FAIRNESS AND DYNAMIC PRICING: COMMENTS

William W. Hogan[i]

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Introduction

In "The Ethics of Dynamic Pricing," Faruqui (Faruqui 2010) lays out a case for improved efficiency in using dynamic prices for retail electricity tariffs and addresses various issues about the distributional effects of alternative pricing mechanisms. The principal contrast is between flat or nearly constant energy prices and time-varying prices that reflect more closely the marginal costs of energy and capacity. Dynamic pricing includes time-of-use (TOU) rates with set periods for higher and lower prices, critical peak pricing (CPP) with higher prices applicable on selected days after notification of critical conditions, and real time pricing (RTP) that follows the actual prices updated on an hourly over even more frequent basis. The greater variability of dynamic prices at different times implies variability in average prices and total bills, which might increase the associated risks and costs for some customers. The fairness issues of electricity market design focus on residential and small electricity customers; industrial and large commercial customers are different and deemed capable of managing and hedging real-time prices.

The data and analysis from Faruqui show that (i) there are potential gains in economic efficiency through dynamic pricing and (ii) existing tariff designs with constant prices already embed distributional consequences, where customers with different load curves impose different costs but pay the same prices. The comments here address related issues of fairness criteria, contracts, risk allocation, cost allocation, means testing, real time pricing, and ethical policies.

Fairness Criteria

When considering the design and implementation of dynamic electricity pricing tariffs, the New Jersey rate counsel laid out a set of criteria that would help underpin any cost benefit analysis of advanced metering infrastructure (AMI), cost allocation, and any associated dynamic pricing that would differentiate among customers.

> "…Rate Counsel maintains that four essential elements must be present in order for the program to be fair: 1) the program must provide accurate information to the consumers regarding the rate design and usage; 2) customers must be educated to act on the information given; (education may include information about energy efficiency programs available from utility or clean energy programs or a manual that can teach customers how to use programmable thermostats); 3) there must be an ability to change behavior (i.e., demand may not be elastic for some consumers); and 4) the goal of the program must be reached in a cost effective manner so that the cost of the program is lower than the expected savings." (Stefanie A.

> Brand, Acting Public Advocate & Director - Rate Counsel, New Jersey Department of Public Advocate, Letter to Professor Martin Bunzl, February 9, 2010.)

The reference is to a "fair" program, but these criteria really speak to the cost-benefit balance and efficiency of a program of dynamic pricing, and not directly to the allocation of the costs and benefits. However, it is the allocation of costs and benefits that dominates the discussion of ethics in Faruqui. A key part of the argument identifies ways to mitigate any distributional impacts in the application of dynamic pricing tariffs.

The philosophical principles underpinning analysis of social justice and redistributive polices of taxation and social welfare do not much illuminate the choices for electricity regulators in setting pricing regulations. Rather than the larger questions of social justice from behind the Rawlsian veil of ignorance (Rawls and Kelly 2001), the focus here is on distribution of costs and benefits in the small:

> "…we shall not be concerned here with distributive justice in the large, that is, with the question of what constitutes a just social order. Rather, we are interested in distributive justice in the small, that is, how institutions divide specific types of benefits and burdens. Social justice is a crucial issue, of course, because it is ultimately concerned with the legitimacy of different forms of government. For various reasons, however, theories of justice in the large have little to say about what it means in the small. They do not tell us how to solve concrete, everyday distributive problems such as how to adjudicate a property dispute, who should get into medical school, or how much to charge for a subway ride." (Young 1995, 6)

In fair division problems the allocation of costs and benefits is constrained by rights of the parties, endowments of resources, and available alternatives to participating in the cooperative venture. In the electricity sector, the benefits of participation are so large that there is not much guidance from an analysis of the alternatives to purchasing power from the grid. Hence we assume there is a right to connect to the grid and participate in the electricity system, and this right includes more than just the opportunity to disconnect. Participation in the grid includes rules for setting prices, allowing each party to optimize its position given those prices, and allocating the associated costs and benefits according to the resulting market transactions. As pointed out by Faruqui, setting aside transaction costs the usual Coasean argument applies: given market clearing prices, this emulation of the competitive market maximizes the economic efficiency of the utilization of electricity.(Stigler 2010) Furthermore, given the initial endowments and rights of the parties, the same solution has a strong ethical claim:

> "This leads us to a natural question. Is there any way to design an allocation procedure that leads to outcomes which are *visibly* fair and efficient, and does not require that the claimants know each other's utility functions? …we suggest an answer to this question. Suppose that the claimants have well-defined shares in the common property (not necessarily equal shares), and different preferences for the goods it contains. A *competitive allocation* is one for which there exists a set of *prices*, such that every claimant likes his portion best among all the

> portions that he can afford to buy given the value of his share at these prices. Such an allocation can be discovered through a market-like mechanism that does not require the claimants to know anything about each other's utilities. Moreover, the resulting allocation can be justified on grounds of equity. *It is the only efficient and consistent way of reallocating the property that leaves everyone at least as well off as he was initially*." (Young 1995, 19, emphasis in original)

If the initial state is fair, then the result of competitive allocation has a claim to be fair. A key element in this ethical determination is the definition of the endowment of initial rights and resources. Ignoring transaction costs (such as the cost of installing smart meters), it is easy to see that with appropriately designed contracts, the ethical interpretation applies to dynamic pricing as meeting the fairness criteria.

Contracts

Assume that AMI and the associated meters are available. The simplest case to consider is a forward contract for a given quantity at a fixed price for electricity. If the customer participates in the dynamic pricing market, the customer can choose to purchase and consume the fixed quantity. Or the customer can buy or sell the amounts above or below the fixed quantity at the dynamic price. In equilibrium, where the contract is set at the average dynamic price for the class, the customer is better off with than without the dynamic pricing alternative (Borenstein, Jaske, and Rosenfeld 2002) (Chao 2010).

If the contract is for an option to purchase up to a fixed amount at a fixed price, then the same argument holds. Exercising the option and selling at the dynamic price, whenever the price is higher, makes the customer better off under dynamic pricing.

These cases are easy and demonstrate that with appropriate definitions of the initial conditions, dynamic pricing can improve both efficiency and satisfy the fairness criteria.

A more complicated case would be the implicit contract of a full requirement customer. As is typical, the right is to take as much energy as the customer wants to consume at the regulated rate. In New Jersey, for example, this is the arrangement for customers who operate under Basic Generation Services (BGS). The regulated fixed rate is the result of a competitive auction, and since the suppliers face real-time pricing, presumably this price reflects the collective best expectations about the average of the dynamic prices and various risks associated with the unlimited upper bound on sales and the right of customers to seek other sources of supply. However, the lack of a fixed quantity makes it harder to treat this as a contract that can be integrated with a simultaneous right of the customer to sell at dynamic prices.

Integrating dynamic pricing with full requirements service is not an insurmountable problem. For example, it is exactly the problem that arises when customers seek payment for demand response when the customer has a full requirements service. Allowing the customer to sell demand response and to take power under a full requirements service requires some administrative estimate of the customer baseline. The baseline determines the additional electricity that would have been consumer "but for" the demand response and sale at dynamic prices. From this perspective, the fairness of efficient payment for demand response for full requirements customers is identical to the fairness of participation in dynamic pricing with a full requirements default service. Assuming an acceptable method of solving the baseline problem, demand response and dynamic pricing satisfy the fairness criteria. The simplest way to implement such a program would be to add the demand response quantity to the actual consumption, for purposes of billing under the full requirements contract, and to pay the dynamic price for demand response (Hogan 2009).

Equilibrium

If the AMI and associated smart meters were free, customers were risk neutral, and there were no other transaction costs, then as explained by Faruqui, the equilibrium result would be that all customers would move to dynamic pricing. If the meters are not free, then the equilibrium would be that customers would install meters and move to dynamic pricing until the cost of the meter just equaled the private savings of dynamic pricing.

The equilibrium impact would depend on how the class of customers is treated under the something like the BGS. If customers leave the BGS and don't have a requirements contract under the BGS, the resulting fixed price for the remaining customers would be higher due to the selection bias removing the subsidy from customers with a better load profile and response, and prices would be lower to the extent that dynamic pricing lowered market prices. The net effect on those who elect not to participate is ambiguous. However, dynamic pricing meets the fairness criteria if customers do not have a right to prevent others in their class from participating in dynamic pricing.

If all customers continue to purchase a hedge through the BGS, then the situation looks the same from the perspective of the BGS auction suppliers. Hence, the net change in expected price would be to lower expected market prices. In this case, dynamic pricing also meets the fairness criteria.

Risk Allocation

Although it is possible in principle to devise dynamic pricing systems with the same ex ante price and bill expectations, the ex post variation of prices and bills differ from flat rates. The resulting risk exposure and risk allocation of the variation differs accordingly. Under flat rates, the risk of quantity variation and total bill changes falls on the customer, but by design there is no exposure to short run variations in the average price of energy. Under TOU pricing the rates are fixed but the timing of quantity variations, whether on or off peak, can produce variation in the total bill and the average price. A similar condition exists for CPP where the quantity variation interacts with the variation of the days when CPP is invoked. Real-time pricing, which reflects the variability of marginal costs, probably produces the greatest variation in total bills and average prices.

In principle, were there no transactions costs, customers could choose to hedge the price and bill variations under dynamic pricing. With the default being dynamic pricing, a customer could recreate a flat rate or various combinations of risk exposure. For large customers, this may be enough and the default of real-time pricing would be efficient and meet the test of fairness for industrial and large commercial customers.

However, for smaller commercial and residential customers, the choice of the default is important. First, transaction costs are not zero. Unless the expected net benefits of dynamic pricing are less than the transaction costs, the dynamic pricing customer who chooses not to hedge may be exposed to the risks which would, by assumption, be bounded on average by the transaction costs of hedging. Second, we know from conventional wisdom and research on related problems that the choice of the default is important. For example, in research on pensions the default option has a major impact on savings choices, even though the narrowly defined transaction costs (filling out a form or calling a benefits hotline) are insignificant. The explanations range from behavioral biases (e.g., procrastination) to seeing an implicit endorsement of the default (Beshears et al. 2008) (Thaler and Sunstein 2009).

One test of the choice of default for any class of customer would include the response to a thought experiment. Suppose that the default is dynamic pricing, and the ex post outcome is a (much) higher average price for customers who failed to hedge. Would the regulator be able to say "no" to those customers when they asked to revert ex post to the flat rate and avoid actually paying the higher realized price in the market? If the regulator could not say no, then the regulator should select some form of a hedged option as the default and let customers provide demand response. Presumably if the customer rejects the default hedge and elects dynamic pricing, the regulator would be able to say no to an ex post request for protection. This default choice of a hedged product with the option to provide demand response would meet the test of fairness.

Interesting variants could be constructed from default contracts that were indexed to address some of the quantity risk. A full requirement hedge is the extreme case of imposing on the supplier all the risk associated with variations in quantity consumed. This creates the need for administrative estimation of a demand response baseline from which to calculate the charges or payments under dynamic pricing. An alternative would be a fixed quantity contract such as the subscription service described by Chao.(Chao 2010) Many variants would be possible. For example, suppose that the hedge offered is a specific quantity contract (or more precisely a load profile contract) where the nominal quantity is indexed by some measure of the total demand of the class. This would reduce the individual customer risk to the idiosyncratic variation in demand but hedge against some of the weather and related variations that would affect all customers. And since the indexing would be effectively independent of the individual choices of the customer, the customer would face the efficient incentives of dynamic pricing.

Cost Allocation

Although they offer much promise, AMI systems are not free and the cost structure differs importantly from the costs of providing energy. The costs of infrastructure and the costs of energy display different characteristics. Most of the energy costs are variable and exhibit short-run decreasing returns to scale. This makes the competitive allocation method for energy purchases easy to define and revenue adequate.

If the cost of metering were variable and showed constant returns to scale, then customers could make individual choices to be metered and participate in demand pricing or choose not to be smart metered and remain at the flat rate for the full requirements product. Choices would be different, but costumers would move to the smart meter and dynamic pricing only when the expected (private) net benefits exceeded the cost of the smart meter. This would meet the test of fairness and replicate the workable efficiency of other markets.

However, deployment of AMI may be much more efficient if it is universal for geographical areas. There are likely to be substantial fixed joint costs (e.g, information systems) and small or zero variable costs. The true variable costs being zero might be the case if the benefits include automated meter reading but the savings of automated reading require all or virtually all customers in a region to have smart meters.

The allocation of truly variable costs would be straightforward through the voluntary choices of the customers. This would put a lower bound on the cost recovery from the customer. The appropriate allocation of the joint costs raises the net benefit calculation and cost allocation issues identified in the rate counsel's criteria.

Assume that the aggregate net benefits meet the rate counsel test. Absent customer choice in installing the smart meters, the allocation of the joint costs raises different questions of fairness. In the competitive allocation, given the prices, there would be no incentive to refuse participation, and the competitive cost allocation may be only cost allocation with this property.[1] In the allocation of joint costs, however, there may be many other allocations where there is no incentive to refuse participation, but this participation test does not much constrain the allocation of costs. Joint costs should not be allocated in excess of the net benefits to the customer, but that test does not provide much guidance for the regulator. And without uniqueness, the participation test does not dispose of the fairness issue.

In principle, other joint cost allocation rules can be suggested that appeal to some proportionality in sharing the net benefits. But by definition these cannot be based on cost causation, and inherently involve a view about the worthiness of the various customers.[2] The important fairness questions may center not so much on dynamic pricing as on the allocation of costs for AMI.

Means Testing

Setting rates to discriminate by consumptions levels is a blunt instrument. Better targeted programs for low income or vulnerable consumers would be means tested rather than applied across the board to customers with similar levels of consumption. There is no reason that the same fairness standard should apply to low consumption second homes as would apply to low consumption poor households.

Programs such as the Low Income Home Energy Assistance Program are means tested and "eligible household's income must not exceed the greater of 150 percent of the poverty level or 60 percent of the State median income."[3] It can be difficult to target low income families, and participation rates are not perfect, but the impact can be quite dramatic (Borenstein 2010). Considerations of fairness would have both greater

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[1] With appropriate convexity assumptions, the competitive allocation is in the core and is unique. (Moore 2005)

[2] Game theory provides various candidate solutions, such as the Shapley value, once we have defined the interpersonal weightings of the benefits. (Moulin 2004, 139-168)

[3] US Department of Health and Human Services, "Low Income Home Energy Assistance Program," Fact Sheet, http://www.acf.hhs.gov/programs/ocs/liheap/about/factsheet.html.

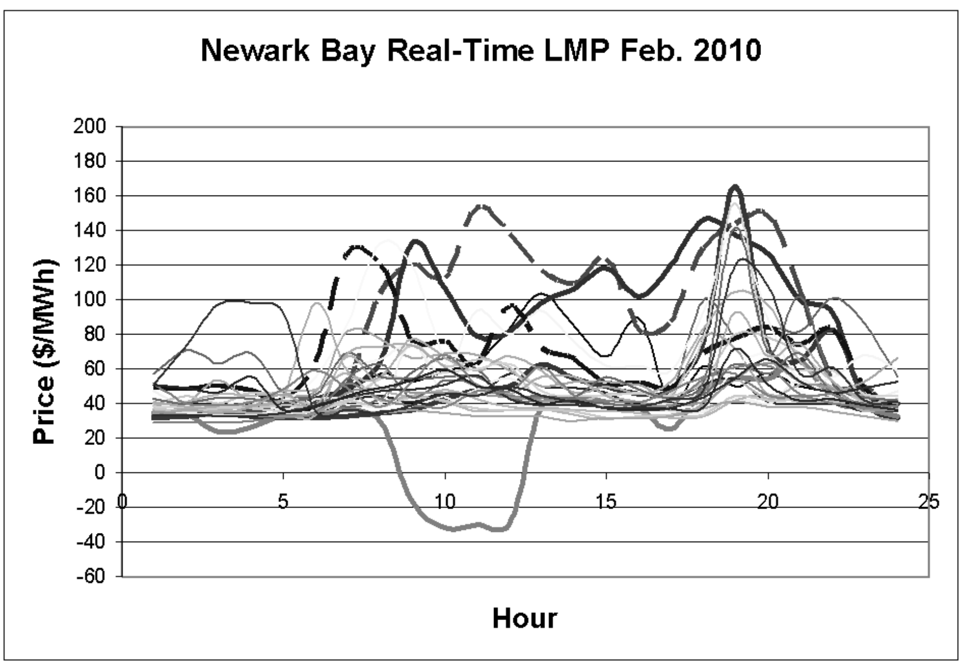
relevance and far fewer restrictions on dynamic pricing if the limitations were constrained by means testing.

Real Time Pricing

The canonical example of 8 to 1 ratio of prices in Faruqui for CPP and TOU rate experiments understates the possible volatility of marginal costs. In 2009, average energy prices in PJM were on the order of $50/MWh. In the organized markets, bid caps are typically $1000/MWh. In principle, the Midwest ISO's operating reserve demand curve could reach a scarcity price of $3,500/MWh that could translate directly into the energy price (MISO 2009). Depending on the duration of outage associated with the planning reliability standard, the implicit value of lost load in typical planning reliability criteria reaches upwards towards $500,000/MWh, or four orders of magnitude above the average price (Wilson 2010). Hence, there is ample opportunity to provide better scarcity pricing and improved signals in the form of smarter real-time prices, and it would be prudent to consider a real-time pricing regime that better reflects true scarcity marginal costs (Hogan 2005).

The restricted periods for application of CPP and TOU will not always match the real-time marginal costs. Even today, the peak costs do not necessarily appear at the same time each day. Real-time pricing would reflect the marginal costs of consumption, which have some structure but do not follow a stable TOU pattern. For example, illustrative PJM data for February, the most recent full month available at the time of this writing, provide a demonstration of the variability of marginal energy costs.

Real marginal costs are locational. A convenient location to illustrate is Newark Bay, a cogeneration facility in Newark, N.J., in the Public Service Electric and Gas service territory. (Chosen because of its proximity to the Rutgers conference location and the convenient reporting summarized separately in the PJM monthly statistics, but it is representative of nearby load buses.) This representative case includes hours of negative prices and high variability in the timing of peak periods.



The figure shows separately the hourly price profile for the twenty four hours of each of the twenty eight days in February. A few of the more interesting days illustrate that the timing and level of the true marginal costs that customers could respond to is not well described by a simple TOU or CPP pattern. On one day the prices were even negative at the same hours that on other days displayed the peak prices. The real goal of dynamic pricing should be capture the incentives of these real time prices.

Finally, as illustrated by the existence of capacity markets and the missing money problem, these energy prices understate the full range of variability of marginal energy costs. Absent the depressing effects of bid caps and poor scarcity pricing, there could be a significant number of hours when prices rise to levels an order of magnitude or more higher than shown.

Ethical Policies

For large industrial and commercial customers, the default option would be dynamic pricing and the market can provide alternative hedging instruments. The expertise required to manage such hedging opportunities is not great, and the transaction costs should be small relative to the potential benefits.

For other customers, a default option could be like the New Jersey BGS, with dynamic pricing and demand response. Customers could elect in advance to have a fixed load profile, and buy-and sell at real-time prices for any surplus or deficit. Or customers could choose to have a full requirement contact and participate with efficient pricing at real-time prices for demand response.

For more vulnerable customers, means testing provides access to rate assistance payments. The default option would be BGS auction the choice of dynamic pricing with demand response.

If there are large economies for comprehensive installation of AMI, then the joint cost allocation would be according to a share in the benefits.

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[i] William W. Hogan is the Raymond Plank Professor of Global Energy Policy, John F. Kennedy School of Government, Harvard University and a Director of LECG, LLC. These comments were prepared as part of a conference on "Fair Pricing - A Conference on Ethics and Dynamic Pricing," Rutgers University, April 9, 2010. This paper draws on work for the Harvard Electricity Policy Group and the Harvard-Japan Project on Energy and the Environment. The author is or has been a consultant on electric market reform and transmission issues for Allegheny Electric Global Market, American Electric Power, American National Power, Aquila, Australian Gas Light Company, Avista Energy, Barclays, Brazil Power Exchange Administrator (ASMAE), British National Grid Company, California Independent Energy Producers Association, California Independent System Operator, Calpine Corporation, Canadian Imperial Bank of Commerce, Centerpoint Energy, Central Maine Power Company, Chubu Electric Power Company, Citigroup, Comision Reguladora De Energia (CRE, Mexico), Commonwealth Edison Company, COMPETE Coalition, Conectiv, Constellation Power Source, Coral Power, Credit First Suisse Boston, DC Energy, Detroit Edison Company, Deutsche Bank, Duquesne Light Company, Dynegy, Edison Electric Institute, Edison Mission Energy, Electricity Corporation of New Zealand, Electric Power Supply Association, El Paso Electric, GPU Inc. (and the Supporting Companies of PJM), Exelon, GPU PowerNet Pty Ltd., GWF Energy, Independent Energy Producers Assn, ISO New England, Luz del Sur, Maine Public Advocate, Maine Public Utilities Commission, Merrill Lynch, Midwest ISO, Mirant Corporation, JP Morgan, Morgan Stanley Capital Group, National Independent Energy Producers, New England Power Company, New York Independent System Operator, New York Power Pool, New York Utilities Collaborative, Niagara Mohawk Corporation, NRG Energy, Inc., Ontario IMO, Pepco, Pinpoint Power, PJM Office of Interconnection, PPL Corporation, Public Service Electric & Gas Company, Public Service New Mexico, PSEG Companies, Reliant Energy, Rhode Island Public Utilities Commission, San Diego Gas & Electric Corporation, Sempra Energy, SPP, Texas Genco, Texas Utilities Co, Tokyo Electric Power Company, Toronto Dominion Bank, Transalta, Transcanada, TransÉnergie, Transpower of New Zealand, Tucson Electric Power, Westbrook Power, Western Power Trading Forum, Williams Energy Group, and Wisconsin Electric Power Company. The views presented here are not necessarily attributable to any of those mentioned, and any remaining errors are solely the responsibility of the author. (Related papers can be found on the web at www.whogan.com).