Price Risk Management and Capital Structure of Oil and Gas Project Companies: Difference between Upstream and Downstream Industries

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May 29, 2019

Abstract

We estimate the causal effect of hedging the future price risk on the debt-to-equity ratio of oil and gas project companies. In particular, we examine how such an effect differs between the upstream and downstream industries, given that relative to downstream projects, upstream projects are exposed to the price risk to magnitude greater. With a sample of 230 loans made to oil and gas projects in 32 countries over the period 1997-2017, we investigate the determinants of the debt-to-equity ratio of oil and gas project loans. To identify the causal effect of the project company's hedging decision that is endogenous, we use the sponsor company's oil (or gas) risk exposure as the instrumental variable for the oil (or gas) project company's hedging decision. Our IV/2SLS regression results show that hedging the future price risk increases disproportionately the upstream project's debt-to-equity ratio relative to that of the downstream project. This suggests that hedging the price risk is an important way to increase lenders' funding amount to the upstream oil (or gas) project but not so much for a downstream oil (or gas) project. We also find the substantial differences in the hedging likelihood between upstream and downstream projects: (i) the upstream company is more likely to adopt the hedging contract; and (ii) the upstream company owned by a sponsor company with the smaller oil exposure is more likely to adopt the hedging contract, whereas the opposite is the case for a downstream company. Taken together, our findings suggest that between upstream and downstream oil (or

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gas) projects, there are substantial differences in both likelihood and effect of hedging the price risk.

Keywords: Risk management; Capital structure; Oil risk exposure; Project finance.
JEL Classification: F3, G3, Q4.

1 Introduction

Oil and gas development projects often require a large amount of capital, whereas the risk of such a project is often quite high (e.g., exploration risk, operation risk, and volatile prices of oil and gas). As such, addressing the funding difficulty is one of important issues in oil and gas projects[1]: what would be, under which conditions, the best way to secure enough funding for the project to safely navigate through turbulent business environments?

The large scale and high risk of investment in oil and gas projects often raises an issue that even when funding via loans from lenders is secured, the loan would increase debt of a sponsor firm, which is a main equity capital provider to the project and in charge of controlling the project development, to the level unbearable by the sponsor firm's shareholders. Thus, a sponsor firm often chooses project financing rather than traditional corporate financing: a sponsor firm creates, as a main equity capital provider, a project company that is solely dedicated to a single oil (or gas) development project and legally separate from the sponsor firm. Thus, a loan made to such a project company, labeled *project finance loan*, is non-recourse to the sponsor firm and hence does not affect the sponsor firm's balance sheet. In short, project financing provides the opportunity that the sponsor firm's balance sheet is not contaminated by the high risk of the project (Esty; 2003; Steffen; 2018).

Project financing can not, however, remove the risk of a project; it simply shifts the project risk from the sponsor firm to lenders (Corielli et al.; 2010). Therefore, lenders are likely to require the project company to use effective risk management strategies so as to keep the lenders' own exposures to the project risk to a bearable level. Otherwise, lenders would be reluctant to provide the project company with a sufficient amount of

[1]For instance, some argues that the U.S. shale oil and gas boom in the late 2000s is due to the abundant supply of capital due to unprecedentedly low interest rates after the 2008 crisis. See McLean (2018).

capital. Thus, it is plausible that the adoption of effective risk management strategies is one of important determinants of an oil and gas project company's borrowing capacity (Leland; 1998). This hypothesis is, despite its importance (given the funding difficulty often experienced), understudied in the literature (Pierru et al.; 2013). We aim to fill this gap.

More specifically, we aim to estimate the causal effect of hedging the risk of future prices of oil and gas on the debt-to-equity ratio of oil and gas development projects (Corielli et al.; 2010). In particular, we examine how such a hedging effect differs between upstream and downstream industries, where we are motivated by the fact that upstream projects (i.e., producers of crude oil and natural gas) are exposed to the price risk to magnitude greater than downstream projects (i.e., refiner/retailer of oil and gas) are. In the oil (or gas) industry, a downstream project company is likely to have some market power, due to strategies for management of distribution channels and inventory adjustment, such that the downstream company has operational capabilities to absorb the price shock (Borenstein et al.; 1997; Deltas; 2008). As such, upstream projects are likely to be exposed to the price risk to magnitude greater than downstream projects are, and hence so is the effect of hedging the future price risk on the project's cash-flow volatility. Therefore, hedging the future price risk can relax disproportionately the upstream company's debt constraint and increase disproportionately this company's debt-to-equity ratio (Keefe and Yaghoubi; 2016).

To identify the causal effect of hedging on the debt-to-equity ratio, we need to address an issue that the hedging decision (i.e., adoption of offtake contracts that fix in advance the future sales of oil and gas) is endogenous (Campello et al.; 2011; Pérez-Gonzáles and Yun; 2013; Chen and King; 2014). For instance, the project company's unobserved credit quality can affect the company's decision to adopt offtake contracts as well as its debt capacity, e.g., a project company with the lower credit quality is more likely to adopt offtake contracts and at the same time has the lower debt-to-equity ratio due to the higher cost of debt. In this case, in the regression of a project's debt-to-equity ratio, the OLS estimate of the coefficient on the offtake-adoption dummy is likely to be downward biased.

We introduce the method in Pérez-Gonzáles and Yun (2013) such that we use the *two-stage least squares (2SLS)* estimator, equivalently the *instrumental variable (IV)* estimator, in regressing the debt-to-equity ratio on the offtake-adoption dummy and its interaction term with the upstream project dummy as well as on other standard controls: We use the sponsor firm's exposure (in terms of stock returns) to the price risk of oil and gas, labeled *oil risk exposure*, as the instrumental variable for the subsidiary project company's decision to adopt offtake contracts. This paper is, to the authors' knowledge, the first to apply such an IV estimator to the case of measuring effects of hedging decisions of oil and gas project companies. This is our methodological contribution to the literature studying the effects of risk management strategies in the oil and gas projects, given that identifying the causal effect is in general quite a challenge in empirical studies (Best and Burke; 2018).

We mainly follow the spirit of the identification strategy used in Pérez-Gonzáles and Yun (2013) but modify it in a way suitable to our purpose: we measure the sponsor's oil (or gas) risk exposure rather than its weather exposure used in Pérez-Gonzáles and Yun (2013), as an instrumental variable for the project company's hedging decision. For comparison, many extant studies use the tax convexity as an instrumental variable for the hedging decision (Campello et al.; 2011; Chen and King; 2014), whereas it is not suitable to our case. The reason twofold. First, it is almost impossible (due to the lack of data) to calculate the tax convexity for project companies that are newly created, as of the loan date, and hence their histories are, by definition, non-existent. Second, our sample covers many countries rather than one country, which reduces greatly the relevance of the tax convexity as an instrument due to substantial differences in institutional features (e.g., tax codes) across countries.

Our sample (provided by *ProjectWare* database) includes 230 loan tranches made to a total of 72 oil and gas projects in 32 host countries, over the period June 1997-May 2017. In the regression of determinants of a project company's debt-to-equity ratio, we control for offtake adoption dummy (our measure of hedging decision) and its interaction term with the upstream dummy as well as other standard control variables.[2]

Our IV/2SLS regression results show that hedging the price risk increases disproportionately the upstream project's debt-to-equity ratio relative to that of the downstream project. That is, the coefficient on the offtake-adoption dummy interacted with the upstream dummy is positive and statistically and economically significant, while that interacted with the downstream dummy is statistically insignificant. More specifically, our IV/2SLS results indicate that in upstream oil and gas industries, the adoption of offtake contracts increases the project company's debt-to-equity ratio (compared to the case of the absence of offtake contracts) by 5.8, quite sizable (i.e., an increase by 200%) relative to the upstream project's average debt-to-equity ratio of 2.9. Note that the OLS estimate of this coefficient (i.e., offtake-adoption dummy interacted with upstream dummy) is about 1.2 (statistically significant), smaller (by about 80%) than the IV/2SLS estimate of 5.8, suggesting that the OLS bias is in the downward direction and of magnitude great.

Taken together, these findings suggest that the effect of hedging the price risk on the oil (or gas) project company's capital structure is substantially different between the upstream and downstream industries: such an effect is of magnitude disproportionately greater for an upstream project. This implies that hedging the price risk is an effective and important way to increase the amount of lenders' funding to the upstream oil (or gas) project but

[2]We control for tranche-level traits (e.g., loan size and maturity); global risk factors (oil (or gas) price volatility and level of oil (or gas) futures price); host country's geopolitical risk factors; and year dummies.

ineffective for the case of the downstream oil (or gas) project. Our findings also suggest that the hedging decision of oil and gas firms is likely endogenous and hence estimating its effect requires a valid identification method, as the OLS method is likely biased.

Results for the test of the over-identification restriction support that the sponsor's oil risk exposure is a valid instrument for the project company's hedging decision.[3] Our main results are robust to controlling for a proxy for the project's unobserved credit risk.[4]

Interestingly, results of the first-stage regression of the offtake adoption dummy reveal substantial differences in the hedging likelihood between upstream and downstream projects[5]: (i) the upstream company is more likely to adopt the hedging contract than the downstream company is; and (ii) the upstream company owned by a sponsor company with the smaller oil exposure is more likely to adopt the hedging contract, while the association between downstream project company's hedging likelihood and sponsor's oil exposure is positive, opposite to the case of the upstream project. For comparison, our companion paper Choi and Kim (2018) examines the overall effect of the sponsor's oil risk exposure on the project company's hedging probability. The first-stage regression results in this paper complements findings in Choi and Kim (2018) by shedding light on the *difference* in such an effect between upstream and downstream industries.

In short, our first- and second-stage regression results suggest that between upstream and downstream oil (or gas) projects, there are substantial differences in both likelihood and effect of hedging the future price risk. This suggests that industry-level characteristics that are closely related to the project company's risk-absorbing operational capability can greatly affect the probability and effect of the adoption of risk management strategies in the oil (or

[3]For this test, we use the sponsor's market risk exposure as an additional instrument.

[4]It is measured as the residual from the regression of the EPC-adoption dummy on control variables (other than the offtake-adoption dummy and its interaction term with the upstream dummy).

[5]Our first-stage regression results are qualitatively robust to the case of logit-regression specification.

gas) projects. This message can be useful to investors as well as to the government agency regulating the country-level aggregate exposure to the oil (or gas) price risk.

Literature Review This paper contributes to the literature that studies the determinants of the capital structure of oil and gas project companies. Our contribution is twofold. First, we provide evidence that between upstream and downstream oil (or gas) projects, there are substantial differences in both likelihood and effect of hedging the future price risk. This finding suggests that industry characteristics are one of important sources of heterogeneity in hedging decision and its effect across oil (or gas) project companies. Second, methodologically, our IV/2SLS estimator, which uses the sponsor's oil (or gas) risk exposure as an instrumental variable for the project company's hedging decision, can be useful in identifying the causal effect of the project company's hedging decision (and, more broadly, financial decisions) on the various outcomes (e.g., profitability) of the project.

Closely related to this paper, Pierru et al. (2013) study the capital structure of LNG infrastructure and gas pipeline projects, which we complements in two ways: (i) we expand the sample to include oil and gas projects, for both upstream and downstream industries, and focus on estimating the difference in the capital structure between upstream and downstream projects, and (ii) we use an IV/2SLS estimation method to identify the causal effect of the project company's hedging decision. This paper also corroborates findings in Corielli et al. (2010) about the effect of risk management on the capital structure; we mainly improve the identification of the causal effect of hedging on the capital structure by using an instrumental variable for the hedging dummy. Steffen (2018) investigates the motives for the use of project finance in the case of renewable projects in a low-risk environment such as Germany and finds that the sponsor's characteristics (e.g., type of sponsor) are important in the adoption of project finance. This paper complements findings in Steffen (2018) by showing that the sponsor's characteristics (e.g., oil risk exposure) can be also an important driver of the project company's decision to hedge the oil price risk. This paper also contributes to the literature that examines effects of corporate risk management on the capital structure (Leland; 1998; Campello et al.; 2011; Keefe and Yaghoubi; 2016), by considering the case of oil and gas project finance loans. Our companion paper (Choi and Kim; 2018) investigates how the sponsor's oil risk exposure is related to the oil project company's hedging decision, of which effect on the project company's capital structure is estimated in this paper.

The rest of the paper is organized as follows: Section 2 discusses hypothesis development and methodology. Section 3 discusses the data source, construction of variables and descriptive statistics. Section 4 discusses the main regression results for debt-to-equity ratio as well as first-stage regression results for the hedging decision. Section 5 concludes.

2 Hypothesis Development and Methodology

In this section, we discuss our empirical method to investigate the determinants of the capital structure of oil and gas development projects. In particular, we discuss the instrumental variable for the hedging decision.

2.1 Hypothesis Development

We estimate the effect of hedging the risk of future prices of oil and gas on the debt-to-equity ratio of oil and gas project companies, especially whether the hedging decision increases disproportionately the upstream project company's debt-to-equity ratio. To this end, we use the difference-in-difference regression method (Pérez-Gonzáles and Yun; 2013). That is, we distinguish between upstream projects and downstream projects, and investigate whether or not the hedging effect on the debt-equity ratio is greater for upstream projects than for downstream projects.

Our motivation to explore the aforementioned hypothesis about the hedging effect on the capital structure, in particular the differential effect of hedging between upstream and downstream projects, is as follows: An oil and gas project company's cash flow is almost entirely generated from the sales of produced oil and gas, making this company greatly exposed to the price risk of oil and gas. As such, an oil and gas project company has an incentive to hedge such a price risk by using oil and gas derivatives. For instance, an offtake contract is a frequently used de-facto forward contract such that it fixes the future delivery price and volume of oil (or gas). (In our analysis, the hedging dummy indicates whether or not an offtake contract is adopted as of the project loan date.) We expect that hedging the future price risk would reduce the project's cash-flow volatility, which would, in turn, relax the hedged project company's debt constraint and increase its debt-to-equity ratio (Keefe and Yaghoubi; 2016).

Moreover, if an upstream oil (or gas) project company's cash flow is exposed to the future oil (or gas) price risk to magnitude greater than a downstream counterpart is, then the hedging effect on the capital structure for an upstream project would be also of magnitude greater than for a downstream project. It is plausible that upstream projects (i.e., producers of crude oil and natural gas) are exposed to the price risk to magnitude greater than downstream projects (i.e., refiner/retailer of oil and gas) are. The reason is follows: In the oil (or gas) industry, a downstream project company is likely to have some market power, due to strategies for management of distribution channels and inventory adjustment, such that the downstream company has operational capabilities to absorb the price shock (Borenstein et al.; 1997; Deltas; 2008). As such, upstream projects are likely to be exposed to the price risk to magnitude greater than downstream projects are, and hence so is the effect of hedging the future price risk on the project's cash-flow volatility. Therefore, hedging the future price risk can relax disproportionately the upstream company's debt constraint and increase disproportionately this company's debt-to-equity ratio (Keefe and Yaghoubi; 2016).

More specifically, let $D/E_{i,t}$ denote the debt-to-equity ratio of project loan i issued at date t as in Corielli et al. (2010). According to our difference-in-difference estimation method, we write the regression equation of $D/E_{i,t}$ as follows:

$$D/E_{i,t} = const + \delta \cdot h_{i,t} + \gamma \cdot h_{i,t} \times U_{i,t} + \mathbf{\Psi} \cdot \mathbf{X}_{i,t} + \epsilon_{i,t} \tag{1}$$

where $h_{i,t}$ refers to the hedging dummy indicating that an offtake contract is adopted as of the project loan date t (i.e., $h_{i,t} = 1$ for the case of the adoption and $h_{i,t} = 0$ for non-adoption), $U_{i,t}$ the upstream dummy indicating that a project is for oil and gas exploration (i.e., $U_{i,t} = 1$ for an upstream project and $U_{i,t} = 0$ for a non-upstream project), $\mathbf{X}_{i,t}$ the vector of other control variables (including the upstream dummy $U_{i,t}$ to capture the upstream industry-specific fixed effect), and $\epsilon_{i,t}$ the error term.

Given that for a downstream project, the upstream dummy is zero, the coefficient δ on the hedging dummy $h_{i,t}$ refers to the effect of hedging on $D/E_{i,t}$ for a downstream project, while the coefficient γ on the interaction term between hedging dummy and upstream dummy $h_{i,t} \times U_{i,t}$ refers to the incremental effect of hedging on $D/E_{i,t}$ for an upstream project relative to that for a downstream project: i.e., $(\delta + \gamma)$ represents the total effect of hedging on $D/E_{i,t}$ for an upstream project.

Hedging the future price risk is expected to increase the debt-to-equity ratio of a downstream project, i.e., δ is expected to be positive, whereas its economic significance can be either small or large, depending on the degree to which a downstream project company's operational capability can absorb the price risk. That is, if a downstream project company's capability to absorb the price risk, in the absence of the financial hedging tools, is sufficiently strong, then the incremental effect of financial hedging (via the adoption of offtake contracts) in terms of reduction in the downstream project's cash flow volatility would be negligible, and hence the effect of hedging on the debt-to-equity ratio would be also small, too. In this case, δ would be small, close to zero.

Meanwhile, the differential effect of hedging on the debt-to-equity ratio for an upstream project relative to that for a downstream project (captured by γ) is expected to be positive. Moreover, γ is expected to be economically significant because an upstream project is, as discussed in the aforementioned hypothesis, exposed to the price risk to magnitude greater than a downstream project is. That is, compared to the case of a downstream project, hedging the future price risk would reduce disproportionately the upstream project's cash flow volatility and hence increase disproportionately the upstream project's debt-to-equity ratio.

2.2 Methodology: Identification Strategy

One of the key challenges in estimating the causal effect of hedging is that the hedging decision is endogenous: it is not an outcome of a randomized experiment (Pérez-Gonzáles and Yun; 2013). For the case of an endogenous treatment (e.g., hedging decision in our data), the estimation of the coefficient on the endogenous treatment variable entering the main outcome regression suffers from the "omitted variable" problem: the error term entering the main outcome regression equation contains unobservable variables that are correlated with the endogenous treatment variable. In this case, the OLS estimator is biased.

For instance, the firm-level unobserved credit risk is one of unobservable variables that can be correlated with the endogenous treatment variable (i.e., hedging dummy). More specifically, the project company's unobserved credit risk can affect both the adoption of offtake contracts and the borrowing cost: i.e., a project company with the higher credit risk is more likely to use offtake contracts and at the same time to pay the lower debt-to-equity ratio. In this case, the OLS estimate of the coefficient on the interaction term between the upstream dummy and the hedging dummy entering the debt-to-equity ratio regression is likely to be downward biased mainly because the effect of hedging on the debt-to-equity ratio is contaminated by the hedger's unobserved high credit risk. This would lead to an erroneous inference that hedging is ineffective in raising the debt-to-equity ratio.

2.2.1 Overview of Identification

To address the endogeneity issue (i.e., the so called "selection bias"), we use the two-stage least squares (2SLS) estimator, equivalently the instrumental variable (IV) estimator, in regressing the debt-to-equity ratio on the hedging dummy and its interaction term with the upstream dummy, and other control variables. The basic idea and procedure of constructing our instrumental variable come from Pérez-Gonzáles and Yun (2013), with minor modification suitable to our context. More specifically, we use the sponsor company's exposure to the price risk of oil and gas observed in the near past, labeled *oil risk exposure*, and its interaction term with the upstream dummy as the instrumental variables for the subsidiary project company's decision to adopt offtake contracts and its interaction term with the upstream dummy. The sponsor company's oil risk exposure is intended to capture the preferences of the project company's shareholder to avoid such a price risk, where a sponsor company is the project company's main shareholder.

To be a valid instrumental variable, the sponsor company's oil risk exposure should be (i) "relevant" to the project company's hedging decision (i.e., the instrument should be highly correlated with the hedging decision); and (ii) "valid" in the sense that the instrument should be uncorrelated with the omitted variables, where the latter "validity" requirement is, in many cases, challenging. In theory, there can be a large number of omitted variables. In practice, it is almost impossible to consider all of the possible omitted variables. As such, researchers often focus on the specific omitted variables that might be important in determining both the treatment and outcome.

Validity of our instrument In this paper, we focus on the unobserved component of the project company's credit risk as one of the omitted variables, as it is important in determining both the hedging decision and debt-to-equity ratio. That is, in discussing the validity of our instrument (i.e., the sponsor's oil risk exposure), we focus on the reason why we argue that our instrument is uncorrelated with the unobserved component of the project company's credit risk, one of important omitted variables.

More specifically, one might think that the sponsor company's oil risk exposure is correlated with the project company's unobserved credit risk via the project loan's recovery rate. For instance, in the event of the project company's default in the aftermath of drops in the oil price, the lenders might request the sponsor to pay on behalf of the project company, whereas the sponsor's capability and willingness to pay back might be affected by the sponsor's own oil risk exposure. We argue that it is not the case. The reason is that the project finance loan is a *non-recourse debt*, i.e., the project company's debtholders can not force the sponsor company to pay the unpaid portion of the project company's debt obligation.

Thus, the sponsor's oil risk exposure is irrelevant to the unobserved component of the project company's credit risk.

Nonetheless, we provide some empirical evidence supporting that our instrument is valid. More specifically, we provide the result of a test of the over-identification restrictions, by using the sponsor company's market risk exposure as an additional instrument.[6]

For robustness check, we also examine how our main findings are affected by additionally controlling for a proxy for the unobserved component of the project company's credit risk as follows: Note that for a project finance loan, the event of default occurs mostly at the pre-completion stage when the production facility is not yet completed (Sorge; 2004). For instance, the cost of completing the production facility sometimes exceeds what was initially expected, leading to default on the project loan. To reduce the lender's concern about a pre-completion default risk, a project company often adopts a turnkey-based engineering, procurement and construction (EPC) contract of which counterparty guarantees that the production facility will be completed at the fixed cost. Thus, an EPC contract is an effective tool to reduce the project's default risk and hence more likely to be used by a project company with the higher credit risk (Choi and Kim; 2018). We use residuals from the regression of the EPC-adoption dummy on control variables (other than the offtake-adoption dummy) as a proxy for the project company's unobserved credit risk.

Discussion: Alternative estimation methods In this paper, we use the IV estimation method to address the possible endogeneity of the key variable: hedging decision of a project company. There are alternative methods other than IV estimator to address this endogeneity issue. For instance, either "matching model" or "treatment effect model" can be used to estimate the "selection" equation of a "treatment" (i.e., the determinants of a "treatment"),

[6] We appreciate one of the reviewers for this suggestion.

where the hedging dummy corresponds to "treatment" in our case.

It is, however, well known that both "matching model" and "treatment effect model" require that the selection equation should be correctly specified and identified (Heckman; 1990; Heckman and Navarro-Lozano; 2004). If some key variables are omitted in the selection equation, then both "matching model" and "treatment effect model" yield biased estimates of coefficients entering the main outcome regression. By contrast, the IV estimator is unbiased as long as the "valid" instrumental variable(s) can be found, without the need for a researcher to fully specify and identify the selection equation.

2.2.2 First-Stage Regression

In this section, we discuss how to estimate the first-stage regression of the hedging dummy and its interaction term with the upstream dummy. We begin by estimating the sponsor company j's past oil risk exposure, which is used as an instrumental variable for the project company's hedging dummy.

Sponsor's Oil and Gas Risk Exposures Consider a project finance loan i made at the loan date t, where this project is owned by sponsor company j. Let $R_{j,i,\tau}$ denote the sponsor company j's daily stock return on date τ (prior to the loan date) over a one-year period, ending one year before the loan date: $t-(360+360) \leq \tau \leq t-360$, where subscript i denotes simply the fact that sponsor company j corresponds to project loan i. Given a project loan, sponsor's past stock returns are regressed on the rate of changes in the oil (or gas) price so that we can estimate the ex-ante measure of the sponsor's appetite for the oil (or gas) price risk.

Note that the sponsor company's oil (or gas) risk exposure is mainly used as an instrumental variable for the subsidiary project company's decision to hedge the future oil (or gas) price risk. To this end, on the one hand, the estimation period of the sponsor company's oil risk exposure should be sufficiently close to the loan date (so that the informativeness of such an estimated oil risk exposure about the project company's hedging decision is strong). On the other hand, this estimation period should be sufficiently earlier than the loan date to minimize the concern that during a period close to the loan date (e.g., one-year period, ending on the loan date) the sponsor's observed exposure to the oil risk could be affected by the news about the expected hedging policies of a project company. Our selection of the sample period (one-year window, ending one year before the loan date) is mainly driven by the balance between these two motives. Put differently, our measure of the sponsor's oil risk exposure is a (one-year ahead) *ex-ante* measure (e.g., lagged variable) of sponsor's *concurrent* oil risk exposure, whereas lagged variables are often used as instrumental variables in the literature.[7]

As in Jin and Jorion (2006), we regress $R_{j,i,\tau}$ on the two factors[8]: (i) return to the market portfolio $R_{m,\tau}$ (where the market refers to the one in which the sponsor's stocks are mainly traded), and (ii) return to the near-month maturity futures price of oil and gas ($R_{oil,\tau}$ and $R_{gas,\tau}$), respectively, depending on whether the project belongs either to the oil sector or to

[7]We consider two alternative cases in which the estimation window of sponsor's oil risk exposure is closer to the loan date: (i) one-year window, ending *nine months* (rather than 12 months) before the loan date, and (ii) 9-month window, ending one year before the loan date. Main results are robust to these two cases and available in section C in Online Appendix.

[8]Jin and Jorion (2006) use monthly stock returns of oil and gas producers, where they aim to estimate the effect of hedging policies on the firms' exposures to the price risk of oil and gas. By contrast, in this paper, we use daily stock returns of sponsor companies. Our primary goal is to use the sponsor's oil risk exposure as an instrumental variable for the project company's hedging decision but not to estimate sponsor's oil risk exposure itself. For this reason, in this paper, the sample period of estimating the sponsor's oil risk exposure is short: one-year window, mainly for the reason that the sponsor company's appetite for the oil price risk can change substantially over a short period of time. Given the short sample period, we choose daily returns rather than monthly returns, to increase the number of observations.

the gas sector. The regression equation of $R_{j,i,\tau}$ is written as:

$$R_{j,i,\tau} = \begin{cases} \alpha_{j,i,t} + \beta_{m,j,i,t} R_{m,\tau} + \beta_{oil,j,i,t} R_{oil,\tau} + \upsilon_{j,i,\tau} & \text{for an oil project} \\ \alpha_{j,i,t} + \beta_{m,j,i,t} R_{m,\tau} + \beta_{gas,j,i,t} R_{gas,\tau} + \upsilon_{j,i,\tau} & \text{for a gas project} \end{cases}, \tag{2}$$

where $\upsilon_{j,i,\tau}$ refers to the error term.

Note that sponsor j's oil beta $\beta_{oil,j,i,t}$ (or gas beta $\beta_{gas,j,i,t}$) is allowed to change over time and estimated to be the loan date t-specific. The reason is that the sponsor firm's risk appetite is likely to change over time: the sponsor firm's willingness to take the oil price risk could be sensitively affected by changes in the various market conditions.

The estimated oil (gas) beta of the sponsor company $\beta_{oil,j,i,t}$ ($\beta_{gas,j,i,t}$) is used in measuring the oil (gas) risk exposure in the same way as for the weather exposure in Pérez-Gonzáles and Yun (2013). More specifically, we calculate the sponsor's oil (gas) risk exposure as the absolute value of oil (or gas) beta, multiplied by the sample standard deviation of the oil (gas) price returns[9], which is labeled *oil risk exposure*. More specifically, for a given project i at the loan date t, sponsor firm j's oil risk exposure $OilRiskExp_{j,i,t}$ is measured as:

$$OilRiskExp_{j,i,t} = \begin{cases} |\beta_{oil,j,i,t}| \times SD_t(R_{oil,\tau}) & \text{for an oil project} \\ |\beta_{gas,j,i,t}| \times SD_t(R_{gas,\tau}) & \text{for an gas project} \end{cases}, \tag{3}$$

where $SD_t(R_{oil,\tau})$ and $SD_t(R_{gas,\tau})$ refers to the standard deviation of the daily returns to oil and gas futures prices, respectively, over the estimation period of the oil and gas betas (i.e., one-year period, ending one year before the loan date). Note that as in Pérez-Gonzáles

[9]Our method is essentially identical to that in Pérez-Gonzáles and Yun (2013) except for the difference that they estimate the energy company's weather risk exposure rather than oil (gas) risk exposure. That is, Pérez-Gonzáles and Yun (2013) measure the energy company's weather exposure as the absolute value of the energy company's weather beta, multiplied by the standard deviation of the weather index.

and Yun (2013), the absolute value, rather than the level, of the estimated oil beta is used in constructing the oil exposure. (Most of estimated oil and gas betas (significant at the five percent level) are positive; see Table 2.) The reason is that for the purpose of risk management, reduction in the *magnitude* of risk exposures is important.

Similar to the way how sponsor's oil risk exposure is defined, sponsor firm j's market risk exposure $MktRiskExp_{j,i,t}$ can be also defined as:

$$MktRiskExp_{j,i,t} = |\beta_{m,j,i,t}| \times SD_t(R_{m,\tau}) \tag{4}$$

where $|\beta_{m,j,i,t}|$ refers to the absolute value of the sponsor firm's market beta and $SD_t(R_{m,\tau})$ the standard deviation of the daily market returns over the estimation period of the market beta (i.e., one-year period, ending one year before the loan date). Sponsor's market risk exposure $MktRiskExp_{j,i,t}$ will be used later as an additional instrument when we conduct a test of over-identifying restrictions.

First-Stage Regression Equation We proceed to discussing the first-stage regressions of the project company's offtake-adoption dummy and its interaction term with the upstream dummy, the key endogenous variable. As discussed earlier, $h_{i,t}$ denotes the project company i's hedging dummy, i.e., $h_{i,t}$ is equal to one for hedging (i.e., an offtake contract is adopted as of the loan date), and zero otherwise. Note that those first-stage regressions are mainly used as a part of the IV/2SLS estimation procedure (for identifying the determinants of the debt-to-equity ratio).

We write the first-stage regression equations of the hedging dummy $h_{i,t}$ and its interaction term with the upstream dummy $h_{i,t} \times U_{i,t}$ as:

$$h_{i,t} = const + \omega_0 \cdot OilRiskExp_{j,i,t} + \omega_1 \cdot OilRiskExp_{j,i,t} \times U_{i,t} + \mathbf{\Omega} \cdot \mathbf{X}_{i,t} + e_{i,t} \quad (5)$$

$$h_{i,t} \times U_{i,t} = const + \widetilde{\omega_0} \cdot OilRiskExp_{j,i,t} + \widetilde{\omega_1} \cdot OilRiskExp_{j,i,t} \times U_{i,t} + \widetilde{\mathbf{\Omega}} \cdot \mathbf{X}_{i,t} + \eta_{i,t} \quad (6)$$

where $OilRiskExp_{j,i,t}$ refers to the sponsor's oil risk exposure, $OilRiskExp_{j,i,t} \times U_{i,t}$ the interaction term between sponsor's oil risk exposure and the upstream dummy, $\mathbf{X}_{i,t}$ the vector of other control variables, which includes the upstream dummy $U_{i,t}$, that enter the second-stage regression of the debt-to-equity ratio, and $e_{i,t}$ and $\eta_{i,t}$ refer to the error terms. (And ω_0 and ω_1 are coefficients on $OilRiskExp_{j,i,t}$ and $OilRiskExp_{j,i,t} \times U_{i,t}$, respectively.)

In the first-stage regressions, we use OLS specification (rather than logit) as in (Pérez-Gonzáles and Yun; 2013; Chen and King; 2014).[10]. Note that in the first-stage regressions, the sponsor's oil risk exposure and its interaction term with the upstream dummy are essentially used as instrumental variables for the project company's hedging dummy $h_{i,t}$ and its interaction term with the upstream dummy, respectively. Let $\widehat{h_{i,t}}$ and $\widehat{h_{i,t} \times U_{i,t}}$ denote the fitted values from the above first-stage regressions of $h_{i,t}$ and $h_{i,t} \times U_{i,t}$, respectively. These fitted values $\widehat{h_{i,t}}$ and $\widehat{h_{i,t} \times U_{i,t}}$ will replace $h_{i,t}$ and $h_{i,t} \times U_{i,t}$, respectively, in the second-stage regression of the debt-to-equity ratio.

2.2.3 Second-Stage Regression

The second-stage regression equation of the debt-to-equity ratio $D/E_{i,t}$ is written as:

$$D/E_{i,t} = const + \delta \cdot \widehat{h_{i,t}} + \gamma \cdot \widehat{h_{i,t} \times U_{i,t}} + \mathbf{\Psi} \cdot \mathbf{X}_{i,t} + \epsilon_{i,t} \quad (7)$$

[10] In terms of the consistency of IV/2SLS estimator, for the first-stage regression, OLS is better than logit; see discussion in Pérez-Gonzáles and Yun (2013) and Chen and King (2014).

where $\epsilon_{i,t}$ refers to the error term, and $\mathbf{X}_{i,t}$ the vector of other control variables (including the upstream dummy $U_{i,t}$ to capture the upstream industry-specific fixed effect).

The coefficient γ of the interaction term between the offtake-adoption dummy and the upstream dummy is of our main interest. For the reason discussed earlier, we expect that the hedging decision ($h_{i,t} = 1$) increases disproportionately the upstream ($U_{i,t} = 1$) project company's debt-to-equity ratio relative to that of a downstream project company.

Control variables In the debt-to-equity regression, we control for offtake adoption dummy and its interaction term with the upstream dummy (set to one if a project belongs to an upstream industry related to exploration and development of oil and gas), where a vector of other standard control variables $\mathbf{X}_{i,t}$ is also controlled for. More specifically, we include into $\mathbf{X}_{i,t}$ the plausible determinants of the credit risk of oil and gas project loans as follows: (i) loan tranche characteristics such as maturity and logged size of a loan tranche, currency risk dummy indicating that the tranche denomination differs from the local currency of the host country, and refinancing dummy indicating that the loan is made to a project that had been previously financed; (ii) project characteristics such as logged total size of loans made to a given project; (iii) industry characteristics of a project, e.g., the gas sector dummy indicating the gas sector against the oil sector, the upstream dummy (to capture the upstream industry-specific fixed effect), and the interaction term between upstream dummy and price volatility (to capture the possible heterogeneity of the effect of the price volatility between upstream and downstream projects); (iv) host country-specific risk factors such as the host country's constant credit rating and time-varying spread of the host country's government bond yield; (v) global factors such as the price volatility—standard deviation of the log of the daily oil (or gas) spot price during a one-year period, ending on the loan date—, and the level of one-year maturity futures price of oil and gas, respectively, on average during a one-year period, ending on the loan date; and (vi) year dummies to control for year-specific fixed effects. (See appendix for definitions of variables and section 3 for more detailed discussion about how to construct these variables.)

Project's Unobserved Credit Risk For robustness check, as discussed earlier, we also examine how our main results for the borrowing-cost regression are affected by the project's unobserved credit risk. Let $EPCResid_{i,t}$ refer to the residual from the regression of the project company's EPC-adoption dummy on control variables $\mathbf{X}_{i,t}$ but not on the offtake-adoption dummy and its interaction term with the upstream dummy. More specifically, let $Dum_{i,t}^{EPC}$ denote the dummy indicating whether the EPC contract is adopted as of the loan date t for the project i. The logit regression of the EPC-adoption decision is written as:

$$Ln\left(\frac{Prob[Dum_{i,t}^{EPC}=1]}{1-Prob[Dum_{i,t}^{EPC}=1]}\right) = const + \mathbf{\Xi}\cdot\mathbf{X}_{i,t} + e_{i,t}^{EPC} \tag{8}$$

where $e_{i,t}^{EPC}$ refers to the error term in the EPC-adoption logit regression. The residual from such a logit regression, labeled *EPC-logit residual* and denoted by $EPCResid_{i,t}$, is, for robustness check, controlled for as a proxy for the project company's unobserved credit risk.

3 Data

In this section, we discuss data sources, descriptive statistics, and how to construct variables. (See appendix for the list of definitions of variables.)

3.1 Project- and Loan-Level Variables

The data on the project finance deals comes from the *Dealogic*'s *ProjectWare* database (the same one used in Corielli et al. (2010)). This database provides descriptions about project finance loans made to oil and other projects during a period between June 1997-May 2017: characteristics of an individual project and details about counterparties and sponsors of the special purpose vehicle (SPV) firm, labeled *project company*.

Industry Classification of a Project: Oil vs. Gas, and Upstream vs. Downstream Our sample is restricted to the oil and gas projects. More specifically, the six sample project categories are counted as oil and gas projects as follows: (i) oilfield exploration and development, (ii) oil pipeline, (iii) oil refinery, (iv) gas exploration and development, (v) gas pipeline, and (vi) gas distribution. The first three (i)-(iii) industries are classified as the oil sector, while the last three (iv)-(vi) the gas sector.

Meanwhile, the oil and gas industries are often also classified, in terms of the location in the supply chain, either as the upstream or as the downstream industry. More specifically, the upstream industry refers to those related to the exploration and development of oil and gas, while the downstream industry the refining and marketing. As such, we classify the two industries (i) and (iv) as the upstream, and the remaining four as the non-upstream, labeled *downstream*.

Loan Tranche Characteristics The sample uses a single loan tranche as a unit of observation (Corielli et al.; 2010; Choi and Kim; 2018): some projects are financed with more than one loan tranche, yielding that multiple tranches sometimes appear as separate observations in our sample. Many characteristics of a given loan tranche are written in the text format, which we read and encode. For instance, we set the offtake adoption dummy to one if the project company has already adopted such a contract as of the loan date when the loan of a given observation is made, and to zero otherwise. Similarly, we also set the EPC adoption dummy to one if an EPC contract has been already arranged as of the loan date.

The dependent variable, a project company's debt-to-equity ratio, is measured as the ratio of the total size of debt (e.g., loans and bonds) to the equity capital as in Corielli et al. (2010) and provided in the "D/E ratio" field of the database, although for many projects, this field is blank (Corielli et al.; 2010). To overcome this problem, we check the calculation rules of the database and manually compute the debt-to-equity ratios from the data on loan amount, bond amount, and equity amount.

We also collect information on microeconomic loan characteristics. More specifically, the loan tranche characteristics include financial closing date when the loan is made, loan tranche size, whether the loan tranche is subject to the currency risk (i.e., whether the currency of the loan denomination differs from the local currency of the project's host country), and whether the loan is a part of refinancing of a project that had been financed previously. The loan tranche size refers to the loan's principal value, which is in terms of millions of the constant 1985 U.S. dollars. We also control for the total size of loans made to a given project, which can be also thought of as a proxy for the project's size (Pierru et al.; 2013) given that in project finance loans, the leverage ratio is often quite high, about 70 percent (Esty and Sesia; 2011).

3.2 Host Country-Specific Risk Factors

The geopolitical risk factors specific to the host country, where the project's production facility is located, are also key to determining the project's credit risk (Corielli et al.; 2010;

Hainz and Kleimeier; 2012). First, the time-varying component of the host country's risk is measured as the country's 10-year government bond yield relative to the 10-year U.S. Treasury bond yield.[11] The government bond yield spread is also supposed to capture changes, if any, in the lenders' risk appetite (due to worsening financial market conditions). Second, the constant component (i.e., fixed-effect) of the host country's risk is measured as the host country's credit rating provided by the *Standard & Poor's* (*S&P*). More specifically, as in Corielli et al. (2010), we encode the host country's *S&P* credit rating such that a higher value corresponds to a better credit quality as follows: five for the best grade (from AAA to A+); four for the investment grade (from A to BBB-); three for the speculative grade (from BB+ to BB); two for the poor grade (from BB- to CC); and one for other grades such as default, unrated, or undisclosed.[12]

3.3 Global Factors

Price Volatility The volatility of gas and oil prices could be one of important determinants of the project company's capital structure. Let σ_t^{Oil} and σ_t^{Gas} denote the average daily volatility of logged *spot price* of oil and gas, respectively, during a one-year period, ending on the loan date t as follows:

$$\sigma_t^J = \sqrt{\sum_{s=1}^{T} \left[Ln\left(p_{t-s+1}^J\right) - \overline{Ln(p_t^J)} \right]^2 \Big/ (T-1)}, \quad \overline{Ln(p_t^J)} \equiv \frac{\sum_{s=1}^{T} Ln\left(p_{t-s+1}^J\right)}{T}, J \in \{\text{Oil, Gas}\} \tag{9}$$

[11] We construct the (relative) government bond yield by using government bond yield data, taken from *Thomson Reuters' DataStream.* For countries which do not have information of government bond yield—e.g., Brazil and China—, we use *JP Morgan global bond index* instead.

[12] Differently from Corielli et al. (2010), we use this rating variable as is and do not convert it to several dummy variables.

where p^J_{t-s+1} refers to the spot price of oil (or gas) observed s days before the loan date t, and T the number of observations of the daily spot prices per year.

Expected Level of the Price The expected *levels* of oil and gas prices in the near future may be also important in determining the project company's capital structure. For instance, if the oil and gas prices are expected to be significantly higher in the near future, then the project company's cash flow in the near future is also expected to be higher, and hence this company's debt capacity is greater. By contrast, it is also possible that for an increase in the expected oil price in the near future, the project's shareholder (i.e., the sponsor company) is willing to provide more equity capital to reap the expected benefit of the increased profit in the future, resulting in the drop in the debt-to-equity ratio of an oil project company. Depending on which one of these two opposing forces dominates the other, it will be determined whether the relationship between the oil project's debt-to-equity ratio and the expected oil price is positive or negative.

More specifically, the expected levels of oil and gas prices in the near future are measured as follows: For each oil and gas, we take its one-year maturity futures price (on average during a one-year period, ending on the loan date t) as the measure of the expected level of its price in the next year.

Year Dummy We control for year-specific fixed effects.

3.4 Descriptive Statistics

[Insert Table 1]

Table 1 presents summary statistics for project- and loan-level variables, where one project is sometimes financed by multi-tranche loans (Corielli et al.; 2010), where Panel

A in Table 1 provides statistics unconditionally for all of the sample projects. (Statistics conditional on upstream vs. downstream projects are available in section E in Online Appendix.) The sample includes a total of 72 projects and a total of 230 loan tranches. The project size is US $556 million (in constant 1985 U.S. dollars) on average (US $305 million for the median). The size of a loan tranche is US $210 million on average ($115 million for the median). For a given project, the ratio of the single loan size to the total is 38.3 percent on average (28.4 percent for the median). This means that two or three loan trances are issued per project on average. For projects being refinanced, the loan tranches are of the slightly larger (average) size than all loans are, while for projects under the currency risk, the loan tranches are slightly smaller than all loans are.

The debt-to-equity ratio is 2.9 on average (about 2.3 for the median), while its standard deviation is about 2.1, quite sizable compared to its average. That is, we observe a substantial degree of variation in the debt-to-equity ratio across the sample oil and gas project companies. The offtake adoption dummy has a mean of 0.375 (i.e., 37.5% of oil and gas project companies adopt the offtake contacts) and standard deviation of 0.487, indicating a substantial degree of variation in the adoption of offtake contracts. About 61% of loans are made to the upstream projects.

Panel B and C in Table 1 present statistics conditional on hedgers vs. non-hedgers, respectively. One notable difference between these two groups of projects is that for the hedgers (i.e., projects that have adopted offtake contracts as of the loan date), the average debt-to-equity ratio is higher than for non-hedgers: 3.07 for a hedged project vs. 2.55 for a non-hedged project. We need to carry out a formal regression analysis to answer the question of how much of the difference in the debt-to-equity ratio between these two groups of projects is caused by the hedging decision itself.

Last, Panel D in Table 1 presents the correlation coefficient matrix for key variables.

3.5 Sponsor's Oil and Gas Risk Exposures

[Insert Table 2]

Table 2 presents results for the estimated oil and gas risk exposures of sponsor companies. Note that oil and gas risk exposures consist, respectively, of two components: (i) (absolute values of) oil and gas betas of a sponsor, and (ii) variability of oil and gas prices, respectively. On the one hand, the oil beta is, on average, larger than the gas beta is: 0.080 for the oil beta and 0.014 for the gas beta. On the other hand, the gas-return variability ($SD_t(R_{gas,\tau})$) is, on average, as about twice large as the oil-return variability ($SD_t(R_{oil,\tau})$) : 0.135 for the oil-return variability and 0.195 for the gas-return volatility. As a result, oil risk exposure is, on average, greater than gas risk exposure: 0.012 for the oil risk exposure, and 0.008 for the gas risk exposure. Last, estimates of oil and gas risk exposures are significant for many (i.e., proportion of about 85%) sponsor firms[13], comparable to significance of their exposures to the market risk (i.e., proportion of about 91% for oil and 83% for gas), whereas most of sponsors with significant oil (or gas) risk exposures have positive oil (or gas) risk exposures.

4 Estimation Results

This section discusses the estimation results of the first- and second-stage regressions, respectively. Robustness check results are also discussed. For all regression results, standard

[13] In our first- and second-stage regression analysis, all observations of sponsor's oil (gas) risk exposure (rather than significant ones only) are used. Our main results are robust to the case in which the sample is restricted such that sponsor's oil (gas) risk exposure is significant at 5% level (i.e., insignificant oil risk exposures are excluded from the sample). Results in such an alternative case are available in section B in Online Appendix.

errors are robust to heteroskedasticity and reported inside parentheses.

4.1 First-Stage Regression: Offtake Adoption, and Its Interaction term with the Upstream Dummy

Table 3 and 4 presents the results for the first-stage regression of the offtake-adoption dummy and its interaction term with the upstream dummy, respectively. The fitted values from these first-stage regressions will be, as discussed earlier, used in the second-stage regression of the debt-to-equity ratio, by replacing the offtake-adoption dummy and its interaction term with the upstream dummy, respectively.

We begin by summarizing the main implications of the first-stage regressions results. In particular, we emphasize that the results of the first-stage regression of the offtake adoption dummy reveal substantial differences in the hedging likelihood between upstream and downstream projects as follows[14]: First, the upstream company is more likely to hedge the price risk than the downstream company is. Second, the upstream company owned by a sponsor company with the smaller oil risk exposure is more likely to hedge the price risk, while the association between downstream project company's hedging likelihood and sponsor's oil risk exposure is positive, opposite to the case of the upstream project; the aforementioned second result is also consistent with the fact that the correlation coefficient between the project's offtake-adoption dummy and sponsor's oil risk exposure is negative for upstream projects but positive for downstream projects.[15] Below we discuss how the specific findings in Table 3 and 4 are connected to the aforementioned implications.

[14]Our first-stage regression results are qualitatively robust to the case of logit-regression specification, of which results are available in section A in Online Appendix.

[15]This correlation coefficient as well as other descriptive statistics, conditional on upstream and downstream project, respectively, are available in section E in Online Appendix.

From the results in Table 3, two findings are noteworthy. First, the estimated coefficient on the upstream dummy is positive (significant at the 1% level). This indicates that for the upstream oil (or gas) project, the project company is more likely to adopt the offtake contract to hedge the future price risk than for the downstream project. Second, the coefficient on the sponsor's oil risk exposure is positive, and the coefficient on the interaction term between sponsor's oil risk exposure and upstream dummy is negative, where both are significant at the 1% level. In particular, these findings imply that for an upstream project, the association between sponsor's oil risk exposure and project company's hedging likelihood (equals the sum of these two coefficients) is negative, while it is positive for a downstream project. That is, the sensitivity of the project company's hedging probability to the sponsor's oil risk exposure is starkly different between upstream and downstream projects.

To understand implications of the aforementioned first-stage regression results, we consider a hypothesis that a sponsor firm wants to *align* the subsidiary project's oil risk exposure with the sponsor's own (extant) oil risk exposure. This hypothesis is motivated by the fact that the offtake-adoption dummy is negatively correlated with sponsor's oil risk exposure (Panel D in Table 1). This hypothesis implies that the sponsor with the smaller oil risk exposure is disproportionately more likely to hedge the oil risk faced by the firm's subsidiary project (Choi and Kim; 2018). Our findings suggest that for an upstream project, a sponsor firm uses the project-level hedging strategy to align the project's oil risk exposure with the sponsor's own extant oil risk exposure to the degree higher than for a downstream project.

The question then arises of why the sponsor's "alignment" willingness (in terms of the oil risk exposure between the sponsor and the project) is stronger for the upstream project than for the downstream project. Theoretically, two hypotheses are possible: such an "alignment" willingness of the sponsor would be stronger if either (i) the sponsor wants to control its oil risk exposure to its desired target level more tightly (i.e., *preferences* of the sponsor firm's shareholders) or (ii) the sponsor's oil risk exposure is affected to magnitude greater by the project's oil risk exposure. Both of these two hypotheses are consistent with the related evidence that investment in upstream oil (or gas) projects responds more sensitively to the oil (or gas) price shock than investment in downstream oil (or gas) projects does.[16] It is interesting, but beyond the scope of this paper, to investigate which one of the two hypotheses is, in reality, more important than the other.

Last, it is also noteworthy that the coefficient on the unobserved credit risk (i.e., measured as the residuals from the Logit-regression of the EPC adoption dummy) is also significantly positive[17], indicating that the project's unobserved credit risk, if any, would increase the incentive to hedge the price risk (Choi and Kim; 2018).

[Insert Table 3]

Table 4 presents the results for the first-stage regression of the interaction term between the offtake-adoption dummy and the upstream dummy. Results in this case are quite similar to those in Table 3: (i) the estimated coefficient on the upstream dummy is positive (significant at the 1% level), and (ii) the coefficient on the interaction term between the sponsor's oil risk exposure and upstream dummy is negative (significant at the 5% level). Their economic implications are similar to those discussed earlier for results in Table 3.

[16]More specifically, we often observe a rather sharp and quick cutback in spending on upstream development projects as a direct result of the price decline. For instance, after 2015, short-term expectations of relatively low prices reduced upstream investment compared to downstream investment. More specifically, according to EY (2015b), oil and gas companies have cumulatively slashed their 2015 upstream budgets by 24% year on year (based on announcements from 116 companies), when the oil (WTI) price declined by about 30.5% percent year on year. By contrast, downstream investment levels in 2015 were similar to those in 2014; rather it had increased for last three years (EY; 2015a). Meanwhile, in 2017, when the oil (WTI) price increased by about 13 percent year on year — the overall recovery of the oil and gas, the total deal value of upstream projects increases by about 30% year on year, while the downstream deal value decreases by 12% (higher than the average for the past five years) year on year (EY; 2017).

[17]Results for the EPC-adoption logit regression are available in section D in Online Appendix.

[Insert Table 4]

4.2 Second-Stage Regression of the Debt-to-Equity Ratio

In this section, we discuss the main results for the second-stage regression of the project company's debt-to-equity ratio. In the second-stage regression, we replace the offtake adoption and its interaction term with the upstream dummy by their fitted values from the earlier first-stage regression of (4) and (5), respectively. We begin by discussing the main regression results and proceed to discussing robustness-check results.

Main Results Table 5 presents the 2SLS (IV) estimation results for the project company's debt-to-equity ratio, where column '(2)' is the benchmark case, whereas column '(3)' in Table 5 presents the robustness-check results when we additionally control for the proxy for the project's unobserved credit risk. (Results in column '(1)' in Table 5 are the case in which the interaction term between the price volatility and upstream dummy is dropped from the benchmark case of column '(2)' in Table 5.) We begin by discussing some general insights from these results and proceed to discussing the main findings.

[Insert Table 5]

Results in Table 5 suggest several general insights as follows: First, we can see that the government bond yield spread is negatively related to the project company's debt-to-equity ratio, suggesting that geopolitical risk factors can increase significantly the funding difficulty faced by oil (or gas) project companies.

Second, our evidence does not support the hypothesis that the price volatility may decrease the project company's debt-to-equity ratio, whereas the effect of the expected oil price in the near future (proxied by the futures price) on the project company's debt-to-equity ratio is negative (significant at the 1% level). The negative effect of the futures price on the debt-to-equity ratio may support, as discussed earlier, the hypothesis that for an increase in the expected oil price in the near future, the project's shareholder (i.e., the sponsor company) is willing to provide more equity capital to reap the expected benefit of the increased profit in the future, resulting in the drop in the debt-to-equity ratio of an oil project company.

Third, the coefficient on the upstream dummy is negative but insignificant, implying that when many factors, including the hedging decision, are controlled for, there is no significant difference in the debt-to-equity ratio between upstream and downstream projects.

Fourth, our evidence does not support that many loan characteristics variables (e.g., maturity and loan size) are important in determining the project company's debt-to-equity ratio. These results could be due to the low efficiency of the IV/2SLS estimator. Such an issue is beyond the scope of this paper.

We turn to discussing the main findings. Table 5 shows that the coefficient on the offtake adoption dummy is insignificant, implying that hedging the future price risk does not significantly help to increase a downstream project's debt-to-equity ratio. By contrast, from Table 5, we can see that the coefficient on the interaction term between offtake adoption dummy and upstream dummy is positive (about 5.8 in column (2) in Table 5) and significant at the 5% level. These results suggest that hedging the price risk increases disproportionately the upstream project's debt-to-equity ratio relative to that of the downstream project. Importantly, such an effect is economically significant, too. More specifically, our IV/2SLS estimation results indicate that in upstream oil and gas industries, the adoption of offtake contracts increases the project company's debt-to-equity ratio (compared to the case of the absence of offtake contracts) by 5.8, quite sizable (i.e., an increase by 200%) relative to the upstream project's average debt-to-equity ratio[18] of 2.9. Given the aforementioned result that hedging hardly affects the downstream project's debt-to-equity ratio, these findings suggest that the effect of hedging the price risk on the oil (or gas) project company's capital structure is substantially different between the upstream and downstream industries (i.e., such an effect is of magnitude disproportionately greater for an upstream project).

It is interesting to examine how much OLS estimate differs from our benchmark IV/2SLS estimate, especially for the coefficient on the interaction term between offtake adoption dummy and upstream dummy. OLS results (regression (4) and (5) in Table 5) show that this coefficient is significant (at the five percent level) and positive, consistent with the IV/2SLS result. Importantly, OLS estimate of this coefficient (which is either about 1.1 or 1.2) is smaller substantially (by about at least 80%) than the IV/2SLS estimate (which is either about 5.8 or about 6.2). This suggests that the OLS estimate of this key coefficient is biased: this bias is in the *downward direction* and of *magnitude 80% or more.*

Taken together, our first- and second-stage regression results suggest that between upstream and downstream oil (or gas) projects, there are substantial differences in both likelihood and effect of hedging the future price risk. This suggests that industry-level characteristics that are closely related to the project company's risk-absorbing operational capability can greatly affect the probability and effect of the adoption of risk management strategies in the oil (or gas) projects. This message can be useful to investors as well as to the government agency in charge of regulating the country-level aggregate exposure to the oil price risk.

To illustrate the economic significance of the estimated coefficients on key control variables, we present, in Table 6, the predicted change in the dependent variable (e.g., a project's debt-to-equity ratio) when one variable increases from 25 percentile to 75 percentile. More

[18]Statistics conditional on upstream vs. downstream industry, respectively, are available in section E in Online Appendix.

precisely, we multiply such an increase in one variable by its coefficient in the first- and second-stage regression results (those in column '(3)' in Table 3 and 5), respectively, and present such a calculated predicted change in the dependent variable: see the line headed 'Difference: 75% - 25%' in Table 6.

[Insert Table 6]

Validity of IV/2SLS Regression Results Note that our main results of IV/2SLS regression of the oil/gas project company's debt-to-equity ratio are obtained under the assumption that our instrumental variable (i.e., the sponsor company's oil risk exposure) is not correlated with unobserved omitted variables. Naturally, it is desirable to test whether or not this assumption is valid, i.e., whether or not our instrumental variable is uncorrelated with the second stage residuals. For this purpose, one may use a test of over-identifying restrictions (i.e. a variation of the Sargan-Hansen test), which is possible if the number of instrumental variables is greater than the number of endogenous variable. In our main regression analysis, the number of instrumental variable is equal to, but not larger than, the number of endogenous variable.

In this section, we introduce one more instrumental variable to conduct a test of over-identifying restrictions: sponsor firm's market risk exposure $MktRiskExp_{j,i,t}$, defined earlier in (4).[19] We estimate again the main regression equation of the oil and gas project's debt-to-equity ratio by using market risk exposure as an additional instrumental variable for the project company's offtake-adoption dummy. We also test the null hypothesis that both our main instrument (i.e., sponsor's oil risk exposure) and the additional instrument (i.e., sponsor's market risk exposure) are valid.

[19] $MktRiskExp_{j,i,t}$ is measured as the absolute value of the sponsor firm's market beta (i.e., sensitivity of the sponsor firm's daily stock return to the daily market return), multiplied by the standard deviation of the daily market returns over the one-year period, ending one year before the loan date.

The IV/2SLS estimation results in this overidentification case[20] are presented in regression (6) and (7) in Table 5. We can see that the main results are robust to this case: for instance, the coefficient on the interaction term between the offtake adoption dummy and upstream dummy is positive and significant at the five percent level (as is the baseline case of exact identification, reported in regression (1) and (2) in Table 5).

We also conduct a test of over-identifying restrictions. More specifically, under the null hypothesis that all instrumental variables (i.e., oil risk exposure $OilRiskExp_{j,i,t}$ and market risk exposure $MktRiskExp_{j,i,t}$) are valid, Sargan's (1958) and Basmann's (1960) χ^2 statistic (reported by the *STATA* command "estat overid") in the upper tail is unlikely. That is, if the instrumental variables are uncorrelated with the error terms, then Sargan's (1958) and Basmann's (1960) χ^2 statistic should be close to zero.

The test results show that we can not reject the null hypothesis: the p-value is 0.55 and 0.62 for regression (6) and (7), respectively, and larger than the significance level of 5 percent. This suggests that all instrumental variables are valid instruments (i.e., uncorrelated with the error term). This evidence supports our claim that the sponsor's oil risk exposure, our main instrument, is a valid instrument for the project company's offtake-adoption decision.

4.3 Robustness Check

Note that our regression results are obtained by controlling for various factors potentially relevant to the debt-to-equity ratio: the expected shift in the product-market demand in the near future (measured as the one-year maturity futures price of oil); host country-specific risk factors; and year-fixed effects. We also find that our main findings are robust to the case in which the estimation window of sponsor's oil risk exposure is closer to the loan date

[20]The first-stage regression results in this overidentification case are available in section F in Online Appendix.

(e.g., one-year window, ending *nine months* (rather than 12 months) before the loan date). (Results in such a case are available in C in Online Appendix.)

Moreover, our main findings are also robust to controlling additionally for the proxy for the unobserved credit risk of a project loan. Our proxy for the unobserved credit risk of a project loan is, as discussed earlier, measured as the residuals from the regression of the EPC-adoption dummy on control variables (other than the offtake-adoption dummy and its interaction term with the upstream dummy)[21], where an EPC contract is an effective tool to reduce the pre-completion default risk that accounts for most of the default risk of oil and gas project finance loans (Sorge; 2004). Results in the case of controlling for such a proxy for the unobserved credit risk (i.e., residuals from the logit regression of the ECP-adoption dummy) are presented in column '(3)' in Table 5 for the second-stage regression results, and in columns '(3)' in Table 3 and 4 for the first-stage regression results. We can see that compared to results for the corresponding regression specification reported in columns (2) in Table 3, 4, and 5, main findings are robust to this case: results in this case (i.e., column '(3)'), both significance and magnitude of coefficients on key variables are quite similar to the benchmark results (i.e., column '(2)').

Last, in this paper, the hedging decision is defined as a dummy indicating whether or not the offtake contracts are adopted. That is, we study the extensive margin (i.e., whether offtake contracts are adopted or not), leaving the role of the intensive margin of the hedging decision (i.e., how much fraction of oil production is covered by the adopted hedging tools) unexamined. It would be interesting to study how differently the extensive and intensive margins of the price risk management decisions affect the capital structure, for which our analysis is silent due to the lack of data on the intensive margin.

[21]Results for the EPC-adoption logit regression are available in section D in Online Appendix.

5 Conclusion

This paper provides evidence on the causal effect of price risk management on the oil and gas project company's debt-to-equity ratio. In particular, we investigate how such an effect differs between upstream and downstream industries, motivated by the fact that upstream firms are exposed to the price risk to magnitude disproportionately greater than the downstream firms that have some capabilities to absorb the price shocks.

The oil and gas project company's hedging decision is endogenous. For identification, we use the sponsor company's stock-return exposure to the oil (or gas) price risk as the instrumental variable for the subsidiary project company's hedging decision. Our 2SLS IV regression results show that hedging the future oil (or gas) price risk increases disproportionately the upstream oil (or gas) project company's debt-to-equity ratio than that of a comparable downstream company. This indicates that hedging the price risk is an effective and important way to increase the amount of lenders' funding to the upstream oil (or gas) project but ineffective for the case of the downstream oil (or gas) project.

We also find the substantial differences in the hedging likelihood between upstream and downstream projects: (i) the upstream company is more likely to adopt the hedging contract; and (ii) the upstream company owned by a sponsor company with the smaller oil exposure is more likely to adopt the hedging contract, whereas the opposite is the case for a downstream company. Taken together, our findings suggest that between upstream and downstream oil (or gas) projects, there are substantial differences in both likelihood and effect of hedging the future price risk.

In this paper, we use only the extensive margin of the hedging decision (i.e., whether offtake contracts are adopted or not), leaving its intensive margin (i.e., how much fraction of oil production is covered by the adopted hedging tools), due to the lack of data on such an intensive margin. Examining the effect of the intensive margin of the hedging decision would be interesting. It would be also interesting to estimate the causal effects of other financial decisions (e.g., public bond issuance vs. loans from banks) on the various outcomes of oil and gas projects (e.g., cost of borrowing, probability of successful funding). We leave both the two possible lines of research for future work.

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A Appendix

A.1 Definitions of Variables

- **Upstream dummy**: dummy set to one if the project belongs to the upstream industries and to zero if the project belongs to the downstream industries. More specifically, the upstream industries refer to exploration and extraction of oil and gas and include the two industries: (i) oilfield exploration and development and (iv) gas exploration and development industries. Industries other than these two are related to refining and distribution and defined, in terms of the location in the supply chain, as the downstream industry.

- **Gas sector dummy**: dummy set to one if the project's industry belongs to the gas sector, and zero for the oil sector. The oil sector includes (i) oilfield exploration and development, (ii) oil pipeline, and (iii) oil refinery industries. The gas sector includes (iv) gas exploration and development, (v) gas pipeline, and (vi) gas distribution industries.

- **Sponsor's oil risk exposure**: sensitivity of the sponsor company's stock return to the rate of changes in the near-month maturity futures price of oil (or gas), estimated by using the two-factor regression model in which the other factor is the returns to the market portfolio (where the sponsor's stocks are mainly traded). The sponsor's oil (or gas) beta is estimated using the sponsor's daily stock returns during a one-year period, ending *one-year before* the loan date, where either oil beta or gas beta is estimated according to whether the project belongs either to oil sector or to gas sector. Such a sponsor's stock-price sensitivity to the price of oil (or gas) is then transformed such that we multiply the absolute value of an estimated oil (or gas) beta by the standard deviation of returns to the oil (or gas) price during the oil (or gas) beta estimation period (e.g., one-year period, ending *one-year before* the loan date). Such a constructed variable is labeled "oil risk exposure" even for the case of the gas project.

- **Sponsor's market risk exposure**: the absolute value of the sponsor firm's market beta, multiplied by the standard deviation of the daily market returns over the market beta estimation period (e.g., one-year period, ending *one-year before* the loan date). The sponsor firm's market beta refers to the sensitivity of the sponsor firm's daily stock return to the daily market return.

- **Credit risk: EPC-Logit residual**: the residual from the logit regression of the EPC-adoption dummy.

- **Price volatility**: standard deviation of the log of the daily oil (or gas) spot price during a one-year period, ending on the loan date.

- **Ln(Futures price)**: natural log of the one-year maturity futures price of oil (or gas), on average during a one-year period, ending on the loan date.

- **Ln(Tranche size)**: natural log of the loan tranche size, measured as the principal value in millions of constant 1985 U.S. dollars.

- **Ln(Project's total loan size)**: natural log of the total size of multiple loan tranches made to a given project.

- **Maturity**: the length (in years) of time from the loan tranche date to the maturity date when the principle payment is scheduled.

- **Refinancing dummy**: dummy set to one if the loan tranche is used to refinancing an existing project that had been financed previously.
- **Currency risk dummy**: dummy set to one if the loan tranche denomination currency differs from the local currency of the host country where the project's production facility is located.
- **Host country: Credit quality**: constant (discrete) credit grade of a given host country assigned by the *S&P*; encoded such that a higher value is assigned to a better credit quality.
- **Host country: Gov't bond spread**: time-varying (continuous) spread of the host country's 10-year government bond yield, relative to the 10-year U.S. Treasury rate.

Table 1: Statistics of Oil and Gas Project Finance Loans, June 1997–May 2017

	Obs.	Mean	Median	SD	Min	Max
	Panel A: Statistics for All Projects					
Debt-to-Equity Ratio	72	2.90	2.33	2.11	0.33	11.19
Total amount of loans (mil. US$)	72	556	305	862	58	51,23
Tranche size (mil. US$))	230	210	115	311	1	1,905
Tranche size w/ currency risk	58	191	96	228	1	1,018
Tranche size w/ refinancing	21	225	214	195	29	744
Tranche size/Total amount of loans (%)	230	38.3	28.4	38.9	1.1	100.0
Maturity (years)	230	9.1	8.0	6.4	0.4	30.0
Offtake-adoption dummy	72	0.375	0	0.487	0	1
Upstream dummy	72	0.611	1	0.490	0	1
Sponsor's oil risk exposure	72	0.010	0.005	0.015	0.000	0.100
Host: Credit quality (*S&P* rating)	72	3.1	3.0	0.96	1.0	4.0
Host: Gov't bond spread	72	0.031	0.013	0.055	-0.015	0.350
Price volatility	72	0.168	0.147	0.081	0.053	0.455
Ln(Futures price)	72	2.422	1.837	1.395	0.504	4.889
	Panel B: Statistics for Hedgers					
Debt-to-Equity Ratio	33	3.07	2.70	2.06	0.35	9.00
Total amount of loans (mil. US$)	33	1,045	308	1,910	385	9,289
Tranche size (mil. US$))	111	262	126	385	0.3	1,905
Tranche size w/ currency risk	13	257	144	277	0.3	1,018
Tranche size w/ refinancing	13	244	123	230	57	744
Tranche size/Total amount of loans (%)	111	39.0	32.9	32.0	1.4	100.0
Maturity (years)	111	10.3	10.0	6.4	0.4	25.0
Upstream dummy	33	0.704	1	0.461	0	1
Sponsor's oil risk exposure	33	0.009	0.003	0.017	0.000	0.100
Host: Credit quality (*S&P* rating)	33	3.1	3.0	0.91	1.0	4.0
Host: Gov't bond spread	33	0.025	0.014	0.036	-0.011	0.214
Price volatility	33	0.196	0.176	0.100	0.068	0.455
Ln(Futures price)	33	2.494	1.837	1.446	0.812	4.889
	Panel C: Statistics for Non-Hedgers					
Debt-to-Equity Ratio	39	2.55	2.33	1.57	0.26	9.00
Total amount of loans (mil. US$)	39	531	289	107	58	6,632
Tranche size (mil. US$))	119	163	105	212	1.3	1,579
Tranche size w/ currency risk	32	145	71	175	0.3	733
Tranche size w/ refinancing	8	195	250	128	29	321
Tranche size/Total amount of loans (%)	119	37.6	26.1	44.8	1	100.0
Maturity (years)	119	8.0	6.5	6.2	0.5	30.0
Upstream dummy	39	0.555	1	0.502	0	1
Sponsor's oil risk exposure	39	0.010	0.005	0.016	0.000	0.100
Host: Credit quality (*S&P* rating)	39	3.4	4.0	0.75	1.0	4.0
Host: Gov't bond spread	39	0.024	0.012	0.029	-0.015	0.113
Price volatility	39	0.165	0.142	0.067	0.053	0.322
Ln(Futures price)	39	2.114	1.641	1.346	0.504	4.619

Note: this table presents statistics of key variables of project finance loan data, June 1997–May 2017. 'SD' refers to the standard deviation.

Table 1 Cont'd

	Panel D: Correlation Coefficients								
	Debt-to-Equity Ratio	Offtake Dummy	Upstream Dummy	Sponsor's Oil Risk Exposure	Maturity	Tranche Size	Total Amount of Loans	Price Volatility	Ln(Futures Price)
Debt-to-Equity ratio	1.0								
Offtake dummy	0.05	1.0							
Upstream dummy	0.10	0.13*	1.0						
Sponsor's oil risk exposure	-0.11	-0.14*	0.04	1.0					
Maturity	0.06	0.18*	0.17*	0.12	1.0				
Tranche size	-0.03	0.16*	0.18*	0.10	0.19*	1.0			
Tot. amt. loans	-0.16*	0.06	0.19*	0.52*	0.31*	0.54*	1.0		
Price volatility	-0.07	0.14*	-0.13*	0.19*	0.03	0.03	0.11	1.0	
Ln(Futures price)	-0.04	0.35*	0.12	0.04	0.09	0.04	0.17*	-0.03	1.0

Note: Panel D in this table presents correlation coefficients among key variables of project finance loan data, June 1997–May 2017. '*' indicates significance at the 10% level.

Table 2: Sponsor's Oil Risk Exposure

	Obs.	Mean	Median	SD	Min	Max	Proportion of Obs.	
							Significant at $p < 0.05$	Positive and Significant at $p < 0.05$
Sponsor's Past Stock Return Regression: Oil Projects								
Market beta: $\beta_{m,j,t}$	25	0.729	0.494	0.709	0.003	2.798	91%	84%
Oil beta: $\beta_{oil,j,t}$	25	0.080	0.049	0.124	-0.097	0.478	85%	82%
Adj-R^2	25	0.150	0.068	0.150	-0.006	0.559	-	-
Sponsor's Past Stock Return Regression: Gas Projects								
Market beta: $\beta_{m,j,t}$	47	0.529	0.393	0.504	-0.295	2.052	83%	81%
Gas beta: $\beta_{gas,j,t}$	47	0.014	0.006	0.062	-0.137	0.285	86%	83%
Adj-R^2	47	0.137	0.061	0.168	-0.018	0.591	-	-
Oil-return standard deviation: $SD_t(R_{oil,\tau})$	25	0.103	0.084	0.049	0.057	0.272	-	-
Gas-return standard deviation: $SD_t(R_{gas,\tau})$	47	0.195	0.173	0.085	0.076	0.394	-	-
Sponsor's Oil Risk Exposure								
Oil-induced volatility: $\lvert\beta_{oil,j,t}\rvert * SD_t(R_{oil,\tau})$	25	0.012	0.005	0.020	0.000	0.101	-	-
Gas-induced volatility: $\lvert\beta_{gas,j,t}\rvert * SD_t(R_{gas,\tau})$	47	0.008	0.003	0.015	0.000	0.100	-	-

Note: this table presents results for estimating oil and gas risk exposures of sponsor companies for project finance loans (at tranche levels) during the sample period June 1997 - May 2017. For a given project loan, the sponsor company's oil (or gas) beta is estimated as follows: the sponsor's daily stock returns are regressed on returns to the market portfolio and oil (or gas) near-month futures price over a one-year period, ending one year before the loan date. Oil risk exposure of a sponsor $|\beta_{oil,j,t}| * SD_t(R_{oil,\tau})$ is calculated as the absolute value of the sponsor's oil beta $|\beta_{oil,j,t}|$, multiplied by the standard deviation of returns to the oil futures price $SD_t(R_{oil,\tau})$ (during the estimation period of the oil beta). Gas risk exposure is measured in the same way as for the oil risk exposure.

Table 3: First-Stage Regression: Offtake Adoption

Dependent variable	Offtake adoption		
Regression	(1)	(2)	(3)
Instrument			
Sponsor's oil risk exposure	5.340**	6.030***	6.547***
	[2.145]	[2.027]	[2.049]
Sponsor's oil risk exposure	-10.229***	-8.064***	-7.394***
× Upstream dummy	[2.266]	[2.502]	[2.199]
Controls			
Upstream dummy	2.272***	0.642***	0.645***
	[0.097]	[0.189]	[0.189]
Price volatility		-2.114**	-1.910*
× Upstream dummy		[1.033]	[1.038]
Credit risk:			0.213***
EPC-Logit Residual			[0.031]
Price volatility	1.106	2.187**	1.807*
	[0.740]	[0.978]	[0.925]
Ln(Futures price)	0.194*	0.200*	0.067
	[0.114]	[0.113]	[0.113]
Host: Credit quality	-0.136**	-0.153**	-0.155***
	[0.058]	[0.060]	[0.056]
Host: Gov't bond spread	-0.806	-0.736	-3.568**
	[1.092]	[1.094]	[1.410]
Ln(Tranche size)	-0.007	-0.001	-0.001
	[0.027]	[0.025]	[0.025]
Ln(Project's total loan size)	0.031	0.024	-0.002
	[0.037]	[0.036]	[0.037]
Maturity	0.003	0.005	0.004
	[0.006]	[0.006]	[0.005]
Refinancing dummy	-0.005	0.025	0.091
	[0.133]	[0.133]	[0.092]
Currency risk dummy	-0.013	-0.024	-0.004
	[0.085]	[0.086]	[0.072]
Gas sector dummy	0.149	0.248**	0.246**
	[0.102]	[0.111]	[0.120]
Constant	0.316	0.071	0.437
	[0.368]	[0.365]	[0.350]
Observations	230	230	203
Adjusted R^2	0.39	0.41	0.59
Year dummy	Yes	Yes	Yes

Note: this table presents results for the first-stage OLS regression of the project company's offtake-adoption dummy on the sponsor company's oil risk exposure, its interaction term with the upstream dummy, and other control variables. Standard errors—robust to heteroskedasticity—are reported inside parentheses. '*' indicates significance at the 10% level, '**' at the 5% level, and '***' at the 1% level.

Table 4: First-Stage Regression: Offtake Adoption × Upstream Dummy

Dependent variable	Offtake adoption × Upstream dummy		
Regression	(1)	(2)	(3)
Instrument			
Sponsor's oil risk exposure	-1.682	-1.821	-0.201
	[1.330]	[1.332]	[1.354]
Sponsor's oil risk exposure	-3.967**	-4.401**	-4.466**
× Upstream dummy	[1.593]	[1.895]	[1.955]
Controls			
Upstream dummy	0.624***	0.550***	0.568***
	[0.069]	[0.149]	[0.155]
Price volatility		0.423	0.572
× Upstream dummy		[0.758]	[0.782]
Credit risk:			0.083***
EPC-Logit Residual			[0.021]
Price volatility	-0.535	-0.752	-0.966*
	[0.392]	[0.508]	[0.556]
Ln(Futures price)	0.271***	0.268***	0.188
	[0.099]	[0.100]	[0.113]
Host: Credit quality	-0.093**	-0.090**	-0.079**
	[0.042]	[0.042]	[0.039]
Host: Gov't bond spread	0.342	0.328	-0.869
	[0.923]	[0.925]	[1.267]
Ln(Tranche size)	0.019	0.019	0.024
	[0.017]	[0.017]	[0.018]
Ln(Project's total loan size)	0.045*	0.047*	0.032
	[0.027]	[0.027]	[0.030]
Maturity	-0.002	-0.002	-0.003
	[0.004]	[0.004]	[0.004]
Refinancing dummy	0.096	0.089	0.113
	[0.084]	[0.087]	[0.079]
Currency risk dummy	0.056	0.058	0.055
	[0.049]	[0.049]	[0.049]
Gas sector dummy	0.306***	0.286***	0.261**
	[0.083]	[0.093]	[0.102]
Constant	0.006	0.055	-0.088
	[0.249]	[0.270]	[0.260]
Observations	230	230	203
Adjusted R^2	0.66	0.66	0.71
Year dummy	Yes	Yes	Yes

Note: this table presents results for the first-stage OLS regression of the interaction term between the project company's offtake-adoption dummy and the upstream dummy on on the sponsor company's oil risk exposure, its interaction term with the upstream dummy, and other control variables. Standard errors—robust to heteroskedasticity—are reported inside parentheses. '*' indicates significance at the 10% level, '**' at the 5% level, and '***' at the 1% level.

Table 5: Second-Stage Regression: Debt-to-Equity Ratio of Oil and Gas Projects

Dependent variable	Debt-to-Equity Ratio						
Regression	(1) IV/2SLS	(2) IV/2SLS	(3) IV/2SLS	(4) OLS	(5) OLS	(6) IV/2SLS	(7) IV/2SLS
Overidentified	No	No	No	-	-	Yes	Yes
Offtake adoption	-1.899	-1.918	-2.223*	0.272	0.324	-1.336	-1.735
	[1.444]	[1.460]	[1.274]	[0.328]	[0.306]	[0.997]	[1.324]
Offtake adoption	6.171**	5.785**	5.328**	1.170**	1.134**	4.892**	4.991**
× Upstream dummy	[3.079]	[2.554]	[2.134]	[0.559]	[0.571]	[1.917]	[1.840]
Controls							
Upstream dummy	-2.646*	-2.106	-1.125	-0.514	-0.480	-2.010	-1.692
	[1.609]	[1.780]	[1.910]	[0.507]	[0.922]	[0.990]	[1.327]
Price volatility		-1.682	-4.132		1.816		-1.616
× Upstream dummy		[5.379]	[5.424]		[3.425]		[5.160]
Credit risk:			0.027				
EPC-Logit Residual			[0.263]				
Price volatility	2.507	3.181	2.829	-2.112	-3.125	1.319	2.543
	[4.117]	[4.973]	[4.873]	[2.946]	[3.176]	[3.630]	[4.714]
Ln(Futures price)	-3.014***	-2.895***	-2.980***	-2.031***	-2.047***	-2.764***	-2.717***
	[0.969]	[0.919]	[0.902]	[0.696]	[0.706]	[0.737]	[0.732]
Host: Credit quality	0.301	0.249	0.158	0.142	0.157	0.262	0.197
	[0.311]	[0.338]	[0.336]	[0.233]	[0.230]	[0.284]	[0.320]
Host: Gov't bond spread	-10.456**	-10.283**	-12.974	-6.840*	-6.901*	-9.521***	-9.914**
	[5.038]	[4.742]	[9.215]	[3.675]	[3.710]	[3.902]	[4.165]
Ln(Tranche size)	0.001	0.008	-0.025	0.110	0.113	0.029	0.028
	[0.132]	[0.129]	[0.139]	[0.136]	[0.137]	[0.122]	[0.122]
Ln(Project's total loan size)	0.289	-0.277	-0.327	-0.165	-0.166	-0.258	-0.256
	[0.212]	[0.201]	[0.213]	[0.219]	[0.220]	[0.208]	[0.206]
Maturity	0.028	0.029	0.039	0.007	0.004	0.023	0.026
	[0.026]	[0.026]	[0.027]	[0.023]	[0.024]	[0.024]	[0.026]
Refinancing dummy	-0.646	-0.584	-0.340	-0.175	-0.199	-0.526	-0.511
	[0.471]	[0.458]	[0.505]	[0.354]	[0.372]	[0.374]	[0.377]
Currency risk dummy	-0.058	-0.045	-0.017	0.150	0.161	-0.005	-0.006
	[0.381]	[0.378]	[0.382]	[0.349]	[0.348]	[0.349]	[0.350]
Gas sector dummy	-1.494	-1.293	-0.729	-0.141	-0.189	-1.150	-1.036
	[1.128]	[1.109]	[1.125]	[0.539]	[0.562]	[0.843]	[0.872]
Constant	4.555**	4.368***	5.414***	3.583**	3.943**	4.289***	4.301***
	[1.802]	[1.692]	[1.946]	[1.729]	[1.989]	[1.530]	[1.588]
Test of over-identification							
Sargan's (1958) χ^2 statistic						0.345	0.234
p-value						0.55	0.62
Observations	230	230	203	230	230	230	230
R^2	0.03	0.07	0.10	0.28	0.28	0.13	0.10
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: this table presents results for the second-stage regression of the project company's debt-to-equity ratio. The project company's offtake-adoption dummy and its interaction term with the upstream dummy are the fitted values from their first-stage regressions, respectively. Standard errors—robust to heteroskedasticity—are reported inside parentheses. '*' indicates significance at the 10% level, '**' at the 5% level, and '***' at the 1% level.

Table 6: Changes in the Predicted Debt-to-Equity Ratio and Offtake-Adoption Probability

	Panel A: Effects on Debt-to-Equity Ratio							
	Offtake-Adoption-	Offtake-Adoption × Upstream dummy	Upstream Dummy	Price Volatility × Upstream dummy	Price Volatility	Credit Risk: EPC-Logit Residuals	Host: Credit Quality	Host: Gov't Spread
25th %	-0.123	0.463*	-0.086	-0.041	0.119	-0.059	0.223	-0.005
75th %	-1.221	0.811**	-0.467	-0.248	0.254	0.053	0.264	-0.216
Difference: 75% - 25%	-1.098	0.348	-0.381	-0.207	0.135	0.112	0.041	-0.211

	Panel B: Effects on Offtake-Adoption Probability							
	Sponsor's Oil Risk Exposure	Sponsor's Oil Risk Exposure × Upstream dummy	Upstream Dummy	Price Volatility × Upstream dummy	Price Volatility	Credit Risk: EPC-Logit Residuals	Host: Credit Quality	Host: Gov't Spread
25%	0.034**	-0.014**	0.513*	-0.097*	0.530	-0.329**	-1.086**	-0.008**
75%	0.178**	-0.077**	0.806**	-0.793*	0.739**	0.198**	-1.864*	-0.367*
Difference: 75% - 25%	0.144	-0.063	0.293	-0.696	0.209	0.527	-0.0778	-0.359

Note: The table presents the predicted changes in debt-to-equity ratio (Panel A) and offtake-adoption probability (Panel B), when the independent variables are increasing in their values from 25th percentile to 75th percentile, respectively. Such predicted changes are reported in the lines headed 'Difference: 75% - 25%,' in Panel A and B, respectively. The regression coefficients in Column (3) of Table 5 and 3 are used, respectively. * indicates significance at the 5% level and ** at the 1% level.