Empirical Analysis of Further Liberalisation in Norway

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This paper analyses possible accelerated postal liberalisation in Norway. Results are from a detailed study by London Economics and commissioned by the Norwegian Ministry for Telecommunications and Post. The focus is to analyse the balance between achieving competition and postal incumbent finances. This balance is especially interesting in Norway because, although Norway Post is given a direct subsidy for the cost of their USO, Norway Post has been running large deficits and current pricing structures entail large money losing cross subsidies not explicitly paid for by the USO-subsidy. The paper makes use of two modelling approaches. First, we make use of detailed accounts of Norway Post's products, pricing, volumes, and costs. While specific product information from this database remains confidential, financial results indicate that a very large portion of Norway Post's products that cover institutional costs are now open to competition. In addition, we calibrate and employ a slightly modified version of the model of pricing and the 'death spiral' introduced by Crew and Kleindorfer. The two approaches give broadly similar results, i.e., that the "death" spiral is not likely to occur, while also suggesting Norway Post could face significant financial pressures. We conclude the largest pressures on Norway Post arise from existing pricing structures and currently liberalised product markets. Additional liberalisation, coupled with further rationalisation and corporatisation, should thus provide benefits for both incumbent and customers.

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1 INTRODUCTION

Liberalisation of postal services is underway both in the EU and in EEA countries such as Norway. Because Norway is not a member of the EU, it has the option of following the policies set out in EU postal directives to the letter, but it is not obliged to do so. Up to now, Norway has chosen to keep pace with the EU liberalisation programme, but Norwegian policymakers have kept under review the possibility of either accelerating or decelerating the pace of postal liberalisation.

London Economics was retained by the Norwegian Ministry of Transport and Communications (hereafter "the Ministry") to study the consequences of further liberalisation. This paper draws upon research carried out by the authors for the Ministry.[1]

1.1 Approach and Overview

In this paper, we analyse some of the likely effects of additional liberalisation of postal services in Norway. A range of approaches to predicting the impact of incremental liberalisation are employed the literature on this subject, and they often seem to give different results. We therefore use two different modelling approaches to better understand the processes involved and increase the robustness of our findings. The first approach evaluates details of Norway Post's product accounts. Our findings using this approach are subject to confidentiality restrictions, and thus that element of the paper is largely descriptive. The second approach makes use of the model developed by Crew and Kleindorfer (2001). We estimate key parameters and calibrate the model to Norway Post's accounts.

The rest of the paper is organised as follows. The next section gives a short description of the Norwegian mail market. Section 3 discusses our financial modelling results based on product specific accounts. Section 4 discusses the results of modelling based on the Crew and Kleindorfer model, while section 5 sets out conclusions and suggests directions for future research.

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[1] London Economics (2003), http://odin.dep.no/sd/engelsk/028021-070094/dok-bn.html.

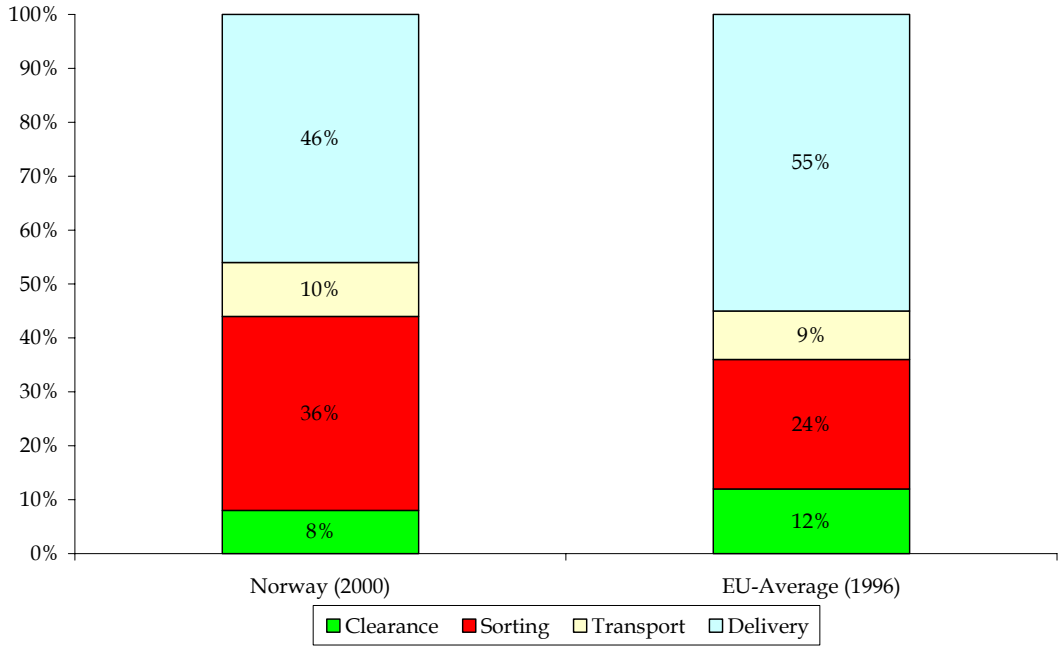
2 Norway Post and Its USO

Norway Post (NP) is the USP in Norway. NP has a legal concession and protection from entry as well as USO obligations, including delivery of items up to 2kg six days per week. In addition, at least one permanent postal facility must be located in each municipality.[2] One unusual feature of Norway's USO mechanism is particularly important to our analysis: Norway's government provides a direct payment to Norway Post that is intended to cover the cost of universal service.

Cost data for Norway Post's operations varying by route or geographical region were not available to the study team. However, it is possible to draw some broad conclusions about Norway Post's cost structure from basic data on cost shares of operations. These are presented in Figure 2.1 below. Norway Post, in spite of having very large distances between certain delivery points, has a total cost share of delivery that is well below the EU average. Transport cost share is broadly in line with the EU average, while the share of cost associated with sorting in Norway is significantly above the EU average.

[2] For more details on the USO mechanism in Norway, see London Economics (2003), http://odin.dep.no/sd/engelsk/028021-070094/dok-bn.html.

Figure 2.1: Cost Distribution in the Postal Sector: Norway and EU-Average

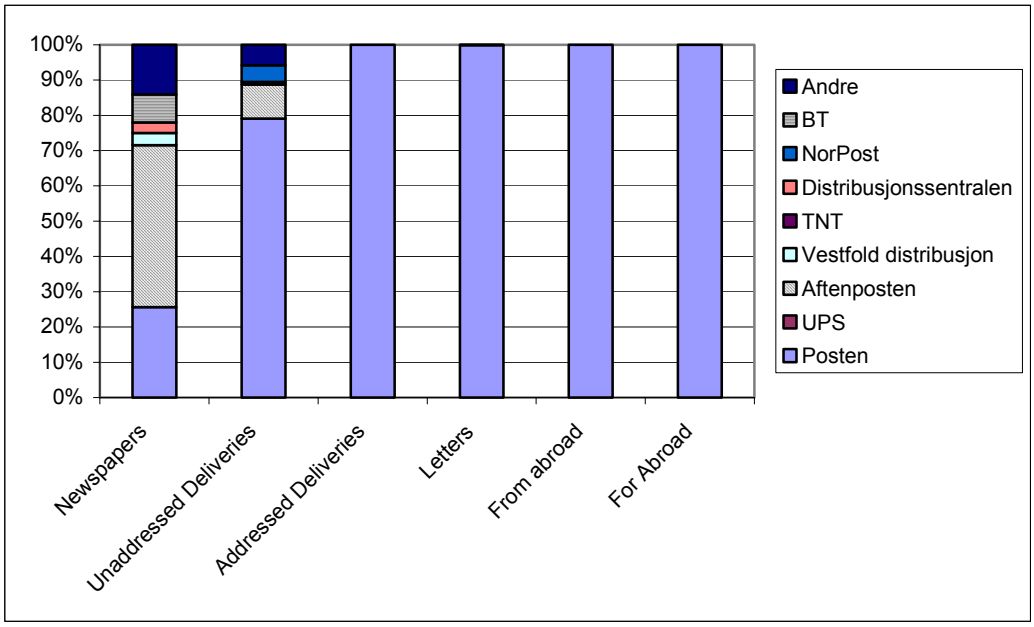


It is also useful to get an overview of Norway's mail markets in the context of competition. Summary data on revenue, volumes, and concentration measures are presented below in Table 2-1. It is interesting to note that there is significant volume growth in some segments of Norway's mail markets, including newspaper and magazine delivery. On the other hand, volumes of standard addressed mail items fell for both domestic and international post. Volumes went in the same direction as revenues, with the exception of international post. Revenues nearly doubled for magazines, while revenues rose slightly for newspapers and actually fell for addressed domestic mail. International revenues rose from 2001 to 2002, evidently from price increases.

Figure 2.2 below gives an indication of the extent of competition across a number of postal products in Norway. As can be observed, addressed domestic and international mail is provided solely by Norway Post, whereas

competitors have a significant presence in newspaper delivery and a limited share of unaddressed deliveries.

Figure 2.2:Market Share for Unregistered Deliveries – 2002



Source: PT

Table 2-1: Overview of Sales and Competition in Norway - 2000-2002

	Volume		Revenue[3]		Degree of Competition	
	2001	**2002**	**2001**	**2002**	**2001**	**2002**
	('000)	**('000)**	**(€'000)**	**(€'000)**	**HHI Index**	**HHI Index**
Unregistered deliveries						
Domestic						
Addressed letters	1,160,652	984,047	726,516	601,892	1.00	1.00
Newspaper subscriptions	411,334	441,608	114,068	125,807	0.34	0.29
Magazine subscription	136,280	285,524	40,926	100,087	1.00	1.00
Total domestic deliveries	1,287,879	1,355,790	107,349	115,479	0.65	0.64
For Abroad	40,052	36,727	52,953	53,826	0.95	0.95
From Abroad	86,402	80,212	47,834	51,660	1.00	1.00
Addressed registered deliveries						
Domestic	30,833	31,579	286,622	283,665	0.80	0.78
For Abroad	1,298	1,485	46,335	60,050	0.39	0.27
From abroad	4,315	5,059	46,620	76,313	0.32	0.27
Total	**1,450,779**	**1,510,853**	**587,712**	**640,992**		

Source: Norwegian Ministry for Post & Telecommunications

[3] Conversions from Norwegian Kroner to Euro in this paper use an exchange rate of 0.119088 NOK/EUR as per x-rates.com, 31 December 2003.

3 DETAILED PRODUCT ACCOUNTS

Our approach to studying the impact of potential accelerated liberalisation of post in Norway starts with financial analysis by products. In spite of the lack of cost details that vary by geographical location or "route type", considerable variation in operating margin or 'variable profit' exists in Norway Post's product accounts and regulatory accounts. We are subject to confidentiality restrictions that do not permit us to present these data here. The rest of the data used in our research is drawn from London Economics estimates, Norway Post's regulatory accounts, Norway Post's statutory accounts and other publicly available sources (e.g. published tariffs).[4]

Table 3-1: Description of Norway Post's Current Pricing Structure – Daily Letters - Prepaid with Stamps – 2002 Prices in Euro

A-PRIORITY (incl. VAT)						
Grams	**20**	**50**	**100**	**350**	**1000**	**2000**
Norway	0.65	1.01	1.31	2.62	6.55	14.29
Nordic countries*	0.83	1.31	1.67	3.22	8.93	17.86
Europe	1.07	1.61	2.14	5.36	11.91	22.15
World	1.19	2.38	3.57	7.38	17.86	30.96
B-ECONOMY (incl. VAT)						
Grams	**20**	**50**	**100**	**350**	**1000**	**2000**
Norway	0.60	0.89	1.19	2.38	5.95	11.91
Nordic countries*	0.77	1.19	1.43	2.98	7.38	14.77
Europe	0.89	1.31	1.79	4.17	8.93	17.86
World	1.01	2.02	3.10	6.19	13.34	22.15

Source: Norway Post

Note: Nordic countries include Denmark, Faeroe Islands, Greenland, Finland, Iceland and Sweden.

[4] In this paper, we use only non-confidential sources. Our work for the Ministry included analysis of additional sources.

To gain some insight into the structure of the tariffs in Norway, it is useful to make some comparisons. We first show the relative levels of Norway's tariffs at higher weight steps in comparison to its own basic stamp, and then compare these levels to those prevailing in the UK, EU-average and Ireland. Comparing Norway Post's tariffs to its basic stamp gives a rough indication of the margin on each product/weight step.[5] Comparing across countries, assuming they employ similar technologies, the "slope" of the increase also gives an indication of where potential entry might occur at certain weight steps. In other words, while wage differences and other cost drivers may differ across country, it would be hard to argue that it costs (an efficient operator) *relatively more* to deliver a 100g or 250g letter in Norway than in the rest of the EU.

Suppose that the average costs across weight steps and operators are unknown.[6] The average cost for a given product cannot be too much higher than the tariff for the lower weight steps or the postal administration would be losing very large sums, since average weight tends to be quite low (certainly < 350g in the EU). It is also reasonable to assume that average cost does not change much among lower weight steps (350g and below) or among higher weight steps (1 to 2kg). The hypothesis that average cost varies little across lower weight steps is reflected in the Irish tariffs, where the administration has made an explicit move towards format-based pricing, and to a lesser extent in the EU and UK tariff structures.

[5] We restrict ourselves to priority stamped letters, but the structure of the tariffs is very similar across speed, quality, format, and franking method in Norway.

[6] LE and the Ministry had estimates of these average costs from the regulatory accounts of Norway Post, but these are subject to confidentiality restrictions.

Table 2: Comparison of % increase on basic tariff									
Country	**Standard A-class domestic letters**								
	Weight (g)	**20/25**	**50**	**100**	**250**	**350**	**500**	**1000**	**2000**
Norway	%change on basic	0%	55%	100%	300%	300%	900%	900%	2082%
UK	%change on basic	0%	0%	50%	214%	311%	500%	1132%	2361%
EU Avg	%change on basic	0%	0%	33%	118%	174%	241%	389%	641%
Ireland	%change on basic	0%	0%	0%	100%	200%	200%	400%	1254%
Source: LE and published tariffs									

Although estimating the impact of further liberalisation based on little more than published tariffs is a challenging task, it is possible to make some inferences. To study the regulatory accounts and price structures further, we first used the regulatory accounting data to derive average costs by dividing the reported total costs by total volumes for broad mail class categories, such as priority/economy, domestic/international, parcel non-parcel, and reserved/non-reserved. We were also able to estimate average total cost and average variable cost figures based on the regulatory accounts. These average cost figures were then matched to their corresponding tariffs for each weight step and mail type, thus creating an estimated margin for each product. With the application of the volumes by specific mail types, *total variable profits*[7] per product were calculated. Thus, we were able to identify specific mail products that contributed significantly to Norway Post's financial health by covering fixed (institutional) costs.

[7] We use the term total variable profit to mean (price – average variable cost) x volume.

We found that some products gave rise to high volumes at low margins, contributing large net revenues. Other products contributed significantly to Norway Post's bottom line through relatively high margins.

Analysis then proceeded by sorting on total variable profits and total margins. This analysis revealed that several of Norway Post's products showed high margins and high volumes, and were in the category of mails that were recently liberalised, i.e., down to 100 grams. In addition, the analysis revealed that some products were losing significant amounts of money even on a variable profit basis, and so effectively were receiving a cross-subsidy from other mail types within the Norway Post tariff system.

3.1 Liberalisation Scenarios

We next consider two of the most likely possibilities for further liberalisation: further reduction of the reserved area to items up to 50g and full abolition of the reserved area.

Scenario 1 – Further reduction of the reserved area to items up to 50g

Reducing the reserved area to items up to 50g would open Norway Post's products above 50g to competition. This would include two weight steps currently within the reserved area. To estimate the potential impact of the reduction in the reserved area, it is necessary to look at the margins and the amount of total variable profit generated by product for this category of mail. The mail category now includes items from 100 to 350g and from 50 to 100g. The high margin products are relatively more likely to be affected by competition. We sorted the data from the model based on reserved and non reserved. Then within the non-reserved area, we then sorted the data based on weight step, and finally sorted the data based on total variable profits. Then, within the reserved area, we again sorted the class of mail from 50g to 350g by total variable profits.

Through this procedure, we were able to determine which products within the next weight step contribute the most to the institutional costs at Norway Post. The numeric results must remain confidential, but we can give some descriptive details. The results suggest that some significant financial pressures might arise for Norway Post should further liberalisation occur,

but that the largest impacts would likely come from the weight steps that were already being liberalised under Norway's existing programme.

Scenario 2 - Abolish reserved areas altogether

Full abolition of the reserved area would mean that all of Norway Post's products from 0g to 350g would be subject to competition. This includes four weight steps below the newly introduced reserved area, 0-20g, 20- 50g, 50-100g, in addition to now liberalised 100-350g. Our method of analysis continues in the same way as discussed above when considering the restriction of the reserved areas to lower weight steps. To estimate the potential impact of this, it is we examined the margins and the amount of total variable profit generated by product for this category of mail. The mail category in this case includes items from 0 to 350g, and all high margin products are assumed relatively likely to be affected by competition.

Although the product margins tended to be low for the lowest weight steps, it is possible that some products have higher margins due to geographical dispersion in costs—which are not reflected in the cost data provided by Norway Post. Norway Post's profitability will be affected by changes in competition and competitive entry to the extent that the firm receives total variable profits for each product.

To calculate the impact from a further reduction of the reserved area, we sort the data from the model based on reserved and non reserved. Then within the non-reserved area, we then sort the data based on weight step, and then finally sort the data based on total variable profits. Then, within the reserved area, we sorted again the class of mail from 0g to 50g by total variable profits.

Thus, we determined which products within the next weight step contribute the most to Norway Post institutional costs. The numeric results must remain confidential but we give descriptive details below.

3.2 Results

Summary comparisons of the estimated impact of the current liberalisation programme and the incremental impact of additional liberalisation can be

made (within the confines of confidentiality requirements).[8] The results showed that the *incremental* impact of full liberalisation in Norway was estimated to be NOK 78m (€9.3m), while the estimated impact of the current liberalisation programme was estimated to be NOK 250 million (€30m). These impacts could manifest themselves through either entry or price reductions.

While the precise impact estimates are clearly subject to a degree of uncertainty, we can be more confident about the likely effect of the current liberalisation programme *relative* to liberalisation of the remaining weight steps. What matters for this comparison is whether the estimates are *differentially* biased, and we consider this unlikely. While there is the possibility that cream-skimming has been poorly estimated (since we do not have a geographical or high-cost –low cost routes structure), we feel that it would be hard to argue that, say, 200g letters have a significantly different route-cost variation from 50g letters. Thus the result that the current liberalisation programme is potentially twice as painful as full liberalisation is likely invariant to incorporating more detailed cost and revenue data.

4 CREW & KLEINDORFER MODEL

LE's financial and competitive modelling results discussed in the previous section rely on rather uncertain estimates of the amount of entry that might occur in product markets at certain weight steps based on product margins. Given the degree of judgement involved, considering alternative modelling methods would presumably be useful. For this reason, we also implemented the model developed by Crew and Kleindorfer (2001) (C&K).

4.1 Model description

The C&K model provides a model of entry and sustainability in postal services with a fixed USO. In contrast to our previous approach, it incorporates heterogeneity in mail types and routes but is homogeneous with

[8] These figures were made public on the Ministry's website in the public version of our report.

regard to different weight steps and quality classes.[9] A fundamental assumption is that fixed USO costs must be financed with uniform stamp prices. It imposes some structure on demand (linear) and cost structure (linear in the type of routes). It also assumes the objectives of the regulator or government are to maximise the total social welfare arising from the whole postal sector.

The model itself has both benefits and drawbacks vis-à-vis other potential models. One benefit of the model is that it is able to take key parameters that can be estimated and return predictions about quantities such as the market share of entrants, the percentage of routes served end-to-end by entrants, and the profitability impacts on the incumbent postal operator. Potential drawbacks of the model are that it appears to be sensitive to certain parameters and that it seems to predict a seemingly high degree of work-sharing across a wide range of parameter estimates. This is perhaps of interest, since work-sharing is wide-spread in the US, but less prevalent in the EU.

4.2 Empirical implementation

The model takes as inputs a number of key parameters. A comparison of our parameter inputs and the C&K inputs is found below:

[9] It is likely that "types" could be indexed by a number of categories; speed, weight, etc, in addition to geography. C&K's model assumes there is a continuum of types along cost and demand parameters. However, the model does not allow for different prices to be charged, such as for first and second class service, heavy items, etc.

Table 4.2-1: Comparison of C&K parameter inputs and London Economics parameter inputs

AFCi	AVCi	AFCe	AVCe	presort AVC	Fixed cost of USO	Fixed cost of entry	demand parameter 1	demand parameter 2	demand parameter 3
a0	**a1**	**b0**	**b1**	**c0**	**F**	**f**	**d0**	**d1**	**gamma**
20	20	30	60	5	4,000	400	4,000	2,000	5
2.49	2.27	3.73	7.46	0.62	373,000,000	37,300,000	10,266,666,667	5,133,333,333	6

Source: London Economics calculations

The first set of parameters is the average fixed costs for postal operators: AFCi in our table or a0 in C&K. Average variable cost with respect to route is the a1 parameter, or AVCi. These are estimated for the incumbent using volumes data and the regulatory cost accounts. The average fixed cost and average variable cost (b0 and b1) for the entrant is assumed to be proportional to the incumbent's estimated data. The factor of proportionality is 1.5 and 2 for the b0 and b1 parameters each. These values were taken from the C&K paper. The model also takes the total demand or volumes of mail items implicitly as data. The demand structure is based on two parameters, and we calibrated the model such that the actual demand of Norway Post is reflected by the two parameters.

The model also takes as an estimate the fixed cost of the USO to the postal operators; we use the estimates of this number from the actual cost estimates of the USO from Norway Post. While Norway Post receives a subsidy towards this costs, total variable profit losses from certain mail types, mainly newspapers,[10] were, at NOK 360m (€32.9m), of a similar magnitude to the USO cost estimates of NOK 373m (€44.4m). The fixed cost of entry is also a key parameter. This was estimated to be 10% of the fixed cost of the USO, based on C&K.

[10] We note that this represents a "fixed" cost of the USO vis-à-vis standard mail volumes.

A final parameter is the gamma parameter, which reflects the "peakiness" of volumes as related to customers. Thus, a gamma of 5 implies that the top 10% of customers account for 50% of all mail volume. We were unable to estimate this from Norway Post data, but LE's experience from other EU postal markets suggests that this should be even higher.[11] In other words, the top 2.5 to 5% of customers are more likely to represent 50% of all mail volumes. We therefore set this parameter to 6 as opposed to C&K's 5.

One of the more important parameter estimates in the C&K model is the fixed cost of the USO. One of the interesting features of using the C&K model in Norway is that, as we have noted earlier, Norway receives a direct subsidy intended to meet the cost of its USO. In spite of this, Norway's current product-based pricing and cost structure effectively enforces large cross-subsidies between different types of mail within Norway Post. This effectively becomes an added USO cost for which Norway Post is not compensated. This assumption takes account of the fact that Norway Post is evidently losing more than NOK 500m (€60m) on local and regional newspaper delivery. In terms of total variable profit, newspapers on the whole are estimated to lose about NOK 360m (€42.9m). Note also that it is the existence of such subsidies built into the pricing structure makes Norway Post vulnerable to entry, and may even give rise to the possibility of inefficient entry.

4.3 Results

The results of three modelling scenarios using the C&K model are shown below in Table 4.3-1. The table shows scenarios for a number of basic prices. We start with average revenue from mail of approximately NOK 5 (€0.60), which is the case with Norway Post. At this level of pricing by the incumbent, the entrant is predicted to serve 8.6% of routes end-to-end, and serve 33% of customers. Note that an entrant can serve a customer by providing some portion of the value chain in mail, so a relatively large figure here is not surprising as a large percentage of customers will receive *some*

[11] LE has carried out analysis of confidential mail volume data for a number of jurisdictions. In general, we find that smaller European countries tend to have a higher percentage of mail made up by top customers, as central government and a small number of big mailers like banks and insurance companies would make up a larger percentage of volumes, vis-à-vis a larger country like the US.

mail that has been either pre-sorted or somehow handled by the entrant. The percentage of customers served by the incumbent is 67%.

Table 4.3-1: Outputs of the C&K model

Headline price/average revenue	Entrant % routes served end to end	Entrant % customers served	Incumbent % customers served	Postal operator profit (€millions)
5.0	8.6%	33%	67%	46.0
4.6	3.3%	8.4%	91.6%	14.6
4.45	-	0	100%	10.1

Source: London Economics calculations

At this level of pricing and entry, and given the parameter inputs used above in Table 4.3-1, the incumbent postal operator is predicted to make profit of NOK 386m (€46m). Nonetheless, the main focus of our modelling exercise is not the levels, but the changes given a particular policy action and pricing response.

What impact on entry and profitability would occur if prices were lowered? We first consider the case of prices lowered to NOK 4.6 (€0.54) (again, consider this the average revenue or headline rate). The degree of entry now falls dramatically. Only 3.3% of routes are served end-to-end and only 8.4% of customers are served. If the stamp price is lowered further, to NOK 4.45 (€0.53), then entry is effectively blockaded. The profits of the post fall significantly, to NOK 85m (€10.1m), as they have lowered price but not costs—representing a net impact of NOK 301m (€35.8m). These results are sensitive to the parameter inputs.

This shows, however, is that, given reasonable assumptions and estimates, the balance is rather delicate. If prices remain too high then Norway Post can face significant loss of market share, and significant cream skimming. At the same time, Norway Post is predicted to be able to effectively blockade entry, mainly by lowering price.

5 SUMMARY, CONCLUSIONS AND FUTURE DIRECTIONS

This paper has considered the potential impact should Norway adopt an accelerated liberalisation programme. We used two modelling approaches to study the question: one based on sorting product accounts based on margins and total variable profits and one based on the model developed by Crew and Kleindorfer (2001). Both modelling approaches were allowed significant analysis of the possibility and likelihood of entry on profitable products/types, in spite of the lack of route specific cost or revenue data.

Our study leads to a number of conclusions and raises a few possible areas for future research. An overarching conclusion is that significant analysis of *additional* liberalisation can be done without route-specific cost and revenue data. This is because we can exploit differences in margins on existing mail product and rely on the generally weaker assumption that route-specific cream skimming is not likely to differ significantly *between* weight-steps. In addition, the use of models that account for heterogeneity in costs and types of mail such as the C&K model is developing.

Our first modelling approach combined product accounts and regulatory accounts data and a sorting approach to identify products that were vulnerable to entry under current or accelerated liberalisation scenarios. The main result was that the current liberalisation programme had potentially twice as big a financial impact on Norway Post as a full liberalisation programme. This relative result is predicted to be invariant to incorporation of more detailed data that vary by route type.

A second modelling approach used the model of entry and cream skimming developed by Crew and Kleindorfer. Despite the payment to Norway Post of an USO explicit subsidy, current pricing/cost structures at NP imply large cross subsidies between mail types. The modelling results suggest the that at existing price levels and structures significant entry may occur: about 33% of users might be served by an entrant, while 8.6% of customers might be served end-to-end. The results suggest that the incumbent can effectively block entry by price reductions, and the so-called death spiral is not likely to

occur. At the same time, the results suggest caution, because small price cuts can lead to big profit losses; alternatively, small price rises can lead to big market share losses.

The main conclusions of our analysis are therefore two-fold. One is that the current liberalisation programme likely gives rise to a higher relative financial risk than an incremental liberalisation programme in Norway. Norway Post is unlikely to face a death-spiral and can effectively block entry by lowering prices. This weighing of relative risks suggests that an accelerated liberalisation programme in Norway before rationalising existing inefficient price-cost structures could exacerbate existent financial pressures on Norway Post.

The two modelling approaches both raise some interesting directions for future research. For example, the first approach posits that the degree of route-type cream-skimming is not likely to be significantly variable *between* mail products, such as lower weight steps, flats and packets, etc. Sampling or detailed cost evidence could test this hypothesis. In terms of the C&K model, more detailed work estimating some of the cost parameters could prove interesting. For example, does the cost of entry change relative to the cost of the USO, a key ratio of parameters in C&K, across countries?

References

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Annex 1 Some details of Crew and Kleindorfer Model

Crew and Kleindorfer Model takes as inputs estimates of parameters that define the following terms under various assumptions:

- $c_r(s,t)$= the unit cost for the incumbent to service mail of type *(s, t)*that has been presorted by an entrant.
- F= The total cost of the USO.
- $c_e(s,t)$= the entrant's unit cost to service mail of type *(s, t)* .
- $f(h)$= the fixed set up costs of an entrant.
- P_u= the uniform unit price for USO service
- P_r= price paid to entrants for pre-sorted mail deposited with the postal operator for delivery to end-user by the postal operator.

The model then assumes that a regulator maximises consumer surplus as a function of the constraints that the incumbent makes zero profits.

Under this assumption, the only decision variable is the uniform USO price to charge, and a large number of policy outcomes such as market shares can then be determined by the model.

The model is then operationalised by making the simplifying assumptions that unit mail costs for incumbents and entrants, and aggregate demand ($Z(p,t,h)$) take the following forms, linear in the variable t, a description of the relative costs of serving different "types" of delivery:

Equation A4.1 $$c_I(s,t) = c_0 + a_o + a_1 t$$

Equation A4.2 $$c_e(s,t) = c_0 + b_o + b_1 t$$

Equation A4.3 $$D(p,t,h) = h^{\gamma}(\delta_o - \delta_1 t)$$