THE USE OF CUSTOMER OUTAGE COST SURVEYS IN POLICY DECISION-MAKING: THE ITALIAN EXPERIENCE IN REGULATING QUALITY OF ELECTRICITY SUPPLY

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INTRODUCTION

This paper summarizes the objectives, the methodological aspects, and the key results of the survey on customer outages cost conducted in Italy in the year 2003. The paper reports the main findings and the estimated costs for various interruption scenarios. The Italian regulatory regime for quality of electricity supply entered a new regulatory period at the beginning of the year 2004: the paper illustrates the decisions made by the regulator on the basis of the described analysis. Finally, the paper comments on the differences in numerical values that were observed in comparison with other surveys.

REGULATION OF CONTINUITY OF SUPPLY IN ITALY

Quality regulation in electricity distribution has received significant attention in recent years, following a widespread adoption of performance-based regulation in the form of a price cap. It is known that price cap regulation, while providing strong incentives to reduce costs, always results in quality levels that are sub-optimal [1]. Regulators, thus, usually design incentive mechanisms specifically targeted at quality of supply, assuming the form of financial penalties and rewards for the distribution company. Theoretically, financial incentive are set at a level where the incremental costs for the utility to provide continuity of service equal the loss incurred by consumers for poor continuity. This ensures that quality standards are set at a level where the sum of utility and consumers’ costs are minimized.

The Regulatory Authority for Electricity and Gas (AEEG) introduced, in the year 2000†, a quality targeted incentive mechanism designed according to this theoretical background. The regulation links the electricity distribution tariff to a unique indicator of quality of supply, the cumulative duration of long, unplanned interruptions, expressed in minutes per consumer per year (SAIDI). This indicator is measured separately in more than 300 territorial districts, homogeneous in population density, and covering the entire national territory. This enables the regulator to account for exogenous (mainly geographical and technical) factors that influence company performances. At the beginning of the regulatory period the regulator fixes, for each territorial district, yearly improvement targets in SAIDI, differentiated according to population density and initial level of continuity. The baseline, or, yearly-required improvement per district, is designed so that higher improvements are required in districts having an initial quality level that is worse. Quality-related company performances are measured annually, as the difference (positive or negative) between the baseline and a two-year moving average of the measured SAIDI per each territorial district (ΔSAIDI). Financial incentives are calculated on an annual basis, as a function of a monetary incentive rate, the energy delivered in a given district at MV and LV customers, and the ΔSAIDI. The distribution tariff, $p_t$, in the year $t$ varies according to a modified price cap formula, of the type:

$$p_t = p_{t-1} \cdot (1 + RPI - X \pm Q)$$

where $RPI$ is the retail price index, $X$ is the efficiency gain fixed by the regulator for the four year tariff period, and $Q$ is a quality parameter. Yearly values of the parameter $Q$ are calculated, ex post, on the basis of company performances and relative financial incentives [2], [3]. The financial incentive scheme is, thus, symmetric and provides penalties (rewards) for under-performance (over-performance) with respect to the baseline.

In the period 2000-2003 the regulatory mechanism reached most of the objectives it was designed for: average duration and number of interruptions were significantly reduced, especially, in those regions were the initial situation was worse [4]. In view of the new regulatory period, beginning in 2004, the incentive rate used in the regulatory scheme needed to be updated. To this end, the AEEG commissioned a customer survey for investigating and quantifying the impact of electric service interruptions on customers. This survey is the first one ever conducted by the regulatory authority on this specific subject. Lacking precise information on consumer valuation of quality, for the first regulatory period the incentive rate was set using utility costs, as the main reference.

CUSTOMER OUTAGE COST SURVEYS

Many different approaches in various countries have been employed to investigate the impacts and costs of interruptions to users. These studies show that the interruption cost varies over a wide range of values and depends on the country of origin and type of consumers. There are two principal measurement techniques used in estimating interruption costs: market based methods (using data related to observed

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1 Other European countries adopted similar incentive schemes only in subsequent years: Norway and Ireland in 2001, UK in 2002, and Hungary in 2003.
consumer valuation), and contingent valuation methods (using survey and experimental settings to reveal consumer valuation). A discussion about keys issues and recent international estimates can be found in [5] The experience with contingent valuation methods goes back to the analyses based on consumers’ Direct Costs (DC), conducted in Canada, beginning from the 1980s. Similar analysis were conducted in Norway in 1991 and 2001. The latter one included also the analysis of consumer Willingness To Pay (WTP) and Willingness to Accept (WTA). The Italian survey was based on this latter approach, with all due modifications for adapting the methodology to the characteristics of the Italian system. Together with the Norwegian (2001) [6] and the UK ones (2004) [7], the Italian survey is one of the very few in Europe to date commissioned by regulators.

THE SURVEY IN ITALY

The main objective of the survey was to provide an economic valuation of interruption costs incurred by two categories of end users: domestic and non-domestic consumers. The survey comprised 1100 face to face domestic interviews and 1500 business interviews across Italy and was structured to include geographical diversity (both rural and urban locations), a variety of experiences in interruptions, and, for business interviews, different company sizes. The samples represented the Italian low-voltage end-user population, an intersection of the subsets defined on economic activity (residential, industrial, commercial) and network type (high, medium and low density areas). All together, the populations identified covered an extremely large share of consumers in terms of number (97% of total consumers) and accounted for approximately half of the total Italian electricity consumption. The collection of data took place over the July-September 2003 period. The fieldwork did however conclude before September 27th, 2003, when the national black-out occurred. On the contrary, the interruptions due to load shedding requested by the National Transmission Network Operator on June 26th, 2003 did have an impact on the research. The initial programme schedule was thus modified to mitigate the effects of this event: in July only pilot interviews were carried out, all other interviews took place in September.

Methodology And Sample Design

The project was implemented in collaboration with two Norwegian institutions: SINTEF Energy Research and SNF Institute for Research in Economics and Business Administration. Their contribution was particularly significant in adapting the model of valuation, already used in Norway as well as in other countries, to the Italian context. The reference universe for the domestic customer target group was composed of Italian households, in the number of 22 millions. The sample was defined by stratifying total contacts according to the fundamental variables shown in Table 1. The reference universe for the economic operators target group was in the order of 3.8 million businesses. The sample was segmented in three activity sectors classes: industry, commerce and service. The last two classes were, however, extremely heterogeneous. For this reason, quotas were identified for single segments of sub-sector activity (wholesale commerce, retail commerce, hotels/restaurants, and so on).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Domestic</th>
<th>Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of interviews</td>
<td>1100 face to face</td>
<td>1500 face to face (600 in the industrial sector and 900 in commerce and services)</td>
</tr>
<tr>
<td>Size of the company</td>
<td>n.a.</td>
<td>On the basis of number of employees, in 4 classes: 1-2, 3-9, 10-49 and 50-499</td>
</tr>
<tr>
<td>Geographic macro-area</td>
<td>North West, North East; Centre, South and Islands</td>
<td></td>
</tr>
<tr>
<td>Size of locality</td>
<td>Metropolitan areas, Large, Medium, Small locality</td>
<td></td>
</tr>
</tbody>
</table>

The high number of interviews, combined with the complex stratified sample design, limited the margins of statistical error even on rather detailed sub-target groups.

Questionnaires

Interviews were conducted directly at the home of the residential respondents and at the productive units of the business respondents and lasted on average 30 minutes. The use of personal interviews was as an important innovation: surveys have been conducted in other countries by postal interview. In Italy, however, response to postal interviews is extremely limited and this would have led the sample to self-select, even when performing follow-up operations. The questionnaire submitted to households focused on the valuation of economic damage ensuing from an hypothetical interruption scenario (Direct Costs) and on the quantification two key variables:
- willingness to pay (WTP), expressed as the price which the consumer would be willing to pay another company ready to take over with a reserve service in the event of supply interruptions on the part of the main supplier;
- willingness to accept (WTA) expressed as the amount that would be considered satisfactory if the company supplying electricity should decide to discount payment of the supply each time an interruption occurs.

It is important to note that WTP and WTA act also as tools by which to verify the consistency of gathered information. From an economic point of view these two aspects express the same concept of valuation of damage ensuing from the interruption: the amount a rational person is willing to pay for a replacement service should be no more than the damage one sustains if said service is deficient. Similarly, a discount equal to the loss suffered should be sufficient to provide a full coverage of the damage. As it will be clear from the results of the survey, practical experience shows that this is not the case: WTP is systematically less than WTA and the disparity between the two is often extremely significant.

Scenarios

A contingent valuation model requires respondents to imagine themselves in a few hypothetical scenarios in which the electricity supply is interrupted. For each scenario the respondents must draw on their own experience and provide a monetary quantification of the immediate damage that would
ensue. Each respondent was presented with a 2 hour interruption scenario, characterized by a time of the day in which it occurred and a day of the week (workday, holiday, Saturday). In order to investigate the impact of interruption duration, the respondent was required to estimate how much more or less (in percentage terms) would the afore-stated damage be if the interruption lasted 3 minutes, one hour, 4 hours or 8 hours.

Available Power And Annual Consumption

A prime indicator of the quantity of energy used by consumers in Italy is the available power in kW: all residential consumers fall within the 1.5 – 6 kW band. The highest concentration is found at the 3 kW value, which is the customary level for domestic power. The higher power classes concern the industry sector only.

As a consequence of limited power for households, a prevalence of small businesses in the economical structure, high electricity costs, and a mild climate, annual consumption records values in Italy are not particularly high. This peculiarity will be important when the survey results will be compared to those emerged from international available data. For the average household consumption is lower than 3000 kWh per year, while businesses as a whole record an average which is approximately ten times higher.

ANALYSIS OF THE RESULTS

The model’s input variables (annual consumption, direct costs for the various scenarios, WTA and WTP) were subject to outlier analysis (analysis of anomalous values, exceeding specific thresholds calculated on the basis of answer distribution). The anomalous values were censored (suppression of interviews featuring extreme values, considered anomalous, or missing values) and winsorised (repeated replacement of extreme values with other closer values, until these fall within the acceptability interval), on the basis of both statistical and logical consistency criteria. As a result of these interventions, the number of basic cases submitted to analysis dropped to 909 for the residential target group and to 1217 for the business target group.

Direct Costs

As far as Direct Costs are concerned, Figure 1 shows that, as expected, costs of energy interruptions increase as the duration of the interruption itself increases and as the size of the customer increases (power and consumption). The cost values refer:

- for households, to the average domestic consumer (3 kW power and 2800 kWh/year consumption);
- for business consumers, to three consumer groups: up to 10 kW, 10 to 30 kW, and 100 kW.

The direct cost curve has a non zero intercept: the damage caused by a three minute interruption. It should be interpreted as the cost associated to the occurrence of the interruption itself (not the duration of it). The curve then increases with a decreasing slope, producing a curve with a downward concavity. As indicated in Figure 1 (please note that data are reported using a logarithmic scale), the survey goes up to 8 hours as costs of interruptions of over 8 hours have not be examined in so far as the circumstance is unlikely to occur.

![FIGURE 1 Direct costs, logarithmic scale](image)

**Normalization**

Direct costs, WTA and WTP were then normalized on Energy Not Supplied (ENS). ENS, in kWh, indicates the quantity of energy that would on average have been consumed if the supply had not been interrupted in a given scenario for a given duration. The annual consumption of each consumer interviewed was divided by the energy quota consumed in the reference scenarios. Dividing the consumption pertaining to each scenario by the number of hours which are annually required in the scenario, the value of ENS for one hour in that scenario is obtained.

The normalised direct costs of interruptions (in euro/kWh not supplied), are obtained dividing the direct costs (for each duration, at both scenario level and at global level regardless of the scenario) by the relative ENS2.

In the same manner, dividing the WTP and WTA values by the ENS of the corresponding interruption duration, the normalised WTP and WTA values are obtained. Normalized values constitute the final output of the valuation model. The effect of normalisation is to achieve a damage valuation which is not subordinate to consumption, or rather to the size of the customer which, as shown in Figure 1, influences direct costs. Thus, normalisation provides values which allow comparison between different consumer types, by detaching the results from the quantity of energy used at the time of the interruption. Furthermore, it is important to notice that normalisation produces cost values expressed in euro/kWh not supplied, which can be more easily used in continuity regulation to define financial incentive rates.

**Normalized Direct Costs**

Table 2 shows that normalised Direct Costs vary in relation to the duration of the interruption. It is interesting to notice that the per hour costs diminish as the duration increases, as the increase in damage is less than proportional to the energy not supplied.

On the other hand, it is reasonable to expect

2 Short interruption (3 minutes) direct costs were normalized using the interrupted power at the time of the interruption: these values are expressed in Euro/kW interrupted.
normalised values to present interruption costs that decrease from a certain duration onwards: in terms of both emotive and real valuation of consequences, the initial impact and the early period tend to have the greatest effect.

**TABLE 2** – Normalized direct costs, €/kWh (3 min. interruptions, €/kW)

<table>
<thead>
<tr>
<th></th>
<th>Households</th>
<th>Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 minutes</td>
<td>8.02</td>
<td>55.16</td>
</tr>
<tr>
<td>1 hour</td>
<td>25.34</td>
<td>117.98</td>
</tr>
<tr>
<td>2 hours</td>
<td>20.41</td>
<td>83.79</td>
</tr>
<tr>
<td>4 hours</td>
<td>15.73</td>
<td>67.18</td>
</tr>
<tr>
<td>8 hours</td>
<td>9.68</td>
<td>40.01</td>
</tr>
</tbody>
</table>

While non-normalised costs were found to be of the same order of magnitude as other available results, normalised values are decidedly much higher in Italy than in other countries [5]. This difference may be explained by a number of reasons.

First of all, cultural reasons which lead to overestimation of direct costs. The electricity supply service is still perceived in Italy as a public service, even though electricity companies have been partially privatised. The customer-utility relationship is not regarded as a commercial relationship, but rather as one between a consumer and a state-company. Hence, cost assessment still features an element of “compensation”, given that anything that is public is often perceived as inefficient and negligent. Reported costs also contain an element of irritation which is probably associated with the impression that interruptions are the fruit of insufficient determination, neglect and lack of care for the consumer. Perceiving the service as public increases the sense of entitlement to the service, regardless of the costs incurred by the supplier.

Secondly, the very structure of electricity consumption in Italy is different from that of other countries. It has already been observed that both households and companies feature rather modest electricity consumption, owing to the costs of electricity. Hence, electricity usage is often restricted to areas where it is indispensable, while alternative sources, such as gas, are used in other areas. The situation is also influenced by the configuration of the Italian productive structure, not only extremely heterogeneous, but also characterised by a high portion of small businesses, which often achieve levels of consumption similar to households. A consumption level which is much lower (up to ten times) than that of other countries does not necessarily mean a proportional reduction in damage ensuing from interruptions. For these reasons, the use of a model in which consumption plays a fundamental role, for the purposes of normalisation – through the ENS value – means that it is difficult to compare the normalised results to those of other countries in which electricity is much more available and therefore more widely used.

**REGULATORY DECISIONS**

Given the structure of the electricity tariff, the regulator needed to transform the multiple information coming from the survey into a small number of parameters only, representing the value of undelivered energy for two consumer categories (domestic and business). In addition, given the symmetric structure of the Italian regulatory framework, the incentive rate had to be the same for both penalties and rewards.

Translating the information coming from surveys into very few numerical values required an effort of synthesis and, in part, also discretionary decision-making. The reference numbers used by the regulator were the normalised values of WTP and WTA. As in other surveys, these values were found to be very different: WTA was 4 to 7 times higher than WTP (see Table 3 and 4). A similar result was found also in Norway, whereas US literature indicates a ratio of 2 [8].

**TABLE 3** – Households – WTA and WTP normalized values, €/kWh (3 min. interruptions, €/kW)

<table>
<thead>
<tr>
<th></th>
<th>WTA</th>
<th>WTP</th>
<th>WTA + WTP/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 minutes</td>
<td>5.35</td>
<td>1.38</td>
<td>3.36</td>
</tr>
<tr>
<td>1 hour</td>
<td>17.03</td>
<td>3.75</td>
<td>10.39</td>
</tr>
<tr>
<td>2 hours</td>
<td>13.92</td>
<td>2.68</td>
<td>8.36</td>
</tr>
<tr>
<td>4 hours</td>
<td>11.24</td>
<td>2.25</td>
<td>6.75</td>
</tr>
<tr>
<td>8 hours</td>
<td>6.89</td>
<td>1.36</td>
<td>4.12</td>
</tr>
</tbody>
</table>

**TABLE 4** – Business – WTA and WTP normalized values, €/kWh (3 min. interruptions, €/kW)

<table>
<thead>
<tr>
<th></th>
<th>WTA</th>
<th>WTP</th>
<th>WTA + WTP/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 minutes</td>
<td>34.16</td>
<td>4.90</td>
<td>19.53</td>
</tr>
<tr>
<td>1 hour</td>
<td>79.75</td>
<td>10.70</td>
<td>45.23</td>
</tr>
<tr>
<td>2 hours</td>
<td>57.09</td>
<td>7.75</td>
<td>32.41</td>
</tr>
<tr>
<td>4 hours</td>
<td>48.42</td>
<td>6.63</td>
<td>27.53</td>
</tr>
<tr>
<td>8 hours</td>
<td>28.99</td>
<td>3.98</td>
<td>16.48</td>
</tr>
</tbody>
</table>

Furthermore, as already mentioned, the amount of energy consumed (and therefore not served in case of interruptions) is lower in Italy than in other countries: for similar absolute values of WTP and WTA, the Italian normalized values clearly resulted in much higher numbers. Despite the different approach taken by the UK regulator, Ofgem, in conducting the 2004 survey on WTP, the outcomes were similarly higher than indicated in the previous literature [7].

Normalized WTP and WTA values are represented in Figure 2, with reference to the one hour interruption scenario. Given the extensive spread between the WTP and WTA values, each target group is presented with a range of values consisting of:

- a lower limit, the WTP parameter;
- an upper limit, the (WTP+WTA)/2 parameter.

This range may be interpreted as the interval of values within which the regulatory body may act in establishing unitary incentive rates. The symmetric structure of the Italian regulation would have required to fix the incentive rate at (WTP+WTA)/2.

**FIGURE 2** Range between WTP and (WTP+WTA)/2
As indicated in Figure 2, given the large difference in numerical values, a prudential choice was made for business consumer. The decision to select a value towards the lower end of the range makes allowance for the relatively low levels of willingness to pay and is dictated by a principle of “caution”. Thus, on the one hand, additional tariff costs tend to be avoided even in the event of quality improvement while, on the other, penalties tend to be low in the event of failure to reach objectives.

The incentive rate for domestic consumers was set, instead, in the upper range of the interval \( \frac{\text{WTP}}{2} \times \frac{\text{WTP} + \text{WTA}}{2} \). The decision to select a value towards the upper end of the range makes allowance for the fact that the parameters used in regulation have a symmetrical effect on both incentives distributed and penalties imposed on distribution companies. A comparison of the incentive rates chosen by regulators in Norway and Italy is given in Table 5. It is clear that, despite caution, a choice based on normalized WTP and WTA that present much higher values resulted in higher incentive rates in the Italian case.

**CONCLUSIONS**

The paper described the motivation, the methodology, and the numerical outcomes of the customer outage cost survey carried out by the Italian regulatory authority in the year 2003. The normalization procedures of raw data, the different final use of electricity, and the mode and timing of data collection were found to be among the main factors affecting the numerical outcomes of a survey.

The views expressed by consumers through the survey were not easy to interpret, not only for the complexity of the data collected, accounting for different consumer types and interruption scenarios, but also for the large spread in final, normalized values. In any case the results found an important application in the choice of the financial incentive rates for the new regulatory period, beginning in 2004.

**REFERENCES**


