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Risk Shifting and Long-Term Contracts

Evidence from the Ras Gas Project

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Risk shifting and incomplete contracting lie at the heart of the agency relationship inherent in the procurement and financing of large-scale projects such as power plants, oil and gas pipelines, and liquefied natural gas facilities. An investigation of Ras Gas bonds provides empirical evidence of the risk-shifting consequences of contractual incompleteness.

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Summary findings

Risk shifting and incomplete contracting lie at the heart of the agency relationship inherent in the procurement and financing of large-scale projects such as power plants, oil and gas pipelines, and liquefied natural gas (LNG) facilities. Resolving this agency problem is critical in structuring the nexus of long-term contracts—construction, operating, output sale, and financial contracts—commensurate with the projects' underlying technological and market organization.

By investigating the Ras Gas bonds—the largest and most liquid global project bonds ever issued in an emerging market economy—Dailami and Hauswald provide empirical evidence of the risk-shifting consequences of contractual incompleteness.

They relate the credit spreads of Ras Gas bonds to the bond spreads of the Korea Electric Power Company (Kepco), the major customer, in the context of a 25-year supply agreement, the oil price index used to price the LNG, emerging debt market returns, and various systematic and unsystematic risk variables.

Consistent with theoretical predictions, they find that the risk factors affecting the sales and purchase agreements drive perceptions of market risk for Ras Gas bonds. In particular, Ras Gas yield spreads reflect the market's risk assessment of Kepco. Other priced risks are energy price and foreign currency exposure (which influence Ras Gas credit spreads through their impact on Kepco), Korean economic variables, and spillovers from turbulence in European and Latin American emerging debt markets.

The authors' analysis shows that the design of each contractual arrangement is not independent, because risk factors relevant to one contract determine the price and risk premium of the other. Despite heavy capitalization and partial guarantees by the parent companies of Ras Gas, the off-take agreement essentially determines the riskiness of the bonds. Dailami and Hauswald interpret this as evidence of the nexus-of-contracts view of the firm in the presence of contractual incompleteness: Investors bear all residual risks and price their financial claims accordingly.

This paper—a product of the Governance, Regulation, and Finance Division, World Bank Institute—is part of a larger effort in the institute to disseminate the lessons of experience and best practices in infrastructure finance and risk management. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact William Nedrow, room J3-283, telephone 202-473-1585, fax 202-334-8350, email address wnedrow@worldbank.org. Policy Research Working Papers are also posted on the Web at www.worldbank.org/research/workingpapers. The authors may be contacted at mdailami@worldbank.org or rhauswald@rhsmith.umd.edu. November 2000. (30 pages)

Risk Shifting and Long-Term Contracts: Evidence from the Ras Gas Project

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Risk Shifting and Long-Term Contracts: Evidence from the Ras Gas Project

1. *Introduction*

The presence of risky debt in a firm's capital structure is known to lead to *ex post* conflicts of interests between the firm's equity holders and bondholders.[1] Given equity's convex pay-off profile, firms that are managed in the interest of equity holders have an incentive to shift risk to their bondholder. Excessive risk taking, if not controlled through contractual and pre-commitment devices, could result in suboptimal investment decisions (over- or under-investment). The associated investment distortions cause deadweight losses to the economy. The risk shifting incentives of risky debt and the associated suboptimal investment problem arise from the interplay of pay-off profiles and informational asymmetries between equity holders and bondholders, e.g., in circumstances where monitoring and contracting costs prevent bondholders from sufficiently observing investment choices made by inside managers.

To address such agency problems, recent research has advanced a variety of incentive compatible solutions, including financial contracting (restrictive bond covenants, and convertibility clauses, Kahan and Yermack, 1998), project finance (Berkovitch and Kim, 1990), tax policy (John, John and Senbet 1991), and reform of bankruptcy procedures (Schwartz, 1997). Through or because of such devices, it is claimed, borrowers can credibly signal to lenders that they choose efficient levels of risk. This strand of literature, however, neglects a further source of risk shifting that has a direct incidence on debt finance: *contractual incompleteness*. Thus, in markets where transactions are characterized by a high degree of uncertainty and relationship specificity conditions, contracting parties often have to leave many contingencies and provisions out of *ex ante* agreements, creating incomplete contracts. Prime examples of such transactions are investments in large scale projects, i.e., power plants, oil and gas pipelines, and liquified natural gas (LNG) facilities.

In this paper, we analyze risk shifting as a consequence of contractual incompleteness[2] and relate its sources to the price of risky debt in the context of project finance. The project in question is the Ras Laffan Natural Liquified Gas Company (Ras Gas), set up to extract, process and sell liquefied natural gas from a field off the shore of Qatar. Ras Gas signed a 25 year supply

[1] See Jensen and Meckling (1976), Myers (1977), Smith and Warner (1979), John (1987), Green (1984).

[2] The theoretical underpinnings of contractual incompleteness are well understood in the literature on contract theory, whether in its principal-agent or transaction cost setting. According to the transaction-cost approach, contract incompleteness is attributed to high transaction costs of writing, negotiating of contracts, and costs associated with monitoring of contractual performance. (See, for instance, Joskow (1987, 1988), Hart (1988), and Aghion and Bolton (1992).

contract to sell most of the output to the Korea Gas Corporation (Kogas) for re-sale to the Korea Electric Power Company (Kepco) for electricity generation[3]. The contractual incompleteness primarily stems from the long-term sales contract, the absence of a spot market for liquefied natural gas, and the economics of LNG fired power plants. At the same time, the incentive to shift risk to investors arises from potential opportunistic behavior by the output buyers and the specificity of the required investment in LNG infrastructure.

If investors are rational and markets reasonably efficient from an informational point of view, any material change affecting the buyer of a project's output should immediately feed through to the price of debt and equity. From an analytic perspective, the Ras Gas joint venture offers the unique advantage of having two large global bond issues outstanding and only one major off-taker, Kogas, on behalf of Kepco. Hence, any change affecting the prospects of Kepco and, more largely, the electricity market in Korea should be reflected in the Ras Laffan bond yields. The Asian and Russian financial crises just provide two such external events that adversely affected investor expectations and, in case of the former, Kepco's perceived ability to honor the off-take agreement. Related events revolve around rating changes for Korea and Kepco that permit the definition of further events, both negative ones (downgrades) and, more recently, positive changes (upgrades). Finally, Kepco has both ADRs and global bonds outstanding whose prices and yields provide valuable information about the market's assessment of the company's prospects.

Given the contractual arrangements in the off-take agreement and bond covenant that creates a legal and economic link between the output purchase and debt contracts we formulate several hypotheses regarding risk factors. Any risks that can not be explicitly addressed in the nexus of contracts comprised of the off-take agreement and debt contract (covenant) is ultimately borne by investors.[4] Having bond yields of both the seller and buyer of the output allows us to investigate which risks are priced by bondholders and, hence, shifted to them. In particular, we expect that any deterioration in the economic prospects of Kepco should increase the likelihood of breach of contract. Ras Gas bondholders' exposure to Kepco comprises several components: exposure to the Korean economy and its demand for energy (electricity, gas), and corporate exposure to Kepco proper in the form of operational, financial and regulatory risks. Since Kepco yields reflect both corporate and Korean exposure we attempt to differentiate the two by including a set of Korean control variables. Finally, both Ras Gas and Kepco bonds belong to the emerging debt market segment of global bond markets so are subject to emerging market risk and contagion (the spill-over effects from the Asian and Russian financial crises).

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[3] The parties later renegotiated the initial contract doubling its volume and dropping price guarantees for Ras Gas in return for the significant economies of scale realized.

[4] Contrary to a large company, projects such Ras Gas have only one cash flow stream from which all debt obligations are to be met and dividends paid to project sponsors. Construction, start-up and operational phase tend to be clearly separated fitting the typical time structure of financial contracting models. Consequently, one can easily isolate the various risks and conflicts of interest involved and analyze their incidence on the financial and contractual arrangements. Furthermore, output tends to be sold to very few customers and often a single off-taker. Consequently, investor and creditor concerns necessitate explicit links between capital structures and off-take agreements creating a web of interwoven contracts. (For further discussion of project finance see Kesinger, and Martin (1998), and Finnerty (1996), Dailami and Leipziger (1998).

Using a sample of daily data from January 1997 to March 2000 we find that Ras Gas yield spreads exhibit a very high degree of persistence. By far the most important explanatory variable for both levels and changes in credit spreads is the Kepco credit spread: investors rationally anticipate on the incidence of the off-taker's financial and economic condition on the riskiness of their bond. However, we also find evidence for over-reaction: while Ras Gas spreads widen with contemporeanous Kepco spread movements, they narrow in lagged ones. The price of crude oil, which serves as a reference for LNG pricing, comes out largely insignificant: investors seem to disregard commodity price risk.. While rising energy prices increase revenue and debt service capacity it also raises the cost of electricity generation for Kepco leading to higher breach of contract risk. Further investigation shows that the direct energy price impact on Ras Gas is insignificant but that the indirect impact via Kepco's financial position is highly significant: revenue and off-taker quality effects off-set each other but the indirect effect via Kepco yields survives.

In terms of Korean exposure variables we find evidence of Ras Gas exposure to the Korean currency both directly and indirectly through Kepco yields despite the fact that the off-take agreement is USD based. Also, Ras Gas bond holders acquire significant Korea country risk which, in light of the energy dependence of the Korean economy, makes sense. Finally, we find significant evidence for "guilt by association" effects related to financial contagion. As returns in European, Asian, Middle Eastern and Latin American emerging debt markets fall Ras Gas spreads are predicted to widen considerably. In particular, the impact of contemporaneous and past events in European emerging debt markets stands out. This responsiveness reflects the turmoil in global debt markets following the Russian financial crisis of summer and fall 1998 which heavily affected other market segments. Similarly, Ras Gas spreads exhibit a delayed reaction to Asian, Middle Eastern and Latin American emerging debt markets with only a few but highly significant lagged returns accounting for most of the explanatory power.

The paper is organized as follows. In the next section we provide background information on the Ras Gas project and its web of inter-related contracts. Section 3 describes the project-specific sources of contractual incompleteness and risk factors. Section 4 contains a description of our variables and how they are related to the various risk factors. In Section 5, we summarize the results of our empirical analysis. Next, we carry out a decomposition of the risk factors' direct and indirect effects. Section 7 concludes. We relegate all tables to the Appendix.

2. *Ras Gas: Project and Contract Design*

The Ras Laffan Natural Liquified Gas Company Limited (Ras Gas) is a joint venture between the Qatar General Petroleum Corporation (70%) and Mobil Corporation of the US (30%). Ras Gas has the right to develop 10m tons of liquified natural gas (LNG) annually from Qatar's North Field, the world's largest unassociated natural gas field with about 380bn cubic feet of confirmed recoverable reserves (about 9% of global gas reserves). To this end, Ras Gas has constructed a 5.2 MMTA (metric tons per annum) liquification facility in Ras Laffan consisting of two identical LNG processing trains, offshore drilling platforms, storage facilities, pipelines and port loading facilities. Construction was completed in summer 1999 and cost approximately USD 3.4b including interest during the initial contract phase.

As is customary in such projects most of the output was sold through long-term supply contracts even before construction started. The principal off-taker, Korea Gas Corporation (Kogas), is a state-owned company whose shareholders include the Republic of Korea (50%), Korea Electric Power Corporation (Kepco: 34.7%) and regional governments (15.3%). As such, Kogas shares its credit rating with the sovereign rating of Korea as does Kepco, which is currently being privatized. Most of the Ras Gas LNG bought by Kogas, who has a legal monopoly of gas sales and purchases in Korea, is currently re-sold to Kepco for electricity generation. Kepco, in turn, is about to double its existing LNG powered electricity generation in the next years which makes it Ras Gas' *de facto* off-taker with only the balance going toward residential and commercial gas supplies. Kogas-Kepco currently accounts for more than 75% of the projects expected revenue.

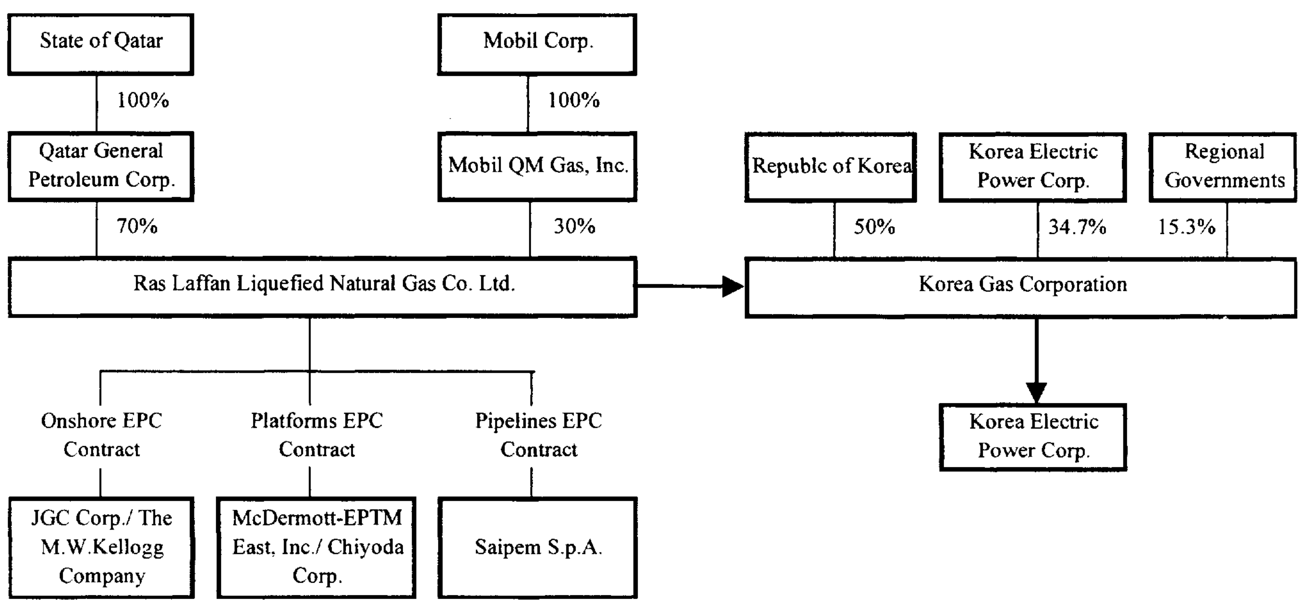


Exhibit 1. Ras Gas Project Participants

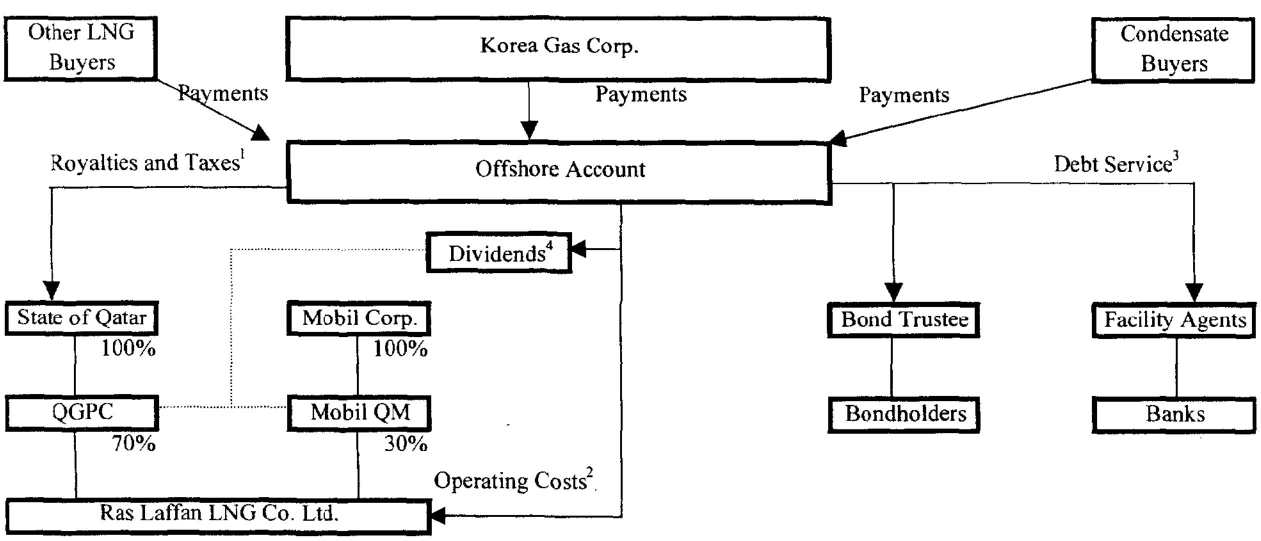
Taken together the two sales and purchase agreements (SPAs) with Kogas account for a total of 4.8 MMTA of LNG. Beginning in the last quarter of 1999 Kogas will receive LNG shipments for 25 years on a take-or-pay basis. Under such an agreement the purchaser (Kogas on behalf of Kepco) is obligated to pay for the gas whether or not they take delivery. Hence, Kogas can make a cash payment in lieu of delivery which are credited against charges for future deliveries. The off-take agreement effectively indexes LNG prices to world crude oil prices and contains minimal off-take quantities. As part of the second off-take agreement, which doubled the quantity of output sold and thus yielded significant economies of scale to Ras Gas, the initial off-take agreement was significantly modified. In particular, the parties replace a price guarantee (floor price for LNG) with a minimum off-take guarantee (minimum quantity to be purchased and its evolution over time). Exhibit 2 summarizes the final capital structure and construction budget.

Ras Gas Two-Train Financing

Uses of Funds	(USD millions)	Sources of Funds	(USD millions)
Capital cost	2,750	Bonds	1,200
Finance & Interest during Construction	650	Bank/ ECA	1,400
		Equity	800
Total project Cost	3,400	Total project Cost	3,400

Exhibit 2. Ras Gas Construction Budget and Capital Structure

The preceding discussion reveals that a project such as Ras Gas represents a nexus of contracts contingent on each other. For instance, debt financing and take-off agreements are intimately linked since the latter serves as security for the former. The corresponding financial transactions reflect this reality. They attempt to find an optimal balance of the various parties' rights and obligations and serve to distribute risks to the entities best suited to bear them. The following figure summarizes the contractual arrangements and cash flow structure of the Ras Gas project making the nexus of contracts transparent in terms of the precise cash flows mechanics. In order to minimize moral hazard in payments Kogas will make payment for shipments directly to an off-shore trust account whose administrator then services public and private debt and remits the balance to Ras Gas for operational expenses and dividends.



Note: Superscript numbers indicate payment order of priority.

Exibit 3. Ras Laffan Contract and Cash Flow Structure

3. *Ras Gas, Kogas and Kepco: Contractual Incompleteness and Risk Shifting*

A large scale project such as Ras Gas typically requires a huge up-front investments with a high degree of asset and relationship specificity. By their very nature, the necessary physical assets cannot readily be removed and utilized elsewhere.[5] As a result, there is a danger that the company and its financial backers suffer opportunistic behavior such as unilateral renegotiation of contracts or the redefinition of property rights. In the absence of a well functioning legal system that is willing to define and enforce property rights and contractual clauses the physical assets – always subject to hold-up problems – are of limited value as security to investors. Hence, while the debtholders are, in theory, secured the location of the assets in Qatar and the lack of credible legal institutions (enforcement) renders them inadequate for creditor protection. Instead, the off-take agreement with Kogas provides the only security.

However, the SPA suffers from contractual incompleteness that arises from the interplay of the investment characteristics, Kogas-Kepco's use of the LNG, and certain peculiarities of the world market for LNG. At the heart of the problem lies the non-existence of a spot market for LNG due to the lack of transportation capacity.[6] Consequently, the parties often build dedicated vessels for LNG transportation tied to a specific project[7] and, in order to protect the very specific investments in physical infrastructure, sign long-term off-take agreements. Hence, most LNG is sold through long-term supply contracts, which, in turn, severely hinder the emergence of spot markets. In their absence, the most important hold-up risk consists of breach of contract or unilateral renegotation by Kogas, the off-taker. These risks are directly passed through to debtholders: they are locked into the project and, hence, vulnerable to opportunistic and strategic behavior from the customer. Investors risk being the victims of what has been called the obsolescent bargain should the Korean customers not honor the off-take agreement (Klein and Roger 1994).

Kepco's use of LNG fired power stations for peak load generation exacerbates the contractual incompleteness in the off-take agreement. These plants are the marginal ones meant to smooth out demand cycles and most likely to be shut down in case of weakening electricity demand. While the Asian financial crisis does not seem to have significantly affected the overall LNG market, electricity demand was significantly affected. In Korea, electricity demand, which

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[5] Contracting problems arising from relationship specificity, sunk costs, and the associated "hold-up" problem, were first described in other areas of economics by Klein, Crawford and Alchian (1978), and Williamson (1979, 1983). Three types of solutions have been proposed in the literature that balance incentives for *ex-ante* efficient investments and *ex-post* trade efficient: (i) writing contracts with proper legal remedies in case of breach of contract (Shavell, (1980, 1984); Rogerson, (1984)), (ii) agreeing on a rule for the re-negotiation of contracts (Aghion, Dewatripont and Rey, 1994), and (iii) writing option contracts (Nöldeke and Schmidt, 1995).

[6] With the availability of LNG tankers not tied to specific projects the nascent LNG market for immediate delivery is expected to develop into a full-fledged spot market over the next decade.

[7] Part of the off-take agreement with Kogas-Kepco stipulated the construction of landing, storage and regasification facilities in Korea as well as 7 to 8 LNG tankers, two of which have already been built and two more to be completed each year between 2000 and 2002.

had been growing by 10% annually during the previous decade, declined in 1998 by about 3.6% and Kepco, using LNG fired power plants as peak load reserves, correspondingly reduced its LNG purchases from Kogas by as much as 22%. The much decreased demand for LNG by Kepco explains why Kogas had to defer about 10% of its 1998 LNG cargoes. However, electricity demand has recently picked up (8.1% increase in 1999) and while demand growth is expected to fall short of initial forecasts Kepco still plans to add about 20,000 MW of generation capacity including LNG fired power stations over the next years.

The resulting bilateral monopoly between producer and customer now leads to an interesting contractual dynamic that directly impacts the financial backers of the project. Investors, for instance, negotiating over the terms of the contract after an investment has already been made, may be taken advantage of since there is no other use for their investment. Anticipating such a scenario, contracting parties are hesitant to make relationship-specific investments without adequate contractual protection. In the Ras Gas project, signing and renegotiating the SPA with Kogas provided *ex ante* security, all other things being equal. However, the Asian financial crisis and ensuing recession in Korea forcefully brought out that the parties to such a project can not anticipate on all possible contingencies.[8]

At the same time, from the off-taker's perspective, commitment to a long-term contract such as a Sales and Purchase Agreement (SPA) poses the difficulty of not knowing at the time of contracting the future value of the output, i.e., the availability of re-contracting and alternative suppliers. She faces a loss in the real option value of its flexibility. Conversely, a project such as Ras Gas faces the danger that their dominant buyer walks away from the contract as alternative sources of supplies are more cheaply available elsewhere than through the SPA. Hence, the off-taker has always an implicit real option through breach of contract. This scenario came about in 1998 when Kogas started to defer LNG cargoes as Kepco diminshed its purchases in response to reduced electricity demand. While the renegotiated Ras Gas-Kogas SPA included deferral options, meant to pre-empt breach of contract, the risks from their exercise is directly passed on to investors and, especially bondholders, given the total lack of an LNG spot market.

Since the assets are highly relationship specific through the construction of dedicated LNG terminals and storage facilities, the necessary project specific tanker fleet and the absence of a spot market, long-term supply contracts such as the 25 year SPA between Ras Gas and Kogas seem to offer a remedy. However, as we have argued the remedy is far from perfect since there always exists the threat of unilateral renegotiation or breach of contract. These incomplete contract risks are passed on to debtholders who presumably price them into their investment decision. Economic circumstances may change so that the absence of enforceable, complete contracts means that investors have to reassess their initial financing decisions. Here, Ras Gas affords the unique opportunity to analyze the price (yield) evolution of its outstanding global bonds to identify the sources of contractual incompleteness and how they shape project risk, a topic to which we now turn.

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[8] In the absence of sufficient contractual protections, the outcome is likely to be an inefficiently low investment, often referred to as the under-investment phenomenon (Hart and Moore, 1988).

4. *Project Risk Factors and the Ras Gas Bonds*

The two Ras Gas bond issues proved to be in very high demand. Despite increasing the issue size, they sold out on the first offering day (December 16, 1996) and were twice over-subscribed. The long bond due 2014 had a total size of USD 800m and was priced at an issue yield of 8.2940% or 187.5 basis points above 15 year US Treasury bond yields (interpolated). Issued as both a global and 144A (foreign) bond it was targeted at institutional investors with strong international demand (20% international, 80% US based investors). The bond trades actively which permits us to use its spread over US Treasuries to gauge market perceptions of changes in Ras Gas' prospects and, hence, its riskiness.

From an analytic perspective, Ras Gas offers the advantage of few, clearly identified risk factors whose effects make themselves felt through the nexus of contracts underlying the company. The deeper root of Ras Gas very particular risk profile is the sales arrangement with one dominant customer. Hence, we would expect that events affecting the economic prospects of Korea, Kogas and Kepco should be reflected in Ras Gas bond yield spreads over US Treasuries. In the sequel, we discuss several key risk variables that have a direct incidence on the project's economic and financial success and, therefore, should determine the riskiness of Ras Gas bonds in terms of yield spreads.

The first variable behind the postulated chain of contractual risks is the oil price, which effectively determines the price for LNG through energy equivalent conversions. Electricity generation from LNG becomes non-viable at an oil price in excess of USD 23.00. As a direct consequence of the project's nature and contract structure the oil price is one of the principal state variables affecting Ras Gas. In the sequel, we will use the logarithm of the price of Brent (*BRENT*) – one of two commonly used crude oil reference standards for LNG pricing[9] – to analyze the incidence of world energy prices on the riskiness of Ras Gas.[10] We also decompose the *BRENT* variable into three bands (below USD 14, between USD 14 and 23, above USD 23) based on the project's economics. S&P reckons that below USD 14 per barrel various guarantees by Mobil will have to be used to insure full debt service coverage while above USD 23 electricity generation from LNG becomes uneconomical.

The contractual provisions of the off-take agreement permit us to separate demand from price risk because Kogas, by and large, has committed to buying a fixed amount of output annually.[11] Hence, demand risk essentially translates into breach of contract risk. As Kogas does not have any publicly traded global bonds outstanding and is reselling most of its Ras Gas purchases to Kepco, we take the yield spread of the Kepco 7.75% global bond maturing in April 2013 (*KORELES*) over 10 year US Treasury yields to measure the economic and financial prospects of the LNG buyer as assessed by capital markets. The fortunes of Kepco and its bonds

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[9] Gas prices turned out to be non-significant which is not really surprising given that about 0.12 metric tons of LNG are priced as one barrel of crude oil.

[10] Diagnostic testing reveals that logarithms offer superior fit over levels for several of the independent variables.

[11] Kogas can vary gas shipments by deferring about 5% per annum up to a total of 10% which must be paid for within 5 years whether Kogas accepts delivery or not.

are closely tied the Korean economy so that we expect the bond yield to reflect both idiosyncratic Kepco factors (operational, regulatory and financial risks) and Korea country risk. However, even if the Korean economy does not experience any difficulties and electricity demand is strong Kepco might suffer operational or unrelated financial problems that might force it to breach the off-take agreement with Kogas and, ultimately, Ras Gas.

Ras Gas' fortunes also depend on Korea's macroeconomic environment. Independent of oil price fluctuations the economic situation of Korea might deteriorate to a point where LNG sourced according to the contract becomes too expensive or is simply not needed as electricity and gas demand slump, e.g., in a recession. This risk is all the more relevant that 40% of LNG imports are primarily used for marginal (peak load) generation and that Kepco already reduced its LNG purchases by 22% in response to weakened electricity demand after the Asian financial crisis. Hence, a severe recession might cast serious doubts over Kogas-Kepco's ability to honor the contractual commitments. In addition to *KORELES,* the spread of the Kepco global bond, we include a second measures to analyze this effect: the logarithm of the Korea Composite Stock Index (*KOSPI*). In a similar vein, we also use *KEPCO*, the logarithm of Kepco's stock price, as a measure for Ras Gas' direct exposure to the Korean economy.

A further risk factor is the credit quality of the off-taker which, in Kogas' case, might reflect both systematic changes in the Korean macroeconomic environment, the industry structure (i.e., loss of gas monopoly, privatization) or purely idiosyncratic risks. However, Kogas and Kepco share their credit ratings with the Republic of Korea, whose rating over the sample period has varied from AA- to B+ back to BBB. How important the credit quality of the off-taker is to debtholders can be seen from the fact that the Ras Gas bond convenants restrict additional SPAs to buyers rated A or better.[12] We, therefore, construct a rating index (*KRR*) that reflects not only the changes in S&P credit ratings but also their magnitude.

Exposure to foreign currency risk can drastically change the economic viability of a project, as evident from the South-East Asian experience. In Ras Gas' case, this risk appears to be of relatively minor concern as all revenues and costs accrue in USD. However, by the very nature of the off-take agreements, the customer still poses a very subtle and indirect currency risk. Both Kogas and Kepco generate their revenue in local currency so that an adverse currency movement (devaluation or depreciation of the Korean Won against the USD) might imperil their ability to honor the SPA. The Asian financial crisis was a stark reminder of this fact: as the Korean Won depreciated against the USD the effective cost of LNG to Kogas and Kepco doubled in local currency terms. Hence, exchange rate risk when borne by the off-taker has a tendency to transform itself into a credit risk. To untangle the two effects, we include *KRW*, the logarithm of the KRW-USD exchange rate, as an explanatory variable.

Finally, we need to control for the effects of financial contagion and other "guilt by association" characteristics of financial markets. Events and particularly financial crises in emerging economies have a tendency to affect other, seemingly unrelated countries through the propagation of financial shocks via global capital markets. In the data these effects show up as

[12] In spring 1997 Kogas, Kepco and Korea were still rated AA- satisfying the bond covenants for the second SPA.

correlated shocks. In order to better understand how these propagation mechanisms affect the Ras Gas project and its bond yields we use the JP Morgan emerging market bond regional indices, i.e., Asia, Middle East, Europe and Latin America. We summarize the direct and indirect effects via Kepco credit spreads of the various variables on Ras Gas yield spreads and their first differences in the following table:

Dependent Variable		*Ras Gas Yield Spread*		*Changes in RG Spread*	
Effect		Direct	Indirect	Direct	Indirect
Variable	Description	Coefficient	Coefficient	Coefficient	Coefficient
RGS(-1)	Lagged Ras Gas spread	persistent			
BRENT	(Log) oil price	indeterm.	+	indeterm.	+
BRENT<14	(Log) oil price below USD 14	insign.	+	indeterm.	+
BRENT: 14-23	(Log) oil price: USD 14 to 23	indeterm.	+	+	+
BRENT>23	(Log) oil price above USD 23	indeterm.	+	indeterm.	+
KORELES	Kepco yield spread	+		+	
KORELES(-1)	Lagged Kepco spread	insign.	persistent		persistent
KEPCO	(Log) Kepco stock price	insign.	-	indeterm.	-
KRW	(Log) Korean Won FX rate	+	+	insign	+
KOSPI	(Log) Korea Stock Price Index	insign	-	insign	-
KR rating	Korean country rating index	+	+	insign.	+
ASIA	Emerging debt returns Asia	-	-	-	-
EUROPE	Emerging debt returns Europe	-	-	-	-
LAT	Emerging debt returns Latin Am.	-	-	-	-
MEA	Emerging debt returns Middle East	-	-	-	-

Exhibit 4. Explanatory Variables

5. *Empirical Analysis of Interacting Risks: Breach-of-Contract Factors*

In the sequel, we investigate how risk factors are transmitted through the nexus of contracts represented by the take-off agreement and bond covenant to bondholders. Our analysis relies on daily data covering the period from January 1997 to March 2000 that is drawn from various sources, mainly Bloomberg, IDC and Baseline. Whenever we found missing observations we cross checked the time series with other news sources and filled in the missing data or, if this was not possible, deleted the observation. Depending on the included variables we have 725 to 750 observations before taking lags. Our dependent variable is the spread of the 17 year Ras Gas bond[13] yield over the 10 year US Treasury yield. The explanatory variables are the above mentioned risk factors affecting the contractual relationships at the heart of the Ras Gas project.

[13] The bond is highly liquid and widely traded contrary to the 10 year one and, therefore, constitutes a much better measure of investor and market assessment of the project's prospects.

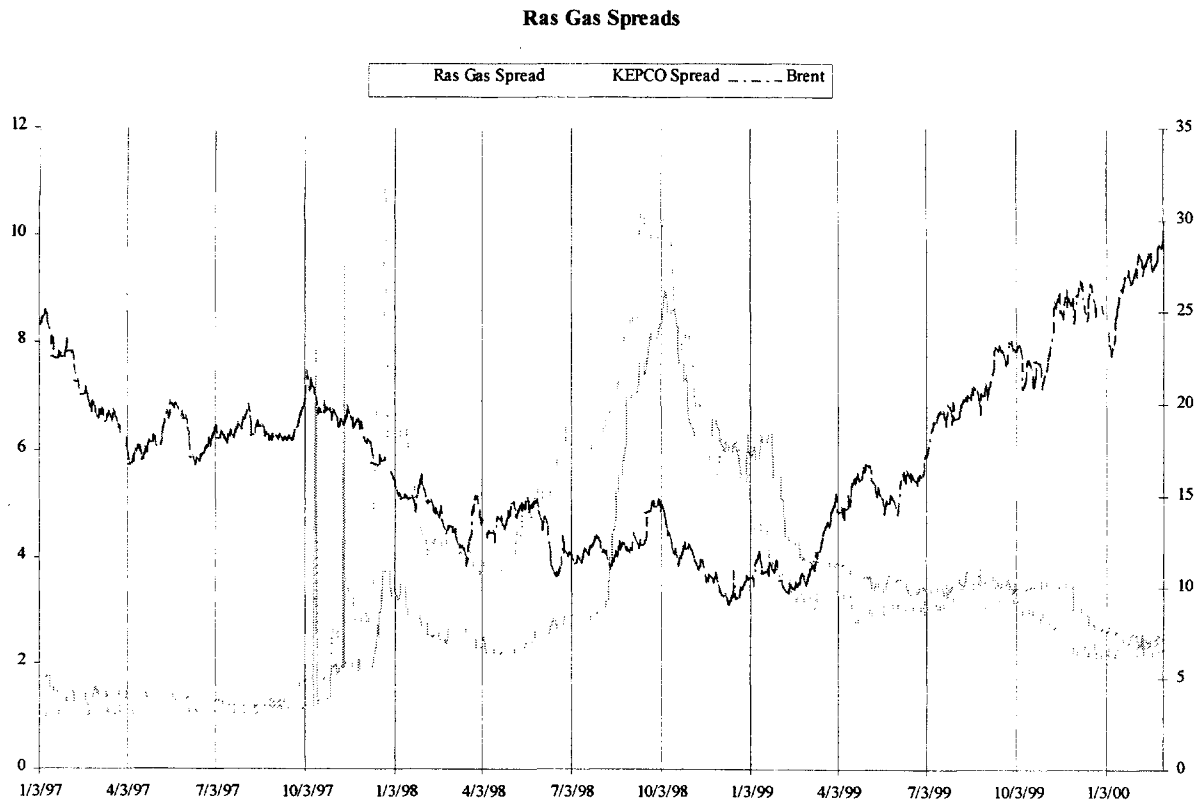

Exhibit 5. Ras Gas bond spreads, KEPCO bond spreads and Oil Prices

As the preceding plot suggests the data is highly volatile. Table 1 in the Appendix contains summary statistics for the entire sample period that further highlight this point. The correlation matrix indicates that some of the variables are highly collinear, a point which we will address in our statistical specifications. The preceding diagram clearly indicates the two defining events during the sample period: the Asian financial crisis that hit Korea in December 1997 and the Russian financial crisis that shook emerging debt markets in August 1998. In the attempt to uncover the complex dynamics underlying the time series in Exhibit 5 and explain their interactions from a nexus of contracts view of the firm, we estimate variants of the following empirical relationship in the sequel:

$$\begin{aligned} RGS_t = \beta_0 &+ \sum_{0\le l\le L}\alpha_{-l}RGS_{t-l} + \beta_1 BRENT_t + \sum_{0\le l\le L}\beta_{2,-l}KORELES_{t-l} \\ &+ \beta_3 KEPCO_t + \beta_4 KRW_t + \beta_5 KOSPI_t + \beta_6 KRR_t \\ &+ \sum_{0\le l\le L}\left[\gamma_{1,-l}MEA_{t-l} + \gamma_{2,-l}ASIA_{t-l} + \gamma_{3,-l}EUR_{t-l} + \gamma_{4,-l}LAT_{t-l}\right] + \varepsilon_t \end{aligned}$$

where RGS_t is the spread of the Ras Gas bond over 10 year US Treasury yields, $BRENT_t$ the logarithm of the Brent blend oil price index, $KORELES_t$ the spread of the 2013 7.75% Kepco global bond over 10 year US Treasury yields, $KEPCO_t$ the logarithm of the Kepco stock price,

KRW_t the logarithm of the Korean Won – US Dollar spot rate, $KOSPI_t$ the logarithm of the Korea Composite Stock Price Index, KRR_t a credit rating index for Korea, Kepco and Kogas, and $MEA_t, ASIA_t, EUR_t, LAT_t$ the continuously compounded daily returns of the JP Morgan regional total return indices in USD for emerging markets in the Middle East-Africa, Asia, Europe and Latin America, respectively.

In terms of estimation strategy, we start with the two key variables depicted in Exhibit 6, the oil price and Kepco bond yield spreads, and successively add explanatory variables to the regression equation estimated by OLS. First, we focus on the supply contract specific variables of oil price and Kepco bond yield. Next, we will add contemporaneous and lagged emerging debt market returns to analyze systematic effects such as spill-overs and contagion. We then include variables related to Korean country risk before estimating models with all variable categories. It turns out that for any number of variables and their lags the residuals exhibit high serial correlation. Adding a lagged dependent variable generally fixes this problem as evidenced in Table 2 (Durbin and Watson d statistic). Given the high frequency of the data, it comes at no that daily credit spreads exhibit a very high degree of persistence: the coefficient on lagged spreads is close to unity.

Tables 2 to 7 in the Appendix report the best fit estimation results after specification testing eliminated highly insignificant control variables. As we would expect, Ras Gas spreads vary positively with Kepco credit spreads: the second specification in Table 2 indicates that a 100 basis point increase in Kepco spread widens the Ras Gas spread by about 2 basis points. Hence, the perceived riskiness of the off-taker feeds through immediately to Ras Gas yield spreads which is consistent with the nexus of contract view of the firm. In light of the contractual incompleteness of the off-take agreement, credit migration by the dominant output buyer affects market risk perceptions of the firm in terms of yield spreads: off-take risk is shifted from Ras Gas owners to its bondholders as predicted by debt agency theories.

Including the lagged Kepco spread reveals that bondholders overreact to news about the off-taker. Initially, Ras Gas spreads widen by 15.5 basis points for every 100 basis point increase in Kepco spreads. However, the next day they narrow by 13.6 basis points (coefficient on the lagged Kepco yield spread) all other things being equal. A comparison between the second and third regressions reported in Table 2 shows the 2 basis points spread widening is the net reaction over a two day period. Since further lags of the Kepco spread come out insignificant we interpret the change of sign between the initial and lagged reaction as a sign of over-reaction: Ras Gas bondholders over-react to news about the off-taker. The results in Table 2 show that this pattern is stable across all specifications. One possible explanation for the market's apparent overreaction to changes in the off-taker's credit spread might lie in Kepco's importance for debt service. Since most revenue comes from one single source, any deterioration in its prospects calls into question the financial viability of Ras Gas.

Regarding oil prices we find that the coefficient is marginally significant at best. Independent of the set of control variables energy prices do not seem to significantly determine Ras Gas yield spread levels and, hence, the bond's riskiness as priced in global markets. It is quite remarkable that markets seem to view the oil price as irrelevant because it determes the output price and, ultimately, the revenue that Ras Gas will generate from LNG sales. In the sequel we will further investigate this puzzle by decomposing the impact of *BRENT* into its direct revenue and indirect credit migration effect via Kepco and looking at different oil price bands.

Turning to the impact of emerging markets on Ras Gas credit spreads we include contemporaneous and up to five lags of daily regional emerging debt market returns. Successively testing for their statistical significance and eliminating the most insignificant variables leads to the emerging market propagation pattern reported in specifications 4 and 5 of Table 2. As one would predict, Ras Gas spreads vary negatively with emerging debt market returns. The remaining significant lags hint at the time structure of the shock propagation mechanism behind this contagion effect. While Ras Gas spreads show a particularly strong contemporaneous reaction to European emerging debt markets (dominated by Eastern European countries and Russia in particular) the other debt markets' impact is delayed. European and Latin American debt returns are particularly persistent: 3 and 5 days later they have their most significant effect.

Adding Korea specific variables (specifications 6 to 8 in Table 2) reveals that the Korean rating index *KRR* is insignificant but the Kepco price *KEPCO* significant at the 1% level. Concerning exchange rate exposure as measured by the exchange rate *KRW* we find that coefficient comes out negative. The negative association of Ras Gas spreads and the Korean Won – US Dollar exchange rate is puzzling: one would have expected that breach of contract and default risk increases as the Won depreciates, i.e., *KRW* increases. Instead, a depreciation of the Won seems to reduce Ras Gas credit spreads.

The last regression reported in Table 2 puts together the three components of Ras Gas bond riskiness: variables representing contract risk, Korean exposure and emerging debt market spill-over effects. The net impact of Kepco yields is still 2 to 3 basis points, the significant Korea variables do not change in either identity or magnitude and the same is true for the emerging debt market contagion structure.

Given the very high degree of persistence in Ras Gas yield spreads as evidenced by a coefficient of about 0.98 we next look at the hypothesis that the spread might follow a random walk by testing for unit roots. Dickey-Fuller and Augmented Dickey-Fuller tests show, that we can not reject the hypothesis that Ras Gas spreads follow a random walk (see Table 3). The same is true for Kepco spreads and Brent oil prices. Similarly, we can not decisively reject co-integration between Ras Gas spreads and Brent or Kepco spreads by Engle-Granger and Augmented Engle-Granger tests (see Table 3). However, error correction models of the Ras Gas credit spread do not perform well. Given that Kogas and Kepco buy 75% of Ras Gas output and but that Ras Gas is only one among many suppliers to Kogas – Kepco (and the marginal at that) the absence of a statistical equilibrium relationship comes as no surprise. Kepco influences Ras Gas in equilibrium but not the reverse.

Since we can not easily distinguish between persistence and unit root in the dependent variable we replicate the preceding analysis for changes in Ras Gas credit spreads, i.e., taking first differences of the dependent variable to address possible non-stationarities:

$$\begin{aligned}\Delta RGS_t = \beta_0 &+ \beta_1 BRENT_t + \sum_{0\le l\le L} \beta_{2,-l} KORELES_{t-l} \\ &+ \beta_3 KEPCO_t + \beta_4 KRW_t + \beta_5 KOSPI_t + \beta_6 \Delta KRR_t \\ &+ \sum_{0\le l\le L} \left[\gamma_{1,-l} MEA_{t-l} + \gamma_{2,-l} ASIA_{t-l} + \gamma_{3,-l} EUR_{t-l} + \gamma_{3,-l} LAT_{t-l}\right] + \varepsilon_t\end{aligned}$$

The results in Table 4 and diagnostic testing reveal that first differences in the independent variables leads to inferior statistical performance so that we keep them in levels except for the rating variable *KRR*. We also experimented with using Kepco yields rather than the credit spreads but the results are virtually identical. Table 4 reports the results for best fit regression specifications. The results confirm our earlier findings from the level analysis that markets price output buyer related risk factors and that, therefore, the project shifts risk to bondholders. With spread changes as dependent variable, the oil price's logarithm becomes significant at the 10% or 5% level whereas the Won exchange rate becomes insignificant. The emerging debt markets contagion patterns are very similar and the over-reaction result also obtains: again, the coefficients on the contemporaneous and lagged Kepco spreads change in sign.

6. *Direct and Indirect Effects of Risk Factors*

To the extent that both Ras Gas and Kepco fall into the same emerging markets and energy bond categories, we would expect that a common set of factors affect both their credit spreads. In order to distinguish the direct, contract related effects from the indirect, common factor induced ones we next specify a simultaneous equation model of the Ras Gas and Kepco yield spreads. We use the contractual arrangements to derive restrictions on the system's parameters. Since the off-take agreement effectively collateralizes the Ras Gas bonds, their credit spread critically depends on the prospects of Kepco, the ultimate buyer of its LNG output. The reverse does not hold. Kepco has a well diversified portfolio of fuel types and sources and, in any event, LNG is used for peak-load electricity generation. In addition, we conjecture that the Korean control variables primarily influence Ras Gas bond yields and credit spreads through Kepco's exposure to the Korean economy: the Ras Gas' Korean exposure acts through Kepco.

We estimate the simultaneous equation system by Maximum Likelihood methods. We can then carry out diagnostic tests to determine which risk factors affect Ras Gas bonds directly and which ones operate indirectly through their incidence on Kepco's financial health. Under the restriction that Kepco spreads influence Ras Gas ones but not the reverse we arrive at the following specification:[14]

---

[14] Ras Gas spreads in the Kepco equation come out insignificant as expected.

$$
\begin{aligned}
RGS_t &= \beta_{01} + \sum_{0\le l\le L} \alpha_{-l1} RGS_{t-l} + \beta_{11} BRENT_t + \sum_{0\le l\le L} \beta_{2,-l1} KORELES_{t-l} \\
&+ \beta_{31} KEPCO_t + \beta_{41} KRW_t + \beta_{51} KOSPI_t + \beta_{61} KRR_t \\
&+ \sum_{0\le l\le L} \left[\gamma_{1,-l1} MEA_{t-l} + \gamma_{2,-l1} ASIA_{t-l} + \gamma_{3,-l1} EUR_{t-l} + \gamma_{4,-l1} LAT_{t-l}\right] + \varepsilon_{t1} \\
KORELES_t &= \beta_{02} + \beta_{12} BRENT_t + \sum_{0\le l\le L} \beta_{2,-l2} KORELES_{t-l} \\
&+ \beta_{32} KEPCO_t + \beta_{42} KRW_t + \beta_{52} KOSPI_t + \beta_{62} KRR_t \\
&+ \sum_{0\le l\le L} \left[\gamma_{1,-l2} MEA_{t-l} + \gamma_{2,-l2} ASIA_{t-l} + \gamma_{3,-l2} EUR_{t-l} + \gamma_{4,-l2} LAT_{t-l}\right] + \varepsilon_{t2}
\end{aligned}
$$

As the lagged Kepco spreads are insignificant in the Ras Gas spreads equation we drop them in the sequel. Similarly, all emerging debt market returns are insignificant in the *KORELES* equation as evidenced by the first simultaneous equation specification in Table 5. The results show that the oil price impacts the riskiness of Ras Gas through its effect on the financial position of Kepco rather than directly: while *BRENT* is insignificant in the *RGS* equation it is highly significant in the *KORELES* equation. We interpret this outcome, which holds for the full set of explanatory variables as well as sub-sets (see specification 3 and 4 in Table 5), as evidence that investors discount the direct revenue effect of oil prices on Ras Gas. Instead, they are more concerned about the impact of energy prices on Kepco's financial health. An increase in crude oil prices by USD 2.72 translates into a widening of Kepco spreads by about 18 basis points so that the indirect impact on Ras Gas credit spreads is about 0.66 basis points (systems 3 or 4 in Table 5). A comparison with equation 3 in Table 5, which also includes *BRENT* in the Ras Gas spread equation, reveals that the direct effect on Ras Gas spreads is 0.24 basis points. However, it is so highly insignificant that capital markets apparently disregard the oil price revenue effect in the pricing of Ras Gas default risk.

In terms of the emerging markets shock propagation mechanism, the surviving significant emerging debt market returns confirm our earlier lag structure. Europe and the Russian financial crisis had the most lasting impact on investor perceptions. However, Kepco credit spreads seem to be unaffected by emerging debt markets. As we conjectured, the country risk variables primarily affect Kepco's credit spread through their impact on Kepco's economic and financial fortunes. In terms of direct effects on Ras Gas, only Kepco's share price *KEPCO* as an indicator for Korea's electricity demands together with the Won exchange rate come out significant. As economic prospects improve so does the risk profile of Kepco as reflected in stock prices. Hence, its yield spreads and, ultimately, Ras Gas credit spreads should decrease.

The second significant country risk variable is again the Korean Won – USD exchange rate. Equation systems 3 or 4 reveal an interesting pattern: the *RGS* equation in each of the two specifications confirms the previously identified puzzle that a weakening Won on average directly decreases market risk perceptions as spreads decline. However, the indirect impact via Kepco yields in the *KORELES* equation clearly exhibits the conjectured currency exposure effect in terms of a positive *KRW* coefficient. As the Won depreciates Kepco yields rise as servicing Kepco's foreign debt and its oil, coal and gas purchases all denominated in USD become more expensive. Consequently, Kepco's financial position deteriorates, increasing its riskiness and, hence, requiring higher yields to compensate bondholders for more risk: Korean Won exposure clearly is an indirect exposure. The direct, negative impact on the yield spread might now be explained in terms of improved economic outlook and the high correlation of the Won with the country rating. Alternatively, a weakening Won might lead to higher exports so that an economy as energy dependent as Korea's would require more gas and electricity which decreases the demand, i.e., direct breach of contract risk all other things being equal.

In Table 6, we replicate the simultaneous equation analysis for *RGS* and *KORELES* in first differences. As in the previous analysis (see Table 4) levels of the explanatory variables perform better than their differences with the exception of the rating variable *KRR*. When the Kepco yield spread equation is specified in levels we obtain results that, by and large, mirror the results in Table 5. However, the insignificant coefficient on *KORELES* in the ΔRGS equation indicates that the model is misspecified. Repeating the estimations with $\Delta KORELES$ (specifications 3 and 4) reveals several new effects. First, changes in Kepco yield spreads respond to Asian and Latin American debt markets while levels do not (see Table 5). Second, energy prices are marginally less significant in the $\Delta KORELES$ than the ΔRGS equation so that direct and indirect impact are very comparable. Finally, the only significant Korean variables are *KOSPI* and the rating index, both for changes in *RGS* and *KORELES*. As Korea's economic prospects improve as measured by a higher stock price index, both Ras Gas and Kepco credit spreads change by less.

In order to further investigate the insignificance of the oil price variable *BRENT* we next compose it into three distinct bands: oil prices under USD 14, between USD 14 and 23, and above USD 23. The choice of these bands corresponds to the contractual provisions and economics of electricity generation from LNG. Below approximately USD 14 per barrel, price support and debt service guarantees by Mobil to the bondholders will be triggered. Above USD 23, the electricity generation from LNG becomes uneconomical so that breach of contract risk escalates at such prices all the more that the LNG fired power plants are Kepco's marginal ones. As a result, we split the oil price's logarithm into three explanatory variables in all our estimations:

$$\beta_1 BRENT_t = \delta_1 1_{\{BRENT_t \le 14\}} BRENT_t + \delta_2 1_{\{14 < BRENT_t < 23\}} BRENT_t + \delta_3 1_{\{23 \le BRENT_t\}} BRENT_t$$

Table 7 summarizes the results for our four main specifications after substituting in for *BRENT* from the preceding expression. The oil prices are still statistically insignificant in determining Ras Gas yield spread levels for the contract related and full set of explanatory variables (specifications 1 and 2). Investors seem to regard oil price levels as irrelevant for contract default or renegotiation, debt service and firm risk. The picture changes for credit spread changes where decomposed oil prices become statistically significant as compared to the non-decomposed variable (Table 4, specification 8). The most plausible explanation revolves around the absence of Korean variables which are highly collinear with oil prices. The simultaneous equation estimations in Table 7 further confirm these and earlier results: oil prices affect Ras Gas credit spreads and their changes mainly through their indirect effect on Kepco's credit quality.

Markets apparently do not distinguish between different oil price levels in pricing Ras Gas' credit risk. Given the intricate economics of LNG it might simply be the case that investors lack the information to make the link between different oil price levels and Ras Gas' prospects. Alternatively, the high volatility of oil prices in the past decade might have induced the belief that oil prices never stay long enough in any of the three bands to trigger the corresponding economic and financial consequences. In this case, the relative unimportance accorded to oil prices might reflect the market's collective view that the revenue impact is only temporary and that contracts are not renegotiated unless the oil price settles permanently way beyond one of the trigger points.

7. *Conclusion*

Much of current corporate finance theory draws upon the view that a firm is a nexus of contract. Nowhere is this view more evident than in project finance where construction, operating, output purchase and financial contracts form an interwoven web that determines the project's value and risk. In this paper we analyze how in the face of contractual incompleteness risks are transmitted and allocated between the different contracts and investors. Of particular importance is the relationship between off-take and financial contracts because the former effectively serves as security for the latter. Since such long-term supply contracts are necessarily incomplete and subject to opportunistic behavior, one would expect that factors affecting the off-take agreement impact a project's riskiness. Using daily data from the Ras Gas project, we investigate the link between off-take contract and financial structure by relating Ras Gas bond spreads to credit spreads of the major output buyer, the Korean electricity monopoly Kepco, emerging market returns and variables affecting the economic prospects of the parties. We find evidence for risk-shifting in the sense that non-contractible risks arising from the 25 year sale and purchase agreement determine the pricing and riskiness of the Ras Gas bonds. Ras Gas essentially passes on the output contract risk to its investors who, in consequence, closely identify the company with the prospects and riskiness of the ultimate buyer.

As predicted by the nexus of contract view of the firm, the market's perception of the output buyer's (Kepco) credit quality is the most important variable for explaining bondholders' attitudes to Ras Gas' riskiness. With the lack of a spot market for the output, Ras Gas needs the long-term supply contract for fixed quantities, which generates 75% of the company's revenue, as the basis for its funding. Bondholders accordingly assess the financial prospects of Ras Gas in terms of the output buyer's credit quality as a proxy for contract default or renegotiation risk. However, we also find evidence that bondholder over-react to movements in the off-taker's credit spreads.

The second critical contract variable, the oil price to which the sales are indexed, is surprisingly insignificant. Markets seem to view price risk as secondary to counter-party (breach of contract) risk. However, high oil prices adversely affect the financial position of Kepco so that we decompose the various risks into their direct effects on Ras Gas credit spreads and the indirect ones via Kepco spreads in a simultaneous equation model. It emerges that oil prices are an indirect risk rather than a direct one: when they rise they essentially increase the overall riskiness of Kepco through their adverse financial impact which is not off-set by the additional revenue they represent for Ras Gas

Controlling for spill-overs from other segments of emerging debt markets highlights the contagion risks stemming from the Asian and Russian financial crises. The most serious contagion effect comes from the Russian financial crisis, which impacted emerging debt markets more severely than the Asian crisis. Through the lag structure, the analysis reveals both an instantaneous and delayed reaction to European emerging debt markets (dominated by Russia) while events in Middle Eastern and Latin American debt markets take 2 to 5 days to feed through to Ras Gas spreads. The curious absence of Asian emerging debt markets as risk factors is explained by the inclusion of variables related to the Korean economy. Changes in the common credit rating of Korea, Kepco and Kogas (the intermediary), the Korean Stock Price index and Kepco's share price as well as the Won-USD exchange rate pick up all the Asian financial crisis effects.

Since projects so closely conform to stylized models of the firm, we would argue that the lessons drawn from this analysis are of wider applicability to the study of corporate finance. By analyzing projects where one output buyer generates most of the revenue we can gain valuable insights into the precise workings of the nexus of contract. This paper represents a first attempt at opening up the black box of the contractual web and to empirically investigate how risks and returns of one contractual relation impact others. Our analysis shows that the design of each contractual arrangement is not independent as risk factors pertaining to one contract determine the price and risk premium of the other. Despite heavy capitalization and partial guarantees by the parent companies of Ras Gas, the off-take agreement essentially determines the riskiness of its bonds. We interpret this as evidence for the nexus of contracts view of the firm in the presence of contractual incompleteness: investors bear all residual risks and price their financial claims accordingly.

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APPENDIX

Table 1: Summary statistics

Descriptive Statistics
All results based on nonmissing observations.

Variable	Mean	Std.Dev.	Minimum	Maximum	Cases
RGS	3.15457597	1.76512011	1.14000000	8.95800000	724
RGS [-1]	3.15347514	1.76580229	1.14000000	8.95800000	724
LBRENT	2.79499119	.279653669	2.19722458	3.36867419	724
BRENT	17.0073066	4.72004282	9.00000000	29.0400000	724
KORELE	9.37895580	1.80951711	7.09000000	16.7000000	724
KORELES	3.58997099	2.26258625	1.01000000	10.9700000	724
LKEPCO	3.25205674	.347627996	2.55722731	3.91800508	724
LKRW	7.05355026	.185291648	6.73494831	7.58197445	724
KRW	1176.82124	216.996477	841.300000	1962.50000	724
LKOSPI	6.39619862	.361655049	5.63478960	6.96511812	724
KOSPI	637.435967	211.383129	280.000000	1059.04000	724
KRR	4.68922652	3.02389652	.000000000	10.0000000	724
LMEAR	.263418143E-03	.404848157E-02	-.261950747E-01	.201192051E-01	724
LASIAR	.192941156E-03	.805700969E-02	-.610478681E-01	.420264714E-01	724
LEURR	.916357139E-04	.692969809E-02	-.114747733	.247232517E-01	724
LLATR	.641730716E-03	.479112097E-02	-.418460416E-01	.262899561E-01	724

Correlation Matrix for Listed Variables

	RGS	RGS[-1]	LBRENT	BRENT	KORELE	KORELES	LKEPCO	LKRW
RGS	1.00000	.99763	-.53166	-.47943	.71445	.79947	.06002	.51766
RGS[-1]	.99763	1.00000	-.53124	-.47826	.70356	.79071	.06935	.51464
LBRENT	-.53166	-.53124	1.00000	.98948	-.50880	-.62350	.42638	-.48591
BRENT	-.47943	-.47826	.98948	1.00000	-.48879	-.59834	.44880	-.46235
KORELE	.71445	.70356	-.50880	-.48879	1.00000	.97795	-.44896	.70817
KORELES	.79947	.79071	-.62350	-.59834	.97795	1.00000	-.41950	.74216
LKEPCO	.06002	.06935	.42638	.44880	-.44896	-.41950	1.00000	-.24101
LKRW	.51766	.51464	-.48591	-.46235	.70817	.74216	-.24101	1.00000

	RGS	RGS[-1]	LBRENT	BRENT	KORELE	KORELES	LKEPCO	LKRW
KRW	.47006	.46687	-.47967	-.46269	.70423	.72941	-.28449	.99354
LKOSPI	-.36611	-.35708	.71442	.71717	-.72865	-.74218	.86010	-.48504
KOSPI	-.31670	-.30915	.74300	.75109	-.64733	-.67386	.87491	-.43038
KRR	.63763	.63648	-.48416	-.44050	.66987	.72687	-.02869	.93973
LMEAR	.02549	.03022	.04179	.04118	-.02219	-.02522	.06171	-.03496
LASIAR	.12995	.13299	-.06085	-.05374	.06662	.07565	.04467	.03038
LEURR	-.00788	.00275	.01079	.00552	-.01167	-.00493	.02205	.02743
LLATR	.04876	.05694	-.00955	-.00129	-.00721	.00291	.04240	-.00142

	KRW	LKOSPI	KOSPI	KRR	LMEAR	LASIAR	LEURR	LLATR
KRW	1.00000	-.50266	-.45531	.90893	-.03469	.01651	.02937	-.00286
LKOSPI	-.50266	1.00000	.98591	-.35775	.05783	-.01695	.03677	.02413
KOSPI	-.45531	.98591	1.00000	-.29443	.05139	-.01328	.03490	.02035
KRR	.90893	-.35775	-.29443	1.00000	-.02877	.06910	.01607	.00015
LMEAR	-.03469	.05783	.05139	-.02877	1.00000	.09719	.24120	.32864
LASIAR	.01651	-.01695	-.01328	.06910	.09719	1.00000	.07889	.11365
LEURR	.02937	.03677	.03490	.01607	.24120	.07889	1.00000	.09531
LLATR	-.00286	.02413	.02035	.00015	.32864	.11365	.09531	1.00000

Table 2: Contract and Emerging Market Analysis

$$RGS_t = \beta_0 + \sum_{0\le l\le L} \alpha_{-l} RGS_{t-l} + \beta_1 BRENT_t + \sum_{0\le l\le L} \beta_{2,-l} KORELES_{t-l} + \beta_3 KEPCO_t + \beta_4 KRW_t + \beta_5 KOSPI_t + \beta_6 KRR_t$$
$$+ \sum_{0\le l\le L} \left[\gamma_{1,-l} MEA_{t-l} + \gamma_{2,-l} ASIA_{t-l} + \gamma_{3,-l} EUR_{t-l} + \gamma_{4,-l} LAT_{t-l} \right] + \varepsilon_t$$

where the dependent variable *RGS* is the spread of the Ras Gas bond over 10 year US Treasury yields, *BRENT* the logarithm of the Brent blend oil price index, *KORELES* the spread of the 2013 7.75% Kepco global bond over 10 year US Treasury yields, *KEPCO* the logarithm of the Kepco stock price, KRW the logarithm of the Korean Won – USD spot rate, *KOSPI* the logarithm of the Korea Composite Stock Price Index, *KRR* a rating index for Korea, and *MEA, ASIA, EUR, LAT* the continuously compounded daily returns of the JP Morgan regional total return indices in USD for emerging markets in the Middle East-Africa, Asia, Europe and Latin America.

Specification	1	2	3	4	5	6	7	8
Dep. Variable	*RGS*	*RGS*	*RGS*	*RGS*	*RGS*	*RGS*	*RGS*	*RGS*
Variable	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value
Constant	1.9684 .0004	-.1300 .0374	-.0980 .1011	0.01273 0.1515	-.1132 .0488	.8682 .1637	.6125 .0115	.4158 .0778
RGS(-1)		.9755 .0000	.9819 .0000	0.99812 0.0000	.9834 0.0000	.9679 .0000	.9650 .0000	.9817 .0000
BRENT	-.3427 .0571	.0424 .0340	.0309 .1064		.0368 .0462	-.0089 .7345	.0038 .8518	.0348 .0584
KORELES	.5972 .0000	.02496 .0000	.1558 .0000		.1499 0.0000	.1631 .0000	.1609 .0000	.1523 .0000
KORELES(-1)			-.1365 .0000		-.1312 0.0000	-.1230 .0000	-.1213 .0000	-.1282 .0000
KEPCO							.0704 .0016	
KRW						-.1934 .0219	-.1248 .0006	-.0762 .0207
KOSPI						.0717 .0238		
KRR						.0050 .3450		
EUR				-2.13609 0.0007	-2.0387 .0005	-2.0053 .0005	-1.9789 .0006	-1.9841 .0006
LAT				-2.27699 .0129				
LAT(-1)				-2.09425 0.0218	-1.5725 .0624	-1.5412 .0660	-1.5594 .0621	-1.5663 .0626
MEA(-2)				-3.09962 0.0040	-2.7622 .0058	-2.8062 .0048	-2.8438 .0042	-2.8012 .0051
EUR(-3)				-3.07837 0.0000	-3.2586 .0000	-3.3701 .0000	-3.2883 .0000	-3.2260 .0000
LAT(-5)				-2.57983 0.0050	-2.1537 .0114	-2.0545 .0151	-2.1006 .0127	-2.1405 .0116
Obs.	724	724	724	719	719	719	719	719
Adj. R^2	.63995	.99558	0.99596	0.99569	.99631	.99636	.99638	0.99633
DW *d* Stat.	.02340	1.90390	2.00086	1.89391	2.05283	2.05791	2.05229	2.06149

Table 3: Unit Roots and Cointegration

Testing for unit roots and co-integration we appeal to Dickey-Fuller, Augmented Dickey-Fuller, and Augmented Engle-Granger tests of the form, respectively, where in the AEG test case the residuals are drawn from the corresponding co-integration equation:

$$\Delta y_t = \beta_0 + (\gamma - 1)y_{t-1} + \varepsilon_t,\ \Delta\hat{\varepsilon}_t = \alpha_0 + (\alpha - 1)\hat{\varepsilon}_{t-1} + u_t$$

where the dependent variable y is either *RGS*, the spread of the Ras Gas bond over 10 year US Treasury yields, or *KORELES*, the spread of the 2013 7.75% Kepco global bond. The (one-sided) simulated asymptotic critical values for the τ statistic for unit root tests under the null hypothesis are drawn from the Davidson and McKinnon (1993).

Dependent Variable	ΔRGS_t	ΔRGS_t	$\Delta KORELES_t$	$\Delta KORELES_t$	Residuals: *RGS* KORELES	Residuals: *RGS* BRENT
Variable	Coefficient τ-Value	Coefficient τ-Value	Coefficient τ-Value	Coefficient τ-Value	Coefficient τ-Value	Coefficient τ-Value
Constant	.0097	.0099	.0277	.0318		
RGS(-1)	-.0027 -1.076	-.0028 -1.126				
DRGS(-1)		.0846				
KORELES(-1)			-.0072 -1.700	-.0085 -2.029		
DKORELES(-1)				.2079		
E(-1)					-.0132 -2.262	-.0041 -1.212
DE(-1)					.0671	.0940
Crit. value: 1%	-3.43	-3.43	-3.43	-3.43	-3.90	-3.90
Crit. value: 5%	-2.86	-2.86	-2.86	-2.86	-3.34	-3.34
Crit. value: 10%	-2.57	-2.57	-2.57	-2.57	-3.04	-3.04
Crit. value: 97.5%	0.24	0.24	0.24	0.24	-0.30	-0.30
Obs.	724	723	724	723	723	723
Adj. R^2	.00022	.00596	.00261	.04444	.00931	.00885
DW *d* Stat.	1.83052	2.01473	1.58662	1.92602	1.98719	2.01310

Table 4: Changes in Ras Gas Spreads

$$\Delta RGS_t = \beta_0 + \beta_1 BRENT_t + \sum_{0\le l\le L}\beta_{2,-l}KORELES_{t-l} + \beta_3 KEPCO_t + \beta_4 KRW_t + \beta_5 KOSPI_t + \beta_6 \Delta KRR_t$$
$$+ \sum_{0\le l\le L}\left[\gamma_{1,-l}MEA_{t-l} + \gamma_{2,-l}ASIA_{t-l} + \gamma_{3,-l}EUR_{t-l} + \gamma_{3,-l}LAT_{t-l}\right] + \varepsilon_t$$

where the dependent variable ΔRGS is the first difference of the Ras Gas bond spreads over 10 year US Treasury yields, *BRENT* the Brent blend oil price index in logarithms, *KORELES* the spread of the 2013 7.75% Kepco global bond and *DKORELES* its first difference, *KEPCO* the Kepco stock price in logarithms, KRW the Korean Won – USD spot rate in logarithms, *KOSPI* the Korea Composite Stock Price Index in logarithms, *KRR* a rating index for Korea, and *MEA, ASIA, EUR, LAT* the continuously compounded daily returns of the JP Morgan regional total return indices in USD for emerging markets in the Middle East-Africa, Asia, Europe and Latin America.

Specification	1	2	3	4	5	6	7	8
Dep. Variable	*DRGS*	*DRGS*	*DRGS*	*DRGS*	*DRGS*	*DRGS*	*DRGS*	*DRGS*
Variable	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value
Constant	-.1319 .0283	.0008 .8438	.0189 .6575	.3312 .2437	.1364 .2534	-.1448 .0121	.0048 .2475	.0626 .8187
BRENT	.0365 .0594		-.0064 .6701	.0560 .0336	.0617 .0058	.0423 .0233		
DBRENT		-.0185 .9073					-.9211 .9524	
KORELES	.1597 .0000			.1550 .0000	.1429 .0000	.1530 .0000		.1455 .0000
KORELES(-1)	-.1512 .0000			-.1468 .0000	-.1386 .0000	-.1443 .0000		-.1326 .0000
DKORELES		.1565 .0000	.1566 .0000				.1499 .0000	
KEPCO				-.0149 .6858				-.0659 .0290
KRW				-.0406 .2438				-.0506 .1261
KOSPI				-.0282 .5983	-.0506 .0118			.0730 .0642
DKRR					.0380 .0397			.0384 .0302
EUR						-2.0585 .0005	-2.0501 .0006	-2.057 .0005
LAT(-1)						-1.8165 .0331	-1.8228 .0346	-1.755 .0391
MEA(-2)						-3.1005 .0022	-3.0727 .0027	-3.058 .0025
EUR(-3)						-3.1628 .0000	-3.1450 .0000	-3.195 .0000
LAT(-5)						-2.4008 .0052	-2.4026 .0057	-2.317 .0069
Obs.	724	724	724	724	724	719	719	719
Adj. R^2	.12408	.10983	0.1100	.13066	.13514	.20389	.18877	.20901
DW *d* Stat.	1.98276	1.94776	1.9487	2.00345	2.00340	2.03588	1.99468	2.05788

Table 5: Simultaneous Equations: Ras Gas Spread Levels

$$RGS_t = \beta_{01} + \sum_{0 \le l \le L} \alpha_{-l1} RGS_{t-l} + \beta_{11} BRENT_t + \beta_{21} KORELES_t + \sum_{0 \le l \le L} \left[\gamma_{1,-l1} MEA_{t-l} + \gamma_{2,-l1} ASIA_{t-l} + \gamma_{3,-l1} EUR_{t-l} + \gamma_{4,-l1} LAT_{t-l} \right] + \varepsilon_{t1}$$

$$KORELES_t = \beta_{02} + \beta_{12} BRENT_t + \sum_{0 \le l \le L} \beta_{2,-l2} KORELES_{t-l} + \beta_{32} KEPCO_t + \beta_{42} KRW_t + \beta_{54} KOSPI_t + \beta_{64} \Delta KRR_t + \varepsilon_{t2}$$

where the dependent variable *RGS* is the spread of the Ras Gas bond over 10 year US Treasury yields, *BRENT* the Brent blend oil price index, *KORELES* the yield on the 2013 7.75% Kepco global bond, *KEPCO* the Kepco stock price in logarithms, KRW the Korean Won – USD spot rate in logarithms, *KOSPI* the Korea Composite Stock Price Index in logarithms, *KRR* a rating index for Korea, and *MEA, ASIA, EUR, LAT* the daily returns of the JP Morgan regional total return indices in USD for emerging markets in the Middle East-Africa, Asia, Europe and Latin America. We use Maximum Likelihood estimation (asymptotically equivalent to Generalized Least Square).

Specification	1		2		3		4	
Dep. Variable	*RGS*	*KORELES*	*RGS*	*KORELES*	*RGS*	*KORELES*	*RGS*	*KORELES*
Variable	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value
Constant	-.0962	-.6018	-.1037	.3452	.5383	.6506	.5397	.6536
	.1072	.2639	.0832	.5649	.0288	.2924	.0193	.2894
RGS(-1)	.9785		.9782		.9653		.9642	
	.0000		.0000		.0000		.0000	
BRENT	.0335	.1276	.0359	.1883	.0024	.1816		.1796
	.0809	.0110	.0613	.0009	.9069	.0014		.0013
KORELES	.0206		.0210		.0370		.0373	
	.0000		.0000		.0000		.0000	
KORELES(-1)		.9586		.9446		.9469		.9469
		.0000		.0000		.0000		.0000
KEPCO				.2191	.0625	.2382	.0633	.2380
				.0047	.0047	.0023	.0012	.0023
KRW		.2696		.2636	-.1090	.2195	-.1083	.2193
		.0003		.0003	.0028	.0034	.0024	.0034
KOSPI		-.2354		-.5073		-.5145		-.5137
		.0000		.0000		.0000		.0000
DKRR				.2431	.0717	.2898	.0695	.2899
				.0000	.0000	.0000	.0001	.0000
EUR	-2.1776	-1.3301	-2.0705		-1.9705		-2.0013	
	.0003	.3363	.0004		.0006		.0005	
ASIA(-1)	-.9312	-1.0715			-.92728			
	.0754	.3682			.0605			
MEA(-2)	-2.8146	.1324	-2.8355		-2.9679		-3.0781	
	.0070	.9554	.0045		.0025		.0017	
EUR(-3)	-3.3677	-.0418	-3.4154		-3.4000		-3.4034	
	.0000	.9762	.0000		.0000		.0000	
LAT(-5)	-2.2099	-.0261	-2.1757		-2.1589		-2.1215	
	.0127	.9897	.0105		.0096		.0111	
Obs.	719	719	719	719	719	719	719	719
Log-Likelihd	554.8793	554.8793	576.4339	576.4339	591.7214	591.7214	589.9580	589.9580
DW *d* Stat.	1.9353	1.5691	1.9411	1.7267	2.0017	1.7684	2.0025	1.7684

Table 6: Simultaneous Equations: Ras Gas Yield Spread Changes

$$\Delta RGS_t = \beta_{01} + \sum_{0\le l\le L} \alpha_{-l1} RGS_{t-l} + \beta_{11} BRENT_t + \beta_{21} KORELES_t + \sum_{0\le l\le L}\left[\gamma_{1,-l1} MEA_{t-l} + \gamma_{2,-l1} ASIA_{t-l} + \gamma_{3,-l1} EUR_{t-l} + \gamma_{4,-l1} LAT_{t-l}\right] + \varepsilon_{t1}$$

$$KORELES_t = \beta_{02} + \beta_{12} BRENT_t + \sum_{0\le l\le L}\beta_{2,-l2} KORELES_{t-l} + \beta_{32} KEPCO_t + \beta_{42} KRW_t + \beta_{54} KOSPI_t + \beta_{64} KRR_t + \varepsilon_{t2}$$

where the variables are as previously defined and we use Maximum Likelihood estimation (asymptotically equivalent to Generalized Least Square). The last two specifications are obviously in first differences.

Specification	1		2		3		4	
Dep. Variable	*DRGS*	*KORELES*	*DRGS*	*KORELES*	*DRGS*	*DKORELES*	*DRGS*	*DKORELES*
Variable	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value
Constant	.2805	.7475	.1623	.6532	.2743	.2670	.2252	.2573
	.3310	.2329	.1721	.2767	.0003	.1120	.0020	.1258
BRENT	.0670	.1839	.0670	.1897	.0551	.1103	.0482	.1023
	.0122	.0015	.0024	.0009	.0106	.0201	.0213	.0340
KORELES	.0039		.0030					
	.3923		.2854					
KORELES(-1)		.9469		.9449				
		.0000		.0000				
DKORELES					.1393		.1320	
					.0000		.0000	
KEPCO	.0056	.2585		.2522				
	.8805	.0014		.0010				
KRW	-.0158	.2132		.2320				
	.6463	.0044		.0012				
KOSPI	-.0599	-.5338	-.0556	-.5381	-.0669	-.0899	-.0555	-.0846
	.2739	.0000	.0054	.0000	.0001	.0143	.0006	.0223
DKRR	.0809	.2934	.0802	.2895	.0388	.2918	.0422	.2957
	.0000	.0000	.0000	.0000	.0344	.0000	.0166	.0000
EUR	-2.1165	-.9579	-1.9981				-1.9498	
	.0005	.4696	.0006				.0008	
ASIA(-1)	-1.2024	-1.7498	-.94852				-.85582	-2.2242
	.0227	.1273	.0593				.0902	.0555
LAT(-1)	-1.8331	-2.0736	-1.5452				-1.4995	-2.3931
	.0380	.2803	.0671				.0773	.2193
MEA(-2)	-3.0974	-.6686	-2.9841				-2.9304	
	.0031	.7691	.0028				.0035	
EUR(-3)	-3.0841	.5065	-3. 1667				-3.0908	
	.0000	.7072	.0000				.0000	
LAT(-5)	-2.3687	-.7892	-2.3499				-2.3191	
	.0076	.9673	.0055				.0064	
Obs.	719	719	719	719	724	724	719	719
Log-Likelihd	582.2974	582.2974	579.8411	579.8411	533.3478	533.3478	563.6408	563.6408
DW *d* Stat.	2.0046	1.7752	2.0007	1.7643	2.0007	1.7897	2.0423	1.8022

Table 7: Oil Price Decomposition

$$\beta_1 BRENT_t = \delta_1 1_{\{BRENT_t \le 14\}} BRENT_t + \delta_2 1_{\{14 < BRENT_t < 23\}} BRENT_t + \delta_3 1_{\{23 \le BRENT_t\}} BRENT_t$$

Having split the Brent blend oil price index into three different price ranges in accordance with contractual provisions and economic consequences (all in logarithms) we estimate the preceding four models with the decomposed oil prices replacing the previous *BRENT* variable and report the most significant specifications surviving after diagnostic testing.

Specification	1	2	3	4	5		6	
Dep. Variable	*RGS*	*RGS*	*DRGS*	*DRGS*	*RGS*	*KORELES*	*DRGS*	*DKORELES*
Variable	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value	Coefficient P-Value
Constant	-.1873 .0776	.5167 .0636	-.2706 .0103	-.2674 .0080	.3961 .1613	.4297 .5299	.2437 .4274	.0437 .9487
RGS(-1)	.9832 .0000	.9665 .0000			.9661 .0000			
BRENT<14	.0651 .1123	.0277 .4922	.0899 .0284	.0885 .0240	.0397 .3363	.2429 .0098	.1036 .0163	.1779 .0616
BRENT: 14-23	.0618 .0830	.0242 .4977	.0853 .0166	.0851 .0125	.0340 .3510	.2313 .0058	.1010 .0085	.1648 .0516
BRENT>23	.0540 .0915	.0196 .5399	.0722 .0245	.0717 .0193	.0285 .3834	.2239 .0035	.0914 .0090	.1538 .0463
KORELES	.1551 .0000	.1510 .0000	.1582 .0000	.1415 .0000	.0363 .0000			
KORELES(-1)	-.1360 .0000	-.1124 .0000	-.1487 .0000	-.1317 .0000		.9470 .0000		
DKORELES							.1387 .0000	
KEPCO		.0713 .0015			.0626 .0050	.2376 .0025	.0347 .2459	-.0141 .8307
KRW		-.1201 .0015			-.1017 .0074	.2243 .0033	.0035 .9019	-.0027 .9661
KOSPI						-.5077 .0000	-.1034 .0066	-.0696 .4081
DKRR		.0382 .0289		.0413 .0195	.0716 .0000	.2897 .0000	.0382 .0374	.2910 .0000
EUR		-1.9365 .0008		-2.0216 .0006	-1.9817 .0005			
ASIA(-1)		-.92218 .0653		-1.0567 .0365	-.92898 .0601			
MEA(-2)		-2.9791 .0027		-3.2279 .0013	-2.9539 .0026			
EUR(-3)		-3.3475 .0000		-3.2658 .0000	-3.4137 .0000			
LAT(-5)		-2.1336 .0115		-2.3750 .0055	-2.1167 .0113			
Obs.	724	719	724	719	719	719	719	719
Adj. R^2/Log-L	.99596	.99638	.12835	.21364	592.4560	592.4560	535.7771	535.7771
DW *d* Stat.	2.00686	2.05491	1.99629	2.05796	2.0029	1.7697	2.0080	1.7923

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