A DYNAMIC SPATIO-TEMPORAL QUANTILE REGRESSION ANALYSIS OF THE RETAIL OIL PRICES IN EU COUNTRIES

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Overview

Retail gasoline prices are considerably fluctuating over time and different across countries within the Europe, due to many different factors, such as environmental policy, cost of crude oil, and macroeconomics. Numerous studies have examined the impact of crude oil price on retail gasoline prices, particularly focusing on the asymmetries in price transmission (c.f. Blair et al., 2017; Wlazlowski et al., 2009). The large majority of these literature, however, has neglected the possible cross-market dependency in retail gasoline markets (Wlazlowski et al., 2009). Note that the price disequilibria of retail gasoline in neighbour countries can create significantly cross-national spatial price spillovers (Banfi et al., 2005). Negligence of the spaital dependency in retail gasoline markets may cause the biased result in estimating the effect of the crude oil price on the retail gasoline prices. In addtion, due to the increasing knowledge of reality and harmfulness of carbon emissions and global warming, climate change has received considerable attention in recent years and has been gradually placed on the top of policy-making for all the governments. Therefore, carbon cap-and-trade systems have been designed to reduce the carbon emission. As one of the biggest sources of world greenhouse gases, the consumption of gasoline will also be declined by this system. Correspondingly, the interaction betweeen the carbon price and the retail gasoline prices has been increasingly closer. Moreover, the stock market index is a predictor of economic variables and reflects the macroeconomic conditions, which may also impact the regional retail gasoline prices.To study the above problems, we therefore propose applying a novel spatial quantile regression to estimate the effects of the oil, stock and carbon price shocks on the regional retail gasoline price returns and uncover the price shock propagation and cross-market dependency of retail gasoline markets. By this model, the dynamic effects of the crude oil price, stock market index and carbon price on the retail gasoline price returns can be well investigated. The spatial neighouring effects in this model can provide a broader perspective for decision-making processes and deepen our understanding of the effect of carbon cap-and-trade systems. Moreover, the recognised tail behaviour can help investors hedge against energy price risks and maximize their profits.

Method

In this study, we use a spatial panel quantile regression model to examine the determinants of diesel prices throughout the conditional distribution, especially the spatial neighbouring effects of diesel prices. To take into account the spatial neighbouring effects and unobserved individual heterogeneity, we employ a spatial panel quantile model with fixed effects.

$$Q_{\Delta InY_{i,t}}(\tau \mid \Delta InY_{\mathrm{i},t-1}, \Delta InX_t, \Delta InC_t, \Delta InS_t) = \lambda_\tau{}^{+}(Y^{sl}_{\mathrm{i},t-1})^{+} + \lambda_\tau{}^{-}(Y^{sl}_{\mathrm{i},t-1})^{-} + \alpha_0(\tau)\Delta InX_t + \alpha_1(\tau)\Delta InC_t + \alpha_2(\tau)\Delta InS_t + \beta_i,$$

$$Y^{sl}_{\mathrm{i},t-1} = \sum_{j=1}^{N} W_{ij}\Delta InY_{j,t-1},\ i = 1,\dots,N, t = 1,\dots,T$$

The main problem on estimating the model is that traditional linear approaches are unfeasible in the quantile regression model. Moreover, to additionally control for time-invariant unobserved heterogeneity, we apply a two-step technique to estimate the following model:

$$\arg\min_{(\alpha,\lambda)} \sum_{i=1}^{N}\sum_{t=1}^{T} \rho_{\tau_k}\Big\{\Delta InY_{i,t} - \lambda_{\tau_k}{}^{+}(Y^{sl}_{\mathrm{i},t-1})^{+} - \lambda_{\tau_k}{}^{-}(Y^{sl}_{\mathrm{i},t-1})^{-} - \alpha_0(\tau_k)\Delta InX_t - \alpha_1(\tau_k)\Delta InC_t$$
$$-\alpha_2(\tau_k)\Delta InS_t - \beta_i\Big\},\quad i = 1,\dots,N, t = 1,\dots,T$$

where $\rho_\tau(y) = y(\tau - I(y < 0))$ is the check function, $I(A)$ is indicator function of set A. $\Delta\mathrm{In}Y_{i,t}$denotes the the return of diesel price in country i at time t. $\Delta\mathrm{In}X_t$, $\Delta\mathrm{In}C_t$ and $\Delta\mathrm{In}S_t$ denote the crude oil price return and the carbon future price return and stock market index return, respectively. $(\dots)^{+}$ is the slope dummy (Heaviside indicator) set to unity when the argument is positive, zero otherwise. The parameter λ accounts for the scalar spatial autoregressive parameter. The term $Y^{sl}_{i,t-1}$ denotes lag spatial neighboring effects of the dependent variable, where W_{ij} is a spatial weight for

$1 \le i, j \le N$ of a pre-specified nonnegative spatial weighting matrix $W = [W_{ij}]_{i.j=1}^{N}$. This matrix reflects the geographic relationship among different countries. There are different kinds of weighting matrix using in the literature, among which distance function matrix and binary contiguity matrix are the most commonly used specifications. Due to the existance of "fuel travels" Banfi et al. (2005); Wlazlowski et al. (2009), we use the spatial binary contiguity weight matirx in this research, and consider the power distance weight matrix in robustness analysis.

Results

The model is also estimated by fixed effects OLS panel model for comparison (Column 1 in Table1). Other columns show the results of the spatial panel quantile regression estimation. The results are reported for the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th and 90th percentiles of the conditional diesel price returns distribution. The estimation results indicate that the impacts of various factors on diesel price returns are clearly heterogeneous.

Table 1 Spatial panel quantile regression results

Variables	OLS	Quantiles								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
intercept	-0.0015***	-0.0127***	-0.0069***	-0.0037***	-0.0017***	-0.0004*	0.0010***	0.0030***	0.0063***	0.0125***
	(0.0003)	(0.0013)	(0.0008)	(0.0006)	(0.0003)	(0.0002)	(0.0002)	(0.0005)	(0.0008)	(0.0011)
λ^+	0.3495***	0.2342***	0.2081***	0.2035***	0.2186***	0.2695***	0.3643***	0.4617***	0.5361***	0.5982***
	(0.0235)	(0.0423)	(0.0301)	(0.0259)	(0.0361)	(0.0412)	(0.0490)	(0.0731)	(0.0896)	(0.1072)
λ^-	0.3193***	0.6986***	0.5500***	0.4514***	0.3816***	0.2499***	0.1833***	0.1508***	0.1355***	0.1125**
	(0.0219)	(0.0861)	(0.0703)	(0.0580)	(0.0439)	(0.0360)	(0.0418)	(0.0325)	(0.0315)	(0.0485)
α_0	0.0478***	0.0379***	0.0505***	0.0430***	0.0361***	0.0363***	0.0383***	0.0434***	0.0538***	0.0701***
	(0.0035)	(0.0102)	(0.0106)	(0.0108)	(0.0081)	(0.0085)	(0.0089)	(0.0111)	(0.0103)	(0.0112)
α_1	0.0061***	0.0123***	0.0128***	0.0075***	0.0044***	0.0034**	0.0036**	0.0018	-0.0003	-0.0079
	(0.0020)	(0.0036)	(0.0036)	(0.0025)	(0.0017)	(0.0016)	(0.0016)	(0.0022)	(0.0034)	(0.0036)
α_2	-0.0003	0.0171	0.0217	0.0110	0.0188*	0.0148**	0.0151***	0.0202***	0.0329***	0.0485***
	(0.0055)	(0.0223)	(0.0136)	(0.0124)	(0.0086)	(0.0067)	(0.0058)	(0.0084)	(0.0110)	(0.0134)

Note: Numbers in the parentheses represent standard deviation. This table shows the results of the spatial panel quantile regression model with regional diesel prices as dependent variables, and spatial neighbouring effects, Brent oil price, Carbon future price and Stock market index as independent variables.

*significant at 10% level
**significant at 5% level
***significant at 1% level

Conclusions

The empirical findings clearly indicate that the coefficients across the conditional distribution of the gasoline price returns are significantly heterogeneous, which is obscured using conditional mean regression. In particular, the effect of carbon price return on retail gasoline price returns has a decreasing trend and is significantly positive at low quantiles, but insignificant at high quantiles, which supports effectiveness of the carbon cap-and-trade systems. Moreover, the asymmetric price transmission from crude oil to retail gasoline, stock market shock and spatial neighbouring effect are also evidently proved by this model. The results of this study have wide-ranging implications. Taking the possible cross-country effects into account is vitally important when discussing effectiveness of the policy within the EU. The analyses without considering the spatial neighbouring effects in the EU borders might be biased and not necessarily successful. In-depth understanding of the effects of oil price, carbon price and stock market on retail gasoline prices could help industry to reduce the negative impacts from expected or unexpected price changes in the oil, carbon and stock markets, and then help them to enact appropriate investment decisions.

References

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