A Cost-Benefit Analysis of Implementing Mobile Number Portability in Bahrain

Report to Batelco - February 2008
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1 Executive Summary

This report provides the first national cost-benefit analysis of technical options for the introduction of mobile number portability (MNP) in Bahrain. It concludes that the main technical options (Onward Routing and All Call Query) employed in markets with MNP are too costly for Bahrain. Also, they will be overtaken by technological changes which will change how we think about numbering and customer switching. This report recommends an alternative option to facilitate switching between carriers (Temporary Diversion) that should meet regulatory objectives and is more efficient and quicker to implement than the traditional technical options.

The implementation of MNP is a complex and significant undertaking as it over-turns a fundamental assumption in the way networks are built – that number blocks are associated with a particular service provider. Implementing MNP involves large up-front fixed costs; and with an Onward Routing solution there are also large on-going costs. These costs are incurred by all operators.

The appropriate way to test whether there is "sufficient demand" for mobile number portability is cost benefit analysis – surveys of demand are unreliable, as observed overseas. On our analysis, the implementation of traditional technical options for mobile number portability in a small market like Bahrain is not efficient – costs outweigh benefits.

Overseas experience of MNP is mixed. It is not clear whether the percent of mobile customers who use mobile number portability in any year (the port rate) will be in single digits (like the UK and Australia) or in double digits (like Hong Kong and Finland). This report models both scenarios and the conclusion does not change – only Temporary Diversion proves-in on the cost-benefit analysis.

There are several reasons to expect that demand for mobile number portability in Bahrain might be lower than used in either scenario in this report. First, there is the poor take-up of fixed carrier preselection in Bahrain. Second, modern mobile phones make updating contact lists very easy; and calling circles are often small. Third, the use of two SIM cards is already very high by international standards and with mobile penetration well over 100 percent, it will increase. This multiple use is not due to the lack of portability but to take advantage of different pricing schemes. And, new phones make using multiple SIM cards easier. Fourth, competition is likely to be fiercer because the market is mature and customers may not see enough reason to switch despite a porting option. And, while voice and SMS services can be ported, there are new services available today on mobile phones that cannot be ported (eg MMS, email).

In this environment and given the cost-benefit analysis of technical options, the most efficient and quickest way to facilitate customer switching in Bahrain is Temporary Diversion.

2 Introduction and Overview

This report provides an analysis of the technical options and their associated costs and benefits for the introduction of mobile number portability (MNP) in Bahrain. The two main technical options employed in markets with MNP ("All Call Query" and "Onward Routing") are costly for a small country and will be overtaken by new options arising from new generation networks (NGNs). So, a third option of "Temporary Diversion" which is more economical and meets regulatory objectives is also considered.

The Telecommunications Regulatory Authority (TRA) of the Kingdom of Bahrain released its ***Strategic and Retail Market Review*** for public consultation on the 27th August 2007. It makes many references to the issue of number portability in its various forms throughout the report.[1]

At the invitation of Batelco, Hibbard Consulting has undertaken a cost-benefit study of introducing mobile number portability in Bahrain under three technology choices:

1. Database with All Call Query (ACQ); an advanced solution for MNP,
2. Onward Routing (OR); which is used in many markets (eg UK) and
3. Temporary Diversion (TD); which we think is a practical solution for Bahrain

These technical options were presented to the TRA at a presentation on 8th November and are discussed again below in Section 4.

In Section 3 below, we discuss the different concepts of number portability and their relevance to Bahrain. This section also looks at some of the practical issues, options and decisions associated with the introduction of the different types of number portability. But, we have chosen to focus on mobile number portability (MNP) because it is more important than fixed number portability (FNP) in Bahrain (both in terms of the number of subscribers and the importance of each issue to business users) and MNP includes all the costing and other issues that would apply to FNP, as well as many that are specific to mobiles (ie it is more complex than FNP).

Section 4 discusses the role of cost-benefit analysis in public policy. We also show with international experience that surveys are a poor guide to take-up of MNP. The section also provides the standard taxonomy of the benefits of number portability and how they have been estimated in this study. We note that the public Type 2 benefits of MNP are likely to be small relative to other drivers of efficiency. We have not attempted to quantify these benefits or the costs imposed by the lack of tariff transparency introduced by MNP.

Section 5 discusses the past, present and future techniques of implementing number portability. It also provides estimates of the costs for each of three technology options used in the cost-benefit analysis of implementing MNP in Bahrain. Of the two main systems, OR

[1] Sections 11.2.2 and 11.2.3 on fixed and mobile telephony.

is cheaper than ACQ for Bahrain. But, we recommend that a close substitute for MNP, which we term TD, be considered for Bahrain as a cheaper and quicker way to meet regulatory objectives.

Section 6 discusses the estimation of the economic benefits of implementing number portability in Bahrain. It reconciles the different views of current churn rates in Bahrain and provides international evidence on churn and port rates associated with MNP. A key question is whether Bahrain will have more in common with Hong Kong and Finland or with the Australia, UK and the Netherlands. We suspect the latter but provide two scenarios for each of the three technology options.

Section 7 discusses charging principles for cost recovery. A basic economic principle is that an efficient charge for porting is not zero (except for public goods). There should be a Donor Network port fee even if the Recipient Network chooses not to pass that on to the customer at full cost. We also note that there is a case for a government subsidy to cover fixed costs. There is no clear relationship between port fees and port rates.

Section 8 provides the results and a summary of findings and recommendations. Our key finding is that there is no economic case for MNP, but there are net benefits for its temporary and close substitute, TD, which is efficient and meets the regulatory objective to "*facilitate competition amongst existing operators, as well as supporting new entrants"*. The main reason for this result is that Bahrain is a small market.

Bahrain is a "late mover" so it can learn from past mistakes and seize new opportunities. In particular,

- MNP is not the driver of switching – it only facilitates it. Other countries have generally over-estimated the demand for MNP
- The industry is on the cusp of a major migration to all IP networks which will change the way we think about numbering and lead to more efficient solutions for customer switching

Countries that are now implementing MNP should consider using "bridge models" rather than investing in legacy network-based models which will become obsolete.

3 What is Number Portability?

It is generally considered there are three generic forms of number portability:

1. **Provider Portability**, where a customer is able to retain their service number while moving to a similar service delivered by a different Provider. It is the most widely adopted and is the focus of this paper.
2. **Service Portability** which enables a customer to move their service number between different service types eg fixed and mobile services. These arrangements are generally governed / constrained by the national number plan of a particular country and service provider offerings.
3. **Location Portability** which enables a customer to move the geographic location of their service while retaining their number.

3.1 Provider Portability:

The introduction of Provider Portability in the fixed (FNP) or mobiles (MNP) markets is a complex and significant undertaking as it separates a fundamental building block of telecommunications that has existed since its early existence ie that a block of numbers, whether a 1,000 numbers or a million number block, have been allocated to a particular provider for a particular service or location.

This has resulted in network and support system architectures that rely on that underlying assumption. Many systems consider only part of the number / prefix for their operation. Examples would include call routing where the prefix is analysed to determine the call type, provider, location, charging regime etc.

The introduction of portability breaks this fundamental assumption and its impact on increased complexity and costs, both implementation and on-going costs, is significant.

In our analysis of Provider Portability, it is assumed that number allocation arrangements would not be altered and blocks of numbers would still be allocated to providers. Any change from a block allocation approach to other more complex and costly methods has not been canvassed.

3.1.1 Fixed Number Portability

Fixed Number Portability (FNP) is also known as Local Number Portability (LNP).
FNP provides a customer the opportunity to transfer their service to a new provider and retain the use of their number. It does not involve the transfer of the service, features and information associated with that service only the migration of the number from the Donor Network[2] to the Recipient Network[3]. The service and its features need to be re-established

[2] Donor Network – the network with the number block from which the number is ported.

[3] Recipient Network – the network to which a number is ported. If the service associated with the number is terminated / cancelled the number reverts to the Donor. In addition, any subsequent port needs also to involve the Donor to ensure a cascading effect of porting is not established.

with the new provider on their network and customers need to be aware these may vary between networks. The regulatory objective of FNP is to foster competition and diversity; not to drive networks to offer identical services and features.

A diverse range of network technical options has been used to introduce FNP in other markets. These have ranged from:

- "simple" call forwarding ("on-switch") solutions where calls are delivered to the terminal exchange of the Donor network and then forwarded to the new / recipient network using a new called number [4] ; through to the
- "Intelligent network" ("off-switch") approach where all calls are analysed by the Donor Network using an IN look-up to determine which network owns the called number.

Following any decision to introduce FNP, there are many issues that need to be determined in relation to its introduction which include:

- Whether an "initial" lower cost solution is introduced as uncertainty normally exists on take-up rates. This provides the option to migrate to more complex but comprehensive solutions only if it is justified by porting volumes ;
- Who has the responsibility to determine the terminating network on a call ie is it undertaken early in the call at or near the origin, or delivered to the Donor network to determine? This matter links to network technology solutions.
- Is there any "obligation" on a Donor Network to provide transit routing on calls to numbers ported from its network.
- Costs and how additional call conveyance costs are compensated.
- The role the regulator takes in either
    - prescribing the technical network solution/s as well as other operational requirements, which would need to be implemented, or
    - adopting an outcomes focused approach where timing and customer experience are prescribed and the solution is left to the providers to develop.

While the second approach is often used, there would be a need for bilateral or multilateral arrangements to be established to determine the many common issues shared by the providers. These include not only technical network matters but also a broad range of operational procedural matters such as:

- Call routing arrangements and the need to prevent circular routing of calls ie where each network believes the caller party resides on the other network.
- The porting process and its many requirements including how customer validation, acknowledgement of a port and advice of completion are prescribed.

[4] It should be noted that customers, particularly business customers, with a driving need to retain their number while changing provider would normally having "call forwarding" options available to them to provide some (temporary) assistance. This could be utilised where their number is well known or important to them.

- While a customer is considered to hold a "right to use" a number and therefore to port it, does that right lapse upon cancellation / termination of a service?
- How outstanding or bad debts are handled and how that impacts on a customer's right to port a number. In many regimes debt settlement is a necessary pre-condition for porting a number.
- Commercial arrangements and the right to recoup additional per call and / or operational costs.
- What is the expected timeframe in which a port should occur? What are the normal hours of operation when porting should be available?
- With fixed services access infrastructure (eg WiMax or unbundled loop) that needs to be deployed with portability, how will changes be coordinated to minimise customer down time?
- Is there a need to establish a Register of Ported Numbers as the database of record? Is this a single common database or a series of databases held by the providers? Who has access to the data?
- How disputes are managed and resolved.
- When a number is ported in error, how reversals are managed.

3.1.2 Mobile Number Portability

Mobile Number Portability (MNP) provides a customer with the ability to change mobile provider and retain their mobile service number (MSN) / Mobile Subscriber ISDN (MSISDN) number.

Where a customer ports their MSN / MSISDN, they would be supplied a new SIM card and International Mobile Subscriber Identity (IMSI) by the Recipient Network. The IMSI is a unique global identifier held on the SIM card that is used by the GSM network to initiate calls and messaging to and from the mobile service.

While for the voice, fax and data components of a call to a ported mobile number is similar to that of a fixed number, as discussed above, there are other mobile centric matters, which need to be addressed. These include:

- Messaging, SMS and MMS, which require different routing systems from voice calls (eg SMS uses the SS7 signalling network), including the delivery of messages generated from outside Bahrain.
- Any impact on a customer's ability to roam onto international networks. .

MNP has been successfully introduced into a number of overseas countries and reports of its success often overlook the complexity, cost and significant difficulties that have presented themselves during its introduction and post MNP because of its complexity.

In Australia there have been several occurrences both at initial implementation and post-implementation where a network and / or operational procedures have not performed as expected for extended periods because of the complexity introduced by MNP. This has

resulted in frustrated customers and questions arising as to whether the conduct of a provider was anticompetitive.

3.2 Service Portability

Service Portability allows a customer to migrate to another service type and retain their service number/s.

Within the fixed network, it has been common for customers to migrate from PSTN to ISDN and maintain their numbers. Although network and system constraints normally resulted in the development of "local" rules as to what numbers or the size of a number block that could be moved.

These arrangements have only been used where it has not generally had an impact on callers to these numbers from a performance or charging perspective ie callers incurred similar call charges regardless of the terminating technology on calls to these fixed / geographic numbers. In the case of PSTN to ISDN porting, customers were able to obtain additional features and/or services without receiving any adverse "surprise" in relation to call charges.

In TRA's ***Strategic Review***, Service Portability between the fixed and mobile networks has been raised. Fixed to Mobile Service Portability would allow a number recognised as a "fixed" number, prefixed with a '1', '2' or '7' in Bahrain to be used as a mobile service, normally prefixed with a '3'.

If Provider Portability was introduced for the fixed and mobile networks, it would be technically possible at additional cost and complexity to expand it for Fixed to Mobile Service Portability. There are a number of significant matters that would need careful consideration before such an approach was mandated. These include:

- Retail call charging – callers and customers hold an expectation of the charges they will incur for a call depending on whether it is a Fixed or a Mobile call. This charging differential can be significant; in Bahrain a Fixed to Mobile call is double that of a Fixed to Fixed call[5]. Some examples of how other countries try to prevent a customer being "surprised" are discussed later around Table 1.
- Wholesale charging – which is primarily an operational matter of adding complexity and cost to the differential interconnection rating, charging and billing for fixed and mobile calls.
- Managing caller and customer expectations in relation to service features and performance such as porting times, international roaming and SMS, national and internationally originated and terminating.

That is, introducing Service Portability over the top of either FNP or MNP or both raises significant additional levels of complexity[6].

[5] Batelco's fixed to fixed tariff is 21 fils per 3 minutes and for fixed to mobile calls it is 21 fils every 90 seconds.

[6] While unusual, it is possible to see how Service Portability could be used to allow mobile numbers

Fixed mobile convergence (FMC) has been hampered by the different regulation of different access technologies in terms of factors such as licensing, call charges, numbering and service features. The widespread deployment of IP / packet based backbone and access, wire line and wireless, networks creates an opportunity to pass over these distinctions (not only between fixed and mobile access but also with others such as broadcasting). The new IP technologies could potentially allow customers seamless voice, video or messaging services independent of the access technology utilised. Service Portability between fixed and mobile services has to be seen in this larger context that is emerging.

3.3 Location Portability

Mobile numbers are not constrained by location constraints on numbers. However, fixed numbers are generally constrained by the charging and billing regime within the country, the national number plan and service provider offerings. This is probably not a problem for FNP in Bahrain which does not have geographic numbers and the issues associated with moving service numbers from, say, Delhi to Mumbai or Melbourne to Sydney.

Location portability in Bahrain could be constrained only by a provider's ability to support a particular number of number ranges in a particular geographic location.

Voice over Internet Protocol (VoIP) service has the potential to provide "nomadicity". That is, it may be feasible to use an E.164 telephone number from outside the Bahrain number plan to provide a service within Bahrain. This matter is not explored in this paper but the possibility needs to be considered in regard to VoIP regulation in Bahrain.

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to be used as a fixed service for "HomeZone" services that apply PSTN tariffs to a mobile used at home and mobile tariffs away from home.

4 Cost-benefit analysis

Section 40 of the Telecoms Law requires the TRA to mandate number portability only *"when the Authority is satisfied that sufficient demand exists for such a service"*[7]. In private enterprise, "sufficient demand" exists when it is profitable to supply. But, with MNP there is (a) a case of market failure – no operator is going to introduce number portability unilaterally and (b) it cannot do it without the cooperation of other carriers. The public policy analogue to a business case for efficient decision-making is a cost-benefit analysis. This requires analysing the incremental costs and benefits of a proposed course of action from the national perspective (ie excluding within-country transfers).

Box 1: EU and NP

European Law is different from that in Bahrain because it treats number portability as a human right under the EU Universal Service that has applied since July 2003.

The report by Ovum/Indepen[8] urges NRAs to undertake regulatory impact assessments to ensure that the remedies employed in macro-states make economic sense (ie cost-benefit analysis).

4.1 Survey

The TRA is to be commended for its customer research but the survey should not be relied on as evidence of "sufficient demand" for number portability. It is commonly found that stated preferences do not accurately reflect revealed preferences (see below) and the survey implies a free option. If you asked any customer if they would like a new car, a negative response is unlikely. Demand is not independent of price.

The TRA's survey (p51) finds that *"For businesses, over 70 percent said it was important to keep their number when switching compared to 40 percent for residential consumers."* This partly reflects how the survey questions are framed. For example, the relevant question in the business survey (Q44) asks *"Please tell me if you are thinking about changing your telecom provider both for mobile and fixed line, how important would it be to* ***retain your existing telephone number(s)****?"* (emphasis in survey form). Not surprisingly, 71% of business customers said it was "very important" and another 26% said it was "important" (sourced from data results). But, the survey also shows (Q41) that only 38% and 31% of business customers "might" switch fixed or mobile carriers respectively. That is, the rest are either not currently interested in switching or would do it anyway (ie without number portability).

Also, the take-up of any number portability option will be influenced by customer charges and the time to port[9]; neither of which will be zero. So, the absence of these constraints in

[7] Section (40) of the Telecommunications Law, 2002

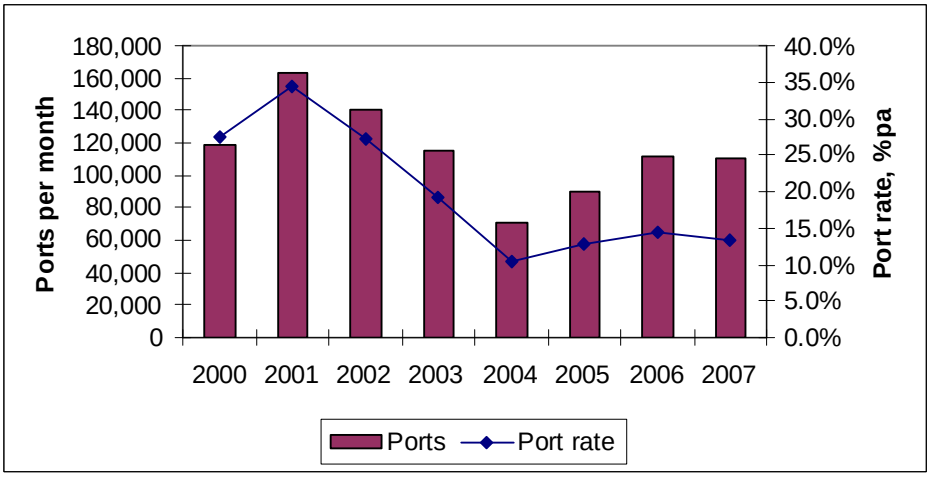
[8] Page 5, Ovum and Indpen (June 2005) *Applying the EU Regulatory Framework in microstates*: A report to the CYTA, EPT and Maltacom

the survey questions will lead to over-estimates of the likely attractiveness of the portability option to survey respondents.

The difference between stated and revealed preferences can be seen in overseas experience. In the UK, *"As part of a wider study of switching costs for the UK Office of Fair Trading, NERA (2003) examined the usage of MNP for inter-operator switching in UK mobile telephony markets. They found that in the first two years after MNP was introduced, the usage of MNP was very limited for residential customers, with only 12% of customers that switched operator taking up the portability option. This is far lower than the rate predicted in ex ante assessments."* [10]

Similarly, Hong Kong did a survey of mobile users from which it was assumed that churn rates might increase by 5, 10 or 15%[11]. As seen in the Figure 1 below, ports increased dramatically in Hong Kong in the first two years of MNP and then declined over the next three years. Over the eight years from 2000 to 2007 the average number of successful mobile number ports was 115,000 per month or 1.38m per year compared with average mobile subscribers over the period of 7.2m representing 19% of the customer base[12].

Figure 1: Mobile Number Portability in Hong Kong



Note: Ports are successful ports of numbers
Source: http://www.ofta.gov.hk/en/datastat/main.html

Number portability is not the driver of switching – it only facilitates it. The current similarity of prices across the two existing mobile carriers in Bahrain will reduce the benefits of MNP: *"the introduction of mandatory MNP is less likely to generate welfare gains (i) the closer substitutes mobile networks are, and (ii) the larger the market for fixed*

[9] Lyons (2006) notes that poor take-up of MNP in the UK was a result of it taking an average of 25 days to port a number.
[10] p5 Lyons, S. (July 2006) *Measuring the Benefits of Mobile Number Portability*
[11] page 66, NERA (1998)
[12] Some people express port rates as a percentage of switching customers but in this report we express port rates as a percent of total mobile subscribers.

line telephony. The intuition of these results is straightforward: If mobile networks are close substitutes and competition is thus intense, introducing MNP does not strongly affect the consumers' subscription decisions. That is, the benefits of introducing MNP are small"[13].

Box 2: Incumbents may be the winners in MNP

"Incumbent service providers are often market leaders in terms of quality of services, network availability and coverage, customer service, and packaging and pricing. Therefore, incumbents are able to retain their high-value mobile users, who contribute to the significant bulk of their overall mobile revenue. These high-value mobile users are often postpaid subscribers, business users, or heavy consumer users who value the ability to retain their numbers. With MNP, incumbents could easily attract other postpaid or business users from other lower performing service providers, who otherwise would be reluctant to switch due to the inconvenience of losing their current mobile numbers."(Frost & Sullivan, January 2007)

4.2 Benefit typology

We note that there are few published cost-benefit studies on MNP. The seminal studies were those done by Oftel with Ovum (1997) and the study done by NERA/Smith (1998) for OFTA in Hong Kong. These share the same framework. They both distinguish between three types of benefits and associated costs[14]:

4.2.1 Type 1 benefits

Type 1 benefits are those that accrue to people who switch operators. These are "private benefits" that accrue only to those who port and they can be sub-divided into,

1A: those who would have switched even without NP and
1B: those who did because of NP.

4.2.1.1 Type 1A

These benefits accrue to users who reduce their switching costs (e.g. the need to inform others of changed numbers is avoided). An ex-post study of mobile switching in Korea[15] found switching costs could be reduced by as much as 35%.

Nera (1998, p150) assumed that the avoided switching costs ranged from USD 21 to USD 60 for personal and business customers respectively. The lower figure reflects the cost of informing friends and contacts while the latter also includes changing stationery. The

[13] P4 Buehler, S. and Haucap, J (July 2004) *Mobile Number Portability*

[14] Buehler et al (2006) identify a fourth type due to enhanced property rights in numbers increasing customers' incentives to invest in, say, "nice" numbers.

[15] Kim, J. (October 2005) *The effect of mobile number portability on switching costs in the telecommunication industry*.

Ovum/Oftel (1997) study assumed corresponding costs of USD 5 and USD 160. Applying the personal and business shares of mobile phones in Bahrain[16], the weighted averages for Nera and Ovum/Oftel are USD 27 and USD 28 respectively. We have conservatively assumed an average cost of USD 50 (subjected to sensitivity tests in Section 7 below). This estimate is applied to the OR and ACQ technology scenarios – but with TD there is a change of number and so we assume only 20% of these costs can be avoided.

Extra time is needed to set-up the call, except for TD when it ceases. This imposes waiting costs on the Type 1A (and Type 1B) customers which have to be netted off the benefits they receive.

Another example of Type 1A benefits is the avoidance of "dual sourcing". That is, in the absence of mobile number portability some customers may retain their existing mobile service to continue receiving calls on their existing service. However, if customers choose to keep more than one mobile (or SIM card) to take advantage of different charges; especially for international calls (or to because of the different geographic coverage of networks or for security against network failure), then there is no benefit from MNP. The study for Hong Kong study says "*We conclude that few people in Hong Kong currently dual source because of the lack of MNP. In other words, a majority of the subscribers that currently dual source in Hong Kong would continue to do so if MNP were available because of geographic coverage and other reasons.*"[17] There is some acknowledgement of similar circumstances in Bahrain in the TRA's recent survey. And we return to this in Section 6.2.

4.2.1.2 Type 1B

These benefits arise for users who switch providers because of NP.

Type 1B benefits exclude rent transfers. That is, the reasons that customers switch will "*represent genuine economic benefits only to the extent that new operators offer lower charges or higher quality because they are more efficient than existing operators. If instead, lower charges or higher quality result in reduced profit margins then there is a transfer of producer surplus (profit) from the original operator which is shared between the subscriber and the new operator. This transfer should not be included as a benefit in the cost benefit analysis*" [18]

To illustrate the quote above, if the consumer's "willingness to pay" is 15 cents and the price is only 10 cents then the consumer is better-off by 5 cents (the "consumer surplus"). And, if the marginal cost is only 7 cents but the price is 10 cents then the operator makes a profit of 3 cents (the "producer surplus"). National economic welfare is the sum of consumer and producer surplus. This is 8 cents on the single sale just described but the

[16] TRA's survey in June 2007 sampled 1,052 residential consumers and 159 businesses. The weighting of the Nera and Ovum/Oftel results assumes 85% are personal users.

[17] Page 72, NERA-Smith (1998) Feasibility Study & Cost Benefit Analysis of Number Portability for Mobile Services in Hong Kong. Final Report for OFTA

[18] p74 NERA-Smith (1998)

actual calculation is summed across all customers who will differ in their willingness to pay.

Suppose that a new entrant with marginal costs of 8 cents wins the single customer discussed above with a price of 9 cents. The consumer and producer surplus are now 6 (=15-9) and 1 (=9-8) respectively and economic welfare is 1 cent lower (ie 7 rather than 8 cents). Although prices are lower, there is no genuine economic benefit because total economic welfare is less.

Ovum/Oftel (1997) assumed a bill saving of USD 2 per month could be attributed as a Type 1B benefit. This is low because Oftel's market research found that residential customers would be prepared to switch carriers without MNP for USD 14 of savings per month but with MNP they would be prepared to switch for only USD 12 per month in bill savings[19]. Oftel notes that the benefit of MNP is only the USD 2 difference between these two figures. Nera (1998) found an even smaller saving benefit. It assumed a 1.5% saving on the bill or USD 1. We have assumed USD 2.50 which is just over 3% of the average monthly mobile bill in Bahrain.[20] Each port induced by MNP is credited with three years of bill savings.

However, there are costs are incurred by Type 1B users. In the case of mobiles, these include the costs of SIM cards (USD 13), handset changes and other migration costs. The resource cost of a new handset is assumed to be USD 300. The model assumes that only 12% and 10% of porting post-paid and pre-paid customers respectively get a new handset, but this may be an under-estimate as a new handset may be one of the main inducements to switch. These costs are off-set against Type 1B benefits[21].

4.2.2 Type 2 benefits

Type 2 benefits are "public benefits" that are enjoyed by all users because of increased competition resulting from the introduction of MNP. The estimation of these benefits is contentious because they are also caused by other competitive factors, technological change and, sometimes, regulation:

1. It is not clear a-priori whether entrants might discount less aggressively as switching costs fall (as implied by Oftel research quoted above) or whether they might be more inclined to lower prices if the barriers to switching were lower.

2. If industry prices fell but costs did not, there would be only a transfer of some "producer surplus" to "consumer surplus" with no change in economic welfare (ie the sum of the producer and consumer surplus). This is why estimation of Type 2 benefits is based on the efficiency improvements induced by NP.

[19] Figure 4.15, Oftel (1997)

[20] P 41 of the TRA Strategic Review notes BD24 per month is spent on calls and VAS to which BD 6 has been added for the monthly rental and amortised registration fee.

[21] The Recipient Provider may subsidise the cost of the hand-set to the end customer but it still off-sets the national benefits of MNP wherever it is booked.

3. The estimation of the link between competition (of which NP is only a part) and efficiency is tenuous and uncertain. NERA's 1994 study[22] of FNP for Oftel found Type 2 benefits accounted for 69% of total benefits. The Monopolies and Mergers Commission[23] review of the study found that this result relied on an unpublished study[24] from which it was assumed that each 1% decrease in market share would lead to a 0.47% increase in BT's productivity (MMC, p113). But, changes in market share are a poor indicator of changes in the strength of competition and they depend on 10 year forecasts of market share. In its 1998 study of MNP for OFTA, NERA relied on another study[25] of 700 UK manufacturing companies to argue that a 25% decrease in market share leads to a 1% increase in productivity over the long-run leading to a Type 2 benefit that "*is very low relative to the Type 1 and Type 3 benefits*" in Hong Kong[26].

4. NP is only one of many competitive forces that lead to increased efficiency. In the case of Bahrain, the fixed network is subject to WiMAX competition and because the mobiles market is now mature, competition for share will become the main avenue for growth. Combining each of these with the relaxation of price controls means that prices may be expected to fall without NP.

5. Technology is leading to increased efficiency. Figure 2 below shows the increased efficiency derived from the migration to new wireless platforms[27]. In Bahrain, according to the TRA, Zain is already offering 3.5G (HSDPA) services and Batelco is rolling out its 3.5G network with commercial services expected before 2008.[28] The migration to more efficient mobile technology by both mobile carriers in Bahrain will lead to increases in profits and/or price reductions which will both increase economic welfare even without MNP.

6. Regulation can also lead to efficiency improvements. For example, price-cap regulation has been used to incent incumbents to be more efficient and in the review of NERA's study of FNP it was noted that BT was subject at the time to an exacting RPI-7.5% price cap.

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[22] NERA (1994) *Cost-Benefit Analysis of Number Portability*, report to OFTEL.

[23] MMC (Dec 1995) *Telephone number portability: A report on a reference under section 13 of the Telecommunications Act 1984*

[24] Haskel J and Szymanski S (1992) *The effects of privatisation, restructuring and competition on productivity growth in the UK public corporations,*

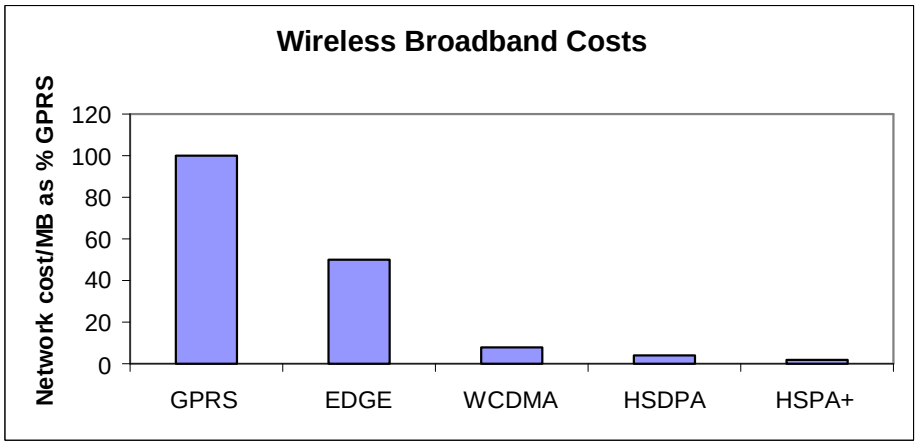
[25] Nickell S J (1996) *Competition and corporate performance*

[26] Section 5.3.2, NERA (1998)

[27] These costs assume average data throughput which would vary with the mix of services provided over the broadband service.

[28] page 24, TRA Strategic Review

Figure 2: Technology Induced Reductions in Costs



Source: Telstra, Investor Presentation, Nov. 2007

Considering these issues, it is not surprising that Ovum's cost-benefit study for Oftel excluded Type 2 benefits partly because they "*are notoriously hard to quantify*" (Oftel Section 3.6) and partly because "*fortunately the NPV of the central case here is positive without having to rely on the more controversial Type 2 benefits*" (Oftel Section 6.7).

However, Ovum did not let it rest at that and suggested another methodology to estimate Type 2 benefits. This assumed that one operator (BT) would bring its cost per minute down to the same level as the most efficient operator two years earlier as a result of the competitive stimulus of MNP. Ovum took the incremental cost improvement and multiplied it by the number of (BT) call minutes over two years, discounting the second year benefits. The resulting £350m compares with Type 1 NPV benefits in the Central Case of £272m[29]. However, this method is as just dubious as the NERA method relying on a linkage between (total) competition effects and efficiency. For example, as the incumbent operator, which Ovum assumes[30] will be the carrier to lose share, is likely to have greater economies of scale its costs per minute are likely to be lower than for a smaller operator.

Figure A1.4 in the TRA's Strategic Review shows little difference between Batelco and Zain in retail mobile prices. The TRA also says at page 74 that "*Both Batelco and MTC present regulatory accounts to the TRA which can be used to assess profitability. As presented in Table 7.3 below, Batelco earned from its retail mobile business a rate of return significantly above its regulated cost of capital (WACC) whilst MTC earned a rate of return below its cost of capital (unregulated) in its start-up year and above the following year.*" It is not possible to draw inferences about relative profitability from this table.

[29] See Section 6.7 and Fig 6.3 of Oftel (1997)

[30] Which may be incorrect, as noted in the box in Section 3.1 above.

4.2.3 Type 3 benefits

Type 3 benefits are "public benefits" enjoyed by calling parties who avoid the inconvenience and cost of finding new numbers. Previous cost-benefit studies of MNP found that these are around 5-10% of the size of Type 1 benefits.

This inconvenience can be exaggerated. Section 4.2 below notes that modern handsets make keeping a current contact list much easier. And, a study for the EU found that "*Despite the emergence of mobile number portability, however, there is still evidence that a significant proportion of callers will be aware of the identity of the called mobile network. For example, consumer research by a fixed incumbent in the United Kingdom revealed that more than 50% of fixed to mobile calls are made to just one number, while additional research by NOP in the United Kingdom suggested that the median residential mobile user receives between 81% to 90% of all calls from his/her immediate circle of friends and family and that 36% receive 100% of their calls from such sources. It is likely in many cases that the caller will be aware of the identity of the underlying mobile network of the called party".* (p11 WIK Consult and Squire Sanders)

Similarly, a recent Australian study which examined mobile users last 10 phone calls found that 48% were to contact family and 26% were to friends and just 16% were work related[31].

Previously published studies (and this one) do not take into account the loss of tariff transparency associated with MNP. That is, customers will no longer have certainty over the cost of a call to a mobile if the pre-fix of the called number can no longer tell them this (see example in box below). This is another cost of MNP.

Box 3: 'Free' cellphone call costs woman $50

Auckland Vodafone customer Emma Cooper is unhappy she was charged for a call to a friend with an 021 mobile number who had changed networks.

Vodafone customer Emma Cooper was charged $49.71 after calling a friend on an 021 number - a call she thought was free. But she was unaware that her friend had switched to the Telecom network under the "number portability" plan.

Vodafone head of communications Alison Sykora said her company had publicised the changes involved in portability, but it was ultimately the responsibility of phone owners to tell friends of their switch.

Number portability was introduced in April, allowing phone and mobile users to switch phone companies and take their number with them. By August, 35,000 New Zealand customers had switched phone companies.

[31] Wacjeman J. and Bittman M. (2007) *The impact of the mobile phone on work/life balance,* study by Australian National University, reported in AFR 17 July 2007

The telecommunications industry is understood to have spent $100 million preparing systems to handle number portability.

Source: Isaac Davison , NZ Herald, 9 October, 2007

There are different options to increase tariff transparency in the presence of MNP. Customers may be informed by enquiry numbers or SMS services to learn about the network of a given number. Acoustic signals may alert subscribers when placing off-net calls, or verbal announcements could inform customers about tariffs when calling different networks. Table 1 describes the methods are used in some countries. In Finland, consumers can call a toll-free number and in Germany both a toll-free number and toll-free SMS service is available. In Portugal, Ireland and Belgium, consumers are informed by an acoustic signal when placing off-net calls. Consequently, users are informed that they are placing an off-net call, but they do not learn the price of the call.

Table 1: How to Increase Transparency of MNP

Country	Method
Austria	Verbal announcement
Belgium	Acoustic signal when placing off-net calls
Finland	Toll-free enquiry numbers
Germany	Toll-free enquiry numbers and toll-free SMS service
Ireland	Acoustic signal when placing off-net calls
Portugal	Acoustic signal when placing off-net calls

Source: Buehler et al (2006)

4.3 Costs

The costs incurred by customers which off-set benefits have been discussed, but, the net benefits to customers also have to exceed the costs to Providers. Operator costs are discussed in the following section.

As well, there are costs to the TRA associated with setting up and administering the processes, including the cost for the monitoring of fair practices. These have not been included in this report.

5 Techniques and costs of MNP

There are many different ways to achieve the objectives of MNP; and new ones are emerging with new technology. Each of them has different costs; although the benefits do not vary between the technical options employed.

The two major parts to operator-specific MNP projects are:

- Network upgrades to support calls to and from ported numbers
- Integration of the porting process into operations and business support systems.

The second component is the biggest and most expensive component and touches on each and every part of each operator's systems and processes. This includes changes to service activation (ie establishing a new service with a ported number from a "donor" provider) and changes to charging and billing as there is significant added complexity in "rating" calls at the wholesale and retail level as the originating and termination prefixes no long indicates which network/s were involved in a call.

External to each operator there is a need for cooperation between operators in order to agree inter-provider processes, procedures and rules such as how porting requests would be exchanged and validated. Commercial arrangements and timeframes are important and a substantial adjunct to the internal integration process.

Any implementation of MNP can be placed on a global map of its evolution:

Legacy network models:

- Onward routing (OR)
- Centralised database (ACQ)

Bridge models:

- Temporary diversion (TD)
- Changed number (CN)

Future network models:

- NGN
- ENUM and other changes

In 2005, the UK decided not to migrate to ACQ from OR because it would not be cost-justified within the time-frame that NGN-based portability solutions were expected to become available[32]. Countries that are now implementing MNP, like Bahrain, should be

[32] Ofcom (2005) *An assessment of alternative solutions for UK number portability*. In November 2007, Ofcom further decided that direct routing using a centralized database will occur for FNP as NGNs are implemented and by 31 Dec 2012 at the latest and for MNP by 1 Sept 2009.

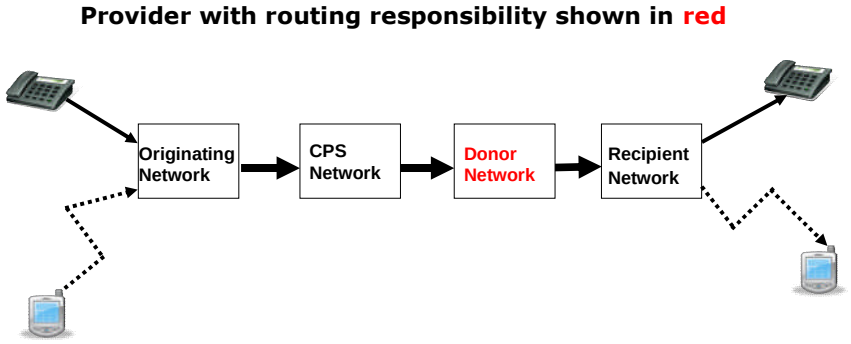
considering "bridge models" ahead of new number portability models rather than investing in legacy network based models which will become obsolete.

5.1 Legacy models

An Onward Routing (OR) or Call Forwarding approach shown in Figure 3 below places an obligation and additional costs on the Donor Network [33] to determine the Recipient Network [34] and transit switch the call to that network.

Figure 3: Onward Routing (OR)

Also known as Call Forward and On-Switch



Source: Hibbard Consulting

While OR is somewhat simpler and therefore less expensive to implement than ACQ, it carries additional on-going costs, including additional call conveyance costs of transit routing and (potentially) more complex porting arrangements as numbers need to be "retuned" to the Donor Network to be re-ported to the new Recipient Network.

The All Call Query (ACQ) or Centralised Database approach in Figure 4 below, places an obligation and additional costs on Carrier Preselection (CPS) networks, or the Originating Network if CPS is not used, to determine the terminating network of all calls through an Intelligent Network / Database look-up. This routing obligation would apply to all networks, fixed and mobile, before the first fixed or a mobile number is ported.

The concept of a "Centralised Database" is based on holding network provider information on all numbers. The Centralised Database would normally be established as a Database of Reference rather than as an operational database. The per call look-up, operational databases, would normally be operated by each carrier / provider. This allows the basic network security and reliability that is required in telecommunications networks, to be

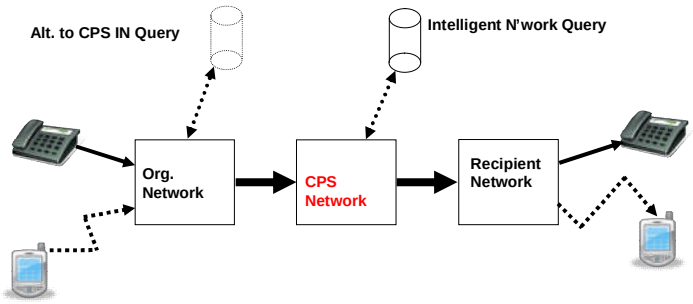
[33] The Donor network is the network that holds the allocation for a block of numbers, from which a customer has ported a number away.

[34] The Recipient Network is the network to which the number has been ported.

maintained. The alternative is a single national centralised operational database on which all networks / providers would rely, with is inherent single point of failure risks.

Figure 4: All Call Query (ACQ)

AKA Centralised Database and Off-Switch



Provider with routing responsibility shown in red

Source: Hibbard Consulting

The architecture of a Centralised Reference Database can be provided by a single, possibly independent operated entity. Alternatively a distributed approach could be adopted where each provider / carrier holds information on the current provider / recipient network on a number-by-number basis for the blocks of numbers they have been allocated by the TRA. Updates to the Reference Database occur as part of the porting process as is the dissemination of porting information to all operators of operational databases.

5.2 Bridge models

As an alternative to mandating the introduction of NP, carriers could introduce a 'Temporary Diversion" (TD) service that would provide customers who migrate to another provider, call diversion from their old service to their new service number for some months for a fee. It has several advantages:

- It reduces barriers to switching
- It is cheap and fast to implement
- It is a bridge to leap-frog out-dated models
- It does not suffer from the lack of tariff transparency (Section 3.2)
- It is analogous to a postal service providing a mail forwarding service

It was noted in the discussion of Type 3 benefits in Section 4.2 that calling circles tend to be concentrated so that updating contact lists would not take long. It is also facilitated by the technology embedded in modern phones:

"All handsets now come with a phonebook feature that enables easy access, storage and update of a contact list. Mobile calls are now mostly made through a convenient, efficient,

auto-dialling process after selecting the 'names' of contacts stored in the phonebook. As such, generally, mobile users do not memorise the phone numbers of their contacts.

The key reason for wanting to retain phone numbers is to ensure contactability by friends/contacts. With most handsets being equipped with 'Send a Business Card' or 'Send SMS to Distribution List' features, any changes to phone numbers can also be broadcast to friends/contacts easily and speedily. The update of phone numbers of contacts is also facilitated with CLI delivery to update the phonebook"[35]

Another possibility is "Changed Number" (CN) which would alert the caller to the new number. Some of the possible methods were noted in Table 1 above. A disadvantage is the need for the caller to re-dial the new number. But a clear advantage is that the caller is informed of the number change and has the new number for future use. And, like TD, CN is cheap and fast to implement and provides a bridge to future portability models.

A complementary activity, which is often used when a mobile customer changes their number, is to SMS all the (relevant) numbers in the phone directory / memory, advising them of the customer's new mobile number. Simple practices such as this approach should be promoted to ease costs of changing numbers.

5.3 Future models

Any implementation of MNP must be robust to change. Unlike previous MNP implementations, the industry is on the cusp of a major migration to all IP networks which will change the way we think about numbering and lead to more efficient solutions for customer switching.

OR and ACQ are based on legacy (circuit-switched) technology. Batelco is already well-advanced in the deployment of its NGN.

Ofcom decided not to mandate a move from its current OR solution to ACQ for FNP because "*migration to NGNs over a 5-10 year time frame offered opportunities to migrate to a new solution to number portability*" and "*investment now in legacy circuit-switched infrastructure risked assets becoming obsolete in only a few years time*"[36].

A number of other developments linked to NGNs are likely to undermine the importance of the telephone number and so also number portability. New and enhanced applications deployed on NGNs that could see users' need for telephone numbers diminish or disappear include:

- ENUM, which translates a (E.164) telephone number to an IP address and has the potential to provide a comprehensive directory application. There are trials in a number of markets now.

[35] Singapore carrier M1's response to IDA consultation, October 2005

[36] Para 2.8, Ofcom (2005) *An assessment of alternative solutions for UK number portability*

- Changes in communication preferences such as email and Instant Messaging (IM) and there naming / addressing arrangements.

- Intelligent directory services, where up to date information on people's contact preferences and details, are readily available.

5.4 Costs

A visit by a member of the Hibbard Consulting team to Bahrain in early November 2007 obtained cost information for the three Number Portability solutions (OR, ACQ and TD) considered in this study[37]. Where it is available, this information has been used in the Cost Benefit Analysis (CBA). Where information is not available, it has been estimated based on our industry knowledge and previous studies.

All information has been tested for its validity against earlier Number Portability studies undertaken in Hong Kong and the United Kingdom. The data from those studies was normalised for changes that occur over time such as equipment / technology price reductions, cost increases in relation to manpower and local circumstances (eg how networks interconnect in Bahrain).

Each of the three technical options we examine has different impacts on,

- Set-up
- On-going costs
- Porting costs ie costs per port
- Conveyance costs ie additional costs per call

5.4.1 Set-Up Costs

Set-up costs were considered across the three elements of the industry: Dealers, Service Provider and Network Operators.

We considered the costs of planning the changes required to support portability, the development, implementation and the testing of each solution. A significant part of theses costs related to Operational Support Systems such as Service Activation and Rating and Billing and the changes required to the operating software. Other matters considered included network technology, fraud and legal interception.

Estimates of the costs of staff training have also been included.

[37] A further aim of the visit was to provide information to the TRA to help ensure regulatory decisions on MNP are well informed with factual information and an understanding of their commercial implications.

As part of developing a cost for Bahrain, 80% of Batelco's costs were taken as the likely cost Zain would incur to implement NP in order to provide an overall estimate of costs. The 80% value was used to reflect the limited economies of scale with NP implementation.

The total set-up cost for ACQ is estimated to be USD 23m which is nearly triple the estimated cost of USD 8m for the OR system. But the TD regime is cheaper still at USD 0.3m.

5.4.2 On-going Costs

These costs reflect the increasingly complex environment is a provider has to operate and the costs associated with that complexity. An estimate of 15% of the initial set-up cost was used as indicative of the increased ongoing costs of operating in a portability environment.

5.4.3 Porting Costs

The porting costs are primarily the manpower costs to establish the ported services on the Recipient's network. Three hours are used for the porting activity which includes establishing the port in both networks for both OR and ACQ. The cost of manpower has been scaled back to one third of the general manpower rate leading to a cost per port of USD 46. However, TD takes only a few minutes to set-up leading to a cost of only USD 3 to establish TD.

The port costs of Type 1B customers are slightly higher than for Type 1A customers because they include not only the port cost above but also the account set-up costs. These are not included for Type 1A customers as these would be incurred by them even without MNP. This adds about USD 9 to the port costs in all three technology cases. The costs for ACQ and OR ports of Type 1B customers are therefore USD 56 and USD 12 for TD.

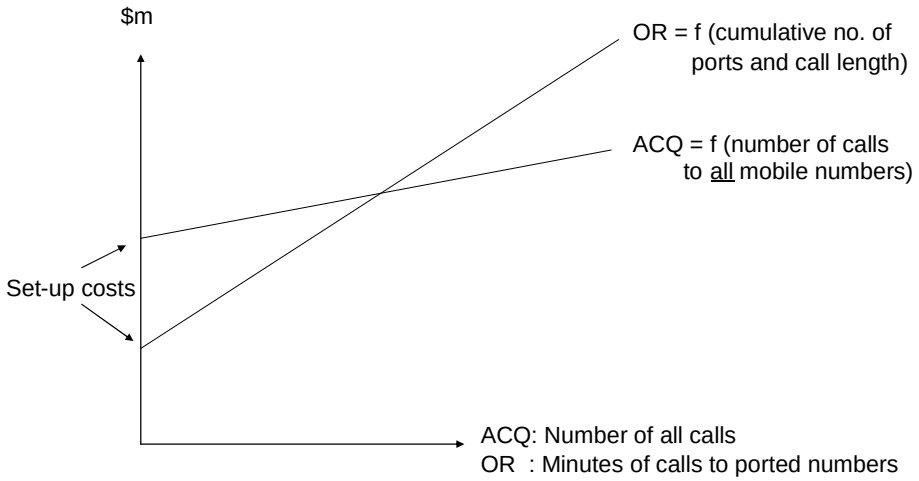
5.4.4 Conveyance Costs

With the OR solution as the number of ports increases, the additional transit traffic in the Donor network increases. Estimating porting volumes to estimate the additional carriage cost per call has been included in the study. For OR and TD, the study has assumed this cost to be 5 cents for 3 minutes.

The ACQ approach requires that all calls need an IN lookup to determine the terminating network. While this solution produces more efficient call routing, there are additional IN lookup costs. That is, instead of a traffic cost, there is the cost of IN data dip to determine the terminating network. But, this has to done for all calls to mobiles; for both ported and non-ported numbers.

The trade-off between the costs of ACQ and OR is illustrated in Figure 5 below.

Figure 5: OR vs ACQ



Source: Hibbard Consulting

6 Estimation of the benefits of MNP

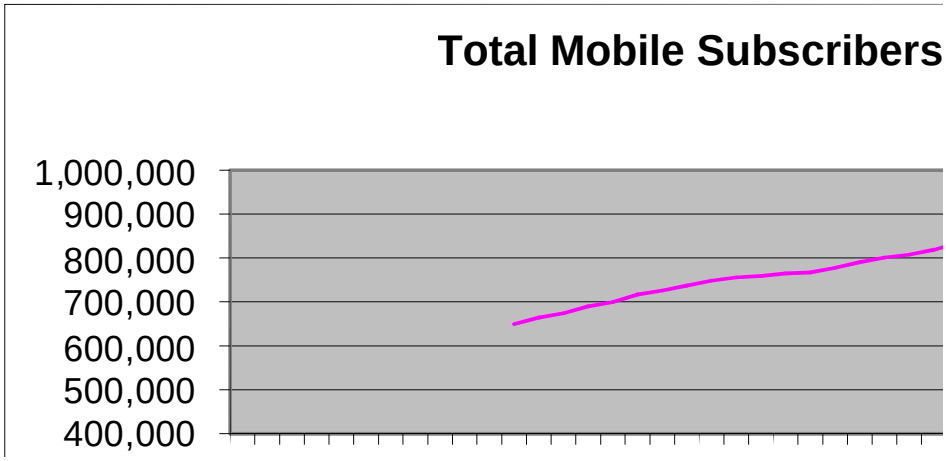
To consider the costs and benefits of mobile number portability requires a comparison against some benchmark scenario of what would occur without it. That benchmark will not be a simple extrapolation of recent trends

6.1 Base case

6.1.1 Market Size

The number of mobile subscribers is slightly uncertain but the trend is clear. Three series [Series 1 and Series 2 have been excised] for total mobile subscribers are compared in Figure 6. One is from the TRA[38] and two are from Batelco[39]. While the numbers are slightly different across the three sources, the trend is similar.

Figure 6: Mobile Subscriber Growth: History



Sources: The TRA and Batelco

On all measures, growth is in double digits and the penetration rate is over 130 per hundred of population. With penetration rates over 100%, it is clear that many customers have more than one mobile telephone number. Where customers are on different mobile networks, there will be less demand for MNP (as discussed in Section 6.2.2).

The model takes annual data from the "original" series and extrapolates this to 2017 assuming growth converges to the population growth rate by the end of the period. This implies a penetration rate in 2017 of 205% (see Figure 7 below) which seems very high – the highest reported in the OECD 2007 Communications Outlook was 157% for Luxembourg in 2005.

[38] Based on data provided by licensees, at http://www.tra.org.bh/en/MarketCustomer.asp

[39] [Excised]

[Figure 7 has been excised]

For the purpose of the model, it is assumed that post-paid and pre-paid subscribers have different characteristics (eg churn and port rates for pre-paid are higher).

6.1.2 Churn

We have to distinguish between "gross churn" (which is what Batelco measures) and "net churn" as defined below:

"Churn rate, as applied to a customer base, refers to the proportion of contractual customers or subscribers who leave a supplier during a given time period…The distinction is usually made between voluntary and involuntary churn. Involuntary churn occurs when the company terminates the customers' contract or account - usually on the basis of a poor payment history. Voluntary churn is when the customer decides to take their business elsewhere[40].

The churn rate can be minimized by creating barriers which discourage customers to change suppliers (contractual binding periods, use of proprietary technology, unique business models, etc.), or through retention activities such as loyalty programs. It is possible to overstate the churn rate, as when a consumer drops the service but then restarts it within the same year. Thus, a clear distinction needs to be made between 'gross churn', the total number of absolute disconnections, and 'net churn', the overall loss of subscribers or members. The difference between the two measures is the number of new subscribers or members that have joined during the same period."[41]

Batelco measures "involuntary/voluntary churn" which it defines as "*disconnected lines due to credit limit/violation/end of grace period/customer request*". This includes the pre-paid accounts that Batelco terminates when they have been inactive for several months. As noted above, this measure might be better termed "gross churn".

The TRA reported that "*in a data request to operators, one of the mobile operators stated that in 2006 21% of its customer base terminated their service, compared to 17% in both 2004 and 2005. However, according to the TRA's residential survey, only 8% of respondents stated that they had switched from one operator to another*"[42]. These two figures are consistent with the gross churn (disconnection) rate of [excised]% and net churn (the number of people who switched carriers) rate of [excised]% shown in Table 2 below for the 12 months to August 2007.

Table 2: Gross and Net Churn Rates for Bahrain

[40] Berry and Linoff (2000). *Mastering Data Mining: The Art and Science of Customer Relationship Management*

[41] http://en.wikipedia.org/wiki/Churn_rate

[42] TRA Review p73

Mobile subscribers	Zain	BTC	Total	Comments
Sep-06				
Aug-07				
Growth - G		[Figures have been excised]		
Average subscribers				
New users - A				
Connections - B				
Disconnections - C				
Switched-off - D				
Switched-in - E				
Switched-out - F				
Test growth				
Gross churn rate				
Net churn rate				

Source: Hibbard Consulting

All the cells in Table 2 are actual data except for the two lines highlighted in orange. On the first, the equal growth assumption comes from BTC's report that "*Zain has been successful both in attracting new users (about 50% of new additional users have signed up with Zain) and in acquiring existing Batelco users*"[43]. The assumptions at D about the number of people discontinuing mobile service are arbitrary.

Since the net churn rate is not visible to operators (unless they conduct exit interviews for all disconnecting customers), it is the gross churn rate that is normally reported. But, for the cost-benefit analysis, it is the net churn rate that matters with the numbers of these customers that also port which drives Type 1 benefits.

As further support for the difference between gross and net churn rates, Oftel conducted a survey for the UK which showed an average of 8.2% residential and small businesses switched[44] (ie net churn) compared with its "*estimate that between 18 and 24% of customers have left mobile networks each year*"[45]. While the latter estimate is clearly what should be described as gross churn, it seems to be the basis for Oftel's different "churn" cases with the additional implicit assumption that all churn is ported. It has the churn/port rate trend to 6%, 15% and 27% by 2007 in its Low, Central and High Cases respectively.

The current gross churn (disconnection) rates reported by Batelco are consistent with those shown in Table 3. There are many gaps because "*Unfortunately, there are no statistics on churn rates available for most European countries.*"[46]

Table 3: International Comparisons

[43] Batelco 7 October Submission to TRA Strategic review, Para 181

[44] Figure 4.6 in Oftel (1997) taking actual number switching against number of subscribers.

[45] Statement above Figure 6.1 in Oftel (1997)

[46] Page 393 Buehler et al (2006)

Country	MNP date	Gross churn rate, % pa	Port rate as % of subs., pa	Time to port	Comments
Hong Kong	March 1999	40-50% Pre-MNP churn rate was 2.5 to 3.5% pm which jumped to 9-10%pm for 3 months before it fell back to pre-MNP level.	15% Peaked at 32% and is now 15% versus the 26-36% (65-90% of churn) assumed by NERA	1-2 days	
UK	January 1999	27 and 30% for O2 pre and post paid in year to Dec,'05 respectively *"Before MNP, 18-24% customers left mobile networks each year"* (Oftel, S. 6.3)	5% cited by Ofcom and 1% and 3% quoted to EU and according to Syniverse.	5 days < 2 days by April 2008 and < 2 hours by Sept. 2009	Free porting to end users. Port rates low versus the 15% used in Oftel's Central Case (Fig 6.1)
Singapore	April 1997		1% (post paid) OFTA hopes for >5% with a move to ACQ and inclusion of pre-paid	7 days	MNP unavailable for pre-paid Monthly user fees abolished 2003 but one-time fees still apply
Australia	Sept. 2001		7% (2005-06)	2 days But 90% in < 3 hours	$A8 fee charged by some operators
Finland	July 2003		20%	5 days	No end user port fee
France	June 2003		<1%	10 days	
Germany	November 2002		<1%	6 days	20 Euros end user fee
Netherlands	January 1999	35-40%	7%	> 4 days	9 Euros end user fee and SIM lock permitted for 1 year
Taiwan	October 2005			4 days	
Ireland	July 2003		4%	2 hours	No end user fee

Sources:
Ofcom (2006) for UK port rate and time to port
Frost & Sullivan (2007) for some comments
Pyramid Research (2007) for some Hong Kong data
The Observer newspaper (UK) for comments on O2 in the UK

Based on Table 3 above, we now have to decide whether MNP in Bahrain will lead to (net) churn and port outcomes more like Hong Kong and Finland or more like those in the UK, Australia and the Netherlands.

6.2 Bahrain case

We understand that it would take at least 18 months to implement MNP using OR or ACQ. TD could probably be implemented before the end of calendar 2008. The model assumes MNP operates from the beginning of 2009, but this is not critical for a cost benefit analysis comparing options.

6.2.1 Churn

As noted in Table 2, the current net churn rate in Bahrain is about 7%. Assuming pre-paid customers outnumber post-paid by a ratio of 5 to 1, the current churn rates for pre-paid and post-paid customers are assumed to be 8% and 4% respectively; which gives an average net churn rate of 7.2%.

Will churn rates increase after MNP? The international experience of churn after the introduction is not uniform:

- *"We analyzed nearly 15 markets in which MNP was implemented in the past 6-7 years; overall, the impact has been mixed. A look at the evolution of subscriber churn rates over the first 24-36 months following the introduction of MNP shows limited upward movement in the churn rate curve; indeed, churn remained stable and in some cases, even declined, suggesting that MNP did not dent carriers' efforts to improve subscriber loyalty."*[47]

And,

- *"In several countries where MNP implementation took place, analysts predicted that churn would "go through the roof". This prediction never materialized. NP does not cause churn; rather the impact of portability only exaggerates existing reasons to churn -- clear quality issues, holes in coverage, better data services, availability of more exciting handsets"*[48].

Those experiencing the higher churn rates (eg Hong Kong, Finland) have markets that are either predominantly prepaid (or have very short contract periods), low portability fees, and intense competition; Hong-Kong has six operators battling for 7-8m customers and six small MVNOs. Competition in Finland is similarly intense, with MVNOs accounting for 25% of the overall subscriber base and service offerings that vary substantially from one operator to the next.

[47] Pyramid Research, *Mobile Number Portability: Much Ado about Nothing?*

[48] Syniverse Technologies Inc (2004) *A global perspective on number portability*

We believe that Bahrain has more in common with other countries like the UK, Australia and the Netherlands so that in our "Low Churn and Port Rate Case" the net churn rate is assumed to increase from 7% to just over 11%. But, we have also modelled a "High Churn and Port" case where the net churn doubles to 15%.

6.2.2 Porting

In looking at international evidence, it is important to be aware that some "port rates" are reported as the share of switching (net churn) customers who use MNP. But others and this report define port rate to mean the share of the total mobile customer base that uses MNP.

For the purpose of calculating Type 1A and 1B benefits, it is the port rate rather than the net churn rate which matters.

Will Type 1A customers who were going to switch anyway take-up MNP? How many Type 1B customers will emerge because of MNP? The disparity in port rates in other countries is quite marked. Does Bahrain have more in common with Hong Kong and Finland that have port rates in double digits or with Singapore and the European countries that have port rates less than 5% (see Table 3)?

- Singapore was the first country to implement MNP. It required two mobile numbers and was not available to pre-paid customers. In 2006, the annual porting rate was 1% of total post-paid mobile subscribers. In August 2006, the regulatory authority, the IDA, decided to replace the existing call-forward (OR) solution with a centralised database combined with ACQ and to extend MNP to pre-paid customers. The IDA believes that this will see the annual porting rate increase to between 5% and 16%; the range it observes for the USA, Australia and Hong Kong[49].

- In Hong Kong, the porting rate went from about 17% to 32% in the first two years then fell back to 15% for the next five years, as shown in Figure 1 above.

- For the UK, the study for the EU reported that "*There is some debate as to whether mobile number portability actually results in greater network churn and whether its significant implementation costs are justified. For example, the Study Team understands that* (gross) *network churn stands at approximately 25% in the United Kingdom, while only 1% of mobile users port their numbers."*[50]

- In Australia it is reported[51] that there were 1.3m mobile number ports during 2005–06 versus a total mobile customer base of 19.7m. So, 6.8% of total customers switched using MNP.

[49] page 15, IDA (2006) *Decision on the Review of Number Portability in Singapore*

[50] Footnote 26 Annex VI: *Broader Competitive Issues Relating to Mobile Markets* by WIK Consult and Squire Sanders

[51] Pages 60 and 71 ACMA (November 2006) Australian Communications and Media Authority *Communications Report: 2005-06*

- In the Netherlands, the churn rate is running at 35-40% per year but only 5% of customers who change networks choose to port[52]. One reason is that porting times typically take 3-12 weeks. Also, "*the demanding and inflexible criteria for validation imposed by the donor causes many port attempts to be rejected"*. Another deterrent to porting in the Netherlands is the use of an SIM lock which is permitted by law for up to one year.

- In Finland, up to half of ported subscribers go to MVNOs, in a given period[53]. Finland has some special features that lead to high porting rates. It banned handset subsidies, SIM-locked phones and long contracts. Single rate call plans led to a price war with generous promotions and giveaways. The MNP process was easy and costless for end-users.

[52] Syniverse, May 2004

[53] Pyramid Research, "Mobile Number Portability: Much Ado about Nothing?"

A check-list of factors that might affect the port rate in Bahrain is shown in Table 4 below.

Table 4: Checklist of Impacts on Port Rate

Factor	Higher	Lower	Comments
Competition	HK Finland	**Bahrain**	Duopoly in Bahrain
Dual SIM use		**Bahrain** UK	See Table 5 for others
Un-portable services (MMS, email, roaming)		All countries	Becoming more important
Low port fee	Finland Ireland	**Bahrain** Sweden Germany	See Table 7 for others
Share of pre-paid	**Bahrain** HK	UK	In 1999, the Hong Kong and UK rates were 65% and 46% respectively
No SIM-locks	**Bahrain** Finland	Netherlands	
Easy to use port process	Australia Finland	Singapore Germany Netherlands	

Source: Hibbard Consulting

Also, as noted earlier, customers need reasons to switch rather than simply to be offered MNP which merely facilitates their choices.

A special factor in the case of Bahrain is the high level of Dual SIM and/or mobile phone use, which will reduce the demand for MNP. Customers choose to operate more than one SIM card to optimise their use of different networks. Oftel research found users prepared to manually change their SIM cards for 50% to 75% of their calls and that without SIM-locking the UK could see dual use taken-up by 15% of all mobile users[54]. This would apply with or without MNP. Bahrain is already higher than 15% as shown in Table 5.

[54] Oftel (2001) *Use of multiple SIM cards in mobile phones by consumers in Finland, Italy and Portugal*, cited by WIK study for EU at footnote 3

Table 5: Use of More than One SIM Card

Country	Dual SIM penetration	Source
Bahrain	17%	See text below this table
Hong Kong	12%	NERA, page 78
Italy	13%	Oftel
France	7%	Oftel
Portugal	4%	Oftel

The TRA reports 907,433 mobile subscribers in December 2006[55] which combined with population of 698,585 means a penetration rate of 130%. However, on the same chart the TRA reports a penetration rate of 108% which "*takes into account dual ownership of mobile phones*". Perhaps, the 8% represents expatriates who do not count in population statistics. The TRA's analysis implies that 153,000 phones or 16.9% of all mobile phones were a second (or third) phone. This is higher than the 11% reported for residential customers in the TRA's recent survey of customers (page 40, Strategic Review) because it includes business. That also means dual use by business must be considerably greater than 16.9%[56].

With mobile penetration heading towards 200%, Bahrain's level of multi-SIM use will increase. And, it should be noted that new technology is also likely to further promote the use of dual SIM cards and further reduce the take-up of MNP. Some new mobile handsets now have the capability to accommodate 2 SIM cards (some offer 3 SIM card capability). These handsets allow incoming calls to either mobile number / SIM to be answered and outgoing calls to be made via each SIM at the touch of a button.

The "Low Churn and Port Rates" scenario assumes port rates increase from 4.7% to 6.2% and the "High Churn and Port Rates" scenario assumes port rates increase from 9.9% to 13.8%. In both cases, all Type 1B customers port their numbers by definition. The difference in the porting element of the scenarios comes from assuming that 30% or 80% of Type 1A customer's port; in each case reaching the target level over three years.

The number of ported customers accumulates but some customers will port more than once. The model assumes a running total of cumulative over three years with the net churn rates applied to two years.

[55] www.tra.org.bh/en/marketMaobiles.asp

[56] If 30% or more of mobile subscribers are businesses, their dual use is greater than 30%

6.2.3 Present Value of Benefits

Our findings of net benefits are compared with those found for Hong Kong and the UK in Table 6 below.

All the columns show the present value of benefits measured over ten years. The discount rates used in the Hong Kong and UK studies (for costs as well as benefits) were 6% and 8% respectively. The three last columns for Bahrain under the three technology assumptions are discounted at 8% (subject to sensitivity analysis in Section 7). This is less than the 12.2% set in the TRA's November 2005 decision on the WACC for Batelco because it is a social discount rate.

It has been argued that *"a possible 3%-4% range for the social discount rate is the fact that opportunity costs in terms of private sector returns are not relevant in **most** social project appraisals"* (our emphasis, Evans, p2). But this is based on the assumptions that the public sector is funding the project and that there will be no crowding-out of private sector investment. Neither of these assumptions is true in the case of MNP in Bahrain. On the TRA's own analysis, the opportunity cost of Batelco spending money on MNP is 12.2%; and the cost of capital for Zain will be higher than the social discount rate too.

Table 6: Comparisons of Benefit Estimates, USDm

			High Churn & Port Rates		
NPVs, USDm	**HK**	**UK**		**BH**	
Benefits			**TD**	**OR**	**ACQ**
Type 1A	$145	$359	$4	$22	$22
Type 1B	$26	$322	$7	$21	$6
Type 2	$2				
Type 3	$7	$42	$6	$6	$6
Total	$180	$724	$17	$49	$34
			Low Churn & Port Rates		
	HK	**UK**		**BH**	
			TD	**OR**	**ACQ**
Type 1A	$84	$137	$1	$8	$8
Type 1B	$10	$95	$3	$11	$3
Type 2	$2				
Type 3	$4	$11	$3	$3	$3
Total	$99	$243	$8	$22	$14

Sources:
Hong Kong: Nera (19998) Tables 5.2 and 5.8 and sections 5.3.2 and 5.4.2
UK : Oftel (1997) Figures 6.6 and 6.9
Bahrain: Hibbard Consulting

7 Charging Principles

Costs of implementing MNP are ultimately borne by consumers. The net present value (NPV) of implementing MNP ranges from plus USD 4 (with TD) to over minus USD 90 per mobile customer, depending upon the technology and porting assumptions. However, it is important not only that the NPV is positive (ie benefits exceeds costs) but also that costs are efficiently recovered.

Economic efficiency typically requires that users of a given resource or service pay for their usage if the resource under consideration is scarce (i.e. carries an opportunity cost). If users are not made to pay even though their usage causes costs, an inefficient over-use of the resource will result.

An exception to such charging occurs for "public goods" which are characterised by,

(a) Non-excludability; ie it is not economically feasible to exclude consumers from the service.
(b) Non-rivalry in use; ie additional users do not cause additional costs.

It should be clear that MNP is not a public good as (a) people unwilling to pay for MNP can be excluded and (b) additional ports cause additional costs.

7.1 Who pays?

MNP can be viewed as a new service offered to consumers. In a perfectly competitive market, new services will be offered if providers expect the total revenues from these services to cover the costs. That is, even in a perfectly competitive environment, MNP would not be offered free of charge. Accordingly, Donor and/or Recipient Networks should be allowed to charge for porting.

Type 1 customers cause the costs of MNP but all customers benefit from it. So, a reasonable starting point might be that Type 1 customers pay their incremental costs and fixed costs are recovered from all customers. However, our analysis finds that the majority of benefits are Type 1 private benefits in Bahrain (see Table 6); suggesting that porting customers or their Recipient Network hosts should bear the full incremental costs of MNP.

Taking a slightly different approach, there is a case for a public subsidy to cover the fixed costs. Having both fixed and variable costs, MNP gives rise to similar problems as the determination of efficient charges in natural monopoly settings. In economic theory, the efficient price for natural monopoly services is at the marginal or incremental cost level and the government should cover the fixed cost associated with the development and implementation of mandatory MNP.

Another reason for the TRA to bear the fixed costs of implementing MNP is that it will prevent the distortion of technology choices. If the Donor Network can charge the Recipient Network or porting customer only for incremental or variable costs and is

expected to recover fixed costs from their own customers, *"operators are likely to choose a technology with relatively low fixed and high variable costs (such as an on-switch solution), which may lead to productive inefficiencies"*[57]. But, this bias only applies in large markets where ACQ is more efficient than the OR (on-switch) solution. In Bahrain, the real choice is between OR and TD (or no MNP) and given a free choice[58], Networks would choose TD which has both lower fixed and variable costs relative to OR.

7.2 How much?

Where the porting charge is just one element of the service packages offered by different provider Recipient Networks it is conceivable that providers voluntarily offer MNP at efficient prices so as to convince consumers to sign a contract. However, with the duopoly that exists in Bahrain, the Recipient Operator could set inefficiently high porting fees.

Box 4: Germany and port fee

It should thus not come as a surprise that the German regulatory authority (RegTP) felt it had to step in and to regulate charges for MNP ex post after two small service providers decided to charge their customers a price of 116.00 € for porting their number. Most other European countries have regulated MNP charges ex ante.

Source: http://www.regtp.de/aktuelles/pm/03140/index.html

A survey conducted in 2003-2004[59] indicates that in many countries either the Donor Network (as, e.g., in Sweden) or the Recipient Network (as in Finland, Italy and Norway) is allowed to charge fees for porting (See Table 7). A typical situation is that the Donor Network charges the Recipient Network which then charges the customer. Table 6 shows that some countries have mobile networks that do not charge customers for porting numbers. For instance, in addition to Finland, porting is typically free in the UK and in Ireland. In Belgium, only pre-paid subscribers pay for porting their mobile number. Across Europe, the fees charged ranged up to USD 70 and averaged USD 20.[60]

[57] Buehler, S., Dewenter R. and Haucap J. (August 2006) *Mobile Number Portability in Europe,* Telecommunications Policy

[58] The TRA should not prescribe the technology to be used as operators typically have better information about the efficient use of technologies than regulators. It is well known from principal-agent analysis that the regulator (the principal) has to reward the operators (the agents) to induce an efficient technology choice in the presence of asymmetric information.

[59] Buehler, S., Dewenter R. and Haucap J. (August 2006)

[60] p15 CEPT (2003) using conversion rate in Table 6

Table 7: Port rate and Port Fee

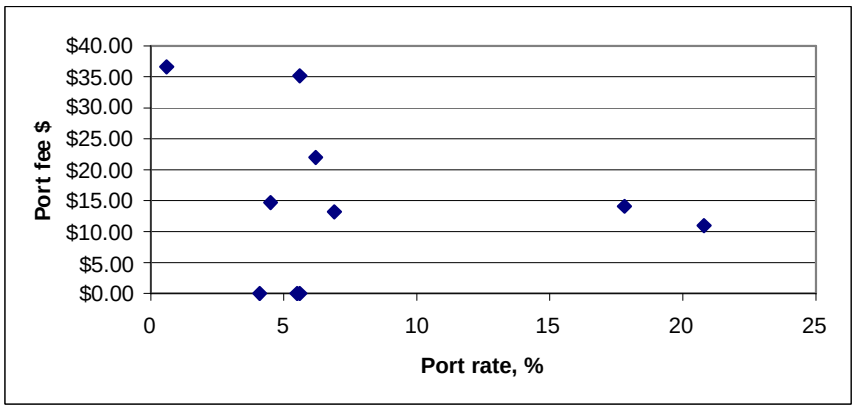
	Months	Ported	Annual Port Rate%	Port Fee (1)	Comment
UK	68	3,036,863	5.6	$0.00	Some operators charge $40.85
Italy	23	2,500,000	4.5	$14.68	Not passed on to customers
Spain	21	2,091,515	5.5	$0.00	
Finland	13	993,578	20.8	$10.99	Not passed on to customers
Netherlands	64	925,343	6.9	$13.19	
Denmark	37	918,000	17.8	$14.06	
Belgium	23	500,408	6.2	$21.98	Max. and only for pre-paid
Sweden	36	486,936	5.6	$35.16	Max. Cannot be passed to user
Germany	22	349,000	0.6	$36.63	
Ireland	13	142,414	4.1	$0.00	
France	14	100,000	0.2		
Note (1) Converting to USD:				and	
Euros			1.465	STLG	1.634

Source: Tables 4 and 6 from Buehler et al (2006) and Hibbard Consulting

In Bahrain, the Donor Network could charge the Recipient Network the USD 46 port cost (which excludes the account set-up costs reported in Section 4.4 above). This is slightly higher than the rates reported for Sweden and Germany in Table 7 above. And, of course, the TD option would cost only USD 3. In any case, the Recipient Network can choose how much of the Donor's port fee (and its own costs) to pass on to the customer.

There is no clear relationship between the port rate and the port fee as shown in Figure 8 below. This suggests that a Donor Network fee is not an impediment to porting.

Figure 8: Port Rate and Port Fee



Source: Table 7

8 Summary and Conclusions

8.1 Summary

Our cost-benefit analysis of implementing MNP shows that it is not in the national interest of the Kingdom of Bahrain to do this using either OR or ACQ.

Section 5 presented the fixed and variable costs for three ways of implementing MNP in Bahrain. These cost structures are very different as noted earlier and as summarised in the lower half of Table 8. As noted in Section 6, the net present values for both costs and benefits in Table 8 are discounted over the period to 2017 at 8%.

Each technology scenario is compared to a common benefit scenario. As noted through this report, a key driver of benefits is the assumed churn and, especially, port rates. For that reason, and following the practice of previous studies, we offer two porting scenarios:

- In the "High Churn and Port Rate" scenario, it is assumed that the net churn rate doubles to 15% and that the port rate achieves 14%.
- In the "Low Churn and Port Rate" scenario, it is assumed that the net churn rates increases from 7% to 11% and that the port rate reaches 6% of mobile customer each year.

Table 8: Summary Results

	High Churn & Port Rates			Low Churn & Port Rates		
NPVs, USDm	**TD**	**OR**	**ACQ**	**TD**	**OR**	**ACQ**
Benefits						
Type 1A	$4	$22	$22	$1	$8	$8
Type 1B	$7	$21	$6	$3	$11	$3
Type 2						
Type 3	$6	$6	$6	$3	$3	$3
Total	$17	$49	$34	$8	$22	$14
Costs						
Set-up	$0.3	$8	$23	$0.3	$8	$23
Ongoing	$0.3	$7	$7	$0.3	$7	$7
Ports	$5	$58	$58	$2	$26	$26
Traffic	$0	$58	$59	$0	$27	$59
Total	$6	$132	$147	$3	$69	$115
Net MNP benefit	$11	-$82	-$113	$5	-$47	-$101

Source: Hibbard Consulting

There are two striking take-outs from these results. First, the net benefits are negative across all cases except for TD. Second, higher churn/porting increases the costs of porting and traffic faster than the increase in benefits for OR. And, while there is no change in

traffic costs for ACQ, the cost of the increase in ports is greater than the increase in benefits from higher churn/ports. Only TD has higher net benefits with increased churn/ports.

8.2 Sensitivity tests

The conclusions drawn from the Base Case for the three technology scenarios in Table 8 above are robust to large changes in key assumptions. The most critical assumptions concern the change in churn rates and take-up of the porting option due to MNP. These have already been considered in Table 8.

Table 9 tests the sensitivity of the results to variations in the discount rate and the costs avoided by Type 1 customers.

Table 9: Sensitivity Results

	High Churn & Port Rates			Low Churn & Port Rates		
NPVs, USDm	**TD**	**OR**	**ACQ**	**TD**	**OR**	**ACQ**
Total Benefits						
Base Case	$17	$49	$34	$8	$22	$14
Discount rate 12%	$14	$41	$28	$6	$18	$11
Discount rate 4%	$21	$61	$41	$10	$27	$17
Avoided cost $25	$15	$38	$22	$7	$17	$9
Avoided cost $100	$22	$73	$57	$10	$30	$23
Total Costs						
Base Case	$6	$132	$147	$3	$69	$115
Discount rate 12%	$5	$111	$127	$3	$59	$101
Discount rate 4%	$7	$158	$172	$4	$81	$133
Avoided cost $25	$6	$132	$147	$3	$69	$115
Avoided cost $100	$6	$132	$147	$3	$69	$115
Net Benefits						
Base Case	$11	-$82	-$113	$5	-$47	-$101
Discount rate 12%	$9	-$71	-$100	$4	-$41	-$89
Discount rate 4%	$14	-$97	-$131	$6	-$55	-$117
Avoided cost $25	$9	-$94	-$125	$4	-$51	-$106
Avoided cost $100	$16	-$59	-$90	$7	-$38	-$92

Source: Hibbard Consulting

The discount rate is used to bring future benefits and costs back to one present value figure. Note that no changes in prices are assumed for benefits and costs, so the discount rates are real discount rates. As Section 6 argued, 8% is a reasonable assumption for the Base Case. In Table 9, we show the impact on benefits, costs and the net benefits of a discount rate set at 12% (reflecting the opportunity costs of the private sector funds used to implement MNP) and 4% (which would assume the public sector pays for the implementation of MNP).

The key benefit of MNP for Type 1A customers is the reduced cost of switching. In Section 3.2 it was reported that that the Nera and Ovum/Oftel studies found a Bahrain-weighted average saving of USD 30. In Table 9 sensitivity tests of savings at half and double the Base Case assumption of USD 50 are shown. It can be seen that they do not affect the main conclusions.

8.3 Conclusions

Implementing number portability is a non-trivial exercise with large up-front fixed costs and possibly, with a call-forwarding (OR) solution, large on-going costs. These costs are incurred by all participating operators; not just the incumbent. For example, Vodafone (which was - and remains - the third largest mobile operator in Australia) observed in relation to the implementation of MNP in Australia that,

"we spent A$50 million putting it in place and no-one is using it ... our perspective is that it was regulator thinking rather than customer thinking … the bottom line is that we spent A$50 million and nothing's changed. It hasn't been a success from a competition perspective"[61]

The TRA has seen the Ovum/Indepen 2005 report for the EU[62]. In this context, we are pleased to note that the *"TRA will ensure regulation is appropriate to the local environment by adjusting the international regulatory best practice to suit conditions in Bahrain rather than simply adopting ready made solutions from elsewhere*". [TRA p8] This is precisely what Ovum/Indepen did for the European Commission when looking at how the implementation of the European Directives should be tailored to the circumstances of micro-states within the EU. That study concludes that while,

"The cost of developing, implementing and enforcing regulation varies relatively little with the size of the market being regulated while the benefits are typically proportionate to the size of the market. Given these differences in the way costs and benefits vary with market size it is possible that regulatory approaches and remedies which are appropriate in macrostates lead to economic losses in microstates. Figure 6.1 illustrates."

We note that the Ovum/Indepen study considers the specific case of mobile number portability in its Figure 6.2, about which it says that,

"Figure 6.2 illustrates the point from a recent Ovum study which looked at the costs and benefits of mobile number portability. It plots the set up cost per head of population against the size of the country. We can see that, as the population declines, the cost of MNP per person rises sharply while the benefits remain roughly constant. In Ireland the costs and the benefits were found to be roughly equal. In a microstate it is hard to believe that the costs would not outweigh the benefits several times over".

We note also that Bahrain is much smaller than any of the micro-states to which the Ovum/Indepen study refers.

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[61] ZDNet Australia, *Australia's MNP a AU$50 million failure: Vodafone,* 25 September 2002

[62] Ovum and Indpen (2005) *Applying the EU Regulatory Framework in microstates: A report to the CYTA, EPT and Maltacom*

Box 5: A precedent for regulatory failure

Bahrain has both indirect access (8-digit call over-ride) and carrier pre-selection (CPS or dial-tone) access for calls. These were introduced at considerable cost to provide customers with greater choice and convenience in the selection of which operator should bill them for calls.

According to the TRA, *"Five operators currently offer CPS services. As at May 2007 there were 913 business CPS subscribers and 316 individual CPS subscribers giving a total of 1,229 CPS subscribers"* (Review p109). This represents only 1.2 percent of business lines in Bahrain and 0.3 percent of residential lines.

Since the main beneficiaries of MNP will only be those who actually use it, it must be of concern that customers in Bahrain are not making much use of an existing similar tool.

The TRA, we believe, will not want a repeat of a costly implementation exercise associated with poor customer take-up. Rather, it might consider whether MNP is worth pursuing and, if so, whether TD is the most efficient solution for Bahrain.

The implementation of MNP is a complex and significant undertaking as it over-turns a fundamental assumption in the way networks are built – that number blocks are associated with a particular service provider.

Bahrain is a "late mover" so it can learn from past mistake and seize new opportunities. In particular,

- MNP is not the driver of switching – it only facilitates it. Other countries have generally over-estimated the demand for MNP
- The industry is on the cusp of a major migration to all IP networks which will change the way we think about numbering and lead to more efficient solutions for customer switching

Countries that are now implementing MNP should use "bridge models" rather than investing in legacy network-based models which will soon be obsolete.

The main technical options (OR and ACQ) employed in markets with MNP are costly for Bahrain and will be overtaken by new options arising from new generation networks (NGNs). "Temporary Diversion" is efficient and meets regulatory objectives.

Our cost benefit analysis comparing three technical options shows that the net benefits are negative across all cases except for TD.

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