The oil price exchange rate nexus in a small oil exporting economy

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- The empirical literature has established that oil prices are volatile (fluctuate). Volatility is a measure of risk. It can be measured by standard deviation. Standard deviation is a measure of how the actual value of a time series may very from its average value.
- The limitation of standard deviation is that it assumes the fluctuating movements will constant over time. In the financial econometrics literature, it has been well established that the volatility of many commodities is not constant over time.
- One of the tools that have been developed over the years to model volatility is the GARCH model.

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- The GARCH model assumes that the conditional variance of the residual of a univariate model can be modeled as a function of past values of its squared residual and past values of the variance
- $\sigma_t^2 = \omega + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2 + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-1}^2$
- GARCH models are performed in 2 steps, first a univariate model may be run (note, a multivariate model could also be specified), then residuals are obtained and squared. The squared residuals are then used to model the conditional variance of the residuals.

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- Over time, the GARCH model has been extended to the EGARCH model. The EGARCH model is an asymmetric model. It contains 2 asymmetric terms: size of shock effect term, and leverage (sign) of shock effect. This is because shocks affect the volatility of series differently.
- The EGARCH model
- $\log(\sigma^2) = \omega + \sum_{i=1}^{q} \alpha_i \left|\frac{u_{t-i}}{\sigma_{t-i}}\right| + \sum_{k=1}^{r} \lambda_k \frac{u_{t-k}}{\sigma_{t-k}} + \sum_{j=1}^{p} \beta_j \log(\sigma_{t-j}^2)$
- ω is a constant, α is the size of shock term, λ is the sign of shock term, β is the persistence of shocks (GARCH term).

Why is this relevant?

- Because oil prices can affect exchange rates.
- An increase in oil prices can lead to appreciation of the exchange rate in oil exporting countries (due to the increase in revenue). And a depreciation in oil importing countries (due to oil demand being inelastic, and a lot of expenditure being spent on oil).
- A decrease in oil prices can lead to a depreciation in the exchange rate in oil exporting countries (due to the decline in government petroleum revenue). And appreciation of exchange rate in oil importing countries (due to oil becoming cheap, more foreign currency is available for other things). See Golub (1983), Corden (1984), Bergvall (2004), Adeniyi et al (2012).

Why is this relevant?

- In 2010 annual oil prices were US$79 per bbl. In 2013 it was US$97 per bbl. By 24th October 2014 it was US $82 per bbl. Oil prices has thus declined.
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1994	2001	2005	2006	2007	2008	2009	2010	2011	2012	2013	24-Oct-2014
17.2	25.98	56.64	66.05	72.34	99.67	61.95	79.48	94.88	94.05	97.98	81

- The exchange rate is important because it can affect interest rates for internationally financed projects, it affects the reserves of foreign currency, it affects the domestic money supply, it can indirectly affect aggregate demand and supply through the money supply.
- Changes in the exchange rate as a result of oil price change can also show Dutch Disease type effects upon the economy.

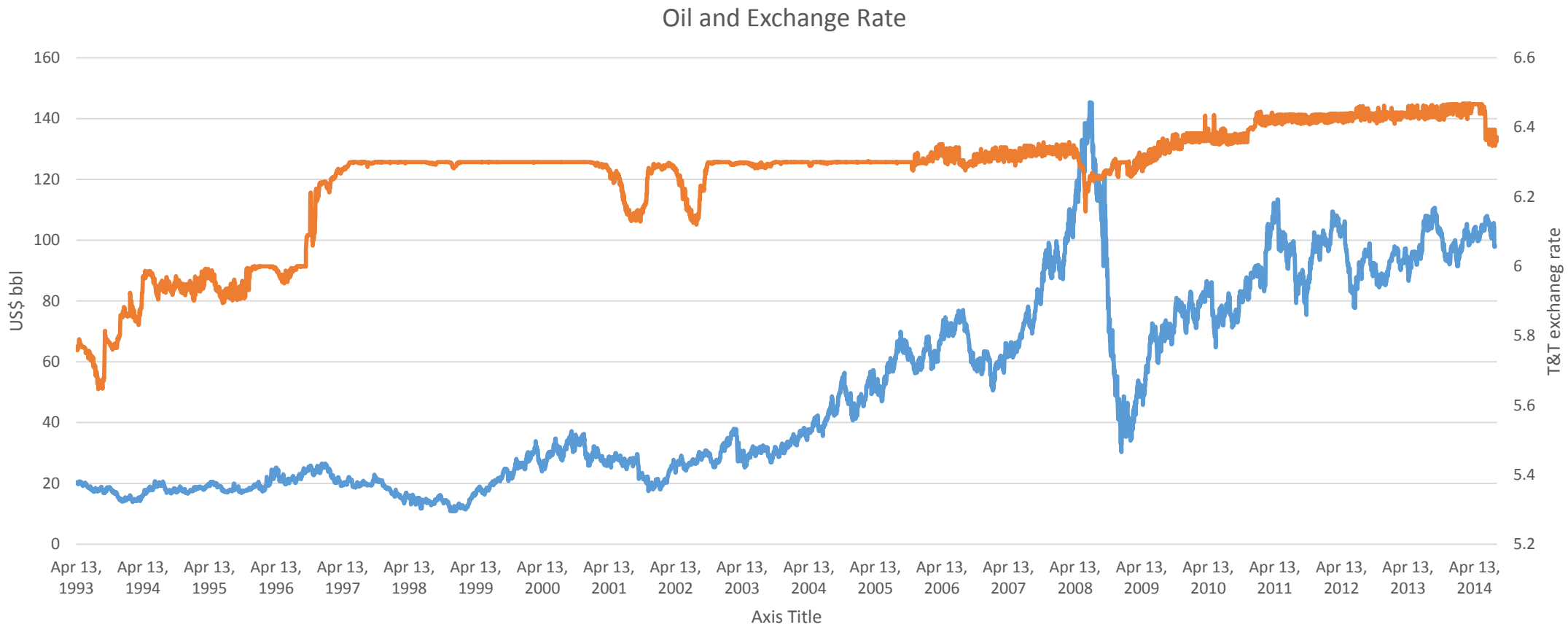
Why is this relevant?

- There are different types of exchange rate risk:
- Transactional risk: that is short term depreciation in a currency can increase import costs
- Economic risk: unexpected changes in the currency can cause a reduction in net cash flows. E.g. an appreciation can reduce export sales of non-booming tradable goods.
- Translation risk is the extent to which a firm's financial reporting is affected by exchange rate movements.
- When the exchange rate risk is modeled, the type of risk that will be observed all depends on the perspective of the firm (economic agent).
- Risk must be estimated.
- Thus the objective of this study is to estimate T&T's exchange risk (volatility).

Methodology and data

- Daily Data on oil prices were obtained from EIA from 13/04/1983 to 04/08/2014. 7784 observations. Daily data on the nominal exchange rates was obtained from CB database. Nominal data was used because an appropriate deflator was not found.
- Test were conducted for stationarity (PP, ADF, KPSS), test were conducted for normality (JB).
- All variables were non-stationary and I(1). They were converted into continuously compounded returns to become stationary.
- Rt= log(Pt/Pt-1)
- A test was conducted for ARCH effects. Arch effects were present.
- The GARCH(1,1) and EGARCH(1,1) models were used.
- In the mean equation, exchange rates was made a function of oil prices. $\boldsymbol{log(exch) = \alpha + \beta log(wti) + \varepsilon_t}$

Results. Fig 1 plot of oil price and exchange rate



Normality Results

Table 1 Normality results

	WTI	GLWTI	GLEXCH	EXCH
Mean	49.874	0.000	0.000	6.257
Median	34.720	0.000	0.000	6.300
Maximum	145.310	0.164	0.016	6.469
Minimum	10.820	-0.171	-0.012	5.646
Std. Dev.	32.325	**0.020**	**0.001**	0.169
Skewness	0.601	-0.207	-0.439	-1.481
Kurtosis	2.009	11.852	17.364	4.530
Jarque-Bera	786.561	25,467.26	67,156.69	3,603.696
Probability	0.000	0.000	0.000	0.000
Sum	388,171.4	1.578	0.097	48701.62
Sum Sq. Dev.	8,131,522.	3.005	0.012	223.514
Observations	7,783	7,783	7,783	7,783

Source: Computed

Results

Table 2: GARCH results

Parameter model	GARCH (1,1)	EGARCH (1,1)
C	6.2997 **(0.000)**	6.2705 **(0.000)**
WTI	2.21E-06 **(0.0000)**	0.0018 **(0.0000)**
Variance Equation		
ω	1.42E-09 (0.000)	-0.3117 (0.000)
α_1	0.7637 **(0.000)**	0.2080 **(0.000)**
β_j	0.4075 **(0.000)**	0.9863 **(0.000)**
γ		**-0.0151** (0.000)

Source: Computed

In both models, all variables are significant. Significance of oil prices in the mean equation of the exchange rate implies that oil prices have an explanatory relationship with the exch rate. It is a positive relationship. However the small coefficient implies a small causal relationship.

The α in the EGARCH is the size of shock effect. Its significance implies large shocks increase volatility of the exchange rate more than small shocks.

The α in the GARCH is the ARCH term. It means 76% of the squared residual in this period can be used to explain the next period volatility.

The β coefficient is the GARCH term. In the EARCH it means that 98% of this period volatility will affect the next period volatility. This implies a persistence of shocks.

The leverage effect term is negative. This means positive shocks increase exch rate volatility more than negative shocks.

Diagnostic test

Table 3: Predictive accuracy results

Statistics	Value
RMAE	0.2549
MAE	0.2232
Theil	0.0708

Source: Computed

To access the predictive accuracy of the EGARCH model before the out of sample forecast is generated, the Root Mean Squared Error (RMSE), Mean Absolute Error (MAE) and the Theil Inequality Coefficient is computed for the within sample forecast.

The RMSE, MAE and the Theil U-statistic all have very small values. This suggests high predictive accuracy of the EGARCH model. Given such results an out of sample forecast is generated.

N-step ahead forecast

This was done with Matlab

Table 4: 100-step ahead forecast

N-step ahead	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
conditional variance	0.0022	0.002	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0013	0.0012	0.0011	0.0011	0.001	0.001	0.0009
N-step ahead	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
conditional variance	0.0009	0.0009	0.0008	0.0008	0.0008	0.0007	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006
N-step ahead	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
conditional variance	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
N-step ahead	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
conditional variance	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
N-step ahead	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
conditional variance	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
N-step ahead	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
conditional variance	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
N-step ahead	91	92	93	94	95	96	97	98	99	100					
conditional variance	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004					

Source: Computed

Conclusion

- An increase in oil price causes an appreciation of the T&T dollar. The effect is small and significant.
- There is a tendency for a persistence of shocks. Past shocks will affect future volatility.
- There are positive leverage effects. Positive shocks have the tendency to increase T&T's exchange rate volatility more than negative shocks.
- Also, each of the n-step ahead out of sample forecast of the conditional variance of exchange rates was small. This result is not surprising as the Central Bank of T&T operates a managed float of the exchange rate. Thus such management would marginalize the impact of oil prices upon the exchange rate.

Conclusion

- Note: This paper modelled volatility. Volatility is a measure of risk. It is a measure of the tendency of prices to increase or decrease. Risk is quantified so that it may be used as a tool in risk management.
- Further research:
- How the exchange rate risk may affect other macro economic variables, such as inflation, foreign reserves, interest rates, money supply, etc.
- Note: once the risk is quantified, firms engaging in international trade may counter such risk with derivative hedges (forwards, futures, options, swaps).
- A forward contract will lock in an exchange rate today at which the currency transaction will occur at the future date. E.g. If a firm is an importer and they expect TT to depreciate against the US, they can go long and buy US on a forward contract.
- Or if a firm is an exporter and they expect TT to appreciate against the US, they can short US on a forward contract. Or they may take an option where they may exercise a strike price where the TT currency has a lower value to the US than the current exchange rate.

Conclusion

- The end