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Abstract

This paper presents a game-theoretic analysis of multimarket competition with strategic capacity investments, motivated by recent developments in international natural gas markets. It studies the competitive implications of heterogeneity in firm structure arising from asset specificity. A single-market focus confers advantage even in the absence of superior value or cost. Lower costs and a sharper organizational focus are self-enforcing in generating competitive advantage. This establishes a novel connection between two of Porter's "generic strategies". The model speaks to competition between pipeline gas and liquefied natural gas (LNG) and the global impacts of the Fukushima nuclear accident.

Keywords: Competitive advantage, strategic commitment, generic strategies, cost pass-through, value capture.

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1 Introduction

A long tradition in industrial-organization economics examines the impact of strategic commitment on market outcomes. In the classic Stackelberg model, for example, the underlying mechanism comes as a first-mover advantage. This paper shows how a similar commitment can be achieved via a form of "asset specificity" (Williamson, 1985) that binds an individual seller, but not all of its rivals, to a particular market. It draws out the implications for core themes in strategy: the intensity of rivalry between firms, different routes to achieve competitive advantage and their interaction, as well as the degree of value capture across different markets. In developing these results, the paper highlights a connection—which appears under-appreciated in existing research—between the literature on the sources and consequences of asset specificity and that on competition with strategic commitment.

The analysis is motivated by recent developments in international natural gas. This industry features two types of sellers: on one hand, traditional sellers of gas that is transported by pipeline, such as Russia and Norway; on the other hand, exporters of seaborne liquefied natural gas (LNG), such as Qatar, Australia and Nigeria. Following the expansion of international trade over the 10 years, pipeline gas and LNG now increasingly compete head-to-head, notably in the European market. But they are also fundamentally different. Gas pipelines are large investments with a very high degree of asset specificity: once built, they are physically bound to a particular route, with no alternative use (Makholm, 2012). LNG, by contrast, is transported by tanker, which gives exporters a *choice* of markets for any given cargo. Put simply: LNG is mobile, pipelines are not. The Fukushima Daiichi accident of March 2011, probably the largest single event in energy markets over the last decade, highlighted the ability of flexible LNG supplies to "fill the gap" in Japan's energy mix after its nuclear shutdown. This paper analyzes how such a difference in organizational structures affects the competitive playing field between firms.

The global gas market lends itself to such an analysis for several reasons. First, there is little doubt that the interaction between the major players is of a highly strategic nature. There is significant sell-side concentration in natural gas, and its regional fragmentation—into US, European and Asian markets, with widely varying prices—is, at least in part, driven by imperfect competition (Ritz, 2014). Gas infrastructure investments are observed by market participants and largely irreversible; this gives them substantial commitment value (Ghemawat, 1991). In this way, these markets are well-suited to the toolkit of game theory.

Second, the significant commercial and public-policy interest in natural gas mean that understanding the industry has some merit in its own right. The shale gas "revolution" has had large impacts on the US economy and across energy markets; the US itself looks set to become a significant LNG player over the coming years, with Cheniere Energy's US$5 billion export facility at Sabine Pass due to come online in early 2016. Russia and China agreed the biggest-ever deal in the history of natural gas in May 2014, worth US$400 billion over 30 years, to construct a pipeline connection from Siberia to China. Many policy analysts and energy companies also see an important role for natural gas in the transition to a low-carbon economy.[1]

[1] The natural gas industry is also under-researched in the academic literature. While economists have been

Section 2 provides a detailed overview of global gas markets.

Section 3 presents a stylized model with two firms and two markets, A and B. A multimarket firm sells to both markets while the other firm, due to the specificity of its production technology, serves only market B. The model is a two-stage game of capacity investments followed by quantity competition (with simultaneous choices). A key feature is that the multimarket firm chooses how to deploy its capacity across the two markets in the second stage. This creates a supply-side link and yields an analysis of how local "shocks" spill over from one market into another. Section 4 solves for the equilibrium.

There are two main sets of results. First, asset specificity confers a strategic advantage on the single-market firm in the common market B (Section 5). Why? The multimarket firm's optimal strategy in stage 2 equalizes marginal revenues across its two markets. Recognizing this, the "focused" firm strategically overinvests in capacity (and achieves higher market share) in their common market, thus depressing the local price, knowing that its rival can employ its capacity elsewhere. The magnitude of this *strategic effect* also depends on the multimarket player's ability to capture value in its other market A.

Different strands of the strategy literature think of a firm's competitive advantage as derived from its lower cost and/or higher value to buyers (e.g., Porter, 1985; Petaraf, 1993; Brandenburger and Stuart, 1996). Yet a focused firm can here enjoy a competitive advantage purely due to heterogeneity in organizational structures, that is, without superior costs or value. Moreover, a single-market focus and a cost advantage are complementary: its competitive advantage is *supermodular* in its cost advantage and the strategic effect.[2] So a focused firm's competitive advantage arising from superior costs is greater in the presence of the multimarket effect than without. That is, the asset specificity of its investment helps this firm *exploit* a cost advantage.

These results speak to two of Porter's (1980) three generic strategies: "cost leadership" and "focus". In the model, both of these individually generate competitive advantage. Yet their interaction differs from Porter's mechanism: "The strategy rests on the premise that the firm is thus able to serve its narrow strategic target more ... efficiently than competitors ... as a result the firm achieves lower costs" (p. 38). By contrast, a focused strategy here allows for a *given* cost advantage to be better exploited—without itself leading to any (further) cost reduction.

The second set of results is motivated by the Fukushima accident: how does a demand boom in market A (Asia) affect market B (Europe)? Section 6 examines both short-term impacts—when firms' capacity levels are fixed—and longer-term effects—when firms can re-optimize capacity levels in light of changes in market conditions. Long-term impacts are driven by changes in the magnitude of the strategic effect that links the two markets. If the multimarket firm already has strong pricing power in market A, and the local demand boom enhances its ability to capture value, then this mitigates its strategic weakness due to multimarket exposure.

influential in the analysis and design of liberalized electricity markets, and there is a substantial literature on the influence of OPEC on market performance in crude oil, there is much less on natural gas—and especially little speaking to recent events. This paper attempts to fill some of these gaps.

[2] The basic definition is that a function g is supermodular if $g(\inf(x,y)) + g(\sup(x,y)) \geq g(x) + g(y)$ for all x, y. This paper works with a differentiable case, for which (strict) supermodularity boils down to a positive cross-partial derivative, i.e., $g_{xy} > 0$.

Thus a demand boom in market A has the knock-on effect of making it a stronger competitor in market B. By contrast, in the short run, raising sales to market A for the multimarket firm means cutting those to market B, so its position there declines. A general point is that outcomes in market B cannot be fully understood without considering market A.

This paper analyses "value capture" in market A in terms of the rate of *pass-through* from marginal cost to price. High value capture is formally equivalent to a *low* pass-through rate; intuitively, the firm then has substantial pricing power because the market price tracks buyers' willingness-to-pay more than it resembles costs. Pass-through provides a useful way to think about competitive interactions and the division of gains from trade in a way that has not been recognized in the strategy literature. Perhaps closest are Besanko, Dranove and Shanley (2001) who estimate the elasticity of pass-through (i.e., $\%\Delta P/\%\Delta MC$ rather than $\Delta P/\Delta MC$) and relate this to product differentiation, capacity utilization, and a firm's relative cost position.

The stylized model captures key elements of international trade in natural gas markets. The single-market firm is Russia which exports pipeline gas solely to the European market, and the multimarket firm is Qatar, the world's largest LNG exporter, which serves both European and Asian buyers.[3] Section 7 applies the results: the strategic advantage of pipeline gas over multimarket LNG; implications for energy-policy discussions around "security of supply"; and the wider impacts of the Fukushima accident. The paper argues that the above conditions for long-term impacts are likely satisfied in global gas, with Fukushima inducing new LNG investment projects and over time making LNG a stronger competitor to Gazprom in Europe.

Section 8 presents conclusions. Proofs are in the Appendix.

Further applications of the results. The combination of multimarket contact and strategic investment can run counter to a fundamental result from the theory of imperfect competition. In standard models (such as Cournot, Bertrand, Hotelling, etc.), a more efficient firm always has higher market share and profits. Yet a focused firm can here be more profitable than a multimarket rival despite *much* higher costs. Differences in firm structure can dominate those due to cost efficiency. In contrast to the "mutual forbearance" view and the classic repeated-game analysis of Bernheim and Whinston (1990), multimarket contact here tends to *raise* market competitiveness—rather than facilitating tacit collusion.

While this paper emphasizes investments in physical capacity, a similar role can be taken on by other strategic choices preceding product-market interaction that (i) determine a firm's subsequent scale of operation and (ii) can be deployed across markets (to varying degrees). This includes the volume of loan commitments a firm obtains from its banks or the hiring of employees. For example, large management consultancies like BCG or McKinsey operate across a range of geographic, industry, and functional practices. They frequently deploy individual consultants on projects outside their home country and/or to different client sectors. That is, they to some degree treat their consulting "capacity" as "global". By contrast, boutique competitors often only serve a particular sector in their domestic market, with human-capital investments that are

[3] This paper follows the gas-market literature in treating countries as players; there is often a close association with a company, e.g., Russia (Gazprom), Norway (Statoil), Algeria (Sonatrach), Qatar (Qatargas).

specific to this business area.

The results have a similar flavour to the corporate-finance literature on the "diversification discount" applied to conglomerate firms by stock-market investors (Lang and Stulz, 1994; Campa and Kedia, 2002; Kuppuswamy and Villalonga, 2015). One leading explanation for the discount is that multi-business firms are susceptible to wasteful rent-seeking by individual divisions who try to gain additional funding from corporate HQ—which chooses how to allocate funds across divisions (Meyer, Milgrom and Roberts, 1992). Similarly, the disadvantage of diversified firms here arises because "headquarters" chooses how to allocate production capacity across markets—which can be influenced by rivals' competitive moves. The results here also suggest that the discount may vary with the business cycle, and be larger during periods of market decline.

Another industry application is to airline markets. Consider the case of Frontier Airlines in the 1980s, as described by Bulow, Geneakoplos and Klemperer (1985). Frontier had diversified into new markets away from its original Denver hub. Following this, other airlines began to compete more aggressively in the Denver market. The present analysis offers an explanation: diversification gave Frontier a choice of where to deploy its airline fleet, allowing its competitors to expand by gaining a Stackelberg-type position at Denver. (This holds unless Frontier was able to appropriate *all* value in new markets, which is unlikely.) More generally, the model gives a reason for why focused new entrants, especially low-cost carriers (LCCs) such as Southwest Airlines, enjoyed a strategic advantage over large incumbent airlines (e.g, Porter, 1996).

Other related literature. This paper relates to multiple strands of literature, spanning business strategy, industrial organization, and energy economics. The pass-through perspective on value capture is distinct from prominent value-based models in the strategy literature beginning with Brandenburger and Stuart (1996) and recently reviewed by Gans and Ryall (2015). These employ coalitional games, usually solved for a small number of buyers and sellers, to study how value creation and appropriation vary with industry primitives. Chatain and Zemsky (2011) introduce "frictions" into a value-based model which lead to some suppliers being linked to more buyers than rivals, that is, heterogeneity in firm structure—albeit of a different kind to the present paper.

This paper also relates to the earlier resource-based theory (Wernerfelt, 1984; Petaraf, 1993) on the sources of sustainable competitive advantage: in the application to gas, for example, the geographic location, physical properties and resulting cost structure of individual players' natural resource endowments are necessarily unique and as such not imitable by others.

A large economics literature related to asset specificity mostly focuses on vertical relations and the "make or buy" decision but says little about competition *between* firms (Williamson, 1985; Bresnahan and Levin, 2012). A large game-theoretic literature on strategic commitment, beginning with Spence (1977) and Dixit (1980) on investment and entry deterrence, is well-reviewed by Vives (2000); the classic reference in the strategy literature is Ghemawat (1991). This paper is in line with Bresnahan and Levin's call for more research on the interface between industrial organization and organizational economics. Its main focus on large infrastructure investments in the gas industry means that concerns about the "fragility of commitment" (Morgan and Várdy, 2013) are probably less pronounced than in other applications.

A smaller number of papers emphasizes supply-side links between otherwise distinct markets; the classic reference is Bulow, Geneakoplos and Klemperer (1985). In another early paper, Cooper (1989) uses a price-setting model of spatial competition to show how a "straddling" firm which sells to two markets can intensify competition in both. The model presented here builds on and extends parts of Shelegia (2012), who emphasizes how competition between two firms in a given market can be influenced by a third firm competing in another market. Compared to the present paper, key differences are that (i) firms here are heterogeneous in terms of production as well as investment costs (e.g., piped gas vs LNG), and (ii) demand conditions are allowed to vary across markets (e.g., Asia vs Europe). Both of these features are crucial to the application to global gas markets, in terms of being able to (i) adequately represent the different production technologies and (ii) analyze the competitive implications of a regional demand shock.[4]

The present paper joins a small but growing literature addressing particular aspects of competition in gas markets. Ritz (2014) shows that regional gas price differentials are inconsistent with models of perfect competition but can be rationalized by incorporating the market power of large LNG exporters such as Qatar. Hawk, Pacheco-de-Almeida and Yeung (2013) examine entry strategies into the then-emerging LNG market over the period from 1996 to 2007. They also emphasize the commitment role of LNG investments, and find that firms with superior speed capabilities can afford later entry dates. Growitsch, Hecking and Panke (2014) simulate a large global gas model to explore the impact of a hypothetical blockage of LNG tankers in the Strait of Hormuz. Their analysis also incorporates supply-side concentration and the regional transmission of shocks. Taking a different approach, based on cooperative game theory, Hubert and Ikonnikova (2011) analyze the power structure in the Russian pipeline network, focusing on the balance between Russia and transit countries such as Belarus and Ukraine, while Ikonnikova and Zwart (2014) examine the potential role of trade quotas in enhancing countervailing power in EU natural gas markets. Their approach has the advantage—akin to that of value-based strategy theory—of incorporating the bargaining power of both (large) sellers and buyers.

Finally, this paper takes a different approach to the bulk of the existing literature on natural gas markets, which is dominated by a small number of large-scale numerical models (which mostly also have Cournot-style setups). A representative but non-exhaustive list includes Egging, Gabriel, Holz and Zhuang (2008), Holz, von Hirschhausen and Kemfert (2008), and Chyong and Hobbs (2014). These are well-suited to policy analysis via numerical simulation of scenarios in terms of gas demand, investment volumes, etc. However, their complexity means that it can be difficult to understand what is driving the numbers. This paper instead emphasizes the microeconomic intuition and strategic interaction between key producers.[5]

[4] In examining how local shocks spill over to other markets, this paper relates to a growing literature on "networked" markets. There has recently been a renewed interest in how production networks lead to the propagation of shocks around a system (Bimpikis, Ehsaniy and Ilkiliç, 2014; Carvalho, 2014). An oft-cited example is the Fukushima accident, with its repercussions for global supply chains in automotives and electronics, amongst others. While the modelling approaches are different, the underlying economic issues are closely related to those considered here. See also Elliott (2014) for a related network model which focuses on relationship-specific investments between trading partners.

[5] A disadvantage of the present approach is that it yields only comparative-statics results—rather than realistic-

2 Competition and international trade in natural gas markets

This section gives further background on salient features of international competition in natural gas markets, in particular: (1) the presence of distinct regional markets—Asia, Europe and the US—with large inter-regional price differentials, (2) the co-existence of two different production technologies—pipeline gas and LNG—which compete head-to-head especially in the European market, and (3) significant market concentration amongst gas sellers, lead by Russia (pipeline gas) and Qatar (LNG) as the two largest producers.

Production technologies. There are two technologies for the transport and sale of natural gas: international trade is around 70% by pipeline and 30% as LNG.[6] For piped gas, exploration, development and production are followed by pipeline transportation, which usually but not always takes place onshore. LNG involves the liquefaction of natural gas at very low temperature in preparation for shipping on dedicated LNG tankers before regasification at the receiving import terminal. All parts of this chain require capital investment in the millions or even billions of dollars, and ongoing maintenance expenditure also plays an important role. Nonetheless, both technologies ultimately lead to a homogeneous product with identical end-uses on the buyer side, for example, in industrial production and residential heating.

From a cost perspective, pipeline connections to end-consumer markets are preferable for short-to-medium medium distances while LNG is more economical for longer distances (Jensen, 2004). Thus, for a given consumer market served by both producer types, the LNG imports tend to come from further away—with higher transportation costs. Yet connecting to this market by pipeline was too costly or technologically infeasible for the LNG seller(s); due to its geographic location, it cannot "imitate" the pipeline setup. Crudely put, it makes no sense to build a gas pipeline from the US to Spain.

Regional markets. Global gas trade takes place in regionally fragmented markets. As shown in Figure 1, average gas/LNG prices in 2013 were around US$17 per million metric British thermal units in Asia (Japan and South Korea), US$11/MMBtu in Europe (UK and Germany), and US$4 in the US (at Henry Hub, the leading US gas trading hub located in Louisiana). Significant price differentials—apparent departures from the "law of one price"—have persisted for many years. Over 1992 to 2014, the average "Asian premium" over European gas prices was over 36%; it was negative for a relatively short period in 2008/9, then rising again following the Fuskuhima accident of March 2011.[7]

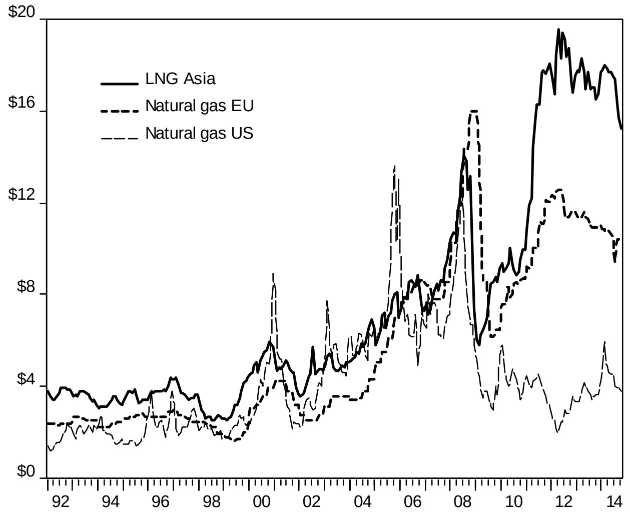
The US is now the world's largest gas producer but is disconnected from international trade—apart from pipeline trade with Canada—given its well-publicized current lack of LNG export

looking numbers of the global gas market as a whole. Another difference is that existing large-scale models are typically "mixed complementarity problems" solved as "open loop" equilibria, in which capacity and production decisions are, in effect, made simultaneously; the analysis here instead derives a "closed loop" equilibrium in which firms' capacity decisions have a strategic impact on subsequent play.

[6] The trade data described in this section are from BP (2014).

[7] Li, Joyeux and Ripple (2014) also find that the world gas market is not integrated but do find integration between European and Asian markets; part of the reason is likely that their dataset ends in May 2011 and therefore contains almost no after-effects of Fukushima.

Figure 1: Global gas prices over 1992 to 2014 in US$/MMBtu (Source: IMF)



infrastructure (Joskow, 2013). As a result, the shale gas boom has reduced domestic US natural gas prices, with significant distributional impacts, but not those in higher-price overseas markets (Hausman and Kellogg, 2015).

Industry structure. There is significant market concentration amongst international gas producers, with Russia and Qatar as the two major players together accounting for 35% of international trade (outside North America). Russia is the world's 2$^{\text{nd}}$ largest producer of gas and its largest exporter, with Gazprom controlling around 75% of production and holding a legal monopoly over exports of piped gas. Of its pipeline exports, over 80% go to European markets while the remainder goes to countries of the former Soviet Union, some of which also perform a transit role. Russia's share of international pipeline trade (outside North America) is around 35%; other large pipeline producers are Norway (17%), the Netherlands (8%), and Algeria (4%)—which all also serve the European market.[8]

On the LNG side, Qatar is the world's largest exporter with a global LNG market share of almost 35%. Its largest LNG destinations are *both* "mid-price" Europe (especially UK and Italy) and "high-price" Asia (especially Japan and South Korea), with a split of around 25% and 75%. The next largest LNG exporters are Nigeria, Australia, Indonesia, Malaysia, and Trinidad & Tobago which all have market shares in the range of 6% to 11%. In addition to Qatar, *multimarket* LNG exporters—serving both Europe and Asia—include Nigeria, Trinidad & Tobago, and Peru.

From the European viewpoint, around 80% of total gas imports are by pipeline and 20% as LNG. Around 40% of Europe's total gas consumption is met via Russian pipelines, and the majority of imports come from Russia. This import dependency on Russia has been the source of

[8] Russia also has a small presence in LNG at less than 5% of its total gas sales. But this LNG is based out of different gas fields than its pipeline sales to Europe, so in effect represents a different actor to the main one considered in this paper. Incorporating this in the model would not alter any of the insights presented in what follows; see Section 5 for related discussion.

political and economic concerns about "security of supply". LNG plays a particularly important role for the UK, Italy, and Spain (for which LNG imports can exceed pipeline trade), and close to 50% of European LNG imports come from Qatar.

By contrast, many Asian countries rely heavily on LNG imports given their lack of domestic resources and pipeline infrastructure (with the main exception of China); LNG makes up 100% of Japanese and South Korean gas imports, and Japan is the world's largest LNG importer, with Qatar as its top supplier.

Price drivers. What are the drivers of the international price differences, notably between Asia and Europe? There are several potential reasons, only one of which is well-supported by the data. First, differences in transport costs across export markets can rationalize different prices—even under perfect competition. The problem is that price differentials in many cases have *far* exceeded any such cost differences; Qatari LNG's transport costs to Asia and Europe are very similar because the shipping distances are similar. In some cases, routes with higher transport costs have *lower* prices (Ritz, 2014).

Second, binding capacity constraints at LNG *import* terminals, which result in import demand exceeding capacity, could make the local gas price rise above marginal cost. If the strength of this effect varies across markets, then it could rationalize price differences. The problem is that the import capacity utilization rate has been stable at only around 40% *globally* since 2000; even in *post*-Fukushima Japan, regasification terminal utilization only rose to 49%, and there are almost no countries in which these constraints are even close to binding (IGU, 2013).

Third, price differences could be the result of third-degree price discrimination by LNG exporters, which exploits differences in price elasticities of demand across regions. Demand is likely less elastic in Asia than in Europe because of more limited substitution possibilities (e.g., to pipeline gas). This was likely exacerbated by the Fukushima accident, which led to a sharp rise in Japan's willingness-to-pay for gas. Ritz (2014) shows that exporter market power can rationalize observed prices and trade patterns, combined with limited access to the LNG tanker market which makes it difficult for third-party traders to (fully) arbitrage prices.

In short, competition in global gas markets is far from perfect. The model laid out in the following section captures these key features; the application of the modelling results to global gas is presented in Section 7.

3 Setup of the model

Firm 1 sells to both markets, A and B, with outputs denoted by x_1, y_1. Firm 2 can sell only into market B, with sales of y_2.

On the demand side, market B features homogeneous products via an linear inverse demand $p^B(y_1, y_2) = \alpha - \beta(y_1 + y_2)$ with parameters $\alpha, \beta > 0$. Market A has a general demand curve $p^A(x_1)$; let $\xi^A \equiv -x_1 p^A_{xx}/p^A_x$ denote a coefficient of its curvature. (So demand in market A is concave if $\xi^A < 0 \iff p^A_{xx} < 0$, and convex otherwise.) Direct demand is assumed to be *log-concave*, $\xi^A < 1$ (Bagnoli and Bergstrom, 2005). This is a common assumption in models of imperfect competition which ensures that second-order conditions are satisfied. Competition between firms is therefore in *strategic substitutes* (Bulow, Geneakoplos and Klemperer, 1985).

The game has two stages. In the first stage, firms simultaneously invest in production capacities, K_1 and K_2, respectively at unit costs of capacity $r_1 > 0$ and $r_2 > 0$. Note that firm 1 can deploy its capacity in both markets, while firm 2's investment is specific to market B. In the second stage, firms simultaneously decide how much output to sell into markets A and B, at unit costs of production $c_1 \geq 0$ and $c_2 \geq 0$, subject to their installed production capacities. These unit costs of production are interpreted as including transportation costs. Choices are observable to players, and there is no discounting.

Firms maximize their respective profits and the equilibrium concept is subgame-perfect Nash equilibrium. Assume throughout that demand and cost conditions are such that both firms are active in equilibrium, selling positive amounts to their respective markets; standing assumptions are $\alpha > r_j + c_j$ for $j = 1, 2$, $c_j < \frac{1}{2}(\alpha + c_i)$ for $j \neq i$, $p^A(0) > r_1 + c_1$ and $p^A(x_1) < 0$ at sufficiently high x_1. Also assume that both producers sell up to capacity in Stage 2.[9] Conditions on parameter values which ensure these assumptions are met in equilibrium are given in Lemma 1.

4 Solving the model

Define firms' revenue functions across the two markets, $R_1^A(x_1) = p^A x_1$ and $R_1^B(y_1, y_2) = p^B y_1$, $R_2^B(y_1, y_2) = p^B y_2$. Also define the corresponding marginal revenues $MR_1^A(x_1) = \frac{\partial}{\partial x_1}\left(p^A x_1\right) = p^A + p_x^A x_1$ and $MR_1^B(y_1, y_2) = \frac{\partial}{\partial y_1}\left(p^B y_1\right) = p^B - \beta y_1$, $MR_2^B(y_1, y_2) = \frac{\partial}{\partial y_2}\left(p^B y_2\right) = p^B - \beta y_2$.

4.1 Stage 2: Output decisions

Consider firms' output choices in Stage 2, given the capacity investments of Stage 1. By assumption, producers are capacity-constrained, implying that firm 1's sales satisfy $x_1 + y_1 = K_1$, while $y_2 = K_2$ for firm 2. The main question at this stage, therefore, is how firm 1 splits its sales across markets.

Clearly, firm 1 maximizes its profits by equating the contribution at the margin of each market. That is, it chooses a sales strategy (x_1, y_1) that equalizes marginal revenue, net of the short-run marginal cost of production, for each market: $MR_1^A(x_1) - c_1 = MR_1^B(y_1, y_2) - c_1 \Longleftrightarrow MR_1^A(x_1) = MR_1^B(y_1, y_2)$. Since the firms are capacity-constrained, the equilibrium condition can be rewritten in terms of capacities:

$$MR_1^A(K_1 - y_1) = MR_1^B(y_1, K_2). \tag{1}$$

Firm 1's choice of output to market B thus depends on the capacity installed by its rival, firm 2. This plays a crucial role, and is examined more closely, in what follows. By contrast, for firm 2, $y_2 = K_2$, irrespective of firm 1's actions. The key difference is that, having sunk their

[9] The assumption that producers are capacity-constrained simplifies the analysis considerably. In effect, it reduces the "dimensionality" of the problem from five choice variables (two capacity choices plus three output choices) to three.

investments, firm 1 has an alternative use for its capacity while firm 2 does not.

To summarize, given capacities $\mathbf{K} = (K_1, K_2)$, firms' output choices are $x_1(\mathbf{K})$, $y_1(\mathbf{K})$, and $y_2(\mathbf{K}) = K_2$.

4.2 Stage 1: Capacity decisions

Anticipating these output decisions, consider firms' decisions to invest in capacity at Stage 1. Firm 1 chooses its investment to maximize its joint profits from both markets:

$$\max_{K_1} \left\{ R_1^A(x_1(\mathbf{K})) + R_1^B(y_1(\mathbf{K}), y_2(\mathbf{K})) - r_1 K_1 - c_1[x_1(\mathbf{K}) + y_1(\mathbf{K}) \right\},$$

which makes explicit the indirect dependency of its revenues and production costs on both firms' capacity choices. The first-order condition is:

$$0 = MR_1^A \frac{\partial x_1}{\partial K_1} + MR_1^B \frac{\partial y_1}{\partial K_1} - r_1 - c_1 \left(\frac{\partial x_1}{\partial K_1} + \frac{\partial y_1}{\partial K_1} \right). \tag{2}$$

This condition can be simplified. First, since the firm is capacity-constrained, $\partial x_1/\partial K_1 + \partial y_1/\partial K_1 = 1$; in other words, total sales across both markets rise one-for-one with capacity. Second, from (1), the firm equates marginal revenue across markets, $MR_1^A = MR_1^B$. So the multi-market firm invests in capacity such that

$$MR_1^A = MR_1^B = r_1 + c_1, \tag{3}$$

where the right-hand side is its combined unit cost of capacity and production, i.e., its long-run marginal cost. Thus the outcome in market A is the monopoly price given marginal cost $r_1 + c_1$. Denoting the associated monopoly output by x_m, it follows that $x_1 = x_m$, and so $y_1 = K_1 - x_m$.

Firm 2 chooses its capacity investment to:

$$\max_{K_2} \left\{ R_2^B(y_1(\mathbf{K}), y_2(\mathbf{K})) - r_2 K_2 - c_2 y_2(\mathbf{K}) \right\}$$

The first-order condition is:

$$0 = MR_2^B \frac{\partial y_2}{\partial K_2} + \frac{\partial R_2^B}{\partial y_1} \frac{\partial y_1}{\partial K_2} - r_2 - c_2 \frac{\partial y_2}{\partial K_2}. \tag{4}$$

Analogously to the previous firm, $\partial y_2/\partial K_2 = 1$, due to the binding capacity constraint. Note also $\partial R_2^B/\partial y_1 = -\beta y_2$ given the linear demand structure of market B. Define the *strategic effect* connecting markets $\lambda \equiv (-\partial y_1/\partial K_2)$. Thus simplifying the first-order condition gives:

$$MR_2^B + \beta \lambda y_2 = r_2 + c_2. \tag{5}$$

Firm 2 recognizes that its capacity choice affects the product-market behaviour of firm 1 in their common market B. Totally differentiating the equal-marginal-revenues condition from (1) shows that the strategic effect satisfies:

$$\lambda \equiv \left(-\frac{\partial y_1}{\partial K_2}\right) = \frac{\frac{\partial MR_1^A}{\partial K_2} - \frac{\partial MR_1^B}{\partial K_2}}{\frac{\partial MR_1^A}{\partial y_1} - \frac{\partial MR_1^B}{\partial y_1}} = \left[\frac{\beta}{2\beta + (-p_x^A)\left(2-\xi^A\right)}\right] \in (0, \tfrac{1}{2}). \tag{6}$$

Observe that $\left(-p_x^A\right)\left(2-\xi^A\right)$ is the absolute value of the slope of the marginal revenue curve of firm 1 in market A, $\left|\frac{\partial}{\partial x_1} MR_1^A\right|$.[10] The strategic effect captures how strongly firm 2 can induce firm 1 to cut back output in market B; this raises the marginal return to firm 2 of installing an additional unit of capacity and so, in equilibrium, $MR_2^B < r_2 + c_2$.

4.3 Summary of the equilibrium

Firm 1's output in market A is at the monopoly level, $x_1 = x_m$. By assumption firm 2 sells up to capacity, $y_2 = K_2$, and firm 1 uses all of its capacity across markets, $K_1 = x_m + y_1$. So only two unknowns are left: y_1 and K_2.

The following result gives the equilibrium values $(\widehat{\mathbf{K}}, \widehat{x}_1, \widehat{y}_1, \widehat{y}_2)$, together with a parameter condition which ensures that the equilibrium, (i) is an interior solution with strictly positive outputs to each market, and (ii) it is *optimal* for each firm to produce up to installed capacity.

Lemma 1. *Suppose the following condition on parameter values holds:*

$$(r_1 + c_1) \in \left(\left[2\left(r_2 + c_2\right) - \alpha\right], \min\left\{\tfrac{1}{3}\left[\alpha + 2\left(r_2 + c_2\right)\right], \left[2\left(3r_2 + c_2\right) - \alpha\right]\right\}\right).$$

The equilibrium in firms' capacity investments and production volumes is given by:

$$\begin{aligned}
&\widehat{x}_1 = x_m \\
&\widehat{y}_1 = \left[\left(2-\lambda\right)\left(\alpha - r_1 - c_1\right) - \left(\alpha - r_2 - c_2\right)\right]/\beta(3-2\lambda) \\
&\widehat{K}_1 = \widehat{x}_1 + \widehat{y}_1 \\
&\widehat{K}_2 = \widehat{y}_2 = \left[2\left(\alpha - r_2 - c_2\right) - \left(\alpha - r_1 - c_1\right)\right]/\beta(3-2\lambda)
\end{aligned}$$

where x_m solves $MR_1^A(x_m) = r_1 + c_1$, and the equilibrium value of the strategic effect satisfies

$$\lambda = \left[\frac{\beta}{2\beta + (-p_x^A)\left(2-\xi^A\right)}\right]_{x_1 = \widehat{x}_1}.$$

The parameter condition in terms of firm 1's long-run marginal cost, $r_1 + c_1$, is sufficient for the equilibrium to obtain as described in Lemma 1. It is stated in a way that is *independent* of the value of the strategic effect $\lambda \in (0, \frac{1}{2})$. Importantly, therefore, this condition does not depend on the details of the equilibrium in market A; it varies only with the firms' marginal

[10] The final equality uses that $\partial MR_1^A/\partial K_2 = 0$ (firm 2's actions have no direct impact on revenues in market A), $\partial MR_1^B/\partial K_2 = \partial MR_1^B/\partial y_2$, $\partial MR_1^A/\partial y_1 = -\partial MR_1^A/\partial x_1$, as well as the definition of demand curvature $\xi^A \equiv -x_1 p_{xx}^A/p_x^A$. To understand the expression, note that a small increase $dK_2 > 0$ lowers 1's marginal revenue in market B by $dMR_1^B = (\partial MR_1^B/\partial y_2)(dK_2) = -\beta(dK_2) < 0$. By how much does y_1 need to adjust to restore optimality? Cutting y_1 both raises MR_1^B and lowers MR_1^A; specifically, $dMR_1^B = -2\beta(dy_1) > 0$ and $dMR_1^A = \left(-p_x^A\right)\left(2-\xi^A\right)(dy_1) < 0$, thus leading to the expression for λ.

costs and the state of demand in market B. Later on, this will facilitate the analysis of the cross-market impacts of changes in A on B.[11]

Equilibrium prices follow as $\widehat{p}^A = p^A(\widehat{x}_1)$ and $\widehat{p}^B = \alpha - \beta(\widehat{y}_1 + \widehat{y}_2)$. The standard Cournot-Nash equilibrium (for output choices in stage 2) is nested where $\lambda \equiv 0$.

5 The strategic advantage of asset specificity

The first main insight is that a firm which is focused on a single market enjoys a strategic advantage in that market. The reason is the presence of the strategic effect: firm 2 has an incentive to overexpand capacity and sales to market B, recognizing that its multimarket competitor has an alternative use for its capacity in market A, so it can induce firm 1 to cede market share in stage 2. This effect operates in an asymmetric fashion since firm 2—due to the specificity of its investment—has no such "outside option".

It will be useful to introduce two more definitions. First, let the relative market share of firm i in market B, $\kappa_i \equiv \widehat{y}_i/\widehat{y}_j$, be a measure of the competitive playing field; specifically, firm i is said to have a *competitive advantage* over its rival j if and only if $\kappa_i > 1$. Second, firm j's *value-added* in market B is $\varphi_j \equiv (\alpha - r_j - c_j)$ for $j = 1, 2$. This is the (maximum) willingness-to-pay of consumers in market B minus firm j's unit cost; more value-added here corresponds to lower cost. Under Cournot-Nash competition ($\lambda \equiv 0$), these two concepts are tightly related: firm i has a competitive advantage if and only if it has higher value-added than its rival j. In the present model, there is a richer set of results:

Proposition 1. *The single-market firm 2 can have a competitive advantage despite higher costs ($\varphi_2 < \varphi_1$); specifically, it has a competitive advantage over its multimarket rival firm 1 in market B, $\kappa_2 > 1$, if and only if $(\varphi_1 - \varphi_2)/\varphi_1 < \lambda/3$.*

Strategic considerations enable firm 2 to take on a quasi-Stackelberg role. The difference is that firms here make choices simultaneously rather than sequentially, so the advantage is due to the asymmetry in organizational structure rather than an asynchronous timing of moves. In contrast to much of the literature on strategic commitment, neither firm is "the incumbent" and there is no first-mover advantage. In the strategy literature, a firm's *competitive advantage is usually seen as arising from higher value and/or lower cost; here it can arise purely because of heterogeneity in firm structure.* In the present model, with symmetric value-addeds, $\varphi_1 = \varphi_2$, firm 2's has a competitive advantage with $\kappa_2 = 1/(1 - \lambda) \in (1, 2)$.

These effects of multimarket interaction can run counter to a fundamental result from oligopoly theory, namely that high market share goes hand in hand with low marginal cost

[11] To see that this leaves room for manoeuvre in terms of parameter values, consider the special case where both firms have an identical cost structure with $c_1 = c_2 = c$ and $r_1 = r_2 = r$. The three individual conditions then collapse into two, and become $r \in \left(\frac{1}{5}(\alpha - c), (\alpha - c)\right)$. In this setting, $r + c < \alpha$ is always satisfied since there would otherwise be no gains from trade in market B. Intuitively, the requirement that $r > \frac{1}{5}(\alpha - c)$ ensures that the unit cost of capacity is sufficiently high such the firms' do not install too much capacity—and thus end up using all of it. To see another example, let $\alpha = 1$ with zero production costs $c_j = 0$ for $j = 1, 2$. Then the condition becomes $r_1 \in \left(2r_2 - 1, \min\left\{\frac{1}{3}(2r_2 + 1), 6r_2 - 1\right\}\right)$, and it is easy to check that there is a substantial set of values for r_1, r_2 which satisfies this. For instance, if $r_2 = \frac{1}{4}$, then any $r_1 \in (0, \frac{1}{2})$ works.

(i.e., firms' market shares and efficiency levels are co-monotonic). This applies in all common (single-market) oligopoly models, including Cournot (quantity) and Bertrand (price) competition, as well as spatial competition models such as Hotelling, and the supply-function equilibrium models often used to analyze electricity markets (Vives, 2000).

In the present model, by contrast, firm 2 can have a competitive advantage even if it has *much* higher costs. To illustrate, let the demand parameter $\alpha = 30$, firm 2's marginal cost $r_2 = 5$ and $c_2 = 5$, so $(r_2 + c_2) = 10$, and the equilibrium value of the strategic effect $\lambda = \frac{1}{3}$. (Note from Lemma 1 that it is possible to obtain any $\lambda \in (0, \frac{1}{2})$ by appropriate choice of β.) Then, whenever firm 1's long-run marginal cost $(r_1 + c_1) \in (7\frac{1}{2}, 10)$, firm 2 retains a higher share of market B. So its cost can be over 30% higher than that of the multimarket firm.[12] (The parameter condition of Lemma 1 is satisfied for these values.)

Proposition 1 has implications for making inferences on firms' efficiency levels from observed market performance. Suppose an industry analyst observed that firms 1 and 2 have identical market shares of market B. Guided by standard models of competition, and in the absence of any other discernible differences within market B, the natural conclusion is that both firms therefore have identical productivity levels. Yet this inference can be misleading if at least one of the firms also competes in another market; firms' performance can be the same ($\widehat{y}_1 = \widehat{y}_2$) even if their value-addeds are not ($\varphi_1 \neq \varphi_2$).

The next result pins down the comparative statics of the strategic effect:

Proposition 2. *In market B, in the single-market firm 2's market share and profits rise with the strategic effect λ, while the price and the multimarket firm 1's profits fall. The Herfindahl index rises with the strategic effect λ if and only if firm 2 has a competitive advantage, $\kappa_2 > 1$.*

A stronger multimarket effect shifts market share and profits from the multimarket firm 1 to the focused firm 2. At the same time, the greater intensity of rivalry raises total output and lowers the equilibrium price in market B, similar to the usual Stackelberg model. As long as firm 2 has a competitive advantage, i.e., a larger market share, to begin with, this also pushes up the Herfindahl index (i.e., the sum of squared market shares). Note that higher industry concentration is *good* news for consumers in this setting.

The next result is on the *interaction* of the strategic effect and competitive advantage:

Proposition 3. *The single-market firm 2's relative share of market B, κ_2, is supermodular in its relative value-added φ_2/φ_1 and the strategic effect λ.*

In other words, the two effects are self-enforcing: greater value-added and a stronger strategic effect both individually raise firm 2's market share, but they also raise each other's *marginal*

[12] After completing the working-paper version, I became aware of Arie et al. (2015) who study how a strategic-commitment perspective on multimarket contact differs from the usual tacit-collusion ("mutual forbearance") view, and also show that it is quantitatively significant; the main focus of their applications is US airline markets and merger analysis. They consider a related-but-different model with asymmetric demand conditions across markets (which is needed for a meaningful multimarket-analysis of tacit collusion) but, unlike the present paper, assume that firms have identical cost structures (which is problematic in the context of global gas, but perhaps less so for airlines).

impacts on competitive advantage. This has a number of implications, notably that firm 2's gain in competitive advantage due to superior costs is greater in the presence of the strategic effect than in a world with $\lambda = 0$; put differently, the gain $[\kappa_2(\varphi_2/\varphi_1, \lambda) - \kappa_2(1, \lambda)] > 0$ rises with λ for any $\varphi_2/\varphi_1 > 1$.

In this sense, a superior cost structure and a sharper organizational focus are complements in generating competitive advantage for firm 2. The intuition is that, by Proposition 2, the multimarket effect pushes price and hence firms' profit margins down; in a more competitive market, the benefit from having lower costs than rivals is relatively greater. This establishes a novel link between two of Porter's (1980) generic strategies.

These insights seem consistent with discussions in the strategy literature on competition between different types of companies in the airline industry. In particular, many analysts have observed the advantage that low-cost carriers (LCCs), notably Southwest Airlines, have had in competition against incumbent airlines—originally in the US but over the last decade or so also in Europe. Discussions typically emphasize their lower cost base but also that they are more selective (and less burdened by history) in choosing which routes to fly (e.g., Porter, 1996). The present model suggests that these two features of their setup are not only beneficial but, in fact, also reenforcing. Such a point is arguably difficult to make precise without the aid of a formal model, and thus highlights the contribution of a game-theoretic approach.

Note that none of Propositions 1–3 hinge on the price difference between markets A and B, i.e., the sign or magnitude of $\widehat{p}^A - \widehat{p}^B$.

The analysis thus far has considered the linkage between the two markets by essentially treating λ as a parameter. Yet the strategic effect is, of course, *endogenous* in the model; recall from Lemma 1 that $\lambda \equiv -\beta / \left[2\beta + \left(-p_x^A\right)\left(2 - \xi^A\right)\right] \in (0, \frac{1}{2})$.

Its magnitude thus depends on two factors. The first factor is the relative size of markets A and B, as contained in the ratio $\beta / \left(-p_x^A\right)$. The case with $\beta \to 0$ corresponds to market B becoming very large (relative to market A). In such situations, firm 1 finds this market very attractive, and therefore only reluctantly redirects output away from it, and so λ is small. The case with $\left(-p_x^A\right)$ very large corresponds to consumers in market A being very price-insensitive; a small reduction in price induces little additional demand, and again λ is small. In short, a stronger strategic effect is associated with the common market B being small relative to A.

The second factor relates to demand conditions in the market A, as contained in the term $\left(2 - \xi^A\right)$. The curvature parameter $\xi^A \to -\infty$, corresponds to very concave demand in market A—in the limit, all consumers have (almost) the same willingness-to-pay. This is best understood as reflecting the multimarket firm's ability to capture value in its monopolized market A:

Lemma 2. *The degree of value capture, at equilibrium, by the multimarket firm* 1 *in market* A *is given by* $v^A = 1/(1 + \rho^A)$*, where* $\rho^A \equiv d\widehat{p}^A/dMC = 1/(2 - \xi^A) \in (0, 1)$ *is the rate of pass-through from marginal cost to price.*

Value capture refers to the fraction of the total value (social surplus) generated in the market—to both buyers (consumer surplus) and the firm (producer surplus)—which is captured by the firm as profits. Lemma 2 shows that the last unit of output at equilibrium creates consumer surplus at a fraction ρ^A of extra firm profits, so the degree of value capture is given by $v^A = 1/(1+\rho^A)$.[13] The pass-through coefficient $\rho^A \equiv d\widehat{p}^A/dMC$ measures by how much the equilibrium price responds to a change in marginal cost. Higher value capture, or pricing power, is associated with a *lower* rate of cost pass-through. Intuitively, this means that the price then tracks consumers' willingness-to-pay relatively more closely than it tracks costs. The maintained assumption that demand is log-concave, $\xi^A < 1$, means that pass-through ρ^A lies between zero and 100%. Pass-through is lower, and value capture is higher, when demand is more concave, i.e., ξ^A is smaller.[14]

In the limiting case as pass-through tends to zero ($\xi^A \to -\infty$), the monopolist extracts all the available gains from the trade in market A so value capture becomes 100%; thus, there is no distortion below the "first-best" level of output. In this situation, there is no scope for firm 2 to strategically influence its decision-making, as it will not deviate from its preferred level of output, and so $\lambda = 0$. Intuitively, with such pronounced pricing power, firm 1 will be very careful to divert additional units to market A—and depress price there. By contrast, an almost perfectly competitive seller with little market power would be almost indifferent to selling more to market A, and can thus be more easily manipulated in its decision-making.

This discussion leads directly to the following summary:

Lemma 3. The strategic effect λ is higher if (i) market B is smaller relative to market A ($\beta/\left(-p_x^A\right)$ is larger), or (ii) the multimarket firm 2's degree of value capture in market A is smaller ($v^A = 1/(1+\rho^A)$ is smaller).

This confirms that Propositions 1–3 are logically valid. Changes in the strategic effect are driven as per Lemma 3. The previous analysis of competitive advantage in market B did not depend *directly* on β or on the details of demand conditions in market A. (Doubling β halves the size of the market B but this leaves the firms' *relative* market shares and profits unchanged; it just acts as a scaling factor for market size.) The analysis of competitive advantage is driven only *indirectly* by these factors, precisely because they alter the magnitude of the strategic effect.

How robust are these results? First, the multimarket firm, even though its profitability in market B is lower than that of its rival, is not acting irrationally by operating in both markets. It could be *optimal*, i.e., profit-maximizing, for both the multimarket and the single-market firm to *self-select* into these respective organizational structures. For firm 1, serving both markets A and B can easily be more profitable than serving only market B, simply because the profit contribution of A exceeds the adverse impact on profits from B. Similarly, it may be too expensive (or impossible) for firm 2 to enter market A, e.g., due to the geographic location of its resource base—in a "stage 0" of the game (not explicitly modelled here).

[13] This result also appears, stated in a slightly different way, in Weyl and Fabinger (2013).

[14] The rate of pass-through has no necessary relationship with the conventional price elasticity of demand. Recall that a monopolist facing a linear demand curve extracts 50% of the potential social surplus (with 25% left each as consumer surplus and deadweight loss), *regardless* of the particular equilibrium value of the price elasticity of demand.

Second, the results apply also apply to the alternative definition of competition advantage as the relative *profits* of the firms in market B. The condition from Proposition 1 comes out less cleanly but it is still true that firm 2 can have higher profits despite higher costs. Proposition 2 is unchanged, except that the result on the Herfindahl index does depend on competitive advantage being defined in terms of market share rather than profits. Proposition 3 on supermodularity holds in exactly the same way. The remainder of the analysis is also unaffected.

Third, to bring out the results as clearly as possible, this paper uses a very simple model with only two firms. Yet this setup does not seem critical. For instance, if firm 1 faced a competitive fringe of small producers in market A, it would simply act as a *residual* monopolist rather than an outright monopoly. The logic of firm 2 equalizing marginal revenues across markets—and the resulting strategic vulnerability (of endogenous magnitude) remains. Or, with other single-market producers selling to market B, all would vie to take advantage of firm 2's multimarket exposure. More realistic market structures quickly make the model unwieldy but its main insights appear to be generalizable.

Fourth, firms' products in market B are taken to be homogeneous. This could be relaxed to allow for horizontal product differentiation (e.g., different branding) by letting j's demand $p_j^B(y_1, y_2) = \alpha - \beta(y_j + \delta y_i)$ for $i \neq j$ and $j = 1, 2$, where $\delta \in (0, 1)$ is an inverse measure of differentiation. This reduces the interdependence between firms and hence weakens the strategic-substitutes property of competition. Yet the basic results still qualitatively apply as long as firms remain competitors in this market (rather than independent monopolies as $\delta \to 0$).

Fifth, the analysis assumes that firms are profit-maximizers. This is a canonical assumption which seems appropriate for a wide range of markets. But it is perhaps less clear to what extent it applies when, like in the international gas industry, some actors are *state-controlled* entities. These may have a preference for running a larger operation than would be profit-maximizing. It turns out that the results are not overly sensitive to this. If players instead maximize *utility* functions, the multimarket firm equalizes marginal utility across markets. As long as competition remains in strategic substitutes, the main insights from the analysis again continue to apply; it is more important that players maximize than what exactly is being maximized.

Sixth, the analysis raises the question of how a multimarket firm might *mitigate* its strategic weakness. For example, it could, already at the investment stage, earmark specific capacity shares to individual markets by signing long-term contracts with buyers in each market. Then it would no longer have to (or be able to) allocate capacity between markets in stage 2; in effect, this bundles together the two stages. The strategic effect can also be mitigated by way of improving value capture in market A—which is examined in detail in the following section.

The qualitative insights from the model apply as long as *some* capacity is not pre-allocated in this fashion. Put differently, the strategic weakness from multi-market exposure requires only that some capacity is allocated between markets, not necessarily *all* installed capacity—as is formally the case in the model. Such a mix reflects actual practice in a range of sectors. For example, in the gas industry, long-term contracts play an important role but—as discussed in the introduction—there are significant flexible volumes which LNG producers allocate between export markets.[15] In other sectors like airlines or consulting, capacities are also not fully pre-allocated to individual routes or markets at the investment stage.

6 Spillover effects from a local demand shock

The analysis thus far has concentrated on the strategic advantage enjoyed by a firm which serves fewer markets than its rivals. In practice, uncertainty over demand and costs (and rival behaviour) can play a significant role in driving decisions. There may be trade-offs between committing to particular investments and retaining flexibility to adjust decisions further down the road (Ghemawat and del Sol, 1998).

This analysis in this section was originally motivated by the global repercussions which the 2011 Fukushima nuclear accident in Japan had across a wide range of sectors. It explores how a local demand shock in market A affects the equilibrium in market B, and how the focused and multimarket firms respond differently, both over the short run and long run.

In particular, consider the impact of an upward shift in demand conditions in market A, both on the equilibrium in market A itself as well as spillovers onto market B. Formally, write demand in market A as $p^A(x_1, \theta)$, where θ is a shift parameter, and assume $p^A_\theta > 0$ (everywhere, for simplicity), so a higher θ raises consumers' willingness-to-pay (WTP). Note that such a shift can both change the shape of the demand curve and lead to a movement along it.

6.1 Local effects on the domestic market

Before turning to the main question at hand, it is important to establish the impact of "stronger demand" in market A on market A itself. However intuitive, it is not always true that a demand shift that raises consumers' WTP also raises price and output.

The following result characterizes the set of conditions under which the "expected" local effects prevail. Let $\eta^A_\theta \equiv d\log p^A_\theta / d\log x_1$ denote the elasticity of the higher WTP with respect to market output.

Lemma 4. *(a) In market A, in equilibrium, a demand shift from θ' to θ'' raises output $\widehat{x}_1(\theta'') > \widehat{x}_1(\theta')$ if and only if*

$$\int_{\theta'}^{\theta''} \left(\frac{p^A_\theta (1 + \eta^A_\theta)}{(-p^A_x)(2 - \xi^A)} \right)_{x_1 = \widehat{x}_1} d\theta > 0,$$

and raises price $\widehat{p}^A_1(\theta'') > \widehat{p}^A_1(\theta')$ if and only if

$$\int_{\theta'}^{\theta''} \left(\frac{p^A_\theta \left[(1 - \xi^A) - \eta^A_\theta \right]}{(2 - \xi^A)} \right)_{x_1 = \widehat{x}_1} d\theta < 0.$$

[15] Contracting arrangements have also become more flexible in LNG markets over the last decade. Traditionally, investments were backed up by long-term contracts (of around 20 years duration) between a seller and buyer. Today, trade in spot and short-term markets makes up about 30% of global LNG sales (GIIGNL, 2013). These short-term transactions were key to the market response to the Fukushima accident. Brito and Hartley (2007) present a model in which a shift towards spot trading has self-reenforcing properties.

(b) A sufficient condition for output to rise is $\eta_\theta^A > -1$ for all $\theta \in [\theta', \theta'']$, and a sufficient condition for the price to rise is $\eta_\theta^A < (1-\rho^A)/\rho^A$ for all $\theta \in [\theta', \theta'']$.

In sum, both of the expected local effects go through as long as the elasticity η_θ^A is not too large either way. In other words, the jump in WTP cannot vary too much across consumers. These conditions are necessary and sufficient with a small (i.e., infinitesimal) shift in demand, and sufficient with a large (i.e., discrete) shift. They are always met if demand takes the form $p^A = \theta + f(x_1)$ so WTP rises uniformly ($\eta_\theta^A \equiv 0$), and more likely to be satisfied the *lower* the rate of cost pass-through ρ^A—equivalently, higher value capture v^A. For output to rise, the demand shift must not only raise WTP, $p_\theta^A > 0$, but also raise marginal revenue, $\frac{\partial}{\partial\theta} MR_1^A > 0$ if and only if $\eta_\theta^A > -1$.

6.2 Global spillover effects to other markets

Now turn to the main question: How does a demand shock in market A spill over to market B? The answer will depend on the timeframe under consideration. The analysis begins with the short-run response, in which firms' global capacity levels are fixed. Then it examines the longer-term response, in which firms optimally adjust capacity.

Short-term responses with fixed capacities. In the short run, both firms' capacities are fixed at the levels that were optimal with respect to the "initial" state of demand in market A. So firms can only re-optimize their output choices in light of new market conditions.

For simplicity, suppose the new short-run "equilibrium" features interior solutions (both firms continue serve each of their markets) and firms engage in Nash behaviour.

Proposition 4. *Suppose that $\eta_\theta^A > -1$ for all $\theta \in [\theta', \theta'']$. In the short run, with fixed capacities, a demand boom in market A raises firm 2's market share (κ_2) and the price in market B.*

The reason for the result is as follows. The demand boom makes market A relatively more attractive to firm 1 (see Lemma 4), making it redirect capacity from B to A (since it was already selling up to capacity). For firm 2, there is no direct change in its demand conditions as it serves only market B; its position changes only in that its rival sells less to market B. This, as such, induces it to increase its own sales—but this is impossible given its (already binding) capacity constraint. So total sales to market B decline, and the local price and firm 2's market share rise. Since overall demand conditions have improved, the firms still do best by selling up to capacity—although the spread across markets has shifted.

In terms of profits, note that firm 1 is better off by revealed preference: given that $\eta_\theta^A > -1$, it can achieve strictly higher profits than before by choosing to redirect some capacity toward market A. This is an instance of the benefits of flexibility afforded by multimarket presence. But note that the focused firm 2 also benefits from the demand boom in market A—even though it is committed to *not* serving this market. A focused strategy does not necessarily preclude a firm from benefitting from market developments elsewhere.

Longer-term responses with optimal capacities. In the longer term, firms can adjust their capacity levels to be optimal given the new global market fundamentals. What, then, is the long-run impact on market B of the demand boom in market A?

Formally, compare the equilibrium of the two-stage game, with capacity investments followed by quantity choices, at the initial demand level θ' with that following the demand shift θ'', under the maintained assumption that firms always produce up to their respective capacities.[16]

From the previous discussion with optimal capacities, it follows that the *only* cross-market effect comes via possible changes in the magnitude of the strategic effect. Writing $\lambda(\theta) \equiv -\beta/\left[2\beta + \left(-p_x^A(\theta)\right)\left(2 - \xi^A(\theta)\right)\right]$, the issue is how changes in θ affect $\left(-p_x^A\right)\left(2-\xi^A\right)$, that is, determining the sign of $\frac{d}{d\theta}\left[\left(-p_x^A\right)\left(2-\xi^A\right)\right] = \frac{d}{d\theta}\left[-\text{slope of marginal revenue curve } A\right]$.

The case with linear demand serves as a useful benchmark. If demand in market A is everywhere linear (i.e., its curvature $\xi^A = 0$ for all x_1), then $\left(-p_x^A\right)\left(2-\xi^A\right) = -2p_x^A$ is just a constant. (Note that then also $\eta_\theta^A = 0$.) In this case, the demand shift is "strategically neutral", i.e., $\lambda'(\theta) = 0$ for all θ. As a result, the equilibrium in market B is unchanged in the long run when firms optimally adjust capacity (and market A is affected as per Lemma 4).

More generally, however, the demand shock will not be strategically neutral for market B. The following result gives a general condition to sign its impact and simple sufficient conditions for the demand shock to *weaken* the cross-market connection.

Proposition 5. *(a) A demand boom in market A weakens the strategic effect $\lambda(\theta'') \le \lambda(\theta')$ if and only if:*

$$\int_{\theta'}^{\theta''}\left(\frac{\beta[\frac{p_\theta^A}{x_1}\left(\xi^A + 2\eta_\theta^A\right) + \left(-p_x^A\right)\frac{d}{d\theta}\xi^A]}{[2\beta + (-p_x^A)\,(2-\xi^A)]^2}\right)_{x_1=\widehat{x}_1} d\theta \le 0.$$

(b) Sufficient conditions for $\lambda\left(\theta''\right) < \lambda\left(\theta'\right)$ are that, for all $\theta \in [\theta', \theta'']$, cost pass-through is sufficiently low, $\rho^A < \frac{1}{2}\left(1+\eta_\theta^A\right)^{-1}$, and non-increasing, $d\rho^A/d\theta \le 0$.

The former condition is certainly met if $\rho^A < \frac{1}{2}$ (if and only if demand is concave, $\xi^A < 0$) and the impact of the demand increase on consumers' willingness-to-pay satisfies $\eta_\theta^A \le 0$ (if and only if $p_{x\theta}^A \le 0$).

Combining Propositions 3 and 5 leads directly to:

Proposition 6. *In the long run, with optimal capacities, a demand boom in market A increases price but decreases firm 2's market share in market B, under the conditions of Proposition 5.*

Under these conditions, the demand boom in market A makes firm 1 less strategically vulnerable to aggressive overexpansion by its focused competitor in their common market B. Because competition in market B becomes less aggressive, consumers there lose out.

[16] The analysis does not consider a fully dynamic model in which there is a time-dependence of the capital stock. The technique employed here can be justified on various grounds. For example, it corresponds to a setting in which capacity depreciates after each period, so firm 1 first invests given low demand, and then must make a new investment given high demand. Alternatively, the setup fits the interpretation of capacity as maintenance expenditure, which is required period by period, or as the improvement of existing capacities. Solving a fully dynamic version of the model looks hard.

Roughly put, the conditions are met when firm 1 already has relatively high value capture—equivalently, "low" pass-through—in market A, and this market power tends to be further strengthened by the demand boom. Simple sufficient conditions are that pass-through is less than 50%—and that this rate does not rise following the shift in demand conditions. This is sufficient combined with a non-negative cross-partial on the impact of the demand shift on buyers' WTP, $p^A_{x\theta} \leq 0$. Think of this as $\frac{\partial}{\partial x_1}\left(p^A_\theta\right) \leq 0$: WTP increases for all consumers but tends to rise more strongly for buyers who already have a higher WTP. Again, this is consistent with the idea that the demand boom raises firm 1's ability to capture value in market A.

So, in the longer run, the multimarket firm benefits *twice* from stronger demand in market A. First, via the obvious direct gain in market A from more sales at a higher price. Second, and less obviously, the demand boom in market A makes firm 2 a stronger competitor in market B.

To close this discussion, it is worth stressing a couple of points. First, the conditions identified in Proposition 5(b)—in short, "low" and non-increasing pass-through—are only *grossly* sufficient for a weakened strategic effect, and hence the result of Proposition 6. The conclusions also go through as long as these conditions hold for a sufficiently large portion of the interval $[\theta', \theta'']$ but not everywhere—so demand could be *convex* in some places. Proposition 5(a) makes this statement precise. Second, it is also true that there are counterexamples. In such cases, the demand shift would *strengthen* the strategic effect, and the result of Proposition 6 would flip. The discussion below suggests that these are less likely in the case of the global gas market. Third, it is clear that the multimarket firm has a very strong incentive to raise its value capture in market A, as this also fortifies its competitive position in market B.

Comparing short- and long-term responses. Propositions 4 and 6 identify similarities and differences between the short-run and long-run multimarket effects of the demand shock—Table 1 gives a summary.

Table 1: Spillover effects from higher demand in market A onto market B

		Price level	Single-market firm 2's market share
Short run		+	+
Long run	strategic effect weakens	+	−
	strategic effect strengthens	−	+

In general, the comparison between short- and long-term spillovers depends on the fine details of the market environment. In any case, the short- and long-term are always different, either in terms of the impact on buyers or the rivalry between firms in market B.

Consider the case where the strategic effect weakens. In the short term, by Proposition 4, firm 1 cedes market share as it redirects capacity to market A. However, in the longer term, this is reversed: firm 1 invests in additional capacity to the extent that it *gains* share in market B. The similarity is that buyers in market B always lose out—yet for different reasons. In the short term, sales are diverted to market A; in the long term, buyers lose because the competitive intensity in their market declines. Buyers in market A still have a higher WTP than before, but this extra demand is now satisfied by firm 1's newly installed capacity.

7 Applying the results to international gas markets

This section shows how the preceding results can help understand competitive dynamics, and inform public policy, in the global gas industry.

7.1 Application of the model to global gas

The above model is an abstraction of competitive dynamics in global gas markets, as outlined in the Section 2. Think of market A as the Asian gas market—with Japan and South Korea in mind especially—and market B as Europe. Firm 1 is an LNG exporter, such as Qatar, serving both markets. Firm 2 is a pipeline seller, such as Russia/Gazprom, focused on the European market. This paper's focus on the "balance of power" between Russia and Qatar as the key suppliers is consistent with industry analysis (Stern and Rogers, 2014).

Other modelling assumptions reflect market conditions in global gas. Importantly, the setup allows LNG and pipeline producers to have different cost structures, both in terms of production and investment. It assumes that Qatar has identical sales costs for the European and Asian markets; this is a reasonable assumption since, as noted in Section 2, transport costs are indeed very similar in practice.

There is no price arbitrage between markets A and B by third-party traders. While price differentials between markets are not essential for the the model to work, as noted in Section 5, the equilibrium may thus feature price differentials resulting from price discrimination by producers, which is in line with experience in global gas markets (see Figure 1).

Firms' choices in Stage 1 can be interpreted as investments in production capacity; more generally, these reflect any kind of longer-term decisions, such as maintenance expenditure or procurement/chartering of other parts of infrastructure, which occur before short-run sales. Finally, the assumption that firms sell up to capacity in Stage 2 seems reasonable for the natural gas industry (in which any capacity that is operational is typically also fully used, subject to planned outages).[17]

7.2 Pipeline gas vs LNG: Competitive balance, "energy security", and the optimal import mix

Proposition 1 formalizes the idea that pipeline gas—due to its physical asset specificity—has a strategic advantage over LNG in common export markets. This suggests that Russia enjoys

[17] The application to gas markets is admittedly stylized in other respects. This includes the absence of intertemporal considerations on resource extraction à la Hotelling (sell today, or leave in the ground and perhaps sell tomorrow), as well as gas storage. Furthermore, the capacity investments made by producers are not exactly simultaneous in practice; for example, Russian pipelines in many cases preceded the LNG investments of other players. The paper also follows the large-scale models of gas markets in abstracting from the details of contracting arrangements between buyers and sellers.

two sources of competitive advantage over Qatar in the European market. First, it is likely true that it has lower overall unit costs (IEA, 2009: 481–485), leading to a standard efficiency-based advantage. Second, *magnifying* the cost argument—by the supermodularity logic of Proposition 2—it enjoys the strategic advantage identified here.

In contrast to many energy policy discussions, the analysis here suggests that Gazprom's "dependency" on the European market, because of its strategic commitment value, may be a source of *strength*—rather than a weakness, as is usually claimed in policy discussions. Moreover, European gas customers actually *benefit* from Gazprom having a high market share (for a given number of firms competing in the market) because this goes hand-in-hand with tougher competition overall.

This highlights a limitation to the common practice of using Herfindahl concentration indices as an inverse measure of "security of supply" in energy markets (e.g., European Commission, 2014).[18] Here, as long as Gazprom has a larger market share, a stronger strategic effect *raises* the Herfindahl index (Proposition 3). But this makes European gas buyers better off—with greater consumption at a lower price. So, in some cases, a higher Herfindahl index could be *good* for energy security. (Of course, the present model does not capture all relevant issues; the more modest objective is to point out a consideration that goes against the "conventional wisdom" on energy security.)

Conversely, the result can help explain why European gas-importing countries seem to place a lot emphasis on the benefits of having access to LNG supplies. It shows how an individual gas-importing country is better off with an import *mix* of one each of pipeline and LNG supply than it would be with two dedicated pipeline suppliers (all with identical unit costs, for a clean comparison). (The latter would simply boil down to standard Cournot-Nash competition with $\lambda \equiv 0$.) The reason is that the LNG exporter creates an additional competitive externality on the pipeline supplier, making it compete more aggressively and thus lowering price.

Finally, the analysis also suggests that diversification of a traditionally pipeline-based exporter into LNG (from the same gas fields) comes at a strategic cost. So it can be rational for a pipeline seller to reject apparently profitable diversification to protect its existing business.

7.3 How did the Fukushima nuclear accident affect Gazprom and the European gas market?

The Fukushima Daiichi accident of March 2011 led to a large-scale shutdown of Japanese nuclear reactors. This sharply raised the demand for substitute energy sources, with LNG imports rising by around 25% (GIIGNL, 2013) while prices increased by over 50% in the course of the following year (IMF, 2014). What were its "global" repercussions—in particular, what are the knock-on effects for the European market?

This response of the Japanese energy sector to Fukushima gives an opportunity to calibrate (unobserved) demand parameters. First, this event no doubt qualified as a large shift in Japan's

[18] There are many different definitions of "security of supply". A reasonably representative one is "the availability of sufficient supplies at affordable prices" (Yergin, 2006). While this definition is also imprecise, note that it has similarities with (expected) consumer surplus.

LNG import demand. Second, the market response suggests that its impact on buyers' WTP satisfies the conditions of Lemma 4, in terms of η_θ^A and ξ^A (equivalently, ρ^A and υ^A).

Third, the conditions underlying Proposition 6—a weaker strategic effect—seem plausible for the case of Asian LNG imports, especially by Japan. It is commonly assumed in the analysis of natural gas markets that demand curves are concave (e.g., Doane, McAfee, Nayyar and Williams, 2008). The argument, applied to LNG, goes as follows: At very high prices, buyers will prefer to access substitute sources of energy, such as those linked to oil or coal prices. It follows that, at high prices, the demand curve for LNG imports is almost flat. Conversely, the amount of LNG imports is constrained by the availability of regasification terminals (which are needed to allow consumption). In practice, therefore, the existing regasification capacity places a cap on the feasible import quantity. In other words, the "effective" demand curve for LNG is essentially vertical in the vicinity of the cap. Taken together, this suggests a concave shape of the LNG import demand curve.

Importantly, the presence of such a concave demand curve means that LNG exporters enjoy significant pricing power in market A, which again seems consistent with recent market experience in Asian LNG. In the present model, if consumers' maximum WTP is greater in Asia, $p^A(0) \geq \alpha$, and Gazprom's long-run marginal cost is less than that of Qatari LNG, $r_2 + c_2 \leq r_1 + c_1$, then the price in Asia exceed that in Europe, $\widehat{p}^A > \widehat{p}^B$, consistent with empirical observation. (Then demand conditions are more tilted towards the seller in market A, and, of course, there is an additional seller in market B.)

Thus, in the short-term, Fukushima further improved Russia's position in Europe whilst hurting European gas buyers (Proposition 4) while, in the longer run, it made Qatar a stronger competitor for Russia (Proposition 6).

7.4 Testable predictions and some empirical evidence

The modelling has generated a number of results that are potentially empirically testable. A first prediction is the advantage of pipeline sellers over LNG exporters in common export markets. A second prediction is that a superior cost base and the single-market focus of a pipeline seller are complementary. A third set of predictions is on the cross-market spillovers of Fukushima, in the short versus the long run.

An important constraint is the limited quality of public data on the global gas industry. In particular, even basic information on LNG production volumes and trade is only available at an annual frequency. This makes difficult any econometric analysis, especially around particular market events. The remainder of the discussion here presents some preliminary evidence on the third set of predictions.

The limited evidence that is available is broadly consistent with the above results. The Fukushima accident happened on 11 March 2011. No other large market events appear to have occurred around those days; Fukushima can be assumed to have dominated the "news". The short-term prediction from Proposition 4 is that *both* Asian and European prices rise in the short-run, so Fukushima also makes European gas buyers worse off—from which Gazprom stood to gain.

Table 2 shows the Platts JKM (Japan Korea Marker) LNG price and the European gas price NBP (the UK's National Balancing Point) around the days of the Fukushima accident. Consistent with Lemma 4, the Asian LNG price rose sharply, by over 20%, over four trading days following Fukushima. However, the European gas price also rose by almost 13%. Although this finding is not overly surprising, it does confirm that the supply-side link between regional markets due to global LNG capacities plays an important role in practice. Moreover, LNG imports to Europe peaked in the Spring of 2011 and pipeline imports, especially from Russia, subsequently rose (Stern and Rogers, 2014).

Table 2**:** Asian LNG prices (JKM) and European gas prices (NBP) around the Fukushima accident (11 March 2011) in US$/MMbtu

	10 Mar	11 Mar	14 Mar	15 Mar	16 Mar	% change
Asia	9.40	9.90	11.00	10.95	11.35	+20.7%
Europe	9.30	9.60	10.20	10.50	10.50	+12.9%

Source: Platts data and author's own calculations

Testing the longer-term predictions—the "continuation" of a higher European gas price, greater LNG capacity investment, and Gazprom ultimately *losing* market share (Proposition 6)—is more difficult. First, while 11 of 53 nuclear reactors shut down on the day of the accident, Japanese policymakers closed virtually the entire nuclear fleet over the following 12 months, so the "event" *itself* was drawn out.[19] Second, many other factors vary over time. Third, the observed market response should reflect a *transition* from short-run impacts to the longer term; all else equal, this is predicted to be a rise in Gazprom's market share, followed by a decline to a level below that of the *status quo ante*.

Investment in LNG infrastructure has indeed risen strongly since 2011 (GIIGNL, 2013), and Gazprom is widely seen to have come under pressure in Europe (Stern and Rogers, 2014). While there is anecdotal evidence from industry discussions that the large recent LNG investments in the US and Australia were incentivized by global price differentials, the extent to which these developments have indeed been *driven* by Fukushima is yet to be tested. With better data, future research may be able to test this econometrically.

There is ample scope for more careful empirical work on natural gas markets; the analysis here is clearly only a small first step. The model presented here could also be used to examine other cross-market impacts such as how the future entry of US LNG into Asia (market A) would affect competition in Europe (market B).

[19] As of late 2015, Japan's nuclear fleet has yet to restart, so the impact of Fukushima now stretches out over four-and-a-half years.

8 Conclusion

This paper has studied a model of imperfect competition with strategic investments in which a multimarket firm's global capacity choice indirectly connects otherwise separate markets while its rival's capacity investment is specific to a single market.

A single-market focus confers strategic benefits similar to those associated with a first-mover advantage in the classic Stackelberg model. This can be a large source of competitive advantage for a firm even in the absence of providing greater value to buyers or having lower costs. Moreover, a superior cost structure and a sharper organizational focus are self-enforcing in generating competitive advantage. The game-theoretic approach identifies and makes precise this complementarity between low costs and a narrow focus. This finding establishes a novel connection between two of Porter's generic strategies.

The degree of this strategic advantage is also intimately linked to competitive conditions in the multimarket firm's other markets. Motivated by the global repercussions of the Fukushima nuclear accident in Japan, the paper studied the impact on the common market of a demand boom elsewhere. Short- and long-term impacts are necessarily different, and depend on the fine details of the competitive environment. A general conclusion is that greater value capture in its other markets can help a multimarket firm regain market share from a more focused rival.

The application to the global gas industry motivated the presence of different organizational structures, the role of imperfect competition, and the commitment value of large-scale infrastructure investments. Intuitions about pass-through and demand conditions in natural gas markets were helpful for calibrating parameter conditions obtained from the model, and generated some empirically testable predictions. The interplay between multimarket competition and strategic commitment may also take on an important role in other sectors such as airlines.

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Appendix

This Appendix gives proofs of Lemmas 1, 2 and 4 as well as Propositions 1 to 5. Lemma 3 and Proposition 6 follow directly from arguments given in the main text.

Proof of Lemma 1 (*Equilibrium of the game*). Begin by deriving the equilibrium values $(\widehat{\mathbf{K}}, \widehat{x}_1, \widehat{y}_1, \widehat{y}_2)$, and then determine conditions which ensure that the equilibrium is indeed valid. From the above discussion, the two remaining unknowns (y_1, K_2) are pinned down by two equilibrium conditions. The first follows from firm 1 equalizing marginal revenues across markets, $MR_1^A(K_1 - y_1) - MR_1^B(y_1, K_2) = 0$, by (1). Using the linearity of demand in market B, and recalling from (3) that, by profit-maximization in market A, $MR_1^A = r_1 + c_1$, and some rearranging gives:

$$y_1 = \frac{(\alpha - r_1 - c_1 - \beta K_2)}{2\beta} \tag{7}$$

The second follows from profit-maximization by firm 2 at Stage 1, recognizing the strategic effect of its capacity choice, $MR_2^B + \beta\lambda y_2 = r_2 + c_2$, from (5):

$$K_2 = \frac{(\alpha - r_2 - c_2 - \beta y_1)}{\beta\,(2 - \lambda)} \tag{8}$$

Solving these two equations simultaneously yields:

$$y_1 = \frac{(\alpha - r_1 - c_1)}{2\beta} - \frac{(\alpha - r_2 - c_2 - \beta y_1)}{2\beta\,(2 - \lambda)} \tag{9}$$

$$\Longrightarrow \widehat{y}_1 = \frac{[(2-\lambda)\,(\alpha - r_1 - c_1) - (\alpha - r_2 - c_2)]}{\beta(3 - 2\lambda)} \tag{10}$$

$$K_2 = \frac{[(\alpha - r_2 - c_2) - [(2-\lambda)\,(\alpha - r_1 - c_1) - (\alpha - r_2 - c_2)]\,/(3 - 2\lambda)]}{\beta\,(2-\lambda)} \tag{11}$$

$$\Longrightarrow \widehat{K}_2 = \frac{[2\,(\alpha - r_2 - c_2) - (\alpha - r_1 - c_1)]}{\beta(3 - 2\lambda)} \tag{12}$$

The equilibrium value of the strategic effect λ is defined (implicitly) by (6), evaluated at the equilibrium output in market A. The remaining equilibrium choices follow immediately from $\widehat{K}_1 = \widehat{x}_1 + \widehat{y}_1$ and $\widehat{y}_2 = \widehat{K}_2$.

Confirming this as a valid solution requires two more steps. First, finding conditions for this to be an interior equilibrium in which both firms sell strictly positive amounts to market B. Second, verifying that both firms indeed find it optimal to fully use their installed capacity. These conditions are now derived so as to hold for any possible value of the strategic effect $\lambda \in (0, \frac{1}{2})$.

Step 1: For firm 1, note that $\widehat{y}_1$ is strictly decreasing in the strategic effect λ. It follows that, firm 1's output to market B satisfies $\widehat{y}_1 > \left[\frac{3}{2}\,(\alpha - r_1 - c_1) - (\alpha - r_2 - c_2)\right]/2\beta$, for any value of λ, so that:

$$\tfrac{3}{2}\,(\alpha - r_1 - c_1) > (\alpha - r_2 - c_2) \Longrightarrow \widehat{y}_1 > 0. \tag{13}$$

This condition can be rearranged as $(r_1 + c_1) < \frac{1}{3}[\alpha + 2(r_2 + c_2)]$. For firm 2, by inspection, a necessary and sufficient condition for positive output is:

$$2(\alpha - r_2 - c_2) > (\alpha - r_1 - c_1) \Longleftrightarrow \widehat{y}_2 > 0. \tag{14}$$

This condition can also be written as $(r_1 + c_1) > [2(r_2 + c_2) - \alpha]$.

Step 2: Firm 1 will fully utilize all of its installed capacity as long as this is profit-maximizing, i.e., where the marginal revenue generated from sales exceeds the associated costs. Recalling that firm 1 chooses capacity such that $MR_1^A = MR_1^B = r_1 + c_1$, it follows that $MR_1^A = MR_1^B > c_1$ (since, by assumption, $r_1 > 0$). Thus $\widehat{x}_1 + \widehat{y}_1 = \widehat{K}_1$ is indeed optimal.

For firm 2, it similarly must be verified that $MR_2^B(\widehat{y}_1, \widehat{y}_2) > c_2$, with its marginal revenue evaluated at the equilibrium outputs to market B. Noting that $MR_2^B(\widehat{y}_1, \widehat{y}_2) = \alpha - \beta\widehat{y}_1 - 2\beta\widehat{y}_2$, and using the expressions for outputs from above shows that:

$$(\alpha - c_2) > \frac{3(\alpha - r_2 - c_2) - \lambda(\alpha - r_1 - c_1)}{(3 - 2\lambda)} \Longleftrightarrow MR_2^B(\widehat{y}_1, \widehat{y}_2) > c_2. \tag{15}$$

This condition can be rearranged as $\lambda(\alpha - 2c_2 + r_1 + c_1) < 3r_2$, which is more difficult to satisfy for higher values of the strategic effect λ (since $\alpha - 2c_2 + c_1 > 0$ is assumed). Thus letting $\lambda = \frac{1}{2}$, and some further manipulation shows that

$$(r_1 + c_1) < [2(3r_2 + c_2) - \alpha] \Longrightarrow MR_2^B(\widehat{y}_1, \widehat{y}_2) > c_2, \tag{16}$$

regardless of the value of λ. Thus $\widehat{y}_2 = \widehat{K}_2$ is indeed optimal. The three parameter conditions obtained can be combined into a single condition:

$$(r_1 + c_1) \in \left([2(r_2 + c_2) - \alpha], \min\left\{\tfrac{1}{3}[\alpha + 2(r_2 + c_2)], [2(3r_2 + c_2) - \alpha]\right\}\right),$$

thus completing the proof.

Proof of Proposition 1 (*Competitive advantage of firm* 2**).** Using Lemma 1 gives an expression for firms' relative market shares:

$$\kappa_2 \equiv \frac{\widehat{y}_2}{\widehat{y}_1} = \frac{[2(\alpha - r_2 - c_2) - (\alpha - r_1 - c_1)]}{[(2 - \lambda)(\alpha - r_1 - c_1) - (\alpha - r_2 - c_2)]} = \frac{(2\varphi_2/\varphi_1 - 1)}{[(2 - \lambda) - \varphi_2/\varphi_1]}, \tag{17}$$

where $\varphi_j \equiv (\alpha - r_j - c_j)$ for $j = 1, 2$. Rearranging this expression shows that $\kappa_2 > 1 \Longleftrightarrow 3\varphi_2/\varphi_1 > (3 - \lambda)$, from which the claims follow immediately.

Proof of Proposition 2 (*Comparative statics of the strategic effect***).** It follows from Lemma 1, by inspection, that $\widehat{y}_1$ falls with λ while $\widehat{y}_2$ rises with λ, so that firm 2's market share rises with λ. Firm 2's equilibrium profits are $R_2^B(\widehat{y}_1, \widehat{y}_2) - (r_2 + c_2)\widehat{y}_2 = \beta(1 - \lambda)(\widehat{y}_2)^2$, since $MR_2^B + \beta\lambda y_2 = \widehat{p}^B - \beta(1 - \lambda)\widehat{y}_2 = r_2 + c_2$ by (5), and are easily checked to rise with $\lambda \in (0, \frac{1}{2})$.

Using Lemma 1, equilibrium outputs by both firms in market B satisfy

$$\widehat{y}_1 + \widehat{y}_2 = \frac{[(1+\lambda)\,\varphi_1 + \varphi_2]}{\beta(3-2\lambda)}. \tag{18}$$

Total output rises with λ, so the price $\widehat{p}^B$ falls with λ as claimed. Firm 1's equilibrium profits from market B are $R_1^B(\widehat{y}_1, \widehat{y}_2) - (r_1 + c_1)\widehat{y}_1 = \beta(\widehat{y}_1)^2$, since $MR_1^B = \widehat{p}^B - \beta\widehat{y}_1 = r_1 + c_1$ by (3), and decline with λ since $\widehat{y}_1$ falls with λ. Let firm j's market share $s_j \equiv y_j/(y_1 + y_2)$ so the Herfindahl index $H \equiv \sum_j s_j^2$ can, at equilibrium, be written as $H(\lambda) = 1 - 2\widehat{s}_2(\lambda)[1 - \widehat{s}_2(\lambda)]$. Differentiation gives $H'(\lambda) = -\widehat{s}_2'(\lambda)[1 - 2\widehat{s}_2(\lambda)]$, so since $\widehat{s}_2'(\lambda) > 0$ by the previous argument, $H'(\lambda) > 0 \Longleftrightarrow \widehat{s}_2(\lambda) > \frac{1}{2} \Longleftrightarrow \kappa_2 > 1$, yielding the result.

Proof of Proposition 3 (*Complementarity in competitive advantage*). The expression for relative market shares $\kappa_2 \equiv \widehat{y}_2/\widehat{y}_1$ from (17) is, by inspection, increasing in φ_2/φ_1 and λ, respectively. Differentiating with respect to λ gives:

$$\frac{\partial \kappa_2}{\partial \lambda} = \frac{(2\varphi_2/\varphi_1 - 1)}{[(2-\lambda) - \varphi_2/\varphi_1]^2} > 0, \tag{19}$$

which is positive because $\varphi_2/\varphi_1 > \frac{1}{2}$ follows from the parameter condition of Lemma 1 (where it is necessary for firm 2 to be active). Differentiating again shows that:

$$\begin{aligned}\frac{\partial^2 \kappa_2}{\partial \lambda \partial(\varphi_2/\varphi_1)} &= \frac{2\,[(2-\lambda) - \varphi_2/\varphi_1] + 2\,(2\varphi_2/\varphi_1 - 1)}{[(2-\lambda) - \varphi_2/\varphi_1]^3} \\ &= \frac{2\,(1 - \lambda + \varphi_2/\varphi_1)}{[(2-\lambda) - \varphi_2/\varphi_1]^3} > 0, \end{aligned} \tag{20}$$

which is also positive since $\lambda \in (0, \frac{1}{2})$ by Lemma 1. This positive cross-partial here means that κ_2 is supermodular in $(\varphi_2/\varphi_1, \lambda)$.

Proof of Lemma 2 (*Pass-through and value capture***).** The cost pass-through rate $\rho^A \equiv d\widehat{p}^A/dMC = 1/(2 - \xi^A)$ in a monopoly market is a standard result which follows from its first-order condition (3). It satisfies $\rho^A \in (0,1)$ due to the assumption that demand is log-concave, $\xi^A < 1$. Think of the equilibrium price in market A as $\widehat{p}^A(MC)$, with corresponding optimal output $\widehat{x}_1(MC)$, and write consumer surplus $\widehat{S}^A = \int_0^{\widehat{x}_1} \left[p^A(z) - \widehat{p}^A\right] dz$ and firm 1's optimal profits $\widehat{\Pi}_1^A = [\widehat{p}^A(MC) - MC]\widehat{x}_1$. Now consider the thought experiment of a small increase in MC, which results in a small decrease in output, $d\widehat{x}_1/dMC < 0$, at equilibrium (since pass-through is positive and demand is downward-sloping). This affects consumer surplus according to $d\widehat{S}^A/dMC = -(d\widehat{p}^A/dMC)\widehat{x}_1 = -\rho^A\widehat{x}_1$. By the envelope theorem, profits change only by the direct effect, $d\widehat{\Pi}_1^A/dMC = -\widehat{x}_1$. Hence the total value, i.e., the sum of consumer surplus and firm profits, created by the last unit of output at equilibrium is $(d\widehat{S}^A/dMC)/(d\widehat{x}_1/dMC) + (d\widehat{\Pi}_1^A/dMC)/(d\widehat{x}_1/dMC)$, and the fraction of this total value that is captured by the firm is $d\widehat{\Pi}_1^A/(d\widehat{S}^A + d\widehat{\Pi}_1^A) = 1/(1 + \rho^A)$, as claimed.

Proof of Lemma 4 (*Demand shift***).** The equilibrium in market A is defined by firm 1's first-order condition $MR_1^A(\widehat{x}_1) = r_1 + c_1$ from (3). For part (a), differentiation gives the impact of a small demand increase on output:

$$\frac{d\widehat{x}_1}{d\theta} = \left.\frac{p_\theta^A + x_1 p_{x\theta}^A}{-\left(2p_x^A + x_1 p_{xx}^A\right)}\right|_{x_1=\widehat{x}_1} = \left.\frac{p_\theta^A(1+\eta_\theta^A)}{(-p_x^A)(2-\xi^A)}\right|_{x_1=\widehat{x}_1}, \tag{21}$$

using the definitions of η_θ^A and ξ^A. The denominator is strictly positive by the maintained assumption that demand is log-concave, $\xi^B < 1$. The change in output due to a demand shift from θ' to θ'' is given by $\left[\widehat{x}_1(\theta'') - \widehat{x}_1(\theta')\right] = \int_{\theta'}^{\theta''}\left[\frac{d\widehat{x}_1}{d\theta}(\theta)\right]d\theta$, leading to the first result. Using (21), the impact of a small demand increase on the equilibrium price is:

$$\frac{d\widehat{p}_1^A}{d\theta} = p_\theta^A + p_x^A\frac{d\widehat{x}_1}{d\theta} = p_\theta^A - \frac{p_\theta^A + x_1 p_{x\theta}^A}{(2-\xi^A)} = \frac{p_\theta^A\left[(1-\xi^A)-\eta_\theta^A\right]}{(2-\xi^A)}, \tag{22}$$

again with all terms evaluated at $x_1 = \widehat{x}_1(\theta)$. The result follows from $\left[\widehat{p}_1^A(\theta'') - \widehat{p}_1^B(\theta')\right] = \int_{\theta'}^{\theta''}\left[\frac{d\widehat{p}_1^A}{d\theta}(\theta)\right]d\theta$. For part (b), on the output side, the sufficient condition $\eta_\theta^A > 1$ for all $\theta \in [\theta', \theta''] \implies \widehat{x}_1(\theta'') > \widehat{x}_1(\theta')$ is immediate. On the price side, the sufficient condition $\eta_\theta^A < (1-\rho^A)/\rho^A$ for all $\theta \in [\theta', \theta'']$ follows since $\xi^A = 2 - 1/\rho^A$.

Proof of Proposition 4 (*Short-run impacts*). The initial equilibrium is $\widehat{x}_1(\theta')+\widehat{y}_1(\theta') = \widehat{K}_1$ and $\widehat{y}_2(\theta') = \widehat{K}_2$ by Lemma 1. Begin with the optimal strategy for firm 2 following the demand shift to θ''. It maximizes short-run profits $\max_{y_2}\left\{R_2^B(y_1,y_2) - c_2 y_2\right\}$ subject to the capacity constraint $y_2 \le \widehat{K}_2$. Its marginal profit from an additional unit of output thus equals $MR_2^B(y_1,y_2) - c_2$, which does not depend directly on θ''.

Previously under θ', its marginal profit was $MR_2^B + \beta\lambda y_2 - (r_2+c_2)$. In the initial equilibrium, this was equal to $MR_2^B(\widehat{y}_1, \widehat{K}_2) + \beta\widehat{K}_2\ \lambda|_{x_1=\widehat{x}_1(\theta')} - (r_2+c_2) = 0$, by its first-order condition from (5). Recall that firm 2's capacity constraint was binding, which required $MR_2^B(\widehat{y}_1, \widehat{K}_2) - c_2 > 0 \iff [\beta\widehat{K}_2\ \lambda|_{x_1=\widehat{x}_1(\theta')} - r_2] < 0$ (see Lemma 1's proof).

Comparing marginal profits, $MR_2^B(y_1,y_2) - c_2 \ge MR_2^B(\widehat{y}_1,\widehat{K}_2) - c_2 + [\beta\widehat{K}_2\ \lambda|_{x_1=\widehat{x}_1(\theta')} - r_2]$ holds if $y_1 \le \widehat{y}_1(\theta')$ (since $y_2 \le \widehat{K}_2$ by its capacity constraint). In other words, it is certainly optimal for firm 2 to again sell up to capacity at θ'' whenever firm 1's output is no greater than it was at θ'.

Now consider firm 1. By Lemma 2, $\eta_\theta^A > -1$ for all $\theta \in [\theta', \theta'']$ is equivalent to $\frac{\partial}{\partial\theta}MR_1^A(x_1;\theta) > 0$ for all $\theta \in [\theta', \theta'']$. So the shift from θ' to θ'' raises $MR_1^A(x_1;\theta)$ (given x_1) but again has no direct effect on $MR_1^B(y_1,y_2)$.

The assumption of an interior solution implies that, taking its rival's y_2 as given, firm 1 maximizes its short-term profits by equalizing marginal revenue across markets, $MR_1^A(x_1;\theta'') = MR_1^B(y_1,y_2)$. Previously under θ', its optimal strategy was $MR_1^A(x_1;\theta') = MR_1^B(y_1,y_2)$. Since $\frac{\partial}{\partial\theta}MR_1^A(x_1;\theta) > 0$, it follows that, for any given y_2, firm 1's optimal x_1 is now higher than before, while its optimal y_1 is now lower (because of its capacity constraint).

The short-run "equilibrium" thus has $\widetilde{x}_1(\theta'') > \widehat{x}_1(\theta')$ and $\widetilde{y}_1(\theta'') < \widehat{y}_1(\theta')$, with $\widetilde{x}_1(\theta'') + \widetilde{y}_1(\theta'') = \widehat{K}_1$, for firm 1, and $\widetilde{y}_2(\theta'') = \widehat{y}_2(\theta') = \widehat{K}_2$ for firm 2.

Finally, confirm that it is also optimal for firm 1 to fully use its installed capacities. Firm 1's marginal revenues in this allocation $MR_1^A(\widetilde{x}_1(\theta'');\theta'') = MR_1^B(\widetilde{y}_1(\theta''),\widehat{K}_2) > MR_1^A(\widehat{x}_1(\theta');\theta') = MR_1^B(\widehat{y}_1(\theta'),\widehat{K}_2)$ are both higher than before, so it is again optimal to fully use capacity.

From these results, it is immediate that firm 2's share of market B has risen, and that the price has also increased, $\widetilde{p}^B(\theta'') = p^B(\widetilde{y}_1(\theta'')+\widetilde{y}_2(\theta'')) > \widehat{p}^B(\theta')$ (from Lemma 1), thus completing the proof.

Proof of Proposition 5 (*Demand shift and the strategic effect*). For part (a), write $\left[\lambda\left(\theta''\right) - \lambda\left(\theta'\right)\right] = \int_{\theta'}^{\theta''}\left[\lambda'(\theta)\right]d\theta$ and differentiate $\lambda(\theta) = \beta/[2\beta + \left(-p_x^A\left(\theta\right)\right)\left(2-\xi^A\left(\theta\right)\right)]$ to give:

$$\lambda'(\theta) = \frac{\beta\frac{d}{d\theta}\left[\left(-p_x^A\left(\theta\right)\right)\left(2-\xi^A\left(\theta\right)\right)\right]}{\left[2\beta + \left(-p_x^A\left(\theta\right)\right)\left(2-\xi^A\left(\theta\right)\right)\right]^2}. \tag{23}$$

Consider the components of $\frac{d}{d\theta}\left[\left(-p_x^A\left(\theta\right)\right)\left(2-\xi^A\left(\theta\right)\right)\right]$ in turn:

$$\begin{aligned}
\frac{d}{d\theta}\left(-p_x^A\left(\theta\right)\right) &= \left(-p_{x\theta}^A\right) + \left(-p_{xx}^A\right)\frac{dx_1}{d\theta} \\
&= \left(-p_{x\theta}^A\right) + \left(-p_{xx}^A\right)\frac{\left(p_\theta^A + x_1 p_{x\theta}^A\right)}{\left(-p_x^A\right)\left(2-\xi^A\right)} \\
&= \left(-p_{x\theta}^A\right) - \frac{\xi^A\left(p_\theta^A + x_1 p_{x\theta}^A\right)}{\left(2-\xi^A\right)x_1} \text{ since } \xi^A \equiv -p_{xx}^A x_1/p_x^A \\
&= -\frac{1}{\left(2-\xi^A\right)}\left[\xi^A\frac{p_\theta^A}{x_1} + 2p_{x\theta}^A\right] \\
&= -\frac{1}{\left(2-\xi^A\right)}\frac{p_\theta^A}{x_1}\left(\xi^A + 2\eta_\theta^A\right) \text{ since } \eta_\theta^A \equiv p_{x\theta}^A x_1/p_\theta^A.
\end{aligned} \tag{24}$$

Next, observe that $\frac{d}{d\theta}\left[\left(2-\xi^A\left(\theta\right)\right)\right] = -\frac{d}{d\theta}\xi^A\left(\theta\right)$. Combining these results,

$$\frac{d}{d\theta}\left[\left(-p_x^A\left(\theta\right)\right)\left(2-\xi^A\left(\theta\right)\right)\right] = -\frac{p_\theta^A}{x_1}\left(\xi^A + 2\eta_\theta^A\right) - \left(-p_x^A\right)\frac{d}{d\theta}\xi^A\left(\theta\right), \tag{25}$$

and therefore

$$\lambda'(\theta) = -\left(\frac{\beta\left[\frac{p_\theta^A}{x_1}\left(\xi^A\left(\theta\right) + 2\eta_\theta^A\left(\theta\right)\right) + \left(-p_x^A\right)\frac{d}{d\theta}\xi^A\left(\theta\right)\right]}{\left[2\beta + \left(-p_x^A\left(\theta\right)\right)\left(2-\xi^A\left(\theta\right)\right)\right]^2}\right) \tag{26}$$

which yields the necessary and sufficient condition for $\lambda\left(\theta''\right) = \lambda\left(\theta'\right) + \int_{\theta'}^{\theta''}[\lambda'\left(\theta\right)]d\theta \le \lambda\left(\theta'\right)$. For part (b), the sufficient conditions in terms of cost pass-through, recall that $\xi^A = 2 - 1/\rho^A$, so $\xi^A + 2\eta_\theta^A = 2(1+\eta_\theta^A) - 1/\rho^A$ and $\frac{d}{d\theta}\xi^A\left(\theta\right) = -\frac{d}{d\theta}\left(1/\rho^A\right)$. Then it is clear that jointly sufficient for $\lambda\left(\theta''\right) < \lambda\left(\theta'\right)$ are $\rho^A < \frac{1}{2}\left(1+\eta_\theta^A\right)^{-1}$ together with $\frac{d}{d\theta}\left(1/\rho^A\right) \ge 0 \iff d\rho^A/d\theta \le 0$, for all $\theta \in [\theta',\theta'']$. Finally, $\rho^A < \frac{1}{2} \iff \xi^A < 0$ and $\eta_\theta^A \le 0 \iff p_{x\theta}^A \le 0$ jointly imply $\rho^A < \frac{1}{2}\left(1+\eta_\theta^A\right)^{-1}$.