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RESEARCH ARTICLE

Russia-EU gas game analysis: evidence from a new proposed trade model

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Abstract
This paper represents a new proposed trade model of "Intercountries Trade Force (ITF)" which is inspired by Intermolecular Interaction Forces in chemical sciences, and has potential to compensate for the deficiencies of the gravity trade model proposed by Jan Tinbergen in 1962. The main differences between our new model and the earlier gravity trade theory are (i) there is a time-variant variable called the gravity index (GI) which means that the earlier gravity theory was treated as only a variable in our new proposed model and (ii) our new proposed trade model has a higher chance of adoption in the real trade world rather than the earlier gravity trade model which always needs to be expanded by scholars. In order to empirically test our new proposed trade model, we applied it in an empirical econometric model to analyze the Russian gas export to the EU member states, not explored earlier. Results revealed that our new trade proposed model adjusts with the empirical energy trade pattern.

Keywords Trade pattern · Gas export · Trade theory

JEL Classification F10 · Q43 · C23

Introduction

The approach of gravity model of international trade proposed by Jan Tinbergen in 1962 has been widely used by many scholars in order to analyze bilateral or multilateral trade patterns between countries or groups of countries. The trade theory is derived from Newton's physics theory of gravitation expressing that attraction increases with mass and decreases by distance. Tinbergen (1962) applied this physics theory to the international trade and explained that bilateral trade pattern between two countries has a positive relationship with the economic size of the two countries, while it has a negative relationship with geographical distance between them.

Although this trade theory was developed and used by a large number of scholars such as Projan (2001), Okubo (2007), Masudur Rahman and Arjuman Ara (2010), Taguchi (2013), Bialynicka-Birula (2015), Mazhikeyev et al. (2015), Caporale et al. (2015), Ulengin et al. (2015), Santana-Gallego et al. (2016), De Mello-Sampayo (2017), and Kabir et al. (2017), this physics-based model is not compatible with economics. In the real trade world, there are various factors, two of which (economic size and geographical distance) shape the trade pattern between nations. Therefore, many scholars have tried to expand the basic form of Tinbergen's trade theory to adapt to the real trade world. For example, Koo et al. (1994) added two variables of long-term agreements and import quotas to the basic gravity trade formula to analyze meat trade policies. Molini and Filippini (2003) introduced a new variable called "technological distance" to determine the East Asian trade flows through the gravity trade theory. Anderson and Wincoop (2003) revised the theoretical foundation through the concept of multilateral resistance (MR) which refers to the theoretically appropriate average trade barrier. Yu (2010) added some variables to the basic form of gravity trade to investigate the effects of democracy on trade. Narayan and Nguyen (2016) modified the primary form of gravity trade by adding openness of trading partners and exchange rate to test the trade gravity model dependency on trading partners.

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Due to the lack of adequate compatibility of gravity trade theory with the real trade world, we introduced a new trade model called Intercountries Trade Force (ITF) which is derived from the chemical theory of Intermolecular Interaction Forces (IMFs). Our new proposed trade model bridges the gap in the gravity trade theory. Therefore, we expect that our new trade model can create a more efficient link between trade theory and trade reality which was the main shortage of the physical-gravity trade model.

To empirically analyze the new proposed trade model, we formulated it in the form of econometric model and performed estimations for the case of Russia-EU gas trade flows. It should be noted that we did not find any study considering econometrical analysis of the Russian gas export into the EU member states. Therefore, major novelties of our work include introducing a new and more compatible trade model, and analyzing the Russia-EU gas trade flows through a new proposed trade model.

This study is organized as follows: An introduction to the model of Intercountries Trade Force (ITF) is addressed in the "Intercountries Trade Force model" section. The "Empirical examination of ITF: case of Russia-EU gas trade pattern" section elaborates on the "Empirical examination of ITF: the case of Russia-EU gas trade pattern" dealing with the characteristics of Russian gas export into the EU member states, datasets, and model specification. The "Empirical estimations" section addresses the empirical estimation results, and lastly, the "Concluding remarks" section concludes the paper.

Intercountries Trade Force model

In chemical sciences, Intermolecular Interaction Forces (IMFs) refer to any forces which mediate interactions between molecules. The theory of IMFs is based on the nature of microscopic forces which was found in Alexis Clairaut's work. In chemical sciences, this theory can represent what makes the molecules attracted to each other. Generally, the theory of IMFs is considered by several types such as ion-induced dipole forces, ion-dipole forces, and hydrogen bonding. A special case of IMFs is Keesom interaction which was proposed by Willem Hendrick Keesom and is based on the attraction between dipolar molecules and temperature (Appendix).

With some assumptions, it is possible to adopt the chemical equation in the international trade concept:

$\frac{m_1 m_2}{r}$ can be considerd similar to the Newton's gravity model. In our proposed trade model, we consider it as a time-dependent variable called "gravity index" which expresses the gravitational interaction between countries. In the gravity trade theory, this equation was the basic concept of the econometric model, while in the new trade model, the concept is considered only an independent variable, explaining the magnitude of trade flows between nations. A larger magnitude of gravity index for the two nations depicts a more appropriate circumstance of interaction. It should be mentioned that gravity index (GI) contains economic size and geographical distance as two important variables influencing trade flows between nations.

Another quantitative variable in our proposed model is the free space of trade (FST) for country "*i*" as its trading partner(s) which can be formulated for aggregated trade data:

$$\mathrm{FST}_t = \frac{\mathrm{Trade}_{j(w-i)t}}{\mathrm{Trade}_{jt}} \tag{1}$$

where $\mathrm{Trade}_{j(w-i)t}$ denotes the trade flows between country *j* and the world minus country *i*, while Trade_{jt} represents the total volume of country *j*'s trade. A larger FST of the trade partner of country *i* reveals a less free space to trade and a smaller FST shows a higher free trade space to do trade with country *j*.

Temperature (*T*) is treated as all other variables such as population, urbanization, industrial growth, economics agreements, and common border affecting and shaping bilateral trade flows between countries. Absence of this variable in the gravity trade theory leads the earlier trade theory to be adopted less often in the real trade world.

According to the above variables, our basic econometric model which is based on the Intercountries Trade Force (ITF) model can be formulated as:

$$\mathrm{Trade}_{ijt} = \alpha_0 + \alpha_1 \cdot GI_{ijt} + \alpha_2 \cdot \mathrm{FST}_t + \alpha_3 \cdot T_t + \varepsilon_t \tag{2}$$

where Trade shows trade flows between countries *i* and *j*, GI denotes the gravity index between countries *i* and *j* at time *t*, FST represents free space of trade, and *T* contains all variables affecting bilateral trade flows between countries.

In contrast with the earlier gravity trade theory, there is no individual account of economic size and geographical distance. We included these two variables in the gravity index.

Empirical examination of ITF: case of Russia-EU gas trade pattern

To empirically examine the ITF, we considered the case of Russia-EU gas trade pattern which is not explored in earlier studies.

Russia-EU gas trade overview

The volume of consumption of natural gas has been increased rapidly around the world (Saboori et al. 2017). The major end uses of this kind of energy in different nations are electric power generation, industrial, residential, commercial, lease and plant fuel consumption, pipeline and distribution, and vehicle fuel. The vast economic scope using natural gas is the main component of increased global volume of energy, particularly natural gas. Besides, natural gas' more environment-friendly nature rather than other fossil fuels has formed this energy source as a preferential one in last decades. According to Solarin and Shahbaz (2015) and Zhang et al. (2019), natural gas consumption emits 50% less environment pollution compared with other fossil fuels, which pushes countries, particularly European ones, to use it more rather than coal or crude oil.

According to the BP statistical review of world energy 2017, while primary energy consumption has been increased from 3730.7 million tonnes oil equivalent in 1965 to 9390.5 million tonnes oil equivalent in 2000 and 13276.3 million tonnes oil equivalent in 2016, natural gas consumption has increased significantly from 643.1 billion cubic meters in 1965 to 2417.8 and 3542.9 billion cubic meters in 2000 and 2016, respectively.

The increased importance of natural gas role in the economy of countries has changed gradually this energy source to a strategic commodity creating various global and regional geoeconomics and geopolitical issues in natural gas importers and exporters. Yegorov and Wirl (2011) express that developing natural gas transportation needs the mixture of geography, politics, and technology matters. Medlock et al. (2014) emphasize on this fact that the global gas market is making the global superpowers like the USA, China, and Russia to care more about geopolitical and geoeconomics topics. Furthermore, Sudhir Kulkami and Kristle Nathan (2016) go further and consider gas trade as a main factor influencing on energy security and geopolitics of nations. They believe that in many countries, natural gas trade is classified in energy and national securities and has been considered as a top national issue in the current decade.

Gas export from the Russian Federation to the EU is one of the most potential economic-political issues which categorized in national security of both trade sides. Lund Sagen and Tsygankova (2008) express that the EU gas market is vital for the Russian federal budget, whereas the Gazprom (the dominant Russian gas company) supplying gas to the EU is an essential article of the EU energy security (Rasoulinezhad and Saboori, 2018). Soderbergh et al. (2010) mention that the gap between EU gas supply and demand may require an 87% increase of import volumes by 2030 and Russia rather than Norway or Algeria is likely to play a major role of meeting the anticipated growing gas demand of the EU.

Since the first gas pipeline construction agreement between the USSR and Germany in 1970s, the gas trade structure between these two gas supplier-consumer has been shaped, and in the last decades, by serious efforts to construct new gas pipelines such as Nord-Stream 2, the gas trade tie between them has been strengthened more and more. According to the BP statistical review of world energy 2017, the main gas markets of the Russian Federation are the European Union and the CIS. In 2016, the Russian gas export volume to the EU was 166.13 billion cubic meters, whereas Germany (46.01 billion cubic meters), Turkey (23.17 billion cubic meters), and Italy (22.70 billion cubic meters) were the main gas export destinations of Russia among the EU member states in 2016. Furthermore, the Russian Federation is the main gas supplier of the EU among all other global gas exporters. Russia, Norway, the Netherlands, and Algeria were the main EU gas suppliers with the contributions of 39.95%, 26.30%, 12.58%, and 7.81%, respectively to the total EU gas imports in 2016.

This level of gas trade integration and interdependence relationship highlight the importance of analyzing the EU-Russia gas trade which has not been drawn attention by earlier studies. Despite some focus on different aspects in gas trade between Russia and the EU by a number of scholars such as Quast and Locatelli (1997), Spanjer (2007), Baker Schaffer (2008), Soderbergh et al. (2010), Le Coq and Paltseva (2012), Konoplyanik (2012), Locatelli (2015), Khrushcheva and Maltby (2016), Sharples (2016), Tichy and Odintsov (2016), Mitrova et al. (2016), Stulberg (2017), and Dignum et al. (2018), we did not find any serious study concentrating on the gas trade pattern between Russia and the EU via a reliable empirical trade model.

Data and Model

The data for this study was gathered annually from 2006 to 2017 for the gas export flow from Russia to the EU member states. The five quantitative variables comprise gas export (GE), gravity index (GI), free space of trade (FST), urbanization growth (UR), and bilateral exchange rate (EX).

Primary data were gathered from the World Bank to calculate GI (measured in thousand US $ to kilometers) and UR (http://data.worldbank.org). Data for Russia's gas export and FST were collected from the Russian Federation State Statistics Service (http://gks.ru). The source of the data on bilateral exchange rate between the Russian Federation and the EU member states is The Central Bank of the Russian Federation (http://cbr.ru). Besides the quantitative variables explained above, we used two dummy variables affecting the gas export flow from Russia to the EU. The first one is SANC (sanctions imposed by the West against Russia since 2014) and the second one is WTO (Russian membership to WTO in 2012). Table 1 provides primary characteristics of the research variables:

Table 2 illustrates descriptive statistics (mean and standard deviation) associated with quantitative variables namely Russian gas export into the EU member states, GI, FST, urbanization growth, and exchange rate. The mean of Russian gas export to the EU member states is nearly 34,187,000 US dollars, while its stability (standard deviation) is quite high during

Table 1 Primary characteristics of variables

Variable	Definition	Unit
LGE	Logarithm of Russian gas export flow into the EU member states	Thousand US $
LGI	Logarithm of gravity index (GI)	US $/km
LFST	Logarithm of free space of trade (FST)	Thousand US $
LUR	Logarithm of urbanization level in the selected countries	Percent (%)
LEX	Logarithm of bilateral exchange rate	Russian ruble/national currency of country *j*
SANC	Dummy variable taking a value of 1 if there are sanctions against Russia, otherwise it will be 0	Dummy [0,1]
WTO	Dummy variable taking a value of 1 in years of Russia's membership to the WTO, otherwise it takes 0	Dummy [0,1]

Trade openness is the sum of exports and imports as a share of GDP

Source: authors' compilation

2006–2017. Based on the data, GI has a mean of 4.00E+20 which is so high and shows an optimum condition for economic ties between Russia and the EU. The FST which is measured in thousand US dollars has the mean of approximately 103,418 (nearly 103,418,000 US dollars). Considering the Russian gas export to the EU, the high mean of the FST reveals a trade potential in the gas field between Russia and the EU. In realizing the urbanization growth, it can be seen that the total EU member states reached the mean of 72.94% urbanization during 2006–2017. Finally, in terms of bilateral exchange rate, the Russian ruble has a mean of 18.48 with standard deviation of 29.46 contrasted to the national currencies of the EU member states over the period of 2006-2017.

To explain the Russian gas export pattern to the EU member states, we use our new trade model named the Intercountries Trade Force model. Following our explanations of this new proposed trade model in the last section, our econometric model can be written as:

$$\ln GEx_{ij} = \beta_0 + \beta_1 \ln \mathrm{GI}_i + \beta_2 \ln \mathrm{FST}_j + \beta_3 \ln \mathrm{UR}_{ij} + \beta_4 \ln \mathrm{EX}_{ij} + \beta_5 \mathrm{SANC} + \beta_6 \mathrm{WTO} + \varepsilon_{ij} \quad (3)$$

where the Russian gas export flows (GE) depends on gravity index, free trade space, urbanization growth, bilateral exchange rate, the West-imposed sanctions against Russia since 2014, and Russia membership to WTO since 2012.

To estimate the econometrics of our Intercountries Trade Force (ITF) model, we considered several preliminary analyses. The first preliminary test comprises of the panel unit root tests. The results of the first preliminary test showed whether all our variables can be integrated in the same order. To achieve more reliable results, we ran three types of the panel unit root tests, namely Levin, Li, and Chu (LLC), ADF-Fisher, and PP-Fisher statistics. The second preliminary analysis was performed in the situation in which the results of the panel unit root tests proved same the order integration of all the series. In this situation, we employed the Pedroni panel co-integration containing seven various statistics which contain 4 within-dimension statistics and 3 between-dimension statistics (these statistics allow for heterogeneity of the variables in cross sections). When the results of the Pedroni panel co-integration indicated a long-run relationship between variables, the co-integration panel model could be run. In this study, the panel fully modified ordinary least squares (FMOLS) was applied as an estimator of this kind of panel model is applied.

Empirical estimations

Prior to representing the model estimation results, we consider the findings in preliminary tests in the earlier section. As we stated above, the first preliminary test determined the stationarity of all the underlying series. To this end, three panel unit root tests, namely LLC, ADF-Fisher, and Philips-Perron-Fisher tests, were performed for the variables at levels and first differences. The findings of the first preliminary analysis are listed Table 3.

According to Table 3, it is obvious that all the series are non-stationary at levels and stationary at their first difference which means the integration of variables at $I(1)$. Integration of

Table 2 Summary statistics for the variables, 2006–2017

	Gas export volume (thousand US $)	Gravity index (US $/km)	FST (thousand US $)	Urbanization (%)	Bilateral exchange rate (ruble/currency *j*)
Mean	34187.45	4.00E+20	103418.8	72.94	18.48
Stdev	96162.87	5.57E+20	580644.5	12.27	29.46

Source: authors' compilation

Table 3 Panel unit root test results

Variable	Levin, Lin, and Chu *t*	ADF-Fisher chi-square	Philips-Perron-Fisher chi-square	H0 (majority)	Stationary
LGE	− 0.18 [0.29]	23.48 [0.34]	11.49 [0.87]	Accept	No
D(LGE)	− 17.83 [0.00]	163.21 [0.00]	182.83 [0.00]	Reject	Yes
LGI	− 0.47 [0.51]	4.28 [0.76]	6.87 [0.25]	Accept	No
D(LGI)	− 18.95 [0.00]	192.75 [0.00]	168.07 [0.00]	Reject	Yes
LFST	− 0.09 [0.48]	5.19 [0.16]	7.74 [0.36]	Accept	No
D(LFST)	− 147.89 [0.00]	413.07 [0.00]	493.79 [0.00]	Reject	Yes
LEX	1.82 [0.96]	11.32 [1.00]	10.53 [1.00]	Accept	No
D(LEX)	− 10.23 [0.00]	170.34 [0.00]	170.56 [0.00]	Reject	Yes
LUR	− 0.11 [0.33]	41.69 [0.79]	37.30 [0.90]	Accept	No
D(LUR)	− 15.29 [0.00]	163.94 [0.00]	170.39 [0.00]	Reject	Yes

Numbers in brackets indicate *p* values

LGE, LGI, LFST, LEX, and LUR indicate logarithm of Russian gas export into the EU, logarithm of gravity index, logarithm of free space of trade, logarithm of bilateral exchange rate, and logarithm of urbanization, respectively

Source: authors' compilation

variables at $I(1)$ allows us to move to the second preliminary test which is Pedroni panel co-integration test. The results of this test are shown in Table 4.

Considering all the panel, group, and weighted statistics, six statistics out of the seven are less than 0.1. Therefore, majority of all statistics tests demonstrate significance at 10% significance level. In other words, the results show an evidence of long-run relationships between our variables.

Since the Pedroni co-integration test proved a long-run relationship between variables, the co-integrating coefficients of the series were estimated by the panel co-integration model. Running the FMOLS as a popular estimator of the panel co-integration model to find out the Russia's gas export pattern to the EU within the gravity trade framework represents the empirical findings listed in the Table 5.

Gravity index (GI) has a significantly high positive coefficient. By 1% increase in gravity index (the mix of economic size and distance), the Russian gas export to the EU member states may increase to nearly 2.18%. The coefficient for the free space of trade (FST) reveals the positive relationship between this variable and Russia's gas export to the EU. For urbanization level, it can be seen that although these variables are negative for gas import of the EU states from Russia, it has the largest magnitude among gravity variables. By a 1% increase in urbanization level of the EU members, the volume of gas export from Russia to these states may decrease by approximately 4.4%. It should be noted that earlier studies have demonstrated positive relationship between urbanization (population density in urban) and energy consumption. In the case of our study, the negative relationship between urbanization and gas imports of EU from Russia means that by increasing population density, EU member states need more energy sources to use and it may be a signal to more dependence on Russia's gas export. The negative long-run relationship reveals that the EU would not want to accept more dependence on Russia's gas export, which may lead to diversification in the EU energy basket or diversification in the EU energy providers. Regarding the bilateral exchange rate, it is clear that a 1% depreciation in bilateral exchange rate between Russia and the EU member states increases the gas export flow of this country to the EU states by nearly 1.6%. In the case of the West's sanctions against Russia and WTO membership, results show that these two dummy variables have statistically significant effect on Russia-EU gas trade flow. Imposing sanctions by the West (the USA and the EU) against Russia since 2014 led to the increase of Russia's gas export to the EU member states by nearly 1% (1% = Exp [0.01] − 1), while Russia's membership in WTO in 2012 accelerated Russia's gas export to the EU member states by approximately 6 % (6.18% = Exp [0.06] − 1). In other words, analyzing

Table 4 Pedroni panel co-integration test results

	Statistic	Prob.	Weighted statistic	Prob.
Panel *v*-statistic	− 3.27	0.99	− 8.87	1.00
Panel rho statistic	5.72	1.00	5.57	1.00
Panel PP statistic	− 2.14*	0.01*	− 7.34*	0.00
Panel ADF statistic	− 1.28*	0.00	− 3.62*	0.00
Group rho statistic	7.71	1.00	–	–
Group PP statistic	− 10.82*	0.00	–	–
Group ADF statistic	− 1.99*	0.02	–	–

*Statistical significance at the 10% level

Source: authors' compilation

Table 5 ITF (Intercountries Trade Force) model estimation: Russia-EU gas export

Dependent variable	Variables	Coefficient	*t*-statistic	Prob.
Gas export	Gravity index (GI)	2.18	44.79	0.00
	Free space of trade (FST)	0.28	5.61	0.00
	Urbanization (UR)	− 4.48	− 279.10	0.00
	Bilateral exchange rate (EX)	− 1.67	− 55.84	0.00
	Sanctions (SANC)	0.01	67.27	0.00
	WTO accession (WTO)	0.06	15.67	0.00

Source: authors' compilation from Eviews 9.0. *GDP*, gross domestic product

Numbers in brakets show *p* value

membership in WTO as a proxy for globalization and imposing sanctions as a proxy for de-globalization shows that the effect of globalization (according to the coefficient of WTO accession) is more than the effect of de-globalization (imposing sanctions) for Russia. Due to the weak effect of sanctions of the West against Russia, the Russia-EU trade volume including energy sources has increased from 202,201 million US dollars in 2015 to about 294,392 million US dollars in 2018 (Trademap.org).

Concluding remarks

A severe shortage of the gravity trade theory is its non-compatibility with the real trade world. Since the main formula of the gravity trade theory contains only two variables named economic size and geographical distance, many scholars have tried to compensate for this shortage by adding several different quantitative and dummy variables.

In this study, we introduced a new trade model named the Intercountries Trade Force (ITF) extracted from the chemical sciences. Our new proposed trade model bridges the gap in the earlier physics gravity trade theory. Overall, the major differences of our new introduced model with the earlier gravity trade theory can be expressed as follows: (i) in our new trade model, the formula of the earlier gravity trade theory changed to a time-dependent variable named gravity index. Thus, the gravity trade theory is only an index in a form of quantitative variable in our new trade model; (ii) the limitation of number of variables affecting trade flows which is in the gravity trade theory was compensated by variable "T = temperature in chemical formula" representing all the variables affecting trade flows between nations; (iii) in the new proposed trade model, there is a variable named "free space of trade" which indicates trade space between countries i and j, by considering the volume of trade between country j and the world.

To empirically test our new trade model, we constructed a panel data framework for the case of Russia-EU gas trade flows for a large data from 2006 to 2017. In doing so, we performed various panel unit root tests to seek the variables' order of integration. The long-run relationship among Russian gas export to the EU member states was analyzed as an independent variable and regressors by using the Pedroni panel co-integration test. Moreover, the long-run coefficients were investigated by applying the fully modified OLS (FMOLS).

The empirical results indicated that by a 1% increase in gravity index (the mix of economic size and distance), the Russian gas export to the EU member states may increase nearly 2.18%. The coefficient for the free space of trade (FST) reveals the positive relationship between this variable and Russia's gas export to the EU. By a 1% increase in urbanization level of the EU members, the volume of gas export from Russia to these states may decrease by approximately 4.4%. Regarding the bilateral exchange rate, it is clear that a 1% depreciation in bilateral exchange rate between Russia and the EU member states increases the gas export flow to the EU states by nearly 1.6%. Sanctions imposed by the West (the USA and the EU) against Russia since 2014 has led to an increase in Russia's gas export to the EU member states by nearly 1%, while Russia's membership in WTO in 2012 has accelerated Russia's gas export to the EU member states by approximately 6.1%.

The research suggests that:

1. The structure of our new trade model proves that it fits the data reasonably better than the earlier gravity trade theory which was introduced by Jan Tinbergen in 1962. Hence, employing the Intercountries Trade Force (ITF) model in the academic studies is more reliable than employing the earlier gravity trade model which has a shortage in compatibility with the real trade world.
2. The link between ITF model and the empirical econometric models are more logical than between gravity trade theory and the econometric models. Because in the new trade model, we have a new variable which represents all variables influencing on trade flows between nations.
3. Considering the empirical estimations for the case of Russia-EU gas trade flows shows that sanctions against Russia and its membership in WTO as well have a positive impact on its gas export to the EU member states.

Further research should try to explain our new trade model through the CGE or DSGE framework which can develop the theoretical base of our new trade model. Furthermore, empirically comparison of the gravity trade theory and our Intercountries Trade Force model for a case study in energy fields may be interesting which we suggest for future studies.

Appendix

In chemical science, Kessom interaction can be shown by the following formula:

$$V = \frac{-m_1^2 m_2^2}{24\pi^2 \varepsilon_0^2 \varepsilon_r^2 k_b T r^6} \tag{4}$$

Here, m indicates the dipole moment, ϵ_0 and ϵ_r represent free space, and dielectric constant of surrounding material, respectively. T is temperature, k denotes Boltzmann constant, and r shows distance between molecules.

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