RESOURCE ACQUISITION WINDFALLS AND FIRM AGGRESSIVENESS IN OUTPUT MARKETS: EVIDENCE FROM INPUT HEDGING IN ELECTRICITY GENERATION

[Working paper]

December 2022

Afonso Almeida Costa[1]
Nova School of Business and Economics, Universidade Nova de Lisboa
(afonso.almeida.costa@novasbe.pt)

Karel Cool
INSEAD
(karel.cool@insead.edu)

Javier Gimeno
INSEAD
(javier.gimeno@insead.edu)

Acknowledgments

We are thankful to Peter Zemsky for helpful comments. We acknowledge the financial support provided by the INSEAD R&D Committee. The first author is grateful for the financial support provided by the Portuguese Foundation for Science and Technology.

[1] Corresponding author. Office address: Afonso Almeida Costa, Nova School of Business and Economics, Universidade Nova de Lisboa, Campus de Carcavelos, 2775-405 Carcavelos, Portugal.

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ABSTRACT

Under uncertainty, different resource acquisition strategies recurrently create competitive heterogeneity by engendering different historical acquisition costs for the same resources across competing firms. In this paper, we follow Gimeno, Yu, and Zhang's (2015) study on the airline industry and assess empirically the connection between firms' input hedging outcomes and the aggressiveness of competitive conduct in output markets. We specifically use evidence from the generation segment of the U.S. electric power industry (1999-2009) and link resource acquisition windfalls – defined as the difference between the spot price of natural gas (the opportunity cost of natural gas) and the reported fuel cost of gas-fired power plants (arising due to firms' hedging strategies) – with firm conduct in electricity markets. Similar to Gimeno et al. (2015), we find a significant association between positive resource acquisition windfalls and the aggressiveness of firm conduct, suggesting that firms leverage relatively low resource acquisition costs to try to gain market share. Given the fine-grained nature of our data, we are able to look not only at a broader range of contingency factors, but also to assess the influence of competitors' resource acquisition windfalls on a firm's conduct.

KEYWORDS: *Resources; Hedging; Windfalls; Competitive Conduct; Risk Management*

The *resource-based view* (RBV) (*e.g.* Barney 1991, Dierickx and Cool 1989, Makadok 2001, Wernerfelt 1984) places great emphasis on the notion of strategic factor markets (Barney 1986), wherein firms acquire some of the critical resources needed for the implementation of their strategies. Extant theory stresses that resource *acquisition* decisions are complex and made under uncertainty (Amit and Schoemaker 1993, Barney 1986) such that the value of a given resource may change from the time at which it was acquired (*ex-ante*) to the time at which it is deployed (*ex-post*). For instance, a technology firm could acquire the rights to a new promising, yet unproven, data transmission technology for a given ex-ante cost that would reflect the uncertainty associated with that technology. In turn, the ex-post value of the technology would depend on crucial attributes that may only be verifiable at a later stage (*e.g.* cost-effectiveness, reliability, versatility). Conditional on the verification (or not) of those attributes, the ex-post value of the acquired technology can end up being higher or lower than its ex-ante cost to the firm. Due to their inherent uncertainty, resource acquisition processes like this can engender firm heterogeneity (*e.g.* Lippman and Rumelt 1982) and be sources of economic rent for firms that experience a positive difference between the ex-post value of a resource and its ex-ante cost (Amit and Schoemaker 1993).[2]

The cost of a firm's resources is especially important for resources that are both fungible and (at least somewhat) rivalrous in use, such that their use in one activity hinders their use in another activity. In these cases, the RBV (and economic) theory proposes that a firm must consider carefully the alternative uses for its resources, be they internal (Levinthal and Wu 2010, Penrose 1959) or external (Teece 1982). Drawing on our previous example, upon acquiring the data transmission technology, the firm could decide to use the technology in its own applications and products, license it to other firms, or sell the intellectual property to another firm. For any potential resource deployment choice, the value of the best alternative use for a resource will represent the *opportunity (or economic) cost* of that resource (Besanko *et al.* 2013, p. 19).

[2] Furthermore, due to the same inherent uncertainty, factor market theory posits that the only way for a firm to consistently obtain systematic above-normal returns (*i.e.* economic rents) from resource acquisitions is through persistent luck (Barney 1986), superior information (Makadok and Barney 2001), or factor market imperfections (Peteraf 1993).

Within the RBV tradition, a firm should deploy resources in particular uses or activities only if the expected returns from doing so are above the *opportunity cost* of those resources (*i.e.* expected *economic profits* are positive), regardless of their historical a*cquisition costs* (Cool *et al.* 2002, Dierickx and Cool 1989). Thus, analyzing a firm's activities on the basis of their *opportunity costs* is considered paramount for efficient (*i.e. economic-profit-maximizing*) resource deployment decisions. On the flipside, the RBV literature warns against firms basing their resource deployment decisions on resource *acquisition costs* – and therefore on the *accounting profits* of different activities –, since doing so can significantly hamper deployment efficiency, by promoting the subsidization of activities with relatively higher *accounting profits* at the expense of activities with relatively higher *economic profits* (Cool *et al.* 2002).

In this paper, we follow Gimeno, Yu, and Zhang (2015) and try to empirically link firms' *resource acquisition windfalls* – defined as the difference between the ex-post opportunity cost of a resource and its acquisition cost – with firms' resource deployment decisions. In spite of the aforementioned prescriptions from the RBV literature, this is a link that has not yet been explored empirically in great detail. Thus, venturing into this topic represents an opportunity to fill gaps in the RBV literature in general, and in the literature on factor markets in particular.

Similarly to Gimeno *et al.* (2015), we study this topic by looking at the context of *input hedging* as a risk management tool for firms. Specifically, we focus on resources that are homogeneous tradable inputs, for which spot market prices correspond to the opportunity costs effectively faced by firms. In these cases, hedging refers to ex-ante investments – in either financial instruments or real assets – made by firms to reduce their exposure to volatility in input spot prices. For example, take the case of British Petroleum's (BP) refining operations *vis-à-vis* crude oil prices: to protect its refining operations from fluctuations in the spot price of crude oil – the main input resource of refining operations – BP can either buy crude oil derivatives and futures (*financial hedging*) or further extend its presence in oil extraction (*natural hedging*). In the risk management literature, the financial protection given by an adequate hedging strategy is considered very important for both firm performance and strategy execution since, in the face of financial constraints, it can ensure that a firm has enough cash available to make value-enhancing investments (Froot *et al.* 1993).

Beyond varying degrees of financial protection, different input hedging strategies will, in all likelihood, recurrently create heterogeneity across competitors in output markets. This is because different input hedging strategies will engender situations in which competing firms end up with *different acquisition costs* for otherwise equivalent inputs (with the *same* spot prices or *opportunity costs*). In competitive contexts, this heterogeneity can allow a firm experiencing a *positive* resource acquisition windfall in a crucial input – given its positive margin between opportunity costs and acquisition costs for that input – to compete more aggressively and gain market share at the expense of its competitors. As such, *positive* resource acquisition windfalls (resulting from firms' input hedging strategies) can be valuable for firms in competitive contexts, by coincidentally allowing those firms to depart from some of the resource deployment prescriptions that are traditionally put forward in the RBV literature (*i.e.* resource deployment as a function of opportunity costs).

Drawing on this conjecture, Gimeno *et al.* (2015) inquired whether differences between input *opportunity costs* and *acquisition costs* (*i.e. resource acquisition windfalls*) resulting from different input hedging strategies would affect firms' resource deployment decisions in competitive contexts. Specifically, Gimeno *et al.* (2015) used the U.S. airline industry and assessed whether differences in historical fuel acquisition costs - due to heterogeneous airline hedging practices – had an impact on the aggressiveness with which airlines pursued market share through ticket pricing. They found evidence that positive fuel acquisition windfalls (as defined above) were associated with more aggressive ticket pricing by airlines to support market share gains, but that negative fuel acquisition windfalls were not associated with symmetric increases in ticket prices. In addition, they also found that the effect of positive fuel acquisition windfalls on aggressive pricing was positively moderated by a firm's growth opportunities (measured as a firm's *market-to-book* ratio), and negatively moderated by a firm's market share.

This paper takes Gimeno *et al.*'s (2015) approach and uses a different empirical setting to examine the impact of input resource acquisition windfalls on the aggressiveness with which firms pursue market share in output markets. Specifically, we use the generation segment of the U.S. electric power industry (1999-2009) as our empirical setting, and take discrepancies between the spot price of natural gas and the reported fuel costs of *gas*-fired power plants as our operationalization of resource acquisition windfalls. Our setting and approach allow us to depart from Gimeno *et al.* (2015) in some significant ways. First, we are able to test the link between resource acquisition windfalls and competitive conduct in a context of quantity competition, as opposed to price competition. Second, the fine-grained nature of our data makes it possible to use windfall metrics that are built by going from the level of each power plant to the level of a firm's activities in a given market, instead of relying on aggregate firm-level windfall metrics. This also allows us to explicitly consider the windfalls experienced by a firm's competitors in a market. Third, our data also makes it possible to elaborate on Gimeno *et al.*'s (2015) proposed contingencies. Specifically, we are able to use both opportunity metrics based on market supply and demand, and a firm's downstream presence in electricity retail as moderating factors. Furthermore, we also assess the moderating role of market concentration in our analysis.

Our empirical results suggest that resource acquisition windfalls influence the aggressiveness of firm conduct in output markets, corroborating Gimeno *et al.* (2015). In particular, we find that *positive* resource acquisition windfalls are significantly associated with higher capacity utilization by a firm in a market, whereas *negative* windfalls do not display a significant association with capacity utilization. Confirming some of our predictions, we also find that the basic relationship between positive windfalls and higher capacity utilization is moderated positively by the tightness of supply capacity relative to demand in a market; negatively by market concentration; and positively by the level of a firm's presence in downstream electricity retail. Furthermore, our evidence also suggests that competitors' windfalls have an influence on a given firm's conduct: in this case, contrary to our expectations, we find a positive association between the average windfalls of competitors and the aggressiveness of a firm's conduct. Albeit puzzling at first, a possible justification for this result is the pre-existence of collusive market equilibria, which are destabilized when generalized *positive* resource acquisition windfalls across competitors occur.

This paper contributes to the literature in the RBV tradition, by adding empirical evidence that connects firm heterogeneity stemming from the resource acquisition stage with resource deployment decisions in output markets. Indeed, the lack of attention to the link between resource deployment decisions and competitive outcomes in output markets has been one of the main criticisms made of the RBV literature (Priem and Butler 2001), and one that only recently started to be studied theoretically in greater detail (*e.g.* Chatain 2014, Costa *et al.* 2013, Makadok 2010). The paper also contributes to the risk management literature, and especially to an emerging – and mostly theoretical – research strand that examines the relationship between hedging and competition in output markets (*e.g.* Adam *et al.* 2007, Haushalter *et al.* 2007, Léautier and Rochet 2014).

The remainder of the paper is structured as follows. The next section provides some background on hedging. The following section puts forward our hypotheses. Thereafter, the data, methods and variables are presented and the empirical results are provided. The last section of the paper discusses the results and offers concluding thoughts.

BACKGROUND ON HEDGING

In broad terms, the objective of a hedging strategy is to reduce a firm's exposure to price volatility of core resources, such as production inputs or foreign currencies. In practice, a firm will hedge by making investments whose value or resulting cash flows will – at least to some extent – offset potential losses from volatility in the price of those resources.

There are two main ways through which a firm can hedge: *financial hedging* and *natural hedging*. Financial hedging is the most common way of hedging by firms. To financially hedge itself, a firm either signs long-term contracts or uses financial instruments (like derivatives or futures contracts) to effectively limit its exposure to volatility in the price of a critical resource. For instance, firms involved in electricity generation (our empirical setting) routinely protect themselves from volatility in fuel prices, by either signing long-term supply contracts that ensure some fuel price stability (more prevalent for *coal*-fired power plants) or buying fuel derivatives and futures contracts (more prevalent for *gas*-fired power plants). Another example of this hedging strategy would be a multinational company purchasing currency derivatives to protect its revenues generated abroad from currency volatility. In contrast, a firm will resort to natural hedging by either investing in physical assets or getting involved in certain activities to offset the effects of resource price volatility in its main business. An example of this type of hedging behavior is Arcelor Mittal's presence in iron ore mining, which works as a natural hedge against iron ore price fluctuations affecting its main business – steel production (*Arcelor Mittal Annual Report 2015*).

The primary function of both financial and natural hedging is to smooth the potentially disruptive impact of resource price volatility on a firm's earnings and cash flows, not a systematic beating of the market. Thus, a firm's hedging strategy might lead to resource acquisition costs that are *higher* or *lower* than the spot prices of those resources at the time of their use (*i.e.* opportunity costs), with the associated *negative* or *positive resource acquisition windfalls* and corresponding accounting losses and gains.

The risk management literature has provided several motivations for firms to resort to hedging to reduce the volatility of their earnings and cash flows. These include: (i) making firms more easily able to invest in valuable opportunities when financial constraints exist (Froot *et al.* 1993, 1994, Géczy *et al.* 1997, Nance *et al.* 1993);[3] (ii) managerial motives such as risk aversion (Stulz 1984, Tufano 1996) or reputational concerns (Breeden and Viswanathan 2016, DeMarzo and Duffie 1995); and (iii) and the non-linearity of tax codes (Nance *et al.* 1993, Smith and Stulz 1985). For more comprehensive reviews of these reasons, see Froot *et al.* (1993) and Gimeno *et al.* (2015).

The risk management literature also examines the consequences of hedging for firm value. For example, using a sample of U.S. non-financial firms, Allayanis and Weston (2001) found a positive relationship between firm value and the use of foreign currency derivatives. In another study using a sample of airlines, Carter, Rogers, and Simkins (2006) found that fuel hedging was positively related to airline firm value. Carter *et al.*'s (2006) evidence suggested that most of the hedging premium was attributable to the influence of hedging on firm investment, corroborating Froot *et al.*'s (1993) conjecture that the main benefit of hedging for a firm comes from the mitigation of underinvestment in valuable opportunities.

Notwithstanding some evidence suggesting benefits of hedging for firm value, there is substantial heterogeneity in hedging practices. This can be attributed partly to the complex considerations involved in the implementation of an effective hedging strategy (*e.g.* "The right way to hedge" | McKinsey & Company 2010, Froot *et al.* 1994). It can also be attributed to some skepticism

[3] This argument is closely related to explanations that justify hedging on the grounds of reducing the likelihood that a firm will incur in costs associated with financial distress – *i.e.* bankruptcy costs and debt covenants (Smith and Stulz 1985) –, that can by themselves distort a firm's investments (Froot *et al.* 1993).

about the merits of financial hedging,[4] an issue that became salient in the aftermath of the 2008-2009 financial crisis. As a result, firm hedging behavior varies widely, both between and within industries.

As pointed out by Gimeno *et al.* (2015), such heterogeneity is quite salient in the context of fuel hedging in the airline industry: while companies like Southwest, JetBlue and Delta aggressively hedge their exposure to fuel price volatility, there are also markedly opposing views to hedging in the airline industry. These views are encapsulated in Rod Eddington's – former CEO of British Airways – comments: "I don't think any sensible airline believes that by hedging it saves on its fuel bills. You just flatten out the bumps and remove spikes. (…) When you hedge, all you do is bet against the experts of the oil market and pay the middleman, so you can't save yourself any money long term." (Cobbs and Wolf 2004)[5] In contrast with the airline industry, in electricity generation (our empirical setting) there seems to be a wider consensus about the benefits of fuel hedging, with most companies using some sort of financial hedging strategy for fuel, in particular *gas*.[6] Nonetheless, heterogeneity in hedging behavior is also present in this case, as different electricity-generating firms resort to different mixes of long-term contracts, derivatives, and futures contracts to try to insulate themselves from fuel price fluctuations. In the case of a particular futures contract, when the time for the specified fuel delivery comes, a firm typically liquidates the contract and buys the fuel from its usual suppliers ("Utilities Turn to Fuel Hedging to Reduce Price Risk" | Black & Veatch).

The last example highlights the fact that firms' hedging strategies can be quite heterogeneous within industries, even when hedging is generally accepted and widespread. In the specific case of input hedging, heterogeneity in hedging strategies will engender variation across firms in terms of the acquisition costs of otherwise homogeneous inputs (like fuel). Hence, competitive heterogeneity will naturally result, with potential consequences for firm conduct in output markets.

A few studies in risk management have explored the connection between firms' hedging choices and competition. With the exception of an empirical paper by Haushalter, Klasa and Maxwell

[4] In the particular case of derivatives, Warren Buffett's famous branding of them as "financial weapons of mass destruction" (*Berkshire Hathaway Annual Report 2002*, p. 15) epitomizes the skepticism among some practitioners about this type of financial instrument.
[5] The mixed reactions of industry analysts upon Delta Air Lines announcing that it would buy an oil refinery in 2012 (Rivers 2012) further substantiate the contrasting views on fuel hedging within the airline industry.
[6] According to Richard McMahon, Vice-President for Finance and Energy Supply at the Edison Electric Institute (source: "Utilities Turn to Fuel Hedging to Reduce Price Risk" | Black & Veatch).

(2007), this literature is made of formal modeling papers that seek to explain firms' hedging choices as a function of the characteristics of competition in output markets (Adam *et al.* 2007, Léautier and Rochet 2014, Loss 2012). See Gimeno *et al.* (2015) for a short summary of these papers.

Within this literature stream, there is still a dearth of empirical work looking at the impact of hedging outcomes on firm conduct in output markets. Here, we empirically examine the connection between resource acquisition windfalls and the aggressiveness of firm conduct in output markets focusing on natural gas hedging outcomes in the context of electricity generation. This allows us to test some of the theoretical mechanisms put forward in Gimeno *et al.* (2015) in a different setting and, given the fine-grained nature of our data, assess a number of additional theoretical effects and contingencies. We put forward several hypotheses below.

HYPOTHESES

As our broad research aim is to examine the connection between input hedging outcomes and firm conduct in output markets, we do not focus on a firm's input hedging choices *per se* (whether it hedged or not, and which hedging strategy it followed) but on the resulting resource acquisition windfalls. Specifically, we examine whether an electricity-generating firm had a *positive* or *negative* resource acquisition windfall (or, equivalently, hedging *gains* or *losses*) by acquiring natural gas at a *lower* or *higher* price than the current spot price, and connect this with that firm's level of capacity utilization in a market. Given that the evolution of natural gas spot prices is unpredictable to some extent, resource acquisition windfalls can be treated as random shocks experienced by a firm.

Null hypothesis: Irrelevance of resource acquisition windfalls

Our null hypothesis seeks to establish a baseline that is anchored in the resource deployment prescriptions of the RBV literature. Given that natural gas is a homogeneous resource traded in competitive markets, its current spot market price is both the amount that a firm would pay for additional gas, and the amount that a firm would receive for selling gas. Thus, the spot price represents its opportunity cost since firms' best alternative to using their acquired gas to generate electricity is selling it in the spot market at the current price. In this context, both the RBV literature and traditional economic theory prescribe that a firm should generate electricity as a function of the spot price of natural gas – not its acquisition cost – so as to ensure efficiency in its deployment of resources. This implies that historical acquisition costs of natural gas (and potential resource acquisition windfalls) should be irrelevant for a firm's capacity utilization in a market.

Null Hypothesis: The capacity utilization of an electricity-generating firm in a market is affected only by natural gas spot prices, not by its historical acquisition costs

Effects of resource acquisition windfalls

Contrasting with the above, some arguments from the risk management literature suggest that resource acquisition windfalls can affect a firm's competitive conduct. Froot *et al.* (1993, 1994) justify hedging behavior *vis-à-vis* certain environmental fluctuations as a means for a firm to buffer itself from potentially binding financial constraints that could preclude it from making value-enhancing investments. Applied to the context of competition, Gimeno *et al.* (2015) argue that this rationale justifies hedging on the grounds of a firm's need to sustain investments in its competitive position, especially at times in which a firm would otherwise face financial constraints.

Firms are most likely to be financially constrained when natural gas spot prices are high (or rising) since competitive pressures might not allow them to easily pass on those high gas prices to their customers. These are also the times in which a hedged firm is most likely to benefit from a resource acquisition windfall, in the form of lower acquisition costs than the current natural gas spot prices (or opportunity costs). In turn, such a windfall could be used by that firm to increase its capacity utilization (or to keep it at relatively high levels), with sights on gaining market share from relatively more unhedged and financially-constrained competitors. Thus, by protecting a hedged firm from potential financial constraints experienced by some of its competitors, resource acquisition windfalls will allow that firm to be more aggressive in its pursuit of market share. This conjecture is in agreement with empirical evidence that links greater firm financial capacity with increased competitive aggressiveness in markets (*e.g.* Chevalier 1995). Following this rationale, it is likely that resource acquisition windfalls will be positively associated with the aggressiveness of competitive conduct, in the form of higher capacity utilization by a firm in a market.

Hypothesis 1: A firm's resource acquisition windfalls (i.e. resource opportunity costs minus resource acquisition costs) will be positively associated with the aggressiveness of its competitive conduct, in terms of a higher level of capacity utilization in a market.

Hypothesis 1 did not attempt to explicitly distinguish between the potential effects of *positive* and *negative* resource acquisition windfalls on the conduct of a hedged firm. Nonetheless, following Gimeno *et al.* (2015), contrasting predictions can be made for the two cases. On the one hand, a hedged firm is more likely to experience a positive resource acquisition windfall when natural gas spot prices have increased and, in general, the margins and cash flows of its competitors have shrunk. This positive resource acquisition windfall will allow a firm to compete more aggressively in these situations, and gain market share at the expense of its financially-constrained competitors. On the other hand, a hedged firm is more likely to experience a negative resource acquisition windfall when natural gas spot prices have decreased and, in general, competitors' margins have increased. In these circumstances, a firm experiencing a negative resource acquisition windfall will likely prefer to write off that windfall as a financial loss and keep its capacity utilization at competitive levels, thus avoiding the deterioration of its market position. In sum, this leads to the expectation that positive resource acquisition windfalls will be positively associated with the aggressiveness of competitive conduct, whereas negative resource acquisition windfalls will not display an association with competitive conduct.

Hypothesis 2: The capacity utilization of an electricity-generating firm in a market is positively associated with its resource acquisition windfalls when those windfalls are positive (i.e. resource opportunity costs > resource acquisition costs), but is not associated with its resource acquisition windfalls when those windfalls are negative (i.e. resource opportunity costs < resource acquisition costs).

Competitors' resource acquisition windfalls

In addition to a firm's own resource acquisition windfalls, we also expect the windfalls experienced by its competitors to have an influence on that firm's competitive conduct. Following the rationale laid out for the previous hypotheses, increases in the average level of windfalls experienced by a firm's competitors will likely lead those competitors to be generally more aggressive, by increasing their capacity utilization levels to gain market share. Since, due to their depressing effect on market prices, competing firms' capacity utilization choices are *strategic substitutes* (*e.g.* Besanko *et al.* 2013, Fudenberg and Tirole 1984), we may expect that a given firm will accommodate its competitors' increased aggressiveness by being less aggressive and lowering its own capacity utilization level. Therefore, we test whether a firm's capacity utilization in a market will be negatively associated with the average level of its competitors' resource acquisition windfalls.

Hypothesis 3: The capacity utilization of an electricity-generating firm in a market is negatively associated with the average level of resource acquisition windfalls of its competitors.

Moderating effects

Building on Hypotheses 1 and 2, we do not expect that a firm's expected returns to aggressive competitive conduct will be the same in every circumstance. Hence, similar to Gimeno *et al.* (2015), we posit that the predicted positive association between positive resource acquisition windfalls and capacity utilization in a market is likely to be moderated by certain firm and market characteristics. Given the specific empirical setting at hand, we chose to focus on the following four moderating factors: the tightness of supply capacity relative to demand in a market (a market-based metric of opportunity); a firm's market share; market concentration; and a firm's level of presence in downstream electricity retail.

In electricity generation, increases in the tightness of supply capacity relative to demand in a market – driven by upward fluctuations in demand – are very closely associated with higher market prices, and will therefore arguably provide an extra stimulus for a firm to pursue market share by being more aggressive. Furthermore, in oligopolistic contexts like ours,[7] some theory and evidence also show that during market expansions any form of implicit (or tacit) collusion is more difficult to sustain, because the benefits from defecting increase (due to higher current market prices) relative to the potential punishment that a firm might receive from its competitors later (Rotemberg and Saloner 1986). In general, this suggests that increases in the tightness of supply capacity relative to demand in a market will constitute opportunities for a firm to compete more aggressively.

Following this rationale, it is likely that the tightness of supply capacity relative to demand in a market will influence a firm's incentives to leverage positive resource acquisition windfalls to pursue

[7] That is, contexts with easily-available public information on demand and supply levels.

market share. As pointed out by Gimeno *et al.* (2015), both theory and empirical evidence in the risk management literature suggest that positive resource acquisition windfalls are more likely to be used by firms to support investments when opportunities exist (Gimeno *et al,* 2015; Froot *et al.* 1993, 1994, Géczy *et al.* 1997, Nance *et al.* 1993).[8] Translated to the context of electricity generation, this suggests that a firm will be more aggressive in leveraging a positive resource acquisition windfall to gain market share when there is more tightness of supply capacity relative to demand in a market. Thus, we expect that the association between a firm's capacity utilization in a market and its positive resource acquisition windfalls will be positively moderated by the tightness of supply capacity relative to demand in that market.

Hypothesis 4: The positive association between the capacity utilization of an electricity-generating firm in a market and its positive resource acquisition windfalls is positively moderated by the tightness of supply capacity relative to demand in that market.

A firm's relative market position is also likely to influence its incentives to use positive resource acquisition windfalls in order to pursue gains in market share. First, a firm with a large share of the market will arguably not benefit as much from improving its market position as a firm that has a relatively smaller market share. Furthermore, the larger the market share, the higher a firm's costs from engaging in aggressive competitive behavior, since the resulting lower market prices will reduce the margins on the electricity that it already sells. Therefore, it is likely that a firm with a larger market share will be less aggressive in leveraging a positive resource acquisition windfall to gain market share. As a result, we expect that the positive association between a firm's capacity utilization in a market and its positive resource acquisition windfalls will be negatively moderated by the firm's market share.

Hypothesis 5: The positive association between the capacity utilization of an electricity-generating firm in a market and its positive resource acquisition windfalls is negatively moderated by the firm's market share.

[8] Accordingly, Gimeno *et al.* (2015) find that airlines with more opportunities (measured as relatively high *market-to-book* ratios) are more likely to leverage positive windfalls to price aggressively.

Adding to the two prior moderating effects, we also propose that market concentration levels are likely to influence the degree to which a firm will be prone to leveraging positive resource acquisition windfalls to gain market share. In accordance with standard oligopoly theory, markets with higher concentration levels are those in which higher prices are more likely to be sustained in equilibrium, with resulting higher margins for competing firms. Moreover, higher levels of concentration also make it easier for firms to monitor each other and to coordinate among themselves, both important factors to sustain (tacit) collusion in a market. In light of this, it is likely that firms in highly-concentrated markets will be warier of using their positive resource acquisition windfalls for pursuing market share gains, so as not to upset favorable market equilibria. Hence, we expect that the main positive association between a firm's capacity utilization in a market and its positive resource acquisition windfalls will be negatively moderated by the level of market concentration.

Hypothesis 6: The positive association between the capacity utilization of an electricity-generating firm in a market and its positive resource acquisition windfalls is negatively moderated by the level of market concentration.

Furthermore, looking at the whole value chain of the electric power industry, electricity generation is followed downstream by both transmission and retail (or distribution) of electricity. In particular, competitive electricity generation is formally separated from the other downstream activities,[9] and interacts with electricity demand from downstream retail activities through market mechanisms. Taking this into account, we posit that a firm's degree of presence in downstream retail activities will likely influence its incentives to compete aggressively in electricity generation upstream. We argue that this will happen because upstream electricity prices will also represent costs for electricity-generating firms that resort to upstream electricity markets to supply their downstream retail activities. Hence, by being aggressive in an upstream electricity market, a firm with significant presence in downstream electricity retail will also be able to indirectly benefit from lower costs of electricity for its downstream activities. In these cases, the salience of upstream electricity prices as costs – as opposed to marginal revenues – will be more pronounced the greater a firm's presence in

[9] This is part of the regulatory requirements, to ensure effective competition in electricity generation.

downstream retail activities.[10] Thus, it is likely that a greater presence in downstream retail activities will, on its own, be positively associated with the aggressiveness of competitive conduct, in the form of a higher level of capacity utilization by a firm in a market.

For the same reason, a firm's presence in downstream retail activities will also likely influence its incentives to leverage positive resource acquisition windfalls to compete more aggressively in electricity generation upstream. As discussed before, situations in which a firm enjoys positive resource acquisition windfalls are typically associated with high (or rising) natural gas spot prices, with corresponding inflationary pressures on upstream electricity prices. In these cases, a firm with a significant presence downstream will have an even greater incentive to leverage a potential positive windfall to compete more aggressively in the upstream electricity market, so as to indirectly lower the costs of its downstream activities. Therefore, we expect that the positive association between a firm's capacity utilization in a market and its positive resource acquisition windfalls will be positively moderated by the firm's level of presence in downstream electricity retail.

Hypothesis 7: The positive association between the capacity utilization of an electricity-generating firm in a market and its positive resource acquisition windfalls is positively moderated by the firm's level of presence in downstream electricity retail.

DATA, METHODS AND VARIABLES

We chose the competitive (*i.e.* non-regulated) generation segment of the U.S. electric power industry as the empirical setting for our analysis because the economic and institutional characteristics lend themselves toward looking at the connection between resource acquisition windfalls and the aggressiveness of competitive conduct. The fact that electricity is a homogeneous product helps identification of firm conduct, by reducing the relevance of product differentiation as a conduct dimension for electricity-generating firms (Zhang and Gimeno 2010). In electricity markets, electricity generators typically supply their output to downstream retailers (or distributors) of electricity for different daily periods on a day-ahead or spot basis, and the joint behavior of total supply and demand determines electricity prices. Given these characteristics, theoretical research in

[10] This rationale is akin to double-marginalization arguments put forward in literature that deals with vertical integration within the industrial organization tradition (*e.g.* Salinger 1988, Tirole 1988).

economics has approximated competition in electricity markets with the Cournot model of quantity competition (*e.g.* Borenstein and Bushnell 1999). From a regulatory standpoint, the U.S. Energy Policy Act (EPACT) of 1992 constitutes the landmark legislative piece for the electricity generation segment, since it established guidelines for the creation of competitive electricity markets for eligible generators. Currently, the territory comprising the contiguous U.S., most of Canada, and small parts of Mexico is divided into eight mutually-exclusive electricity markets, called the North American Electric Reliability Corporation (NERC) regions (described in the Appendix). The existing heterogeneity across markets is important from the standpoint of identification of our proposed effects, since it provides us with a potential source of variation in competitive conditions.

Within the competitive generation segment of the U.S. electric power industry, we focused on *gas*-fired power plants for the following reasons. First, fuel costs are by far the most important component in the production costs of gas-fired power plants and thus a crucial determinant of competitive heterogeneity across plants.[11] Furthermore, because gas-fired power plants have the highest marginal costs across the different power plant technologies, they are typically the marginal plants in a market's supply schedule, and their marginal costs are the ones that end up determining market prices.[12] Thus, the monitoring and management of fuel costs are crucial for the relative capacity utilization and profitability of gas-fired power plants.

Second, natural gas is a homogenous product with integrated intrastate and interstate competitive wholesale markets in the U.S. since the early 1990s. The existence of a consolidated network of pipelines and trading hubs together with the development of liquefaction and compression techniques (the latter especially important for road transportation of natural gas) helped the decline of geographic differences in natural gas prices within the U.S. (Joskow 2012). Because of this, firms dispose of a wide range of financial hedging instruments to manage volatility in natural gas prices, with approximately 300 natural gas futures, options and swap contracts available in the New York Mercantile Exchange (NYMEX) and the Intercontinental Exchange (ICE), covering different delivery

[11] For instance, in our sample, fuel costs correspond on average to 93 percent of a gas-fired power plant's variable production costs in 1999, and 89 percent in 2009 (the equivalent shares of total – fixed plus variable – production costs are 79 percent and 72 percent, respectively). The drop in the relative weight of fuel costs from 1999 to 2009 can be in part attributed to the decrease in natural gas prices.

[12] Indeed, given these characteristics, gas-fired power plants are said to have a "natural hedge" (Guo *et al.* 2014).

points, quantities, and time spans ("Utilities Turn to Fuel Hedging to Reduce Price Risk " | Black & Veatch). Given this and the aforementioned importance of managing natural gas costs, most firms owning gas-fired power plants financially hedge their natural gas purchases. As a result of heterogeneity in firms' hedging strategies, firm differences in the acquisition costs of natural gas commonly occur.

In contrast to gas-fired power plants, coal-fired power plants do not have all of the desirable characteristics from the standpoint of identification, despite fuel costs being as well the most important component of production costs for these plants. [13] First, coal is a base-load technology that lies in the lowest ranges of a market's supply schedule due to its relatively low marginal costs. For this reason, the relative capacity utilization of coal-fired power plants will arguably be less affected by fuel cost differentials. Second, and even though a global market for coal exists, coal is not a completely homogeneous input and has sizable transportation costs.[14] This leads coal-fired power plants to co-locate and co-specialize with specific coal mines, and to either trade coal mostly on the basis of long-term contracts or to vertically integrate with coal mines upstream due to potential hold-up problems (Joskow 1985). As a result, compared to gas-fired power plants, spot market transactions are relatively less frequent, fuel costs are more idiosyncratic, and fuel price volatility is less relevant for coal-fired power plants. Thus, the use of financial instruments to hedge coal purchases is much less prevalent than in the case of gas. These characteristics reduce the applicability of the arguments connecting fuel opportunity costs and windfalls with the aggressiveness of competitive conduct in the case of coal-fired power plants.

The main data source we use is a database on the North American electric power industry provided by SNL. SNL is a reference source for business intelligence in several industries (*e.g.* energy, banking, insurance, real estate), which collects data from various sources and produces its

[13] In our sample, fuel costs correspond to 92 percent of a coal-fired power plant's variable production costs in both 1999 and 2009; and to 73 and 71 percent of total – fixed plus variable – production costs for 1999 and 2009, respectively.

[14] As reported in aggregate by the U.S. Energy Information Administration, for our final sample period (1999-2009) the average yearly coal price per MMBTU (Millions of British Thermal Units) paid by electricity generators in the U.S. is 23 percent higher than the average yearly coal spot price (1.53 US$ (US dollars) vs. 1.25 US$). In the case of natural gas, the same difference between the average yearly price per MMBTU paid by electricity generators and the average yearly spot price (measured at the Henry Hub) is 3 percent (5.66 US$ vs. 5.51 US$). This corroborates the idea that coal has sizable transportation costs.

own industry analysis reports. The subscribed database aggregates publicly-available data on power plant operations from the U.S. Energy Information Administration (EIA) and the Federal Energy Regulatory Commission (FERC), in addition to including plant ownership information at multiple levels – from immediate to ultimate parent firms. Furthermore, this database also includes financial information at the level of the ultimate parent firm.

The SNL database was complemented with publicly-available data. We used the U.S. Securities Exchange Commission (SEC) EDGAR database to collect information on whether firms financially hedged their natural gas purchases from their annual 10K filings. We also collected data from EIA's 411 data file on market-level energy loads (demand levels) and overall available supply capacity, to construct our measure of tightness of supply capacity relative to demand in a market.

Taking the ultimate parent firm as the relevant unit of analysis, the final dataset merges all of these data sources. The aforementioned eight NERC regions correspond to our markets.[15] We aggregated the operational data on power plants to the firm-market-year level, and then merged it with firm-year level financial variables, as well as with market-level metrics. We restricted the sample to U.S. firms, since the data coverage for those firms was more consistent than for foreign ones. We also restricted ourselves to firms whose major reported SIC codes were in electric power (4911, 4931, or 4991).[16] Finally, we set the starting year of the sample to 1998, since it was the year in which the Financial Accounting Standards Board issued Standard No. 133, requiring derivative instruments to be recorded by firms in their balance sheets as either assets or liabilities at fair value, and also that changes to their value be recognized in current earning statements.

The above process led to an unbalanced panel of 1,850 firm-market-year observations, with 57 distinct firms followed from 1998 to 2012 in eight markets. Given our interest in the association between natural gas acquisition windfalls and competitive conduct, we further restricted our sample to firms with non-regulated gas-fired power plants in a given market-year. This step reduced our consolidated sample to 35 distinct firms and a total of 840 firm-market-year observations.

[15] As a result, Hawaii and Alaska are not considered in our sample. This is because these two regions are too small and concentrated to come close to properly-functioning competitive markets.
[16] Some exceptions to this rule exist (firms with reported code 4900, 4932, or no code reported). We checked individually those firms to ensure that electricity was not a negligible component of their businesses.

Methods

To control for the fact that firms' decisions to financially hedge their fuel purchases are endogenous, our regression models use a two-stage approach, in a similar way to Gimeno *et al.* (2015). In the first stage, we estimate the likelihood that a firm will financially hedge its natural gas purchases, and then we control for this estimated likelihood in the second-stage models of firm conduct. Specifically, we use a two-step endogenous treatment selection model, with the predicted value of a first-stage Probit regression on the likelihood of a firm financially hedging its gas purchases being used to compute an inverse-Mills ratio that enters a second-stage linear regression as a control (*e.g.* Pincus and Rajgopal 2002).

First-stage model variables

To control for a firm's overall propensity to financially hedge its natural gas purchases, our dependent variable in the first-stage model is called *Gas hedging dummy*. This variable is coded 1 if a firm's 10K report mentions that the firm financially hedged at least some of its natural gas purchases during the previous year, and 0 otherwise. We use a simple dummy variable in this case because we found risk management data to be coarse and not very well detailed in firms' 10K reports. Thus, we were not able to retrieve the specific terms – physical quantities and monetary amounts – that characterize a given firm's gas hedging strategy.[17]

We use different measures as independent variables for the first-stage model, all of them lagged 1 year. *Firm size* is the log of the value of a firm's total assets (in billions of U.S. dollars (US$)). *Debt over total assets* is the ratio of a firm's total debt to its total assets. *Market-to-book ratio* represents the ratio of a firm's market capitalization to the book value of its equity. *Cash and equivalents over total assets* is self-explanatory. *Overall downstream retail presence log ratio* is the log of (1 plus) the ratio of a firm's total volume of electricity sold directly to downstream retail customers in the U.S. (in Megawatt-hours (MWh)) to the total volume of electricity generated by a firm's plants across the eight different electricity generation markets considered (in MWh). The *Gas revenues over total*

[17] In this regard, our data is not as complete as Gimeno *et al.*'s (2015) or Carter *et al.*'s (2006) data on fuel hedging by airlines. These authors are able to use airlines' 10K reports to retrieve information on both whether a firm hedged and which percentage of a firm's fuel needs were hedged.

operating revenues variable represents the ratio of a firm's revenues from gas distribution and retail activities over its total operating revenues. Lastly, we also added year dummy variables to the first-stage model specification.

Second-stage model variables

Deviation from expected non-regulated capacity utilization. This is the second-stage dependent variable that is used to proxy for the aggressiveness of a firm's conduct in a given market and year. Because different generation technologies have disparate levels of expected capacity utilization – due to technical and economic reasons –, this variable looks at the aggressiveness of a firm's conduct by measuring the deviation of the capacity utilization of a firm's non-regulated plants in a market from a relevant capacity utilization benchmark. In this context, a firm's higher capacity utilization in a market – with the corresponding larger deviation from the relevant capacity utilization benchmark – represents more aggressive behavior since, *all else being equal*, that firm will be more likely to earn market share at the expense of its competitors.

To compute this variable, we started by calculating the relevant capacity utilization benchmark: *Firm expected non-regulated capacity utilization*. For firm i in market m and year t, this measure was calculated in the following way:

$$\frac{\sum_{p \in P_{imt}^{nr}} Plant\ capacity_{pit} * Plant\ capacity\ utilization\ benchmark_{p\tau_p t}}{\sum_{p \in P_{imt}^{nr}} Plant\ capacity_{pit}}$$

P_{imt}^{nr} represents the set of firm i's *non-regulated* power plants in market m and year t; $Plant\ capacity_{pit}$ is plant p's capacity (in Megawatts (MW)) in year t; τ_p indexes plant p's technological class; and $Plant\ capacity\ utilization\ benchmark_{p\tau_p t}$ represents the average across-sample yearly capacity utilization for plants in technological class τ_p in year t, excluding plant p. For any plant in the sample, yearly capacity utilization was calculated as the ratio of the plant's net annual generation output (in MWh) – equal to gross output minus electricity spent on internal use – divided by the number of hours in a year (8,760) and by plant capacity (in MW).

For firm i in market m and year t, the *Deviation from expected non-regulated capacity utilization* variable is just the difference between the total yearly level of capacity utilization of firm i's *non-regulated* plants in market m and year t and the corresponding *Firm expected non-regulated capacity utilization* measure, divided by the latter measure.

Firm imputed non-regulated gas cost per MWh. This variable operationalizes the opportunity cost of natural gas as a resource for a firm in a given market and year. As a first step, we calculated the *imputed* yearly gas cost per MWh which would have been incurred by each gas-fired power plant if its fuel needs were met through purchasing natural gas in the spot market. As the reference point for natural gas spot market prices, we used the spot price set at the Henry Hub in Louisiana. The Henry Hub is arguably the main natural gas trading hub in North America, connecting nine interstate pipelines and four intrastate pipelines, which together grant it access to many of the major gas markets in the US. Because of this, the spot and futures natural gas prices that are set at the Henry Hub work as reference points for North American natural gas markets (source: Investopedia). Given its relevance, the Henry Hub serves as the official location for deliveries of the natural gas futures contracts that are traded on the NYMEX, and lends its name to the over-the-counter (OTC) natural gas swaps that are traded on the ICE.

For each gas plant p belonging to firm i in year t, the measure of imputed yearly fuel cost per MWh is called *Plant imputed gas fuel cost per MWh* – in US$ – and takes the form:

$$Gas\ spot\ price\ per\ MMBTU_t \times heatrate_{pit} \times \frac{1}{1000}$$

$Gas\ spot\ price\ per\ MMBTU_t$ is the average of the natural gas spot price at the Henry Hub in year t, in US$ per MMBTU (millions of British thermal units). $heatrate_{pit}$ is the heat rate of plant p in year t, which corresponds to an (in)efficiency measure of the average amount of natural gas (in BTUs) spent by plant p in year t to produce one Kilowatt-hour (KWh) of electricity.

Finally, for firm i in market m and year t, the *Firm imputed non-regulated gas cost per MWh* variable – in US$ – is then given by:

$$\sum_{p \in P_{imt}^{nr\ gas}} expected\ share_{pimt} * Plant\ imputed\ gas\ fuel\ cost\ per\ MWh_{\ pit}$$

$P_{imt}^{nr\ gas}$ is the set of firm i's *non-regulated gas-fired* power plants in market m and year t. $expected\ share_{pimt}$ is the share of plant p's *expected* generation out of the total *expected* generation of all of firm i's plants in market m and year t. For each of firm i's plants, expected generation is computed as $Plant\ capacity_{pit} * Plant\ capacity\ utilization\ benchmark_{p\tau_p t}$ (analogously to what is done for the second-stage dependent variable), and thus represents that plant's expected average hourly generation in year t. We use $expected\ share_{pimt}$ instead of just looking at plant p's *actual* generation out of the total *actual* generation of firm i's plants in market m and year t because of endogeneity concerns – *i.e.* as argued before, changes in the spot price of fuel are likely to influence the amount of electricity generated by a given plant.

We use a natural gas opportunity cost measure per MWh – instead of per MMBTU – for the following reasons. First, we need to take into account the different technological mixes of firms (*i.e.* the relative share of a firm's generation in a market that is non-regulated and gas-fired), and the resulting differences in the relevance of natural gas spot prices for their overall electricity generation activities. Second, we also sought to implicitly control for efficiency differences in firms' non-regulated gas-fired power plants. These concerns also drive the construction of the windfall variables, presented next.

Firm windfall per MWh. This variable operationalizes the discrepancy between the opportunity cost of natural gas and a firm's acquisition cost of natural gas in a given market and year. For each firm i in market m and year t, *Firm windfall per MWh* – in US$ – takes the form:

$$\sum_{p \in P_{imt}^{nr\ gas}} expected\ share_{pimt} * (Plant\ imputed\ gas\ fuel\ cost\ per\ MWh_{pit} - Plant\ reported\ gas\ fuel\ cost\ per\ MWh_{\ pit})$$

$P_{imt}^{nr\ gas}$ represents the set of firm i's *non-regulated gas-fired* power plants in market m and year t. $expected\ share_{pimt}$ and $Plant\ imputed\ gas\ fuel\ cost\ per\ MWh_{\ pit}$ have the same definitions as those presented for the previous variable. $Plant\ reported\ gas\ fuel\ cost\ per\ MWh_{pit}$ is reported by the SNL database as the average cost of natural gas consumed per MWh of electricity generated by plant p in year t (in US$). These data are originally collected from the FERC form 1, a detailed financial and operational annual report that major electric utilities are required to submit to the FERC.[18] FERC form 1 data include reported fuel costs at the level of each power plant owned by a major electric utility. The way in which fuel costs are reported for each power plant is *free-on-board* (at the point of first loading), including taxes and quality-related charges or credits, and net of gains or losses from hedging contracts.[19]

Firm positive windfall per MWh. This variable is equal to the *Firm windfall per MWh* variable if *Firm windfall per MWh* is positive; and is coded 0 otherwise.

Firm negative windfall per MWh. Conversely, this variable equals *Firm windfall per MWh* if the *Firm windfall per MWh* variable is negative; and is coded 0 otherwise.

Competitors' average windfalls per MWh. The objective of this variable is to operationalize the degree of windfalls that a firm's competitors have in a given market and year. For each firm i in market m and year t, this variable is a simple arithmetic average of the *Firm windfall per MWh* variable for every competitor of firm i that is also present in market m during year t.

Focal market capacity tightness. Gimeno *et al.* (2015) use a firm's *market-to-book* ratio to proxy for a firm's growth opportunities. In contrast with their approach, we use a variable that operationalizes the level of opportunities faced by a firm in a given market and year. Our variable does so by measuring the tightness of existing generation capacity relative to demand in a market. The nature of electricity and its wholesale trade make the tightness of supply capacity in a given market a very relevant metric of opportunities in that market. Because electricity is a homogeneous product whose bulk storage cannot be done in an economic way, demand needs to be matched to supply in every circumstance, in spite of potential demand volatility due to weather changes and economic fluctuations. Furthermore, electric utilities make up most of the demand side and have very inelastic demand requirements, because of their pre-existing commitments to supply retail customers downstream. In addition, supply is also very inelastic in its highest ranges, due to the relatively high marginal costs of peak-load – typically gas-fired – power plants. As such, the tightness of generation

[18] According to FERC form 1 instructions, major electric utility means having, in each of the three previous years, sales or transmission that exceed one of the following: (i) 1 million MWh of total annual sales; (ii) 100 MWh of annual sales for resale; (iii) 500 MWh of annual power exchanges delivered; or (iv) 500 MWh of annual wheeling for others (deliveries plus losses). Overall, this is a relatively low threshold, which is surpassed by every firm in our data.

[19] This definition is taken from the instructions of the EIA 923 survey on cost and quality of fuels delivered to electric power plants. These specific data on cost and quality of fuels delivered to power plants used to be collected by the FERC form 423 until 2007 and started being collected by the EIA 923 survey in 2008.

capacity relative to demand in a given market is a very salient indicator of the likelihood of high electricity prices, and thus high returns to electricity generators in that market (*e.g.* Borenstein and Bushnell 2015, Credit Suisse 2013, SNL Energy 2013).[20]

Thus, for market m and year t, the *Focal market capacity tightness* variable is calculated in the following way:

$$\frac{Market\ average\ hourly\ net\ energy\ for\ load\ (MW)_{mt}}{Market\ total\ summer\ capacity\ (MW)_{mt}}$$

The numerator in the above expression is a proxy for average demanded electricity in market m and year t, and corresponds to the sum of the average hourly net generation of all generating units in market m and year t (in MW), plus energy receipts and minus energy deliveries. The denominator is the proxy used for available supply capacity in market m and year t, and is the sum of existing net generation capacity in market m and year t (in MW), netted out of the capacity that either enters or leaves the market due to purchases, sales, ownership, or entitlements.

Firm focal market share. This is a firm's share of the total electricity generated by all firms in a given market m during the previous year.

Focal market HHI. This variable is meant to operationalize the level of concentration in a market and corresponds to the Herfindahl-Hirschman Index (HHI). It is calculated based on the electricity generated by all firms in a given market m during the previous year.

Downstream retail presence in the focal market log ratio. This operationalizes the relative level of downstream retail presence by a firm in a given market. For firm i in market m and year t, it is calculated as the log of (1 plus) the previous-year ratio of the total volume of electricity sold directly by firm i to downstream retail customers in the geographic area corresponding to market m (in MWh), to the volume of electricity generated by firm i's plants in market m (in MWh).

Control variables. The presented model specifications include a number of added variables to control for other factors that might influence the aggressiveness of a firm's conduct. We describe those

[20] The California electricity crisis of 2000-2001 (Borenstein, Bushnell, & Wolak 2002; Joskow & Kahn 2002) – in which wholesale electricity prices increased over tenfold relative to normal levels (Pope 2002) – and price spikes in the New York wholesale market in 2001 (Kwoka & Sabodash, 2011) represent extreme examples of this instance.

variables in detail in Table 1. In addition, our second-stage models include firm and market dummy variables, to control for time-invariant firm and market characteristics.

- Insert Table 1 about here -

Final Sample

Due to the implemented two-step estimation procedure and data availability issues, the final sample used in our estimations is smaller than the initial consolidated sample. Firstly, the sample dropped to 680 observations – with the same 35 firms – since the upper bound on the time frame for the analysis is 2009 instead of 2012. This is because the basic metrics used to build the *Focal market capacity tightness* variable (*Market average hourly net energy for load* and *Market total summer capacity*) are not reported by the EIA for some markets after 2009. Secondly, because of our implementation of the two-step estimation procedure and application of 1-year lags to some variables, the final sample was further reduced to an unbalanced panel of 596 firm-market-year observations, with 33 distinct firms followed from 1999 to 2009 in eight markets.

RESULTS

Descriptive statistics

Confirming our prior expectations, a large percentage of firms in our setting financially hedge their natural gas purchases: the *Gas hedging dummy* variable is coded 1 for 96 percent of the firm-years in the sample. Second-stage variable summary statistics and correlations are presented in Table 2. An inspection of the correlations reveals some interesting patterns. First, structural characteristics of market supply and demand display strong associations, with *Share of focal market generation that is regulated* being highly positively correlated with both *Focal market HHI* (0.509) and *Focal market capacity tightness* (0.581). Second, *Firm focal market share* is highly negatively correlated with *Share of a firm's generation in the focal market that is gas-fired and non-regulated* (-0.516), which justifies the highly negative correlation between *Firm focal market share* and *Firm imputed non-regulated gas cost per MWh* (-0.494). Third, the high absolute-value correlations between *Firm imputed non-regulated gas cost per MWh* and some windfall variables are warranted by the way those variables are constructed. The same is true for the high correlations found between some windfall variables. Fourth, given that most firms in the sample financially hedge their gas purchases, the positive correlation between *Firm windfall per MWh* and *Competitors' average windfalls per MWh* (0.250) confirms our expectations. Nonetheless, the fact that this correlation is not very high also indicates that there is some degree of heterogeneity in hedging strategies and outcomes across firms, which is good from the standpoint of our arguments and identification. Fifth, the remaining high-magnitude correlations are also justifiable by construction.[21]

- Insert Table 2 about here -

First-stage regression results

Table 3 shows the results for the first-stage Probit regression model predicting the likelihood of firms financially hedging their natural gas purchases. Despite the aforementioned very high percentage of firms that financially hedge their natural gas purchases in our sample, some of the included covariates have statistically significant effects. Specifically, whereas firm *Firm size*, *Debt over total assets*, and *Gas revenues over total operating revenues* have positive and significant coefficients (at the 5%, 10%, and 5% levels, respectively); *Overall downstream retail presence log ratio* has a negative and significant coefficient (at the 5% level).

- Insert Table 3 about here -

Second-stage regression results

Tables 4 and 5 display the results for the second-stage linear regression models on the aggressiveness of firm conduct, measured by the dependent variable (*Deviation from expected non-regulated capacity utilization*) as the relative difference between a firm's capacity utilization in a market and a benchmark. The difference between the regression models presented in the two tables is that the models in Table 5 discriminate between positive and negative windfalls, by including both *Firm positive windfall per MWh* and *Firm negative windfall per MWh*; whereas the models in Table 4 do not make such a distinction, and just include the *Firm windfall per MWh* variable.

- Insert Table 4 about here -

- Insert Table 5 about here -

[21] Namely, the negative correlation between *Share of a firm's generation in the focal market that is regulated* and *Share of a firm's generation in the focal market that is gas-fired and non-regulated* (-0.680), and the correlations of these variables with *Firm imputed non-regulated gas cost per MWh* (-0.534 and 0.720, respectively).

The Null Hypothesis predicted that the capacity utilization of an electricity-generating firm in a market would be affected by natural gas spot prices (*i.e.* opportunity costs), and not by historical fuel acquisition costs. Corroborating the first part of this prediction, the estimated coefficient for *Firm imputed non-regulated gas cost per MWh* is negative and statistically significant across all model specifications (at the 1% (0.1%) level for Model 3 in Table 4 (5)). For Model 3 in Table 5, an increase of 1 US$ in the *Firm imputed non-regulated gas cost per MWh* is associated with a drop of 0.013 in the dependent variable; in other words, a drop of 1.3 percent in a firm's market capacity utilization relative to the benchmark, which is *a priori* sizable.

Contrasting with the Null Hypothesis, Hypothesis 1 predicted that resource acquisition windfalls would be positively associated with the aggressiveness of competitive conduct. Looking at the estimated coefficients for *Firm windfall per MWh* in Table 4, this prediction does not seem to be fully supported: albeit positive, the estimated coefficients are never statistically significant. This does not mean that firms only behave as a function of opportunity costs, given that the estimated coefficients for *Firm windfall per MWh* and for *Firm imputed non-regulated gas cost per MWh* in Table 4 are never statistically different from one another in absolute value.

Delving deeper into this issue, Hypothesis 2 predicted that positive windfalls would be positively associated with the aggressiveness of competitive conduct, while negative windfalls would not display an association with competitive conduct. The evidence obtained from Model 3 in Table 5 supports these predictions: whereas the coefficient for *Firm positive windfall per MWh* is positive and statistically significant (at the 5% level), the coefficient for *Firm negative windfall per MWh* is negative and insignificant. Thus, in a similar way to Gimeno *et al.* (2015), these results support the idea that firms respond asymmetrically to hedging gains and losses.

Furthermore, for Model 3 in Table 5, the (negative and significant) estimated coefficient for *Firm imputed non-regulated gas cost per MWh* is not significantly different in absolute value from the estimated coefficient for *Firm positive windfall per MWh*; and the point estimate for the coefficient of *Firm positive windfall per MWh* is actually larger in absolute value. In that same model, an increase of 1 US$ in the *Firm positive windfall per MWh* variable is associated with an increase of 5.6 percent in a firm's capacity utilization relative to the benchmark, which is a large effect. This suggests that firm conduct is determined more by historical acquisition costs than by opportunity costs of fuel, since the estimated effect for *Firm imputed non-regulated gas cost per MWh* is cancelled out. This goes against the baseline situation predicted in the Null Hypothesis and corroborates Gimeno *et al.*'s (2015) results.

In Hypothesis 3, we predicted that the average level of competitors' windfalls would be negatively associated with the aggressiveness of a firm's conduct in a market. However, countering our prediction, the estimated coefficients for the *Competitors' average windfalls per MWh* variable are always positive and significant across all of our models (at the 5% level). The implied effect size of the estimated coefficients is large as well: for Model 3 in Table 5, an increase of 1 US$ in the *Competitors' average windfalls per MWh* variable is associated with a 2.2 percent increase in a firm's capacity utilization relative to the benchmark. Albeit puzzling at first, this result might be due to pre-existing collusive market equilibria in our setting, and the destabilizing effect that generalized firm windfalls can have on such equilibria. The move to a more competitive situation could justify the observed positive association between *Competitors' average windfalls per MWh* and a firm's capacity utilization. We discuss this issue in more detail below.

Hypotheses 4 to 7 were put forward to further validate the link between positive resource acquisition windfalls and the aggressiveness of competitive conduct. To test these hypotheses, for Model 3 in Table 5 we introduced interactions between different moderators and *Firm positive windfall per MWh*. For model calibration reasons, we also included interactions of those moderators with both *Firm negative windfall per MWh* and *Firm imputed non-regulated gas cost per MWh*.[22]

Hypothesis 4 predicted that the tightness of supply capacity relative to demand in a given market would positively moderate the relationship between *Firm positive windfall per MWh* and the aggressiveness of competitive conduct. Supporting this conjecture, the estimated coefficient for the interaction between *Focal market capacity tightness* and *Firm positive windfall per MWh* is positive and significant for Model 3 in Table 5 (at the 5% level). In addition, the estimated coefficient for

[22] For any interaction including continuous variables, each continuous variable was centered to its sample mean value, following Aiken and West (1991). Thus, the main effect of each variable that we interact with another continuous variable can be read as the former variable's effect at the mean level of the other interacting continuous variable.

Focal market capacity tightness is also positive, albeit not statistically significant. This last result does not fully support the conjecture that the tightness of supply capacity relative to demand in a market would, on its own, be positively associated with the aggressiveness of competitive conduct. In Figure 1, we depict graphically the interaction effect predicted in Hypothesis 4. There, we can see that an increase of 1 US$ in *Firm positive windfall per MWh* is associated with an increase of almost 10 percent in capacity utilization relative to the benchmark when *Focal market capacity tightness* is high (one standard deviation above the mean), whereas it is associated with a mere 2 percent increase when *Focal market capacity tightness* is low (one standard deviation below the mean). This result is akin to Gimeno *et al.*'s (2015) finding of a positive moderating effect of high investment opportunities (operationalized as a firm's *market-to-book* ratio).

- Insert Figure 1 about here -

Hypothesis 5 predicted that a firm's market share would negatively moderate the relationship between *Firm positive windfall per MWh* and the aggressiveness of competitive conduct. However, contrary to this prediction, for Model 3 in Table 5 the estimated coefficient for the interaction between *Firm focal market share* and *Firm positive windfall per MWh* is positive (albeit not significant statistically). Figure 2 displays this interaction graphically, and shows that increases in *Firm positive windfall per MWh* are more highly associated with increases in capacity utilization relative to the benchmark when *Firm focal market share* is high than when it is low (respectively, one standard deviation above the mean and the sample minimum). This effect may be due to firms with larger market shares being relatively more present in base-load technologies (*e.g.* coal or nuclear), which typically have higher levels of capacity utilization than gas-fired power plants. This is corroborated by the fact that the estimated coefficient for *Firm focal market share* is always positive and statistically significant (at the 5% level for Model 3 in Table 5), and by the high negative correlation between *Firm focal market share* and *Share of a firm's generation in the focal market that is gas-fired and non-regulated*. Thus, the particular characteristics of our sample might be driving this result (or lack thereof).

- Insert Figure 2 about here -

Hypothesis 6 conjectured that market concentration would negatively moderate the association between *Firm positive windfall per MWh* and the aggressiveness of competitive conduct. Lending support to this prediction, for Model 3 in Table 5 the estimated coefficient for the interaction between *Focal market HHI* and *Firm positive windfall per MWh* is negative, although not statistically significant. Figure 3 further supports the conjecture of Hypothesis 6, by showing that an increase of 1 US$ in *Firm positive windfall per MWh* is associated with an increase of around 2.5 percent in capacity utilization relative to the benchmark when *Focal market HHI* is high (one standard deviation above the mean), and with an increase of around 7 percent when *Focal market HHI* is low (one standard deviation below the mean).

- Insert Figure 3 about here -

Finally, Hypothesis 7 predicted that a firm's level of presence in downstream electricity retail would positively moderate the relationship between *Firm positive windfall per MWh* and the aggressiveness of competitive conduct. Supporting this, for Model 3 in Table 5 the estimated coefficient for the interaction between *Downstream retail presence in the focal market log ratio* and *Firm positive windfall per MWh* is positive and highly statistically significant (at the 0.1% level). In addition, the estimated coefficient for *Downstream retail presence in the focal market log ratio* is positive and highly statistically significant (at the 0.1% level, for Model 3 in Table 5). This also supports our conjecture that a greater presence in downstream retail activities would, on its own, be positively associated with the aggressiveness of competitive conduct. Figure 4 graphs the interaction effect predicted in Hypothesis 7, showing that an increase of 1 US$ in *Firm positive windfall per MWh* is associated with an increase of around 10 percent in capacity utilization relative to the benchmark when *Downstream retail presence in the focal market log ratio* is high (one standard deviation above the mean), whereas it is associated with an increase of around 4 percent when *Downstream retail presence in the focal market log ratio* is low (zero, the sample minimum).

- Insert Figure 4 about here -

In broad terms, our results agree with the predictions put forward in the hypotheses. In accordance with Gimeno *et al.*'s (2015) application of Froot *et al.*'s (1993, 1994) risk management rationale to competitive contexts, the results suggest that positive resource acquisition windfalls –

arising due to fuel hedging choices – can help a firm compete more aggressively to gain market share when its competitors are generally constrained by high fuel spot prices.

DISCUSSION

In this paper, we sought to empirically link firms' resource acquisition windfalls – defined as the difference between the ex-post opportunity cost of a resource and its acquisition cost – with their resource deployment decisions in output markets. To do so, we leveraged heterogeneity in firms' input hedging outcomes in the context of the generation segment of the U.S. electric power industry (1999-2009), and looked at how differences between the spot price of natural gas (proxy for opportunity costs) and its historical acquisition cost influenced the aggressiveness of a firm's competitive conduct.

Our empirical findings suggest that a firm's resource deployment decisions are influenced not only by the opportunity costs of those resources but also by their acquisition costs, contrasting with the general prescriptions of the RBV literature. Corroborating Gimeno *et al.* (2015), we found that positive resource acquisition windfalls were associated with a greater aggressiveness of a firm's competitive conduct in a market, in the form of a higher level of capacity utilization. In contrast, and also somewhat similarly to Gimeno *et al.* (2015), we did not find a significant association between negative windfalls and the aggressiveness of competitive conduct. By highlighting the role that positive resource acquisition windfalls can have in supporting firms' pursuits of market share, these findings are a further testimony to the applicability of Froot *et al.*'s (1993, 1994) risk management framework to the domain of competitive interactions.

We also sought to examine the role of critical moderators on the basic relationship between positive resource acquisition windfalls and the aggressiveness of competitive conduct. In this case, most of the estimated effects agreed with our predictions. We found that the aforementioned basic relationship was stronger when the tightness of supply capacity relative to demand in a market was higher; weaker when market concentration was higher; and stronger for firms with a greater presence in downstream electricity retail. Overall, these results reinforce our confidence in the proposed theoretical mechanisms. Against our predictions – and some of Gimeno *et al.*'s (2015) findings –, we did not find a negative moderating effect of a firm's market share on the relationship between positive resource acquisition windfalls and the aggressiveness of competitive conduct. This last result (or lack thereof) might be driven by the specific characteristics of our sample.

Furthermore, we also found a positive association between the average resource acquisition windfalls of a firm's competitors and the aggressiveness of a firm's competitive conduct. Given that competing firms' capacity utilization choices are strategic substitutes, this result seems puzzling at first. Nonetheless, a consistent explanation for it would be the pre-existence of collusive market equilibria in our setting. If that were the case, generalized *positive* windfalls across competitors could have a destabilizing effect on such equilibria, by increasing firms' incentives to defect from collusion to gain market share. Upon the collapse of a collusive equilibrium, any given firm would be more aggressive, by increasing its capacity utilization – with the potential help of a positive resource acquisition windfall – in order to preserve its market position.

Lending support to this idea, research in economics has highlighted the concentrated (and potentially collusive) nature of deregulated wholesale electricity markets, by uncovering evidence of firms performing "strategic withholding" of electricity to manipulate market prices (Fabra and Toro 2005, Joskow and Kahn 2002).[23] Hence, the upsetting of pre-existing collusive market equilibria is a likely justification for the positive association found between average competitors' windfalls and the aggressiveness of firm conduct. Such a transition from collusion to a situation in which all market players increase production levels to keep their market shares has some similarities with the current situation seen in global oil markets (*e.g.* Bowler 2015, Krauss 2016). Moreover, pre-existing collusion might be an additional justification for the absence of a negative moderating effect of market share on the aggressiveness of firm conduct.

Contributions

This paper makes contributions to several literature strands. First and foremost, by adding empirical evidence connecting firms' resource acquisition windfalls with resource deployment decisions in output markets, it contributes to the RBV literature. In particular, our evidence

[23] In fact, during the aftermath of the California electricity crisis of 2000-2001 (mentioned before), judicial investigations revealed that some generators artificially created power plant outages in order to tighten supply conditions and jack up prices, increasing their profits in the process (McLean & Elkind 2003).

corroborates that of Gimeno *et al.* (2015) and shows that the historical acquisition costs of resources – in addition to their opportunity costs – can have a bearing on deployment decisions, going against some of the prescriptions in RBV literature. The link between resource deployment decisions and competitive outcomes in output markets constitutes one of the most prominent gaps in the RBV literature (Priem and Butler 2001), which only recently received a substantial theoretical impetus (*e.g.* Chatain 2014, Costa *et al.* 2013, Makadok 2010).

Second, this paper also contributes to the risk management literature and, specifically, its emergent body of literature connecting hedging with competition in output markets (*e.g.* Adam *et al.* 2007, Haushalter *et al.* 2007, Léautier and Rochet 2014). In this case, our results conform with predictions (*e.g.* Adam *et al.* 2007, Léautier and Rochet 2014) and prior findings (Gimeno *et al.*, 2015) that hedging strategies can make firms compete more aggressively, consistent with Froot *et al.* (1993, 1994).

In contrast to Gimeno *et al.*'s (2015) study of the airline industry, the fine-grained nature of our data on power plants allowed us to build and use windfall metrics at the firm-market level, instead of relying on aggregate firm-level windfall metrics. This also made it possible to look at the influence of competitors' windfalls on the aggressiveness of a firm's conduct. Moreover, we also examined further contingencies to the role of windfalls on competitive conduct. Given the characteristics of electricity trade, we were able to look at the tightness of supply capacity relative to demand in a given market – a market-based metric of opportunity – as a moderating effect. Likewise, our setting also made it possible to assess the influence of a firm's presence in downstream segments of the industry value chain on its competitive conduct, contributing to the literature that examines empirically the influence of firms' vertical scopes on conduct (*e.g.* Corts 2001, Hastings 2004, Mullainathan and Scharfstein 2001). Lastly, our analysis also considered the moderating effect of market concentration.

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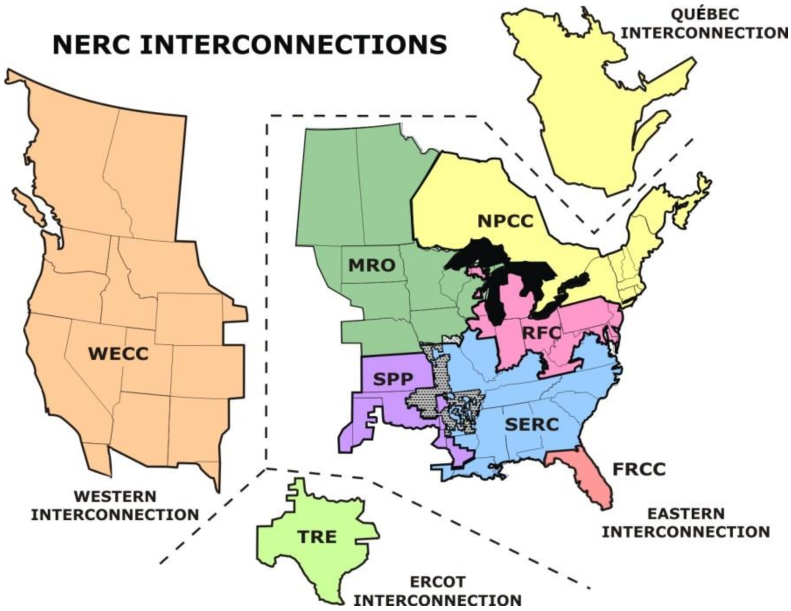
APPENDIX: NERC REGIONS (MARKET DEFINITION)

Figure A1: NERC Regional Entities for the Contiguous United States, Canada, and Northern Baja California, Including the Main Interconnections (Source: NERC - North American Electric Reliability Corporation**)**[24]



U.S. electricity markets

Electricity markets in the U.S. electric power industry work within ten mutually-exclusive North American Electric Reliability Corporation (NERC)[25] regions, which encompass also most of Canada, and northern Baja California (Mexico). Figure A1 shows the relevant eight regions for the contiguous U.S. – excluding the Alaska (ASCC) and Hawaii (HICC) NERC regions – which are further aggregated into three major interconnection networks to help balance supply and demand across regions (EIA 2000).

The broad mandate of the NERC is to foster reliability and adequacy of bulk power transmission in North America. To do so, the NERC develops and enforces compliance with standards for power system operation and monitoring. Furthermore, the NERC also assesses supply resource adequacy within each of its regions and provides educational and training resources to power system operators.

In spite of the progressive increase of electricity flows between NERC regions, the overwhelming majority of trade still occurs within each region (EIA 2008), justifying the choice of NERC regions as our relevant market definition. Since data on electricity flows between regions are not publicly available, we tried to approximate them. Looking at data from the EIA 411 file, we took each of the eight relevant NERC regions and examined the ratio of anticipated capacity resources from adjacent NERC regions to the internal capacity resources of each region in 2010. Across the eight NERC regions, the average ratio was 3 percent – with a maximum value of 8 percent and a minimum of 0 – which corroborates the idea of relatively small volumes of inter-regional trade. This is also consistent with prior evidence showing that the law of one price does not prevail across adjacent electricity markets (Joskow 2006).

[24] The white space between regions delimits the main interconnection networks (Western, Eastern, and ERCOT Interconnections (plus Québec)).

[25] The NERC acronym only adopted this meaning in 2006. Previously, it stood for North American Electric Reliability Council, originally founded in 1968.

FIGURES AND TABLES

Table 1: Control Variable Descriptions

Variables	Definitions
Share of focal market generation that is regulated	This variable is meant to control for any influence that the relative weight of regulated generation in a focal market might have on competitive conduct. For each market m and year t, it is the 1-year lag of the following expression: $$\frac{\sum_{p\in P_{mt}} Electricity\ generated_{pt} * I[if\ regulated]_{pt}}{\sum_{p\in P_{mt}} Electricity\ generated_{pt}}$$ P_{mt} is the overall set of plants in market m and year t; $Electricity\ generated_{pt}$ is plant p's electricity generation in year t (in MWh); and $I[if\ regulated]_{pt}$ is an indicator variable, coded 1 if plant p is regulated, and 0 otherwise.
Share of a firm's generation in the focal market that is regulated	This variable is included to control for any potential effects of a firm's involvement in regulated generation activities in a focal market on its competitive conduct. For each firm i in market m and year t, it is calculated as the 1-year lag of the following expression: $$\frac{\sum_{p\in P_{imt}} Electricity\ generated_{pit} * I[if\ regulated]_{pit}}{\sum_{p\in P_{imt}} Electricity\ generated_{pit}}$$ P_{imt} is the set of firm i's plants in market m and year t; $Electricity\ generated_{pit}$ is plant p's electricity generation in year t (in MWh); and $I[if\ regulated]_{pit}$ is an indicator variable, coded 1 if plant p is regulated, and 0 otherwise.
Firm non-regulated gas-fired generation in the focal market	This variable is aimed at controlling for any influence of the *absolute* level of a firm's non-regulated gas-fired generation activities in a focal market on that firm's competitive conduct. For each firm i in market m and year t, it takes the 1-year lag of the following formula: $$\sum_{p\in P_{imt}} Electricity\ generated_{pit} * I[if\ non-regulated\ and\ gas]_{pit}$$ P_{imt} represents the set of firm i's plants in market m and year t; $Electricity\ generated_{pit}$ is plant p's electricity generation in year t (in MWh); and $I[if\ non-regulated\ and\ gas]_{pit}$ is an indicator variable, which is coded 1 if plant p is a non-regulated gas-fired power plant, and 0 otherwise.
Share of a firm's generation in the focal market that is gas-fired and non-regulated	This variable is included to control for any potential effect of the *relative* weight of a firm's non-regulated gas-fired generation activities in a focal market on that firm's competitive conduct. For each firm i in market m and year t, it is computed as the 1-year lag of the following expression: $$\frac{\sum_{p\in P_{imt}} Electricity\ generated_{pit} * I[if\ non-regulated\ and\ gas]_{pit}}{\sum_{p\in P_{imt}} Electricity\ generated_{pit}}$$ P_{imt} is the set of firm i's plants in market m and year t; $Electricity\ generated_{pit}$ is plant p's electricity generation in year t (in MWh); and $I[if\ non-regulated\ and\ gas]_{pit}$ is an indicator variable, coded 1 if plant p is a non-regulated gas-fired power plant, and 0 otherwise.
Firm non-regulated efficiency relative to focal market competitors variables	These variables are meant to control for the effects that the relative efficiency of a firm's overall set of non-regulated plants in a focal market can have on that firm's competitive conduct. Given the complexity added by the fact that firms' non-regulated plant portfolios can have different technological mixes, we built two separate variables aimed at capturing different aspects of a given firm's relative efficiency in a market: *Firm non-regulated "within-generation-technology" efficiency relative to focal market competitors*, which operationalizes the average efficiency of a firm's non-regulated plants relative to the average efficiency level of non-regulated plants in the same generation technology in the focal market; and *Firm non-regulated "between-generation-technology" efficiency relative to focal market competitors*, capturing the average efficiency of a firm's portfolio of non-regulated plants across generation technologies relative to the non-regulated plant portfolios of other firms in the focal market. These two variables are described in detail below. - *Firm non-regulated "within-generation-technology" efficiency relative to focal market competitors:* For each firm i in market m and year t, this variable takes the form: $$\sum_{p\in P^{nr}_{imt}} nr\ share_{pimt} * \left(1 - \frac{standardized\ avg.\ variable\ cost_{p\tau_p mt} - min\ standardized\ avg.\ variable\ cost_{\tau_p mt}}{max\ standardized\ avg.\ variable\ cost_{\tau_p mt} - min\ standardized\ avg.\ variable\ cost_{\tau_p mt}}\right)$$ P^{nr}_{imt} corresponds to the set of firm i's non-regulated plants in market m and year t, $nr\ share_{pimt}$ is the share of plant p's generation out of firm i's total *non-regulated* generation in market m and year t, and τ_p is an index of plant p's technological class. For each plant p in market m and year t, the $standardized\ avg.\ variable\ cost_{p\tau_p mt}$ component is the standardized measure of plant p's average *non-fuel* variable expenditure in year t relative to its technological class τ_p in market m; and it is obtained by subtracting from plant p's actual average non-fuel variable expenditure (US$/MWh) in year t the mean of the average non-fuel variable expenditure across all *non-regulated* plants in the τ_p technological class in market m and year t, and then dividing that difference by the standard deviation of the average non-fuel variable expenditure across all non-regulated plants in the τ_p technological class in market m and year t. The $max\ standardized\ avg.\ variable\ cost_{\tau_p mt}$ and $min\ standardized\ avg.\ variable\ cost_{\tau_p mt}$ variables correspond to the maximum and the minimum standardized average non-fuel variable expenditures across all non-regulated plants from technological class τ_p in market m and year t; and they are used to bound the efficiency measure for each plant between 0 and 1. We obtain plant-market-year level *within* efficiency measures – in parenthesis above – by multiplying the above ratio by -1 and adding 1 to it, so that higher values reflect higher plant efficiency levels. The final firm-market-year *within* efficiency variable is the sum of the plant-market-year within efficiency measures for plants belonging to the P^{nr}_{imt} set, weighted by $nr\ share_{pimt}$. - *Firm non-regulated "between-generation-technology" efficiency relative to focal market competitors:* For each firm i in market m and year t, this is given by the following expression: $$\sum_{p\in P^{nr}_{imt}} nr\ share_{pimt} * \left(1 - \frac{standardized\ avg.\ variable\ cost_{pmt} - min\ standardized\ avg.\ variable\ cost_{mt}}{max\ standardized\ avg.\ variable\ cost_{mt} - min\ standardized\ avg.\ variable\ cost_{mt}}\right)$$ P^{nr}_{imt} is the set of firm i's non-regulated plants in market m and year t, and $nr\ share_{pimt}$ is the share of plant p's generation out of firm i's total *non-regulated* generation in market m and year t. For each plant p in market m and year t, $standardized\ avg.\ variable\ cost_{pmt}$ is the standardized measure of plant p's average *non-fuel* variable expenditure in year t relative to *all* other *non-regulated* plants in market m; obtained by subtracting from plant p's actual average non-fuel variable expenditure (US$/MWh) in year t the mean of the average non-fuel variable expenditure across *all non-regulated* plants in market m and year t, and then dividing that difference by the standard deviation of the average non-fuel variable expenditure across *all non-regulated* plants in market m and year t. The $max\ standardized\ avg.\ variable\ cost_{mt}$ and $min\ standardized\ avg.\ variable\ cost_{mt}$ variables correspond to the maximum and the minimum standardized

	average non-fuel variable expenditures across *all non-regulated* plants in market m and year t; and serve to bound each plant's efficiency measure between 0 and 1. Plant-market-year level *between* efficiency measures – in parenthesis above – are obtained by multiplying the above ratio by -1 and adding 1 to it, so that higher values reflect higher plant efficiency levels. To get to the final firm-market-year *between* efficiency variable, we sum the plant-market-year between efficiency measures for plants belonging to the P_{imt}^{nr} set, each weighted by $nr\ share_{pimt}$.
Firm non-regulated gas heat rate	This variable is meant to control for the influence that the absolute level of efficiency of a firm's non-regulated gas-fired power plants in a focal market can have on that firm's competitive conduct. For each firm i in market m and year t, it is calculated in the following way: $$\sum_{p \in P_{imt}^{nr\ gas}} nr\ gas\ share_{pimt} * heatrate_{pit}$$ $P_{imt}^{nr\ gas}$ is the set of firm i's non-regulated gas-fired power plants in market m and year t, and $nr\ gas\ share_{pimt}$ is the share of plant p's generation out of firm i's total *non-regulated gas-fired* generation in market m and year t. The $heatrate_{pit}$ component is the heat rate of plant p in year t, and corresponds to the average amount of natural gas (in BTUs) spent by plant p in year t to produce one KWh of electricity. A plant's heat rate is commonly used as a metric of (in)efficiency for gas- and coal-fired power plants, with *lower* heat rate values being indicative of *higher* plant efficiency in transforming fuel inputs into electricity. The final firm-market-year level efficiency measure is the weighted average of $heatrate_{pit}$ for all plants belonging to the $P_{imt}^{nr\ gas}$ set, with $nr\ gas\ share_{pimt}$ used as weights.

Table 2: Variable Summary Statistics and Correlations

		Nr. of Obs.	Mean	St. Dev.	Min.	Max.
1	*Deviation from expected non-regulated capacity utilization*	596	0.1414747	0.7732302	-0.9973035	2.907381
2	*Share of focal market generation that is regulated*	596	0.4772285	0.2325154	0.104021	0.9256973
3	*Share of a firm's generation in the focal market that is regulated*	596	0.2952701	0.3795817	0	1
4	*Firm non-regulated gas-fired generation in the focal market*	596	3376083	4661238	0	3.23E+07
5	*Share of a firm's generation in the focal market that is gas-fired and non-regulated*	596	0.4992001	0.4209424	0	1
6	*Focal market capacity tightness*	596	0.4968098	0.0311525	0.4146237	0.5871201
7	*Firm focal market share*	596	0.0369051	0.047392	0.0000162	0.2211192
8	*Focal market HHI*	596	0.1638661	0.0645897	0.0787233	0.4072076
9	*Firm non-regulated "within-gen.-technology" efficiency relative to focal market competitors*	596	0.8965088	0.1693155	0	1
10	*Firm non-regulated "between-gen.-technology" efficiency relative to focal market competitors*	596	0.9738962	0.0705572	0.0396059	0.9998481
11	*Firm non-regulated gas heat rate*	596	9821.269	1968.126	7122.842	15074.57
12	*Downstream retail presence in the focal market log ratio*	596	0.3744235	0.7300207	0	5.600089
13	*Firm imputed non-regulated gas cost per MWh*	596	29.37659	27.70539	0.1579235	146.1755
14	*Firm windfall per MWh*	596	-2.624726	14.59458	-255.1728	30.8074
15	*Firm positive windfall per MWh*	596	1.22017	3.468313	0	30.8074
16	*Firm negative windfall per MWh*	596	-3.844896	13.84102	-255.1728	0
17	*Competitors' average windfalls per MWh*	596	-1.74695	3.479973	-12.71168	7.61892

Table 2 (continued): Variable Summary Statistics and Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1													
2	-0.174***	1												
3	0.000291	0.286***	1											
4	0.366***	-0.175***	-0.0821*	1										
5	0.115**	-0.182***	-0.680***	0.189***	1									
6	-0.122**	0.581***	0.113**	-0.0628	-0.0885*	1								
7	0.203***	0.0591	0.413***	0.303***	-0.516***	-0.0108	1							
8	0.132**	0.509***	-0.0128	0.0436	0.134**	0.399***	0.0204	1						
9	0.203***	0.00237	0.0199	0.117**	0.195***	0.00952	0.0175	-0.0254	1					
10	0.252***	0.0789	0.0635	0.100*	-0.0861*	0.0339	0.0566	0.0163	0.248***	1				
11	-0.261***	0.0162	-0.0337	-0.189***	-0.119**	0.0948*	0.0451	-0.0704	-0.179***	-0.107**	1			
12	-0.137***	-0.151***	0.0487	-0.0944*	-0.017	-0.109**	0.0303	-0.172***	-0.183***	-0.382***	0.0757	1		
13	-0.0857*	-0.160***	-0.534***	0.0332	0.726***	-0.0979*	-0.494***	-0.0322	0.116**	-0.0821*	0.139***	0.0713	1	
14	0.132**	0.0387	0.103*	0.067	-0.141***	-0.0168	0.107**	0.0169	0.0932*	0.200***	-0.0478	-0.0313	-0.0951*	1
15	0.0025	-0.0239	-0.172***	0.0515	0.273***	-0.0411	-0.166***	-0.00992	0.0658	-0.00663	0.151***	-0.0581	0.461***	0.330***
16	0.139***	0.0468	0.152***	0.0577	-0.216***	-0.00738	0.155***	0.0203	0.0818*	0.212***	-0.0881*	-0.0184	-0.216***	0.972***
17	0.182***	0.0606	-0.000945	0.203***	0.202***	0.0144	-0.0355	0.0934*	0.149***	0.0317	0.0285	-0.203***	0.233***	0.250***

	15	16
15	1	
16	0.0979*	1
17	0.333***	0.180***

* p < 0.05, ** p < 0.01, *** p < 0.001

Table 3: First-stage Probit Regression on Firms' Gas Hedging Decisions – Results

	(1)
Firm size	0.4209*
	(0.1707)
Debt over total assets	3.0428+
	(1.5874)
Market-to-book ratio	-0.3464
	(0.3219)
Cash and equivalents over total assets	7.9148
	(8.9440)
Overall downstream retail presence log ratio	-1.1620*
	(0.4609)
Gas revenues over total operating revenues	18.4303*
	(8.3058)
Constant	-0.7174
	(0.8199)
Number of observations	596
Number of firms	33
Year dummies	Yes
Log likelihood	-41.5815
Chi-Squared statistic	56.92
- *p-value*	0.0000
McFadden's pseudo R-squared	0.4063

Standard errors in parentheses

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Second-stage Linear Regressions on the Aggression of Firms' Competitive Conduct (Not Discriminating between Positive and Negative Firm Windfalls) – Results

		(1)	(2)	(3)
Share of focal market generation that is regulated		-1.7737	-1.5018	-1.7892
		(1.6234)	(1.6241)	(1.5933)
Share of a firm's generation in the focal market that is regulated		-0.1693	-0.1687	-0.2513*
		(0.1093)	(0.1093)	(0.1088)
Firm non-regulated gas-fired generation in the focal market		0.0000	0.0000	0.0000+
		(0.0000)	(0.0000)	(0.0000)
Share of a firm's generation in the focal market that is gas-fired and non-regulated		0.2131+	0.2273+	0.1351
		(0.1178)	(0.1191)	(0.1225)
Focal market capacity tightness		1.2749	1.0432	0.6781
		(1.0318)	(1.0336)	(1.1234)
Firm focal market share		4.1103***	4.2023***	2.7623*
		(0.8585)	(0.8576)	(1.1841)
Focal market HHI		-1.4529+	-1.4071+	-0.0031
		(0.8172)	(0.8151)	(0.8619)
Firm non-regulated "within-gen.-technology" efficiency relative to focal market competitors		0.2954+	0.2825+	0.2425
		(0.1535)	(0.1536)	(0.1519)
Firm non-regulated "between-gen.-technology" efficiency relative to focal market competitors		1.8970***	1.9811***	2.2974***
		(0.3555)	(0.3629)	(0.3623)
Firm non-regulated gas heat rate		-0.0001***	-0.0001***	-0.0001***
		(0.0000)	(0.0000)	(0.0000)
Downstream retail presence in the focal market log ratio		0.0665	0.0794+	0.2720***
		(0.0459)	(0.0464)	(0.0679)
Firm imputed non-regulated gas cost per MWh		-0.0039**	-0.0043**	-0.0084**
		(0.0014)	(0.0014)	(0.0029)
Firm windfall per MWh	H1:		0.0000	0.0043
	$\beta > 0$		(0.0017)	(0.0105)
Competitors' average windfalls per MWh			0.0165*	0.0186*
			(0.0081)	(0.0086)
Focal market capacity tightness X Firm imputed non-regulated gas cost per MWh				-0.0489
				(0.0385)
Focal market capacity tightness X Firm windfall per MWh				0.0402
				(0.0668)
Firm focal market share X Firm imputed non-regulated gas cost per MWh				-0.1008
				(0.0626)
Firm focal market share X Firm windfall per MWh				0.1344
				(0.2174)
Focal market HHI X Firm imputed non-regulated gas cost per MWh				-0.0621**
				(0.0190)
Focal market HHI X Firm windfall per MWh				-0.1443*
				(0.0648)
Downstream retail presence in the focal market log ratio X Firm imputed non-regulated gas cost per MWh				-0.0045***
				(0.0012)
Downstream retail presence in the focal market log ratio X Firm windfall per MWh				0.0066*
				(0.0026)
Constant		0.9685	0.7763	0.7360
		(1.5041)	(1.5014)	(1.4974)
Lambda		0.1861	0.1709	0.0922
		(0.1797)	(0.1795)	(0.1765)
Number of observations		596	596	596
Number of firms		33	33	33
Firm dummies		Yes	Yes	Yes
Market dummies		Yes	Yes	Yes
Chi-Squared statistic		822.7528	833.5671	926.0580
- p-value		0.0000	0.0000	0.0000

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Second-stage Linear Regressions on the Aggression of Firms' Competitive Conduct (Discriminating between Positive and Negative Firm Windfalls) – Results

		(1)	(2)	(3)
Share of focal market generation that is regulated		-1.7737 (1.6234)	-1.4641 (1.6230)	-1.8221 (1.5707)
Share of a firm's generation in the focal market that is regulated		-0.1693 (0.1093)	-0.1694 (0.1092)	-0.2713* (0.1076)
Firm non-regulated gas-fired generation in the focal market		0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Share of a firm's generation in the focal market that is gas-fired and non-regulated		0.2131^{+} (0.1178)	0.2318^{+} (0.1191)	0.1651 (0.1217)
Focal market capacity tightness		1.2749 (1.0318)	1.0138 (1.0332)	0.3134 (1.1262)
Firm focal market share		4.1103*** (0.8585)	4.2264*** (0.8572)	2.7971* (1.1692)
Focal market HHI		-1.4529^{+} (0.8172)	-1.3889^{+} (0.8144)	0.1629 (0.8521)
Firm non-regulated "within-gen.-technology" efficiency relative to focal market competitors		0.2954^{+} (0.1535)	0.2808^{+} (0.1534)	0.2244 (0.1507)
Firm non-regulated "between-gen.-technology" efficiency relative to focal market competitors		1.8970*** (0.3555)	2.0195*** (0.3645)	2.3814*** (0.3594)
Firm non-regulated gas heat rate		-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)
Downstream retail presence in the focal market log ratio		0.0665 (0.0459)	0.0823^{+} (0.0465)	0.3232*** (0.0687)
Firm imputed non-regulated gas cost per MWh		-0.0039** (0.0014)	-0.0048** (0.0015)	-0.0132*** (0.0038)
Firm positive windfall per MWh	H2: $\beta > 0$		0.0078 (0.0077)	0.0563* (0.0275)
Firm negative windfall per MWh	H2: $\beta = 0$		-0.0007 (0.0018)	-0.0091 (0.0146)
Competitors' average windfalls per MWh	H3: $\beta < 0$		0.0161* (0.0081)	0.0217* (0.0086)
Focal market capacity tightness X Firm imputed non-regulated gas cost per MWh				-0.1022* (0.0417)
Focal market capacity tightness X Firm positive windfall per MWh	H4: $\beta > 0$			0.6347* (0.2645)
Focal market capacity tightness X Firm negative windfall per MWh				-0.0261 (0.0802)
Firm focal market share X Firm imputed non-regulated gas cost per MWh				-0.1735* (0.0814)
Firm focal market share X Firm positive windfall per MWh	H5: $\beta < 0$			0.8973 (0.5921)
Firm focal market share X Firm negative windfall per MWh				-0.0926 (0.3060)
Focal market HHI X Firm imputed non-regulated gas cost per MWh				-0.0514* (0.0206)
Focal market HHI X Firm positive windfall per MWh	H6: $\beta < 0$			-0.2905 (0.2578)
Focal market HHI X Firm negative windfall per MWh				-0.0965 (0.0766)
Downstream retail presence in the focal market log ratio X Firm imputed non-regulated gas cost per MWh				-0.0070*** (0.0014)
Downstream retail presence in the focal market log ratio X Firm positive windfall per MWh	H7: $\beta > 0$			0.0397*** (0.0113)
Downstream retail presence in the focal market log ratio X Firm negative windfall per MWh				0.0021 (0.0031)
Constant		0.9685 (1.5041)	0.7518 (1.5002)	0.9296 (1.4773)
Lambda		0.1861	0.1772	0.0912

	(0.1797)	(0.1793)	(0.1739)
Number of observations	596	596	596
Number of firms	33	33	33
Firm dummies	Yes	Yes	Yes
Market dummies	Yes	Yes	Yes
Chi-Squared statistic	822.7528	836.0407	974.7155
- *p-value*	0.0000	0.0000	0.0000

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1: Interaction Effects of Positive Windfalls and Focal Market Capacity Tightness

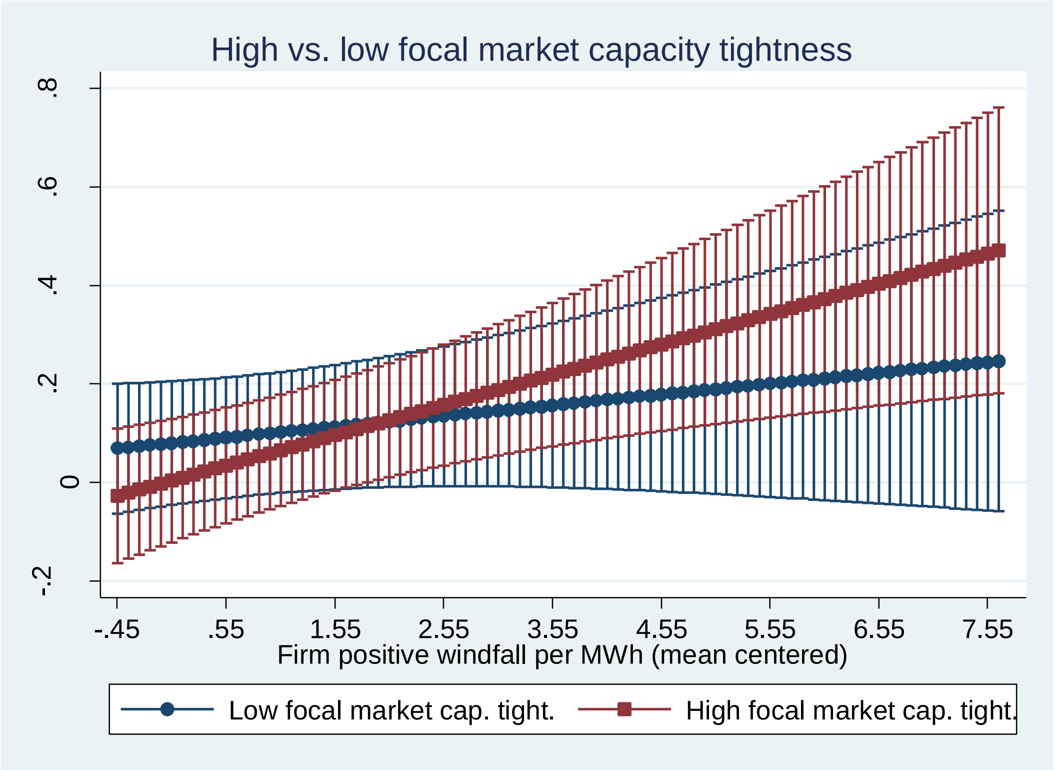


Figure 2: Interaction Effects of Positive Windfalls and Firm Focal Market Share

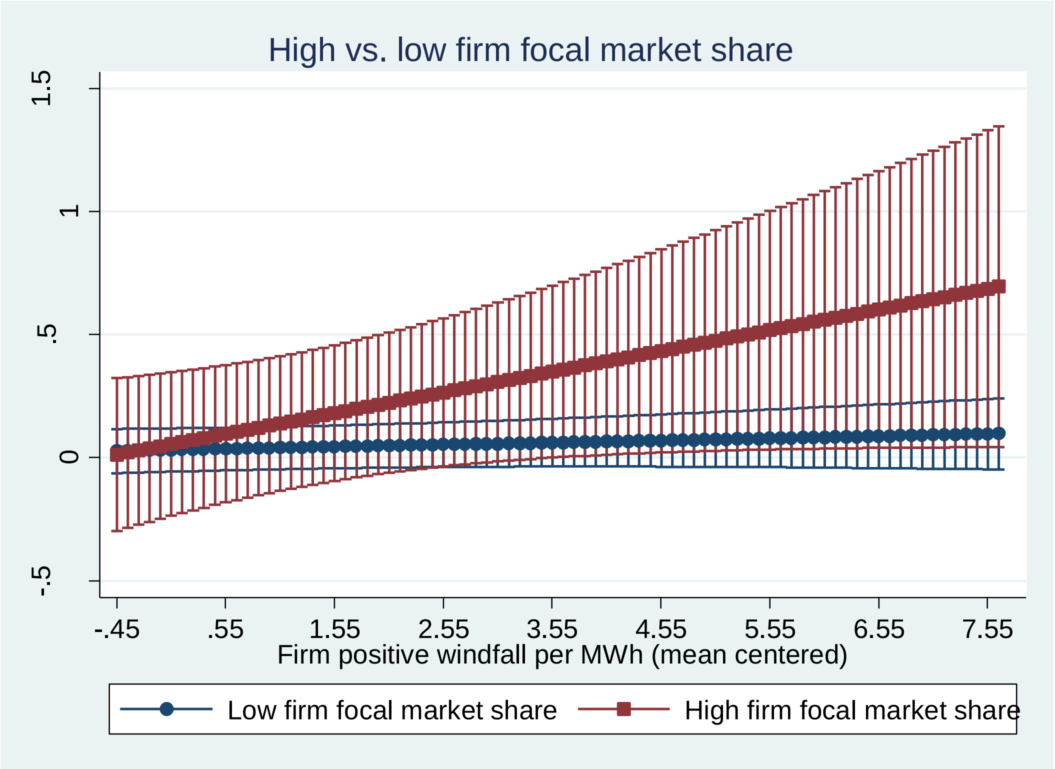


Figure 3: Interaction Effects of Positive Windfalls and Focal Market HHI

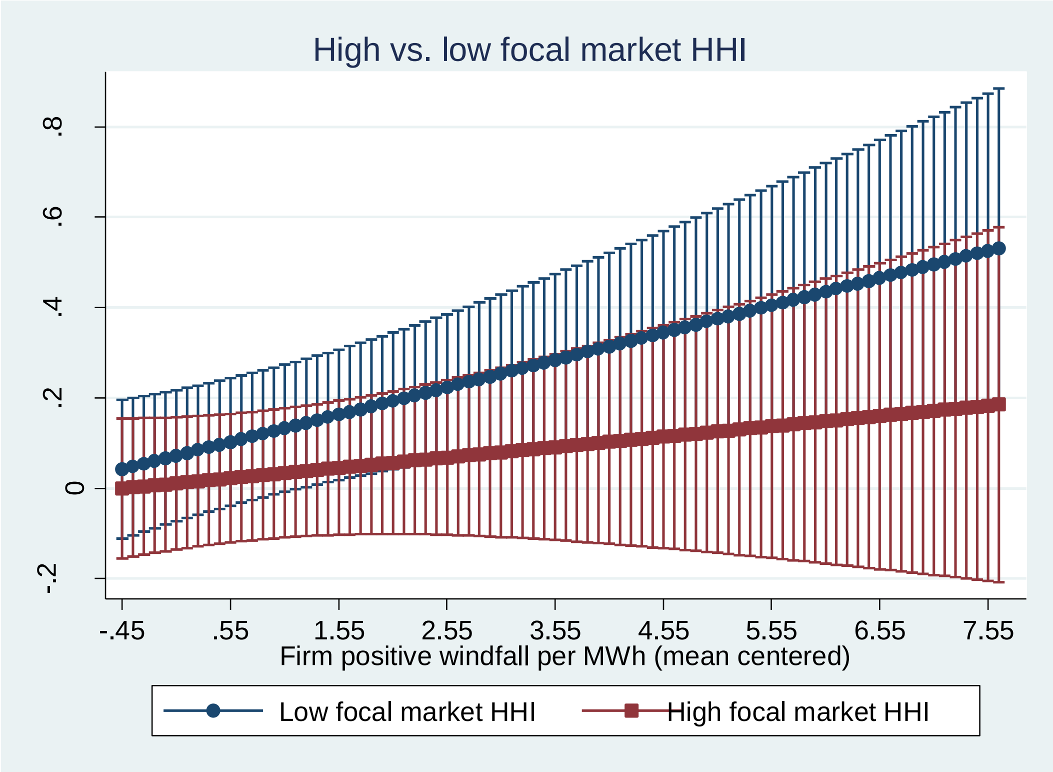


Figure 4: Interaction Effects of Positive Windfalls and Downstream Retail Presence in the Focal Market Log Ratio