European University Institute
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Changing Contract Structures in the International Liquefied Natural Gas Market: A First Empirical Analysis

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Gas PhD Day

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Agenda

1. Introduction

2. Theoretical Framework

    i. Trade-off between the costs of repeated negotiation and the hazard of being bound to an inflexible agreement

    ii. The impact of transaction frequency on governance choice

3. Data and Methodology

4. First Results and Conclusions

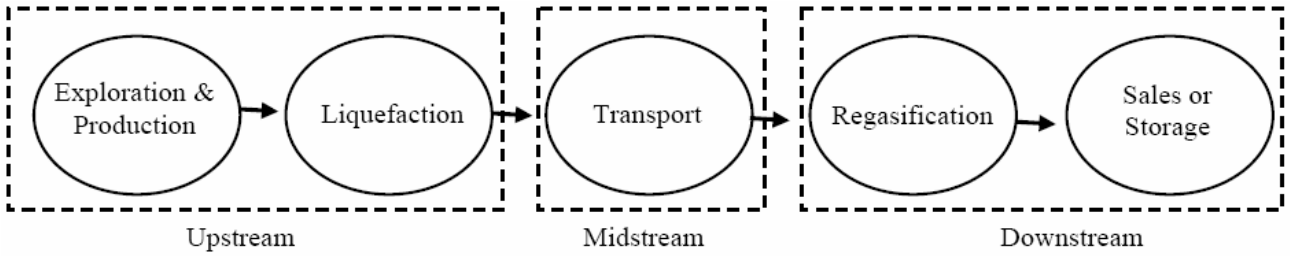
Literature & Backup

Introduction

- Future role of long-term contracts in energy sectors intensively debated
- Changing structure of natural gas markets:
  - Globalization
  - Downstream restructuring
  - Long-term contracts increasingly accompanied by short-term agreements

- Liquefied natural gas (LNG) industry:
  - Very dynamic market
  - Changing contract structures

  - Value chain:



Paper Related to Existing Literature

Selected empirical studies on LTCs in the energy sector [selected results]

- ***Joskow (1985, 1987):*** Longer contracts in the presence of specific investments
- ***Crocker/Masten (1988):*** Confirm trade-off between costs of repeated bargaining in presence of specific investments and hazard of being bound in inflexible agreement
- ***Saussier (1999, 2000):*** CD (resp. completeness) increases with level of quasi rents at stake and decreases with level of uncertainty
- ***Kerkvliet/Shogren (2001):*** CD decreases with rising trading experience
- ***Neuhoff/Hirschhausen (2005):*** LTCs diminish in importance with increasing downstream competition
- ***Hirschhausen/Neumann (2008):*** CD decreases as market structure evolves to more competitive regimes

This paper

- Empirical assessment of LNG supply contracts' optimal contract duration

  → Trade-off between the minimization of transaction costs due to repeated bilateral bargaining and the risk of being bound in an inflexible agreement
- Adds to discussion an analysis of different dimensions of transaction frequency and their impact on governance choice

Theoretical Framework I

Optimal Contract Duration: A Trade-Off

Trade-off between the costs of repeated negotiation and the hazard of being bound to an inflexible agreement:

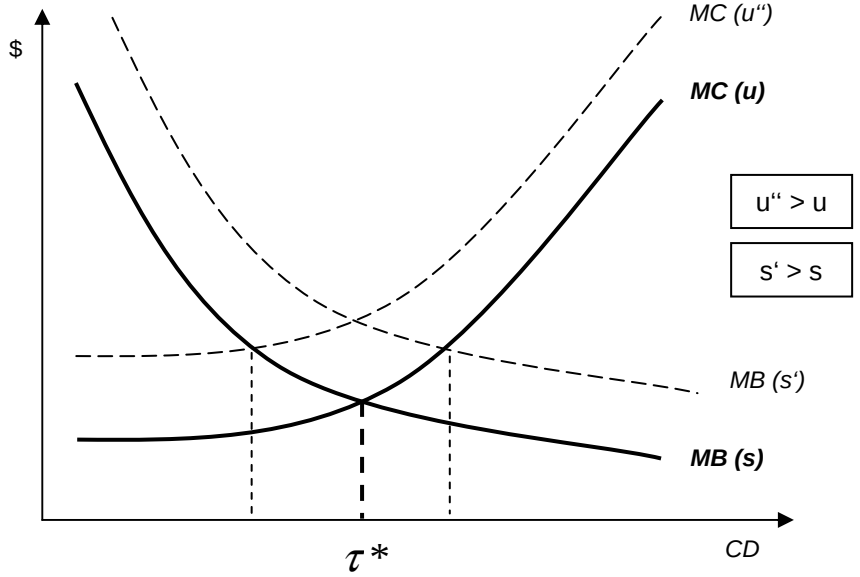
- Optimal CD τ^* equates marginal costs *MC* and marginal benefits *MB* of contracting
- *MC* of being bound in the contract depend mainly on the level of uncertainty *u* and increase with CD
- *MB* of avoiding repeated negotiation depend mainly on the level of specific investments *s* and decrease with CD

$$MB(\tau^*) = MB(\tau, s, \nu) = \alpha_0 + \alpha_1\tau + \alpha_2 s + \nu$$

$$MC(\tau^*) = MC(\tau, u, \omega) = \beta_0 + \beta_1\tau + \beta_2 u + \omega$$

$$\tau^* = \gamma_0 + \gamma_1 s - \gamma_2 u + \varepsilon$$

with $\gamma_0 = \frac{\alpha_0 - \beta_0}{\beta_1 - \alpha_1}, \gamma_1 = \frac{\alpha_2}{\beta_1 - \alpha_1}, \gamma_2 = \frac{\beta_2}{\beta_1 - \alpha_1}, \varepsilon = \frac{\nu - \omega}{\beta_1 - \alpha_1}$



Working Hypothesis

- Proposition 1a: Contract duration increases with the level of investments in idiosyncratic assets in order to avoid repeated bilateral bargaining and mitigate the vulnerability to ex-post holdup.

- Proposition 1b: Higher environmental uncertainty reduces contract duration in order to minimize the risk of being bound by a long-term commitment that no longer reflects market realities.

Theoretical Framework II

Hypotheses on the Impact of Transaction Frequency

High frequency may lead to more “firm-like” governance forms:

- TCE argues that transaction costs increase with transaction frequency *f* due to repeated bargaining and the repeated hazard of opportunistic behavior
- Williamson (1985): High frequency results furthermore in a greater potential for internal specialization and for exploiting scale economies

High frequency may lead to more “market-like” governance forms:

- Decreasing transaction costs due to learning processes, developing routines and reputational effects (e.g. Milgrom/Roberts, 1992; Langlois, 1992; Garvey, 1995)

Theoretical Framework II

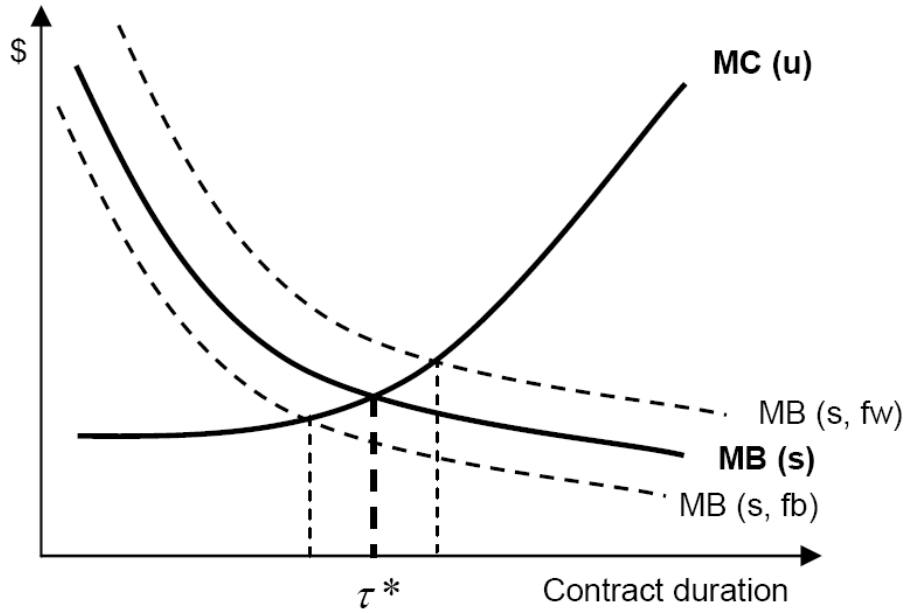
Hypotheses on the Impact of Transaction Frequency

These are <u>complementary</u> perspectives:

→ Within the relationship versus between the trading partners:

•With increasing 'within frequency' (*fw*) the benefits of contracting will rise due to the repeated hazard of opportunistic bargaining

•With increasing 'between frequency' (*fb*) the benefits of contracting will fall due to lower ex-ante as well as ex-post transaction costs



$$\tau^* = \gamma_0 + \gamma_1 s - \gamma_2 u + \gamma_3 fw - \gamma_4 fb + \varepsilon$$

Working Hypothesis

- Proposition 1a: Contract duration increases with the level of investments in idiosyncratic assets in order to avoid repeated bilateral bargaining and mitigate the vulnerability to ex-post holdup.

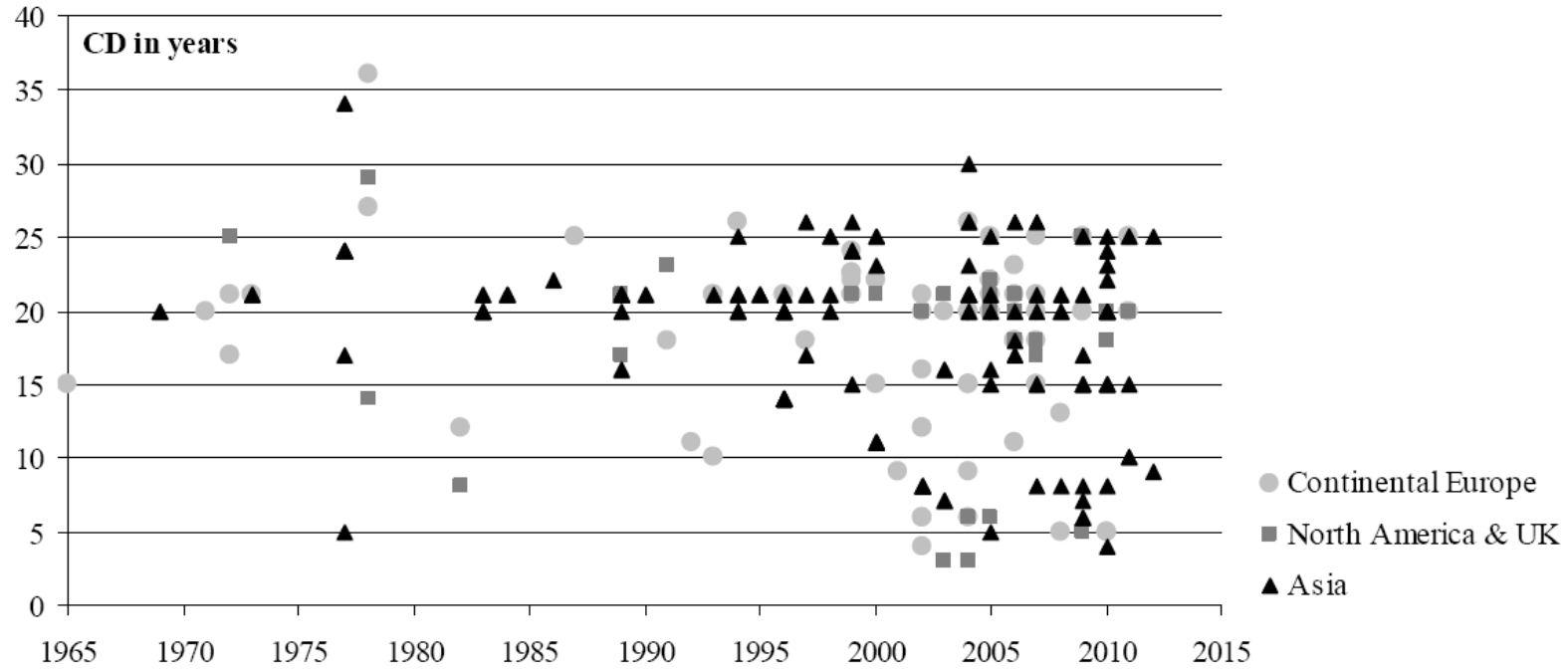
- Proposition 1b: Higher environmental uncertainty reduces contract duration in order to minimize the risk of being bound by a long-term commitment that no longer reflects market realities.

- Proposition 2a: Contract duration increases with the level of frequency of the transactions within the trading relationship in order to avoid the repeated hazard of post-contractual opportunism by the non-investing party.

- Proposition 2b: Contract duration decreases with the frequency of transactions between the same trading partners due to learning and reputational effects.

Dataset

- Global dataset, compiled from various publicly available information
- Unit of analysis: LNG supply contract concluded between upstream seller and downstream buyer (261 observations)
- Transactions are defined as cargo deliveries of LNG



Exogenous Variables

Characteristic	Proxy	Unit	Denotation	Exp. Sign	Mean	Std. Dev.	Min	Max	N
Propositions 1a and 1b									
Relationship specificity	Ratio to which the contract exploits the nominal capacity of the import terminal	%	RCAPSHARE	+	0.214	0.245	0.002	1	261
External uncertainty and need for flexibility	Political instability in the supplying country		UNC	-	0.622	0.387	0	1	261
	Standard deviation of WTI crude oil spot price in the year before contract signature		STDEVOIL	-	3.778	2.733	0.874	12.853	224
	Start-up of deliveries after 1999	Dummy	D2000	-	0.598	0.491	0	1	261
Propositions 2a and 2b									
Within frequency	Annual contracted volume	bcm/a	VOL	+	1.779	1.496	0.03	6.75	261
Between frequency	Cumulative number of contracts negotiated between the two parties	Count	BILEXP1	-	1.678	1.239	1	9	261
	Cumulative number of years of trading relationship between the two parties	Count	BILEXP2	-	5.755	8.151	1	31	261
	Contract representing a contract renewal	Dummy	RENEW	-	0.134	0.341	0	1	261
Control variables									
Dependence on LNG imports	LNG share in total natural gas imports	%	LNGSHARE	+	0.718	0.376	0.03	1	261
Downstream competition	Contract dedicated to competitive downstream market (i.e., US from 1992; UK from 1997)	Dummy	COMP	-	0.126	0.333	0	1	261
Instruments									
Self-sufficiency import country	Domestic production / total consumption	%	SELFSUFF		0.202	0.367	0	1	261
Import terminal capacity	Nominal capacity of regasification terminal	bcm/a	CAP		18.076	18.164	0.21	75	261
Number of import terminals	Number of import terminals in import country	Count	TERMINALS		10.126	9.635	1	29	261
Atlantic Basin value chain	Contract destined to Atlantic Basin customers	Year	ATLANTIC		0.411	0.493	0	1	261

Methodology

- Contract duration as dependent variable:

$$CD_i = \phi_0 + \phi_1 RCAPSHARE_i + \phi_2 UNC_i + \phi_3 STDEVOIL_i + \phi_4 D2000 + \phi_5 VOL_i + \phi_6 BETWFREQ_i + \phi_7 LNGSHARE_i + \phi_8 COMP_i + \varsigma_i$$

- However, contracted volume and CD are determined simultaneously, therefore we estimate the model applying two-stage least squares (2SLS)

$$VOL_i = \theta_0 + \theta_1 RCAPSHARE_i + \theta_2 UNC_i + \theta_3 STDEVOIL_i + \theta_4 D2000 + \theta_5 BETWFREQ_i + \theta_6 LNGSHARE_i + \theta_7 COMP_i + \theta_8 SELFSUFF_i + \theta_9 CAP_i + \theta_{10} TERMINALS_i + \xi_i$$

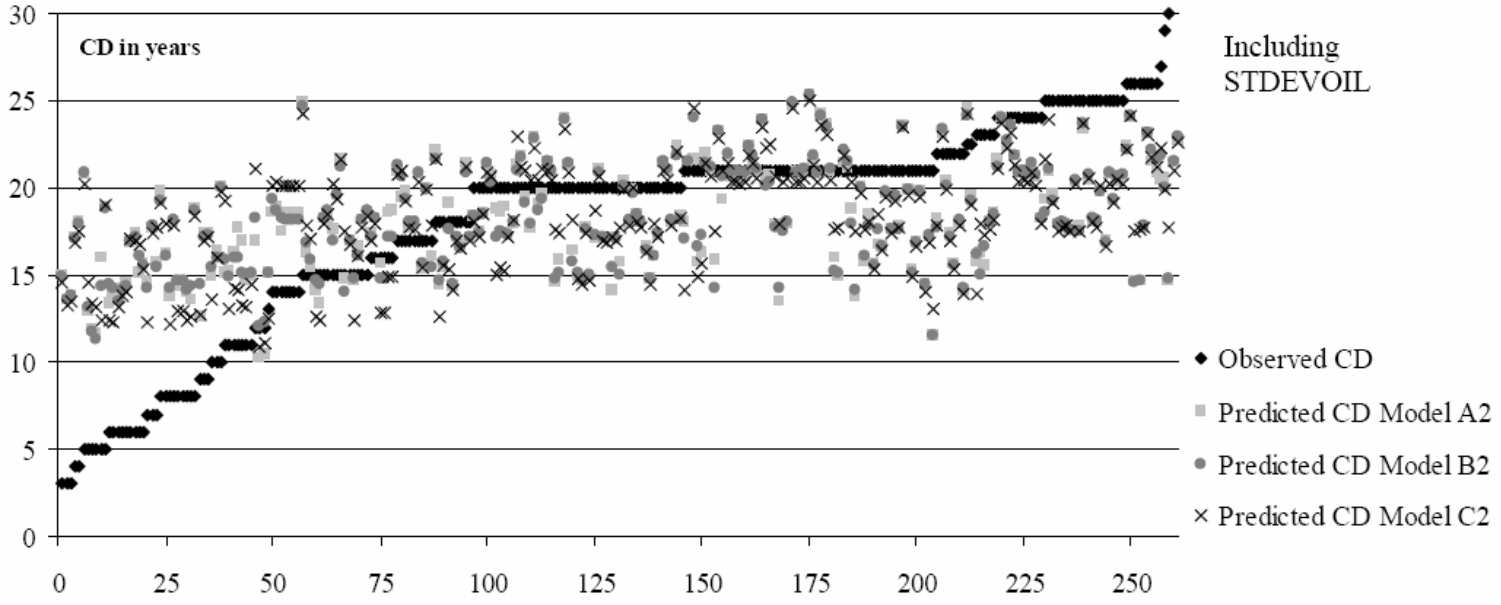
Estimation Results

Specification	OLS (VOL as exogenous variable)			2SLS (VOL as endogenous variable)			System GMM (VOL as endogenous variable)		
	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
CONSTANT	18.98 ***	18.67 ***	18.45 ***	19.59 ***	19.17 ***	19.05 ***	19.69 ***	19.29 ***	18.99 ***
	(1.60)	(1.58)	(1.52)	(1.68)	(1.66)	(1.60)	(1.53)	(1.51)	(1.54)
RCAPSHARE	3.52 *	3.24 *	3.29 *	5.69 **	5.18 **	5.64 **	5.64 **	5.02 **	5.50 **
	(1.85)	(1.85)	(1.77)	(2.51)	(2.54)	(2.44)	(2.37)	(2.38)	(2.30)
UNC	-0.36	-0.37	-0.23	-0.29	-0.32	-0.18	-0.41	-0.50	-0.35
	(0.97)	(0.97)	(0.94)	(0.98)	(0.98)	(0.95)	(1.00)	(0.99)	(0.93)
STDEVOIL	-0.24 *	-0.25 *	-0.23 *	-0.24 *	-0.25 *	-0.24 *	-0.22	-0.23	-0.22
	(0.14)	(0.14)	(0.13)	(0.14)	(0.14)	(0.14)	(0.16)	(0.16)	(0.15)
D2000	-2.67 ***	-2.81 ***	-2.70 ***	-2.47 ***	-2.63 ***	-2.49 ***	-2.45 ***	-2.63 ***	-2.42 ***
	(0.86)	(0.86)	(0.83)	(0.89)	(0.88)	(0.86)	(0.75)	(0.74)	(0.74)
VOL	0.72 **	0.80 ***	0.92 ***	0.05	0.22	0.22	0.08	0.28	0.28
	(0.29)	(0.29)	(0.28)	(0.59)	(0.59)	(0.57)	(0.57)	(0.56)	(0.56)
ln(BILEXP1)	-2.77 ***			-2.77 ***			-2.83 ***		
	(0.70)			(0.71)			(0.68)		
ln(BILEXP2)		-1.23 ***			-1.19 ***			-1.23 ***	
		(0.29)			(0.30)			(0.29)	
RENEW			-5.63 ***			-5.33 ***			-5.53 ***
			(0.97)			(1.01)			(0.85)
LNGSHARE	1.76	2.41 *	1.83	1.68	2.32 *	1.73	1.57	2.19 *	1.70
	(1.27)	(1.28)	(1.23)	(1.29)	(1.30)	(1.25)	(1.15)	(1.14)	(1.18)
COMP	-2.70 **	-2.35 *	-2.85 **	-2.93 **	-2.54 *	-3.05 **	-3.14 **	-2.75 **	-3.20 **
	(1.30)	(1.29)	(1.25)	(1.33)	(1.31)	(1.28)	(1.37)	(1.36)	(1.41)
Adjusted R^2	0.234	0.239	0.288	0.214	0.225	0.267			
Centered R^2							0.243	0.255	0.296
N	224	224	224	224	224	224	224	224	224

- The more important the respective contract to the import terminal the longer CD
- CD decreases with the risk of being bound by an agreement that no longer reflects the actual market situation with respect to prices
- CD has decreased over time
- No statistical significant impact of VOL
- CD decreases with bilateral trading experience

Predicted Values

- Error terms do not follow a random scatter but rather depend on the observed contract duration
  - → Non-observable factors
  - → Contract provisions play an important role in real-world contracts
  - → Players often contract for a portfolio of supply agreements including large-scale LTCs and more flexible shorter-term contracts



Conclusions

- This paper provides an empirical study investigating the optimal contract duration of LNG supply contracts
  - Presence of high dedicated asset specificity results in longer contracts
  - Increasing need for flexibility in today's "2nd generation" LNG industry reduces contract duration
  - "Within" versus "between" perspective concerning transaction frequency

- Limitations (i.e. challenges for future research):
  - Ambiguous and non-significant results for uncertainty variables → external uncertainty should be split into different components
  - Contractual provisions interact, but: very limited data availability → simultaneous choice of contract provisions should be investigated
  - Test of reduced form equations only

Thank you very much for your attention

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Backup

Estimation Results 1st Stage incl. STDEVOIL

Specification	2SLS			System GMM		
	Model A	Model B	Model C	Model A	Model B	Model C
CONSTANT	0.38 (0.33)	0.38 (0.33)	0.38 (0.32)	0.38 (0.31)	0.38 (0.31)	0.38 (0.30)
RCAPSHARE	4.04 *** (0.39)	4.05 *** (0.39)	4.04 *** (0.39)	4.04 *** (0.41)	4.05 *** (0.41)	4.04 *** (0.41)
UNC	0.05 (0.20)	0.04 (0.20)	0.02 (0.20)	0.05 (0.17)	0.04 (0.17)	0.02 (0.17)
STDEVOIL	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)
D2000	0.24 (0.18)	0.25 (0.18)	0.24 (0.18)	0.24 (0.19)	0.25 (0.19)	0.24 (0.18)
ln(BILEXP1)	0.11 (0.15)			0.11 (0.13)		
ln(BILEXP2)		0.08 (0.06)			0.08 (0.06)	
RENEW			0.46 ** (0.21)			0.46 (0.22)
LNGSHARE	-0.09 (0.32)	-0.10 (0.32)	-0.04 (0.32)	-0.09 (0.34)	-0.10 (0.34)	-0.04 (0.34)
COMP	-0.29 (0.32)	-0.29 (0.33)	-0.23 (0.33)	-0.29 (0.29)	-0.29 (0.29)	-0.23 (0.30)
SELFSUFF	0.23 (0.33)	0.23 (0.33)	0.21 (0.33)	0.23 (0.31)	0.23 (0.31)	0.21 (0.32)
CAP	0.03 *** (0.004)	0.03 *** (0.004)	0.03 *** (0.005)	0.03 *** (0.01)	0.03 *** (0.01)	0.03 *** (0.01)
TERMINALS	-0.02 ** (0.01)	-0.03 ** (0.01)	-0.03 ** (0.01)	-0.02 ** (0.01)	-0.03 ** (0.01)	-0.03 ** (0.01)
Adjusted R^2	0.466	0.469	0.477			
Centered R^2				0.490	0.493	0.500
N	224	224	224	224	224	224

Backup

Estimation Results 2nd Stage excl. STDEVOIL

Specification	OLS (VOL as exogenous variable)			2SLS (VOL as endogenous variable)			System GMM (VOL as endogenous variable)		
	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
CONSTANT	17.73 *** (1.45)	17.39 *** (1.44)	17.16 *** (1.39)	18.49 *** (1.54)	18.05 *** (1.53)	17.89 *** (1.49)	18.44 *** (1.49)	17.97 *** (1.46)	17.66 *** (1.49)
RCAPSHARE	3.53 ** (1.73)	3.28 * (1.74)	3.27 * (1.68)	6.18 ** (2.42)	5.69 ** (2.44)	5.97 ** (2.39)	6.12 *** (2.28)	5.52 ** (2.29)	5.87 *** (2.25)
UNC	0.28 (0.90)	0.18 (0.90)	0.21 (0.88)	0.31 (0.92)	0.20 (0.91)	0.23 (0.89)	0.26 (0.92)	0.10 (0.91)	0.16 (0.87)
D2000	-3.02 *** (0.71)	-3.06 *** (0.71)	-2.84 *** (0.69)	-2.87 *** (0.72)	-2.94 *** (0.72)	-2.72 *** (0.71)	-2.87 *** (0.65)	-2.94 *** (0.65)	-2.66 *** (0.65)
VOL	0.67 ** (0.27)	0.72 *** (0.27)	0.82 *** (0.26)	-0.10 (0.56)	0.03 (0.56)	0.04 (0.54)	-0.07 (0.53)	0.11 (0.53)	0.12 (0.53)
ln(BILEXP1)	-2.92 *** (0.66)			-2.90 *** (0.67)			-2.92 *** (0.65)		
ln(BILEXP2)		-1.24 *** (0.28)			-1.20 *** (0.28)			-1.22 *** (0.28)	
RENEW			-5.61 *** (0.98)			-5.32 *** (1.00)			-5.43 *** (0.89)
LNGSHARE	2.11 * (1.16)	2.64 ** (1.16)	2.17 * (1.13)	2.07 * (1.18)	2.59 ** (1.18)	2.13 * (1.15)	2.11 * (1.13)	2.67 ** (1.12)	2.30 ** (1.15)
COMP	-2.36 * (1.27)	-2.03 (1.26)	-2.45 ** (1.23)	-2.61 ** (1.30)	-2.24 * (1.28)	-2.65 ** (1.26)	-2.57 * (1.40)	-2.14 (1.39)	-2.57 * (1.42)
Adjusted R^2	0.236	0.236	0.272	0.211	0.216	0.247			
Centered R^2							0.234	0.241	0.271
N	261	261	261	261	261	261	261	261	261

Backup

Estimation Results 1st Stage excl. STDEVOIL

Specification	2SLS			System GMM		
	Model A	Model B	Model C	Model A	Model B	Model C
CONSTANT	0.44 (0.31)	0.45 (0.31)	0.45 (0.31)	0.44 (0.28)	0.45 (0.28)	0.45 (0.28)
RCAPSHARE	4.29 *** (0.36)	4.29 *** (0.36)	4.29 *** (0.35)	4.29 *** (0.36)	4.29 *** (0.36)	4.29 *** (0.36)
UNC	-0.03 (0.19)	-0.03 (0.19)	-0.04 (0.19)	-0.03 (0.17)	-0.03 (0.17)	-0.04 (0.17)
D2000	0.11 (0.15)	0.12 (0.15)	0.10 (0.15)	0.11 (0.16)	0.12 (0.16)	0.10 (0.16)
ln(BILEXP1)	0.12 (0.14)			0.12 (0.13)		
ln(BILEXP2)		0.07 (0.06)			0.07 (0.06)	
RENEW			0.43 ** (0.21)			0.43 ** (0.22)
LNGSHARE	0.02 (0.29)	0.01 (0.06)	0.05 (0.28)	0.02 (0.29)	0.01 (0.29)	0.05 (0.29)
COMP	-0.11 (0.29)	-0.11 (0.30)	-0.06 (0.30)	-0.11 (0.25)	-0.11 (0.25)	-0.06 (0.25)
SELFSUFF	-0.03 (0.29)	-0.04 (0.29)	-0.06 (0.29)	-0.03 (0.25)	-0.04 (0.25)	-0.06 (0.25)
CAP	0.04 *** (0.00)	0.03 *** (0.00)	0.03 *** (0.00)	0.04 *** (0.01)	0.03 *** (0.01)	0.03 *** (0.01)
TERMINALS	-0.03 *** (0.01)	-0.03 *** (0.01)	-0.03 *** (0.01)	-0.03 *** (0.01)	-0.03 *** (0.01)	-0.03 *** (0.01)
Adjusted R^2	0.455	0.456	0.462			
Centered R^2				0.473	0.475	0.481
N	261	261	261	261	261	261