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Short Communication

Residential outage cost estimation: Hong Kong

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HIGHLIGHTS

- Use a contingent valuation survey to obtain residential preferences for reliability.
- Use an ordered logit analysis to estimate Hong Kong's residential outage costs.
- Find high outage cost estimates that imply high reliability requirements.
- Conclude that *sans* new evidence, Hong Kong should not reduce its reliability.

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ABSTRACT

Hong Kong has almost perfect electricity reliability, the result of substantial investments ultimately financed by electricity consumers who may be willing to accept lower reliability in exchange for lower bills. But consumers with high outage costs are likely to reject the reliability reduction. Our ordered-logit regression analysis of the responses by 1876 households to a telephone survey conducted in June 2013 indicates that Hong Kong residents exhibit a statistically-significant preference for their existing service reliability and rate. Moreover, the average residential cost estimate for a 1-h outage is US$45 (HK$350), topping the estimates reported in 10 of the 11 studies published in the last 10 years. The policy implication is that absent additional compelling evidence, Hong Kong should not reduce its service reliability.

1. Introduction

Since 1997, Hong Kong has been a Special Administrative Region (HKSAR) of China. Its unemployment rate in 2012 was only 3.3% and its 7.1 million residents enjoyed a per capita income of US$36.6K at the pegged exchange rate of US$1 = HK$7.8 (http://www.censtatd.gov.hk/hkstat/sub/bbs.jsp). Hong Kong's economic performance could not have occurred without a reliable electricity supply (Chen et al., 2007; Ho and Siu, 2007; Ozturk, 2010; Apergis and Payne, 2011).

Hong Kong is served by two integrated utilities: Hong Kong Electric (HKE) and China Light and Power (CLP). Table 1 shows that despite frequent typhoons Hong Kong had: (a) an average of fewer than five unplanned outage minutes per customer in 2010–2012, which is less than the 19 min to 40 min for New York, Sydney and London (Power Assets Holdings Ltd., 2013; CLP, 2013a); and (b) a system average interruption duration index (SAIDI) of 30 min per customer (CLP, 2013b), below the SAIDI of over two hours in North America (Eto and LaCommare, 2008; PG&E, 2012). This remarkable reliability performance is due in part to the Scheme of Control (SOC) Agreement between the two companies and the HKSAR Government (Woo et al., 2006b). As electricity rate and reliability are inextricably intertwined, how much of a bill decrease are Hong Kong residents willing to accept for lower electricity reliability?

This question is apt because of three pertinent observations:

- A rate decrease to compensate for a reduction in reliability could mitigate the projected rate increase caused by displacing coal-fired generation with natural-gas-fired generation, so as to comply with the government's "carbon intensity reduction target of 50%–60% by 2020 as compared with 2005 level" (⟨http://www.gov.hk/en/residents/environment/global/climate.htm⟩).
- In response to the reliability reduction, Hong Kong may pursue reliability differentiation (Horowitz and Woo, 2006; Woo et al., 2008).

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Table 1
Local system characteristics of Hong Kong Electric (HKE) and China Light and Power (CLP) in 2012; the financial numbers in [ ] are in US$M at the pegged exchange rate of US $1=HK$7.8.
Sources: 2012 Annual Reports issued in 2013 by HKE (Power Assets Holdings Ltd., 2013) and CLP (CLP, 2013a, 2013b) and communication with C.W. Tso, a former General Manager (Projects) of HKE.

Variable	HKE	CLP
Number of customers (000)	567	2400
System sales (000 MWH)	11,036	31,995
System peak (MW)	2494	6769
System capacity (MW)	3737	8888
Reserve margin=(System capacity-system peak) as percent of system peak (%)	49.8	31.3
Generation mix (MW)		
Coal	2500	4108
Natural gas	680	2500
Nuclear	0	1378
Other	557	902
System average of unplanned outage minutes per customer	Under 5	2.6
System average interruption duration index (SAIDI)=Minutes per customer= Total customer interruption minutes/Total number of customers	Not available	30
Net income based on the Scheme of Control (SOC) Agreement (HK$M/year).	4624 [593]	8499 [1090]
SOC fixed assets (HK$M)	49,345 [6326]	85,522 [10,964]
SOC shareholders' funds (HK$M)	14,488 [1857]	43,070 [5522]
Return on assets (ROA)=Net income/SOC fixed assets (%/year)	9.35	9.94
Return on equity (ROE)=Net income/SOC shareholders' funds (%/year)	31.91	19.73

- There is an ongoing debate as to whether Hong Kong should integrate with China to effect workable competition (Sioshansi and Pfaffenberger, 2006; Woo et al., 2003, 2006a, 2006c). As China will continue to see severe shortages (Cheng et al., 2013), Hong Kong would likely experience post-integration reliability deterioration.

This paper estimates Hong Kong's residential outage costs based on an ordered-logit regression analysis of responses by 1876 households to a telephone survey conducted in June 2013.[1] Our key findings are as follows:

- Hong Kong residents exhibit status quo bias, underscoring their favorable preference for their existing service reliability and rate.
- Hong Kong's residential outage costs for a 1-hour outage have an estimated mean of US$45 (HK$350), topping the estimates in 10 of the 11 studies published in the last ten years.

The contributions of our paper are as follows. First, it offers an approach that can be adapted for major cities elsewhere, including those in China.[2] Second, it is the first study of Hong Kong's residential outage costs, which are important inputs for reliability planning and operations (Billinton and Allan, 1996; de Nooij et al., 2010). Finally, it shows that Hong Kong residents have high outage costs and prefer the status quo level of reliability.

2. Material and methods

2.1. Literature review

Residential outage cost is the economic loss incurred by a household due to an electricity outage. This loss has been measured by: (a) direct cost (DC) of an outage (e.g., food spoilage and inconvenience); (b) willingness to accept (WTA) to tolerate the outage; and (c) willingness to pay (WTP) to avoid the outage (Munasinghe et al., 1988; Caves et al., 1990; Woo and Pupp, 1992). The WTA estimate can far exceed the WTP estimate because of the endowment effect, status quo bias, and loss aversion in consumer behavior (Thaler, 1980; Samuelson and Zeckhauser, 1988; Kahneman et al., 1991; Rabin, 1998; Horowitz and McConnell, 2002).

Since market data with sufficient outage details are seldom available, residential outage costs are often estimated with the contingent valuation method (CVM) (Mitchell and Carson, 1989; Bateman and Willis, 1999; Champ et al., 2003). There are two ways to obtain residential CVM survey data. The first is to ask survey respondents to directly self-state their WTA, DC and WTP (Caves et al., 1990; Woo and Pupp, 1992; Sullivan et al., 2009). While the self-stated WTA and DC data are mostly positive, up to 90% of the self-stated WTP data consist of zeroes, implying that the Tobit model should be used for estimating an outage cost regression (Maddala, 1983; Moeltner and Layton, 2002). The second way is to collect customer preference data to infer a household's willingness to tradeoff between customer bill and service reliability (e.g., Hartman et al., 1991). For a reliability improvement (deterioration), the bill change required to keep the household as well off as before the reliability change is the requisite WTP (WTA) estimate.

There are two ways to collect customer preference data:

- A choice experiment that asks survey respondents to make a discrete choice from a menu of reliability-differentiated service options (e.g., Hartman et al., 1991; Pepermans, 2011). To analyze these customer responses, one can use a logit regression model (e.g., Train, 2009) or the choice-probability approach (Blass et al., 2010).
- A conjoint analysis that asks survey respondents to: (a) assign relative weights and absolute scores to electricity attributes such as the bill level, outage timing, and outage duration; and (b) rank an electricity product made up of such attributes (Green, 1984). To analyze the ranking data (e.g., 1=least preferred, …, 10=most preferred), one can use ordinary least squares (Baarsma and Hop, 2009) or ordered-logit regression (Goett et al., 1988).

To benchmark our estimates, we select 11 recent publications for OECD countries with per capita incomes comparable to those

[1] As shown below, our regression analysis focuses on the proportion of respondents supporting a hypothetical tradeoff between monthly bill and outage duration. Thus, our sample is sufficiently large, beyond the size requirement of 1061 (1849) observations to achieve a ±3% error margin at the 0.95 (0.99) confidence level (Cochran, 1977). Finally, it is a representative sample, as suggested by the sample means for the key demographics of age, education and family size, which are within 5% of their respective population means based on Hong Kong's 2011 census (http://www.census2011.gov.hk/pdf/summary-results.pdf).

[2] Both the English and Chinese versions of our outage cost survey questionnaire are available from Alice Shiu (afshiu@polyu.edu.hk).