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Dynamics of Australia's LNG export performance: A modified Constant Market Shares analysis

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Abstract:
With continuous growth, the global LNG market is becoming increasingly competitive over time, and Australia is at the forefront. This paper makes the first attempt to analyse the dynamics of Australia's LNG export performance, using an improved Constant Market Share (CMS) model and UN Comtrade LNG trade data in four sub-periods spanning 1989 to 2017. It reveals that apart from the aggregate unfavourable Market Effect and favourable Adaptation Effect, the Competitiveness Effect has contributed the most to Australia's LNG export performance over the past three decades, particularly in Australia's existing LNG markets. A further breakdown of Australia's Competitiveness Effect quantifies the direct bilateral competition between Australia and its rivals. The results reveal that Australian LNG export performance faces challenges in the future. This study suggests that Australian LNG exporters must keep their pace with the new players, expand existing markets, and prepare for the impacts of changes in the pricing mechanism.

Key words: Export Performance; Constant Market Share (CMS); bilateral competition; LNG Export; Australia.

1 Introduction

Due to the development of LNG technologies, LNG trade makes it possible to transport natural gas to places that pipelines do not reach. The International Energy Agency (IEA), in its "World Energy Outlook 2016", interprets the dynamic growth of LNG production and trading as a second gas revolution, after the shale gas revolution in 2010-2012 (IEA, 2016). In its November 2018 forecast, it predicted that LNG would account for 60% of the global gas trade in 2040 (IEA, 2018). With continuous growth, the LNG market has become increasingly competitive over time, and this competition is expected to become fiercer in the next few decades. On the one hand, the LNG trade integrates geographically dispersed gas markets. Without the presence of LNG, gas trade would occur through pipelines, rendering exporters and importers inevitably dependent on each other, and thus leading to a segmentation of the gas market and limited competition. On the other hand, the LNG markets are liberalizing and becoming more competitive. Traditionally, LNG has been traded based on bilateral and long-term contracts with destination restrictions and prices linked to oil prices. Now, however, the trade is increasingly being liberalized, and LNG supplies are increasingly flexible: contract terms have been shortened, prices are increasing linked to hub prices and destination restrictions are being relaxed or eliminated (GIIGNL, 2018; IGU, 2019). This liberalization, in tandem with an increasing number of LNG exporters and importers, is contributing to steadily increasing competition in the LNG market (EIA, 2017; IGU, 2019). The financialisation of natural gas and

LNG commodities moves them toward a global and competitive market, as in the case of crude oil (Wang et al., 2019; Zhang and Ji, 2018; Zhang et al., 2017). As the LNG market is becoming more competitive, a large amount of research has described the development of the LNG trade. Chen et al. (2019) found that the consumption competitiveness of LNG significantly improved between 2008 and 2015. IGU (2019) found evidence that the LNG short-term trading is increasing globally in the past decade and Asia is likely to remain dominant in the global LNG trade. Geng et al. (2014) argued the network of LNG trading countries is more closely linked relative to the network of pipeline gas trading countries. Among others (Neumann, 2009; Siliverstovs et al., 2005), Barnes and Bosworth (2015) use a gravity model and finds evidence supportive of the de-regionalization of the total natural gas market as a result of the development of LNG trade. Recently, H. Y. Zhang et al. (2018) employed a gravity model to identify the determinants of the development of LNG trade flows, namely economics, supply and demand, price, energy structure, trade feasibility and politics.

Despite an increasing number of studies on LNG trade, only a few studies have examined competition in LNG trade. Arora and Cai (2014) employed a CGE model to assess the potential costs and benefits for U.S. natural gas importers and exporters in a global framework. They found evidence that selected natural gas exporters (Canada, Russia, and OPEC) gain as a group only with the U.S. exogenous pipeline gas exports. Based on complex network theory, Chen et al. (2016) employed an LNG trade competition network method to analyse the global competition pattern and

national role in the LNG trade market. A limitation is that their method can only measure the magnitude of the competition intensity between LNG exporters. The network method cannot quantify the bilateral competition outcome. By using vessel movement data, Shibasaki et al. (2020) shed light on the details of the shipping pattern of LNG trade and quantitatively clarified the functions of each element in the LNG supply chain in terms of efficiency and competitiveness.

Despite now being the largest LNG exporter, how Australian LNG exports perform and what factors contribute to its performance changes have not been studied in the literature. To the best of our knowledge, this is the first such analysis. Following Tyszynski's work (1951), the Constant Market Shares (CMS) model has been widely used to investigate export market share change or foreign trade volume change and international competitiveness in export products (Ahmadi-Esfahani, 2006; Batista,2008). However, the previous application of the CMS in the energy field or in the Australian context is limited. A handful of studies use a CMS methodology to estimate the export performance (international competitiveness) of energy products, mainly clean energy products such as Wang et al. (2017) and Shuai et al. (2018). Still, LNG export performance has not been studied. Among the few studies pertaining to Australia's export competitiveness, there is no dedicated study of energy products. Drysdale and Lu (1996) used the CMS model to assess Australia's overall export performance between 1980 and 1994. Ahmadi-esfahani (1995, 1993), Ahmadi-esfahani and Jesen (1994) and Ahmadi-Esfahani (2006) used the CMS model to analyse Australian wheat exports to Egypt, Japan, and China, and the export

performance of the Australian processed food sector in Southeast Asia from 1980 to 2003, respectively.

Further understanding of the competitiveness of LNG exports is critical for understanding the future of Australia's LNG industry, the Australian gas sector and, given its large scale, even the Australian economy. Australia was the 2nd largest LNG exporter in 2017, exporting 55.86 Mt, after Qatar's 77.50 Mt and double Malaysia's 26.87 MT (3rd largest) (GIIGNL, 2018). Australia overtook Qatar as the world's largest LNG exporter in 2019 and will be among the top three LNG exporters in the longer term (IGU, 2019). Increasing competition in LNG markets has put more pressure on Australian LNG exports compared to those from other countries due to the relatively high cost of its LNG production (Grafton et al., 2018; Shi and Variam, 2015). Given Australia's leading role in the global LNG sector, this study is also relevant to the global LNG industry.

In this paper, we undertake a CMS methodology to analyse the dynamics of Australian LNG export competitiveness in the world market from 1989 to 2017. The total change in the market share of Australian LNG exports is decomposed into three main additive terms: Competitiveness Effect (CE), Market Effect (ME) and Adaptation Effect (AE). By doing so, we can achieve two benefits. First, we can identify the factors underlying the market share change. Specifically, we can associate market share change with changes in competitive positions (Competitiveness Effect), target market's importance in the world (Market Effect) and success in adapting to changes in the target market's importance in the world (Adaptation Effect). Second,

after isolating the indirect competition effects (Market Effect and Adaptation Effect) from the market share change, we can use the remaining direct competition effect, namely the Competitiveness Effect, to quantitatively analyse the bilateral competition between Australia and each of its competitors. Then we further exclude the impact of "Disappearing Market Effect" (discussed below) from the decomposition effects, as well as quantify the bilateral competition between Australia and its rivals.

Our contributions to the literature are threefold. Our first contribution is to introduce the modified CMS methodology that allows analysis of bilateral export competitiveness in the energy field. Compared with Wang et al. (2017), our CMS method can distribute the Competitiveness Effect among competitors, which allows us to quantify the bilateral competition. This can generate additional insights that are helpful to Australian policy-makers and the LNG industry as they prepare and stimulate the healthy development of the sector. Our second contribution is to enrich the CMS study literature by further decomposing each component of the CMS analysis into a "Disappearing Market Effect" and a "Pure Effect" as introduced in Section 3. The exclusion of the "Disappearing Market Effect" is the most significant improvement in this paper. Such improvements are critical in our research because the CMS analysis will not produce an unbiased result until the Disappearing Markets Effects are excluded. Also, the resulting quantified bilateral competition between Australia and its rivals can allow us to propose insightful policy suggestions. Our third contribution, to the best of our knowledgethis paper is the first attempt to employ the CMS to analyse LNG export performance. The modified CMS approach

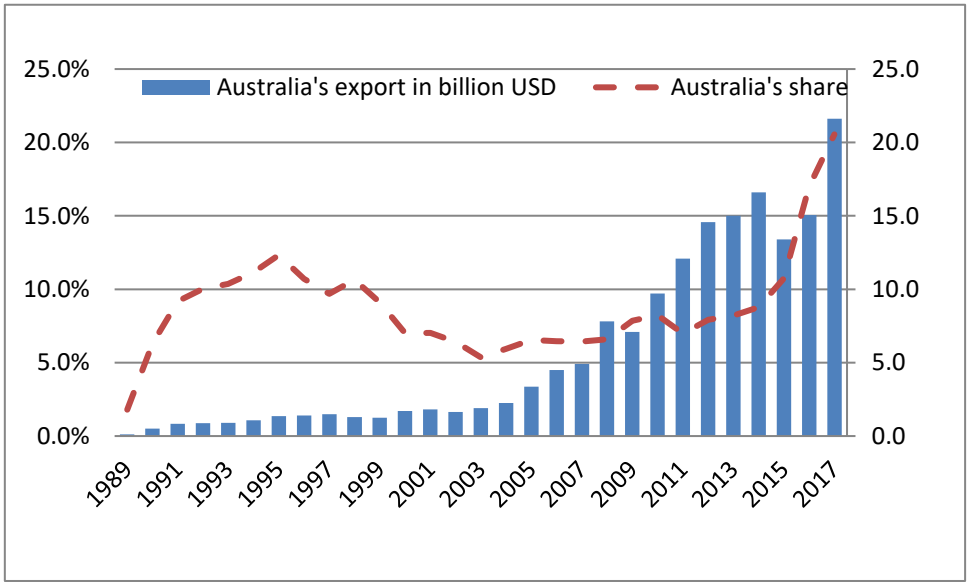
is applicable to study competition issues in other energy markets.

The remainder of this paper is structured as follows: the next section briefly presents Australia's LNG exports in the global context, as well as some stylised facts from the data. This is followed by an outline of the methodology and the results. The final section concludes with a discussion of the policy implications.

2 Australia's LNG exports: data and stylised facts

Australia began exporting LNG in 1989 upon completion of the first LNG plant under the North West Shelf. Due to the continuous commercial operation of LNG projects since 2015, Australia's LNG exports increased from five Mt in 1993, to 24 Mt in 2014 and to 68.6 Mt in 2018. However, its share in the global LNG trade (measured as the ratio of physical amount) experienced some fluctuation between 6.31% (in 2003) to 21.67% (in 2018) (Figure 1).

Figure 1 Australia's LNG Exports in Global Context: Value and Share (billion USD)



Source: UN Comtrade.

In value terms, which is a general practice in export competence analysis, Australia exported LNG worth USD 100 million in 1989, accounting for 1.8% of the global LNG imports. In 1995, its LNG exports to the world increased in value to USD 1.4 billion, and its world market share increased to a record level of 12.3%. However, in 2003, although its export value increased to USD 1.9 billion, its share dropped to a historic low of 5.4%.

Between 2003 and 2014, Australia's LNG exports kept pace with global LNG trade. Although its LNG exports increased by over eight-fold from USD 1.9 billion to USD 16.6 billion, its market share increased to only 8.8%. This is indicative of the fierce competition that Australia faces in the world LNG market.

In 2015, due to the commission of new LNG projects on the east coast, although Australia's LNG exports declined to USD 13.4 billion due to low LNG prices, its world market share grew to 10.7%. In 2017, Australia's LNG exports increased to a peak of USD 21.6 billion and its share increased to a peak of 20.6%.

For analysing the dynamics of Australia's LNG export competitiveness, we need to have the longest time coverage possible. We, therefore, extracted the earliest available LNG import data[1] (HS 271111, natural gas, liquefied) from the UN Comtrade database. This starts from 1988 and employs the HS1988/92 nomenclature.

[1] The quality of Australia's LNG export data is less than ideal. For instance, it documents only 56 observations between 1988 and 2017 and 44.6% of these have no information about the partner countries. This renders us unable to undertake the CMS analysis. A more serious problem, namely missing data, is also observed in the export data when we use the HS 1996 nomenclature. It documents only 22 observations for Australia's LNG exports between 1988 and 2017, and none of these has information about the partner country.

Since partner countries first reported LNG imports from Australia in 1989, our analysis starts from 1989. A total of 172 observations of LNG imports from Australia between 1989 and 2017 were reported, all of which had information about their partner countries. This enabled us to employ the CMS analysis to measure the dynamics of Australia's LNG exports.

To examine Australia's LNG export competitiveness with the CMS methodology, we divided the sample period into four sub-periods: (1)1989-1995, when Australia had a significant increase in its market share in the world market; (2)1995-2003, when Australia's share dropped to the lowest; (3)2003-2014, when Australia's share increased gradually; and (4) 2014-2017 when Australia's share grew significantly.

The change in Australia's export value and market share indicates the dynamics of its export competitiveness. Compared with other major LNG exporters, Australia's ranking in global LNG trade increased from No. 8 in 1989 to No. 4 in 1995. After sliding into the sixth position in 2003, Australia rose to No. 3 in 2014 and No. 2 in 2017 (Table 1).

Table 1 Market share of the top ten LNG Exporters, 1989-2017(%)

	Country	**1989**	**Country**	**1995**	**Country**	**2003**
1	Indonesia	48.0%	Indonesia	37.2%	Indonesia	19.8%
2	Malaysia	15.5%	Algeria	15.3%	Algeria	18.1%
3	Brunei	12.3%	Malaysia	14.6%	Malaysia	12.0%
4	Soviet Union	8.9%	Australia	12.3%	Qatar	10.6%
5	United Arab Emirates (UAE)	5.4%	Brunei	10.1%	Trinidad and Tobago	5.7%
6	Algeria	3.8%	UAE	6.6%	Australia	5.4%
7	United States	2.3%	United States	2.0%	Nigeria	5.2%
8	Australia	1.8%	Libya	1.1%	Oman	5.1%

9	Libya	1.7%	Denmark	0.3%	Brunei	4.8%
10	Czechoslovakia	0.3%	France	0.2%	UAE	4.0%
No	**Country**	**2014**	**Country**	**2017**		
1	Qatar	31.3%	Qatar	25.7%		
2	Malaysia	10.8%	Australia	20.6%		
3	Australia	8.8%	Malaysia	8.7%		
4	Nigeria	6.9%	Nigeria	6.5%		
5	Indonesia	6.2%	Indonesia	5.1%		
6	Algeria	5.8%	Algeria	4.6%		
7	UAE	4.6%	United States	4.2%		
8	Russian	4.3%	Russian	3.5%		
9	Trinidad and Tobago	4.1%	Oman	3.3%		
10	Oman	3.1%	Papua New Guinea	2.6%		

Source: UN Comtrade.

From the destination market perspective, along with the growth of Australia's LNG exports in value, Australia extensively expanded to new markets or intensively exported to its original partners. For instance, in 1995, Australia's LNG exports expanded to Korea, Kiribati, Spain and Turkey compared to exporting only to Japan in 1989. In 2006, Australia exported LNG to China for the first time (Table 2).

Table 2 Importing Countries of Australia's LNG

importing country	1989	1995	2003	2014	2017
Japan	0.1	1.3	1.9	15.0	10.9
China				0.7	6.2
Korea, Rep.		0.0	0.0	0.6	2.9
India					0.7
Singapore				0.0	0.6
Malaysia				0.1	0.2
East Timor					0.0
Uganda					0.0
European Union			0.0		
Kiribati		0.0			
Other Asia				0.2	
Papua New Guinea			0.0		
Samoa				0.0	
Spain		0.0	0.0		
Turkey		0.0			

United States				0.0	
total	0.1	1.4	1.9	16.6	21.6

Note: 0.0 indicates a small amount in billion USD; no value indicates no imports.
Source: UN Comtrade.

3 Methodology

The Constant Market Shares (CMS) methodology has been a useful tool for decades, and is often used to identify the factors underlying export performance across countries (Fagerberg and Sollie, 1987; Jepma, 1989; Merkies and der Meer, 1988; Richardson, 1971; Tyszynski, 1951). Most recently, the CMS has been widely used in the international trade and its inter-disciplinary literature (Batista and Liu, 2017; Gilbert and Muchová, 2018; Liu et al., 2018; Shuai et al., 2018; Wang et al., 2017).

3.1 CMS Model Selection

Since export performance can be analysed by either export market share change or export value change, the CMS model has two main versions, namely a market-share-change version and a value-change version. The market-share-change version CMS model is pioneered by Tyszynski (1951) and developed by Fagerberg and Sollie (1987) with its recent extensions (Batista, 2008; Gilbert and Muchová, 2018). The value-change version CMS model is proposed and popularized by Leamer and Stern (1970) and improved by Jepma (1989) and among others, respectively.

Both CMS models are based on an identity in which the fluctuation of market share or export value is decomposed into components. Theoretically, both versions of the constant share norm hold exactly under Armington's preference assumptions. Based on the reltive CES demand function aring from the Armington model, Gilbert

and Muchová (2018) proved that the market share change is a fuction of relative price competitiveness, initial market structure, and constant elasticity of substitution σ[2], which corresponds to the market-share-change version of CMS decomposition items in this paper. Similarly, Merkies and der Meer (1988) borrowed Armington's CES functions for both stages of the demand function and provided the theoretical foundation for the value-chage-version CMS model.

Relative to the value-change version model, the market-share-change version has two recent insightful extensions, which bring it an advantage over the other version. As a result, we employ the market-share-change version CMS model in this paper. Chronologically, Batista (2008) developed a new extension of the CMS by attributing one's gain or loss in market share (positive or negative Competitiveness Effect) to various competitors in zero-sum games. This allowed us to measure the extent of direct bilateral competition.

The second extension was made by Gilbert and Muchová (2018). They further decompose the CMS components into the extensive margin and intensive margin, which helps us to understand whether exporters have been more or less successful at developing new market destinations. In this paper, before we can borrow the above two previous extensions, we introduce a new extension by excluding the Disappearing Market Effect, which can reduce the bias of the CMS decomposition results.

[2] Empirically, it can be proportionally related to the decomposition term of Adaptation Effect (AE) in the market-share-change version CMS model. A positive and greater elasticity of substitution parameter corresponds to a positive and greater AE term, or vice versa.

3.2 CMS Decomposition

Following Fagerberg and Sollie (1987), the basic form of CMS model is constructed from the following identity.

$$M_w^t \equiv \mathbf{a}^t\mathbf{b}^t \equiv \sum_k a_k^t b_k^t \qquad (1)$$

Where:

M_w^t is the market share of Australian LNG exports in the world w from the initial year t.

$\mathbf{a}^t \equiv (a_1^t,...a_k^t...,a_n^t) \equiv (X_1^t / M_1^t,...X_k^t / M_k^t...,X_n^t / M_n^t)$ is a row vector of n dimensions of the shares of Australian LNG in the imports of country $k = 1,...,n$ at the initial year t, where X_k^t is the LNG import value of country k from Australia at the initial year t; and M_k^t is the LNG total import value of country k at the initial year t.

$\mathbf{b}^t \equiv (b_1^t,...b_k^t...,b_n^t) \equiv (M_1^t / M_w^t,...M_k^t / M_w^t...,M_n^t / M_w^t)$ is a column vector of dimension n of the shares of country $k = 1,...,n$ in the LNG total imports of the world w at the initial year t, where M_w^t is the total world imports of LNG in the initial year.

The total market share increment between the initial year t and final year $t+1$ can be expressed as:

$$\begin{aligned}\Delta M_w^{t+1,t} &\equiv \sum_k (a_k^t + \Delta a_k^{t+1,t})(b_k^t + \Delta b_k^{t+1,t}) - \sum_k a_k^t b_k^t \\ &\equiv \sum_k \Delta a_k^{t+1,t} b_k^t + \sum_k a_k^t \Delta b_k^{t+1,t} + \sum_k \Delta a_k^{t+1,t} \Delta b_k^{t+1,t}) \qquad (2) \\ &\equiv \underbrace{(\mathbf{a}^{t+1} - \mathbf{a}^t)\mathbf{b}^t}_{CE} + \underbrace{\mathbf{a}^t(\mathbf{b}^{t+1} - \mathbf{b}^t)}_{ME} + \underbrace{(\mathbf{a}^{t+1} - \mathbf{a}^t)(\mathbf{b}^{t+1} - \mathbf{b}^t)}_{AE}\end{aligned}$$

The first component of identity (2) is the Competitiveness Effect (CE), which measures the LNG world market share change of Australia that arises from competition against its rivals. The second component of identity (1) is the Market

Effect (ME), which can be interpreted as the world market share change of Australia that arises from changes in the weights of LNG importing countries in the world market. The third component of identity (1) is the Adaptation Effect (AE), which corresponds to the degree of adaption of exporting countries to the relative importance of trade partners in the global trade (Fagerberg and Sollie, 1987). A negative AE implies that Australia either loses market share in a market that has increased its global market share or gains market share in a market that has reduced its global market share (Ahmadi-Esfahani, 2006). The second and third components are also named as the "Indirect Competition Effect" in the literature (Batista and Liu, 2017).

3.3 CMS model extensions

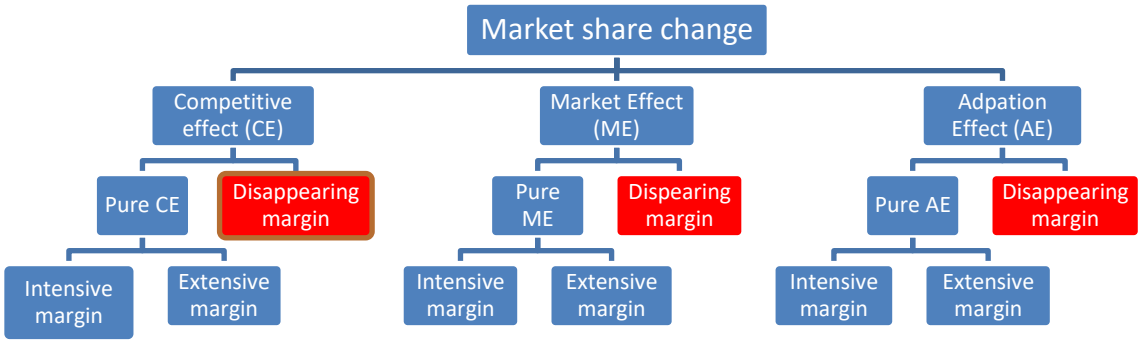
In practice, we find that the existence of a Disappearing Market may impose a biased impact on the CMS decomposition results. A Disappearing Market refers to a market that has imports of LNG in the initial year but not in the final year of a particular sub-period. The existence of a Disappearing Market can lower the Competitiveness Effect with no economic meaning. For instance, during the sub-period of 1995-2003, Turkey imported LNG accounting for 1.155% of the world demand in value in 1995 but had no imports in 2003. Australia accounted for 20.19% of Turkey's LNG imports in 1995. According to the Competitiveness Effect specification in formula (1), Australia's Competitiveness Effect will be 0.23% lower (i.e., 0.219*1.155), which only results from the fact that Turkey stopped LNG imports from around the world and has no causal relationship with Australia's LNG export competitiveness. Here we define a Disappearing Market Margin as the market share

change arising from the Disappearing Market. We isolate the Disappearing Market Margin from the Competitiveness Effect. By doing so, the remaining Pure Competitiveness Effect with economic meaning can allow us to calculate the direct bilateral competition facing Australia's LNG exports. In accordance with the Competitiveness Effect, we do the same operations for the Market Effect and Adaptation Effect.

In addition, as new markets emerge, it is also interesting to separately measure Australia's LNG export performance in existing markets and entirely new markets. Therefore, we followed the extension made by Gilbert and Muchová (2018) to further break down each component of the CMS model into Extensive and Intensive Margins. Extensive Margin refers to Australia's global market share changes arising from a market that has no LNG imports from Australia in the initial year but has LNG imports from Australia in the final year of a particular sub-period. Intensive Margin refers to Australia's global market share change arising from a market that has LNG imports from Australia in both the initial and final year of a particular sub-period. Keeping this in mind, we further decompose each Pure Effect into extensive and Intensive Effects. To the best of our knowledge, this paper is the first to use the CMS in this way.

The relations of these effects are illustrated as Figure 2 below:

Figure 2 Illustrative relations of decomposed effects



Following the extension made by Batista (2008), we further distribute Australia's Pure Competitiveness Effect across its rivals as in equation (3).

$$\Delta M_{Aus,s}^{t+1,t} = \mathbf{a}_s^t CE_{AUS}^{t+1,t} - \mathbf{a}_{Aus}^t CE_s^{t+1,t} \qquad (3)^3$$

Where $\Delta M_{Aus,s}^{t+1,t}$ is the part of the change in Australia's share in the global LNG market that can be ascribed to its competition against a rival country s from the initial year t to the final year $t+1$.

$\mathbf{a}_s^t \equiv (X_{s1}^t / M_1^t, ... X_{sk}^t / M_k^t ..., X_{sn}^t / M_n^t)$ is a row vector of dimension n of the shares of country s 's exports in each LNG import country of $k = 1,...,n$ at the initial year t;

$CE_{AUS}^{t+1,t} \equiv (CE_{Aus,1}^{t+1,t}, ... CE_{Aus,k}^{t+1,t}, ... CE_{Aus,n}^{t+1,t})$ is a column vector of dimension n of Australia's Pure Competitiveness Effect in each l import market $k = 1,...,n$ from the initial year t to the final year $t+1$;

$\mathbf{a}_{AUS}^t \equiv (X_{Aus,1}^t / M_1^t, ... X_{Aus,k}^t / M_k^t ..., X_{Aus,n}^t / M_n^t)$ is a row vector of dimension n of the shares of Australia's exports in each LNG import country of $k = 1,...,n$ at the initial year t;

[3] $\sum_s \Delta M_{Aus,s}^{t+1,t} = CE_{AUS}^{t+1,t}$

$CE_s^{t+1,t} \equiv (CE_{s1}^{t+1,t}, ...CE_{sk}^{t+1,t}, ...CE_{sn}^{t+1,t})$ is a column vector of dimension n of the Pure Competitiveness Effect of Australia's competitor s in each import market $k = 1, ..., n$ from the initial year t to the final year $t+1$.

By doing so, we can quantitatively measure the bilateral competition between Australia and the other LNG major exporters. How much of an exporter market share change can be attributed to each competitor as illustrated in Batista (2008) is consistent with most of the main trade models, especially when the traded good is homogeneous or horizontally differentiated (Batista, 2010).

4 Empirical results

4.1 Aggregated CMS decomposition results

The results of the CMS decomposition of Australia's LNG export performance (equation 1) are presented in **Table 3**. The figures are percentage changes in the world market share. Column (1) displays the CMS decomposition components, including the Competitiveness Effect, Market Effect and Adaptation Effect. Each component is divided into Pure Effect and Disappearing Margin. The Pure Effect is then further broken into Extensive Margin and Intensive Margin. Column (2) reports the CMS decomposition of the change in Australia's share of LNG exports in the global LNG market between 1989 and 2017. Each of columns (3) to (6) represents a sub-period between 1989 and 2017, which can capture the factors underlying the dynamics of Australia's LNG export performance over the past three decades. The last row presents Australia's total share changes in the world LNG market.

As shown in column (2), Australia's share in the world LNG market increased by

18.8% over the past three decades (from 1.8% in 1989 to 20.6% in 2017). As for the sources of the change, the Competitiveness Effect contributed to the largest market share gain of 22.7% for Australia, which implies its strong competitiveness in the world LNG market. The Adaptation Effect added an additional market share gain of 2.7% for Australia. This indicates that Australia undertook appropriate adaption strategies, i.e., reduced market share in importing countries with decreased weight in the global LNG market, but gained market share in importing counties with increased weight. However, the Market Effect is unfavourable for Australia, leading to a market share loss of 6.3%. This suggests that Australia's major LNG destinations experienced a declining share in the global LNG trade. This is reasonable as the total number of LNG importing countries increased from 8 in 1993 to 37 in 2018 (IGU, 2019).

Table 3 CMS Decomposition of Australia's LNG Export

Component	1989-2017	1989-1995	1995-2003	2003-2014	2014-2017
Competitiveness Effect	22.4%	12.0%	-3.4%	3.3%	10.5%
Pure	22.7%	12.0%	-3.2%	3.3%	10.6%
Extensive	1.1%	0.5%		0.1%	0.5%
Intensive	21.6%	11.5%	-3.2%	3.3%	10.0%
Disappearing	-0.3%		-0.2%	-0.0%	-0.1%
Market Effect	-6.3%	-0.2%	-4.8%	-0.3%	-0.9%
Pure	-5.9%	-0.2%	-4.6%	-0.3%	-0.8%
Extensive					
Intensive	-5.9%	-0.2%	-4.6%	-0.3%	-0.8%
Disappearing	-0.3%		-0.2%	-0.0%	-0.1%
Adaptation Effect	2.7%	-1.2%	1.3%	0.3%	2.2%
Pure	2.3%	-1.2%	1.1%	0.3%	2.1%
Extensive	1.0%	0.4%	0.0%	0.4%	0.2%

Intensive	1.3%	-1.6%	1.0%	-0.1%	1.9%
Disappearing	0.3%		0.2%	0.0%	0.1%
Total market share change	18.8%	10.5%	-7.0%	3.4%	11.8%

Source: authors' calculation.

Note: blank means no data, and 0.0% means less than 0.1%.

After controlling for the Disappearing Market Margin for each CMS component, we were able to obtain the Pure Competitiveness Effect (22.7%), Pure Market Effect (-5.9%) and Pure Adaptation Effect (2.3%). The estimated Competitiveness Effect became slightly higher. However, the other two effects were small, but the changes were relatively large.

The further breakdown of each Pure Effect indicates Australia's export performance in both markets, i.e. existing markets and new markets. Specifically, 21.6% of the 22.7% of the Pure Competitiveness Effect were contributed by the Intensive Margin. That is, 21.6% of the Pure Competitiveness Effect was gained in the existing markets, while the gains in new markets contributed only 1.1%.

All of the Pure Market Effect comes from the Intensive Margin. Algebraically, this is because our CMS is a Laspeyres-indices model and Australia's zero initial years' weight in the new markets will generate a zero Market Effect in the same markets.

Although these two margins were closely balanced in the case of the Adaptation Effect in aggregate over the whole period, there was a different story when we observed it by sub-periods. This is discussed in the next subsection.

4.2 CMS decomposition results by sub-periods

When we break down the period into four sub-periods, we can observe the dynamics of Australia's LNG export performance over time.

For the first sub-period (1989-1995), Australia gained a market share of 10.5%. Among this market share gain, 12% was raised from the Competitiveness Effect or the direct competition against rivals. In the 12% of the Competitiveness Effect, 11.5% came from Intensive Margin and only 0.5% came from the Extensive Margin. This indicates the importance of developing existing markets in Australia's LNG exports. The Market Effect is unfavourable and results in a market share loss of 0.2%, which is all captured by the Intensive Margin. The Adaptation Effect was also unfavourable and resulted in a market share loss of -1.2%, indicating that Australia's LNG exports failed to adapt its export geographical distribution to the changing world market geographical structure. This is because the changing geographical distribution was not reflected in the LNG contracts that were signed previously. Specifically, Australia gained 0.4% of the world market through good adaptation in newly emerging markets but lost 1.6% of the world market by failing to achieve adjustment in existing markets. There is no Disappearing Market in this sub-period, so there is no value for the Disappearing Effect in this first sub-period.

In the second sub-period (1995-2003), Australia's share dropped by 7%. It was during this sub-period that Disappearing Markets (Turkey and Kiribati) first emerged. Apart from the Disappearing Market Effect (-0.2%) under the Competitiveness Effect, Australia lost 3.2% of the world market share in direct competition against its rivals,

and all of these losses arose from the direct competition in Australia's existing export market as denoted by the Intensive Margin. The unfavourable Market Effect became more serious than in the past sub-period and led to another market share loss of as high as 4.8%, of which 4.6% came from the Pure Effect in existing markets and 0.2% from the Disappearing Effect. Meanwhile, Australia's Adaptation Effect changed from negative in the previous sub-period to positive (1.3%) in this sub-period, which indicates Australia adapted to the unfavourable Market Effect, especially in existing markets (1.0%).

In the third sub-period (2003-14), which is the longest sub-period, Australia's world market share increased by a relatively small percentage of 3.4%. During this sub-period, the Disappearing Market (Papua New Guinea) had a negligible impact on each CMS component. Almost all of the market share gain in this sub-period came from the Competitiveness Effect (3.3%) especially from the Intensive Margin. This indicates that the recovery of Australia's competitiveness occurred mainly in its existing markets. Meanwhile, a favourable Adaptation Effect (0.3%) offset the unfavourable Market Effect (-0.3%).

In the most recent sub-period (2004-17), Australia succeeded in gaining another 11.8% market share, which is the largest sub-period gain in the smallest number of years. Among those market share gains, 10.6% arose from the Pure Competitiveness Effect. This indicates the recent strong competitiveness of Australia's LNG exports against its rivals. Notably, the Market Effect is still unfavourable especially in its existing markets. However, the favourable Adaptation Effect significantly indicates

that Australia successfully adapted its export geographical distribution to the most recent changes in the world market geographical structure, especially in its existing markets.

Since Australia's LNG export Competitiveness Effect in most sub-periods contributes most to the dynamics of its export performance, one interesting issue is the relative position of Australia when compared with other LNG exporters. Table 4 reports Australia and the top LNG exporting countries' Competitiveness Effect in the ranking. It can be seen that in the earliest sub-period, Australia's export competitiveness ranked first, then fell to the bottom in the second sub-period, then recovered to the top three most competitive exporters in the third sub-period. In the last sub-period, Australia was again the most competitive LNG exporter in the world, followed by the United States.

Table 4 Australia and the Top Exporters' Competitiveness Effect by sub-periods

Country	1989-1995	Country	1995-2003
Australia	12.0%	Qatar	11.9%
Italy	9.0%	Oman	5.0%
United Arab Emirates	1.5%	Nigeria	2.2%
Malaysia	0.1%	Malaysia	1.3%
Brazil	0.05%	Australia	-3.2%

Country	2003-2014	country	2014-2017
Qatar	13.0%	Australia	10.6%
Russian Federation	4.2%	United States	3.5%
Australia	3.3%	Papua New Guinea	1.1%
Nigeria	2.2%	Angola	0.9%
Norway	2.1%	Peru	0.9%

Note: Indonesia (-11.9%) and Algeria (-5.6%) are the bottom two countries in the sub-period of 1995-2003.

In summary, the above sub-period analysis identifies the dynamics of Australia's LNG export performance. First, Australia's export competitiveness experienced an increase then a decrease to the lowest level before 2003, a slow recovery before 2014 and a final significant increase in recent years. Second, the Market Effect seemed to be unfavourable for Australia for each sub-period. Since the Market Effect is due to the continuous expansion of the group of importing countries, and thus the declining share of existing importers, it was always negative across all each sub-period. The only salient point is the size of the effect between 1995 and 2002, which was significantly larger than the rest. Third, Australia managed to adapt itself to the changing geographical demand structure of the world market, especially for the most recent sub-period. Lastly, the Intensive Margin surpassed the Extensive Margin in most cases, indicating that Australia was more successful in developing existing markets than new markets.

4.3 Bilateral direct competition

As the Competitiveness Effect measures the market share gain or loss that arises from direct competition against rivals, one more interesting issue is the source of Australia's Competitiveness Effect. By employing equation (2), the distribution of Australia's LNG export Competitiveness Effect is reported in **Table 5** by sub-periods.

In the first sub-period (1989-1995) when Australia was very competitive in the world LNG market, Australia gained a 6.4% share of the world market in direct competition against Indonesia. In addition, Australia gained a 2.2% share of the world market in direct competition against Malaysia, followed by Brunei (1.8%), UAE (0.7%),

and U.S. (0.3%).

In the second sub-period (1995-2003) when Australia experienced an apparent decrease in its export competitiveness, Australia lost 1.4% of the world market to Qatar in direct bilateral competition, followed by 0.7% to Malaysia, 0.4% to Oman, 0.3% to UAE, and 0.2% to Algeria. It was during this period, specifically 1997, when Qatar, the world's largest LNG exporter, began to export LNG.

In the third sub-period (2003-2014) when Australia's export competitiveness began to restore itself, it started to outpace the Asian LNG exporters, which were traditional LNG exporters. Australia gained 2.4% of the world market share in direct competition with Indonesia, followed by Malaysia (0.8%), Brunei (0.6%), the United States (0.4%) and Oman (0.2%). Australia lost 0.5% of the world market share to Russia.

Table 5 Distribution of Australia's Competitiveness Effect across Competitors

Competitors	1989-1995	Competitors	1995-2003
Indonesia	6.4%	Qatar	-1.4%
Malaysia	2.2%	Malaysia	-0.7%
Brunei	1.8%	Oman	-0.4%
UAE	0.7%	UAE	-0.3%
United States	0.3%	Algeria	-0.2%
Algeria	0.3%	Nigeria	-0.1%
Libya	0.1%	Brunei	-0.1%
TOTAL	12.0%	total	-3.2%
Competitors	2003-2014	Competitors	2014-2017
Indonesia	2.4%	Qatar	4.2%
Malaysia	0.8%	Malaysia	1.3%
Brunei	0.6%	Nigeria	0.9%
UAE	0.4%	Indonesia	0.7%
Oman	0.2%	Yemen	0.6%
United States	0.1%	Russian Federation	0.6%
Equatorial Guinea	-0.1%	Equatorial Guinea	0.5%
Yemen	-0.1%	Oman	0.4%
Algeria	-0.1%	UAE	0.4%

Papua New Guinea	-0.1%	Brunei	0.3%
Nigeria	-0.3%	Algeria	0.2%
Russian Federation	-0.5%	Spain	0.2%
total	3.3%	Trinidad and Tobago	0.1%
		Norway	0.1%
		Belgium	0.1%
		Papua New Guinea	-0.1%
		United States	-0.1%
		total	10.6%

Note: competitors with "0" values were not reported in the table.

In the last sub-period (2014-2017) when Australia experienced a significant competitiveness increase, Australia gained 4.2% more of the world market from Qatar, 1.3% from Malaysia, 0.9% from Nigeria, 0.7% from Indonesia, 0.6% from Yemen. At the same time, Australia lost a small 0.1% to the US.

4.4 Discussion

The analysis results suggest that Australia needs to continue to improve its market competitiveness, in particular, against the new LNG market players, including the US and Russia. Since Australia's LNG is more expensive than its competitors' (Grafton et al., 2018), reducing the cost of LNG production is a key strategy for Australia. Since the US LNG is often priced on the Henry Hub price while the Australian and Russian LNG is priced on oil indexation (D. Zhang et al., 2018b, 2018a), Australia will need to develop differentiated strategies in its LNG markets, in particular the East Asian market, which is the dominant destination of the Australian LNG exports (Grafton et al., 2018; Shaikh et al., 2016).

Australia also needs to hold its position in existing markets, in particular, the growing markets such as China and India, as suggested by the dominance of the Extensive

Margin. By progressively improving China's market, Australia's performance could also be boosted by an enhanced Adaptation Effect. China should be a key target market for at least two reasons: on the one hand, China is an important market for Australia's LNG exports and thus could improve Australia's Extensive Margin. In 2017, China imported 17.82 Mt or 46 percent, of its LNG from Australia, and China's imported LNG accounted for 31 percent of Australia's total exports in 2017 (GIIGNL, 2018). On the other hand, the Chinese market is growing dramatically, which could improve the Market Effect for Australia's LNG exports. In 2017, natural gas accounted for only 8% of China's total primary energy supply, lower than the government target of 10% by 2020 and far from the global average of 23% (BP, 2019; Shi et al., 2017).

Furthermore, East Asia is moving away from oil indexation to hub indexation (e.g. the US style)(Shi, 2016; Shi and Variam, 2016) and this will change Australia's LNG export prices in the near future. China's gas market liberalization has been progressing and this will lead to changes in the gas pricing mechanism (Wang et al., 2020). Australia's LNG exporters need to prepare for the impact of such a transition. Although the majority of Australia's exports are likely to be protected from long-term contracts, their expiration will come in the next decades. Such oil-indexed long-term contracts could be terminated if Australia's LNG buyers liberalized their gas markets, as is happening in Europe (Shi, 2017). Furthermore, Australia's short-term contract selling, totalling 18% in 2017 (GIIGNL, 2018), will have already been exposed to such changes in real time. Considering the fragmentation in the East Asian LNG

markets, there could be several LNG benchmark prices in East Asia (Shi et al., 2019) and thus Australia needs to cooperate with the major LNG or natural gas market players in the region for the emerging change in price mechanisms.

5 Conclusions and policy implications

Although the LNG market is becoming more competitive, only a few studies have examined the competition of LNG trade and no study has investigated how the Australian LNG export performs and what factors contribute to its performance changes. In this paper, we undertake a CMS methodology to analyse the dynamics of Australian LNG export competitiveness in the world market from 1989 to 2017. The total change in the market share of Australian LNG exports is decomposed into three main additive and analytically interpretable terms: Competitiveness Effect (CE), Market Effect (ME) and Adaptation Effect (AE). Since Australia's export competitiveness experienced an increase, then a decrease to the lowest level before 2003, a slow recovery before 2014, and a final significant increase in recent years, we divided the sample period into four sub-periods.

The analysis reveals that the Competitiveness Effect is the dominant component of Australia's LNG export performance and Australia's LNG exports had the highest competitiveness in the world market for the most recent period. Thanks to the oil-indexed long term contracts (Grafton et al., 2018), Australian LNG export still has gained significant world market share in direct competition with the largest LNG exporters in the world. In contrast, the Market Effect seems to be unfavourable for Australia for the whole period due to the increasingly diversified LNG importing

markets.

Our analysis suggests that while Australian LNG exports have performed well in the past, they will face challenges in the future. First, Australia has actively adjusted to the global LNG market changes, especially for the most recent sub-period given the Adaptive Effect is positive overall in three of the four periods. Second, Australia was more successful in developing existing markets than new markets as evidenced by the finding that the Intensive Margin surpassed the Extensive Margin in most cases. Last, the competition between the US, Russia and Australia is a major challenge for Australia in the near future. Bilaterally, Australia had surpassed traditional LNG exporters, such as Indonesia, Malaysia, and Brunei, and even Qatar. However, Australia did not perform well when compared with other emerging LNG exporters, such as Russia and the US.

The findings suggest the following policy implications. First, Australia needs to continue to improve its market competitiveness, in particular, against the new LNG market players, including the US and Russia. Reducing the cost of LNG production is a key strategy for Australia. Australia will also need to develop differentiated strategies in its LNG marketsrts. Second, Australia needs to hold its position in existing markets, in particular, growing markets such as China and India, as suggested by the dominance of the Extensive Margin. Lastly, considering the emerging changes in the LNG price mechanisms of East Asia, Australia could actively face the challenges by engaging in the development of benchmark trading hubs and gas prices in East Asia.

The current research has some limitations, which could be overcome in future work. First, we followed the practice of the CMS research and divided the whole period into sub-periods. This simplifies our analysis, but it makes us unable to identify the year-by-year dynamics of Australia's LNG export performance. Second, although we have employed the CMS to quantify bilateral competition between Australia and other LNG major exporters, there are still ambiguities that we do not address. More careful econometric testing is needed to examine the impact of factors such as relative production costs or political negotiation on bilateral competition demands.

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References

Ahmadi-Esfahani, F.Z., 2006. Constant market shares analysis: Uses, limitations and prospects. Aust. J. Agric. Resour. Econ. 50, 510–526. https://doi.org/10.1111/j.1467-8489.2006.00364.x

Ahmadi-Esfahani, F.Z., 1995. Wheat market shares in the presence of Japanese import quotas. J. Policy Model. 17, 315–323. https://doi.org/10.1016/0161-8938(94)00036-F

Ahmadi-Esfahani, F.Z., 1993. An Analysis of Egyptian Wheat Imports: A Constant Market Shares Approach. Oxford Agrar. Stud. 21, 31–40. https://doi.org/10.1080/13600819308424058

Ahmadi-esfahani, F.Z., Jesen, P.H., 1994. Impact of the US-EC price war on major wheat exporters ' shares of the Chinese market. Agric. Econ. 10, 61–70.

Arora, V., Cai, Y., 2014. U.S. natural gas exports and their global impacts. Appl. Energy 120, 95–103. https://doi.org/10.1016/j.apenergy.2014.01.054

Barnes, R., Bosworth, R., 2015. LNG is linking regional natural gas markets: Evidence from the gravity model. Energy Econ. 47, 11–17. https://doi.org/10.1016/j.eneco.2014.10.004

Batista, J.C., 2010. Theoretical basis for a method of distribution of market share changes in international trade. Rev. Econ. Contemp. 14, 499–514. https://doi.org/10.1590/S1415-98482010000300003

Batista, J.C., 2008. Competition between Brazil and other exporting countries in the US import market: A new extension of constant-market-shares analysis. Appl. Econ. 40, 2477–2487. https://doi.org/10.1080/00036840600970203

Batista, J.C., Liu, Y., 2017. Export Quality and the Dynamics of North–South Competition. World Econ. 40, 207–232. https://doi.org/10.1111/twec.12270

BP, 2019. BP Statistical Review of World Energy 2019, British Petroleum. London. https://doi.org/http://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

Chen, J., Yu, J., Ai, B., Song, M., Hou, W., 2019. Determinants of global natural gas consumption and import–export flows. Energy Econ. 83, 588–602. https://doi.org/10.1016/j.eneco.2018.06.025

Chen, Z., An, H., Gao, X., Li, H., Hao, X., 2016. Competition pattern of the global liquefied natural gas (LNG) trade by network analysis. J. Nat. Gas Sci. Eng. 33, 769–776. https://doi.org/10.1016/j.jngse.2016.06.022

Drysdale, P., Lu, W., 1996. Australia ' s Export Performance in East Asia, Pacific Economic Papers. Canberra.

EIA, 2017. Perspectives on the Development of LNG Market Hubs in the Asia Pacific Region. U.S. Energy Information Administration, Washington D.C.

Fagerberg, J., Sollie, G., 1987. The method of constant market shares analysis reconsidered. Appl. Econ. 19, 1571–1583. https://doi.org/10.1080/00036848700000084

Geng, J.B., Ji, Q., Fan, Y., 2014. A dynamic analysis on global natural gas trade network. Appl. Energy 132, 23–33. https://doi.org/10.1016/j.apenergy.2014.06.064

GIIGNL, 2018. The LNG Industry-GIIGNL Annual Report 2018. International Groupd of Liquified Natural Gas Importers, Paris.

Gilbert, J., Muchová, E., 2018. Export competitiveness of Central and Eastern Europe since the enlargement of the EU. Int. Rev. Econ. Financ. 55, 78–85. https://doi.org/10.1016/j.iref.2018.01.008

Grafton, R.Q., Shi, X.R., Cronshaw, I., 2018. "Making Cents" of the Eastern Australian Gas Market. Econ. Pap. 37, 42–54. https://doi.org/10.1111/1759-3441.12194

IEA, 2018. World Energy Outlook 2018. OECD/IEA, Paris.

IEA, 2016. World Energy Outlook 2016, International Energy Agency. IEA, Paris. https://doi.org/http://www.iea.org/publications/freepublications/publication/WEB_WorldEnergyOutlook2015ExecutiveSummaryEnglishFinal.pdf

IGU, 2019. 2019 World LNG Report. Barcelona.

Jepma, C.J., 1989. Extensions of the constant-market-shares analysis with an application to long-term export data of developing countries, in: The Balance between Industry and Agriculture in Economic Development. Springer, pp. 129–143.

Leamer, E.E., Stern, R.M., 1970. Quantitative international economics. Routledge.

Liu, Y., Shi, X., Laurenceson, J., 2018. Are China's Exports Crowding Out or Being Crowded Out? Evidence from Japan's Imports. China World Econ. 26, 1–23. https://doi.org/10.1111/cwe.12246

Merkies, A.H.Q.M., der Meer, T., 1988. A theoretical foundation for constant market share analysis. Empir. Econ. 13, 65–80. https://doi.org/https://doi.org/10.1007/BF01973315

Neumann, A., 2009. Linking Natural Gas Markets – Is LNG Doing its Job? Energy J. 30, 187–199.

Richardson, J.D., 1971. Constant-market-shares analysis of export growth 1, 227–239.

Shaikh, F., Ji, Q., Fan, Y., 2016. Assessing the stability of the LNG supply in the Asia Pacific region. J. Nat. Gas Sci. Eng. 34, 376–386. https://doi.org/10.1016/j.jngse.2016.07.011

Shi, X., 2017. Experiences of developing European gas trading hubs and their implications for China. Nat. Gas Ind. 37, 108–117. https://doi.org/10.3787/j.issn.1000-0976.2017.08.014

Shi, X., 2016. Gas and LNG pricing and trading hub in East Asia: An introduction. Nat. Gas Ind. B 3, 352–356. https://doi.org/10.1016/j.ngib.2016.12.008

Shi, X., Shen, Y., Wu, Y., 2019. Energy market financialization: Empirical evidence and implications from East Asian LNG markets. Financ. Res. Lett. 30, 414–419. https://doi.org/10.1016/j.frl.2019.02.004

Shi, X., Variam, H.M.P., 2016. Gas and LNG trading hubs, hub indexation and destination flexibility in East Asia. Energy Policy 96, 587–596. https://doi.org/10.1016/j.enpol.2016.06.032

Shi, X., Variam, H.M.P., 2015. China's Gas Market Liberalisation--The impact on China–Australia gas trade, in: Song, L., Garnaut, R., Cai, F., Johnston, L. (Eds.), China's Domestic Transformation in a Global Context. ANU Press, Canberra, pp. 137–174.

Shi, X., Variam, H.M.P., Tao, J., 2017. Global impact of uncertainties in China's gas market. Energy Policy 104, 382–394. https://doi.org/10.1016/j.enpol.2017.02.015

Shibasaki, R., Kanamoto, K., Suzuki, T., 2020. Estimating global pattern of LNG supply chain: a port-based approach by vessel movement database. Marit. Policy Manag. 47, 143–171. https://doi.org/10.1080/03088839.2019.1657974

Shuai, J., Chen, C., Cheng, J., Leng, Z., Wang, Z., 2018. Are China's solar PV products competitive in the context of the Belt and Road Initiative? Energy Policy 120, 559–568. https://doi.org/10.1016/j.enpol.2018.05.042

Siliverstovs, B., L'Hégaret, G., Neumann, A., von Hirschhausen, C., 2005. International market integration for natural gas? A cointegration analysis of prices in Europe, North America and Japan. Energy Econ. 27, 603–615. https://doi.org/10.1016/j.eneco.2005.03.002

Tyszynski, H., 1951. World Trade in Manufactured Commodities, 1899-1950. Manchester Sch. 19, 272–304. https://doi.org/10.1111/j.1467-9957.1951.tb00012.x

Wang, T., Zhang, D., Ji, Q., Shi, X., 2020. Market reforms and determinants of import natural gas prices in China. Energy 196, 117105. https://doi.org/10.1016/j.energy.2020.117105

Wang, T.T., Zhang, D., Clive Broadstock, D., 2019. Financialization, fundamentals, and the time-varying determinants of US natural gas prices. Energy Econ. 80, 707–

719. https://doi.org/10.1016/j.eneco.2019.01.026
Wang, Z.X., Zheng, H.H., Pei, L.L., Jin, T., 2017. Decomposition of the factors influencing export fluctuation in China's new energy industry based on a constant market share model. Energy Policy 109, 22–35. https://doi.org/10.1016/j.enpol.2017.06.050
Zhang, D., Ji, Q., 2018. Further evidence on the debate of oil-gas price decoupling: A long memory approach. Energy Policy 113, 68–75. https://doi.org/10.1016/j.enpol.2017.10.046
Zhang, D., Shi, M., Shi, X., 2018a. Oil indexation, market fundamentals, and natural gas prices: An investigation of the Asian premium in natural gas trade. Energy Econ. 69, 33–41. https://doi.org/10.1016/j.eneco.2017.11.001
Zhang, D., Wang, T., Shi, X., Liu, J., 2018b. Is hub-based pricing a better choice than oil indexation for natural gas? Evidence from a multiple bubble test. Energy Econ. 76, 495–503. https://doi.org/10.1016/j.eneco.2018.11.001
Zhang, H.Y., Xi, W.W., Ji, Q., Zhang, Q., 2018. Exploring the driving factors of global LNG trade flows using gravity modelling. J. Clean. Prod. 172, 508–515. https://doi.org/10.1016/j.jclepro.2017.10.244
Zhang, Y.J., Chevallier, J., Guesmi, K., 2017. "De-financialization" of commodities? Evidence from stock, crude oil and natural gas markets. Energy Econ. 68, 228–239. https://doi.org/10.1016/j.eneco.2017.09.024