the privatization of Telecom in 1990.
[17] This obligation was part of the bundle of 'light-handed' regulatory provisions that governed the New Zealand telecommunications market in the period 1997-2001 (Howell, 2007).

'free' local calling area has become a feature upon which competing providers now differentiate themselves in order to induce switching from Telecom[18].

The emergence of the internet made 'free' local calling extremely valuable to individuals who used internet applications. Furthermore, the nature of the prevailing interconnect contract at the time internet connection numbers surged provided substantial arbitrage opportunities that resulted in ISPs subscribing to non-Telecom networks receiving a share of interconnect revenues as a consequence of the large volume of call minutes originating on the Telecom network. As Telecom was bound under the 'Kiwi Share' contractual obligations to offer unmetered local calling, it could not withdraw the now extremely attractive 'free' local calling tariff. Competing network owners, in order to ensure they recruited a disproportionately large share of Telecom telephony customers generating even larger interconnect revenue flows from Telecom as a consequence of the volume of internet-related interconnect minutes, vigorously recruited ISPs as their customers, usually by sharing the interconnect revenues. In turn, to attract customers, non-Telecom ISPs shared the interconnect revenues (Karel, 2003). Telecom responded by aggressively marketing 'flat-rate' ISP charges to maintain customers. Consequently, a highly-competitive ISP market emerged, with very low-priced and even free connections, and 'flat-rate' ISP charges were common. Together, the free telephony usage and low ISP costs resulted in New Zealand exhibiting very much higher levels of dial-up internet usage (OECD, 2000; Howell, 2003), lower average ISP fees (Boles de Boer, Evans and Howell, 2000) and higher levels of internet connections per capita than other comparator countries despite having fewer ISPs per capita (Boles de Boer, Enright & Evans, 2000).

3.2.2 Tariff Structures and Broadband Infrastructure Development

As one of a number of strategic responses[19] to stop the flow of interconnect revenues to competitors, Telecom moved quickly to roll out widespread, very fast, very low-priced ADSL in an endeavour to bring forward the substitution of dial-up customers from regulated PTSN services to (then) unregulated broadband. To make the product appealing to low-volume as well as high-volume users and again to accelerate substitution, Telecom offered the product via a menu of multiple two-part tariffs[20]. It cannot be discounted that the company also

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[18] TelstraClear's 'Big Back Yard' offers seven extensive 'free calling; areas, crossing boundaries where Telecom still imposes long distance charges. http://www.telstraclear.co.nz

[19] For an analysis of the other strategic responses, see Howell (2007).

[20] Another reason for this pricing pertains to the extensive volume of data (in excess of 90% of internet traffic) sourced from offshore, and carried by the monopoly trans-oceanic Southern Cross cable. The small populations of New Zealand and Australia, which is also served by this cable, the very long length of this cable (it traverses from Australia to New Zealand and thence on to Hawaii and the Pacific seabord of the United States, at which point its owners exchange traffic with United States carriers) and the nature of internet peer-to-peer network charging conventions, mean that the entire cost of traffic traveling in both directions on this cable are borne by only a very small population. Southern Cross cable costs thus impose a substantial cost burden per

offered entry level connections below cost (as indicated above by the very low tariffs compared to TSLRIC-benchmarked prices). As even the average dial-up internet user subscribing to a non-Telecom ISP in 1999 was generating an interconnect liability for Telecom of $12 per month on a PSTN account priced at only slightly over $30 per month, strategically the firm could afford to discount ADSL below cost up to the average interconnect loss per non-Telecom ISP customer and not be any worse off than if the customer remained on dial-up. However, whilst such actions might normally be considered predatory pricing to foreclose competition, in this instance unless such actions were taken, it was likely that Telecom would have faced financial ruin (Howell, 2007).

However, despite its ADSL roll-out and pricing strategies, as Figures 1, 4 and 5 show, Telecom was unsuccessful in achieving its substitution objectives, as the attractiveness of cheap dial-up appears to have overwhelmed the effect of very low priced, high-speed DSL, even for users who were consuming in excess of one hour per day connected to the internet. Re-examination of equation (1) begs the now-obvious question: which of the four pricing factors – the fixed (connection) and variable (usage) fees paid for each of dial-up and broadband – has placed the biggest brake on New Zealand's substitution from dial-up to broadband relative to other OECD countries? This leads directly to a discussion of the role of two-part tariffs, price discrimination and bundling, and their effects upon both technology diffusion and the time of substitution from legacy to frontier technologies.

3.3 A Two-Part Tariff Model of Substitution and Diffusion

Whilst flat-rate tariffs might encourage usage of a technology one an individual has purchased a connection, how does the tariff structure affects the decision to purchase the connection in the first place? As broadband diffusion is measured as the number of connections sold, it is apposite to examine the role of tariff structure in inducing purchases to be made in the first place. As mobile telephony diffusion patterns have illustrated, widespread application of metered usage tariffs does not appear to have impeded purchase of connections to this technology, even in the New Zealand environment where unmetered fixed-line local calling has prevailed. Rather, it has been common in the telephony industry to use two-part tariffs, precisely to increase the number of connections amongst low-using populations, by separating out the price of connection from the price of usage of that connection.

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internet account in Australia and New Zealand. By charging separately for traffic and connection, via so-called 'capped' plans, the costs can be shared according to the data demands of individual users. In the initial years of broadband sale in New Zealand, it was routine for ISPs to charge differently for international and national traffic (e.g. unlimited local traffic, but metered international). However, the very small volumes of local traffic rendered this charging method of little value for the vast majority of internet users, and it has largely been abandoned.

In essence, a two-part tariff for telephony or internet access comprises the ‘tied’ purchase of both connection and usage – both goods must be purchased together for any benefit to be derived from either. Such tariffs have been common due to the historic ‘natural monopoly’ nature of telephony cost structures where the good will not be supplied at marginal cost, as over the relevant quantity range average cost never falls below marginal cost and the provider cannot break even in the long run. If a fixed price for each connection to the network is charged to enable all fixed costs to be recovered, each unit of usage can be charged as at marginal cost. Costs are fully recovered, and the service is produced (Carlton & Perloff, 2000). However, under a single two-part tariff, those who consume fewer call minutes or megabytes of bandwidth in effect pay a higher average price per call minute/megabyte when the two charges are added together. Whether or not a connection is purchased in the first place will be determined by whether the benefits accrued from purchase of the bundle exceed its price, given the usage volume determined by the applications driving demand for usage.

By way of illustration, a consumer with a low call valuation and low demand volume (type 1) will purchase neither connection nor calls because the high average price per call exceeds benefits accrued. However, a consumer with the same call valuation as type 1 but a higher demand (type 2) may purchase the bundle, as the average price faced per call is lower, and may now exceed the benefit threshold. An individual with the same demand volume as the type 1, but a higher (type 2) call valuation (type 3) may purchase as for this consumer the average price per call exceeds the benefit accrued. Likewise, as the call volume demanded increases for individuals with the same valuation as the type 3, the benefit accrued per call increases as the average price per call decreases (type 4).

3.3.1 Price Discrimination and Diffusion

‘Tied’ pricing can also be used as a method of price discrimination when the demand for the two goods is inter-related, in order to increase profits without reducing welfare. The price charged for the first good is set, and the second good charged at a price above cost. Those valuing the second good higher (e.g. make multiple purchases of it) thus pay a higher effective price for the first good (Carlton and Perloff, 2000:302-319). Tying can also be used as a form of ‘progressive tax’ whereby the additional revenues accrued from selling the second good above cost (calls) can be used to offset (subsidise) the cost of the first (connection). Those consuming more call minutes under this arrangement effectively pay more for their connection than those consuming fewer minutes. As connection prices can be reduced below cost, individuals with low call valuations not purchasing a connection under standard two-part tariffs (i.e. type 1 from above) will now purchase one, even though they do not make many calls and do not value them very highly, as the subsidised price paid is now exceeded by the lower level of benefit accrued from calling. However, as the price of calls has increased, type 2, 3 and 4 customers will make fewer calls. As long as the extra welfare accrued from additional connections and calls by type 1 consumers (for example, network effects as well as individual benefits) exceeds the welfare lost from reduced call volumes by types 2, 3 and 4, then such a tariff increase welfare as well as increasing connection numbers.

Two-part tariffs with connections subsidised by usage prices above cost have been commonplace throughout the OECD telephony markets, especially where there are positive network externalities from having more connections. For government-owned telecommunications firms, such pricing has also been desirable for its ability to extend the perceived social benefits of widespread connection, as well as achieving distributional objectives by recovering a higher proportion of revenues from those consumers valuing the combined connection and usage bundle higher as they make more calls (i.e. less elastic demand) (Laffont and Tirole, 2002 chapters 3 and 6). The two-part tariff is able to be viewed as a two-sided market (Rochet and Tirole, 2002; 2003; 2004; Evans and Schmalansee, 2005; Wright, 2004) where calling can be considered the 'money side' and connection the 'subsidy side' (Parker and Van Alstyne, 2005; Eisenmann, Parker and Van Alstyne, 2006). The widespread popularity of pre-paid mobile accounts is a result of the extreme case of such tariffs, where connection costs (excluding the handset) are zero, but calls are priced substantially above cost. Viewed using this frame, Telecom's two-part tariff for ADSL should have accelerated broadband uptake, but it does not appear to have been effective.

By contrast, New Zealand's residential fixed line tariff where connections subsidise calling appears perverse in respect of either the accrual of network benefits from a larger number of connections or wealth transfers favouring specific groups who might otherwise not be able to afford to pay for a connection. Connection prices above cost are applied to subsidise calls priced below cost (i.e. zero). Fewer connections will be purchased, as low-valuers of the bundle will abstain, reducing both connection and calling welfare. Furthermore, the average price paid per call rises for all who purchase a connection, but the increase is least for those consuming most call minutes. The higher revenues per call paid by low-volume callers subsidise the high-volume callers. The smaller the calling price is, the greater the effect of the subsidy.

In essence, flat-rate tariffs (zero usage cost) create an implicit wealth transfer from those consuming few call minutes (lowest call-valuers/money side) who face a high price per call-minute to those consuming most call minutes (highest call-valuers/subsidy side) who face a low price per call minute. As occurs with any subsidy, consumption of call minutes increases beyond the competitive optimum where calling is priced at marginal cost, increasing total costs, requiring further increases in the fixed connection price, and thereby leading to even fewer individuals purchasing a connection. Importantly, however, those who value the calls most receive the greatest effective subsidy, so are likely to increase their usage by a very much larger number of minutes than those who value them least, exacerbating both the increase required in the fixed price and the extent of the implicit wealth transfer, and the reduction in welfare from lost connections and usage from those users who, at the margin, now do not purchase a connection at all.

3.3.2 Tariffs, User Valuation and Diffusion

By extension, flat-rate tariffs for broadband connections will result in higher fixed prices, and all other things being equal, fewer connections being sold. They are favoured by those valuing usage most, as their high usage is in effect subsidised by those who value it least. Broadband usage patterns have been shown to by highly asymmetric in New Zealand (Howell, 2003) and other countries (e.g. Finland – OECD, 2007a), with a very small number of customers consuming very large proportions of the data traffic (median usage lies substantially below average usage per account). Whilst such tariffs have been claimed to reduce risk for consumers of receiving an unexpected bill when they are unaware of the volume of data transferred (e.g. Anania and Solomon, 1998), it has also been claimed that consumers facing multiple two-part tariffs are remarkably adept at switching tariffs if they find they are paying more than expected on a particular plan (Miravete, 2002, 2003).

When applying two-part tariff theory to the diffusion theory model in equation (1), it now becomes material to think about how each of connection and usage are priced in relation to the different valuations of each of these factors by consumers of both telephony access and internet access. It is important to consider that the ability to access the internet using dial-up has altered the factors that have typically been considered relevant in populating the parameters in the equation. This has led to two different effects, termed for convenience the 'bundled connection' effect and the 'tied usage' effect. The different tariff approaches to pricing of both the telephony and broadband networks will affect the rate of substitution because of each of these factors, depending upon the different valuations placed on each of these products by consumers.

3.3.3 The 'Bundled Connection' Effect

Dial-up internet access bundles the telephony-based element of the connection to the internet with the connection to voice telephony services. All of those valuing a telephony connection highly enough to purchase under any tariff are 'gifted' an internet connection, irrespective of how highly they may value it (i.e. the telephony connection component of F_D in equation (1) is zero). The consumer welfare arising from the value of internet connection to the user is thus 'gifted' via the connection bundle. The higher an individual's internet valuation, the greater the effective 'discount' gained from the bundle. Moreover, the higher the price paid for the telephony connection, the greater the extent of the bundling 'gift' to the user (as a separate internet connection does not have to be purchased), and the higher the price that must be paid by an individual who does not value telephony connection highly but does value internet connection highly must pay to get access to the internet. High telephony connection prices thus will inhibit dial-up internet diffusion, but only for those customers placing low values on telephony who do not receive the 'bundling gift'.

The size of the 'bundled connection' 'gift' is material when considering the point at which a dial-up internet user will substitute to broadband. In order to justify substitution, a dial-up user must receive sufficient additional benefit from the purchase of broadband to recover the extent of the 'gift'. The higher the extent of the 'gift', the greater the additional benefit from the new technology must be to justify substitution. Thus, for a given level of broadband connection price, the higher is the telephony connection price, the greater the individual must value internet connection to justify substitution, as the effect of the bundling 'gift' must first be overcome. In New Zealand, where due to connections subsidising usage the price paid for telephony connection is in effect the highest it could be, so too is the connection bundling gift the highest possible. Thus, the internet connection valuation of the marginal substituter from dial-up to broadband will be higher in New Zealand (and other countries with no telephony usage charges such as Australia, Canada and the United States) than in a hypothetical country where the telephony tariff is set so that the fixed price recovers only fixed costs and does not subsidise usage.

More generally, if the hypothetical tariff is presumed to lead to the 'efficient' rate of substitution away from dial-up for a population of internet users with varying valuations of both internet usage and connection, then any tariff whereby the connection charge is lower (higher) than the efficient one will result in the marginal substituter's valuation of connection being higher (lower) than the efficient level. For any given broadband tariff, countries where telephony tariffs resulted in connections being subsidised by usage would have seen substitution from dial-up to broadband happening at lower valuations of internet connection than efficient – that is, earlier in the diffusion process than if the efficient telephony tariff had prevailed. Likewise, in countries where telephony connection subsidised usage, substitution to broadband would have occurred later than is efficient.

Thus, it is not surprising to find three of the four countries where unmetered tariffs prevailed (Australia, New Zealand and the United States) all apparently exhibiting later substitutions than might otherwise be expected. That the fourth country, Canada, has not experienced delays of the same extent is likely accounted for by the fact that, unlike Australia and New Zealand, telephone tariffs were geographically de-averaged (OECD, 2003), meaning the more numerous urban consumers faced lower connection charges and did not face the double subsidisation 'problem' of their telephony connection charges having to subsidise both calling by all consumers and connections servicing higher-cost rural customers. Bluntly, urban Canadian consumers received a smaller 'bundled connection gift' as a consequence of comparatively lower telephony connection charges, so substituted relatively earlier.

3.3.4 The 'Tied Usage' Effect

The second effect to consider is the 'tied usage' effect. An individual who does not value telephony connection and calling but who has to purchase a telephony connection in order to access the internet via dial-up pays the average price per minute connected. The value derived from the combination of access and usage therefore determines the number of minutes consumed. However, a telephone connection purchaser faces only the marginal (usage) price because of the bundled connection gift. If the two individuals each value the use of the internet equally, all other things being equal the gift beneficiary will consume more minutes of dial-up access than the non-beneficiary. The greater the extent of the subsidy from connection to usage, the greater the beneficiary's additional usage relative to the usage of the non-beneficiary. Alternatively, for the same number of minutes of usage, the beneficiary will have a lower valuation of internet usage than the non-beneficiary. The greater the extent of the subsidy from connection to usage, the greater the difference in internet valuation between the two different consumers of that number of minutes.

It now becomes important which type of internet-valuing consumers are purchasing broadband connections. The 'bundled connection' effect gifts connections to all telephony users regardless of their valuation of internet usage. They will consume dial-up to the point where the extra marginal price paid exceeds the benefit received. Where usage is priced at zero, anyone with a positive internet usage valuation will consume, even though they would not have used the internet at all had they faced average cost prices. Substantial internet usage is being consumed by individuals who may value it very lowly (i.e. their demand is very elastic). However, when substituting to broadband, they face a price for both internet connection and usage (either separately or bundled into a fixed rate plan). Only those for whom the benefit exceeds the combined connection and usage cost will substitute. Those with a high valuation of time, or other reasons for highly valuing use of the internet, will substitute at low usage volumes, even though they do not use a large amount of bandwidth. For individuals of equal usage valuation, the higher the per-minute charge, the more will substitute to broadband. By extension, the lower the per-minute charge for dial-up, the higher becomes the marginal valuation of internet usage at which an internet user will substitute.

Once again, as with the connection case, at the extreme, where dial-up usage is fully subsidised from connections, the marginal valuation of internet use at which substitution takes place will be greatest. Relative to the hypothetical case of efficient telephony tariffs, substitution is delayed (occurs at a higher valuation of internet usage) when telephony connection subsidises usage, and occurs earlier (i.e. at a lower valuation of internet usage) when telephony usage subsidises connection.

3.3.5 Application to the New Zealand Data

It can now be seen that flat rate telephony tariffs have had a two-part effect upon the time at which substitution to broadband occurs. It is not at all surprising that, after accounting for all other apparent influencing factors, New Zealand's broadband uptake has been sluggish compared to other OECD countries. The most significant difference which explains the New Zealand pattern is the tariff structure of the legacy technology. New Zealand has been 'doubly disadvantaged' by both the 'bundled connection' and 'tied usage' effects of the free local calling traffic relative to all countries charging two-part tariffs. Importantly, the marginal valuation of both internet connection and internet usage at which substitution to broadband occurs will be lower in countries where two-part telephony tariffs prevail than in countries with flat-rate charges[21].

An interesting by-product of the tariff analysis is the apparently very high levels of dial-up usage at which substitution appears to have been occurring. Until 2004, despite the multiplicitous supply-side advantages and the prevalence of two-part broadband tariffs in New Zealand, very little substitution had occurred. This suggests that, even though internet usage was extensive (averaging around 35 hours per month), that usage was not very highly valued (i.e. demand for the connection and usage bundle was comparatively elastic). As prices did not change substantially in 2004, it appears as though the main driver of the

[21] By this reasoning, Australia's slightly higher broadband uptake than New Zealand's, despite higher broadband prices, is likely a consequence of the fact that whilst fixed line calls are unmetered, in Australia there is a charge levied for each call made.

increased rate of substitution pertained to a fundamental change in individuals' valuation of the internet, from equation (1) likely through either the use of new applications, or increased use of existing applications.

3.3.6 The Link Between Applications, User Valuation and Substitution Timing

A key to explaining the New Zealand pattern lies in the emergence internationally of peer-to-peer applications such as YouTube and Facebook over this period, and, apparently quite material nationally, the increasing use of the most popular New Zealand-based web application, the consumer-to-consumer trading platform TradeMe. TradeMe pages contain a lot of rich graphic material (e.g. photographs of items for sale), and although constraints are placed upon the size of pictures posted in order to make it feasible for members to engage in a meaningful interaction on dial-up connections, for frequent traders loading auction data and individuals browsing many auctions, broadband speeds offer a very much more efficient participation.

Figure 6 shows the growth of TradeMe membership, auction numbers and unique visitor addresses (i.e. the unique computer identifications from which members access the exchange) from 2001 to 2008. TradeMe's growth is strongly correlated with growth in the number of broadband connections sold (and therefore the rate of substitution from dial-up to broadband). In 2003, it had fewer than 150,000 members – about 0.18 per active internet account. In February 2008 if had nearly 2 million members (2 per active internet account), and page views averaged one billion per month – an average of 520 per member per month and around a thousand for each of New Zealand's active internet accounts.

The emergence and growth of TradeMe thus appears to offer the best local demand-side explanation for the timing of New Zealand's change in substitution pattern – the emergence of a new and highly-valued application increased both the volume of internet usage and the value accrued by individuals from that usage. Its effect in altering the value placed upon internet usage by New Zealanders has (by the theories in this paper) been sufficient to counter the strong brakes put on substitution away from dial-up by the 'connection bundling' and 'tied usage' effects of 'free local calling' under the 'Kiwi Share'. Rather than supply-side regulation and competition influencing price and offering differentiation, it has most probably been demand-side valuation of internet use due to the arrival of a new application that led to the 'tipping point' in 2003 graphically illustrated in Figure 1.

4. Lessons from New Zealand

The primary lesson for the rest of the OECD from the New Zealand experience is that the extensive use of flat-rate tariffs for a legacy technology, whilst undoubtedly increasing the use of that technology, poses substantial impediments to substitution to a frontier technology, due to the 'tied usage' effect, which raises the marginal valuation of usage at which a user will move to the new technology. If connection to the legacy technology has also been subsidised by bundling it in with another product which is highly-valued by the user, then this too will delay the point at which substitution occurs by also raising the marginal valuation at which a user will substitute. The 'bundled connection' effect applies to all tariff structures, but is greatest in the case of flat-rate pricing of the legacy.

The current popularity of flat-rate tariffs for broadband access, and extensive use of 'triple play' bundling of telephone, video and internet access may thus have significant effects upon the ability to induce substitution to new frontier internet access technologies (e.g. fibre to the home) relative to the case of 'efficient' pricing where connection is charged to recover fixed costs and usage is priced at marginal cost. Whilst high-valuing users will substitute early, many high-volume users of the legacy technology may not substitute rapidly, as they do not necessarily value either their connection or their usage highly (e.g. the technology in question is the least-valued item in the bundle), as their usage has not been constrained by any meaningful usage pricing. The New Zealand experience suggests that the substitution inertia created by the flat-rate tariff may only be overcome by the development of new applications which are both highly-valued by the majority of users and which can only be feasibly deployed on the frontier. If satisfactory user experiences can be obtained on the legacy technology, bundling and flat-rate tariffs pose substantial barriers to substitution.

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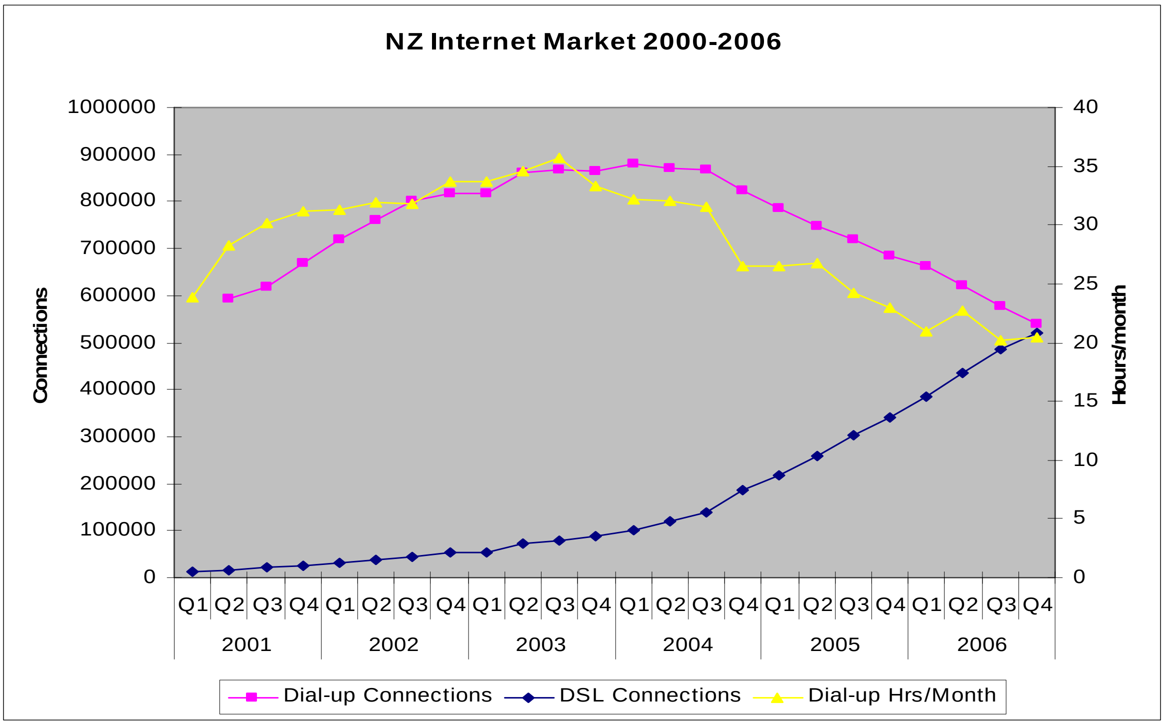
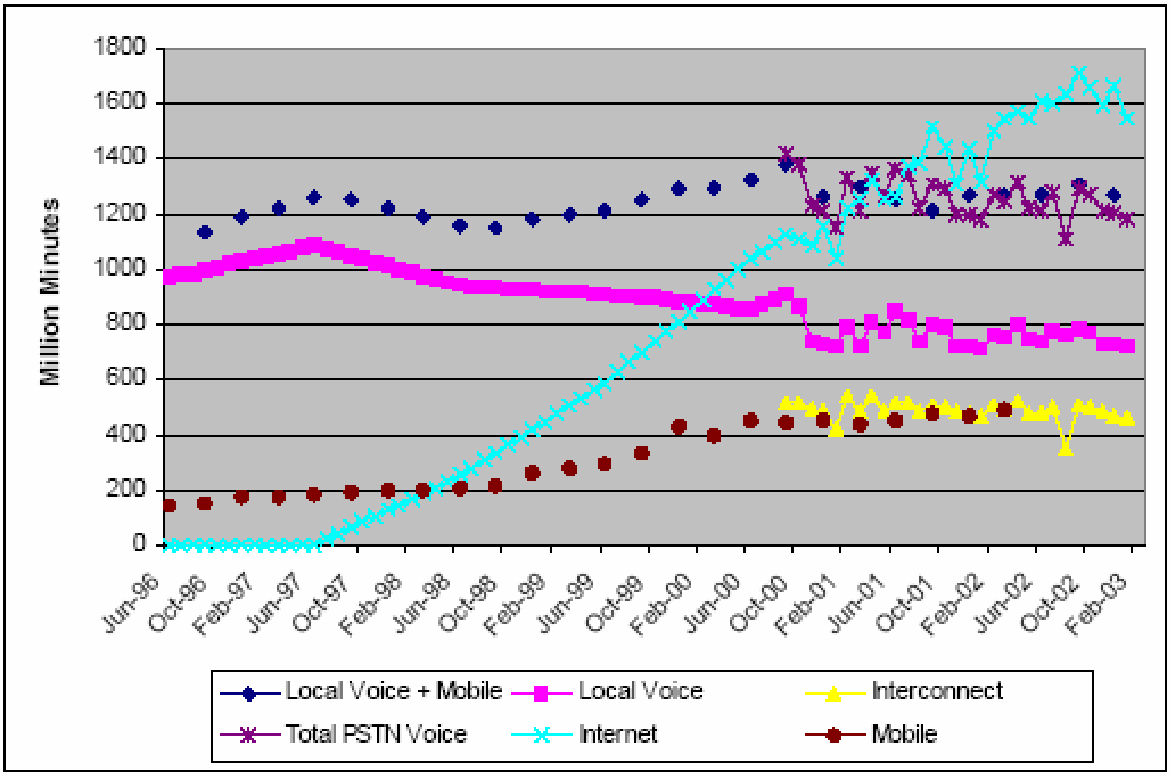
Figure 1



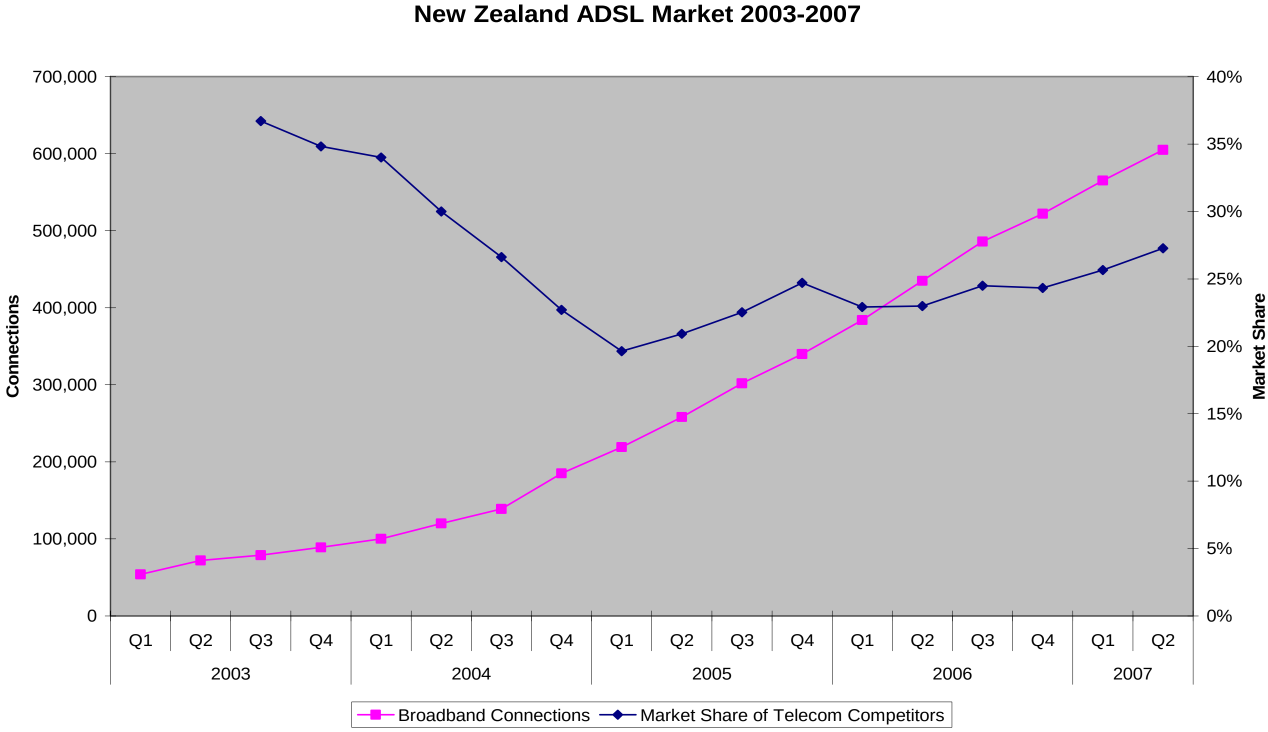
Source data: Statistics New Zealand ISP Surveys and Telecom Management Commentaries

Figure 2. New Zealand Telephone Traffic 1996-2003



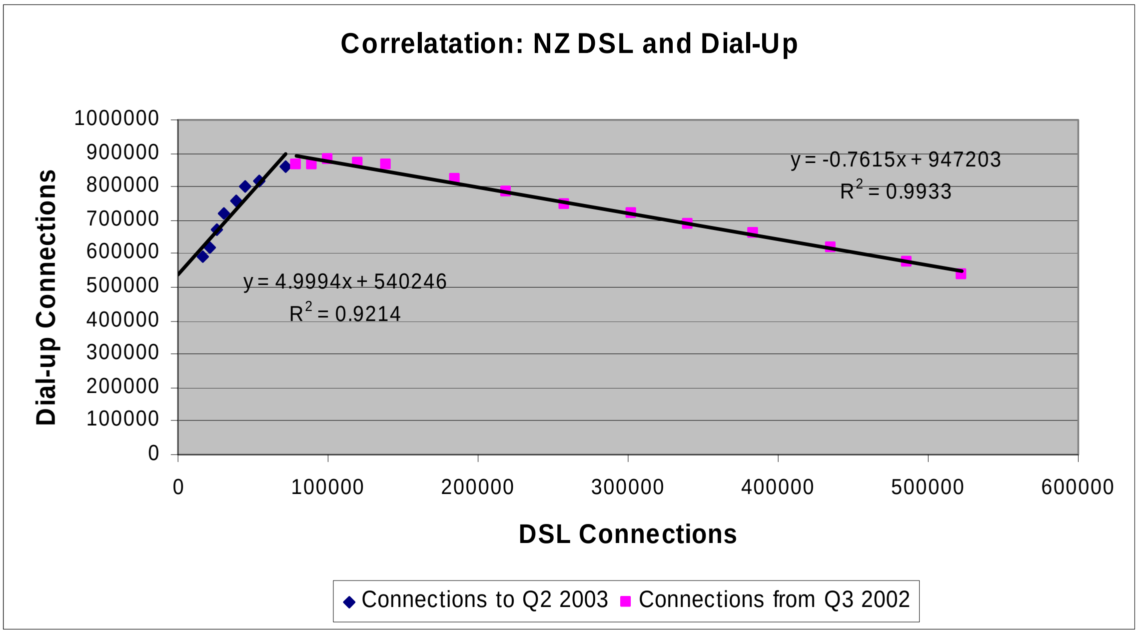
Source: Howell & Obren (2003:33)

Figure 3



Source data: Telecom Management Commentaries

Figure 4



Source data: Telecom Management Commentaries

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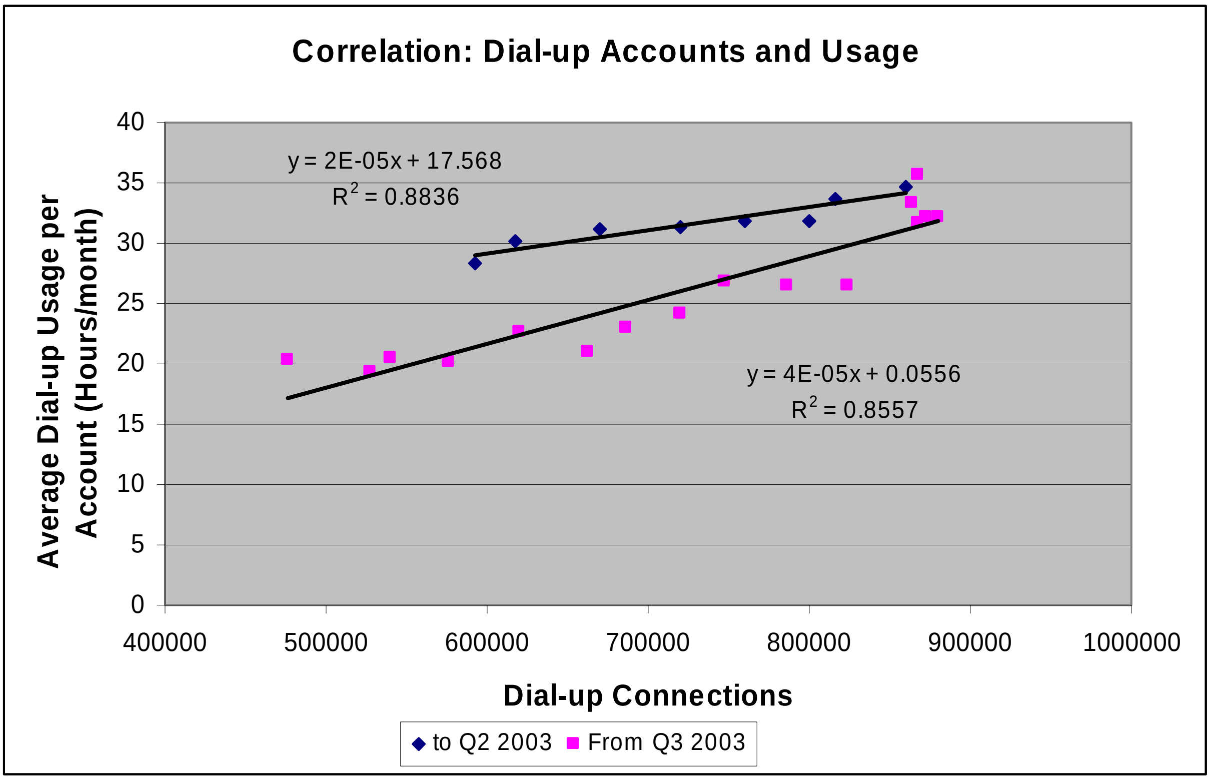
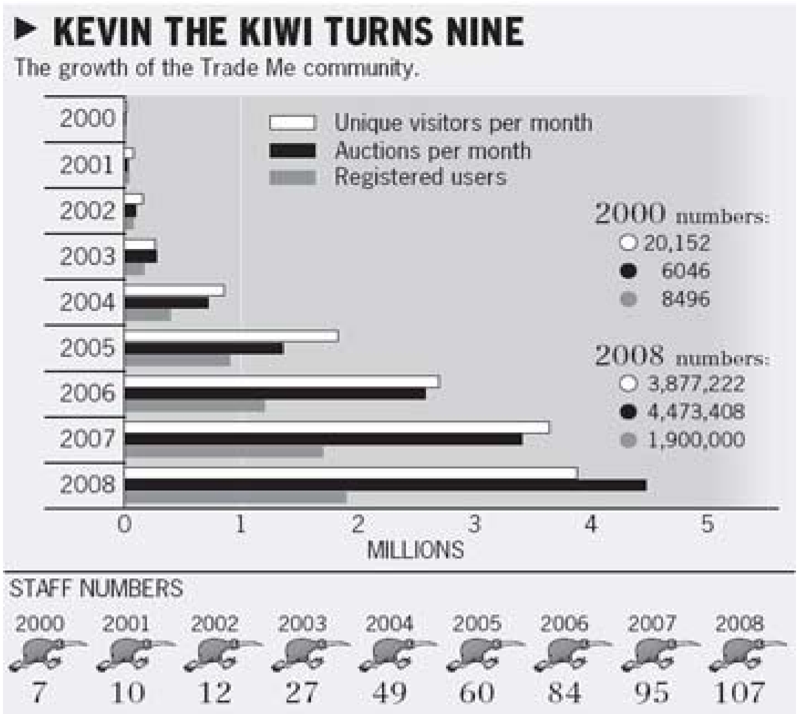
Figure 5



Source data: Telecom Management Commentaries

Figure 6



Source: Dominion Post March 12 2008 p A7; http://www.stuff.co.nz/4435153a6479.html