Short-run and long-run Granger causality analysis of the United Kingdom’s trade patterns in the fossil energy trade

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Abstract. This study describes the trade pattern of UK fossil energy in terms of imports and exports from 1962 to 2019 and deeply explores the internal causality between the comparative advantage of export and policy interventions including import restriction and export promotion. We document that the UK has been deliberately promoted the import of fossil energy. Granger causality tests show that in the short-run, the policy intervention in import is respectively affected by the policy intervention in export and the comparative advantage of export negatively. Moreover, there are Granger causality running from comparative advantage of exports to import restriction with negative effect in the short-run and with positive effect in the long-run. When it comes to the relationship between policy intervention in export and import, export promotion causes import restriction negatively in the short-run and long-run.

1. Introduction
Britain is the pioneer of the first industrial revolution and sounds the clarion the clarion call of the age of steam. One vital reason for its successary revolution is that the Un has abundant reserves of fossil energy. Unfortunately, the paper “Our Future Energy-Creating a Low-Carbon Economy” published by the UK points out that due to the situation that the oil, coal and gas production are declining, they will replace and update most of the energy infrastructures. At the same time, it can be found that the UK is continuing to promote the development of clean energy and the generation of renewable energy surpassed fossil energy in 2019.

This paper mainly focuses on the transformation of policy intervention in the context of a change in UK fossil energy policy. Furthermore, we aim to reveal the variation tendency of comparative advantage in export and dig out the inherent causality between the policy intervention of the UK’s fossil energy imports and exports and the comparative advantages of exports.

2. Methodologies and date

2.1. Symmetric revealed comparative advantage
Generally speaking, revealed comparative advantage proposed by Balassa (1965) is applied to measuring the comparative advantage of products in export or import:

\[ RCA_{BK} = \left( \frac{X_{BK}}{X_B} \right) / \left( \frac{X_{WK}}{X_W} \right) \] (1)

\[ RCA_{KM} = \left( \frac{M_{BK}}{M_B} \right) / \left( \frac{M_{WK}}{M_W} \right) \] (2)
In the above formula, \( X \) and \( M \) respectively represent export and import. Simultaneously, \( B \) and \( K \) mean British and some kind of fossil energy. To calculate the indicator of trade policy intervention, we should symmetricalize the RCA which the range is from zero to infinity. According to the logarithmic conversion method given by Dalum, we get the symmetric revealed comparative advantage (RSCA) which has the value range of \([-1, 1]\) and the mean value of zero [1]:

\[
RSCAX_{BK} = \frac{(RCAX_{BK} - 1)}{(RCAX_{BK} + 1)}
\]

\[
RSCAM_{BK} = -\frac{(RCAM_{BK} - 1)}{(RCAM_{BK} + 1)}
\]

Taking export for example, when \( RSCA_{BK} > 0 \), there must exit \( RCA_{BK} > 1 \), denoting that comparative advantage in export is existent for country British. When \( RSCA_{BK} < 0 \), there must exit \( RCA_{BK} < 1 \), implying comparative disadvantage of \( K \) energies. When \( RSCA_{BK} = 0 \), the comparative advantage of \( K \) energies of country British is non-existent, which means that there is neither comparative advantage nor comparative disadvantage [2].

2.2. Policy intervention index

Hechel-orlin model shows that the products which one country manufacture professionally and export frequently should have comparative advantage and use abundant elements to output, but according to the free trade theory provided by David Ricardo, one country should tend to export more and import less of a product with a stronger comparative advantage [3][4]. \( RSCA_{BK} \) and \( NX_{BK} \) should be consistent in equilibrium. Thus, we get the following equation:

\[
NX_{BK} = RSCA_{BK}
\]

This formula is one sufficient condition for free trade and the difference between \( NX_{BK} \) and \( RSCA_{BK} \)

\[
hm_{BK} = NX_{BK} - RSCAM_{BK}
\]

\[
hx_{BK} = NX_{BK} - RSCAX_{BK}
\]

is the indicator of policy intervention in import and export. Meanwhile, it measures the actual disparity between net export capacity and comparative advantage when British have some comparative advantage of fossil energy product \( k \) in import or export. If \( hx > 0 \), it shows that the net export capacity is more than the level of comparative advantage and the government adopt the export promotion policy. On the contrary, if \( hm > 0 \), there is import restriction policy having been applied.

2.3. Weighted average policy intervention index

There are many fossil energy including \( N \) specific products we research, so if we want to be able to reflect their general level, we can use the weighted average to compare and analyze all types of goods from both horizontal and vertical aspects.

Therefore, in order to obtain the import and export trade intervention index of the entire product category, it is necessary to weight every specific product of fossil energy.

\[
HM_{BJ} = \sum_{k=1}^{N} w_{BK} (NX_{BK} - RSCAM_{BK})
\]

\[
HX_{BJ} = \sum_{k=1}^{N} w_{BK} (NX_{BK} - RSCAX_{BK})
\]

In the above formula, \( HM_{B} \) represent the trade policy intervention index of import of the category \( J \) products and \( HX_{B} \) have the same meaning in export. The weight

\[
w_{BK} = \frac{(X_{BK} + M_{BK})}{\sum_{k=1}^{N}(X_{BK} + M_{BK})}
\]

is the proportion of each specific \( k \) product in the import and export trade of UK fossil energy products and the reason for choosing the total trade amount of import and export instead of import
amount is that there are inevitable reference of import and export amounts when we calculate the indicator of h and H [5].

More importantly, when we weight the NX of the category J products, the method is the same as above equation. But the way weighting the indicator of RSCA, there have some difference that the weight we use is the proportion of UK imports (or exports) of products K in the total imports (or exports) of category J products [6].

2.4. Source of date
This study uses the annual trade data of 1962-2019 from UN Commodity Trade Statistics Database under the first edition classification of Standard International Trade (SITC Rev.1).

For narrowing the range of fossil energy needed, we firstly translate the one-digit code in the SITC Rev.1 and determine that the third and fifth categories are related products. Then, according to the related method of classification for fossil energy [7], we took the United Kingdom as the reporting country and identified five three-digit codes including “coal, coke and briquettes” (code 321), “petroleum, crude and partly refined” (code 331), “petroleum products” (code 332), “gas, natural and manufactured” (code 341) and “mineral tar” (code 521).

3. Evolution of British import and export trade patterns

3.1. The evolution of UK trade patterns
Figure 1 reveals the change path of RSCAXBj, HXBj, and HM Bj from 1962 to 2019 in UK import and export of fossil energy.

![Figure 1. The trade pattern of UK fossil energy imports and exports](image)

Firstly, weighted averaged RSCAXBj fluctuated upwards before 1981 but was always negative and since 1982, it showed a downward trend of fluctuations and remained positive. Unfortunately, it turned from positive to negative and continued to decline during the period of 1983-2015 while in 2016, there was a turning point that the index continued to rise. This complex trend is consistent with the fact that the United Kingdom’s support for fossil energy exceeded 12 billion euros and became the EU country with the most fossil energy subsidies. The entire curve indicates that the UK’s fossil energy exports have turned from comparative disadvantage to advantage, but the degree of comparative advantage is declining.

Secondly, HXBj, having varied distinctly during the sample period, was negative before 1976 but turned to positive after 1977 and in the 2006, it is negative again. This means that the UK has gradually changed from export promotion to restricting exports in the field of fossil energy trade. This conclusion is in line with Britain’s current attitude towards fossil energy exports.
Thirdly, HM$_{ij}$ had been negative, which explained that the import trade policy acted by the UK government is not restrictive, but encouraging.

3.2. ADF unit root tests

ADF unit root tests is the first step of our empirical analysis and the results are as follows.

| Variable | Specification | ADF   | Prob. | Variable | Specification | ADF   | Prob. |
|----------|---------------|-------|-------|----------|---------------|-------|-------|
| HM$_{ij}$ | NN1           | -1.0912 | 0.2462 | ΔHM$_{ij}$ | NN0           | -5.1420 | 0.0000 |
| HX$_{ij}$ | NN0           | -1.2167 | 0.2026 | ΔHX$_{ij}$ | NN0           | -6.5802 | 0.0000 |
| RX$_{ij}$ | NN1           | -2.3482 | 0.0195 | ΔRX$_{ij}$ | NN0           | -5.2934 | 0.0000 |

a. "C, T, p" show the model specification, which stands for intercept, trend, and the lag length respectively. The symbol of "N" is used when there is no an intercept or a deterministic time trend.

According to table 1, the level time series of HM$_{ij}$ and HX$_{ij}$ are non-stationary, fortunately, the first differences of them are stationary. The indicator of RSCA$_{ij}$ is stationary in both the level and first difference. So we could get the result that three indicators involved are first-order integrated, which denotes co-integration and furthermore granger causality test can be performed in the next analyses.

3.3. Johansen Co-integration Test

In this Johansen Co-integration test, by adopting the methods Yu Hong used, we find that the optimal value of lag periods for VAR is 11 and the optimal lag interval in the VECM is 1-10.

| Test       | Data Trend: | None | None | Trend | Trend | Quadratic |
|------------|-------------|------|------|-------|-------|-----------|
| Lag Interval: 1-10 | Test Type: No Const. No Trend | Const. No Trend | Const. No Trend | Const. Trend | Const. Trend |
| Vector: HX, HM, RSCA | Trace 3 | 3 | 3 | 3 | 3 |
|              | Max-Eig 3 | 3 | 3 | 3 | 3 |
|                | AIC -9.2065 | -9.4344 | -9.4293 | -9.9058 | -10.1080* |
|                | SC -5.4275 | -5.6160 | -5.5321 | -5.9693 | -6.0928* |

a. The figure shows the number of co-integrating relations identified by Trace test and Max-eigenvalue test;
b. * indicates the optimum test type as selected by AIC and SC criteria.

It is evident that there is at least one long-term equilibrium co-integration relationship between three variables involved at the 10% significance level under five possible test forms. Hence, we establish five corresponding VECM models at different data trend and test type and obtain the AIC and SC values successfully. Finally, by comparing those values, it is determined that the fifth type of VECM is optimal, that is, “the sequence space has a quadratic trend, and the co-integration space contains intercept and linear.”

4. Results for Granger causality tests

4.1. Short-run Granger causality test results

Table 3 summarizes the results of the short-run Granger causality tests across the indicators of HX, HM and RX.
Table 3. Results of short-run Granger causality tests

| Variable | ΔHM | ΔHX | ΔRX |
|----------|-----|-----|-----|
|          | $\chi^2$ (Prob.) | SE | $\chi^2$ (Prob.) | SE | $\chi^2$ (Prob.) | SE |
| ΔHM      | —   | —   | 11.3352 (0.3320) | —   | 6.4567 (0.7755) | —   |
| ΔHX      | 80.5528 (0.0000) | -7.7843 | —   | —   | 7.7196 (0.6562) | —   |
| ΔRX      | 68.3979 (0.0000) | -16.1708 | 12.9533 (0.2263) | —   | —   | —   |

a. In the brackets are the probabilities of Chi-sq statistics of short-run Granger causality tests.

Two results can be identified for the short-run Granger causality tests. Firstly, HX Granger causes HM negatively, which means that the greater the degree of policy intervention on exports, the smaller the restrictions on imports.

Secondly, there is significant Granger causality runs from RX to HM with negative effect. It reveals that the comparative advantage of export is counterproductive to import restrictions.

4.2. long-run Granger causality test results

Table 4 summarizes the results of long-run Granger causality tests.

Table 4. Results of long-run Granger causality tests

| Variable | ΔHM | ΔHX | ΔRX |
|----------|-----|-----|-----|
|          | F-Stats. (Prob.) | LE | F-Stats. (Prob.) | LE | F-Stats. (Prob.) | LE |
| ECT      | -5.9910 (0.0000) | —   | 2.0576 (0.1734) | —   | 0.8717 (0.3663) | —   |
| ECT,ΔHM  | —   | —   | 1.0794 (0.4385) | —   | 1.4957 (0.2361) | —   |
| ECT,ΔHX  | 7.4666 (0.0004) | -0.4588 | —   | —   | 0.69780 (0.5061) | —   |
| ECT,ΔRX  | 6.4973 (0.0008) | 0.1287 | 1.1936 | —   | —   | —   |

a. In the brackets are the probabilities of F-stats of long-run Granger causality (Wald) tests.

Table 4 reveals three major results for the long-run Granger causality tests that:

1) there exit significant causal relationship between ECT and HM. Therefore, the long-run equilibrium co-integration relationship among HX, HM and RX is one Granger cause for HM in the long-run.

2) Granger causal relationship is from HX to HM with negative effect, meaning that the more exports are encouraged, the more imports will be restricted; and

3) the changes in the degree of comparative advantage of exports lead up to the changes of import restriction in the same direction.
5. Conclusions
This paper used the trade data from 1962 to 2019 provided by UN Comtrade Database to calculate the net export ration, symmetric revealed comparative advantage and policy intervention index of UK fossil energy products, and four conclusions are documented as following:

1) the comparative advantage in export of UK fossil energy shows a complicated trend that successively experiences a process of comparative disadvantage, advantage and disadvantage. Until 2018, it begins to turn to comparative advantage and the degree of that shows an increasing trend;

2) the UK’s policy intervention in fossil energy has been deep over time. In terms of import, encouraging measures are always taken but it is export that has undergone tremendous changes which the government starts to promote exports from the beginning of restriction to 1977 and until 2007, it has begun to restrict the export of fossil energy;

3) Granger causality runs from the comparative advantage of export and policy intervention in export to policy intervention in import respectively with negative short-run effect; and

4) in the long-run or short-run, there exit causal relationship between the comparative advantage of export and the import restriction, but in the short-run, the effect is negative and is adverse in the long-run. At the same time, from the perspective of the relationship between policy intervention in export and import, export promotion causes import restriction negatively in short-run and long-run.

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