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The Role of Price Structure in Telecommunications Technology Diffusion

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Abstract

In most OECD countries, dial up internet accounts have typically been offered under two-part tariffs, where connection and usage are charged separately. By contrast, broadband accounts are typically offered under flat-rate tariffs. As consumers purchase internet accounts based upon their combined valuations of each of the connection and usage components, it would be expected that different broadband tariff structures would result in different rates of broadband diffusion. As broadband is the successor to dial-up internet technology, the diffusion rate will also depend upon the dial-up tariff structure.

Using theories of two-part tariffs, bundling and price discrimination, this paper examines the effect of both dial-up and broadband tariff structures on broadband diffusion. Specifically, flat-rate broadband tariffs slow the rate of diffusion, relative to an optimal two-part tariff. Flat-rate tariffs prevail as a strategic means of extracting rents from early adopters with high connection values, but low usage valuations. Flat-rate dial-up tariffs slow the rate of substitution to broadband via two mechanisms: a larger ‘connection gift’ from bundling with voice telephony and a larger ‘usage gift’ from usage beyond the point of marginal cost. Relative to an optimal two-part dial-up tariff, the marginal substituter from flat-rate dial-up to broadband has both a higher connection valuation and a larger usage volume. Conversely, two-part dial-up tariffs where usage subsidises connection result in earlier substitution to broadband, as both the connection valuation and usage volumes are lower.

Broadband internet technology, as the frontier General Purpose Technology (GPT) (Helpman & Trajtenberg, 1996) via which individuals can access the internet, is widely perceived as a vital factor in driving a country's economic growth potential (OECD, 2003; Crandall, Hahn & Tardiff, 2002). Consequently, there has been considerable interest in the comparative rates at which the technology has diffused in different economies (Ford, Koutsky & Spiwak, 2007). Many empirical studies have been undertaken to determine those economic, policy, demographic and geographic factors which might plausibly explain cross-country differences in the most commonly-used metric – broadband connections per capita (for a summary, see Boyle, Howell & Zhang, 2008).

Whilst there is considerable debate about the relative effect of some policies (e.g. local loop unbundling) and many geographic and demographic factors, unsurprisingly, most studies find the price at which broadband is sold is a significant factor in determining the level of broadband uptake in a given country. Furthermore, as many broadband internet connections are sold to consumers who have previously accessed the internet via dial-up modems, the relative price of the technology compared to the predecessor technology is also likely a significant factor (de Ridder, 2007).

Moreover, the predominant form of pricing of each of the legacy dial-up and frontier broadband technologies varies significantly across countries (e.g. in New Zealand and Australia, almost all dial-up access is sold at a flat-rate and broadband via a range of two-part tariffs, whilst in the United Kingdom and most of Europe, the reverse applies). Yet, in most empirical studies, the broadband and dial-up price variables are modelled as a single price level, usually averaged from a range of plans available or using a standard basket of services, even though both products are sold using a very wide range of flat-rate and two part tariffs, and increasingly in bundles with other products.

Despite the wide range of tariff structures observed in practice, little formal attention has been given to the role of either broadband or dial-up tariff structures in explaining cross-country differences in broadband uptake, in either the theoretical or empirical literature. Unmetered dial-up tariffs have been widely anecdotally linked to both higher internet uptake and usage (OECD, 2000) and increasingly, comparatively slow substitution to broadband in three countries[1] where they were used extensively (e.g. Howell, 2003, Horrigan, 2006; Wallsten, & Sacher, 2005; Network Strategies, 2006). The absence of flat-rate broadband tariffs has been

[1] The United States, Australia and New Zealand: the fourth country – Canada – initially had high broadband uptake, but unlike the others, had substantially geographically de-averaged tariffs and extensive competition from cable, which could account for the difference (Howell, 2007).

further implicated in the comparatively low uptake rates in Australia and New Zealand (e.g. Network Strategies, 2006; MED, 2006). Yet even in these linkages, the explanations rely principally upon tariff effectively lowering the comparative price level for characteristic baskets of connection and usage (e.g. Howell, 2003) rather than on the particular characteristics of the tariff structure, the valuations of different consumers, and how the interaction of these factors result in different effects upon the likelihood of consumers in a given population purchasing the technology, given past technology purchase choices.

This paper begins to address the gap in the literature by examining the characteristics of tariff structures, their use in telephony and broadband markets, and how they might affect technology diffusion. Key to this analysis is the recognition that telecommunications and broadband products are sold as bundles of access (connection) and usage, with flat-rate tariffs being the special case of unpriced usage. In measuring broadband diffusion, uptake per capita is capturing only the access (connection) component at a given point in time. The welfare generated in both dial-up and broadband internet markets is determined by the value to the consumer of the bundle of access and usage relative to the price of each component. As both flat-rate and two-part tariffs typically embody subsidies between the components, the extent to which either connection or usage is subsidised by the other (or indeed even some other product included in the bundle) will affect both the uptake level at a given time and the pattern of diffusion across time. Furthermore, as broadband purchase is in large part reflecting substitution by existing dial-up internet users, broadband uptake will necessarily be affected by price structures and consumer valuations of each of the access and utilisation components of internet consumption as well as the respective prices for each over the legacy and frontier technologies.

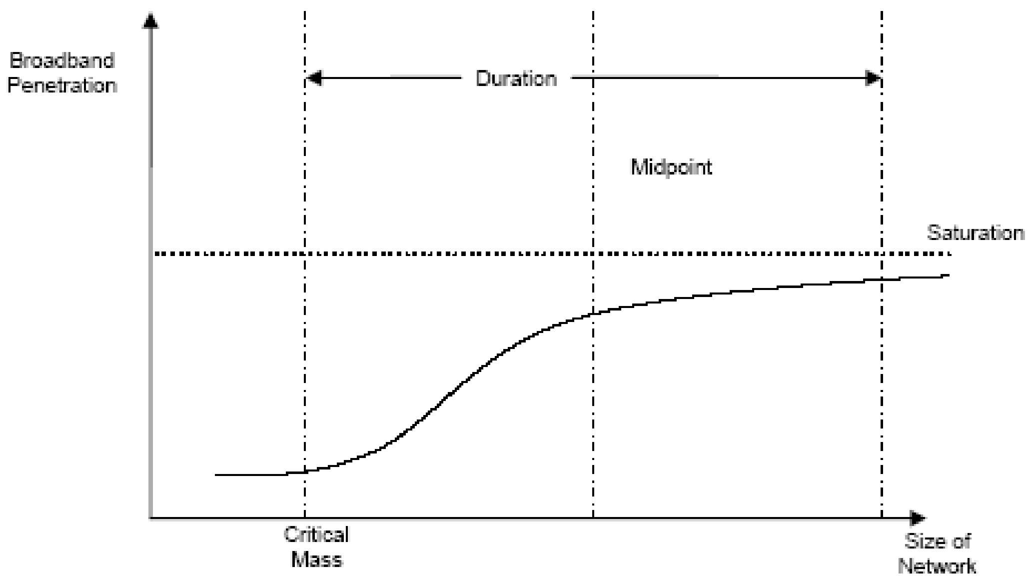
The paper proceeds as follows. Section 1 provides a brief description of technology diffusion patterns. Section two then discusses the use of two-part and flat-rate tariffs in telecommunications markets and their effect upon the diffusion of a specific technology. In section three, the specific issue of the role of interacting tariff structures in the diffusion of a frontier technology when the legacy is already well-diffused is addressed. Both sections also address the effect of bundling of other products into the bundle internet connection and usage. Section three uses the specific example of New Zealand to illustrate the effects. Section four concludes by examining the implications of the paper for the pricing of other technologies, notably the effect that current preferences on flat-rate broadband tariffs will have on diffusion from copper-based ADSL to fibre-based technologies.

1. *Technology Diffusion*

The pattern of a technology's diffusion is a function of consumer valuations of the product, the information about its availability, price and benefits, the interactions between producers and the nature of competition in the market (including the time at which the technology is first made available). It is thus the outcome of a dynamic pattern of interaction between supply and demand for the good, over a period of time (Abramovitz & David, 2001).

A technology typically diffuses through an economy over a period of time, in an 'S'-shaped pattern (Figure 1) (Greenwood & Yorukoglu, 1997). When it is first introduced, it is usually offered only by a small number of providers with market power, supply is restricted and it is highly-priced. Only a very small proportion of potential users, who have a very high willingness to pay (the early adopters), purchase it at this price, and then conditional upon knowing of both the product's existence and its potential value to them (the flat part at the left of the curve). When the technology is introduced in different populations at different times, the curve for the population with the later introduction will, all other things being equal, lag the curve representing earlier introduction (Boyle, Howell & Zhang, 2008).

Figure 1: Technology Diffusion Curve



Source: Grosso (2006: 11)

Over time, more potential consumers come to know of the product and its benefits, and purchase it if the price is below their individual valuation. The curve starts to trend upward after a 'critical mass' of consumers – typically 5% of the addressable market – have purchased (Atkeson & Kehoe, 1997). Furthermore, if there are few barriers to entry, the presence of profits for the first producers and evidence of a pent-up demand for the product (consumers valuing the good at more than its cost of production, generally signalled by the diffusion curve passing the point of 'critical mass') induce new producers to enter the market. Over time, as entry occurs, the quantity produced increases and the price falls, leading to purchase by individuals with increasingly lower valuations of the good (the upward-sloping curve becomes steeper).

At the midpoint, when more than 50% of the potential market has purchased the good, the market begins maturing. The curve becomes less steep, as only those with low valuations are left to purchase ('late adopters'). Furthermore, the potential for price reductions becomes smaller the more competitive the market becomes. When the price stabilises at long run marginal cost, the very last purchasers are those with the lowest valuations of the good ('laggards'), reflected in the flattening at the top right. The market is saturated, as there are no more potential consumers valuing it more highly than the price prevailing at that point in time. Only if there are new applications developed that increase the benefit of the technology to users (net of the costs of acquiring them) will more 'laggards' purchase the technology. The steeper the curve, the shorter the duration of diffusion is. If the product offers very high consumer benefits relative to price, the duration is typically short. Less-highly valued or more expensive technologies tend to have longer durations and flatter curves.

When a technology is completely new, purchase of the technology is determined by the full value of consumer surplus represented by the difference between willingness to pay and price. However, when new technology represents an iterative improvement (the frontier) upon an existing technology that many potential users have already purchased (the legacy), the new technology will be purchased by existing users only if the marginal benefits it offers exceed the additional cost (both purchase and switching, including foregone production of the now-retired legacy plant) (Greenwood & Jovanovic, 1998). If all potential new users purchase the frontier technology because its new features offer sufficient benefits that no-one buys the legacy, it is said to be unconditionally dominant. The frontier diffusion curve will be relatively steep and the legacy curve will start trending downwards. If some new users continue to purchase the legacy, the frontier is only conditionally dominant (the condition being that some consumers do not value the additional benefits sufficiently to pay the higher costs). The frontier curve is less steep in its initial stages than in the case of a new or unconditionally dominant technology, whilst the legacy curve flattens but still trends upwards as sales continue.

2. Two-Part Tariffs in Telecommunications Markets

The majority of telecommunications products have historically been offered to consumers under two-part tariffs, consisting of a charge to connect to the network, and a charge for usage (e.g. minutes of voice traffic or numbers of megabytes downloaded). The extreme cases are pre-paid mobile telephony, where the connection charge is zero and all costs are recovered from usage fees, and 'flat rate' tariffs, where a fixed monthly fee is charged irrespective of the volume of usage consumed. Connection and usage are physically tied in a pure bundle (a connection must be purchased in order to garner any of the benefits of calling). Bundling enables both higher profits and higher total welfare to be engendered. Consumers with high valuations for one product and low valuations for the other trade off the surplus gained from consuming the more-valued good against the smaller benefit gained from the less-valued good when making the decision to purchase the bundle. More units of the less-valued good are sold than if each is priced at cost. Tying is the special case of the purchase of one good only being possible if the other is also purchased (Carlton & Perloff, 2005:319-30).

Menus of two-part tariffs enable consumers with different valuations of each of connection and usage to select the bundle that offers them highest welfare. Consumers with lower usage volumes (e.g. making fewer calls or using fewer call minutes) can purchase a connection at a low fixed monthly charge, but pay a higher price per minute of usage (Carlton & Perloff, 2005:317). Miravete (2003) indicates that telephony consumers are remarkably good at choosing the plan that renders them most welfare for their individual usage patterns, and are quick to substitute when a change in plan or usage renders them worse off than under an alternative.

2.1 Price Discrimination and Technology Diffusion

Two part tariffs are a form of price discrimination, as they result in those subscribers on a given tariff consuming higher usage volumes (call numbers, call minutes or megabytes consumed) paying a higher effective per-unit charge for their bundle of connection and usage than those with lower usage volumes charged the same tariff (Carlton & Perloff, 2005:296-308). In effect, the tariff acts as a progressive 'tax' on usage. The more calls made, the higher the effective tax rate. Those making most calls (presumably because they value calling more highly) pay more of the subsidy towards connection than those making fewer calls (who presumably value calling less). Welfare is maximised under two-part tariffs when the connection charge recovers all of the fixed costs incurred in providing connections, and the usage charge is set at marginal cost.

Price discrimination is common in industries characterised by high fixed costs and low marginal costs, notably software, live and recorded entertainment, and print media, in addition to its widespread use in telecommunications and other network industries such as electricity generation and distribution. As long as resale between customer groups can be prevented (e.g. by technological blocks or other factors such as the time of consumption providing additional value for some consumers), those valuing the good more highly can be separated by their consumption behaviour and charged a higher price than those valuing it less highly. Welfare is increased, relative to the case of charging only a single, high price. Price discrimination can be used to increase profits. However, if the surpluses gained from charging high prices to high-valuing consumers to cover losses incurred in supplying low-valuing consumers at prices below cost, then welfare can be increased without necessarily creating additional supplier rents. Under some circumstances, such pricing can make it feasible to produce when a missing market would arise if the product was sold at a single price (Appendix 1).

Two-part tariffs have played an important role in promoting the diffusion of fixed telephone connections, especially in the very price-sensitive residential market. If the connection component of the charge is discounted below the level required to recover a proportionate share of fixed costs (in effect subsidised from a charge above marginal cost for the usage component), those with lower valuations of the bundle due to their low value of connection[2] will purchase connections that they would not purchase if they were offered at cost, albeit with some trade-off in the reduction in call volumes attendant to the higher per-unit costs of usage (Laffont & Tirole, 2002). If the welfare gains from the extra connections sold and the realisation of increased network effects and other social benefits exceeding individual ones outweigh the losses from lower usage, the outcome is both increased uptake of the technology in question and higher total welfare. The diffusion duration is effectively shortened, and even more individuals will purchase than if connection was priced at cost.

2.2 'Flat-Rate' Tariffs and Diffusion

By contrast, broadband internet access is typically sold as a 'flat rate' bundle. Under flat rate tariffs, the subsidy effect works in reverse to a two-part tariff. Low volume users face a higher per-unit price and therefore subsidise high volume users, whose price per unit consumed is effectively lower. The 'tax' is regressive, as those who consume least pay the highest per-unit rate.

[2] If calls are valued highly, then connection purchase will occur simply because it is a pre-requisite to making the calls in the first place.

The effect of the subsidy will be to induce even higher levels of consumption amongst all users relative to cost-based usage pricing, as all individuals with a connection will now consume to the point where the marginal benefit of usage equals zero rather than a non-zero usage charge. Recovering the additional costs incurred by higher usage volumes requires the network operator to charge even higher connection prices to all customers. As the price of the bundle rises to cover the costs of additional usage, at the margin it will be the low-volume users who would otherwise underwrite the subsidies to the heavy users who will be cease purchasing. Fewer connections will be sold than under the counterfactual of cost-based usage pricing. Essentially, welfare accruing from additional usage (including that which is very low-valued as it falls below the marginal cost of production) is prioritised over welfare accruing from additional connections as the technology diffuses.

Intuitively, a flat-rate broadband tariff structure is counterproductive if, as postulated by a large number of policy bodies (e.g. OECD, 2001), widespread and rapid uptake of broadband connections (as opposed to usage) is necessary to enable the wider social benefits of the 'information economy' to be harvested. If diffusion of the technology into the price-sensitive household sector is a key objective of policy-makers and regulators, then as has occurred historically in the fixed line and mobile telephony markets, both the rate of uptake and the number of connection sold would increase if two-part tariffs were mandated and the use of flat-rate tariffs restricted. The intuition appears supported by data indicating that for flat-rate broadband package purchasers, median consumption levels fall substantially below average consumption. That is, the majority of flat-rate consumers are low-volume user, who are subsidising a minority of very high-volume consumers. For example, Howell (2003:31) finds that in the New Zealand market, average usage for a flat rate product with usage capped at 5000Mb/month was only 1500 Mb/month and median usage 700Mb/month. These usage levels were observed even though the New Zealand market offers an extensive menu of two-part tariffs.

2.3 A Two-Sided Market View of Flat-Rate Tariffs

Further insights into the broadband tariff 'anomaly' come from considering flat-rate tariffs as a form of two-sided market (Rochet & Tirole, 2002;2003;2004; Wright, 2004; Evans & Schmalansee, 2005; Parker & Van Alstyne, 2005; Eisenmann, Parker & Van Alstyne, 2006). Using Parker & Van Alstyne's (2005) typology, on the 'money side' of the market are low volume users, who pay more than their own usage costs in order to underwrite the high volumes of usage on the 'subsidy side' of the market. A two-sided market flourishes because the subsidy enables both sides of the market to grow in order to capitalise upon the network effects to a greater extent than would occur if cost-based prices were charged on each side (Wright, 2004). Pivotal to capitalising on the network effects is the relative demand elasticity of each side of the market. Optimally, the subsidy is offered to the side of the market whose demand is more elastic as increasing prices charged to that side will have a bigger impact upon total network size than if the price is raised to the less elastic party on the other side (Eisenmann, Parker & Van Alstyne, 2006).

Using two-sided market logic, it would appear that for the flat-rate broadband packages observed in practice to be the dominant form of purchase, it is the high volume users who have the more elastic usage demand. By contrast, the usage demand of low-volume users must be less elastic. If not, they would opt for more cost-effective two-part tariffs were they available, or not purchase in the first place if only flat-rate tariffs were offered.

This finding suggests a very different pattern of consumer valuations of connection and usage prevails in the flat-rate broadband market than has been presumed in the two-part tariff telephony market. In the voice market, high call numbers or minute volumes were assumed to be indicative of a high valuation of calling. For a large number of low-volume broadband users to continue to subsidise a small number of high-volume ones, on average their valuation of connection must substantially exceed their valuation of usage. Unlike the telephony market, where as a consequence of extensive use of two-part tariffs, it has been presumed that high volume users were those who valued usage highly, the opposite is the case in the broadband market where flat-rate tariffs prevail. Increasingly higher usage volumes by a given consumer are associated with increasingly lower marginal valuation of that usage.

2.4 Strategic Use of Tariff Structures Over the Product Life Cycle

Of the explanations suggested to explain the popularity of flat-rate tariffs for broadband purchase, the most-offered is that such tariffs offer consumers ‘insurance’ against an unexpectedly high bill under two-part tariffs, possibly because consumers are unaware of the extent of their data transfer volumes (Ananaia & Solomon, 1997). This is likely to be an especial problem in the early stages of a new technology diffusing, where new applications are being used and consumers face an information asymmetry that takes time and experience to overcome (Brownlee, 1997). However, it seems less plausible as the technology matures, and user learning takes place. Whilst new applications may lead to initially uncertain increases in consumption, the effect is only at the margins, and it is increasingly easier to isolate the effect of new applications over time if they are adopted incrementally rather than simultaneously. By comparison, residential electricity is a mature GPT sold in tied bundles of connection and usage that continues to be sold almost exclusively under two-part tariffs. This occurs despite most consumers being unaware of the relative contribution towards the total cost from a myriad of different household appliances with different marginal contributions to the bill, and where consumers are continually purchasing new appliances that add to the total household consumption of electricity and hence the size of the bill.

2.4.1 Two-Part Tariffs to Increase Subscription Numbers

An alternative view is that current consumer preferences for flat-rate broadband tariffs are more plausibly explained by product life cycle factors. Early adopters value connection to the technology more highly than average, and are prepared to pay a premium to gain access to it, even though their usage volumes (and valuation of that usage) may be low. Flat-rate broadband tariffs offer a strategic means of producers with market power extracting maximum connection payments from early adopters with high connection valuation (i.e. inelastic demand) and hence high willingness to pay. Whilst some consumers will also have high usage valuations, and proceed to also become very heavy users, the majority have low usage valuations. Their usage demand is quite elastic, even though their connection demand is inelastic, consistent with recent survey data suggesting most existing broadband users are not prepared to pay very much for substantially faster broadband connections (Horrigan, 2006; EU, 2006[3]). The logic is also consistent with Horrigan's observation that usage volume appears to decrease as income increases. Those with higher incomes are more likely to be less price-sensitive, consistent with the assessment that broadband is still a 'luxury good' in the early stages of its diffusion.

However, once all the early adopters have purchased at the initial flat rate offer, network operators can accrue additional revenues only by increasing customer numbers (increasing unmetered usage by existing customers adds no further revenues, and incurs costs as bandwidth required increases). This necessitates lowering the connection price to attract lower-valuing consumers. To avoid losing existing knowledgeable high-value, low volume consumers to the new, lower tariff, it cannot be offered as a flat rate. Connection and usage must therefore be charged as a two-part tariff. Existing, knowledgeable low-volume users for whom the new tariff offers greater welfare may substitute, but as most are not especially price-sensitive, it is quite likely that many will remain on the flat rate tariff, especially if switching costs are high. Indeed, switching costs can be raised for the most recent, marginally price-sensitive customers who are most likely to substitute by 'locking them in' to

[3] http://ec.europa.eu/information_society/policy/ecomm/doc/info_centre/studies_ext_consult/ecomm_household_study/eb_jul06_main_report_en.pdf

minimum subscription periods (12 months are common in many markets, some are as high as 24 months) when they purchase the flat-rate tariff. Existing high volume users will remain on the flat rate as the usage charges will result in their costs exceeding the existing flat rate.

Thus, the pattern of increasing numbers of two-part broadband tariffs being offered as diffusion increases in the markets where only flat rate tariffs were offered initially (OECD, 2007) is consistent with strategic use of pricing structures across the product life cycle in order to maximise profits rather than to maximise connections sold or total welfare. The good has passed beyond the 'critical mass' and is moving from being a 'luxury item' to a 'mainstream commodity'. The pattern is also symptomatic of the gradual eroding of the market power of the first providers as entry increases and competition becomes more intense (e.g. product variation in the market for otherwise undifferentiated wholesale and bitstream products). The pattern also explains why the most ardent advocates of flat-rate tariffs are the disproportionately small group of high-volume users, who benefit most by having their lower-value usage subsidised by others, and those network operators who by dint of being the first service operators in the market may have been extracting rents from low-using early adopters.

2.4.2 Product Bundling to Attract Laggard Purchasers

Strategic pricing over a broadband product life cycle where flat-rate tariffs are the first offered may also plausibly explain the extensive use of bundling as the product becomes more widely diffused. Rather than cannibalising existing rents from high-valuing low-volume users, it may be more profitable to retain the flat-rate internet package, and bundle it with another product. Ideally that product should be one that is not highly-valued by the broadband early adopters (to avoid cannibalisation of existing revenues from broadband consumers already purchasing that product), but has a large number of existing consumers who value it highly, but have lower valuations of broadband (e.g. video content, fixed line telephony, long distance calling., mobile telephony – the classic triple and quadruple play). By arbitraging off consumer welfare accrued on the more highly-valued product, the less highly-valued one is purchased at a lower effective price than the stand-alone price, whilst maintaining the ability to price discriminately in each of the original markets to those consumers who do not value the other technology sufficiently to purchase it even at the marginal bundled price net of any surplus remaining after purchasing the more-valued product.

As the new broadband customers buying the bundle are consumers valuing broadband connection and usage at less than the flat-rate price, their usage is not likely to be high. They contribute an additional fixed sum towards the cost of the broadband network which, as long as it at least covers their additional costs of physical connection, preserves any profits already accrued by the operator in the flat-rate market. Likewise, as long as any price charged to existing broadband consumers to purchase the new product exceeds their connection costs, margins in that market are preserved also (Carlton & Perloff, 2005:321-2). Specifically, if the marginal costs of servicing each user of the newly-bundled products are low compared to fixed costs, under classic price discrimination reasoning, such a strategy actually increases all of profits, diffusion of both products and consumer welfare (Bakos & Brynjolfsson, 1999).

Bundling across product markets in this manner plausibly explains why, despite prices being similar, empirical studies have found competition between platforms (cable and DSL) is more statistically significantly associated with and has a larger empirical effect on, broadband uptake than in competition on a single platform (e.g. unbundled DSL) (Distaso. Lupi & Manenti, 2006; Denni & Gruber, 2005). Product bundling from another medium (e.g. cable television) maximises the number of low-valuing broadband consumers purchasing the technology, relative to only those consumers having access only to bundles of telephony-based broadband and its associated products (voice telephony, long-distance calling)[4].

3. *Flat Rate Tariffs and Technological Substitution*

Whilst the preceding section describes the strategic use of tariff structure across the life-cycle of a new technology, it does not address the question of how tariff structure affects the diffusion of a new generation of a given technology, especially if extensive cross-subsidisation is already occurring in the legacy technology market as a consequence of extensive use of flat-rate tariffs and bundling. This issue has already been confronted in respect of the internet access market, where legacy dial-up internet access and 2G mobile telephony, have been superseded by frontier broadband and 3G mobile technologies respectively. It will also be confronted in the future, when copper-based broadband technologies become the legacy and are superseded by the new fibre-based frontiers.

[4] It is noted, however, that an especial benefit arises from bundling broadband services with PSTN voice services. As dial-up internet access on the PSTN is substituted by broadband, the substituting consumer's valuation of the PSTN for voice telephony will decrease but not be removed completely. Dial-up internet use is shifted from one technology to the other, decreasing the value of one technology and increasing the value of the other. Tying two products, the consumer valuations of which are almost certainly negatively correlated with each other, offers the best possible scenario for maximising the profits from bundling, in addition to the welfare gains from selling to a larger number of low-valuing consumers on each of the networks.

3.1 *The New Zealand Case*

The tariff structure element of the substitution dilemma is illustrated cogently by the introduction of dial-up internet access and its successor ADSL broadband in the New Zealand telephony market. Since the introduction of telephony to the country in 1879, when the Superintendent of Telegraphs eschewed the practice of charging for calls connected within a given exchange as it was deemed too costly for telephonists to record the relevant details, New Zealand has had 'free local calling' – that is, flat-rate local telephony charges (Howell, 2007). Over time, the 'free local calling zones' became determined by political rather than exchange technology considerations. .

Consequently, the New Zealand 'free local calling' areas are amongst the most extensive in the world (NZIER, 2005). Whilst the tariff policy has resulted in New Zealand having a lower fixed line teledensity than most other OECD countries (OECD, 2003), the volume of calls made is very much larger than in the average OECD country where either call minutes or the number of calls made were subject to a charge (NZIER, 2005; Howell & Sangekar, 2008). The obligation to continue offering free local calling was transferred to the new owners of the incumbent when it was privatised in 1990 (Howell, 2007). Furthermore, New Zealand also has a long history of universal service pricing for telephone connections. The very large numbers of urban consumers pay a premium above cost to subsidise the minority of rural consumers who pay the same monthly tariff, even though the costs they impose are higher. The 'universal service' obligation was also transferred to the private sector owners.

Despite exhibiting one of the highest rates of both uptake and usage of the internet in the OECD between 1996 and 2003 (Howell, 2003), in June 2007, New Zealand exhibited one of the lowest rates of broadband uptake (20th in the OECD and below the OECD average – OECD, 2008), despite having one of the most widespread ADSL networks of high quality and offered at comparatively low prices (Howell, 2008; OECD, 2008). Furthermore, unlike in most other OECD countries, New Zealand's broadband packages have always been offered as menus of two-part tariffs[5], albeit with some of the lowest charges per additional megabyte downloaded[6]. Whilst this should have, all other things being equal, have accelerated the rate of broadband usage amongst a highly-connected, high-using population relative to other

[5] Principally due to the fact that over 90% of New Zealand's internet traffic is downloaded from offshore, via the solitary trans-Pacific Southern Cross Cable and by dint of the fact that this cable 'peers' with the worldwide web in the United States, the small number of New Zealand users must pay a disproportionate share of the cost of data transport relative to other markets where traffic volumes exchanged are more symmetric and the distances to the peering point are more even.

[6] http://www.oecd.org/dataoecd/10/49/39575048.xls

countries where flat-rate broadband offers prevailed, the opposite appears to have occurred in New Zealand. The hypothesis derived from the preceding discussion is that New Zealand's slow broadband uptake is in large part attributable to the flat-rate tariff under which the dial-up internet product was sold. That is, flat-rate dial-up tariffs have resulted in the New Zealand broadband diffusion curve lagging the curve of the 'average' OECD country where two-part dial-up internet tariffs prevailed.

3.2 Bundling, Flat-Rate Tariffs and Substitution

Although dial-up internet technology can be considered a legacy technology, enabling examination of each of the components of connection and usage in prices charged for both it and the frontier broadband technology, it must be taken into account that at the outset, by dint of technological fortune, dial-up internet access and usage were offered as a bundle with existing dial-up voice technology. As the New Zealand case illustrates, this has influenced initial tariffs for both connection and usage of dial-up access. The starting point for analysis must be the patterns of connection and usage induced by the initial bundling, as well as the tariff structure itself.

3.2.1 Bundling Confers a 'Connection Gift'

Due to the 'bundling' of voice telephony and dial-up Internet access, in respect of the telephony component of internet access, existing telephony customers were 'gifted' a free internet connection, regardless of how highly they valued it. The higher the fixed price charged for the connection component of internet access, the greater the extent of the 'connection gift' offered by connection bundling. The connection gift was greatest in respect of those subscribing to 'flat-rate' telephony tariffs, as the higher volume of usage in these accounts would have necessitated a higher fixed charge to compensate for the even greater volumes of usage incurred.

When broadband internet access was introduced, users assessing the desirability of substituting from dial-up to broadband internet access were required to assess not the absolute the price of the access component of broadband, but the marginal outlay given the value of the existing dial-up connection 'gift'. For a given broadband access price, the valuation of internet connection at which the marginal dial-up user subscribing to a flat-rate telephony tariff will substitute is higher than the valuation of the marginal two-part tariff subscriber. The lower the fixed component of the dial-up two-part tariff (i.e. if usage priced above cost was used to subsidise connections, thereby lowering the connection cost to speed up telephony diffusion), the lower the valuation of internet connection at which the marginal user would substitute (Howell, 2008).

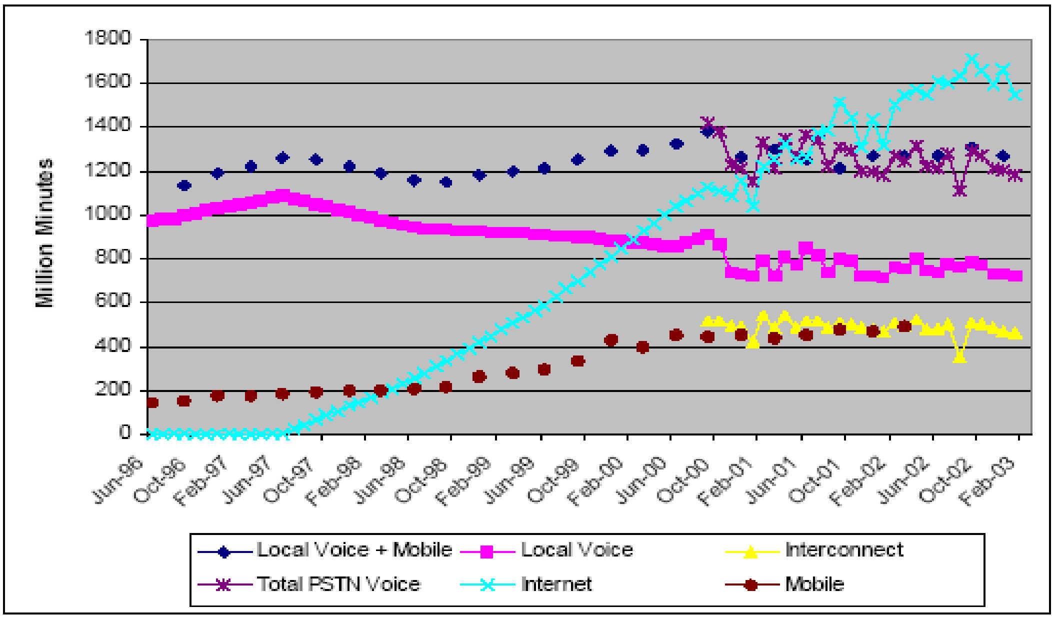
If valuations of internet connection and usage are identically distributed across two populations, one with flat-rate access only and one with two-part tariffs, on the basis of the connection gift alone the population facing a two-part tariff will exhibit earlier substitution to broadband than the flat-rate tariff market (that is, as per Figure 1, the broadband diffusion curve of the two-part tariff market will sit to the left of the curve for the flat-rate tariff market). The smaller the fixed price component in the two-part tariff market, the greater will be the time lag observed in the broadband diffusion curves of the two populations (i.e. the greater will be the gap between the two curves).

In the New Zealand case, due to the combined effect of flat-rate dial-up tariffs and the universal service obligation, the internet 'connection gift' was likely the most substantial in the OECD. Thus, it would be expected that the New Zealand broadband diffusion curve 'connection gift' lag relative to an optimal two-part tariff would be the largest in the OECD. Moreover, the lag behind any country still subsidising PSTN connections from usage would be even greater.

3.2.2 Flat-Rate Tariff Confers a 'Usage Gift'

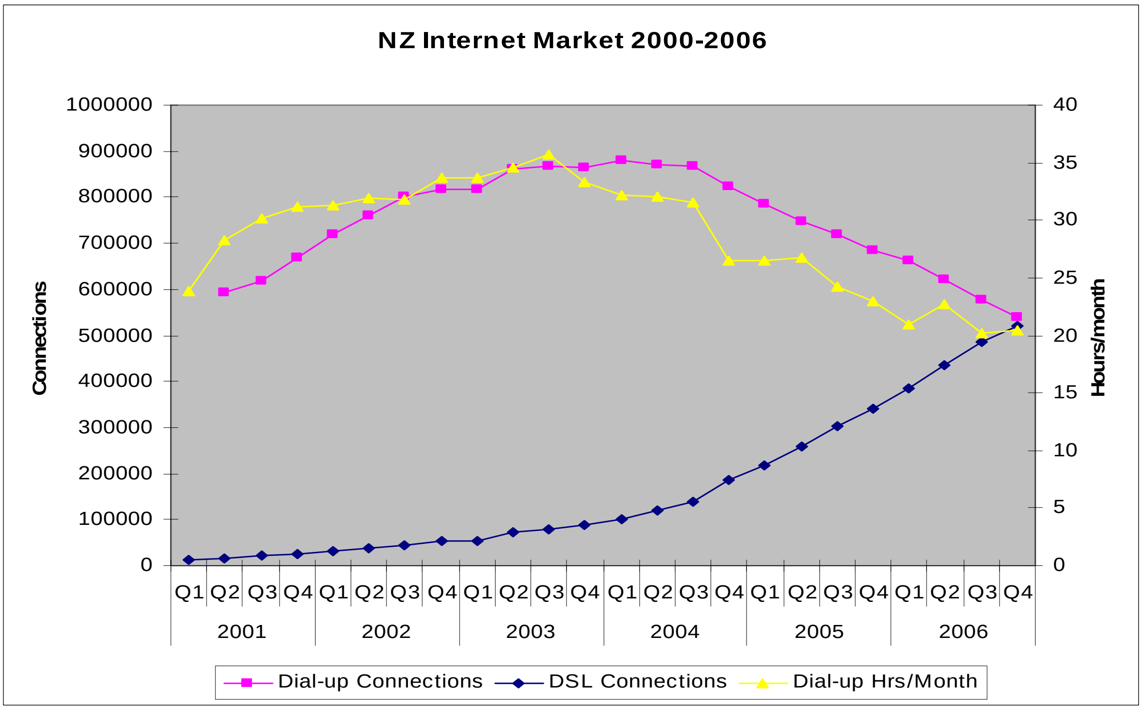
As flat rate tariffs induce usage up to the point where the marginal benefit of usage is zero, bundling dial-up internet access with voice telephony results in the maximum possible use of the technology, regardless of the individuals' valuation of connection (also gifted). Thus it is not surprising to find that not only were New Zealanders amongst the most prolific connectors to the internet (measured in ISP accounts per capita) (Howell, 2003), but also amongst the most prolific users (OECD, 2000). Figures 2 and 3 illustrate both the huge increase in PSTN traffic following the introduction of dial-up internet access, and the very high volumes of connection time – averaging 35 hours per month for each of the 850,000 dial-up accounts at peak. However, as has been noted above, most of this huge volume of usage is very low-valued. Indeed, much of it will be incurred by individuals with both a low value of internet connection and a low value of usage, who may not have purchased either if they were not gifted but instead offered at cost.

Figure 2. New Zealand Telephone Traffic 1996-2003



Source: Howell & Obren (2003:33).

Figure 3



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

As with the 'connection gift', the 'usage gift' affects the point at which a user with a given pair of connection and usage values will substitute to broadband. The higher the usage charge, the lower the volume of usage at which there is a net benefit to the user of substituting to broadband. In the hypothetical populations above, once again at the extreme, flat-rate dial-up internet users will, all other things being equal, exhibit the highest volumes of usage at which the marginal substitution takes place. If, as Figure 3 suggests, substitution to broadband occurs because, over time, internet users are incurring more usage, to the point where the benefits (in time savings) of shifting that usage to faster broadband finally outweigh the benefits of the usage gift, once again, it would be expected to see the diffusion curves of flat-rate tariff markets lagging those of markets where two-part tariffs are charged. The lag will be greater the larger is the charge for usage levied under the two-part tariff.

It can now be seen that flat-rate tariffs for dial-up internet access impose a 'double delay penalty' in the timing of substitution from dial-up internet access to broadband access relative to a two-part tariff, via each of the connection and usage effects. The effect of the delay will be greatest in relation to those two-part tariffs where connection has been most extensively discounted and usage charges increased in order to encourage higher diffusion of the legacy voice telephony technology with which dial-up internet access has been bundled. As New Zealand sits at the extreme opposite end of the spectrum, in respect of its flat rate dial-up tariffs and universal service obligations, the lag in the country's diffusion curve from the two-part tariff optimum would be expected to be the most extensive in the OECD.

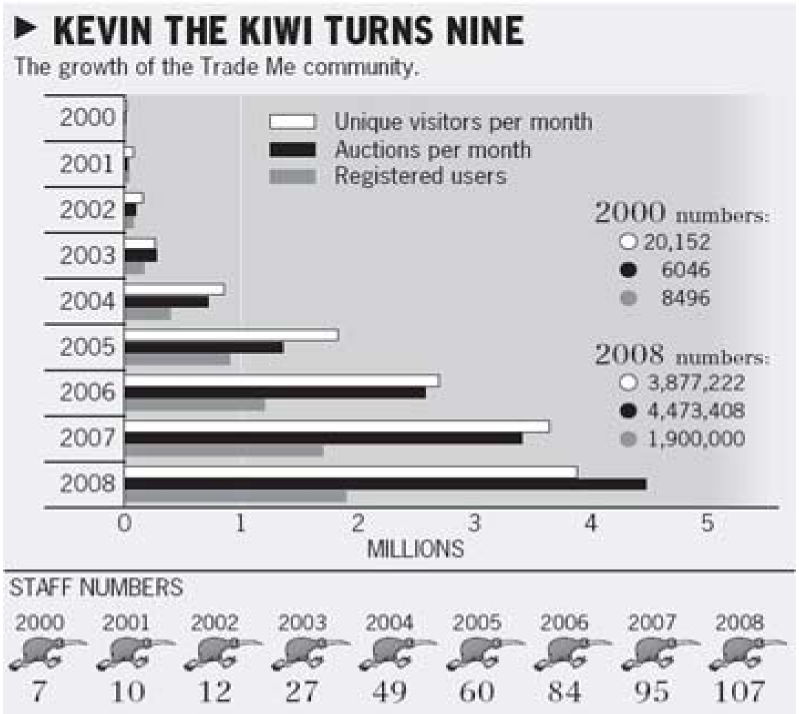
3.2.3 Diffusion Time Lags and the Value of Usage

Figure 3 confirms that, although New Zealand might lag most of the OECD in respect of the point in time when the broadband market passed the 'critical mass' point of 5% of potential diffusion, the effect has been simply a shift to the right of the curve on a time axis. The graph confirms that New Zealand's broadband uptake is almost perfectly accounted for by substitution from dial-up access. The market has gone from 5% diffusion in quarter 4 2003 to 50% diffusion in quarter 4 2006 (measured against the peak number of dial-up accounts as the addressable market). Over the period 2005-6, New Zealand's rate of broadband account growth was one of the fastest in the OECD (OECD, 2007). Figure 3 also confirms that the 'critical mass' 'tipping point' coincided with the point of maximum usage recorded per dial-up account.

As there were no significant changes in broadband price or other market characteristics around the tipping point, it would appear that in flat-rate legacy technology markets, it is only when an increasing volume of usage sufficiently affects the trade-off between the value of the legacy and the value of the frontier to the user that substitution will occur. This may be due to using the same internet applications more extensively, or adding new applications, notably those which offer significantly more benefit on the frontier than on the legacy (e.g. they cannot function effectively on the legacy. Widespread subscription to a new application or set of applications which are increasingly used (thereby increasing the value of internet use to consumers) appears to offer the best explanation for the timing of New Zealand's 'tipping point'.

Whilst peer-to-peer applications such as Skype, YouTube, Facebook and Bebo are universal and started to come into mainstream use around 2003, their use is still confined to a minority of the population. A New Zealand-specific explanation for increasing widespread broadband account sales likely lies in the country's most-visited web property, the consumer-to-consumer trading portal TradeMe. Figure 4 illustrates the expansion of TradeMe, the web pages of which comprise large quantities of rich graphic material which is very time-consuming to download and upload on dial-up. TradeMe is an application that offers a new set of value to New Zealand internet users that, through its diffusion, will increase the value of internet use for those who subscribe to its services.

Figure 4



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

In 2003, TradeMe had fewer than 150,000 members – about 0.2 per active internet account. By February 2008, it had nearly 2 million active members (2 per active internet account). New Zealand's total population is only just over 4 million, indicating very widespread diffusion of the application. Page views averaged over one billion a month – the equivalent of over 520 per member per month, or over 1000 per active internet account. Of the 2 million members, on average each accesses the site from two unique computer addresses (likely home and work). These volumes of TradeMe activity would suggest that the average value of internet use has increased markedly over the period as large numbers of New Zealanders substitute from other methods of consumer-to-consumer trading (e.g. classified advertisements; garage, car boot and jumble sales; physical marketplaces) to electronic exchange. For the large numbers of New Zealanders now using the site, it is this demand-side usage factor, rather than any supply-side broadband price or availability factors, that appear to be driving broadband connection purchase. Co-incidentally, the growth of TradeMe membership (Figure 4) and page view volumes is almost perfectly correlated with the growth of broadband connection purchase (Figure 3).

4. Implications

By separating out the effects of connection and usage in two-part tariffs, this paper has shown that flat-rate tariffs in the first instance slow the diffusion of a new technology relative to an optimal two-part tariff, and in the second instance delay the substitution from a legacy technology to a frontier one. The delay in substitution is even further exacerbated if the initial connection is 'gifted' or subsidised on some form as a consequence of it being purchased in a bundle (i.e. if it is purchased as the lower-valued item in a bundle where the choice to buy relies upon the existence of consumer surplus from the higher-valued good). In order to induce substitution, the consumer must value the benefits sufficiently more than the price paid. If the consumer values the good lowly and is only purchasing it because of either the bundle subsidy ('connection gift') or flat-rate tariff 'usage gift', then the low-valuing users will substitute only when the new good is offered at a price lower than their existing low valuations, or some other exogenous factor (e.g. the development of new applications capable only of functioning on the frontier technology) leads to them increasing their valuations of either connection or usage substantially.

The implications are significant for the migration of users from flat-rate and bundled broadband connections to the new frontier technology, fibre-based internet connections. Unless these technologies are associated with new applications unable to be offered on existing technologies (e.g. ADSL-2), then although a small number of early adopters will substitute, the rate at which the vast majority of existing users will substitute will be delayed relative to the case of two-part tariffs or unbundled products.

There are risks also for network operators, regulators and policy-makers in making the decisions to invest or regulate networks where the products are extensively cross-subsidised from either flat-rate tariffs or bundling. Such tariffs obfuscate information otherwise available about consumers' respective valuations normally available from self-selected two-part tariffs. Without more fully understanding the relationships between the consumers' respective valuations of each of the separate connection and usage components, it is possible to made incorrect assumptions about the appropriate time to invest or regulate a network, or inappropriately price products offered on it. This indicates that effective management and regulation of networks where flat-rate tariffs and bundling prevail necessitates information about patterns of usage as well as patterns of connection. It is not sufficient to presume that past information supporting the management and regulation of markets where two-part tariffs prevailed will suffice in flat-rate and bundled tariff markets.

The salutary lesson in this respect lies in the New Zealand case. In 2006, the government introduced local loop unbundling regulation of the incumbent telecommunications provider because broadband uptake was not occurring as fast in New Zealand as in other OECD countries (MED, 2006). The analysis supporting the regulation consisted almost-exclusively of supply-side factors and failed to take into account the effects of tariff structure (either the historic use of two-part broadband tariffs which would have increased the diffusion rate or flat-rate dial-up tariffs which would have delayed it) on diffusion (Howell, 2007). The risk is that, as occurred in New Zealand in 2006, additional regulation will be introduced to 'speed up' diffusion of a technology when in the Zealand case, retail tariff regulation or historic commercial pricing patterns in the legacy market are a principal cause of delayed diffusion.

Ultimately, technology diffusion is the result of the interaction of supply and demand characteristics. Consumer valuations are the means by which demand enters these interactions. Tariff structure for telecommunications products must take into account both connection and utilisation components. Unless both of these factors are considered, both firm strategy and regulation may be misguided, harming both profitability and social welfare.

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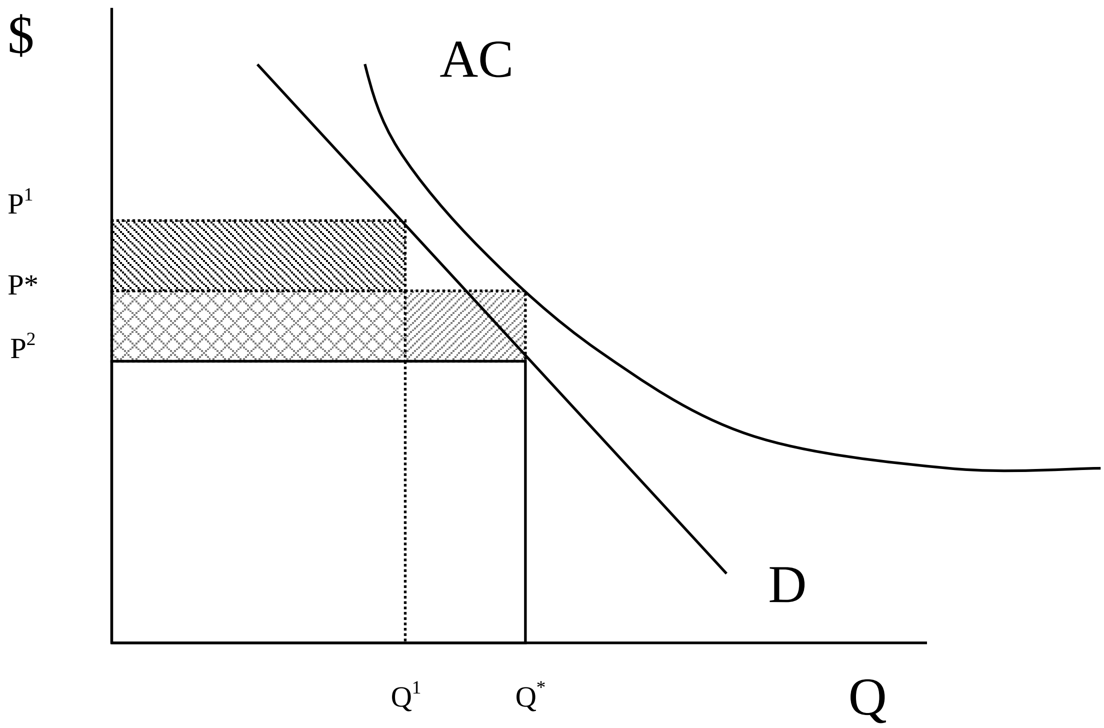
Appendix 1: Price Discrimination and Missing Markets

In some circumstances, the demand for a good indicates consumers are unwilling to pay the costs of production, even though they would derive some welfare from the good. This gives rise to typical 'missing market'. The good is not produced. However, over that portion of the cost curve where economies of scale exist (i.e. the average cost curve is downward-sloping), if it is possible to separate high-valuing customers from low-valuing ones and prevent resale, it may be feasible to charge two prices in such a manner that the firm can recover its costs and therefore justify producing. Figure A1 illustrates.

Figure A1: Price Discrimination Overcomes Missing Market



By producing the larger quantity Q^*, the producer access economies of scale by producing at an average cost of P*. Given the demand curve D above, the producer can sell the first Q^1 units at price P^1 above average cost, generating profits (producer surplus) represented by top left (diagonal stripes top left to bottom right). The next Q^*- Q^1 units are sold at P^2 less than cost, incurring a loss represented by the bottom right rectangle (diagonal stripes bottom left to top right). As only Q^* units are sold in total, as long as the profits incurred on the sale of the first Q^1 units exceed the losses on the next Q^*- Q^1 units, the producer has net profits so will produce the good. Price discrimination thus leads to a good being produced, and welfare accrued from its consumption and production, that would not accrue if the good was sold at a single price.