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Reinforcing buyer power: Trade quotas and supply diversification in the EU natural gas market

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Abstract in English

We consider a market with concentrated domestic buyers and concentrated foreign sellers and explore the extent to which domestic regulation helps to increase the buyers' countervailing power against the foreign sellers. We use the Shapley value to describe the distribution of the trade surplus and market power in this bilateral oligopoly. With the EU natural gas market in mind, we consider how a regulator (the EU) can use import quotas and encourage supply diversification to strengthen the buyers' power and increase their surplus. We find that buyers can benefit from bilateral but not aggregate trade restrictions. Those who invest in supply diversification gain, with other buyers enjoying positive externalities; sellers lose profits and power. Thus we provide a rationale for the current EU support for importers' investment plans.

Keywords: buyer power, Shapley value, strategic trade policy, natural gas market.
JEL classification: F12, L12, L41, C71, Q48.

Abstract in Dutch

We beschouwen een markt waarin binnenlandse inkopers onderhandelen met buitenlandse verkopers en we onderzoeken of regulering van de inkopers hun gezamenlijke inkoopmacht tegenover de verkopers kan vergroten. De verdeling van de markmacht tussen inkopers en verkopers beschrijven we met de Shapley value. Deze analyse is in het bijzonder relevant voor de Europese gasmarkt: in hoeverre kan de EU importquota of beleid tot diversificatie van de gasaanvoer benutten om inkoopmacht te versterken? We tonen aan dat bilaterale handelsquota een effectief instrument daartoe kunnen vormen; een beperking van de totale EU-gasimport van een gegeven aanbieder is dat niet. Voorts laten we zien dat externaliteiten tussen inkopers EU-ondersteuning van de aanleg van nieuwe importinfrastructuur rechtvaardigen.

Steekwoorden: Inkoopmacht, Shapley value, Handelsbeleid, Gasmarkt.

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Summary

We study an international market with a few concentrated producers who possess seller power. The sellers trade with concentrated buyers, who also have a strong position and can exercise buyer power.

This trade structure, referred to as *bilateral oligopoly*, characterises many markets for natural resources, where production is concentrated in only a few countries and the buying side is dominated by large importers who act as gatekeepers to final consumers. We explore how buying countries can use trade policy to improve the negotiating position of their buyers.

The market that motivates our analysis is the natural gas market in the European Union (EU). In the face of growing demand for natural gas and declining indigenous gas production, the growing dependency of EU member countries on non-EU gas exporters is raising concern and has engendered a vigorous energy security debate.

EU policy makers face the challenge of mitigating the exposure to foreign market power. One way of achieving this is by reinforcing the buyer power of the importers. In its second Strategic Energy Review, the European Commission (2008c) stresses the importance of cooperation among Member States and of efforts to diversify natural gas imports. In this paper, we explore more generally how domestic (EU) trade policy can strengthen buyers' positions vis-à-vis the foreign sellers, thereby enhancing buyer welfare. We focus on two policies that have already actually been adopted in some form: i) trade quotas, which restrict imports from sellers with significant market power, and ii) investment stimulation measures aimed at providing market access to new sellers. Both policies – if properly implemented – are indeed shown to raise joint buyer surplus.

We find that in a bilateral oligopoly, a constraint on the quantity contracted by any buyer-seller pair strengthens the position of rival buyers negotiating with the same seller. The intuition for this result is that the constraint limits competition among buyers: when failing to reach an agreement with a given buyer, the seller cannot compensate its loss by increasing its sales to rival buyers. In the EU gas market example, a cap on Russia's sales to, say, Italy makes Germany stronger in its negotiations with Russia. Russia's outside option – exports to Italy – becomes less valuable as a consequence of the cap. Although a cap lowers the achievable surplus for the buyer that it affects directly, we show that (as a result of this spill-over effect) there can be combinations of bilateral caps for which the sum of positive and negative effects for each buyer is positive. In such a case, all buyers will be better off by agreeing on this set of trade restrictions. In particular, we show that in the bargaining model we analyse, a sufficient condition for such beneficial sets of caps to exist is simply that the number of buyers exceeds the number of sellers. For the case of monopsony (i.e. a single buyer), the spill-over effect is absent and an import quota is never attractive. We also find that a simple cap on the *aggregate* exports of one seller to all buyers can never be beneficial.

The second policy would encourage diversification by supporting investments in supply infrastructure, thereby enabling access of new exporting countries to the market. For instance, EU natural gas importers plan to invest in various pipeline projects, such as the Nabucco and Trans-Caspian pipelines, in order to bring natural gas from the Caspian region to Europe, bypassing Russia. These projects receive support from the European Commission. Again, the focus is on how such investment affects buyer power, and in particular why the EU should feel obliged to support such private sector projects. We show that investments in new supply sources have positive spill-over effects on the bargaining positions of those buyers that do not directly trade with the new seller. Therefore, if one buyer expands its import capacity from a new seller, then all of the other buyers, who do not directly have access to the new supply source, will also become stronger. For the natural gas example considered above, Russia's potential gains from trading with Italy will decrease if Italy can buy gas from elsewhere (even if at higher prices). As a consequence, other buyers (such as Germany) also enjoy increased bargaining power when negotiating with Russia. This bargaining-power effect warrants buyers' cooperation in increasing import capacities beyond the level an individual member state would choose. We find that EU coordination on diversification policies may indeed lead to increased rents for all EU buyers.

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1 Introduction

We study an international market with a few concentrated producers who possess market power (which in this paper will be referred to as *seller power*). The sellers trade with concentrated buyers, who also have a strong position and can exercise *buyer power*.

This trade structure, referred to as *bilateral oligopoly*, characterises many markets for natural resources, where production is concentrated in only a few countries and the buying side is dominated by large importers who act as gatekeepers to final consumers. We explore how buying countries can use trade policy to improve the negotiating position of their buyers.

The market that motivates our analysis is the natural gas market in the European Union (EU). In the face of growing demand for natural gas and declining indigenous gas production, the growing dependency of EU member countries on non-EU gas exporters[1] is raising concern and has engendered a vigorous energy security debate[2].

The lion's share of the EU natural gas imports is produced in Russia (45%); the rest comes from Algeria (19%), Norway (27%) and several smaller producers of liquefied natural gas (LNG). The high concentration on the seller side has resulted in significant seller market power (Smeers, 2008). Yet, the seller concentration is met by a highly concentrated demand side. As the EU Commission notes in its 2007 Energy Market Report, "With very few exceptions, electricity and gas markets in the EU remain national in economic scope with limited competition", whilst the HHI in production and imports for most national markets within the EU is larger than 5000 (European Commission, 2008b). The limited competition could be explained by bottlenecks in transport infrastructure between markets, by the reluctance of end-users to switch their supplier, or by anticompetitive collusion between the major players.[3] Thanks to the strong market position of the domestic buyers – often described as national champions – foreign sellers face a stiff negotiator when trying to access the consumer markets.

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[1] In 2008, the EU imported over 70% of its gas consumption, and the figure is increasing (BP, 2008).

[2] See e.g. CIEP (2004), Helm (2007), Röller et al. (2007)

[3] In case COMP/39.401, the Commission fined German E.ON Ruhrgas AG and French Gaz de France (GDF) 553 million euro each for an agreement not to sell in each other's home market (European Commission, 2009a).

shown to raise joint buyer surplus.

In the EU gas market, the policy of capping imports has already been implemented on a national level in Spain[4], a country that relies mainly on Algeria for its gas supplies. Spain's Hydrocarbons Sector Law, introduced in 1998, obliges gas marketers to limit their imports from any single country to 60% of their total portfolio. This has compelled market players to turn to other (often more expensive) sellers and has helped to diversify Spanish supplies: the Algerian share of supplies to Spain dropped from 60% in 2000 to only one-third in 2008 (CNE, 2008). However, while caps have successfully reduced seller concentration, have they also allowed Spain to improve its bargaining position with its foreign sellers? And would it be wise for the EU to adopt a similar regulation? We address this question by analysing how two policies affect the importers' position: i) constraints on imports by any individual EU firm from a given exporter and ii) restrictions on aggregate export from a given seller to the EU.

We find that in a bilateral oligopoly, a constraint on the quantity contracted by any buyer-seller pair strengthens the position of rival buyers negotiating with the same seller. The intuition for this result is that the constraint limits competition among buyers: when failing to reach an agreement with a given buyer, the seller cannot compensate its loss by increasing its sales to rival buyers. In the EU gas market example, a cap on Russia's sales to, say, Italy makes Germany stronger in its negotiations with Russia. Russia's outside option – exports to Italy – becomes less valuable as a consequence of the cap. Although a cap lowers the achievable surplus for the buyer that it affects directly, we show that (as a result of this spill-over effect) there can be combinations of bilateral caps for which the sum of positive and negative effects for each buyer is positive. In such a case, all buyers will be better off by agreeing on this set of trade restrictions. In particular, we show that in the bargaining model we analyse, a sufficient condition for such beneficial sets of caps to exist is simply that the number of buyers exceeds the number of sellers. For the case of monopsony (i.e. a single buyer), the spill-over effect is absent and an import quota is never attractive. We also find that a simple cap on the *aggregate* exports of one seller to all buyers can never be beneficial.

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[4] A similar approach was adopted by Portugal and Poland (European Commission, 2009b).

new seller, then all of the other buyers, who do not directly have access to the new supply source, will also become stronger. For the natural gas example considered above, Russia's potential gains from trading with Italy will decrease if Italy can buy gas from elsewhere (even if at higher prices). As a consequence, other buyers (such as Germany) also enjoy increased bargaining power when negotiating with Russia. This bargaining-power effect warrants buyers' cooperation in increasing import capacities beyond the level an individual member state would choose. We find that EU coordination on diversification policies may indeed lead to increased rents for all EU buyers.

Our work builds on the industrial organization (IO) literature on buyer power. The concept of buyer power (also known as countervailing power) was suggested by Galbraith (1952) to describe the ability of buyers to extract higher rents from sellers. A growing body of industrial organization literature offers a range of bargaining models that attempt to explain when and why buyers possess such power[5]. Many of these studies aim to understand what characteristics drive buyer power (e.g. Tyagi, 2001; Engle-Warnick and Ruffle, 2005; Snyder, 1998). Some works go further and investigate how market players can strategically affect the distribution of power. Horn and Wolinsky (1988), for instance, look at strategic cooperation, Inderst and Wey (2003) consider effects of merger and investments in efficiency, and Farber (1981) studies how R&D efforts may serve to increase buyer power.

Our work uses as a starting point this IO literature – particularly the contribution by Inderst and Wey (2003), who demonstrate how bargaining in bilateral oligopoly can be described in terms of the Shapley value. We extend their work by assuming that competing players (on either side of the bilateral oligopoly) are subject to some common policy. The novel question we raise is how such a policy imposed on one side may help to improve that side's bargaining position. In particular, we explore how countries can use strategic trade policy to tilt the bargaining power in favour of their domestic buyers. This extends the IO literature, which typically focuses on strategies available to individual players to increase their bargaining power.

In considering the effects of trade policy, our analysis is related to the literature on strategic trade policy under imperfect competition that was initiated by the works of Brander and Spencer (1981) and Eaton and Grossman (1986). So far, the effects of domestic trade policies on the extent of buyer power remain underexplored[6]. Among the first to address the issue of buyer power in an international trade context were Deardorff and Rajaraman (2009); Oladi and Gilbert (2009) and Raff and Schmitt (2009).[7] The first of these studies analyzes optimal export subsidies

[5] Snyder (2005) and Inderst and Mazzarotto (2008) provide comprehensive overviews of studies focused on various aspects of buyer power (e.g. size discounts, buyer/seller concentration, and choice of contracts). Ruffle (2009) surveys experimental evidence.

[6] Recently, bargaining power and geopolitical relations have received some attention in the political economy literature (e.g. Victor et al., 2008). Such studies, however, contain predominantly qualitative and descriptive analyses.

[7] Another work loosely related to the issue is Basker and Van (2008), which studies the relation between monopsony power of the Wal-Mart retail chain and growth of US-China trade.

when domestic competitive exporters face a foreign monopsony. Oladi and Gilbert (2009) expand this analysis to consider strategic interactions between different governments' export policies. Raff and Schmitt (2009) study the interactions of a domestic and a foreign producer with local retailers. The authors demonstrate how trade liberalization can weaken retail competition in the presence of buyer power, but do not consider how trade policy can affect buyer power itself. In these three contributions, buyers have all of the bargaining power.

The contribution of our paper to the strategic trade policy literature is that we look at bilateral oligopoly where the bargaining power of buyers and sellers is more evenly distributed. We then explore how the balance of power is affected by trade policy measures. Secondly, we assume that in the bargaining game players are not restricted to offering simple prices or quantities, but can negotiate efficient non-linear contracts to extract higher rents without compromising efficiency. Such non-linear contracts are common in reality, in environments where powerful buyers and sellers negotiate bilaterally.[8] While such contracts are often considered in the IO literature on buyer power, they are rarely taken into account in the strategic trade policy literature (Raff and Schmitt, 2009, is an exception). A standard result in the strategic trade literature is that imposing quantity restrictions cannot be an optimal policy in the face of foreign producers' market power[9]. However, this argument hinges on the assumption that foreign sellers must reduce sales below efficient levels to extract rents. In that case, any further reduction of quantities through quotas could not improve buyer welfare. In contrast, by allowing for non-linear contracts, we relax the assumption that rent extraction goes hand-in-hand with supply restriction. We find that in our model, quantity restrictions can have positive impact on buyer surplus.

In its application, this paper relates to the literature on market power on the European natural gas market. Also here, recent work predominantly considers the situation in which sellers have all the power and buyers are price-takers[10]. This assumption can hardly be justified in practice (see Smeers, 2008, for a similar critique). Our approach relaxes this assumption of unilateral market power and instead develops a more balanced description of buyer and seller relations. Here we follow the line of research adopted in Hubert and Ikonnikova (2010, 2004) and Hubert and Suleymanova (2006), modelling the gas market bargaining game using cooperative game

[8] In the natural gas markets, contracts are usually "take-or-pay" contracts; see, for example, Asche et al. (2002). Also contracts between supermarkets and their suppliers often feature non-linearities, such as quantity discounts or slotting fees (Competition Commission, 2007).

[9] see e.g. Brander (1995, p.1434), who explains that "a quota set below the free trade level of imports has the primary effect of moving the foreign firms closer to the jointly optimal (collusive) output level, and is therefore a facilitating device for collusion."

[10] Most of these studies, starting with the contributions of Mathiesen et al. (1987) and Golombek et al. (1995, 1998), describe producers as Cournot players, and treat buyers as price-takers. Haurie et al. (1987) extended their analysis to allow for stochastic demand. An advantage of such models is that they can be straightforwardly extended to incorporate more detailed descriptions of transport and storage markets. Gabriel and Smeers (2006) provide a survey of the earlier literature, and some recent studies that focus on the European market include Boots et al. (2004), Egging and Gabriel (2006), Holz et al. (2008) and Lise et al. (2008). Inclusion of resource rent considerations in such models is addressed in Zwart and Mulder (2006) and Zwart (2009).

theory. The authors describe the distribution of bargaining power in negotiations between Russia and the Eastern European countries transiting its gas, and explore how investments in pipelines alter this power distribution. In the present study, in contrast, we examine how policy coordination among various gas buyers can change the bargaining game itself and lead to increased surplus shares for the buyers.

The paper is organized as follows. We first discuss the bilateral oligopoly model and its solution – the Shapley value – that we use for defining the distribution of the trade surplus. We then turn to explore how buyer policies can improve buyer bargaining positions. First, looking at the case where buyers can cooperate, we check whether in that situation import caps will strengthen buyers. Since objections may be made regarding the feasibility of such cooperation, the paper proceeds with an analysis of caps and investments when all buyers negotiate individually. We provide some general results on when such policies might help, and when they are ineffective. To illustrate the approach and provide some quantitative intuition, we conclude with a stylized numerical model that roughly captures the supply and demand structure of the EU gas market.

2 The bargaining model

We start our analysis with the description of the market game. The market under consideration has a small number of domestic buyers who buy from a small number of foreign sellers. For the gas market application that we have in mind, note that the EU natural gas market is characterized by few concentrated importers (such as French GdF-Suez, Italian Eni, or Germany's RWE and E.On-Ruhrgas) contracting with a small number of concentrated non-EU sellers (such as Russian Gazprom, Algerian Sonatrach and Norwegian StatoilHydro).[11] We denote the set of buyers by B, with $b_i \in B$ for an individual importer, and the set of sellers by S, with $s_i \in S$.

Each buyer is engaged in negotiations of supply contracts with all of the sellers. We allow supply contracts to be non-linear, enabling trading partners to realize the full trade surplus[12]. Following Stole and Zwiebel (1996a) and Inderst and Wey (2003), we describe the market game as a multilateral bargaining game.

Essentially, the market players $N = B \cup S$ bargain over how the trade surplus will be shared. A group of players generates some trade surplus when it includes at least one buyer contracting with at least one seller. A group of players bound by contracts will be designated as a coalition $M \subseteq N$. For every possible coalition M we define its value as the maximum feasible trade surplus $v(M)$ that equals the sum of the (gross) surpluses of producers $S \cap M$ and buyers $B \cap M$ who are part of that coalition. The function v is called a value or characteristic function of the game.[13]

A general cooperative solution for a game in characteristic function form is the Shapley value (Shapley, 1953). The Shapley value determines how trade surplus is distributed among the players in the market. Formally, the Shapley value assigns to player p a pay-off ϕ_p, defined as a weighted average of p's marginal contributions to all possible coalitions $M \subseteq N \setminus p$:

$$\phi_p = \sum_M \mathscr{P}(M)\left[v(M \cup p) - v(M)\right], \tag{2.1}$$

where $\mathscr{P}(M) = |M|!\,(|N| - |M| - 1)!/|N|!$ is the weight for coalition M, with $|\cdot|$ denoting the number of players in the set.[14]

The Shapley value captures the idea that player i's bargaining position vis-à-vis player j

[11] These supplying companies are monopolistic state-controlled companies; they will therefore be referred to using country names; e.g. Russia rather than Gazprom.

[12] This assumption is not unrealistic in the international wholesale gas market, with complex take-or-pay contracts ruling out double marginalization problems. Contracts are agreed bilaterally and will differ for different buyers; see Asche et al. (2002), Hubert and Ikonnikova (2010). They closely resemble efficient (non-linear) quantity forcing contracts (as also pointed out in Smeers, 2008).

[13] In the gas market, buyer surplus might, for instance, be thought of as profit of the gas importer on his national market, or as the consumer welfare generated by the incumbent retailer's supply of gas to his country's end-users. Seller surplus may also be identified with profits, or perhaps other benefits that the (state) owner of the resources may derive from selling gas. We provide an illustrative example in section 4.

[14] In a non-cooperative random-order sequential bargaining implementation, this factor $\mathscr{P}(M)$ could be interpreted as the probability of coalition M preceding player p.

improves if there are more players offering services that are similar to j's offer. And likewise, player i's bargaining position worsens if more players offer services that are similar to those of i. The presence of substitute players in the coalition reduces the contribution, and hence the pay-off, of a given player. Typically, the presence of a larger number of substitute players at the negotiation table makes the outside options to one's negotiating partner more attractive, and one's own bargaining position weaker. Aside from such differences in outside options, bargaining power is symmetrically distributed in each bilateral bargaining relation. The Shapley value allows one to quantify the value of the outside option available to each player. Since $\sum \phi_p$ over all $p \in N$ gives $v(N)$, by dividing $\frac{\phi_p}{v(N)}$ we obtain a power index, which measures in percentage the market power of each player.

The Shapley value is widely used as a solution concept for multilateral bargaining games – for instance, in the theory of the firm (following the seminal paper by Hart and Moore, 1990), in the corporate finance literature (e.g. Bolton and Scharfstein, 1996), and in the industrial organization literature since Littlechild and Thompson (1977), with recent applications by Kranton and Minehart (2000); Segal and Whinston (2000) and Jeon (2006). The main advantage of the Shapley value is that it can be derived axiomatically so that the outcome of the game does not depend on the protocol of the negotiation process (about which often little is known). Axioms guarantee that the solution has some attractive properties: (i) players who do not bring value receive nothing, (ii) pay-offs depend only on a player's role in the game and his characteristics, but not his identity, and (iii) a player's share can be seen as an expected pay-off (given that players are risk neutral).[15] The game theory literature has also provided non-cooperative foundations of the Shapley value. Gul (1989) derives the Shapley value in a sequential trade situation. More directly relevant to our application, Inderst and Wey (2003) and De Fontenay and Gans (2005, 2007) provide explicit non-cooperative contracting frameworks in buyer-seller networks, and show that the Shapley value is the outcome of a bargaining game in which players have access to sufficiently complex (contingent) contracts[16].

In principle, the value of coalition M may depend on coalitions formed by outside players $N \setminus M$. However, in this study we avoid such contracting externalities by assuming that buyers have independent demand (i.e. they do not compete for end-users). As discussed in Inderst and Wey (2003), this assumption is valid for markets where buyers act in distinct geographic or product areas. Competition across coalitions would introduce externalities and prevent us from describing the game by a characteristic function and solving it by the Shapley value.[17] In the EU

[15] In addition, Myerson (1980) shows this is the unique rule with so-called balanced contributions: for any two players i and j, player i would lose as much if j withdraws from the game, as j would lose if i withdraws.

[16] Stole and Zwiebel (1996a) and Stole and Zwiebel (1996b) look at bilateral negotiations with a central player, assuming that all agreements can be renegotiated before any plans are executed. They prove that only the Shapley-sharing of profits is renegotiation-proof.

[17] See De Fontenay and Gans (2005, 2007) for an extension of the Shapley value for games with externalities.

gas market application, common practice at present has each importer buying gas for his national market, or his tied consumers, so that such externalities can indeed be neglected. The liberalization of the natural gas market presents a challenge to this situation – but, as pointed out in the introduction, competition among European gas incumbents thus far continues to be limited. Besides, after the liberalization, if importers can ensure sufficiently long-term contracts with their consumers, the assumption of independent demand would remain valid.

3 Regulation to increase buyer power

We proceed with the analysis of two policies that affect buyers' trading opportunities: import quotas and investment support. We assess how the buyers' bargaining power changes as a result of these policies.

To do so, we imagine a two-stage model. In the first stage, a regulatory authority (e.g. the domestic government, or the European Commission) establishes the rules that apply to the buyers. In the second stage, buyers and sellers trade and share profits subject to these rules. Of interest are those rules that can lead to higher buyer surplus in the second stage.

We first illustrate how import quotas can increase buyer surplus in a simple bilateral-oligopoly example. Then we proceed with an analysis of their effects in the general case. After exploring how trade quotas affect a monopsonist, the discussion turns to their effect on an oligopsony of buyers. We then explore the second policy measure, promotion of investments that lead to diversification of supplies.

3.1 A motivating example: quotas in the three buyers/three sellers case

The effects of bilateral trade quotas (i.e. quotas restricting trade between a given buyer-seller pair) can be illustrated in a simple way using a stylized model that captures bargaining among three buyers and three sellers. Assume that all sellers have the same quadratic production costs $c(q) = \frac{1}{2}cq^2$. All buyers have the same inelastic demand Q, with reservation price $\bar{p}$: each buyer's gross buyer surplus (or consumer surplus CS) of q units purchased from the strategic sellers equals $CS(q) = \bar{p}q$, as long as $q \leq Q$, and $CS(q) = \bar{p}Q$ otherwise[18]. By rescaling prices and quantities, we can restrict analysis to $c = 1$, $\bar{p} = 1$, so that the situation is in fact completely characterized by Q.

Consider a given coalition, with $s \leq 3$ sellers and $b \leq 3$ buyers[19]. Each seller cannot profitably sell more than $q = 1$ below the reservation price $\bar{p} = 1$, since for larger quantities marginal costs exceed 1. We can distinguish two situations, either $s > bQ$, where the s sellers can optimally satisfy total buyer demand, or $s < bQ$, where in the optimum each seller produces one unit and the buyers turn to the fringe market for buying the remainder.

We denote by q_b the total equilibrium quantity bought by each buyer from the sellers, and by q_s the aggregate equilibrium quantity sold by each seller. The quantity traded for each seller-buyer pair in the coalition equals, in the symmetric solution, $q_{pair} = q_b/s = q_s/b$. Total coalition surplus also only depends on the number of sellers s and buyers b in the coalition,

[18] $\bar{p}$ may be the price of the closest substitute for the good, or the price at which fringe sellers can enter the market. In the natural gas market, $\bar{p}$ could be the price at which liquefied natural gas (LNG) can be bought on the world market.

[19] Symmetry ensures that coalitions are completely characterized by the numbers s and b.

allowing us to denote it as $v(s,b) = bq_b - \frac{s}{2}q_s^2$. Summarizing, we have

	q_s	q_b	q_{pair}	$v(s,b)$
$Q < \frac{s}{b}$	$\frac{bQ}{s}$	Q	$\frac{Q}{s}$	$bQ\left(1-\frac{1}{2}\frac{bQ}{s}\right)$
$Q > \frac{s}{b}$	1	$\frac{s}{b}$	$\frac{1}{b}$	$\frac{s}{2}$

Aggregate buyer welfare is computed using the Shapley value, equation 2.1. With three buyers and three sellers, total buyer welfare ϕ_B equals

$$\begin{aligned}\phi_B =& \frac{1}{2}v(3,3) + \frac{3}{10}\left(v(2,3) - v(3,2)\right) \\ &+ \frac{3}{20}\left(v(1,3) - v(3,1)\right) + \frac{3}{20}\left(v(1,2) - v(2,1)\right).\end{aligned}$$

We can now straightforwardly compute the optimal symmetric constraints. A symmetric constraint of size K on each buyer-seller pair caps each bilaterally traded quantity $q_{pair} \leq K$. Such constraints therefore have an effect only in those coalitions (s,b) in which q_{pair} exceeds this value. With the constraint, $q_{pair} = K$ in those coalitions, while those coalitions involving smaller traded quantities remain unaffected. It is tedious but straightforward to compute total buyer welfare with constraints K, and to optimize over K. The optimum turns out to be $K = \frac{3}{11}$, at least as long as each buyer's demand $Q > \frac{9}{11}$. In equilibrium, each seller will sell $\frac{3}{11}$ to each buyer, and production is therefore inefficiently low. If $Q < \frac{9}{11}$, constraints never increase buyer surplus.

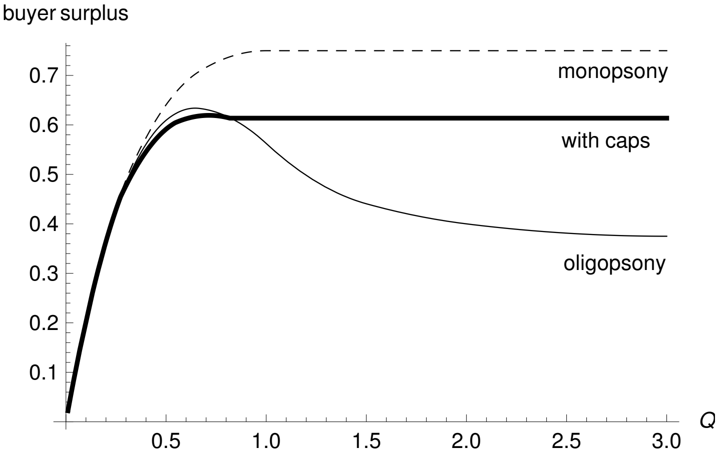
Figure 3.1 compares buyer surplus under optimal constraints and buyer surplus without constraints, as a function of the parameter Q. As a point of reference, we also include buyer surplus if the three buyers merge into one monopsonist buyer with demand $3Q$. The latter is determined by

$$\phi_{B,\text{monopsony}} = \frac{1}{4}v(3,1) + \frac{1}{4}v(2,1) + \frac{1}{4}v(1,1).$$

Observe that when demand Q is small, caps are ineffective but total buyer welfare is similar for all three cases. For large Q, however, bargaining power without constraints diminishes rapidly with Q. Whilst coordinating into monopsony is optimal for buyer power, optimal caps succeed in bridging a significant part of the gap between oligopsony and monopsony buyer welfare.

The results in this toy model suggest that caps may be particularly effective in those situations where the strategic sellers cannot by themselves meet all demand. Indeed, in that situation competition among sellers is least intense, as each seller's contribution is itself essential in meeting buyer demand. We will build on these results in section 4, where we adapt the current model, departing from the symmetry assumption and calibrating parameters to realistic demand and supply on the Western European market. We may also expect there that, if in equilibrium buyers need to resort to the outside (world LNG) market for part of their demand, then caps on imports from the strategic sellers may help in increasing buyer power.

Figure 3.1 Total buyer welfare, as a function of demand Q, for oligopsony without constraints (thin line), oligopsony with optimal caps (thick line), and monopsony (dashed line).



In the following sections, we will explore the benefits of trade restrictions more generally. We first analyse effects of import caps on buyers who can fully coordinate (e.g. because they have merged into monopsony). Then, we will turn to an analysis of trade restrictions in bilateral oligopoly, generalizing the results of the example.

3.2 Coordination and import caps

Merger among buyers is a mechanism for increasing buyer power that has received a great deal of attention (for example, Inderst and Wey, 2003; Engle-Warnick and Ruffle, 2005). Segal (2003) provides a general analysis of cooperation among players in random-order bargaining games, including the Shapley value. He finds that if cooperation among buyers takes the form of exclusive contracts (i.e. veto power for a buyer on its contract partner's transactions), then buyer surplus always increases at the expense of the sellers[20]. We will first argue that in such a situation of full cooperation (whether in the form of merger to monopsony or exclusive contracts between all buyers), import caps cannot further increase buyer surplus.

The argument follows directly from the definition of the Shapley value, equation (2.1). Observe that with full cooperation, only coalitions M in which all buyers (or the single buyer, in case of full merger) are present, $B \subset M$, can have non-zero value $v(M)$. In other words, $v(M \setminus b) = 0$ for any coalition M and buyer b. But this means that a buyer's marginal contribution to any coalition M is the entire value of that coalition $v(M)$, and the buyer's pay-off is a weighted sum of these values:

$$\phi_b^{\text{cooperation}} = \sum_{M:B\subset M} \mathscr{P}(M \setminus b) v(M). \tag{3.1}$$

[20] Perhaps somewhat surprisingly, buyer mergers do not necessarily increase the merging parties' joint surplus; see Segal (2003) for analysis and counterexamples.

An import cap restricts the trade volume. Such a constraint can never increase total surplus $v(M)$ that can be attained in coalition M: $v'(M) \leq v(M)$, where the prime denotes the value with the constraint. But since the buyer's welfare is just a weighted sum of such surpluses, it cannot increase. This leads to

Proposition 1. *If buyers fully cooperate, either by operating as a monopsony or by having exclusive contracts in the sense of Segal (2003), then any constraint on imports can only reduce their surplus.*

The intuition for proposition 1 is that under full cooperation, there are no externalities among buyers. Thus, constraints can only reduce i) overall surplus, and ii) all buyers' contributions to total surplus.

Although buyer coordination (e.g. by centralizing import negotiations in a joint purchasing authority) may be a fruitful approach to raising buyer power, intrusive coordinating measures such as those will often conflict with competition policy on the domestic market – not to forget the questions that will arise as to the distribution of the extra benefits. In the EU, moreover, coordination between different countries' "national champions", which often amounts to delegating power to a joint purchasing institution, seems politically unrealistic[21] [22]. We will therefore turn our attention to two trade-policy measures that leave buyer market structure intact, and that better reflect current EU gas policy views on diversification of supplies. After first discussing the imposition of limits to the dependence on individual sellers, we explore the rationale for promoting investment in capacity to obtain access to new entrant sellers.

3.3 Individual trade and import constraints

Assume that buyers bargain with individual sellers[23] and that a regulator can oblige all buyers to comply with imposed trade quotas, provided that all buyers benefit from these quotas. The example in section 3.1 demonstrates that such constraints might exist. Under what conditions can such collectively agreed constraints on trade volumes make all buyers better off? This

[21] Note, however, that in the case of Caspian gas, the EU itself brought up the suggestion to form purchasing blocks, European Commission (2008a).

[22] Furthermore, an objection to voluntary cooperation among buyers is that there may exist a stability problem if a buyer can pre-empt negotiations. A buyer may have incentives to deviate and to enter (secretly) into a long-term contract with some sellers before all other negotiations on the market occur. Such a contract will reduce the supply from the seller and hence lead to a smaller pie in the second-stage game. All buyers except for the deviating firm will suffer. The cheater may be able to get a total pay-off that is higher than what he may otherwise expect from the cooperation (see Hubert and Ikonnikova, 2004). Hence, monopsony can be an unstable organization.

[23] Throughout the paper we assume that sellers do not cooperate. For the gas market, although in practice gas-producing countries regularly meet in the Gas Exporting Countries Forum, the differences in structure between gas and oil markets make the emergence of a Gas-OPEC organisation less likely (see Hallooche, 2006, and Stern, 2007, 2009).

question is relevant to the present situation on the EU gas market, where some argue for limiting imports, particularly from Russia, pointing to the increasing dependence on this single seller.

If such constraints on trade were introduced, then first any individual buyer would suffer from constraints on his own trade, as in the monopsony case. For example, Italy's marginal contribution to any coalition involving Russia would drop if the constraints on Russia's exports to Italy were binding. However, there might then be compensating positive effects for the other buyers: constraints weaken the seller's bargaining power, and hence improve the other buyers' bargaining positions. Continuing with the same example, Germany's bargaining power vis-à-vis Russia would increase with restrictions on Russian-Italian trade. The reason is that Russia's outside option in its negotiations with Germany would deteriorate. Upon failing to reach an agreement with Germany, Russia would have less scope for increasing sales to Italy, as a consequence of the cap on its sales.

It depends on the type of constraints that are imposed whether the net effect (i.e. the sum of the negative effect of the own constraint and the positive spill-over effect from the other buyers' constraints) can be positive for buyers. We first demonstrate that jointly agreeing on maximum *aggregate* imports from any given seller affects aggregate buyer surplus negatively. This is the extension of proposition 1 to the case with multiple buyers.

Consider any coalition M including the restricted seller s. Obviously, a constraint on s's exports can only decrease the trade surplus: $v'(M) \leq v(M)$. But now note that this drop in value is always at least as large for $v(M \cup b_i)$ as it is for $v(M)$: $v'(M \cup b_i) - v'(M) \leq v(M \cup b_i) - v(M)$. The reason is that in each coalition the shadow price of the constraint equals the difference between marginal buyer benefits and marginal supplier costs at the constraint. This shadow price – representing the marginal effect of relaxing the constraint – can only increase as demand expands by adding buyer b_i to the coalition. As a result, from definition (2.1), buyer b_i's pay-off ϕ_{b_i} can only decrease when such a constraint is imposed. This demonstrates

Proposition 2. *Restricting the* aggregate *imports from an individual seller can never increase aggregate buyer surplus.*

Thus, irrespective of whether or not buyers cooperate, a limit on total imports from any given seller will lower buyer surplus.

The failure of caps on aggregate sales to increase buyer surplus can be traced to the fact that the spill-over effect is only small: for a capped seller, failure to reach a contract with one buyer simultaneously relaxes the cap on trades with other buyers. A policy to circumvent this involves capping sales to each buyer separately. A hypothetical example: Instead of restricting total Russian gas export to Europe to 30% of European demand, consider now what the effects would be of limiting Russian gas sales to Italy to 30% of Italian demand. This would have stronger positive effects on rival buyers such as Germany than in the previous case: a breakdown in negotiations with Germany would now not increase the volume Russia could sell to Italy. Under these rules, Germany would therefore benefit more than before from the cap on Italian-Russian trade.

Clearly, buyers may win jointly if the negative effect on the constrained buyer (Italy, in the example) is smaller than the positive spill-over effects on the other buyers. Of course, in this case of unilateral constraints, again the constrained buyer is worse off, and would oppose the cap (assuming side payments are not possible). The appropriate question is whether one can construct a set of constraints on all bilateral transactions, such that for each buyer the benefits of spill-over effects dominate the negative effects of its own constraint. Whilst it turns out that this is not always the case, proposition 3 provides a simple sufficient condition for existence.

Proposition 3. *If the number of buyers $|B|$ exceeds the number of sellers $|S|$, there will always exist constraints on bilaterally traded quantities that make every buyer individually better off.*

Proof. The proof relies on the fact that bilateral trade among players s_1 and b_1 is highest in the coalition including only these players, $\{s_1, b_1\}$. To see this, denote the traded quantity optimizing the surplus in this coalition by q_{11}^*. Note first that under standard conditions on supply and demand functions, in no other coalition can the optimal traded quantity between s_1 and b_1 be higher than q_{11}^*: this would yield marginal buyer surplus P lower than $P(q_{11}^*)$ and marginal seller costs C' higher than $C'(q_{11}^*) = P(q_{11}^*)$, violating the first-order conditions of joint surplus maximization. For similar reasons (provided that in other coalitions including s_1 and b_1, either one or both have non-zero trade with other members of those coalitions) the volume of trade between s_1 and b_1, q_{11}, in those coalitions will be strictly lower than q_{11}^*.

A constraint on s_1 and b_1's trade that is sufficiently close to q_{11}^* will therefore only affect the value of this two-player coalition, $v(\{s_1, b_1\})$, and leave the trade surplus of other coalitions unchanged. We now demonstrate that such a constraint improves total buyer surplus $\sum_{b_i \in B} \phi_{b_i}$, provided that $|B| > |S|$. Note that in buyer b_1's pay-off ϕ_{b_1} the term involving $v(\{s_1, b_1\})$ appears with positive coefficient $\mathscr{P}(1)$. A constraint lowering $v(\{s_1, b_1\})$ will therefore reduce b_1's own pay-off. In the other buyers' pay-off ϕ_{b_i}, $i > 1$, it appears with negative coefficient $-\mathscr{P}(2)$. A reduction in $v(\{s_1, b_1\})$ therefore raises the other buyers' pay-off, which is the spill-over effect. The coefficient of $v(\{s_1, b_1\})$ in $\sum_{b_i \in B} \phi_{b_i}$ therefore equals

$$\begin{aligned} \mathscr{P}(1) - (|B|-1)\mathscr{P}(2) &= \frac{1}{|S|+|B|}\left(\frac{1}{|S|+|B|-1} - \frac{2(|B|-1)}{(|S|+|B|-1)(|S|+|B|-2)}\right) \\ &= (|S|-|B|)\frac{(|S|+|B|-3)!}{(|S|+|B|)!}. \end{aligned} \tag{3.2}$$

Since any such constraint can only affect $v(\{s_1, b_1\})$ negatively, and since all other terms are by assumption not affected by the constraint, we find that if $|S| < |B|$, then constraints exist that make buyers jointly better off.

To prove that a set of constraints exists that makes every individual buyer better off, note that for each buyer b_i we can pick any seller s_i that has a non-zero trade with this buyer in the coalition $\{s_i, b_i\}$. By the same argument as before, we can find a constraint on this pair's trade that only affects $v(\{s_i, b_i\})$, by a negative amount $-\delta$, and keeps all other surpluses unchanged (for δ sufficiently small). For the set of these $|B|$ constraints, the change $\Delta\phi_{b_i}$ in b_i's pay-off equals

$$\Delta\phi_{b_i} = -\mathscr{P}(1)\delta + (|B|-1)\,\mathscr{P}(2)\delta,$$

where the first term is the own effect, and the second term the externality effect. By the same computation (3.2), if $|S| < |B|$, then each buyer b_i's pay-off improves for this set of constraints.

■

In the proof, the set of bilateral constraints is chosen so that total trade surplus stays the same, $v'(N) = v(N)$. In other words, equilibrium trade continues to be efficient. In this case, it is clear that an increase in buyers' absolute pay-offs automatically translates into an increase in their bargaining power (relative pay-off).

Remark While proposition 3 shows that $|B| > |S|$ is a sufficient condition, it is by no means a necessary condition. Of course, if $|B| < |S|$, then small constraints such as those considered in the proof of proposition 3 will decrease buyer surplus. However, slightly larger constraints might reverse this outcome. Consider, for instance, a situation where $|B| > |S|$, and add to the set of sellers a number of small, capacity-constrained (fringe) sellers so that the total number of sellers $|S'|$ exceeds the number of buyers $|B|$. Evidently, as the importance of these sellers diminishes, we should retrieve the result we had without the fringe sellers, the case $|B| > |S|$. Indeed, suppose we have one very small seller s_n, where "very small" means that $v(M \cup s_n) \to v(M)$. Now, similar to the proof of proposition 3, focus again on constraints affecting only $v(\{s_1, b_1\})$ and $v(\{s_1, s_n, b_1\}) \equiv v(\{s_1, b_1\}) + \varepsilon$ (in the limit of very small s_n these are identical, so then $\varepsilon \to 0$). In buyer b_i's pay-off ϕ_{b_1}, the term $v(\{s_1, b_1\})$ now enters with coefficient $\mathscr{P}(1) + \mathscr{P}(2)$ – the own effect – while in rival buyers' values it has coefficient $-\mathscr{P}(2) - \mathscr{P}(3)$ – the externality. Adding up $v(\{s_1, b_1\})$ terms in the sum of all buyers' valuations now leads to

$$\begin{aligned}\sum_{b_i \in B} \phi_{b_i} &= (\mathscr{P}(1) + \mathscr{P}(2) - (|B|-1)(\mathscr{P}(2) + \mathscr{P}(3)))\, v(\{s_1, b_1\}) + \text{other terms} \\ &= \left(|S'| - 1 - |B|\right) \frac{(|S'| - 1 + |B| - 3)!}{(|S'| - 1 + |B|)!} v(\{s_1, b_1\}) + \text{other terms};\end{aligned}$$

i.e. in the limit that $\varepsilon \to 0$ we duly obtain the result (3.2) that we would have obtained without a fringe seller. For small but finite ε, we may now derive that a sufficiently small constraint decreases a buyer's value, but that a slightly higher constraint will increase it.

To conclude, we showed that buyers might want to agree on a set of *bilateral* trade restrictions with large sellers, in order to increase each buyer's surplus. Aggregate trade restrictions will not achieve this objective. We demonstrated that when $|B| > |S|$ there exist certain bilateral constraints that increase total buyer value. We used constraints that only bite outside of equilibrium (i.e. not in the grand coalition) to prove this. These constraints therefore do not reduce aggregate buyer and seller surplus. This does not mean that optimal constraints will not affect total surplus either, nor that if $|B| \leq |S|$ such constraints do not exist. The toy model with three buyers and three sellers, explored in section 3.1, is a case in point. We saw that, depending on the parameters, certain constraints that are beneficial for buyers exist, and can have large effects. Moreover, optimal constraints do also bite in equilibrium.

3.4 Coordination of investment

In this section, we turn the focus to an alternative policy measure – diversification through investment. Should the domestic regulator promote individual buyers' investments that give them access to new sellers? In the European gas market, the EU Commission indeed stimulates individual member states' investments to build pipeline capacity from new sellers. We demonstrate that such investment support can also be motivated from a desirable spill-over effect on other buyers.[24]

Earlier, we identified a spill-over effect that causes individual buyers to *overconsume* supplies from a particular seller. Failure of individual buyers to commit to limits on quantities purchased from a given seller weakens the bargaining positions of other buyers negotiating with the same seller. We saw that this effect could be countered by trade quotas.

We now demonstrate that an individual buyer b may also *underconsume* supplies from a given seller s, from the rival buyers' perspective. Buyer b's commitment to purchase larger quantities from seller s weakens the bargaining position of other sellers. This in turn confers an advantage on the rival buyers $b_- \in B \setminus b$, even if they cannot trade with seller s itself. The outside option for other sellers $s_- \in S \setminus s$ to shift sales to b becomes less valuable, so that buyers $b_- \in B \setminus b$ have a stronger bargaining position. To return to the gas market illustration, if Italy were to construct a new direct gas pipeline to Libya, then Russia's bargaining position towards Italy would clearly be harmed. But this would also be beneficial for Germany. Since in Russia's negotiations with Germany, Russia's disagreement pay-off would be less valuable, Germany could extract a larger share of the rents from Russia.

The argument is cleanest in the situation in which other buyers cannot trade with seller s. Indeed, in that case the negative spill-over effect of overconsumption – calling for caps on trade – is absent. We formalize these ideas in the next proposition.

Proposition 4. *Assume that only buyer $b_1 \in B$ can trade with seller $s_1 \in S$ (i.e. s_1 can not supply any other buyer in $B \setminus b_1$). Then*

[24] Relatedly, in a recent paper Küpper (2010) shows that an electricity generator's investments in renewable energy production can have positive spill-over effects on other electricity firms' bargaining positions in the gas market.

(i) lower bounds on b_1's trade volume with s_1 can only decrease b_1's pay-off, and can only raise the other buyers' pay-offs;
(ii) there exist lower bounds on b_1's trade volume with s_1 that increase joint buyers' surplus.

Proof. Lower bounds on b_1's trade with s_1 can only affect trade surplus in coalitions that include both b_1 and s_1, $v(M \cup b_1 \cup s_1)$. Moreover, denoting the surplus function with constraints by v', we have $v'(M \cup b_1 \cup s_1) \leq v(M \cup b_1 \cup s_1)$. Writing b_1's pay-off as

$$\begin{aligned}\phi_{b_1} = \sum_{M \subset N \setminus \{b_1, s_1\}} & [\mathscr{P}(M)\,(v(M \cup b_1) - v(M)) \\ & + \mathscr{P}(M \cup s_1)\,(v(M \cup b_1 \cup s_1) - v(M \cup s_1))],\end{aligned}$$

clearly only terms with positive coefficient are affected by a constraint. A lower bound on trade between b_1 and s_1 therefore can only reduce b_1's pay-off (the own effect of the constraint).

Similarly, isolating those terms involving both b_1 and s_1 in any other buyer b_-'s pay-off yields

$$\phi_{b_-} = \sum_{M \subset N \setminus \{b_1, s_1\}} \mathscr{P}(M \cup b_1 \cup s_1)(v(M \cup b_1 \cup s_1 \cup b_-) - v(M \cup b_1 \cup s_1)) + \text{other terms}.$$

Now observe that s_1's sales to b_1 will always be at least as large in the coalition including b_- as in the coalition excluding it. In analogy with the proof of Proposition 2, a lower bound on s_1's sales will affect the coalition without b_- more strongly:

$$v'(M \cup b_1 \cup s_1) - v(M \cup b_1 \cup s_1) \leq v'(M \cup b_1 \cup s_1 \cup b_-) - v(M \cup b_1 \cup s_1 \cup b_-).$$

This allows us to conclude that imposing a lower bound on the pair's trade volume can only increase other buyers' pay-offs (the external effect of the constraint). This completes the proof of the first part of the proposition.

To prove the second part, note that trade between b_1 and s_1 will be strictly lowest in the coalition including only buyer b_1 and all sellers, $M = S \cup b_1$ (provided that other sellers $\in S$ do trade with b_1, of course). We can therefore find values for the lower bound on their bilateral trade that only decrease surplus in this coalition, $v(S \cup b_1)$, and leave surplus in other coalitions unchanged. For such constraints, we find that total buyer surplus increases:

$$\begin{aligned}\sum_{b_i \in B} \phi_{b_i} &= \mathscr{P}(S)v(S \cup b_1) - (|B| - 1)\mathscr{P}(S \cup b_1)v(S \cup b_1) + \text{other terms} \\ &= -S\frac{(|S|)!\,(|B|-1)!}{(|S|+|B|)!}v(S \cup b_1) + \text{other terms}\end{aligned}$$

The first term in the first line contains the own effect and the second one the external effect. Since the constraint only decreases $v(S \cup b_1)$ and leaves the other terms unaffected, the aggregate effect on total buyer surplus is always positive. ■

As a result, we find that the effect of increasing trade on total buyer welfare is not fully captured by the trading partners b_1 and s_1. In the context of construction of new gas pipeline connections, this might lead to underinvestment in pipeline capacity, providing thereby a rationale for coordination in investment. Note that from a social point of view this will lead to overinvestment in capacity: since total welfare does not increase when constraints are imposed, buyer gains come at the expense of sellers.

4 Numerical Example: the EU natural gas market

In this section, we consider a (stylized) model of the EU gas market to explore the quantitative significance of the effects of the two policies. We focus on the old EU members, the EU 15, whose gas consumption forms the bulk of total EU consumption. To keep things clear and to avoid computational complexities, we divide the EU-15 countries into three major gas-importing regions, denoted *France*, *Germany* and *Italy*. The first one includes not only France itself, but also Belgium, Luxembourg, Spain, Portugal and the UK. The region entitled Germany includes Germany, Austria, Finland, Sweden and Switzerland[25]. The final region referred to as Italy consists of Italy and Greece.[26] As for exporters, we again apply some aggregation and distinguish three major non-EU natural gas exporting regions: Russia, Algeria and Norway. Russia represents the producers of natural gas from the Former Soviet Union. Algeria is the collective name for the North African natural gas sellers, including Libya and Egypt. When analysing the effects of investments in new supply, we add the Caspian region producers as new entrant sellers. Finally, we consider fringe supplies in the form of LNG available from other regions, such as the Middle East and West Africa. These LNG supplies are priced in a world market, and their producers are not included in the bargaining game. Rather, we assume that the three buyers can turn to the LNG market for any unmet demand. They pay the exogenous LNG price for these imports. This price effectively limits buyers' willingness to pay for gas from the strategic sellers.

4.1 Calibration

We calibrate the model to describe projected natural gas trade in Europe around 2025-2030. We assume that European importers first consume all projected domestically produced gas; the focus is thus on imports from outside Europe to meet residual gas demand.

Demand We estimate the parameters of residual demand for gas from Algerian, Russian and Norwegian regions using the projections from IEA (2005), OME (2004), and British Petroleum (2008). We assume that demand for gas in each of the importing regions is growing at an average rate of 1.6% per year. Hence, the regions of France, Germany and Italy will demand up to 40% more gas by 2030. Aggregating residual demand (correcting for European production projections), we find that the region of France will buy about 86 billion cubic meters per year (bcm/a) from exporters to the EU (26 bcm/a of which are for the UK), the region of Germany will import around 110 bcm/a, and the region of Italy will demand roughly 96 bcm/a.

[25] We exclude the Netherlands: Dutch production will continue to meet Dutch demand; we focus only on net importers.

[26] We also omit Ireland from the list of consumer countries, because its present and expected future consumption of imported natural gas is negligible.

We retain the assumption that any demand not met by our strategic sellers – Norway, Algeria and Russia – will be obtained from an outside backstop source at an exogenously fixed price. Imports from a global LNG market come to mind, in particular – although other backstop technologies (such as demand response or switching to other fuels) may also contribute. Importers will be willing to buy their residual demand from the strategic sellers at a variable price up to this exogenous price ceiling. We set prices for LNG at 170€/tcm (thousand cubic meters).

Supply To calculate supply surplus for exporters, we estimate linear total long-run marginal cost functions (which include marginal production, transportation and investment costs). The following marginal cost formula is used:

$$\begin{aligned} mc_A(q) &= 160 + 0.25q \\ mc_R(q) &= 127 + 0.35q \\ mc_N(q) &= 148 + 0.35q, \end{aligned}$$

with q in bcm/a, and costs in €/tcm. Details of our assessment are provided in the appendix.

Bearing in mind the results from our toy model (section 3.1, we analyse how total demand compares to total supply at the backstop price. In equilibrium, will the strategic sellers be able to meet all demand? For the assumed LNG price (170 €/tcm), total supply equals 226 bcm/a. With total demand at 292 bcm/a, the remaining 66 bcm/a will have to be purchased in the form of LNG.

4.2 Results

We now explore numerically how the importers' coordination, export constraints, and investments affect trade benefits and the distribution of market power. We report the results in tables 4.1 and 4.3. For each country under the given scenario we provide its absolute pay-off and its relative share in the total trade surplus in that scenario. The latter we interpret as the player's bargaining (or market) power.

The first column in table 4.1 describes the "base" case when there is no cooperation or any type of coordination among the three importers, and there are no constraints on how much can be purchased from a particular exporter.

The second column reports on how the pay-offs and the distribution of the bargaining power change if the buyers could purchase jointly, acting as a single monopsonist. We observe that buyers win through establishing a purchasing block, with their aggregate profits increasing by around 650 mln, or 65%. Since total welfare remains the same as in the base case, buyers thus also improve their strategic position – increasing their bargaining power by as much as 20 percentage points. The exporters, in turn, lose 20 percentage points.

In the final column we compute the effects of caps on bilaterally traded quantities. Rather than

Table 4.1 Impact of coordination and constraints on pay-offs and power distribution

	Base		Monopsony		Constraints	
	bn	%	bn	%	bn	%
Germany	0.37	11			0.52	16
France	0.31	9			0.40	12
Italy	0.33	10			0.45	14
total buyers	1.01	30	1.66	50	1.37	42
Algeria	0.13	4	0.10	3	0.11	3
Norway	0.41	12	0.31	9	0.35	11
Russia	1.78	54	1.25	38	1.41	44
total sellers	2.32	70	1.66	50	1.87	58

attempting to find the precise optimum, we searched among bilateral caps proportional to both the buyer's demand and the seller's production (at marginal costs equal to the LNG price). These assumptions of proportionality leave only one parameter undetermined. Optimizing over this one parameter leads to an outcome in which all sellers are constrained in equilibrium. The bilateral constraints are reported in table 4.2. In equilibrium they are all binding.

Table 4.2 Bilateral trade constraints, in bcm/a

	Germany	France	Italy
Algeria	12.5	9.8	10.9
Norway	18.6	14.6	16.3
Russia	37.4	29.2	32.6

Such constraints have a significant impact on buyer power. Total buyer surplus increases by about 35%. As in the toy model, constraints help to bridge over half the difference between oligopsony and monopsony outcomes.

For verification we also computed the results when each seller's total exports are constrained. By proposition 2, this can only decrease buyer surplus. Indeed, when applying aggregate constraints equal to total seller exports in the bilateral constraints model, we find that total buyer surplus drops by approximately €100 million.

Table 4.3 provides the results for the situation in which the European importers decide upon investment to help new producers (say, producers from the Caspian region) to enter the market. Here we avoid the difficulty of solving the investment problem to find the optimal level of investments, but rather investigate how investment as such will affect the pay-offs of the market players and the distribution of market power. We illustrate the situation discussed in section 3.4.

Again, for comparison's sake, the first column contains the pay-offs and the bargaining power values of the situation when there are three buyers and three sellers and no coordination

Table 4.3 Impact of investments and entry on pay-offs and bargaining power

	Base		Single buyer		All buyers	
	bn	%	bn	%	bn	%
Germany	0.37	11	0.77	18	0.47	11
France	0.31	9	0.34	8	0.39	10
Italy	0.33	10	0.37	9	0.42	10
total buyers	1.01	30	1.48	35	1.28	31
Algeria	0.13	4	0.12	3	0.12	3
Norway	0.41	12	0.40	10	0.39	10
Russia	1.78	54	1.76	42	1.70	42
Caspian			0.40	10	0.58	14
total sellers	2.32	70	2.68	65	2.79	69

or specific constraints imposed on trade. Column two focuses on the situation in which only one buyer benefits from the new pipeline to the Caspian region: the pipeline is completely relation-specific, and geography prevents any sales without the importer's consent. This obliges the new entrant to sell its gas only to this buyer. In the third column, in contrast, the assumption is made that all buyers have access to gas from the new entrant. Both scenarios operate under the assumption that one pipeline with capacity of 30 bcm/a is built. This is the expected capacity for the Nabucco pipeline, which will be used here as an example.

The second column reflects the situation we described in detail in section 3.4. Only one buyer, Germany, is a direct beneficiary of the new line. But as proved in Proposition 4, other buyers obtain part of the rents as a result of their improved bargaining position when negotiating with the old sellers. The old sellers, in turn, lose out.

Finally, in the last scenario, we compare the situation in which the Caspian producer can sell to all three buyers. Although buyers still see their terms improved, they have to, on aggregate, leave a larger part of the rents to the new producer (who now has more options to sell his gas).

5 Discussion and conclusions

We have analysed how strategic spill-over effects among domestic buyers bargaining with a group of foreign sellers can provide a justification for strategic trade policy. We identified both a negative and a positive externality on the bargaining positions of the market players.

We first focused on negative externalities of a buyer's trade with a seller, which motivated consideration of caps on trade for a buyer-seller pair. In offering to increase trade with a seller, a buyer improves that seller's bargaining position. This, in turn, harms the position of rival buyers negotiating with the same seller. Caps on trade in this case increase the rival buyers' welfare, while lowering the capped buyer's welfare. We identified conditions under which joint buyer welfare grows when caps are imposed.

On the other hand (and seemingly contradictory), a buyer's commitment to increase trade with a seller beyond their bilaterally optimal level can also sometimes be beneficial for rival buyers. This positive spill-over effect occurs indirectly: a larger volume traded between seller s_1 and buyer b_1 harms rival sellers' (s_{-1}) bargaining power, as it decreases their opportunity to trade with b_1. Rival buyers b_{-1} benefit from this effect when negotiating with the rival sellers s_{-1}. This benefit may provide a rationale for coordination of buyers' investments in expanding trade opportunities.

The two effects have opposing signs. Depending on the parameters of the bilateral oligopoly, the negative effect or the positive effect may dominate. In section 3.4 we ruled out the negative effect by focusing on a situation in which the seller under consideration, s_1, can only supply one buyer, b_1. Then, there is no negative effect on rival buyers as a consequence of changes in s_1's bargaining power, since s_1 does not bargain with these rival buyers to begin with. The result is stated in proposition 4, which says that only the positive spill-over effects are present: the rival buyers always benefit from the deteriorated bargaining position of the other sellers. The opposite is true if sellers form a monopoly: increased opportunities for trading with buyer b_1 make rival buyers negotiating with the monopolist worse off. Hence, only a negative spill-over effect exists, as stated in proposition 3: under monopoly, $|S| = 1$, multiple buyers can always gain from imposing trade caps.

More generally, the negative spill-over effect is likely to dominate if the competition among sellers is relatively weak. This is the case in the example of section 3.1, when demand is large. In that case, each individual seller's supply is essential for meeting a buyer's demand, and as a consequence sellers have relatively great market power. In contrast, when there is ample competitive production capacity (demand is small), sellers compete more aggressively and the positive spill-over effect dominates. Trade caps are then not beneficial, and trade floors may be more appropriate.

The analysis we presented is particularly relevant for the EU gas market – and indeed both types of arguments have surfaced in the policy discussion. In this case there is also a natural mechanism for committing to trade caps or floors. Since trade volumes are governed by pipeline capacity, restrictions on trade can easily be reinterpreted as restrictions on such capacity.

One observation frequently made in discussions concerning the security of gas supply is that the EU should reduce its dependence on exports from the large sellers (in particular, from Russia). We show that aggregate import caps are ineffective as a tool to improve EU buyer power. The limitations imposed on one producer will make the other sellers stronger, redistributing power among sellers rather than benefiting buyers. Instead, restrictions on bilateral trade of individual member states with individual producers can have a positive effect both on the individual buyers' bargaining power and on buyers' trade surpluses. On a practical level, such a measure may be applied in terms of limits on pipeline capacity between producing regions and the different buyers.

Secondly, we have investigated how diversification of supply (e.g. entry of new producers into the European market) might improve the strategic position of EU buyers. We considered investments in pipeline capacities enabling the entry of new sellers. The EU actively promotes various investment projects, such as the Nabucco pipeline aimed at bringing gas from the Caspian region to Europe. Our results indicate that entry of new sellers is beneficial and strategically favourable for all EU importers – not only for those that directly contract with the entrant. Hence, even if diversification is beneficial, a free-riding problem among importers may occur, and there is scope for coordination of investments in pipeline capacity.

One issue that we have not addressed is whether regulation of quantities is the optimal trade policy. Indeed, a large part of the trade policy literature focuses on the distinction between taxes and quotas. We focused on quantity regulations, as these correspond most closely to the policies that are considered in reality in the EU natural gas market. Of course, one reason for taxes to potentially outperform quotas is that by taxing imports, the domestic government itself takes a share of the grand coalition surplus and leaves buyers and sellers only to bargain over the remainder. A downside of taxation is that it always compromises efficiency in equilibrium, unlike quotas (which, as we observed, may be chosen to be binding only off-equilibrium).

Finally, we restricted the analysis to a market where importers do not compete for market share in the retail sector. As mentioned in the introduction, the EU gas market currently features rather weak competition. This may change as liberalisation gathers pace, and it will be relevant to assess the interaction between buyer power in the upstream market and market power in the downstream market. Our model demonstrated that, without downstream competition, merger among buyers is beneficial for raising EU welfare. The extent to which this will continue to be the case when buying firms compete on the downstream market is an important and challenging question.

References

Asche, F., P. Osmundsen and R. Tveteras, 2002, European market integration for gas? Volume flexibility and political risk, *Energy Economics*, vol. 24, pp. 249–265.

Barina, M., 2005, Future of Natural Gas Markets: LNG, Working paper.

Basker, E. and P. Van, 2008, Wal-Mart as Catalyst to U.S.-China Trade, SSRN Working paper.

Bolton, P. and D.S. Scharfstein, 1996, Optimal debt structure and the number of creditors, *Journal of Political Economy*, vol. 104, pp. 1–25.

Boots, M., F. Rijkers and B. Hobbs, 2004, Trading in the Downstream European Gas Market: A Successive Oligopoly Approach, *The Energy Journal*, vol. 25, pp. 73–102.

BP, 2008, *Statistical Review of World Energy 2008*, BP.

Brander, J., 1995, Strategic trade policy, in G. Grossman and K. Rogoff, eds., *Handbook of International Economics*, vol. III, Elsevier Science.

Brander, J. and B.J. Spencer, 1981, Tariffs and the extraction of foreign monopoly rents under potential entry, *Canadian Journal of Economics*, vol. 14, pp. 371–389.

British Petroleum, 2008, Statistical Review of World Energy 2008, Full Report, BP Annual Report.

CIEP, 2004, Study on energy supply security and geopolitics, Clingendael International Energy Programme, Study for DG-TREN, tREN/C1-06-2002.

CNE, 2008, Report on national gas consumption in 2007, Comisión Nacional de Energía.

Competition Commission, 2007, Groceries market investigation, provisional findings report, appendix 5.4.

De Fontenay, C. and J. Gans, 2005, Vertical integration in the presence of upstream competition, *RAND Journal of Economics*, vol. 36(3), pp. 544–572.

De Fontenay, C. and J. Gans, 2007, Bilateral bargaining with externalities, university of Melbourne.

Deardorff, A. and I. Rajaraman, 2009, Buyer concentration in markets for developing country exports, *Review of Development Economics*, vol. 13, pp. 190–199.

Eaton, J. and G. Grossman, 1986, Optimal trade and industrial policy under oligopoly, *Quarterly Journal of Economics*, vol. 101, pp. 383–406.

Egging, R. and S.A. Gabriel, 2006, Examining market power in the European natural gas market, *Energy Policy*, vol. 34, pp. 2762–2778.

Engle-Warnick, J. and B. Ruffle, 2005, Buyer concentration as a source of countervailing power: Evidence from experimental posted-offer markets, *SSRN Working Paper*.

European Commission, 2008a, Green Paper: Towards a secure, sustainable and competitive European energy network, cOM(2008) 782 final.

European Commission, 2008b, Progress in creating the internal gas and electricity market, cOM(2008) 192 final.

European Commission, 2008c, Second strategic energy review, cOM(2008) 781 final.

European Commission, 2009a, Antitrust: Commission fines E.ON and GDF Suez EUR 553 million each for market-sharing in French and German gas markets, press release.

European Commission, 2009b, Assessment report of directive 2004/67/ec on security of gas supply, cOM(2009) 363.

Farber, S., 1981, Buyer Market Structure and R&D Effort: A Simultaneous Equations Model, *The Review of Economics and Statistics*, vol. 63, pp. 336–345.

Gabriel, S. and Y. Smeers, 2006, Complementarity problems in restructured natural gas markets, in A. Seeger, ed., *Recent Advances in Optimization*, Lecture Notes in Economics and Mathematical Systems 563, Springer.

Galbraith, J., 1952, American capitalism: The concept of countervailing power, *Houghton Mifflin, Boston*.

Golombek, R., E. Gjelsvik and K. Rosendahl, 1995, Effects of Liberalising the Natural Gas Markets in Western Europe, *The Energy Journal*, vol. 16, pp. 85–111.

Golombek, R., E. Gjelsvik and K. Rosendahl, 1998, Increased Competition on the Supply Side of the Western European Natural Gas Market, *The Energy Journal*, vol. 19, pp. 1–18.

Gul, F., 1989, Bargaining foundations of Shapley value, *Econometrica*, vol. 57, pp. 81–95.

Hallooche, H., 2006, The Gas Exporting Countries Forum: Is it really a Gas OPEC in the Making?, Oxford Institute for Energy Studies, NG 13.

Hart, O. and J. Moore, 1990, Property rights and the nature of the firm, *Journal of Political Economy*, vol. 98, pp. 1119–1158.

Haurie, A., G. Zaccour, J. Legrand and Y. Smeers, 1987, A stochastic dynamic Nash-Cournot model for the European gas market, Technical Report G-86-24, GERAD, Ecole des Hautes Etudes Commerciales, Montréal, Québec, Canada.

Helm, D., 2007, European energy policy: meeting the security of supply and climate change challenges, *EIB Papers*, vol. 12, pp. 30–49.

Holz, F., C. von Hirschhausen and C. Kemfert, 2008, A strategic model of European gas supply (GASMOD), *Energy Economics*, vol. 30, pp. 766–788.

Horn, H. and A. Wolinsky, 1988, Bilateral monopolies and incentives for merger, *Rand Journal of Economics*, vol. 19, p. 408–419.

Hubert, F. and S. Ikonnikova, 2004, Hold-Up, Multilateral Bargaining, and Strategic Investment: The Eurasian Supply Chain for Natural Gas, Humboldt University Discussion paper.

Hubert, F. and S. Ikonnikova, 2010, Investment options and bargaining power: the Eurasian supply chain for natural gas, *Journal of Industrial Economics*, vol. forthcoming.

Hubert, F. and I. Suleymanova, 2006, Strategic Investment in International Gas-Transport Systems: A Dynamic Analysis of the Hold-Up Problem, Humboldt University Discussion paper.

IEA, 2005, *World Energy Outlook*, OECD / International Energy Agency, Paris.

Inderst, R. and N. Mazzarotto, 2008, Buyer power in distribution, in W. Collins, ed., *ABA Antitrust Section Handbook, Issues in Competition Law and Policy*.

Inderst, R. and C. Wey, 2003, Bargaining, mergers, and technology choice in bilaterally oligopolistic industries, *RAND Journal of Economics*, vol. 34, pp. 1–19.

Jeon, S., 2006, Shapley bargaining and merger incentives in network industries with essential facilities, *Hitotsubashi Journal of Economics*, vol. 47, pp. 229–248.

Kranton, R. and D. Minehart, 2000, Networks versus vertical integration, *RAND Journal of Economics*, vol. 31, pp. 570–601.

Küpper, G., 2010, What is the strategic value of investments in alternative local energy supply?, KU Leuven CES Discussion paper 10.04.

Lise, W., B. Hobbs and F. van Oostvoorn, 2008, Natural gas corridors between the EU and its main suppliers: Simulation results with the dynamic GASTALE model, *Energy Policy*, vol. 36, pp. 1890–1906.

Littlechild, S. and G. Thompson, 1977, Aircraft landing fees: A game theoretic approach, *The Bell Journal*, vol. 8, pp. 186 – 204.

Mathiesen, L., K. Roland and K. Thonstad, 1987, The European Natural Gas Market: Degrees of Market Power on the Selling Side, in R. Golombek, M. Hoel and J. Vislie, eds., *Natural Gas Markets and Contracts*, North-Holland, Amsterdam.

Myerson, R., 1980, Conference structures and fair allocation rules, *International Journal of Game Theory*, vol. 9(3), pp. 169–182.

Oladi, R. and J. Gilbert, 2009, Buyer and seller concentration in global commodity markets, Utah State University Working paper 200911.

OME, 2004, Future natural gas supply options and supply costs for Europe, Report to Madrid Forum, Observatoire Méditerranéen de l' Energie.

Perner, J. and A. Seelinger, 2004, Prospects to the European market until 2030 - results from the simulation model EUGAS, *Utility Policy*, vol. 12, pp. 291–302.

Raff, H. and N. Schmitt, 2009, Buyer power in international markets, *Journal of International Economics*, vol. 79, p. 1877–1889 .

Röller, L.H., J. Delgado and H. Friederiszick, 2007, Energy: Choices for Europe, Bruegel Blueprint Series.

Ruffle, B., 2009, Buyer countervailing power: A survey of the theory and experimental evidence, in J. Hinloopen and H.T. Normann, eds., *Experiments and Antitrust Policy*, Cambridge University Press: Cambridge.

Segal, I., 2003, Collusion, exclusion and inclusion in random-order bargaining, *Review of Economic Studies*, vol. 70, pp. 439–460.

Segal, I. and M. Whinston, 2000, Exclusive contracts and protection of investments, *RAND Journal of Economics*, vol. 31, pp. 603–633.

Shapley, L., 1953, A value for n-person games, in H. Kuhn and A. Tucker, eds., *Contribution to the Theory of Games II*, p. 307, Princeton University Press.

Smeers, Y., 2008, Gas models and three difficult objectives, CORE Discussion Paper 2008/9.

Snyder, C., 1998, Why do larger buyers pay lower prices? Intense supplier competition, *Economics Letters*, vol. 58, pp. 205–209.

Snyder, C., 2005, Countervailing power, *Contribution to the New Palgrave Dictionary*.

Stern, J., 2006, The new security environment for European gas: worsening geopolitics and increasing global competition for LNG, Oxford Institute for Energy Studies, NG 15.

Stern, J., 2007, Gas-OPEC: A Distraction from important issues of Russian gas supply to Europe, Oxford Energy Comment.

Stern, J., 2009, Continental European Long-Term Gas Contracts: is a transition away from oil product-linked pricing inevitable and imminent?, Oxford Institute for Energy Studies, NG 34.

Stole, L. and J. Zwiebel, 1996a, Intra-firm bargaining under non-binding contracts, *Review of Economic Studies*, vol. 63(3).

Stole, L. and J. Zwiebel, 1996b, Organizational design and technology choice under intra-firm bargaining, *American Economic Review*, vol. 86, pp. 195–222.

Tyagi, R., 2001, Why do suppliers charge larger buyers lower prices?, *Journal of Industrial Economics*, vol. 49, p. 45–61.

Victor, D., A. Jaffe and M. Hayes, 2008, Natural gas and geopolitics: From 1970 to 2040, *Cambridge University Press*.

Zwart, G., 2009, European natural gas markets: resource constraints and market power, *The Energy Journal*.

Zwart, G. and M. Mulder, 2006, NATGAS: a Model of the European Natural Gas Market, CPB memorandum 144.

Appendix A Assessment of costs of supply

We assume that marginal production costs are linear, $mc(q) = c + mq$. These costs are also referred to as the price at source. All three producing countries expect a considerable rise in their production costs. Norway and Russia will switch to new more remote fields in difficult terrain: the former to fields in the Norwegian and Barents seas, the latter to Yamal peninsular permafrost and Shtokman fields. Harsh conditions of the terrain, distance, and peculiarity of the field formation make the producers switch to LNG (liquefied natural gas) technology for supply. Algeria is already a large seller of LNG to Western Europe (in particular, to Spain, France and Italy), and will likely pursue further developments. To this end, Algeria had plans to build more LNG liquefaction capacities along with new field exploration. Based on Perner and Seelinger (2004) and OME (2004) we assess average production costs for Russia, Norway and Algeria with respect the current levels of production as $mc_A(q) = 100.0 + 0.2q$, $mc_R(q) = 85.4 + 0.35q$, and $mc_N(q) = 102 + 0.35q$.

The next step is to integrate the transportation cost into our cost formula. Our results average between those obtained in Hubert and Ikonnikova (2010) and presented in OME (2004), which was shown to provide a good estimate. Finally, we account for investment costs. Exporters (in particular, Norway and Russia) have to invest a significant amount of money to replace the current depleting fields with the new ones, build infrastructure to connect the new fields with the transit grid, and invest in extension of export pipeline system or LNG fleet. We take the projected figures for investments in pipelines and field development, annualize them and take per capacity. We use a common approach for the annualization of investment and find the annual payments as $\frac{I \cdot r}{(1-(1/(1+r)^T))}$, where $r = 0.15$ is the real interest rate.[27] To obtain the final cost figure, we assume that each exporter counts for a minimum 25% mark-up or countries' royalties when reporting costs. We adjust the total marginal cost functions to obtain the predicted increase in production capacities. We obtain a total supply to France, Italy and Germany of about 300 bcm/a. It is the exact amount we estimate for the demand functions. Finally, for our calculations we use the following marginal cost formula:

$$\begin{aligned} mc_A(q) &= 160 + 0.25q \\ mc_R(q) &= 127 + 0.35q \\ mc_N(q) &= 148 + 0.35q. \end{aligned}$$

[27] Data on LNG production, liquefaction, and shipping costs can be found e.g. in Barina (2005).