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Do Crises Tear the Fabric of Oil Trade?

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Abstract

In 1990, Iraq invaded Kuwait, touching off an economic, financial, diplomatic, and military crisis associated with a tremendous spike in oil prices and recession in OECD and oil-importing developing countries. But was the Gulf Crisis a disruption? Did it affect the fabric of oil trade?

To examine this question, this paper examines the changing role of international trade intermediaries (ITIs, often referred to as "trading companies") in the oil market. ITIs connect buyers and sellers, serving as the glue that holds many commodity markets together. Oil trading companies have attracted harsh scrutiny form policymakers as a result of allegations regarding their role in the United Nations' Iraqi Oil-for-Food Program, but minimal scholarly attention.

The paper takes advantage of a unique microdatabase on the Brent market. Produced in the U.K. North Sea, Brent Blend is by far the most widely traded crude oil in the international market. Participants in the Brent market are diverse, with the largest traders falling into two categories. The first comprises "industrial MNEs"—companies active in the business of producing or refining crude oil. The second category comprises financial houses and trading companies. This diversity provides an opportunity to test hypotheses regarding behavioral differences across types of companies and geographic origin, before, during, and after the crisis.

Key Words: oil, trading companies, crisis, Brent, North Sea

JEL Classification Numbers: D740, F230, F510, L140, L710, Q410

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I. Introduction

On August 2, 1990, Iraqi forces invaded Kuwait and quickly seized control of the country. Combined with the ensuing military build-up in the Gulf region and eventual invasion of Kuwait and Iraq by Allied forces, the conflict was associated with a tremendous spike in oil prices and recession in OECD and oil-importing developing countries. But did it affect the fabric of petroleum trade?

Past literature on oil crises typically focuses on macro effects such as economic growth, inflation, and employment, as well as macroeconomic policy responses. In contrast, this paper is part of a research stream examining micro aspects of oil crises.[1] The paper focuses on trade patterns during the Gulf Crisis, especially intermediation and the role of international trade intermediaries (ITIs, often referred to as "trading companies"[2]). Trading companies were the first multinational enterprises (Carlos and Nicholas 1988) and remain important in many countries and markets—yet they have received limited scholarly attention.

The paper is organized as follows. The small literature on ITIs is reviewed in Section II. Section III provides background on the industry, the market, and the data. Section IV provides a brief summary of the Gulf Crisis. Section V presents hypotheses about regarding the role of trading companies in the crisis. Statistical tests are presented in Section VI. Section VII concludes.

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[1] For previous articles in this stream, see Hubbard and Weiner 1983, Weiner 1994, 2005.

[2] Trading companies are known under a variety of names in the literature; this paper follows Perry 1990 in referring to them as ITIs.

II. Literature Review

The transactions-costs approach to international-trade institutions views ITIs as a means of dealing with impediments to trade related to information and contract performance (Roehl 1983, Carlos 1992, Casson 1998, Peng and Ilinitch 1998, Rauch 2001). ITIs' competitive advantage lies in their relational capital – knowing whom to deal with and trust in unfamiliar markets. In eras when information was scarce and costly to obtain, and contracts difficult to enforce, ITIs arose separately in Europe (e.g., Hudson's Bay company, and the Dutch and English East India companies, which date to the seventeenth century), North America (e.g., Cargill, started in 1865), and Japan, where the *sogo shosha* (general trading companies) were created in the nineteenth century (Yoshino and Lifson 1986).

The literature on ITIs (e.g., Roehl 1983; Chan 1986; Yoshino and Lifson 1986; Carlos and Nicholas 1988; Perry 1990; Casson 1998; Peng and Ilinitch 1998; Peng and York 2001; Trabold 2002) is limited primarily theoretical or descriptive, and largely ignores relationships between the international environment and ITI behavior. Empirical analysis of ITIs is confined to a handful of studies (Peng 1998; Peng and York 2001; Trabold 2002). Behind the scarcity of empirical work is the fact that ITIs are both diverse and privately held (and thus report little or no financial data).[3]

Given their diversity, ITIs are difficult to define, and efforts to pin down ITIs are further challenged by their tendency to integrate vertically into production or distribution and horizontally into shipping, insurance, and trade finance (Casson 1998). General Trading companies (GTCs) deal in a broad array of goods and are often associated with Asia, most notably the Japanese *sogo shosha*. European and North American trading companies, in contrast, have tended to specialize in a few commodities (Chalmin 1987). For example, the trading company Sucden specializes in sugar, Cargill and Louis Dreyfus in grain, Glencore (formerly Marc Rich) and Phibro in petroleum and metals, and Lonrho in metals.

The research strategy employed here is to examine changes in the role of ITIs in a case-study market. In addition to allowing avoidance of problems of transaction-cost measurement, this approach has some important advantages: First, information and contract-enforcement problems are likely to be more serious during turbulent periods, when relative prices change

[3] For example, Guex 1998: "In the 1990s, only one of the fifteen main trading companies in Switzerland publishes any figures at all and these are limited to few indicators such as sales figures."

rapidly and unpredictably, and the fabric of trade is strained by difficulties in assessing creditworthiness of contracting counterparties. The financial crises of recent years thus provide a possible laboratory for examining relationships between the environment of international business and the behavior of ITIs.

The conduct of ITIs in oil trading has generated intense scrutiny in the aftermath of the Gulf Crisis. ITIs handled the bulk of Iraqi oil exports under the United Nations' Oil-for-Food Program, in effect from 1996 to 2003. Allegations of unauthorized payments by oil purchasers to the Iraqi government under the Program led to an investigation by an Independent Inquiry Committee, which reported illicit behavior by ITIs (Independent Inquiry Committee 2005).

Moreover, crises are of interest in their own right, as a prominent and dramatic feature of the international economic landscape. The literature on crises tends to focus on macroeconomic and financial effects. In contrast, microeconomic effects—impacts on companies—have received relatively little attention, and the few studies of the impacts of financial shocks on the real side of the international economy have focused on corporate governance (Lemon and Lins 2003), profitability (Forbes 2002a, 2002b), or direct investment (Froot and Stein 1991; Lamont 1997) and have ignored potential effects on patterns of trade.

Past literature has neglected the temporal dimension of ITIs' role and behavior of in international trade, or discussed it only as an evolutionary process (Kim 1986; Perry 1990) (evolutionary approaches are limited by the fact that changes can result from environmental factors unrelated to ITIs). In contrast, this paper takes a "clinical case study" approach, examining high-frequency data over a short period. The setting is the international crude oil market during the Gulf Crisis of 1990–1991, when Iraq's invasion of Kuwait touched off an economic, financial, diplomatic, and military crisis. This paper examines the fabric of trade during the crisis, focusing on the role of trading companies. During a period of unprecedented volatility, did their role change? If so, did it expand or diminish, and why?

To address this question, the paper takes advantage of a unique database of individual sales transactions, which identifies the buyer and seller of each cargo of crude oil sold in the international market. The crisis provides a natural laboratory for assessing two views regarding trade intermediaries: The first view stresses the flexibility and information-gathering advantages of intermediaries; in a rapidly changing environment, these advantages should increase. The second view stresses risk absorption (Roehl 1983, Casson 1998). In the case-study market, trading companies take title to the oil they buy and then resell (or sell and then repurchase),

taking on the risk of adverse price movements.[4] Financial crises, with their associated volatility, should lead not only to an increased need for such risk taking, but also a decreased ability on the part of trading companies that are lightly capitalized. If the second effect is strong enough, it may outweigh the informational advantages of ITIs, and their role in the market will diminish.

III. Industry Background

The World Crude-Oil Market

Crude oil is the largest single component of international commerce (3-digit Standard Industrial Trade Classification code), accounting for 6.2 percent of the value of world merchandise trade in 2000.[5] The commodity is not homogeneous; prices of different crude oils vary, with lighter, lower sulfur types commanding a premium.[6] Most shipments are made by tanker, with pricing primarily free on board (fob) at tanker-loading terminals, either on a spot or forward basis (i.e., one cargo at a time, "spot" indicating delivery as soon as possible) or through long-term contracts, with prices indexed to spot trade.[7]

Oil prices are extremely volatile, far more so than exchange rates, interest rates, and gold prices. Forward sales allow market participants to manage market risk, by locking in prices for future delivery.[8]

This paper examines trading in Brent Blend, a crude oil produced in the U.K. North Sea. Brent is by far the most widely traded crude oil in the international market (Horsnell and Mabro 1993; Verleger 1993; U.S. Senate 2003), despite the fact that Brent has never accounted for more than 3 percent of crude oil in international trade.[9] Roughly two-thirds of internationally traded

[4] In the typology of trading companies in Casson 1998, ITIs in this market are "resellers," not "brokers."

[5] The value is sensitive to the level of oil prices. Data are from United Nations Conference on Trade and Development Handbook of Statistics On-Line, http://www.unctad.org/Templates/Page.asp?intItemID=1890

[6] For background information, see Horsnell and Mabro 1993, Verleger 1993.

[7] Prices of different types of crude oil tend to move together, allowing indexation to a few that are widely traded.

[8] There are also extensive derivatives markets for risk management and speculation, which are discussed in detail elsewhere; see e.g., Weiner 2002; U.S. Senate 2003. Verleger 1993 compares price volatility across markets.

[9] Roughly 75 percent of Brent production is exported from the United Kingdom, primarily to Canada, the United States, Germany, France, and Holland. All Brent sales are denominated in U.S. dollars.

crude oil is sold at Brent-related prices, so the market receives a great deal of scrutiny in the trade press.[10, 11]

Unlike financial markets, portfolio investors (e.g., hedge funds and individuals) cannot play; market participants need to possess not only substantial liquid capital (a single tanker cargo is worth $5–30 million, depending on oil prices), but also the industry contacts and managerial acumen necessary to charter tankers, transfer title to their contents, negotiate port fees, etc.[12]

The Brent market comprises two types of transactions. Spot transactions are for cargoes scheduled to be loaded at the Sullom Voe terminal on specific dates, referred to in the trade press as "dated Brent." Forward transactions are a form of "paper trading"—contracting for delivery in a specified future calendar month—but do not represent a specific physical cargo.[13] An important feature of Brent forward contracts is the "15-day rule:" sellers must give buyers 15 days notice to allow sufficient time for a tanker to be sent to the Sullom Voe terminal.[14] Each cargo loaded in a given month is assigned a three-day delivery window. Thus, forward contracts for a given month can trade up until the fifteenth day before the third-to-last business day of the month. Spot contracts can refer to cargoes to be loaded up to 45 days in the future.[15]

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[10] See U.S. Senate 2003; Bossley 2003. The largest oil-exporting countries restrict reselling of their crude oil, preventing development of spot trade.

[11] Brent Blend contracts are standardized, with all terms except price pre-established. Contract size is 500,000 barrels, roughly one tanker cargo, with delivery at Sullom Voe, the site of a tanker-loading platform in the Shetland Islands, Scotland. Brent prices are quoted fob Sullom Voe, and buyers are responsible for providing tankers to transport the crude oil, which is shipped to refineries in Europe and North America.

[12] According to Bossley 2002, "Apart from a sales contract, a cargo needs: letters of credit, which must be updated with every change in other documents; shipping contracts; date and volume nominations, re-nominations and any date changes; volume tolerance options exercise; notices of arrival and readiness to load; independent inspectors and/or cargo agent access to loading site; documentation requirements; negotiable title documents (usually BLs [bills of lading]); certificates of quality, quantity and origin; terminal timesheets; inspection reports; notices of protest; frequently, letters of indemnity, if other documentation is delayed; invoices; and demurrage and other claims."

[13] Spot transactions account for about 20 percent of the transactions in the database utilized in the paper. Of the paper contracts, roughly 65 percent are for one-month forward, 30 percent for two-months forward, and 5 percent, three or more months forward.

[14] The rule was changed slightly in mid-2002, to provide 20 days notice and allow sellers choice over delivery point. Contract size was raised to 600,000 barrels (Bossley 2003).

[15] The monthly trading and delivery cycle is most easily described by example, say for the month of July. A cargo assigned loading dates of July 29–31 can be traded forward until July 14 (assuming these are all business days). After this date, there no longer remain the requisite 15 days notice, and the cargo can be traded only on the spot market. A cargo assigned lifting dates of July 1–3 "becomes spot" after June 16. The scheduling for July loadings is carried out in mid-June, in time to provide 15 days notice for the earliest July deliveries.

Market Participants

Participants in the Brent market are diverse, allowing the opportunity to test hypotheses regarding behavioral differences across types of companies and geographic origin. The largest traders fall into two categories. The first comprises companies active in the business of producing or using crude oil—majors (descendants of the "seven sisters," the largest petroleum multinationals), other integrated petroleum companies, producers (i.e., upstream only), refiners (i.e., downstream only), and national oil companies (many of the largest firms in the industry are state-owned).

The second category comprises financial houses and trading companies—Wall Street banks, commodity traders, and Japanese general trading companies (*sogo shosha*). ITIs have long been important in commodity trade, starting with the English and Dutch East India Companies (spices, silks) and Hudson's Bay Company (furs) in the seventeenth century. Transaction-cost theory predicts that trade intermediation is more likely to occur in commodities than in more complex goods, sales of which are harder to monitor and tend to require more asset-specific investment, hence lending themselves to vertical integration (Peng and York 2001).

ITIs tend to be important in international commerce in petroleum, just as for other commodities.[16] The wave of nationalizations in oil-exporting countries in the 1970s saw control of marketing channels pass from the hands of the vertically integrated multinational "seven sisters" to newly-created national oil companies (Levy 1982). These companies lacked established commercial relationships and turned in part to ITIs as purchasers.[17]

Financial information on modern ITIs is limited by the fact that most are privately held or subsidiaries of larger firms. The most active ITIs in the Brent market in 1991 were (in order of trading activity) J Aron (part of Goldman Sachs), Phibro (part of Salomon Brothers), Cargill,

[16] ITIs handle 70 percent or more of the international grain trade and are also large participants in international trade in cocoa, coffee, cotton, sugar, and non-ferrous metals (Chalmin 1987). Roehl, Chee, and Cho 1984 discuss the role of GTCs in the Asian markets for aluminum, tin, and plywood. The role of the *sogo shosha* in Japanese crude oil imports is described in Yoshino and Lifson 1986. Cho 1987 lists the main products handled by Taiwanese and Turkish GTCs. The main products handled by GTCs from several countries are set out in Ozawa 1988. Peng 1998 surveyed U.S. report-trading companies; 70 percent of the respondents handled commodities.

[17] For example, Glencore (formerly Marc Rich) got its start in the 1970s based on relationships with the governments of Iran and Nigeria, two large oil-exporting countries (Guex 1998, 167).

Morgan Stanley, and Marc Rich (now Glencore); in 2001, Phibro, Sempra, Morgan Stanley, Vitol, and Glencore.[18] None of these ITIs is publicly held.

Data

As in all markets not conducted through public auctions or organized exchanges, Brent transactions are private. However, the Brent market is sufficiently large and important for price setting in the international crude oil market that its prices are widely reported by firms that specialize in data acquisition and dissemination.[19] The data used in this paper are generated by a daily industry survey of oil traders. The necessity of conducting surveys to obtain data is serendipitous, because the resulting database is composed of individual transactions, which are rarely accessible to researchers.[20]

The database used in this paper covers the period 1990–1991 (which includes the Gulf Crisis, and the periods immediately before and after), and is unusual in identifying the parties in each transaction, as well as the transaction terms. Market participants are categorized by type in a manner that makes investigation of trade patterns feasible. Nine types of firms are identified in the database as players in this market—the five oil company types and three ITI types listed above, plus a residual category (labeled "unknown") for typically small, infrequently-active companies that could not be classified by the survey compilers.[21]

Table 1 provides a summary of trader types and their activity in the Brent market during the period 1990–1991, along with an indication of the relative sizes of the participants, in terms of the number of transactions in this market. Trade patterns during the crisis, as well as immediately before and after, are detailed in Table 2. Of the 10,546 transactions during the

[18] Data for the early 1990s are from Horsnell and Mabro 1993, for 2001, *Petroleum Argus Global Markets* (2001).

[19] The data used in this paper come from one of these firms, the London-based Petroleum Argus, which surveys oil-market participants daily. I am grateful to Petroleum Argus for making the data available.

[20] Two questions of data reliability arise when using survey information: 1) sample representativeness, and 2) respondents' incentives to reply truthfully. While it is impossible to say for sure, neither is likely to be a serious problem here. The market is small enough, and reputation important enough, that deciding whom to survey is not an issue. The survey is carried out every business day and tries to reach all buyers and sellers in the market, rather than a sample of them. Only transactions verified by both buyer and seller are registered. Horsnell and Mabro (1993) estimate that the survey catches 40–50 percent of all transactions. A description of the database, including the names of the companies in each category, can be found in *Petroleum Argus Global Markets* (1987).

[21] Because of their transaction numbers are small, national oil companies are included in the integrated category and producers and refiners are lumped together in the tables and statistical analysis below.

period, roughly 85 percent involved an ITI; in about one-third of the transactions, both parties were ITIs.

IV. The Gulf Crisis

Background[22]

On August 2, 1990 Iraq invaded its neighbor Kuwait, setting off the Gulf Crisis. As part of the diplomatic response to the invasion, the United Nations embargoed oil exports from the two countries, resulting in a supply disruption equivalent to roughly 8 percent of oil consumption (excluding the former Soviet bloc, which remains largely insulated from the world oil market). Because previously loaded oil takes about a month to reach oil-refining centers, the full supply disruption did not register until September.

The fall of 1990 was characterized by diplomatic efforts to resolve the crisis through persuading the Iraqi government to remove its army from Kuwait, by a major military build-up in the Middle East by the United States and its allies (Operation Desert Storm), and by threats of force on both sides. Despite last-minute efforts to negotiate a settlement, diplomacy eventually failed. Allied military intervention (Operation Desert Storm) commenced with air strikes on January 16, 1991, and a ground war began February 24, 1991. A unilateral cease-fire was declared by the allies on February 28, 1991.

The Oil Market in the Crisis[23]

Despite the relatively brief duration of the disruption, oil prices climbed dramatically. The spot price of West Texas Intermediate (WTI) crude oil jumped from $21.60 to $23.70 per barrel on August 2 (the day Iraq invaded Kuwait), and reached $28.75 per barrel on August 6. Prices continued climbing through September and reached a maximum of $41.10 per barrel on October 11. On November 29, the UN Security Council approved a resolution authorizing the use of force if Iraq did not withdraw from the Kuwait by January 15; crude oil prices fell more than $4 per barrel the next day. By the end of year, prices had fallen back to about $30 per barrel. When the air war broke out, the spot price fell about $10 per barrel in a single day, bringing it back to its pre-invasion level.

[22] For an overview of the crisis, see Ridgeway (1991).

[23] Studies of oil-price volatility during the crisis include Melick and Thomas (1997) and Weiner (2005).

Figure 1 displays spot prices for the period 1989 through 1991.[24] The figure reveals the tremendous price-spike associated with the crisis. The rapid increase in prices during the early part of the crisis is likely to have exposed traders with commitments to make delivery to enormous losses; the price plunge in the latter part is likely to have placed those with commitments to take delivery in a similar position.

V. The Role of ITIs in a Crisis

Background

The international oil market in the Gulf Crisis serves as a natural laboratory for examining ITI behavior, for several reasons. First, ITIs compete directly with large, industrial companies, facilitating comparison of their roles in market functioning with non-crisis periods. Second, the extreme price volatility during the crisis evident in Figure 1, in combination with the information structure of the market (where terms of deals done are available only at the end of the day; see discussion above), implies that ITIs should do well, and play a bigger role in trade than during calm periods.

Third, several different types of ITIs compete actively in the market, facilitating comparisons among the widely diversified *sogo shosha*, trading arms of well-capitalized Wall Street banks, trading companies with varying reputations and capital bases, and small, lightly-capitalized, specialty traders. Fourth, the crisis originated far from the trading arena, eliminating the possibility of simultaneity bias in analyzing trading patterns.[25] Finally, the tremendous price volatility evident in Figure 1 increased the risk of contractual nonperformance and even bankruptcy of the lightly capitalized ITIs participating in the market.

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[24] The prices shown are actually for the nearby WTI crude oil futures contract on the New York Mercantile Exchange. As a result of the logistics of scheduling delivery of WTI through the pipeline system, so-called "spot" transactions are actually for one month ahead. Thus the nearby (i.e., one-month-maturity) futures prices and spot prices are virtually identical.

[25] In contrast, default by participants in the case-study market during an earlier period led to a change in trade patterns (Weiner 1994).

Hypotheses

Trade patterns before the crisis:

H1Ø. Pre-crisis trade patterns are consistent with a random-arrival model.[26]

H1A. ITIs played an intermediary role in this market, even before the crisis.

ITIs' role in the market during the crisis:

H2Ø. ITIs' role in the market was not affected by the crisis.

H2A. ITIs became more important during the crisis than before or after.

H2B. ITIs became less important during the crisis than before or after.

Path dependence in non-crisis periods:

H3Ø. Differences in the structure of trading in the market before and after the crisis are random.

H3A. Differences in the structure of trading in the market before and after the crisis result from the crisis.

Trade patterns after the crisis:

H4Ø. Differences in the structure of trading in the market during and after the crisis are random.

H4A. Differences in the structure of trading in the market during and after the crisis are different as a result of changes in the environment, e.g., decreased volatility.

[26] In the absence of intermediation, buyers and sellers come to the market randomly, and the probability of any two trader–types' meeting depends only on the trader–types' respective shares of the buyer and seller populations; i.e., a given trader's transactions by partner type are drawn by pure chance from the pool of all transactions. More detail on the model is provided below.

VI. Statistical Analysis

All the world's a stage,
And all the men and women merely players.
They have their exits and their entrances . . .
—Shakespeare, *As You Like It*, Act II, Scene vii

A Statistical Model of Trade Patterns

This section presents a statistical model of trade patterns, as well as tests of the ITI activity in the international oil market, comparing the crisis with the periods immediately before and after.[27] The approach adopted here is nonparametric, following Weiner 1994. The tests are based on a statistical model of trade patterns. The null hypothesis (H2Ø above) states that there is no change in patterns of trade intermediation associated with the Gulf Crisis. If the null hypothesis is false, then the Gulf-Crisis period should be associated with either fewer direct transactions between oil companies and trading companies (under H2A), or more (under H2B).

As noted above, in the absence of intermediation, the process of trade can be modeled quite simply. Buyers and sellers come to the market randomly ("they have their exits and their entrances"). The stochastic processes governing the arrival of buyers and sellers are independent, so that the probability of any two trader –types' meeting depends only on the trader–types' respective shares of the buyer and seller populations; i.e., a given trader's transactions by partner type are drawn by pure chance from the pool of all transactions.

If certain trader types play the role of intermediaries, however, then the null hypothesis is no longer valid, pairings of buyers and sellers are no longer purely random, and the distribution of a trader type's partners will differ from the distribution in the entire population. In the absence of a model of the arrival processes, the statistical tests are nonparametric, based on counting each trader type's transactions by partner type and are designed to reject the null hypothesis *when a given trader type's partner distribution differs sufficiently from that of the partner population*.

In equation form, the difference D_{ij} between actual and expected (under the null hypothesis) sales from trader type *i* to type *j* is given by:

$$(1) D_{ij} = A_{ij} - s_i b_j / n$$

[27] The data cover the years 1990 and 1991; the pre-crisis, crisis, and post-crisis periods are of comparable length (roughly 7 months, 7 months, and 10 months, respectively).

where A_{ij} is the actual number of sales from type *i* to type *j*, s_i is type *i*'s total sales, b_j is type *j*'s total purchases, and $n = \sum s_i = \sum b_j$ is the total number of transactions in the market.[28]

Under the null hypothesis, the expectation of the random variable D_{ij} is zero. Of course, D_{ij} is unlikely to be exactly zero, due to the stochastic nature of the matching process. In contrast, under the alternative hypothesis that refiners prefer to do business with trading companies through intermediaries, D_{ij} should be negative in the case where type *i* is trading companies and type *j* is refiners.

To conduct statistical tests, standard errors for D_{ij} must be calculated. Taking each type's entirety of trades as its population, samples of its transactions by partner type will be drawn from a multivariate hypergeometric distribution under the null hypothesis.[29]

In the absence of a comprehensive model of traders' propensity to transact, by partner type, the most straightforward way to determine whether the Gulf Crisis affected the role of ITIs in the market is to compare trading patterns before, during, and after the crisis. Accordingly, panels B, C, and D split the trading patterns of Table 2A into pre-crisis, crisis, and post-crisis periods.

Empirical Results

1. Rejection of the first null hypothesis: trade patterns before the crisis are consistent with intermediation by trader types T and W.

Table 3A presents the trade patterns expected under the null hypothesis that buyers and sellers meet randomly each period ($s_i b_j/n$ in equation (1) above); the difference (D_{ij} in equation

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[28] This is an application of the general log-linear statistical model (see Wickens 1989). As an example, suppose that major oil companies as a group account for 20 percent of all forward purchases. In the absence of trade intermediation, they should also account for 20 percent of all purchases from trading companies. An "expected" number of sales from trading companies to majors can be obtained by multiplying the 20 percent figure by trading companies' total sales. Note that in general D_{ij} and D_{ji} are not equal, because actual sales from type *i* to type *j* and actual purchases by type *i* from type *j* will generally differ.

[29] The hypergeometric distribution applies when sampling is done without replacement. The sampling problem described in the text is equivalent to picking a black ball (representing, say, the seller) and a white ball (representing the buyer) together, without replacement, out of an urn with n black balls (purchases) and n white balls (sales). S_i of the black balls are labeled with the *i*th seller type, and b_j of the white balls are labeled with the *j*th buyer type. Because the black balls and white balls are chosen independently, the probability of choosing a black ball of type *i* and a white ball of type *j* is $(s_i/n)*(b_j/n)$. The expected number of sales from type *i* to type *j* is s_i*b_j/n. In the empirical calculations below, the normal approximation to the hypergeometric distribution (see Feller 1968) is used to estimate the standard errors.

(1) above), along with their standard errors, are presented in Table 4A.[30] The table suggests that a model wherein traders meet randomly is very unlikely to have generated the data, even before the crisis; 53 (respectively, 77) of the 196 differences estimated are significant at the 1 percent (respectively, 10 percent) level (two-tailed test of the null $D_{ij} = 0$ against the alternative $D_{ij} \neq 0$), versus 2 (respectively, 20) expected by chance. The χ^2 value for testing the independence of rows and columns implied by the null hypothesis is 367 (36 df), far exceeding the 0.1 percent critical value of 68 for χ^2_{36}; we can be far more than 99.9 percent confident that the null hypothesis is false.

For insight into deviations from the random-arrival model, consider the trade patterns for the integrated oil companies (*I*), which produce some of the commodity and have the second-largest number of transactions over the entire period: 4,586 purchases and sales, roughly 22 percent of the grand total of 21,092 (counting each transaction as both a purchase and a sale). The integrated companies tended not to deal with each other before the crisis; the 64 *I-I* transactions are a significant 42 (40 percent) fewer than would occur by chance.[31] The integrated companies also display, *inter alia*, an unexpectedly large number of sales to, and purchases from, trading companies (*T*) and Wall Street Banks (*W*). A glance at Table 4A suggests that these two trader types indeed functioned as intermediaries, taking the opposite side of trades with the two main oil company groups (*I,M*) more often than would be expected by chance and trading less often than expected within their own groups.

2. Rejection of the second null hypothesis: the fabric of trade during the crisis differs from non-crisis periods.

A simple comparison of the fraction of all sales[32] to intermediaries (types *S,T,U,W*) between periods reveals a decline in intermediaries' market share—from 63 percent before the crisis to 60 percent during the crisis and 54 percent afterward. The differences between periods are significant at the 1 percent level, with χ^2 values of 9.0 (pre- versus crisis), 25.2 (crisis versus post-) and 64.6 (pre- versus post-) respectively, all in excess of the 1 percent critical value of 6.6 for χ^2_1. The experiences of the various trader types were diverse, however, with the *sogo shosha* and unknown types losing share during the crisis and not regaining it, the Wall Street banks

[30] All estimated trade flows are rounded to nearest integer in the tables.

[31] In the text, significance refers to the ten-percent level (two-tailed test). Table 4A indicate statistical significance at the 10, 5, and 1 percent levels by superscripts a, b, and c, respectively.

[32] Purchases are similar, but not reported here.

losing share but regaining it afterward, and other trading companies increasing their share and maintaining it afterward.

Table 3B presents the trade patterns expected under the null hypothesis of no change in structure over time. Unlike Table 3A, no assumptions are made regarding propensity to trade with different types of counterparties; only observed patterns are stable over the three periods. Deviations from actual patterns are shown in Table 4B; for example, the major and integrated companies started trading more with each other and among themselves, bypassing the intermediaries during the crisis—and continued even more so afterward. The χ^2 value (96 df) for testing the independence of time period implied by the null hypothesis, while not requiring independence of rows and columns,[33] far exceeds the 0.1 percent critical value for χ^2_{96}. Thus, we can be far more than 99.9 percent confident that the null hypothesis is false.

3. Rejection of the third and fourth null hypotheses: the fabric of trade differs between pre- and post-crisis periods, and between crisis and post-crisis periods.

Differences in the structure of trading in the market before and after the crisis are too large to be attributable to random factors. Table 3C presents the trade patterns expected under the null hypothesis of no path dependence in non-crisis periods. Just as in Table 3B, no assumptions are made regarding propensity to trade with different types of counterparties—only that observed patterns are stable over the two non-crisis periods.

Deviations from actual patterns are shown in Table 4C. Only the pre-crisis period is shown; the post-crisis period is a mirror image, as these deviations must sum to zero across the two periods. Just as above, the majors and integrated companies bypassed intermediaries, trading more with each other and among themselves after the crisis than before. As above, while not requiring independence of rows and columns, the χ^2 value (48 df) for testing the independence of time period implied by the null hypothesis far exceeds the 0.1 percent critical value for χ^2_{48}; we can be far more than 99.9 percent confident that the null hypothesis is false. A similar result holds for the crisis and post-crisis periods (not shown).

[33] The null hypothesis implies that the two-way contingency tables for each period differ only by random variation and scale factors associated with the total transactions in the period. Failure to reject the null hypothesis implies that the three-way contingency table cannot be reduced to three two-way tables (see Wickens 1989).

VII. Conclusion

This paper has taken advantage of a unique transaction-level database with buyer and seller information to examine the fabric of international oil trade during the period of the Gulf Crisis. Statistical evidence supports the view that trading patterns changed during the crisis, with intermediaries playing a smaller role than before in serving as counterparties to the large oil companies that produce the commodity. Moreover, there is evidence of path dependence: While the market in the aftermath of the crisis looked much like that preceding it, the fabric had changed. One possibility is that lightly capitalized trading companies were seen as less creditworthy after the crisis than before.

ITIs continue to be important in world oil trade, notwithstanding predictions of their demise as a result of improving information systems. Some ITIs have entered upstream or downstream segments of the industry; the reason for others' survival is hard to pinpoint, given the paucity of data. The dominant role played by ITIs as purchasers of Iraq's oil exports during the UN Oil-for-Food Program, and the extensive diversion of funds designated for humanitarian aid suggests the usefulness of ongoing research into their role and behavior in international oil trade.

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Tables and Figure

Table 1. Trader Types, Characteristics, and Number of Transactions, 1990–1991

Code	Company Type	Sales	Purchases	Description
Companies with upstream or downstream capacity				
I	integrated	2,282	2,304	both upstream and downstream capacity (*Statoil*)
M	major	1,728	1,853	descendents of "seven sisters" (*Shell*)
P,R	producer, refiner	206	217	upstream or downstream capacity only (*Enterprise*)
Companies with neither upstream nor downstream capacity				
S	*sogo shosha*	419	298	Japanese general trading companies (*Kanematsu*)
T	trading company	2,646	2,737	other than **S,W** (*Cargill*)
W	Wall Street	2,335	2,039	US Investment banks (*Morgan Stanley*)
U	unknown	930	1,098	companies that could not be classified by the survey

Note: The total number of transactions (equals sales equals purchases) is 10,546. The categories are mutually exclusive and collectively exhaustive. A list of companies by category is given in *Petroleum Argus* (1987).

Table 2. Trade Patterns in the Brent Market

A. Entire Period

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	403	381	45	57	652	526	218	2,282
M	378	239	21	38	459	417	176	1,728
P+R	44	21	2	6	33	76	24	206
S	76	68	3	12	123	99	38	419
T	597	492	52	82	602	573	248	2,646
W	607	499	80	83	661	238	167	2,335
U	199	153	14	20	207	110	227	930
Total	2,304	1,853	217	298	2,737	2,039	1,098	10,546

B. Pre-invasion 1/2/1990–8/1/1990

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	64	73	12	25	151	165	82	572
M	88	55	3	22	107	129	70	474
P+R	7	4	2	1	11	18	7	50
S	28	34	2	7	53	53	17	194
T	143	123	16	39	131	156	80	688
W	175	150	25	51	176	62	58	697
U	61	45	6	15	71	39	139	376
Total	566	484	66	160	700	622	453	3,051

C. Invasion and War 8/2/1990–2/28/1991

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	142	112	14	19	235	170	83	775
M	95	68	10	13	138	101	54	479
P+R	17	8	0	4	9	24	9	71
S	29	14	1	5	41	27	18	135
T	210	116	17	29	211	180	97	860
W	217	117	27	24	201	69	65	720
U	81	52	5	4	79	34	63	318
Total	791	487	74	98	914	605	389	3,358

D. Aftermath 3/1/1991–12/31/91

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	197	196	19	13	266	191	53	935
M	195	116	8	3	214	187	52	775
P+R	20	9	0	1	13	34	8	85
S	19	20	0	0	29	19	3	90
T	244	253	19	14	260	237	71	1098
W	215	232	28	8	284	107	44	918
U	57	56	3	1	57	37	25	236
Total	947	882	77	40	1,123	812	256	4,137

Table 3a. Trade Patterns Expected under Null Hypothesis that Buyers and Traders Meet Randomly Each Period

A. Entire Period

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	499	401	47	64	592	441	238	2,282
M	378	304	36	49	448	334	180	1,728
P+R	45	36	4	6	53	40	21	206
S	92	74	9	12	109	81	44	419
T	578	465	54	75	687	512	275	2,646
W	510	410	48	66	606	451	243	2,335
U	203	163	19	26	241	180	97	930
Total	2,304	1,853	217	298	2,737	2,039	1098	10,546

B. Pre-invasion 1/2/1990–8/1/1990

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	106	91	12	30	131	117	85	572
M	88	75	10	25	109	97	70	474
P+R	9	8	1	3	11	10	7	50
S	36	31	4	10	45	40	29	194
T	128	109	15	36	158	140	102	688
W	129	111	15	37	160	142	103	697
U	70	60	8	20	86	77	56	376
Total	566	484	66	160	700	622	453	3,051

C. Invasion/War 8/2/1990–2/28/1991

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	183	112	17	23	211	140	90	775
M	113	69	11	14	130	86	55	479
P+R	17	10	2	2	19	13	8	71
S	32	20	3	4	37	24	16	135
T	203	125	19	25	234	155	100	860
W	170	104	16	21	196	130	83	720
U	75	46	7	9	87	57	37	318
Total	791	487	74	98	914	605	389	3,358

D. Aftermath 3/1/1991–end

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	214	199	17	9	254	184	58	935
M	177	165	14	7	210	152	48	775
P+R	19	18	2	1	23	17	5	85
S	21	19	2	1	24	18	6	90
T	251	234	20	11	298	216	68	1,098
W	210	196	17	9	249	180	57	918
U	54	50	4	2	64	46	15	236
Total	947	882	77	40	1,123	812	256	4,137

Table 3b. Trade Patterns Expected under Null Hypothesis of No Change in Patterns over Time

A. Pre-invasion 1/2/1990–8/1/1990

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	117	110	13	16	189	152	63	660
M	109	69	6	11	133	121	51	500
P+R	13	6	1	2	10	22	7	60
S	22	20	1	3	36	29	11	121
T	173	142	15	24	174	166	72	765
W	176	144	23	24	191	69	48	676
U	58	44	4	6	60	32	66	269
Total	667	536	63	86	792	590	318	3,051

B. Invasion/War 8/2/1990–2/28/1991

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	128	121	14	18	208	167	69	727
M	120	76	7	12	146	133	56	550
P+R	14	7	1	2	11	24	8	66
S	24	22	1	4	39	32	12	133
T	190	157	17	26	192	182	79	843
W	193	159	25	26	210	76	53	743
U	63	49	4	6	66	35	72	296
Total	734	590	69	95	872	649	350	3,358

C. Aftermath 3/1/1991–end

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	158	149	18	22	256	206	86	895
M	148	94	8	15	180	164	69	678
P+R	17	8	1	2	13	30	9	81
S	30	27	1	5	48	39	15	164
T	234	193	20	32	236	225	97	1,038
W	238	196	31	33	259	93	66	916
U	78	60	5	8	81	43	89	365
Total	904	727	85	117	1,074	800	431	4,137

Table 3c. Trade Patterns Expected under Null Hypothesis of No Path Dependence in Non-Crisis Periods

A. Pre-invasion 1/2/1990–8/1/1990

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	111	114	13	16	177	151	57	640
M	120	73	5	11	136	134	52	530
P+R	11	6	1	1	10	22	6	57
S	20	23	1	3	35	31	8	121
T	164	160	15	22	166	167	64	758
W	166	162	22	25	195	72	43	685
U	50	43	4	7	54	32	70	260
Total	642	580	61	85	774	609	301	3,051

B. Aftermath 3/1/1991–end

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	150	155	18	22	240	205	78	867
M	163	98	6	14	185	182	70	719
P+R	16	7	1	1	14	30	9	78
S	27	31	1	4	47	41	12	163
T	223	216	20	31	225	226	87	1,028
W	224	220	31	34	265	97	59	930
U	68	58	5	9	74	44	94	352
Total	871	786	82	115	1,049	825	408	4,137

Table 4a: Deviations from Trade Patterns—Actual Less Expected under Null Hypothesis that Buyers and Sellers Meet Randomly Each Period

A. Entire Period

	I	*(std err)*	**M**	*(std err)*	**P+R**	*(std err)*	**S**	*(std err)*	**T**	*(std err)*	**W**	*(std err)*	**U**	*(std err)*
I	-96[c]	*(17.47)*	-20	*(16.09)*	-2	*(6.00)*	-7	*(7.01)*	60[c]	(18.54)	85[c]	(16.70)	-20	*(12.91)*
M	0	*(15.71)*	-65[c]	*(14.47)*	-15[c]	*(5.40)*	-11[a]	*(6.30)*	11	(16.66)	83[c]	(15.01)	-4	*(11.61)*
P+R	-1	*(5.87)*	-15[c]	*(5.41)*	-2	*(2.02)*	0	*(2.35)*	-20[c]	(6.23)	36[c]	(5.61)	3	*(4.34)*
S	-16	*(8.29)*	-6	*(7.63)*	-6[b]	*(2.85)*	0	*(3.32)*	14	(8.79)	18[b]	(7.92)	-6	*(6.13)*
T	19	*(18.40)*	27	*(16.94)*	-2	*(6.32)*	7	*(7.38)*	-85[c]	(19.52)	61[c]	(17.58)	-27[b]	*(13.60)*
W	97[c]	*(17.62)*	89[c]	*(16.23)*	32[c]	*(6.05)*	17[b]	*(7.07)*	55[c]	(18.69)	-213[c]	(16.84)	-76[c]	*(13.02)*
U	-4	*(12.03)*	-10	*(11.08)*	-5	*(4.13)*	-6	*(4.83)*	-34[c]	(12.77)	-70[c]	(11.50)	130[c]	*(8.89)*

B. Pre-invasion 1/2/1990–8/1/1990

	I	*(std err)*	**M**	*(std err)*	**P+R**	*(std err)*	**S**	*(std err)*	**T**	(std err)	**W**	(std err)	**U**	*(std err)*
I	-42[c]	*(8.38)*	-18[b]	*(7.88)*	0	*(3.14)*	-5	*(4.81)*	20[b]	(9.06)	48[c]	(8.69)	-3	*(7.67)*
M	0	*(7.78)*	-20[c]	*(7.31)*	-7[b]	*(2.91)*	-3	*(4.46)*	-2	(8.41)	32[c]	(8.06)	0	*(7.11)*
P+R	-2	*(2.73)*	-4	*(2.56)*	1	*(1.02)*	-2	*(1.56)*	0	(2.95)	8[c]	(2.83)	0	*(2.49)*
S	-8	*(5.24)*	3	*(4.92)*	-2	*(1.96)*	-3	*(3.00)*	8	(5.67)	13[b]	(5.43)	-12[b]	*(4.79)*
T	15[a]	*(8.97)*	14	*(8.43)*	1	*(3.36)*	3	*(5.15)*	-27[c]	(9.71)	16	(9.30)	-22[c]	*(8.21)*
W	46[c]	*(9.01)*	39[c]	*(8.47)*	10[c]	*(3.37)*	14[c]	*(5.17)*	16[a]	(9.75)	-80[c]	(9.34)	-45[c]	*(8.25)*
U	-9	*(7.06)*	-15[b]	*(6.63)*	-2	*(2.64)*	-5	*(4.05)*	-15[b]	(7.63)	-38	(7.31)	83[c]	*(6.46)*

C. Invasion/War 8/2/1990–2/28/1991

	I	*(std err)*	**M**	*(std err)*	**P+R**	*(std err)*	**S**	*(std err)*	**T**	(std err)	**W**	(std err)	**U**	*(std err)*
I	-41[c]	*(10.36)*	0	*(4.85)*	-3	*(2.02)*	-4	*(2.32)*	24[c]	(6.13)	30[c]	(5.30)	-7	*(4.41)*
M	-18[b]	*(8.60)*	-1	*(7.14)*	-1	*(2.97)*	-1	*(3.41)*	8	(9.02)	15[a]	(7.79)	-1	*(6.49)*
P+R	0	*(3.54)*	-2	*(2.94)*	-2	*(1.22)*	2	*(1.40)*	-10[c]	(3.71)	11[c]	(3.20)	1	*(2.67)*
S	-3	*(4.83)*	-6	*(4.01)*	-2	*(1.67)*	1	*(1.92)*	4	(5.07)	3	(4.37)	2	*(3.64)*
T	7	*(10.73)*	-9	*(8.91)*	-2	*(3.71)*	4	*(4.26)*	-23[b]	(11.26)	25[b]	(9.72)	-3	*(8.09)*
W	47[c]	*(10.09)*	13	*(8.37)*	11[c]	*(3.49)*	3	*(4.00)*	5	(10.59)	-61[c]	(9.14)	-18[b]	*(7.61)*
U	6	*(7.20)*	6	*(5.97)*	-2	*(2.49)*	-5	*(2.86)*	-8	(7.55)	-23[c]	(6.52)	26[c]	*(5.43)*

D. Aftermath 3/1/1991–end

	I	*(std err)*	**M**	*(std err)*	**P+R**	*(std err)*	**S**	*(std err)*	**T**	(std err)	**W**	(std err)	**U**	*(std err)*
I	-17	*(11.30)*	-3	*(11.02)*	2	*(3.64)*	4	*(2.63)*	12	(11.96)	7	(10.68)	-5	*(6.48)*
M	18[a]	*(10.54)*	-49[c]	*(10.28)*	-6	*(3.39)*	-4	*(2.46)*	4	(11.16)	35[c]	(9.97)	4	*(6.05)*
P+R	1	*(3.83)*	-9[b]	*(3.74)*	-2	*(1.23)*	0	*(0.89)*	-10[b]	(4.06)	17[c]	(3.62)	3	*(2.20)*
S	-2	*(3.94)*	1	*(3.84)*	-2	*(1.27)*	-1	*(0.92)*	5	(4.17)	1	(3.73)	-3	*(2.26)*
T	-7	*(11.93)*	19	*(11.63)*	-1	*(3.84)*	3	*(2.78)*	-38[c]	(12.63)	21[a]	(11.28)	3	*(6.84)*
W	5	*(11.23)*	36[c]	*(10.95)*	11[c]	*(3.61)*	-1	*(2.62)*	35[c]	(11.89)	-73[c]	(10.62)	-13[b]	*(6.44)*
U	3	*(6.27)*	6	*(6.11)*	-1	*(2.02)*	-1	*(1.46)*	-7	(6.63)	-9	(5.93)	10[c]	*(3.59)*

Note: Significance levels (2-tailed test against H_0: actual–expected = 0): a – 10%, b – 5%, c – 1%

Table 4b: Deviations from Trade Patterns—Actual Less Expected under Null Hypothesis of No Change in Patterns over Time

A. Pre-invasion 1/2/1990–8/1/1990

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	-53	-37	-1	9	-38	13	19	-88
M	-21	-14	-3	11	-26	8	19	-26
P+R	-6	-2	1	-1	1	-4	0	-10
S	6	14	1	4	17	24	6	73
T	-30	-19	1	15	-43	-10	8	-77
W	-1	6	2	27	-15	-7	10	21
U	3	1	2	9	11	7	73	107
Total	-101	-52	3	74	-92	32	135	0

B. Invasion/War 8/2/1990–2/28/1991

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	14	-9	0	1	27	3	14	48
M	-25	-8	3	1	-8	-32	-2	-71
P+R	3	1	-1	2	-2	0	1	5
S	5	-8	0	1	2	-5	6	2
T	20	-41	0	3	19	-2	18	17
W	24	-42	2	-2	-9	-7	12	-23
U	18	3	1	-2	13	-1	-9	22
Total	57	-103	5	3	42	-44	39	0

C. Aftermath 3/1/1991–end

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	39	47	1	-9	10	-15	-33	40
M	47	22	0	-12	34	23	-17	97
P+R	3	1	-1	-1	0	4	-1	4
S	-11	-7	-1	-5	-19	-20	-12	-74
T	10	60	-1	-18	24	12	-26	60
W	-23	36	-3	-25	25	14	-22	2
U	-21	-4	-2	-7	-24	-6	-64	-129
Total	43	155	-8	-77	49	12	-175	0

Table 4c: Deviations from Trade Patterns—Actual Less Expected under Null Hypothesis of No Path Dependence in Non-Crisis Periods

Pre-invasion 1/2/1990–8/1/1990

Seller/Buyer	I	M	P+R	S	T	W	U	Total
I	-47	-41	-1	9	-26	14	25	-68
M	-32	-18	-2	11	-29	-5	18	-56
P+R	-4	-2	1	0	1	-4	1	-7
S	8	11	1	4	18	22	9	73
T	-21	-37	1	17	-35	-11	16	-70
W	9	-12	3	26	-19	-10	15	12
U	11	2	2	8	17	7	69	116
Total	-76	-96	5	75	-74	13	152	0

Figure 1: CRUDE OIL PRICES, 1989-1991