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Ramsey Pricing - vs. – EPMU for Regulation of Firms Operating in Competitive and Non-Competitive Markets

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Abstract

There has been debate on whether Ramsey Pricing remains appropriate where part of a regulated firm's product portfolio is provided in competitive markets, and is unregulated. An argument made is that since firms will not necessarily set Ramsey Pricing for their products in competitive markets, there is no guarantee that Ramsey Pricing will remain optimal for the products provide they also provide in non-competitive markets.

This paper investigates the performance of Ramsey Pricing, and EPMU as an alternative regulatory pricing mechanism, in situations where only part of the product portfolio is subject to price regulation.

The analysis suggests that setting the regulated prices at Ramsey levels will yield prices closer to Ramsey levels for the whole product set than will an alternative of EPMU.

An illustration is given on the relative merits of Ramsey or EPMU pricing for incoming calls to mobiles. Under reasonable assumptions illustrative results suggest imposing EPMU pricing on the incoming call service will reduce quantities of all services, with resulting falls in consumer welfare. It may also damage dynamic efficiency of the mobile industry, although this is outside of the modelling framework adopted in this paper.

Introduction

Ramsey Pricing provides the economically efficient regulated pricing rule for a firm in a non-competitive market, where a number of products are supplied under significant fixed common costs.

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There has been debate, however, on whether Ramsey Pricing remains appropriate where part the firm's product portfolio is provided in competitive markets, and is consequently unregulated. An argument made is that since firms will not necessarily set Ramsey Pricing for their products in competitive markets, there is no guarantee that Ramsey Pricing will remain optimal for products provided in non-competitive markets.[2] As a result, it is sometimes argued, Ramsey Pricing should be abandoned altogether, in favour of simpler regulatory pricing rules such as EPMU (Equi-proportional Mark-Up).[3]

Houpis and Valletti (2004)[4], using a demand system built from the indirect utility function for mobile calls show that the welfare maximising termination price (where other prices are determined competitively) lies above the Ramsey Price and below the monopoly price. This is consistent with the findings of the simulation model reported here. However, rather than using an indirect utility function approach, we adopt a general demand system incorporating own and cross-price elasticities, used by Oftel in the UK.[5]

The objective of this paper is to investigate the performance of both Ramsey Pricing and EPMU as alternative regulatory pricing mechanisms in situations where only part of the product portfolio is subject to price regulation. We do this both analytically and also by numeric example of a hypothetical mobile network operator.

Model

Suppose an industry provides three products, to quantities Q_1, Q_2 and Q_3, at prices P_1, P_2 and P_3, and subject to marginal costs of m_1, m_2 and m_3 respectively. In addition, the industry faces fixed common costs (across all three products) of F, which, assuming a stable number of firms in the industry, is effectively the sum of the fixed common costs of the individual firms. The

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2 For example, OFCOM, Wholesale mobile voice call termination consultation, 19 December 2003. See Annex K, paragraph K9.

3 EPMU (Equi-Proportional Mark-up), as the name suggests, is where fixed common costs are allocated to individual products in proportion to directly attributable costs.

4 Houpis and Valletti, Mobile Termination: what is the “right” charge?, presented at the International Telecommunications Conference, Berlin, 2004.

5 See, for example, A Model of Prices and Costs of Mobile Network Operators, Rohlfs, J. (prepared on behalf of OFTEL), 22 May 22 2002, available at http://www.ofcom.org.uk/static/archive/oftel/publications/mobile/ctm_2002/main_report.pdf

demand for each product is determined by its own price (through an own price elasticity), and also by the prices of the other two products (cross-price elasticities) as either substitutes or complements. In order to assist the analytical exploration, we assume a log-linear form for the industry demand functions as follows:

$$log\ Q_1 = {}_{10} + {}_{11} P_1 + {}_{12} P_2 + {}_{13} P_3 \quad (1a)$$

$$log\ Q_2 = {}_{20} + {}_{21} P_1 + {}_{22} P_2 + {}_{23} P_3 \quad (1b)$$

$$log\ Q_3 = {}_{30} + {}_{31} P_1 + {}_{32} P_2 + {}_{33} P_3 \quad (1c)$$

These particular forms imply price elasticities that change in proportion to the relevant price level. For example, if P_1 were to fall, consumers would become less price sensitive to P_1 in regard to their demand for product one, and also each of the other two products insofar as there is a non-zero cross-price elasticity.

It will be convenient to work with the inverse of the industry demand functions, which we write as follows:

$$P_1 = {}_{10} + {}_{11} log\ Q_1 + {}_{12} log\ Q_2 + {}_{13} log\ Q_3 \quad (2a)$$

$$P_2 = {}_{20} + {}_{21} log\ Q_1 + {}_{22} log\ Q_2 + {}_{23} log\ Q_3 \quad (2b)$$

$$P_3 = {}_{30} + {}_{31} log\ Q_1 + {}_{32} log\ Q_2 + {}_{33} log\ Q_3 \quad (2c)$$

Within the industry, a number of firms operate, each providing the same three products. We write an individual firm's quantities as q_1, q_2 and q_3, and prices as p_1, p_2 and p_3. We assume marginal costs are the same for all firms at m_1, m_2 and m_3. An individual firm demand function must now take account of competitors' prices. We do this by introducing additional terms into a **short run** firm demand function, representing the difference between the firm's price and the industry average. However, in order to explore the effects of both competitive and non-competitive markets, we will assume that competitor's prices are influential only for products one and two, as follows:

$$log\ q_1 = {}_{10} + {}_{11} P_1 + {}_{12} P_2 + {}_{13} P_3 + {}_{11} (p_1 - P_1) + {}_{12} (p_2 – P_2) \quad (3a)$$

$$log\ q_2 = {}_{20} + {}_{21} P_1 + {}_{22} P_2 + {}_{23} P_3 + {}_{21} (p_1 - P_1) + {}_{22} (p_2 – P_2) \quad (3b)$$

$$log\ q_3 = {}_{30} + {}_{31} P_1 + {}_{32} P_2 + {}_{33} P_3 + {}_{31} (p_1 - P_1) + {}_{32} (p_2 – P_2) \quad (3c)$$

The difference in intercept terms between the industry and firm demand functions reflect the firm's market share, dependent on non-price characteristics of its products.

We assume that, in the short run, a firm could set prices that differ from the market average for products one and two, but with consequences for the firm's demand levels. In the **long run** we assume that these differences are unsustainable. A firm setting higher prices for products one and two would loss excessive demand, and so prices would be bid down to fully competitive levels where industry profits (across all three products) would equal the cost of capital, i.e. zero economic profit.

It must be acknowledged that, in the short run, the firm demand function will not precisely aggregate to those of the industry, but this is not important to the analysis.

It will be convenient to refer to the inverse of the industry demand functions, which we write as follows:

$$p_1 = \quad _{10} + \; _{11} \log q_1 + \; _{12} \log q_2 - (\; _{11} \; _{11} + \; _{12} \; _{21} - 1) P_1$$

$$- (\; _{11} \; _{12} + \; _{12} \; _{22} - 1) P_2 - (\; _{11} \; _{13} + \; _{12} \; _{23}) P_3 \qquad (4a)$$

$$p_2 = \quad _{20} + \; _{21} \log q_1 + \; _{22} \log q_2 - (\; _{21} \; _{11} + \; _{22} \; _{21} - 1) P_1$$

$$- (\; _{21} \; _{12} + \; _{22} \; _{22} - 1) P_2 - (\; _{21} \; _{13} + \; _{22} \; _{23}) P_3 \qquad (4b)$$

Ramsey Pricing in a Totally Regulated Market

Ramsey Pricing establishes the most economically efficient (maximising welfare - the sum of consumer and producer surplus) set of industry prices, P_1, P_2 and P_3, subject to the constraint that the industry as a whole recovers both marginal and fixed common costs. Given the functional forms assumed above, assuming a sequence of integration for consumer surplus of "product 1 to product 2 to product 3", and measuring welfare from an arbitrary base of quantities $Q^b{}_1$, $Q^b{}_2$, and $Q^b{}_3$, welfare is given by:

$$W \quad = \quad {}_{Qb1}\int^{Q1} P_1(Q_1, Q^b{}_2, Q^b{}_3)\, dQ_1$$

$$+ {}_{Qb2}\int^{Q2} P_2(Q_1, Q_2, Q^b{}_3)\, dQ_2$$

$$+ {}_{Qb3}\int^{Q3} P_3(Q_1, Q_2, Q_3)\, dQ_3$$

$$- m_1 Q_1 - m_2 Q_2 - m_3 Q_3 \qquad (5)$$

The Appendix shows that, under certain assumptions, welfare is maximised subject to the constraint that industry revenue covers cost (zero economic profit for the industry) by the prices:

$$P_1 = m_1 + \frac{}{1 + } \left(\; _{11} + \; _{21} \frac{Q_2}{Q_1} + \; _{31} \frac{Q_3}{Q_1} \right) \qquad (6a)$$

$$P_2 = m_2 + \frac{}{1 + } \left(\; _{22} + \; _{12} \frac{Q_1}{Q_2} + \; _{32} \frac{Q_3}{Q_2} \right) \qquad (6b)$$

$$P_3 = m_3 + \frac{\quad}{1 +}\left({}_{33} + {}_{13}\frac{Q_1}{Q_3} + {}_{23}\frac{Q_2}{Q_3}\right) \qquad (6c)$$

where is a Lagrangian Multiplier applying to the zero industry profit constraint :

$$0 = P_1 Q_1 + P_2 Q_2 + P_3 Q_3 - m_1 Q_1 - m_2 Q_2 - m_3 Q_3 - F \qquad (7)$$

Substituting equations (6) into (7) gives:

$$\frac{\quad}{1+} = \frac{F}{G} \qquad (8)$$

where

$$G_i = {}_{1i} Q_1 + {}_{2i} Q_2 + {}_{3i} Q_3 \qquad (9a)$$

and $G = G_1 + G_2 + G_3$ (9b)

Substituting equation (8) back into equation (6) gives the familiar inverse super-elasticity mark-up rule of Ramsey Pricing, to recover fixed common costs:

$$P_1 = m_1 + \frac{G_1}{G}\frac{F}{Q_1} \qquad (10a)$$

$$P_2 = m_2 + \frac{G_2}{G}\frac{F}{Q_2} \qquad (10b)$$

$$P_3 = m_3 + \frac{G_3}{G}\frac{F}{Q_3} \qquad (10c)$$

From now on in this paper we will use P_1, P_2 and P_3 to denote Ramsey Prices calculated from equations (10).

For this to achieve welfare maximisation, all prices must be determined in this way. However, a regulator will be unwilling to mandate this if product markets one and two are subject to competitive constraint.

Partial Ramsey Pricing

In practise, the regulator can only mandate prices for product three. One option is for the regulator to mandate the "Ramsey Price" for the non-competitive product three, and trust a market outcome for products one and two. The prices for products one and two would, in the long term, be driven down to give zero economic profit for the industry as a whole (across all three products). Whereas P_3 would be set by the regulator from equation (6c), p_1

and p_2 would be set by firms seeking to maximise short term profit, under the constraint that long term economic profit will be zero:

$$0 = p_1 Q_1 + p_2 Q_2 + P_3 Q_3 - m_1 Q_1 - m_2 Q_2 - m_3 Q_3 - F \qquad (11)$$

In algebra, the first order conditions for this problem are:

$$0 = p_1 + {}_{11} + {}_{21}\frac{q_2}{q_1} + {}_{31}\frac{q_3}{q_1} - m_1 + \quad (p_1 + {}_{11} + {}_{21}\frac{Q_2}{Q_1} + {}_{31}\frac{Q_3}{Q_1} - m_1)$$

$$0 = p_2 + {}_{22} + {}_{12}\frac{q_1}{q_2} + {}_{32}\frac{q_3}{q_2} - m_2 + \quad (p_2 + {}_{22} + {}_{12}\frac{Q_1}{Q_2} + {}_{32}\frac{Q_3}{Q_2} - m_2) \qquad (12)$$

where is a Lagrangian Multiplier applying to the zero industry profit constraint of equation as in equation (11).

These conditions can be re-written:

$$p_1 = m_1 + \frac{{}_{11} + {}_{21} q_2 / q_1 + {}_{31} q_3 / q_1 + \quad ({}_{11} + {}_{21} Q_2 / Q_1 + {}_{31} Q_3 / Q_1)}{1 + }$$

$$p_2 = m_2 + \frac{{}_{22} + {}_{12} q_1 / q_2 + {}_{32} q_3 / q_2 + \quad ({}_{22} + {}_{12} Q_1 / Q_2 + {}_{32} Q_3 / Q_2)}{1 + } \qquad (13)$$

As before, these prices can be substituted into the zero profit constraint of equation (11) to solve for the Lagrange Multiplier:

$$= \frac{(1 - G_3 / G) F - g_1 - g_2}{(1 - G_3 / G) F + G_1 + G_2} \qquad (14)$$

where

$$g_i = ({}_{1i} + {}_{2i} q_2 / q_i + {}_{3i} q_3 / q_i) Q_i \text{ where } i = 1, 2 \qquad (15)$$

Substituting equation (14) back into equations (13) gives a modified version of the inverse super-elasticity mark-up rule:

$$p_1 = m_1 + \frac{g_1 G_2 - g_2 G_1 + (G_1 - g_1) (1 - G_3 / G) F}{(G_1 + G_2 - g_1 - g_2) Q_1} \qquad (16a)$$

$$p_2 = m_2 + \frac{g_2 G_1 - g_1 G_2 + (G_2 - g_2) (1 - G_3 / G) F}{(G_1 + G_2 - g_1 - g_2) Q_2} \qquad (16b)$$

$$P_3 = m_3 + \frac{G_3}{G}\frac{F}{Q_3} \qquad (16c)$$

Essentially, prices result in zero economic profit for the industry. Within this umbrella, $P_3 = p_3$ is set by the regulator at the "Ramsey" level, whilst the relativity between p_1 and p_2 will reflect the short run opportunities for the firms to gain (or lose) additional profit by varying prices away from the industry by an amount dependent on the firm specific elasticities (expressed in g_1 and g_2).

We can now find expressions linking the Ramsey and Partial Ramsey prices:

$$p_1 = P_1 + \frac{(g_1 G_2 - g_2 G_1) (1 + F / G)}{(G_1 + G_2 - g_1 - g_2) Q_1} \quad (17a)$$

$$p_2 = P_2 + \frac{(g_2 G_1 - g_1 G_2) (1 + F / G)}{(G_1 + G_2 - g_1 - g_2) Q_2} \quad (17b)$$

$$p_3 = P_3 \quad (17c)$$

Equations (17) show there will only be differences between Ramsey and Partial Ramsey prices to the extent that the firm elasticities differ from the industry elasticities. Even then, there will only be a difference between the two sets of prices to the extent that the ratio of the firm and industry super-elasticties differ between products one and two, i.e. g_1 / G_1 differs from g_2 / G_2.

EPMU

A second option is for the regulator to mandate EPMU for the non-competitive product three, and trust a market outcome for products one and two. p_3 would be set by the regulator to ensure that product three bears an "equi-proportion" of the industry's fixed common cost:

$$Q_3 P_3 = m_3 Q_3 + \frac{F m_3 Q_3}{m_1 Q_1 + m_2 Q_2 + m_3 Q_3} \quad (18)$$

$$p_3 = m_3 + \frac{F m_3}{m_1 Q_1 + m_2 Q_2 + m_3 Q_3} \quad (19)$$

Meanwhile, the prices for products one and two would, in the long term, be driven down to give zero economic profit for the industry as a whole (across all three products). Therefore, p_1 and p_2 would be set by firms seeking to maximise short term profit, under the constraint that long term economic profit will be zero:

$$0 = p_1 Q_1 + p_2 Q_2 + P_3 Q_3 - m_1 Q_1 - m_2 Q_2 - m_3 Q_3 - F \quad (20)$$

The first order conditions for this problem are:

$$0 = p_1 + {}_{11} + {}_{21} \frac{q_2}{q_1} + {}_{31} \frac{q_3}{q_1} - m_1 + [p_1 + {}_{11} + {}_{21} \frac{Q_2}{Q_1} + {}_{31} \frac{Q_3}{Q_1} - m_1]$$

$$0 = p_2 + {}_{22} + {}_{12} \frac{q_1}{} + {}_{32} \frac{q_3}{} - m_2 + [p_2 + {}_{22} + {}_{12} \frac{Q_1}{} + {}_{32} \frac{Q_3}{} - m_2]$$

$$q_2 \qquad q_2 \qquad\qquad Q_2 \qquad Q_2 \qquad (21)$$

where is a Lagrangian Multiplier applying to the zero industry profit constraint of equation (20).

These conditions can be re-written:

$$p_1 = m_1 + \frac{{}_{11} + {}_{21}\, q_2 / q_1 + {}_{31}\, q_3 / q_1 + \ ({}_{11} + {}_{21}\, Q_2 / Q_1 + {}_{31}\, Q_3 / Q_1)}{1 + }$$

$$p_2 = m_2 + \frac{{}_{22} + {}_{12}\, q_1 / q_2 + {}_{32}\, q_3 / q_2 + \ ({}_{22} + {}_{12}\, Q_1 / Q_2 + {}_{32}\, Q_3 / Q_2)}{1 + }$$

(22)

As before, these prices can be substituted into the zero profit constraint of equation (20) to solve for the Lagrange Multiplier:

$$= \frac{[\, 1 - m_3\, Q_3 / (m_1 Q_1 + m_2 Q_2 + m_3 Q_3) \,]\, F - g_1 - g_2}{[\, 1 - m_3\, Q_3 / (m_1 Q_1 + m_2 Q_2 + m_3 Q_3) \,]\, F + G_1 + G_2} \qquad (23)$$

Substituting this back into equations (22) gives:

$$p_1 = \quad m_1 + \frac{g_1\, G_2 - g_2\, G_1 + (G_1 - g_1)\, [\, 1 - m_3\, Q_3 / (m_1\, Q_1 + m_2\, Q_2 + m_3\, Q_3) \,]\, F}{(G_1 + G_2 - g_1 - g_2)\, Q_1}$$

$$p_2 = \quad m_2 + \frac{g_2\, G_1 - g_1\, G_2 + (G_2 - g_2)\, [\, 1 - m_3\, Q_3 / (m_1\, Q_1 + m_2\, Q_2 + m_3\, Q_3) \,]\, F}{(G_1 + G_2 - g_1 - g_2)\, Q_1}$$

$$P_3 \quad = m_3 + F\, S / Q_3 \qquad (24)$$

where

$$S = \frac{m_3\, Q_3}{m_1 Q_1 + m_2 Q_2 + m_3 Q_3} \qquad (25)$$

Essentially, prices result in zero economic profit for the industry. Within this umbrella, $P_3 = p_3$ is set by the regulator at the “Ramsey” level, whilst the relativity between p_1 and p_2 will reflect the short run opportunities for the firms to gain (or lose) additional profit by varying prices away from the industry average.

We can now find expressions linking the Ramsey and EPMU:

$$p_1 = P_1 + \frac{g_1\, G_2 - g_2\, G_1 + \{\, [\, G_3\, (G_1 - g_1) - g_1\, G_2 + g_2\, G_1 \,] / G + (g_1 - G_1)\, S \,\}\, F}{(G_1 + G_2 - g_1 - g_2)\, Q_1}$$

$$p_2 = P_2 + \frac{g_2\, G_1 - g_1\, G_2 + \{\, [\, G_3\, (G_2 - g_2) - g_2\, G_1 + g_1\, G_2 \,] / G + (g_2 - G_2)\, S \,\}\, F}{(G_1 + G_2 - g_1 - g_2)\, Q_2}$$

(26)

As in the partial Ramsey Pricing case, prices result in zero economic profit for the industry. Within this umbrella, p_3 is set by the regulator at the EPMU level, whilst the relativity between p_1 and p_2 will reflect the short run opportunities for firms to generate (or lose) additional profit by varying prices away from the industry average, dependent on firm specific elasticities expressed in g_1 and g_2.

It is evident from the equations above that not only will there be a difference between Ramsey and EPMU prices to the extent that the ratio of the firm and industry super-elasticties differ between products one and two (i.e. g_1 / G_1 differs from g_2 / G_2), but differences will also occur to the extent that the cost share of product three (S) differs from its "share" of the summed super-elasticities (G_3 / G). To see this, note that when $g_1 / G_1 = g_2 / G_2$ we have:

$$p_1 = P_1 + \frac{(g_1 - G_1) (S - G_3 / G) F}{(G_1 + G_2 - g_1 - g_2) Q_1} \qquad (27a)$$

$$p_2 = P_2 + \frac{(g_2 - G_2) (S - G_3 / G) F}{(G_1 + G_2 - g_1 - g_2) Q_1} \qquad (27b)$$

There is strong reason to believe, therefore, that the EPMU prices will deviate further from welfare maximising Ramsey Prices than will the Partial Ramsey Prices.

Numeric Illustration

In this section we report the results of a numeric example, in the context of the mobile network industry.

The basic model adopted here will differ from those used in papers such as Laffont, Rey and Tirole (1998)[6] in that we immediately specify individual demand functions for the three outputs of the industry without imposing any structure or constraint on how these demands are derived. This allows a more general demand system of the type used by regulators when setting controlled prices (e.g. Rohlfs (2002))[7], which fits with empirically observed demand systems.

The three products are:

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[6] Laffont J., Rey P. and Tirole J., Network Competition I (Overview and Nondiscriminatory Pricing) and II (Discriminatory Pricing), Rand Journal of Economics, Vol.29, No.1, Spring 1998, pp 1-56.

[7] Op. Cit.

1. Access to a mobile network, where q_1 is the number of mobile subscribers and p_1 is the fixed monthly payment made by subscribers to their network operator;

2. Outgoing mobile calls, where q_2 is the number of call minutes and p_2 is the price per minute;

3. Incoming calls made by subscribers of other networks under a "calling party pays" system, where q_3 is the number of call minutes and p_3 is the price per minute.

For the purposes of this paper we ignore on-net calls (i.e. calls that originate and terminate within the same network).

We capture externality effects of the size of the subscriber base on the quantity of outgoing and incoming calls by including $log\ q_1$ terms within the structural demand function for $log\ q_2$ and $log\ q_3$. These can be substituted into a reduced form set of demand equations.

We assume a matrix of own and cross-price elasticities shown in Table 1. These reflect the fact that consumer demand for mobile subscriptions is driven by the subscription price and the price of outgoing calls. The assumed elasticities also reflect the complementary nature of subscriptions to both outgoing and incoming calls (i.e. a 10% increase in subscriptions results in a 5% increase in call traffic, reflecting the fact that new consumers have lower than average outgoing and incoming call levels). The implied reduced form elasticities (after substituting for $log\ q_1$) are shown in Table 2. These elasticity assumptions are broadly consistent with those reported in a number of studies submitted to the UK's Competition Commission in connection to the Mobile Phone Inquiry of 2003.[8] In regard to the firm price elasticities, we have made the reasonable assumption that inter-network competition will occur principally at the subscriber level, but in terms of both fixed monthly payments (p_1) and the price of outgoing calls (p_2).

8 See Vodafone, O2, Orange and T-Mobile: Reports on references under section 13 of the Telecommunications Act 1984 on the charges made by Vodafone, O2, Orange and T-Mobile for terminating calls from fixed and mobile networks, paragraphs 8.12 to 8.27 and 8.46 to 8.49.

Table 1
Structural Form Elasticity Assumptions

	Independent variables					
	Fixed monthly price (p_1)	Outgoing call price (p_2)	Incoming call price (p_3)	Fixed monthly price differential (p_1-P_1)	Outgoing call price differential (p_2-P_2)	Subscribers ($log\ q_1$)
Demand Function						
Subscribers ($log\ q_1$)	-0.5	-0.5		-0.5	-0.5	
Subscribers ($log\ q_2$)		-0.5				0.5
Subscribers ($log\ q_3$)			-0.5			0.5

Table 2
Calculated Reduced Form Elasticities

	Independent variables				
	Fixed monthly price (p_1)	Outgoing call price (p_2)	Incoming call price (p_3)	Fixed monthly price differential (p_1-P_1)	Outgoing call price differential (p_2-P_2)
Demand Function					
Subscribers ($log\ q_1$)	-0.5	-0.5		-0.5	-0.5
Outgoing calls ($log\ q_2$)	-0.25	-0.75		-0.25	-0.25
Incoming calls ($log\ q_3$)	-0.25	-0.25	-0.5	-0.25	-0.25

Table 3 shows the cost assumptions. These assumptions result in fixed common costs amounting to about one quarter of total costs.

Table 3
Cost Assumptions

Marginal cost of subscribers (m_1)	10
Marginal cost of outgoing calls (m_2)	0.05
Marginal cost of incoming calls (m_3)	0.05
Industry fixed common cost (F)	10,000

Finally, Table 4 shows the results of the computation of prices, quantities and welfare under the three scenarios outlined in the previous section:

Ramsey Pricing (only possible in a totally regulated market);
Price for product three set at "Ramsey" levels;
Price for product three set at EPMU levels.

Table 4
Results of Numeric Example

	Ramsey Pricing	**Price for product three set at "Ramsey" levels**	**Price for product three set at EPMU levels**
Quantity of subscribers (q_1)	193	233	146
Quantity of outgoing calls (q_2)	182,713	190,080	101,128
Quantity of incoming calls (q_3)	122,539	134,744	121,679
Fixed monthly price (p_1)	-11.48	-16.39	-14.90
Price of outgoing calls (p_2)	0.092	0.097	0.137
Price of incoming calls (p_3)	0.103	0.103	0.090
Welfare relative to Ramsey Pricing	-	-269	-3114

In all cases, the fixed monthly price is subsidised to the extent of paying money back to consumers (which can be interpreted as handset subsidies). This is a result of the strong complementary price elasticities between subscriptions and outgoing and incoming calls. The subsidy is lowest under Ramsey Pricing. Thus, when operators are permitted to price competitively for subscriptions and outgoing calls, they chose to increase the subsidy on subscriptions above Ramsey Pricing levels. This result is driven by the higher firm specific price elasticities (relative to industry elasticities) on subscriptions.

Consequently, the outgoing call price is lower under Ramsey Pricing than in either of the other two cases where prices are competitively determined. In the competitive cases, outgoing call prices need to be increased to cover the additional subscription subsidy.

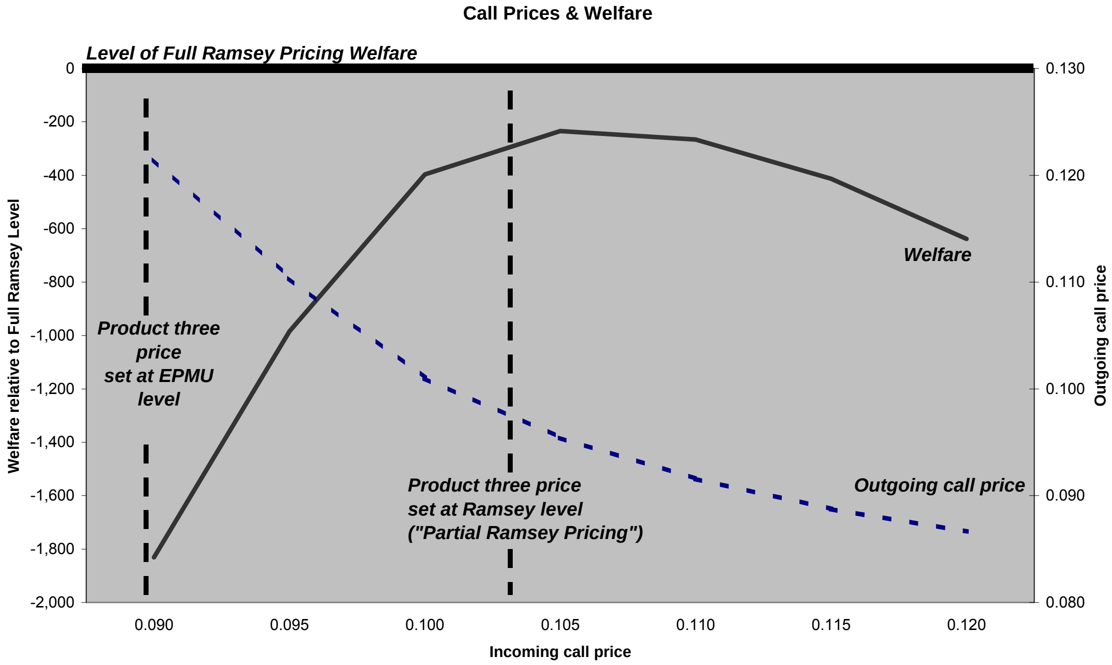
In Ramsey Pricing, the incoming call price is set at a premium over the outgoing call price, reflecting the fact that only the outgoing call price has a cross price elasticity with the quantity of subscriptions (based on an assumption that potential subscribers are unconcerned by incoming call prices). However, the EPMU incoming call price is significantly lower, requiring the outgoing call price to be increased, and the subsidy on subscriptions to be reduced.

The impact of these prices on volumes is interesting. For the sake of comparison take the Ramsey Pricing volumes as a base. In the second scenario, where Ramsey Pricing is imposed on incoming calls, but operators select their own level for subscriptions and outgoing calls, we see that the high level of subsidy that operators choose to give subscriptions expands the volumes for all three services above Ramsey Pricing volumes. In fact, this results in a small drop in welfare since, compared to Ramsey Pricing, there is an inefficient allocation of resources following the eagerness of operators to compete for new subscriptions. Of course, it is arguable whether this loss in "static efficiency" is more than compensated by a gain in "dynamic efficiency" from the competitive process. This, however, is beyond the scope of our modelling system.

Now turn to look at the impact of EPMU pricing for incoming calls on quantities for all services. The first observation is that, even though EPMU has only been applied to incoming calls, quantities for all three services are below Ramsey Pricing levels. This is simply because of the loss of subsidy on subscriptions, which feeds through to lower volumes for both outgoing and incoming calls. Furthermore, there is now less scope to price down outgoing calls to encourage more subscriptions. This has a large detrimental effect on welfare due to the loss of static efficiency. It should also be noted that there is a strong possibility of a further loss of dynamic efficiency under this scenario as firms are less able to compete for subscribers, although this is outside the scope of this framework.

Chart 1 provides more background to these results. In this chart, the incoming call price has been constrained at each level shown on the horizontal axis. At the far end of the axis we see the "EPMU" incoming call price marked at 9.0, and further along the horizontal axis the "Ramsey" price is marked at 10.3. The broken line relating to the right hand vertical axis shows the profit maximising outgoing call price (at each level of incoming call price). The decline reflects the fact that higher incoming call revenue is competed away in lower outgoing call prices (as well as subscription subsides). Shown on the left hand vertical axis, by the solid line, is the level of welfare (consumer plus producer surplus). This is always lower than the level of welfare for full Ramsey Pricing (or all three products), since the profit maximising distribution of subscription subsidy and outgoing call prices does not conform to Ramsey Pricing. Nevertheless, given that full Ramsey Pricing is not achievable, it is clear that welfare is maximised at an incoming call price very similar to (in fact slightly above) the Ramsey Pricing level. EPMU pricing of the incoming call price, on the other hand, yields a significantly lower welfare.

Chart 1:



Welfare Maximising Price Regulation

The discussion above suggests that, in the presence of unregulated (and competitive) products (products one and two in our discussion), there exists a welfare maximising regulated price level for a non-competitive product (product three in our discussion). This welfare optimising price may differ slightly from Ramsey levels, and will be in part dependent upon the competitive (as opposed to industry) price elasticities for the competitive products.

This welfare maximising price can be determined by:

> For any particular level of the regulated price (P_3), determine the (short run) profit maximising levels of the competitive prices. We can write these as functions of P_3 thus: $p^*_1(P_3)$ and $p^*_2(P_3)$;

This gives a modified welfare function $W^*(P_3)$:

$$W^*(P_3) = Q^*_1(P_3)\,[\,P_1(Q^*_1(P_3),\, Q^b_2,\, Q^b_3) - {}_{11}\,]$$

$$-\ Q^b_1\,[\,P_1(Q^b_1,\, Q^b_2,\, Q^b_3) - {}_{11}\,]$$

$$+\ Q^*_2(P_3)\,[\,P_2(Q^*_1(P_3),\, Q^*_2(P_3),\, Q^b_3) - {}_{22}\,]$$

$$-\ Q^b_2\,[\,P_2(Q^*_1(P_3),\, Q^b_2,\, Q^b_3) - {}_{22}\,]$$

$$+\ Q^*_3(P_3)\,[\,P_3(Q^*_1(P_3),\, Q^*_2(P_3),\, Q^*_3(P_3)) - {}_{33}\,]$$

$$-\ Q^b_3\,[\,P_3(Q^*_1(P_3),\, Q^*_2(P_3),\, Q^b_3) - {}_{33}\,]$$

$$-\ m_1\, Q^*_1(P_3) - m_2\, Q^*_2(P_3) - m_3\, Q^*_3(P_3) \qquad (28)$$

where $Q^*_1(P_3)$, $Q^*_2(P_3)$ and $Q^*_3(P_3)$ denote the quantities (as functions of P_3) corresponding to the profit maximising levels of p_1 and p_2. We would expect:

$$W^*(P_3) \le W(P_1, P_2, P_3,) \qquad \text{for all } P_1, P_2, P_3 \qquad (29)$$

In principle, this modified welfare function could be maximised with respect to P_3 to determine a welfare maximising price, taking account of firm's profit maximising behaviour with respect to p_1 and p_2.

Conclusion

This paper has not produced general results on the relative merits of Ramsey or EPMU pricing for incoming calls to mobiles but, under reasonable assumptions, has produced:

Reasons why we would expect that setting a Ramsey Price for the "non-competitive" incoming call price will yield overall prices closer to Ramsey levels than EPMU; and

Illustrative results suggesting that imposing EPMU pricing on the incoming call service will reduce quantities of all services, with resulting falls in consumer welfare. It will also potentially damage dynamic efficiency of the mobile industry, although this is strictly outside of the modelling framework adopted in this paper.

APPENDIX: Ramsey Pricing

Ramsey Pricing establishes the most economically efficient (maximising welfare - the sum of consumer and producer surplus) set of industry prices, P_1, P_2 and P_3, subject to the constraint that the industry as a whole recovers both marginal and fixed common costs. Given the functional forms assumed above, assuming a sequence of integration for consumer surplus of "product 1 to product 2 to product 3", and measuring welfare from an arbitrary base of quantities $Q^b{}_1$, $Q^b{}_2$, and $Q^b{}_3$, welfare can be shown to be given by:

$$W \quad = \quad {}_{Qb1}\int^{Q1} P_1(Q_1, Q^b{}_2, Q^b{}_3)\, dQ_1$$

$$+ {}_{Qb2}\int^{Q2} P_2(Q_1, Q_2, Q^b{}_3)\, dQ_2$$

$$+ {}_{Qb3}\int^{Q3} P_3(Q_1, Q_2, Q_3)\, dQ_3$$

$$- m_1 Q_1 – m_2\ Q_2 – m_3\ Q_3 \qquad \text{(A1)}$$

$$= \quad Q_1 [P_1(Q_1, Q^b{}_2, Q^b{}_3) - \ {}_{11}] – Q^b{}_1 [P_1(Q^b{}_1, Q^b{}_2, Q^b{}_3) - \ {}_{11}]$$

$$+ Q_2 [P_2(Q_1, Q_2, Q^b{}_3) - \ {}_{22}] – Q^b{}_2 [P_2(Q_1, Q^b{}_2, Q^b{}_3) - \ {}_{22}]$$

$$+ Q_3 [P_3(Q_1, Q_2, Q_3) - \ {}_{33}] – Q^b{}_3 [P_3(Q_1, Q_2, Q^b{}_3) - \ {}_{33}]$$

$$- m_1 Q_1 – m_2\ Q_2 – m_3\ Q_3 \qquad \text{(A2)}$$

So:

$$\frac{W}{Q_1} \quad = \quad P_1(Q_1, Q^b{}_2, Q^b{}_3) + \ {}_{21} \frac{Q_2 - Q^b{}_2}{Q_1} + \ {}_{31} \frac{Q_3 - Q^b{}_3}{Q_1} - m_1 \qquad \text{(A3a)}$$

$$\frac{W}{Q_2} \quad = \quad P_2(Q_1, Q_2, Q^b{}_3) + \ {}_{32} \frac{Q_3 - Q^b{}_3}{Q_2} – m_2 \qquad \text{(A3b)}$$

$$\frac{W}{Q_3} \quad = \quad P_3(Q_1, Q_2, Q_3) – m_3 \qquad \text{(A3c)}$$

We now note that:

$${}_{ij} \frac{Q_i - Q^b{}_i}{Q_j} \quad = \frac{{}_{ij}\, Q_i}{{}_{ji}\, Q_j} \ {}_{ji} \frac{Q_i - Q^b{}_i}{Q_i} \qquad i,j = 1, 2, 3 \qquad \text{(A4)}$$

$$\approx \frac{Q_i}{P_j} \Big/ \frac{Q_j}{P_i} \ {}_{ji} \log (- Q^b{}_i / Q_i) \qquad \text{(A5)}$$

$$= \ {}_{ji} \log (- Q^b{}_i / Q_i) \qquad \text{(A6)}$$

by assuming symmetry in the first derivatives of the demand function. This approximation allows us to re-write the first derivatives of the welfare function as:

$$\frac{W}{Q_1} = P_1(Q_1, Q_2, Q_3) - m_1 \qquad \text{(A7a)}$$

$$\frac{W}{Q_2} = P_2(Q_1, Q_2, Q_3) - m_2 \qquad \text{(A7b)}$$

$$\frac{W}{Q_3} = P_3(Q_1, Q_2, Q_3) - m_3 \qquad \text{(A7c)}$$

demonstrating that welfare is maximised when prices are set equal to marginal costs if there is no constraints on industry loss. However, taking account of the constraint that industry revenue must be sufficient to recover costs, the first order conditions to maximise welfare are:

$$0 = P_1(Q_1, Q_2, Q_3) - m_1 + \; (P_1 + \;_{11} + \;_{21} \frac{Q_2}{Q_1} + \;_{31} \frac{Q_3}{Q_1} - m_1)$$

$$0 = P_2(Q_1, Q_2, Q_3) - m_2 + \; (P_2 + \;_{22} + \;_{12} \frac{Q_1}{Q_2} + \;_{32} \frac{Q_3}{Q_2} - m_2)$$

$$0 = P_3(Q_1, Q_2, Q_3) - m_3 + \; (P_3 + \;_{33} + \;_{13} \frac{Q_1}{Q_3} + \;_{23} \frac{Q_2}{Q_3} - m_3)$$

(A8)

Or re-writing:

$$P_1 = m_1 + \frac{}{1 +} (\;_{11} + \;_{21} \frac{Q_2}{Q_1} + \;_{31} \frac{Q_3}{Q_1}) \qquad \text{(A9a)}$$

$$P_2 = m_2 + \frac{}{1 +} (\;_{22} + \;_{12} \frac{Q_1}{Q_2} + \;_{32} \frac{Q_3}{Q_2}) \qquad \text{(A9b)}$$

$$P_3 = m_3 + \frac{}{1 +} (\;_{33} + \;_{13} \frac{Q_1}{Q_3} + \;_{23} \frac{Q_2}{Q_3}) \qquad \text{(A9c)}$$

where is a Lagrangian Multiplier applying to the zero industry profit constraint :

$$0 = P_1 Q_1 + P_2 Q_2 + P_3 Q_3 - m_1 Q_1 - m_2 Q_2 - m_3 Q_3 - F \qquad \text{(A10)}$$

Substituting equations (A9) into (A10) gives:

$$\frac{}{1+} = \frac{F}{G} \qquad \text{(A11)}$$

where

$$G_i \quad = \quad {}_{1i}\, Q_1 + \quad {}_{2i}\, Q_2 + \quad {}_{3i}\, Q_3 \qquad \text{(A12a)}$$

and $$G \quad = G_1 + G_2 + G_3 \qquad \text{(A12b)}$$

Substituting this back into equations (A9) gives the familiar inverse super-elasticity mark-up rule of Ramsey Pricing, to recover fixed common costs:

$$P_1 = \quad m_1 + \frac{G_1}{G} \frac{F}{Q_1} \qquad \text{(A13a)}$$

$$P_2 = \quad m_2 + \frac{G_2}{G} \frac{F}{Q_2} \qquad \text{(A13b)}$$

$$P_3 = \quad m_3 + \frac{G_3}{G} \frac{F}{Q_3} \qquad \text{(A13c)}$$