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Asymmetric dependence structure between emissions allowances and wholesale diesel/gasoline prices in emerging China's emissions trading scheme pilots

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ABSTRACT

This paper investigates the co-movement and dependence structure between China's emissions allowances (CEA) and wholesale diesel (gasoline) markets using a GARCH-copula with a generalized error distribution (GED). Chinese emissions allowances prices exhibit significantly extreme co-movement with wholesale diesel and gasoline prices using GARCH and TARCH models based on a GED. The empirical results confirm that different markets except Hubei's emissions-gasoline market exhibit a greater divergence of asymmetric tail dependence structure between emissions allowances and wholesale diesel (gasoline) markets. Beijing's emissions allowances prices show an asymmetric mixture of right-tail and left-tail dependence structures with wholesale diesel and gasoline prices in northern China, implying stronger right-tail dependence. Shanghai and Guangdong's emissions allowances prices indicate a significant right-tail dependence structure with wholesale diesel and gasoline prices in East and South China. Hubei's emissions allowances prices exhibit an asymmetric mixture of right-tail and left-tail dependence structures with wholesale diesel prices, implying stronger left-tail dependence and a significantly symmetric dependence structure with wholesale gasoline prices in central China.

1. Introduction

Establishing emissions trading scheme (ETS) pilots in China has become an important strategic programme to achieve ambitious greenhouse emissions mitigation. China gradually launched eight required regional ETS pilots in Shenzhen, Beijing, Shanghai, Guangdong, Tianjin, Hubei, Chongqing and Fujian and, since May 2013. The cumulative trading volume in China's ETS pilots is 130.0639 million tons and their cumulative trading value is 2776.9922 million Yuan from January 2, 2014 to July 31, 2017. China has become one of the largest emissions trading markets in the world. Future hot topics are highlighted, including emissions allowances allocation, carbon pricing, alternative energy and environmental policy, unified carbon market construction, and macroeconomic impact assessments [1].

Many scholars have investigated price dynamics and asymmetric effects in diesel and gasoline markets home and abroad. Unleaded and leaded gasoline markets exhibit the compatibility of monopolistic competition and price discrimination from a monopolistic competition model [2]. The crude oil price and exchange rate fluctuations are the main driving forces in changes in diesel and gasoline prices [3,4]. Zone pricing in wholesale gasoline markets had a competitive impact on consumers, retail stations and refiners in a controlled laboratory experiment [5]. Gasoline price uncertainty reduces the level and the price responsiveness of demand and captures the investment and behavioural decisions that determine gasoline usage [6]. Time dependence, asymmetry and the role of cost volatility are consistent with a combination of fairness considerations [7]. Crude oil price shocks can asymmetrically pass through into retail gasoline prices and the responses vary across regions and income groups [8–11]. The crude oil price and exchange rate have long-term asymmetric impacts on retail gasoline price adjustment in the gasoline markets of Germany, France, Italy and Spain [12,13].

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Other factors aside from changes in the crude oil price and exchange rates may affect the asymmetric pricing of diesel and gasoline. Oil consumption intensity, GDP (Gross Domestic Product) and the ratio of oil import expenditure to GDP are the three key indicators for China's oil price crisis response capability [14]. The oil inventory and crude price shock have significantly asymmetric effects on wholesale gasoline prices in U.S. markets [15,16]. Renewable Fuel Standard (RFS) mandates affect the gasoline price variability when supply shocks occur to the market by reducing the price elasticity of gasoline demand [17]. Liquefied Natural Gas fuel price have a unidirectional causal relationship with wholesale electricity price [18]. Local market power, excise taxes for different fuel types and spatial clustering changes have obvious effects on retail prices at gasoline stations [19–22]. Government regulation and market power can control an increase in the retail gasoline price and control the inflation rate [20,23]. The distance between states, fuel taxation, gas stations and the refining capacity converge prices to a long-term equilibrium in the diesel and gasoline markets [24,25]. Oil price shocks are driven by supply or aggregate demand, dollar exchange rates [26,27]. Accordingly, government price regulation, market power, taxation and spatial clustering have important impacts on price adjustment in diesel and gasoline markets.

The dependence structure among different energy markets is very important for investors and risk managers. Crude oil spot and futures price returns exhibit a time-varying and asymmetric tail dependence with a magnitude of the upper tail dependence that is slightly weaker than that of the lower tail dependence [28]. European electricity spot prices are extremely dependent on the amount of renewable energy sources in the power system [29]. In the Turkish energy market, the natural gas price is regulated by the government and energy dependence strongly affects the long-term dynamics of natural gas consumption [30]. Electricity spot and futures prices in European and Australia have positive and asymmetric dependence structures [31,32]. Gasoline prices show a strong dependence on crude oil prices in stable fluctuation periods and their degree of dependence is significantly reduced in sharp fluctuation periods [33]. Market participants generate a strong interest in investigating the interdependence between emissions allowances and fuel markets in emissions trading schemes.

European Union emissions trading markets have significant impacts on fossil fuel (coal, oil and natural gas), electricity, diesel and gasoline demand. Emissions allowances prices indicate coherent and lead-lag relations with energy prices (electricity, coal, natural gas and crude oil) in the EU ETS phase II [34,35]. The average efficiency of European airlines is much higher than that of non-European airlines in the EU ETS phase III [36]. The reallocation of emissions permits in linking international ETS may alter energy consumption cost of the participant countries, the emissions-importer production for energy -intensive products is more cost competitive [37]. Emissions allowances assets and energy commodities present a changing lead-lag behaviour at different frequencies [38]. The market risk of emissions allowance market in the EU ETS is mainly affected by energy price [39]. Emissions allowances assets provide diversification benefits to energy commodity investment and portfolio strategies based on different performance measures to analyze the risk reduction and diversification potential [40]. The carbon tax imposed by the Canadian province of British Columbia caused a decline in short-term gasoline demand [41]. A rise in the gasoline price or a more generous allowance allocation would incur a decrease in the equilibrium carbon price in a personal carbon trading scheme [42]. Briefly, CO_2 emissions trading markets and carbon taxation affect fossil fuel (coal, oil and natural gas), electricity and gasoline prices in EU ETS.

However, China's emissions trading pilots vary widely in policy design and market rules from the EU ETS. Regional emissions trading pilots in China vary widely in sector coverage, covered thresholds, cap setting, permit allocation method, offsets, monitoring, reporting and verification (MRV), market trading rules [43–45]. In the Shanghai ETS pilot, there are potential uncertainties such as changes in economic growth patterns, strategic trading activities, carbon leakage risk, and insufficient MRV capabilities [46]. Compared with other Chinese pilots, the Hubei ETS pilot covers few entities but considerable emissions and applies several mechanisms to manage rapid economic growth and more flexible ex-post adjustment of firms' allowances [47]. Emissions pricing may promote the diffusion of low carbon technologies in China's cement industry [48]. An alternative interval of the carbon price level generates varying degrees of impact in improving the environmental quality, decreasing the energy demand and increasing macroeconomic growth [48]. Emissions prices and economic impacts are closely related to emission constraints and emissions trading schemes; the loss in gross domestic production in China's Guangdong province could be 1.4% [50]. The Hubei Pilot ETS has significantly reduced carbon emission and its adverse impact on the economy is relatively negligible; the provincial GDP only declined 0.06% (1.48 billion Yuan) in 2014 [51]. Seven emissions trading pilot markets in China are net embodied emissions importers, so pilot trading schemes could lead to emissions leakage among the other non-trading regions and sectors [52]. The rate of emissions allowance price return is negatively associated with expected risk and Kurtosis in the trading volume is excessively high and fluctuates in Shenzhen's emissions trading pilot [53]. CO_2 emissions allowances spot prices exhibit significant dynamics, asymmetric clustering and regime-switching behaviours in the new China-wide emissions trading scheme (CETS) pilots [54]. The Beijing carbon emission allowance price, crude oil price, natural gas price and economic development have positive and non-significant correlations [55]. Energy, utilities, industrial and materials sector indices are positively related to the Shenzhen and Guangdong emissions allowances prices [56]. The current emissions trading policy affects Shanghai emissions allowances price through it's the impact of the fundamentals of supply and demand [57]. The liquidities of China's emissions trading markets have significant influences on emissions allowances price movement and pricing efficiency [58]. The above literature mainly focus on policy design of China's emissions trading scheme (CETS) pilots and the influences of CETS on regional economic growth and environmental improvement. However fewer literature study whether China's emissions trading scheme pilots have important impacts on wholesale diesel and gasoline prices.

To sum up, previous relevant studies mainly confirm that emissions trading schemes and carbon taxes have important impacts on gasoline demand and price changes in European Union emissions trading scheme [37] [41–43], while there are still some problems to be solved. Early studies mainly focus on exploring the impacts of crude oil price, exchange rate, government regulation and spatial clustering on gasoline prices. China's emissions trading scheme and wholesale gasoline/diesel market are significantly different from European and American markets. Petrochemical and oil refining industries are mainly covered sectors in China's emissions trading scheme pilots, while fewer scholar study tail dependence structure between China's emissions allowances and wholesale diesel/gasoline prices. In regional emissions trading pilots of China, emissions allowances price may significantly affect the production costs of covered companies and product pricing for diesel and gasoline. However, there is no such study using trades data from China's emissions trading pilots to investigate driving factors of wholesale diesel and gasoline price changes in emerging China's emissions trading scheme pilots. Especially capturing