МАКРОЭКОНОМИЧЕСКАЯ ТЕОРИЯ И МОДЕЛИРОВАНИЕ

Thirlwall's Law: An Application to Poland[1]

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Abstract. The present study validates assumptions of Thirlwall's law and illustrates its implication for Poland. Furthermore, a rarely used "strong" form of Thirlwall's law is tested. This law reflects the importance of trade balance restrictions on economic growth prospects. This aspect is now very relevant. The research aims to find out whether both forms of Thirlwall's law are valid in Poland. The assumption that the relative prices do not influence trade performance of Poland does not hold, therefore, influence of terms of trade was considered and the balance of payments (BOP) constrained growth rate was calculated with and without terms of trade effect. For the "strong" form of Thirlwall's law, the existence of correlation between growth of income of Poland and the rest of the world was tested. The existence of cointegration between rates of growth of export and gross domestic product (GDP) is tested as a main idea of growth model based on export. After verifying that all assumptions of the model hold, Autoregressive Distributed Lag (ARDL) cointegration approach and error correction model are applied to estimate income elasticities. Further, statistical equality of growth rates of predicted and real GDP was tested to validate Thirlwall's law, and it supports the importance of external imbalances for Polish economy for the period between 1995 and 2018. Both "weak" and "strong" forms of Thirlwall's law turned to be valid. Further research may focus on testing the validity of assumptions of Thirlwall's law on data from other countries of Eastern Europe, as well as post-Soviet countries, since there are very few such studies to date.

Keywords: balance of payments constrained growth model, demand-led growth, real exchange rates, terms of trade

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Закон Тирлвола: применение на данных Польши

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Аннотация. Это исследование направлено на проверку обоснованности предпосылок закона Тирлвола и его применения к данным Польши. Кроме того, проверяется редко используемая «сильная» форма закона Тирлвола. Этот закон отражает важность ограничений, связанных с внешнеторговым балансом, для перспектив экономического роста. Данный аспект является сейчас очень актуальным. Цель нашего исследования — выявить, соблюдаются ли обе формы закона Тирлвола в Польше. Предпосылка о том, что относительные цены не влияют на показатели торговли Польши, не подтверждается, поэтому было рассмотрено влияние условий торговли и был рассчитан темп роста, ограниченного платежным балансом с учетом и без учета влияния этих условий. Для «сильной» формы закона Тирлвола проверялось существование корреляции между ростом доходов Польши и остального мира. Наличие коинтеграции между темпами роста экспорта и ВВП проверяется как основная идея модели роста, основанного на экспорте. После верификации всех предпосылок модели для оценки эластичности дохода применяются модель коинтеграции ARDL и модель коррекции ошибок. Кроме того, было проверено статистическое равенство темпов роста прогнозируемого и реального ВВП для подтверждения закона Тирлвола, и это обнаруживает важность дисбалансов внешней торговли для польской экономики в период с 1995 по 2018 год. И «слабая», и «сильная» формы закона Тирлвола оказались обоснованными. Дальнейшие направления исследования могут быть связаны с проверкой обоснованности предпосылок закона Тирлвола на данных других стран Восточной Европы, а также постсоветских стран; подобных исследований на данный момент крайне мало.

Ключевые слова: модель роста, ограниченного платёжным балансом, рост, ведомый спросом, реальный валютный курс, условия торговли

1. Introduction

As it is known, two main approaches to economic growth exist: supply-side and demand-side ones. Many neoclassical theories assume that supply is the main factor affecting economic growth, and that demand adjusts to supply. Therefore, economic development depends only on productivity and factors of production.

However, supply-side theories do not fully explain economic growth and differences in income growth between various countries. That led to the development of demand-side theories. Originally, Keynes highlighted the impact of demand on economic growth. According to him, demand determines economic development and supply adapts to it. Many growth theories ignore the influence of demand, although Post-Keynesian theories continue to insist on its importance. One of them is the balance of payments (BOP)

constraint growth model. Originally it was proposed by Anthony Thirlwall (1979) in the article named "The balance of payments constraint as an explanation of international growth rate differences". After many adjustments, the final version was published in 2011. According to Thirlwall's law, economic growth is limited by trade performance of a country. External demand puts constraints on economic growth, and only by being in constant growing debt, a country can grow above BOP constraint for a long period of time. In general, it is impossible, and a country should finance its import by export. Import is important for economic development because it allows a country to widen production possibilities. In case import value is more than export value, a country must borrow from abroad to pay for its import. That causes balance of trade deficit inflation. Furthermore, it increases net external debt to gross domestic product (GDP) ratio, which makes foreign investors nervous about possible default. While borrowed money boosts economic growth in the short run, debt must be paid back and consumption will be reduced in the long run, leading to a decline in technological progress, decrease in country exports and worsening of the situation. If not able to return its debt, a country must sell its property, including natural resources. Assuming debt cannot be growing in the long run, the BOP constraint growth model is defined.

In the short run, trade surplus boosts economic growth. Growing demand stimulates economy through investments. Factories hire more workers and buy more resources, which leads to higher output because of high demand. Although, higher export not necessary means higher GDP growth. High import income elasticity of demand for imports indicates the dependence from imported goods and negatively affects economic growth.

Thirlwall's law explains differences in growth rates between countries by characteristics of goods produced, in particular its quality. Low export income elasticity and high import income elasticity indicate low non-price competitiveness of domestic goods for both export and internal consumption and dependence from imported goods.

Assuming a country cannot be in debt in the long run, output cannot exceed the pace at which import grows at the similar rate with export. Supply-side factors are not effective in case demand for goods is low, according to Thirlwall's law. Effect of supply-side factors is considered and reflected in import income elasticity. Although, the major determinant of growth in demand is growth of export.

Thirlwall's law is a dynamic form of Harrod's trade multiplier, according to which GDP is equal to export growth divided by the propensity to import. These models were developed independently while relying on the same assumptions. The model is applicable to "small open" economies, which do not influence prices in international market, under the assumption of constant relative prices. McCombie and Thirlwall (2004) argue that this assumption comes not from the "law of one price", but because "international prices are fixed in oligopolistic markets where product differentiation and quality competition are dominant strategies". Therefore, relative prices have little variation. Exchange rate is also assumed to have insignificant effect on economic growth, since a country cannot expand export affecting exchange rate by the depreciation of currency in the long run. Trade is assumed to be balanced. Export is considered as the main source of economic growth because it is assumed that export is the only source of autonomous demand. The point is that it comes from outside the country and it is exogenous. Furthermore, from components of demand, only export can finance import. These assumptions are supposed to hold in the long run, although they seem unrealistic in the short run (Thirlwall, 1997).

Thirlwall's model became one of the most popular heterodox growth models that was widely applied in the 1980s and 1990s; later it was, to some extent, forgotten for a decade. However, global economic crisis in 2008 showed the importance of external balances, which put constraints on economic growth through demand. Countries with huge imbalances suffered the crisis most. US economist and Nobel laureate Paul Krugman (2003)[1] wrote in his blog: "…the really strong relationship within the [eurozone countries] is between interest spreads and current account deficits, which is in line with the conclusion many of us have reached, that the euro area crisis is really a balance of payments crisis, not a debt crisis." European commission also admitted the importance of external imbalances in the European Union Importance of external imbalances shows the relevance of Thirlwall's law for preventing crises, which started a new wave of empirical works on Thirlwall's law in the last years.

This research aims to contribute to empirical studies of Thirlwall's law. We try to validate assumptions of the model and illustrate its implementation in Poland. Our hypothesis is the following: economic development of Poland is constrained by its balance of payments (BOP).

This country was chosen for research for several reasons. Poland's economy is sixth largest in Europe and its growth is stable. Even during the Great Recession, Poland's economy continued to grow. Reasons for its sustainable development are not explored yet. Over last twenty-five years from poor country, Poland became one of the successful countries in Europe. The growth is unique because Poland suffered from lack of natural resources. Nevertheless, the Polish economy is one of the most successful Post-Socialist economies. Possibly, it is because the country had no opportunity to get into huge debt; it had to expand demand on goods to boost economic growth without financing it with foreign capital. Importance of external imbalances for economic growth in Poland will be investigated by testing Thirlwall's law. Knowledge of the reasons of this growth will also be useful for other countries. Our paper is the first work on the validity of Thirlwall's law for Poland.

Works on the empirical validity of Thirlwall's law differ by the extensions of the model, econometric techniques used to demand functions, ways to validate the law, and tested assumptions. Furthermore, different numbers of countries are considered in the works.

The original paper (Thirlwall, 1979) employs Houthakker and Magee (1969) estimates of elasticities. These estimates were derived using the Ordinary Least Squares method. Spearman rank correlation was employed to compare actual and predicted growth rate. These methods were forced out by more complicated modern techniques in further works.

2. Extensions of the original model

Palley (2003) extended the model following neoclassical ideas. He added supply-oriented component in the original equation. Income elasticity of demand for import is considered as endogenous to the degree of utilisation capacity. Setterfield (2006) offered his model, adding supply-side factors to the model. He said that the problem with both demand and supply approaches to growth is that they neglect each other and do not know how their models reconciled. Thirlwall (2011) accepts these models, though

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[1] Krugman, P. (2003). Retrieved from: https://krugman.blogs.nytimes.com/2013/03/08/fatal-fiscal-attractions (Date Access: 18.08.2021).

highlighting that adding utilisation capacity leads to stricter bounds on variables and adds difficulty to the analysis.

Nell's (2003) extension disaggregates world income from the original model (Thirlwall, 1979) to several main trade partners. Such approach allowed the researcher to see contribution of each partner to country's BOP constraint.

Thirlwall and Hussain (1982) proposed an extension of the model that allows for capital inflows. It widens the range of implications of the model and allows applying it to developing countries, which are financed by abroad for a long period of time. Perraton (2003) criticised the extension since capital inflows are not stable and may be negative, indicating the impossibility of deriving growth rate. Furthermore, this allows growing huge current account deficit, which contradicts the idea that BOP puts constraints on GDP. Moreno-Brid (1998) attempted to solve the problem by using nominal capital flows. Thirlwall (2011) notes that capital flows have insignificant effect on the predicted GDP growth and that "Export growth, not capital, is by far the most important variable governing growth performance." Further, this model was extended in order to account for interest rate for accumulated debt. Alleyne and Francis (2008) and other authors worked on this problem, although results of the model with this extension and the original model (Thirlwall, 1979) are close, even with high interest rate.

Another issue with the original model is that it does not consider interactions between countries. Vera (2006) and Sasaki (2008) deal with it and expand the basic Prebisch model of North-South. The idea of North-South model suggests that intermediate goods are produced in the South and from them tradeable goods are manufactured in the North. South economic growth is restricted by economic growth of the North. The model explains interaction between two regions and suites some countries better than the original Law does. The model of Sasaki (2008) allows for technological progress.

Araujo and Lima (2007) offered a multi-sectoral extension to Thirlwall's law. The model provides opportunity to identify elasticities for every sector, which has policy implication. Mironov and Konovalova (2019) used this approach to model the Russian economy and identify main exporting sectors. According to them, stable economic growth could be reached by supporting the sectors with high external demand, which rises with income, and sectors that are independent from imports. The Russian economy was also analysed by Tovar-Garcia and Carrasco (2019) based on bilateral data; this paper concluded that the observed rates of growth of this economy have been higher than what is predicted by Thirlwall's law. Trigg (2020) extended the work of Araujo and Lima (2007) by including Global Value Chains (GVC). Such approach allowed him to consider the fact that different stages of production are located in different countries. Importance of inclusion of GVC is argued in Ibarra and Blecker (2016). Their findings indicate that the results are biased if intermediate goods are not considered. Since intermediate goods can be traded several times in different countries, the problem of double counting arises. It can be solved by input-output approach developed by Araujo and Lima (2007). These approaches lack simplicity of the original model (Thirlwall, 1979); moreover, the results are close to it. Undeniable advantage of this approach is that sectors with high export income can be identified and used for policy implications.

This study employs the model from the original paper, although it includes relative prices effect into the calculation of growth consistent with BOP.

3. Estimation of elasticites and discussion of some assumptions

The main techniques to estimate import and export demand functions and get income elasticities of demand are taken from such works as Andersen (1993), Felipe et. al. (2010), López and Cruz (2000), Perraton (2003).

To choose between two modern and most complicated techniques — ARDL bound test and Johansen cointegration — data characteristics should be considered. Johansen cointegration requires that all variables should be stationary without differing or after taking differences ones. Or, from econometric perspective, they should be the same order of integration. In case variables are integrated of different order, ARDL bound should be used.

Furthermore, Johansen cointegration estimates are likely to be biased in finite samples, according to Cheung and Lai (1993). Using quarterly data allows enlarging the sample, although seasonality and other problems arise. Pesaran et al. (2001) bounds test approach solved that problem using unrestricted error correction mechanism. Estimations made by this method are accurate, despite small samples.

This study employs the method of ARDL bound testing and error correction model due to data characteristics.

Assumption of insignificance of terms of trade is not always validated in literature. Alonso and Garcimartín (1999) argued that this assumption is not necessary for the validation of Thirlwall's law. Perraton (2003) noticed that it is not realistic that relative prices are stable. He argues that the impact of terms of trade should be considered. Razmi (2016) also argues that relative prices have a significant effect on exports and imports, in particular in developing countries.

"Strong" form of Thirlwall's law requires positive correlation between income growth rate of an individual country and the world economic growth rate. This assumption was checked by Razmi (2016) using data sample of 167 countries. His findings indicate no correlation between world GDP and GDP of individual countries for most countries in the sample and negative correlation for one third of the sample. That shows the importance of validation of that assumption before applying model, because it is applicable only to countries that have similar pattern of development with the rest of the world. For developing countries, it is not always true; therefore, studies that do not check this assumption could get opposite results.

The model is applicable to "small open economies"; it implies they do not affect prices in the world market. This assumption holds for the majority of countries, except the largest, as the US and China. The US is an exception for Thirlwall's law for several reasons. Its trade imbalances are growing for a long period of time and it does not lead to decline in economic growth. This country is big enough to be constraint only by internal demand. The biggest economies are unconstrained by BOP for other countries to be constrained, because they determine demand for the rest of the world, according to Thirlwall's law.

Furthermore, assumption of the BOP constraint growth model is relationship between growth of income and export in the long run. That can be verified by testing cointegration between variables using econometric techniques. Moreno-Brid (1999) validated Thirlwall's law for Mexico only by testing cointegration between the rate of export growth and income. This approach was employed by Jeon (2009) to check the assumption of the long-term relationship between export growth and growth of income of China in addition to standard procedures.

This study combines approaches from these works and tests all these assumptions: significance of relative prices (includes its effect if needed), existence of correlation

between world GDP and Poland's GDP and existence of cointegration between export growth and Poland GDP as a main idea of growth model based on the importance of export.

4. Testing the existence of BOP constraint

As we already said, in the original paper, Spearman rank correlation and mean deviation were used to validate the Law.

Later, McGregor and Swales (1985) introduced a different, more accurate method. All countries in the world should be used, actual GDP growth rate is regressed on estimated. After that, the Wald test on joint equality of constant to zero and slope to unity is applied. Although, the main disadvantage of the test is its hard applicability: it requires the data on all countries to cancel out trade deficits and surpluses.

Further, 'McCombie test' (1999) that gives more accurate results was used. It is applied to calculate the value of income elasticity of demand for import at which income growth rate equals to estimated. These two values are compared, and statistical difference is tested to verify Thirlwall's law. The test can be performed both on individual country and on the group of countries.

Alonso (1999) introduced the latest of the main approaches for individual countries. Using cointegration techniques, parameters of demand functions are estimated to get elasticities. After the calculation of BOP constraint growth rate, growth rate of income is regressed on it. Joint equality of constant to zero and slope to unity is tested to verify Thirlwall's law. Perraton (2003) and McCombie and Thirlwall (1994) argue that this order is preferable. BOPC growth rate is calculated using estimates of elasticities, which are subject to errors. The presence if the errors in variables problem leads to biased and inconsistent results; thus, the right order of variables solves the problem.

The last-named method was used for validation of the Thirlwall's law in this work.

The results of some works on the validity of Thirlwall's law are presented in Table 1 below.

Table 1

The results of some works on the validity of Thirlwall's law

Author(s), year	Country	Extension of model	Results
Aricioglu et al. (2013)	Turkey	Initial model	Invalid
Soukiazis, Antunes (2011)	Portugal	Initial model, only "weak" form	Valid
Bagnai et al. (2016)	Sub-Saharan Africa's countries	the BoP constraint is disaggregated amongst partner countries	Valid
Mironov, Konovalova (2019)	Russia	Multisectoral	Explains the lack of economic growth; valid
Tovar-Garcia, Carrasco (2019)	Russia	Multisectoral	Invalid
Gurvich, Prilepskiy (2013)	Russia	Initial model	Invalid
Jeon (2009)	China	Initial model	Valid
Perraton (2003)	51 developing countries	Initial model	"Weak" form could not be rejected for most countries
Podkaminer (2017)	59 countries	Initial model; Dynamic OLS	Invalid for most countries

For most studies, the BOP constraint growth model is valid.

5. Theoretical model

The balance of trade equilibrium means that the value of export equals the value of import,

$$P_d X = P_f M, \tag{1}$$

where X is the export volume, M is the import volume, P_d is the price of exports; P_f is the price of imports. Assume prices are in home country currency and exchange rate is not needed. Taking logarithms gives growth rates

$$p_d + x = p_f + m, \tag{2}$$

Constant elasticities functions are assumed.

Export demand is a function of relative price of export and world GDP (external income). Income and price elasticities represent non-price and price competitiveness of export, respectively.

$$X = a \left(\frac{P_d}{P_f} \right)^{\eta} Z^{\varepsilon}, \ \eta < 0, \varepsilon > 0, \tag{3}$$

where η is the price elasticity of demand for exports, ε is the income elasticity of demand for exports and Z is world income.

Import demand is a function of relative price of import and Poland's GDP,

$$M = b \left(\frac{P_f}{P_d} \right)^{\psi} Y^{\pi}, \ \psi < 0, \pi > 0, \tag{4}$$

ψ is the price elasticity of demand for imports; π is the income elasticity of demand for imports, and Y is domestic income.

Taking logarithms of export and import demand functions gives export and import growth rates:

$$x = \eta(p_d - p_f) + \varepsilon y_w. \tag{5}$$

$$m = \psi(p_f - p_d) + \pi(y). \tag{6}$$

Substituting (5), (6) in (2) for the growth of income gives,

$$y_b = \frac{\left[(1 + \eta + \psi)(P_d - P_f) + \varepsilon z \right]}{\pi}. \tag{7}$$

The lower-case letters indicate growth rates of the variables.

According to assumptions, two forms of the law are possible — "weak" and "strong" (Perraton, 2003).

Assuming the insignificance of relative prices in the long run, terms of trade effects is zero. Equation 7 reduces to

$$y_b^* = \frac{x}{\pi}. \tag{8}$$

It is a "weak" form of Thirlwall's law: the growth rate of GDP is BOP constrained and it is equal to the rate between growth rate of export and income elasticity of import. Equation (6) is used to approximate $\varepsilon y_w = x$. That approximation is based on the assumption that terms of trade have no effect on export growth rate.

If external demand is not approximated by export, Thirlwall's law is

$$y_{BOP} = \frac{\varepsilon(z) \cdot y_w}{\pi}. \tag{9}$$

In this case, BOP constrained GDP growth rate is equal to the growth rate of world income multiplied by the ratio of the income elasticities, it is called a "strong" form of Thirlwall's law. Rate of income elasticities represents non-price competitiveness of a country. BOP growth model does not neglect supply-side effect on the economic growth, it is fully considered in income elasticities.

According to it, a country will grow with a higher pace than the rest of the world if

$$\frac{\varepsilon(z)}{\pi} > 1.$$

Inclusion of other variables contradicts Thirlwall's law, as he argues that economic performance of country is limited by only these variables. In the long run, country cannot exceed BOP growth rate.

Although, assumption of terms of trade negligible effect is not always satisfied. If relative prices have significant export and import functions, they cannot be ignored. Following Perraton (2003), terms of trade effect is calculated as a rate of change in terms of trade to income elasticity of demand for imports and included in the main equation. The effect is added to equations (3), (4) to calculate modified BOP constrained growth rate.

This paper tests Thirlwall in this form: $y_b = \dfrac{x}{\pi} + \dfrac{change\ in\ terms\ of\ trade}{\pi}$. The results

are compared with original form: $y_b = \dfrac{x}{\pi}$. Reasons for inclusion of terms of trade effect

is presented in the section devoted to the estimation results.

Furthermore, the "strong" form of the Law is tested: $y_b = \dfrac{\varepsilon(z) \cdot y_w}{\pi}$ with and without

terms of trade effect. Arguments in favour of the "strong" form are in the section devoted to the Data description.

6. Test of the assumptions and data description

Before applying Thirlwall's law to the Polish economy, its applicability should be verified. In case any of the assumptions do not hold, results of validation of Thirlwall's law could be wrong.

"Strong" form of Thirlwall's law requires a country's GDP to have high correlation with world GDP. For most countries that is true, although there are exceptions. Therefore, this assumption should be checked. Pearson's correlation coefficient between Poland's GDP and world GDP is 0.9966. Figure 1 below shows that these two indicators have similar directions of movement, except 2009. The 2009 financial crisis has led to a decline in GDP in the world, although Poland's economy continued to grow.
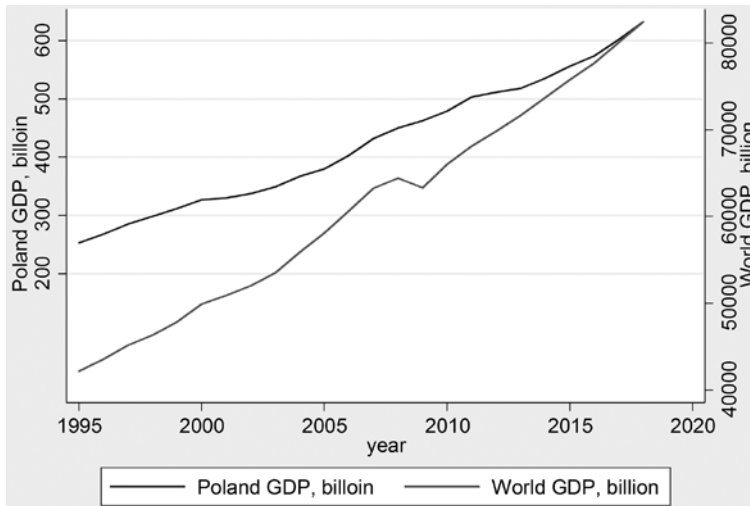
Fig. 1. *The dynamics of world GDP and Poland's GDP*

In general, Poland's economic growth is correlated to the world's. Thus, export growth in Poland can be approximated as world GDP multiplied by income elasticity of demand for export.

Furthermore, export is a key variable that determines GDP growth, according to Thirlwall's law.

Most of empirical works on Thirlwall's law stopped on statistical equality of real GDP and predicted GDP growth rates. Although, cointegration between GDP and export should be present as a main idea of growth model based on export. Figure 2 presents the graph of these two variables.

Patterns of their development are quite similar, although formal testing is required. Bound test is employed to check cointegration. Although graphs show similar development, except for declines in export in 2009 and 2012, GDP continued to grow. Cointegration at 10 % significance level is verified by bound test. Since we are interested
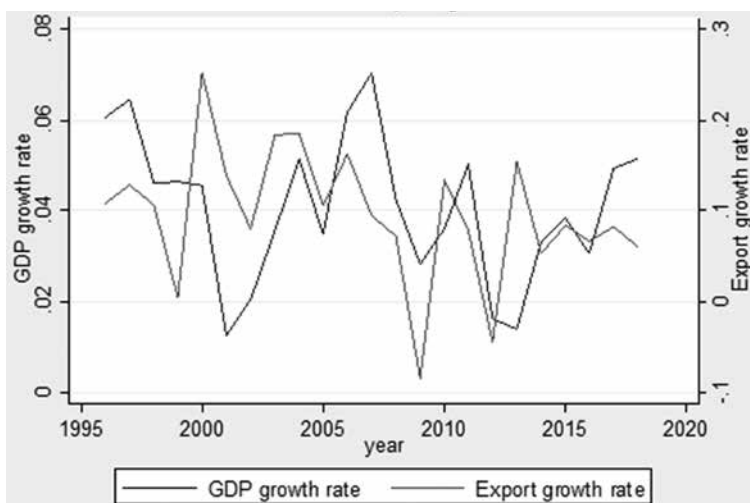

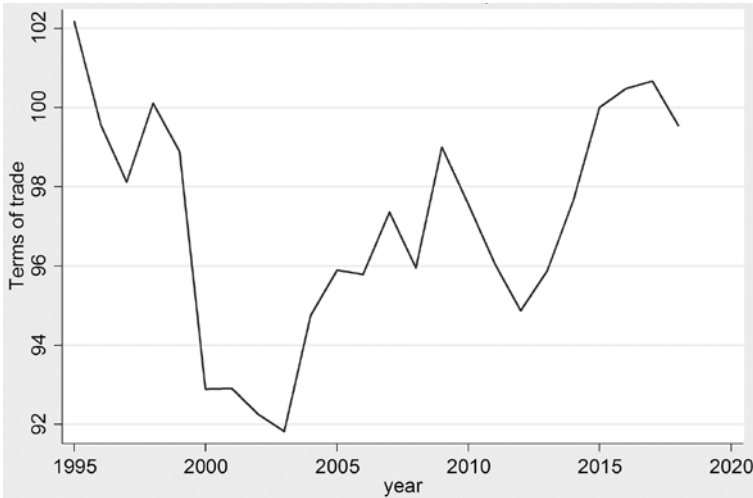**Fig. 2.** *The growth rates of Poland's GDP and export*

Fig. 3. *The dynamics of Terms of Trade of Poland*

only in the existence of cointegration, estimation of coefficients is not needed. Full results on bound test are presented in the "Econometric details" section.

It should be noted that before applying the model, stationarity of relative prices should be checked. Figure 3 indicates the variability in terms of trade, although formal testing is required.

Insignificance of relative prices is tested in the section devoted to the estimation results. Its significance in demand functions indicates that the impact of relative prices could not be ignored. Therefore, terms of trade effect is considered in calculation of BOP constraint growth rate. Furthermore, terms of trade movements capture changes in exchange rate what makes results more accurate.

An analysis of BOP of Poland is useful for research. The current account was in deficit during the whole period. Although, its share, or external debt to GDP ratio is low even in the crisis year with high deficit. That indicates no problems for the economy from debt.
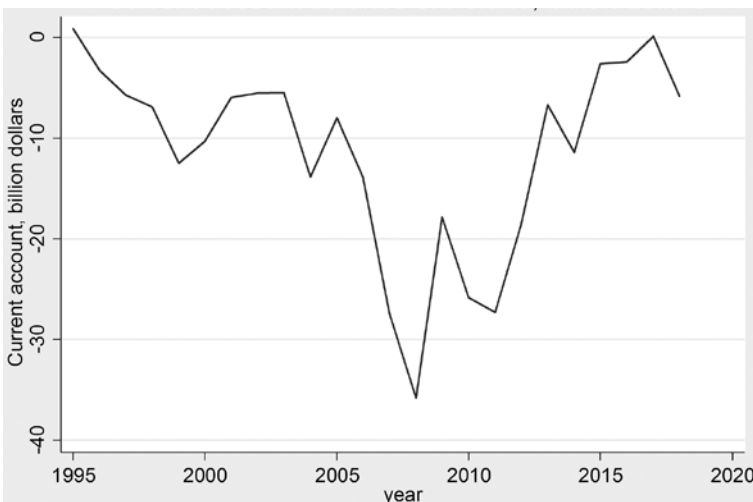

Fig. 4. *The dynamics of Poland's current account balance*

In the last years, current account balance improved and, according to Thirlwall's law, it would lead to better economic performance.

Data on import and export volume, GDP of Poland, World GDP and terms of trade is taken from IMF and Worldbank databases.

Import volume is the ratio of the import value indices to the unit value indices of corresponding goods.

Export volume is the ratio of the export value indices to the unit value indices of corresponding goods.

GDP of Poland and World GDP are in millions of 2010 US dollars.

Terms of trade is the ratio between the index of export prices and the index of import prices, relative price of export in terms of import $-\dfrac{p_{export}}{p_{import}}$. The bigger term of trade index means more import goods can be purchased by unit of export goods. This index is used to estimate export demand function.

For import demand, function terms of trade for import are needed. It was calculated as inverse to the terms of trade $\dfrac{1}{\dfrac{p_{export}}{p_{import}}} = \dfrac{p_{import}}{p_{export}}$. Relative price for import in term for export. Exchange rate is not used because all data are in US dollars; base year is 2010.

7. Econometric Methodology

Cointegration tests of Poland's demand for imports: 1995– 2018

Following empirical studies (Perraton, 2003; Aricioglu et al., 2013), import and export functions in equations (3), (4) are estimated in order to derive income elasticities.

Taking logarithms gives,

$$\log(M) = \propto + \beta\log(tot\_import) + \gamma\log(Y), \tag{10}$$

where M — import volume; tot_import — $terms\,of\;trade\,for\,import = \dfrac{1}{terms\,of\,trade}\left(\dfrac{P_f E}{P_d}\right)$;

Y — GDP of Poland

$$\log(X) = \alpha + \beta\log(tot) + \gamma\log(GDP_{world}),$$

where X — export volume; tot — $terms\,of\,trade\,for\,export = \dfrac{P_d}{P_f E}$; GDP_{world} — world GDP.

Stationarity of variables is checked via the augmented Dickey-Fuller (ADF) test to choose a suitable model and to avoid spurious results.

Bound cointegration test

Prior to the estimation of demand functions, bound cointegration test is applied to investigate the long run interaction between variables. If cointegration exists, further analysis is possible.

Pesaran et al. (2001) bounds test was used to investigate this property in order to avoid spurious results. Kripfganz and Schneider (2018) critical values and approximate p-values were used for conducting Pesaran et al. (2001) bounds test. Null hypothesis is that all parameters for lagged variables are statistically equal to zero (no cointegration).

The estimates are very accurate with any possible sample size and any number of variables.

Autoregressive Distributed Lag (ARDL) cointegration

To test the existence of long run relationship and interaction between variables, Autoregressive Distributed Lag (ARDL) cointegration approach proposed by Pesaran et al. (2001) was adopted for three reasons: this model is better for small size of sample; it gives more statistically significant results, while Johansen cointegration procedure requires large number of observations. Moreover, this method allows the researchers to use variables with any order of integration less than 2.

If cointegration between variables is present, following equation should be estimated.

$$\Delta \log m_t = \beta_0 + \sum \beta_{1i} \Delta \log m_{t-1} + \sum \beta_{2i} \Delta \log Z_{t-i} +$$
$$+ \sum \beta_{3i} \Delta \log tt_{t-i} + \beta_4 \log m_{t-1} + \beta_5 \log Z_{t-1} + \beta_0 \log tt_{t-1} \qquad (11)$$

m_t — import volume, Z_t — real world GDP, tt_t — terms of trade

Equation is estimated by OLS using Stata

Number of lags of variables should be chosen according to AIC.
The equation gives long-run elasticities.

Error correction model

To derive both short run and long run elasticities, the error correction model was applied. It also shows how fast disequilibrium disappears.

Post-estimation diagnostic tests for ECM are applied. They include Ramsey RESET test and Breusch-Pagan/Cook-Weisberg test for heteroskedasticity.

Econometrics hypotheses are given in Table 2 below.

Table 2

Empirical hypotheses

Variable	Sign	Significance
Terms of trade	Negative	Insignificant
World real GDP (elasticity)	Positive	Significant

Real GDP growth rate is compared with BOP constrained growth rate.

"Weak" and "Strong" versions of Thirlwall's law are checked by regressing predicted growth rate on actual. According to Perraton (2003), this order gives more accurate results.

8. Estimation Results

Firstly, import demand function (equation (10)) was estimated. Variables were lag-transformed in order to get elasticities. Then, stationarity is checked — if variables are integrated of order two, all methods would give spurious results. If some variables are integrated of different orders, ARDL cointegration should be used. If they all are integrated of the same order, then Johansen cointegration is more appropriate. Before applying the model, the order of integration of variables should be determined in order to choose an appropriate cointegration technique. ADF-test is used to check for unit root, and the null hypothesis is series has unit root.

The results of ADF test are given in Table 3.

Log of terms of trade is stationary without taking differences, while other variables only after differencing once. It is argued that ARDL cointegration model is more

Table 3

ADF test results

Variable	ADF statistics (levels)	ADF statistics (first differences)	Critical value 1 %	MacKinnon approximate *p*-value for *Z*(*t*)	Order of integration
Log_termsoftrade_import	−3.093	—	−3.00	0.0271	I(0)
Log_GDP_Poland	−1.312	−2.978	−3.00	0.0370	I(1)
Log_import_volume	−2.707	−4.580	−3.00	0.0001	I(1)

Table 4

Bounds test results

H_0: no level relationship							**F = 6.684**	**t = −3.970**
	10 % I(0)	10 % I(1)	5 % I(0)	5 % I(1)	1 % I(0)	1 % I(1)	*p*-value I(0)	*p*-value I(1)
F	3.654	5.055	4.779	6.485	7.929	10.439	0.018	0.046
T	−2.554	−3.251	−2.997	−3.758	−3.974	−4.881	0.010	0.037

appropriate with regressors with different order of cointegration (Pesaran et al., 2001), if the dependent variable has unit root.

Kripfganz and Schneider (2018) critical values and approximate p-values for Pesaran et al. (2001) bounds test are given in Table 4.

The null hypothesis indicates no level relationship between variables. We reject H_0 if both *F* and t are more extreme than critical values for I(1) variables or if p-values < desired level for I(1) variables.

ARDL bounds test shows that there is cointegration between import, world real GDP and terms of trade at 5 % significance level, therefore, regression would not be spurious and variables move in the same direction in the long run. After that, ARDL model is estimated and elasticities are derived. Full information about estimates is presented in the "Econometric details" section.

Post-estimation tests show that there are no omitted variables, no heteroscedasticity and no autocorrelation in the model. Furthermore, residuals are normally disturbed.

Cumulative sum (CUSUM) control chart, which shows stability of coefficients in the model, is presented below in Figure 5. For 95 per cent confidence bands, the graph indicates constancy of parameters through time.

Estimated long-run income elasticity of demand for imports π and equals to about 1.98, the demand for import is elastic.

Table 5

Diagnostic test for the ECM results

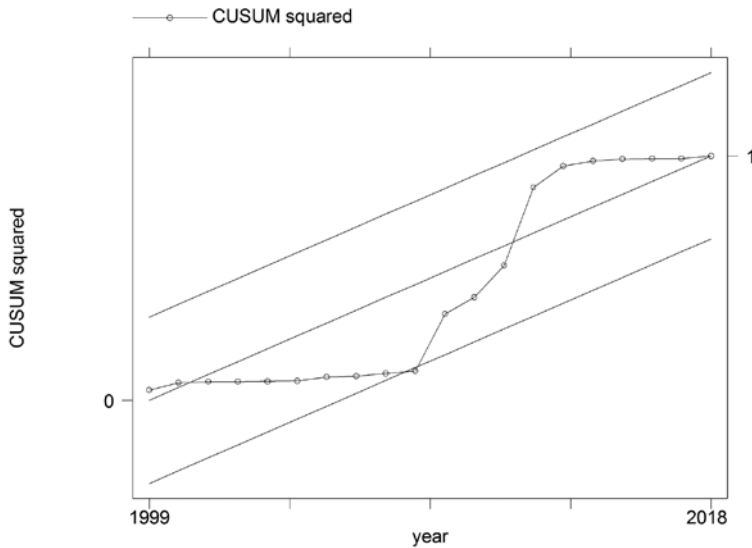| Test	Results	*p*-value
Ramsey RESET Test	F(3, 5) = 3.52	0.1046
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity	chi2(1) = 0.38	0.5401
Breusch-Godfrey LM test for autocorrelation (for autocorrelation of higher orders)	F(1, 7) = 7.058	0.0326
Durbin's alternative test for autocorrelation	F(1, 7) = 3.817	0.0917
Shapiro-Wilk W test for normal data (residuals)		0.60095

Fig. 5. *CUSUM squared test results*

A 1 % increase (decrease) in GDP of Poland will lead to a 1.98 % increase (decrease) in imports. This relationship is found to be significant at the 1 % level that indicates that economic growth in Poland would probably lead to a rise in imports in the long run.

The terms of trade variable (representing relative price of import in terms of export) has a statistically significant effect on the pattern of imports in Poland in the long run. The coefficient indicates that a 1 % increase (decrease) in the terms of trade will generate a 4.48 % increase (decrease) in imports in the long run. It even indicates that if import price is rising, demand on it is increasing even more. This finding contradicts the demand law, according to which demand negatively depends on price. Possible explanation to this fact is that import goods are necessary and some commodities are not produced in a country in sufficient quantity. Even if the price rises, people buy these goods. Big shares of Poland's import are goods for manufacturing, machinery, and pharmaceuticals. Equipment for industry is necessary for economic development. If it is not produced in home country, it is imported even by higher prices. Demand for necessary medicines also will not fall if the price increases. Other possible explanation of that unexpected result is that Poland expects goods in the world market to become more expensive in future, so more goods are bought now. Especially, expensive purchases for manufacture could contribute to these findings.

Significance of terms of trade contradicts Thirlwall's assumption that the effect of relative prices on imports is small in the long run, therefore, we cannot consider terms of trade effect on predicted GDP growth rate as insignificant. It should be included in calculations of BOP growth rate.

Adjustment coefficient shows how fast the dependent variable fits to independent variables, and negative sign represents a causal relationship of real GDP with import volume. In this case, 85 % of disequilibrium is dissipated before the next year and 15 % remains.

Export demand function was estimated in the same way, the results are presented in the "Econometric details" section.

<div align="center">

"Weak" version of Thirlwall's Law

</div>

Following Perraton's (2003) idea, terms of trade effect is considered to calculate BOP constrained growth rate. Although its effect is considered insignificant in the original paper (Thirlwall, 1979), Thirlwall and Hussain (1982), McCombie and Thirlwall (1994) found out that relative prices affect demand for export and import functions in the long run. Furthermore, ARDL model shows that terms of trade have significant impact on demand for import, therefore indirectly affecting BOP constrained growth rate.

To test Thirlwall's law, the Wald test was applied. Null hypothesis is that constant term is zero and slope term is unity. P-value is more than 0.05, therefore, we accept alternative hypothesis, Thirlwall's law is verified.

Terms of trade effect allows to smooth predicted declines and rises in GDP growth and give more accurate results on the data. Both models verify the Law and the difference in results is small, what supports Thirlwall's thoughts that relative prices do not influence BOP constrained growth rate.

Almost for the whole period, predicted GDP is higher than actual. Although, in crises years (1998, 2008 and 2012), BOP constraint growth rate over-predicts the decline in GDP. Real GDP is higher than predicted at crises years probably due to higher capital inflows from foreign countries. And until debt is accumulated over a long period of time, it would not harm the economic performance.

"Weak" version of Thirlwall's law is verified. Terms of trade effect is included, and it makes the prediction more accurate, although this effect is insignificant. Polish economy is BOP constrained.

<div align="center">

"Strong" version of Thirlwall's Law

</div>

To test the validity of the "strong" version of Thirlwall's law, predicted growth rate was regressed on actual growth rate. The Wald test was applied to check the presence of BOP constraint on economic performance of Poland. Null hypothesis is that constant term is zero and slope term is unity. P-value is more than 0.05, therefore, we could not reject joint hypothesis that constant term is zero and slope term is unity.

"Strong" form of Thirlwall's law is valid for the sample, although the "strong" form of the law suites data worse than the "weak" form. Possible reason is that for the "strong"

without terms of trade effect	*with terms of trade effect*
p-value (Wald test): 0.4163	*p-value (Wald test): 0.3698*
Predicted = 0.026 + 0.547*actual	*Predicted = 0.028 + 0.501*actual*

Fig. 6. *"Weak" version of Thirlwall's law test results*

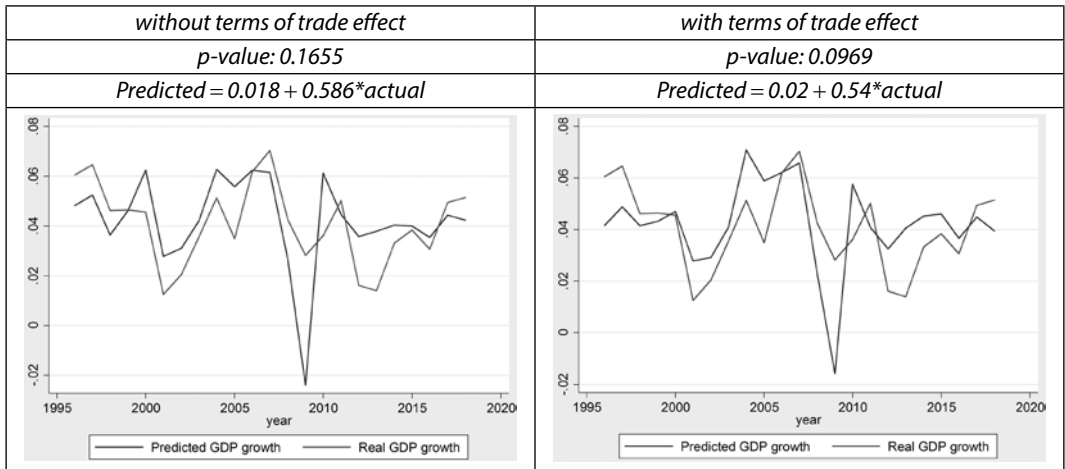| without terms of trade effect	with terms of trade effect
p-value: 0.1655	p-value: 0.0969
Predicted = 0.018 + 0.586*actual	Predicted = 0.02 + 0.54*actual
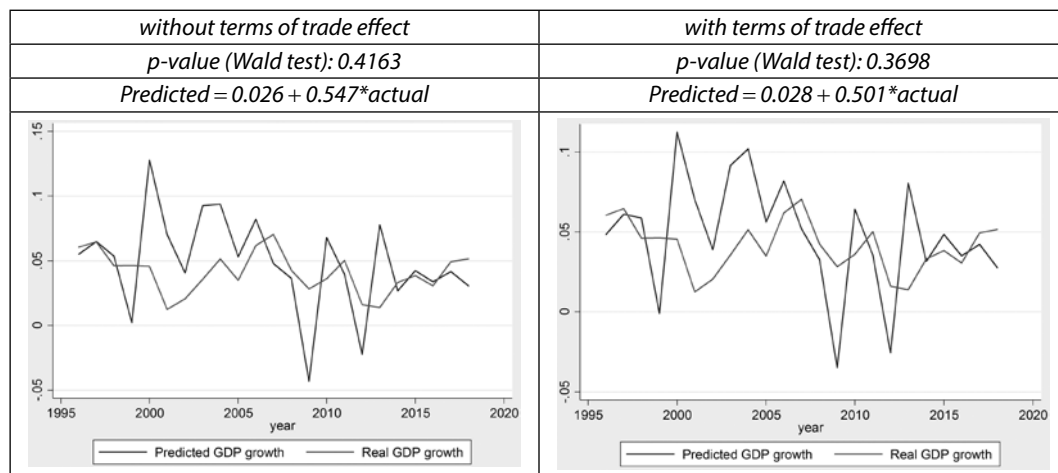
Fig. 7. *"Strong" version of Thirlwall's law test results*

form of the law, two estimates of demand elasticities are derived, leading to less accurate results. Although, at crises years, the "strong" version predicts less optimistic and more accurate results than the "weak" form. In favour of applying the "weak" form, Bairam (1997) argues that income elasticity from export function varies over time, while import elasticity is stable. These findings indicate that the "weak" form of the law is preferable, because Thirlwall's law considers long-run relationship between export and GDP growth. Bairam (1997) argues that the "weak" form of the law is preferable for empirical study.

The summary of both regressions is given in the "Econometric details" section.

Thirlwall's law works in the long run and average results are more relevant for comparison than graphs.

Real GDP annual growth rate on average is 4.1 %. The "strong" version predicts upper constraint on level of 4.23 %, while the "weak" version's long run constraint is 4.85 %. These predictions give maximum sustainable growth rate possible with current demand level. Measures, which would raise constraint on economic development, are proposed in conclusion.

These results validate that, in the long run, GDP growth of Poland is constrained by its BOP. The difference between actual and predicted GDP is small, therefore, to increase economic growth, Poland primarily needs to increase demand and supply will adopt to it. Only by supply-side development, economic growth would increase only to upper constraint of 4.9 per cents.

Descriptive statistics on actual and predicted GDP growth rates are presented in Table 6.

Table 6

Descriptive statistics on actual and predicted GDP growth rates

Variable	N	Mean	SD	Min	Max
real GDP	23	4.1	1.6	1.2	7
growth rate					
"weak" version	23	4.848	3.7	−4.3	12.8
"weak" version with terms of trade effect	23	4.849	3.7	−4.3	12.8
"strong" version	23	4.231	1.8	−2.4	6.3
"strong" version with terms of trade effect	23	4.232	1.8	−2.4	6.3

9. Econometric details

<div align="right">Table 7</div>

ARDL model for import demand function

| ARDL(4, 1, 4) Sample: 1999–2018 Log likelihood = 44.760416					regression Number of obs = 20 R-squared = 0.8705 Adj R-squared = 0.6923 Root MSE = 0.0408	
Log(import_volume)	Coef.	Std. Err.	*T*	*P* > *t*	[95 %Conf.	Interval]
ADJ						
Log(import_volume)						
L1.	−0.853	0.221	−3.860	0.005	−1.364	−0.343
LR						
Log(GDP_Poland)	1.979	0.150	13.210	0.000	1.634	2.324
Log(TOT_import)	4.478	1.147	3.900	0.005	1.832	7.123
SR						
Log(import_volume)						
LD.	0.175	0.218	0.800	0.444	−0.327	0.678
L2D.	0.106	0.193	0.550	0.600	−0.340	0.552
L3D.	0.405	0.199	2.040	0.076	−0.054	0.863
Log(GDP_Poland)						
D1.	2.200	1.088	2.020	0.078	−0.310	4.710
Log(TOT_import)						
D1.	−2.007	0.720	−2.790	0.024	−3.668	−0.346
LD.	−2.574	0.842	−3.060	0.016	−4.515	−0.633
L2D.	−0.588	0.751	−0.780	0.456	−2.320	1.143
L3D.	−1.541	0.634	−2.430	0.041	−3.002	−0.080
_cons	−24.158	8.137	−2.970	0.018	−42.921	−5.395

ARDL model for export demand function

ARDL(4, 1, 4) Sample: 1999–2018 Log likelihood = 54.847566 Root MSE = 0.0246					regression Number of obs = 20 R-squared = 0.9524 Adj R-squared = 0.8870	
lexport_volume	Coef.	Std. Err.	*T*	*P* > *t*	[95 %Conf.	Interval]
ADJ						
lexport_volume						
L1.	−1.075	0.162	−6.62	0	−1.45	−0.7
LR						
lgdp_world	2.82	0.052	54.49	0	2.701	2.939
ltet_poland	1.521	0.118	12.88	0	1.249	1.793
SR						
lexport_volume						
LD.	0.32	0.125	2.55	0.034	0.031	0.61
L2D.	0.509	0.121	4.21	0.003	0.23	0.787
L3D.	0.61	0.108	5.62	0	0.36	0.86

lgdp_world						
D1.	1.406	0.701	2.01	0.08	−0.211	3.023
ltet_poland						
D1.	−1.216	0.253	−4.8	0.001	−1.8	−0.631
LD.	−0.974	0.193	−5.05	0.001	−1.42	−0.529
L2D.	−0.827	0.166	−4.97	0.001	−1.211	−0.443
L3D.	−0.215	0.134	−1.61	0.147	−0.524	0.094
_cons	−99.212	15.295	−6.49	0	−134.48	−63.943

Diagnostic test for the ECM

Test	Results	*p*-value
Ramsey RESET Test	$F(3, 4) = 1.20$	0.4158
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	chi2(1) = 0.72	0.3964
Breusch-Godfrey LM test for autocorrelation	$F(1, 6) = 9.646$	0.0526
LM test for autoregressive conditional heteroskedasticity (ARCH) (for autocorrelation of higher orders)	chi2(1) = 2.866	0.125
Durbin's alternative test for autocorrelation	F(3, 4) = 2.171	0.2341
Shapiro-Wilk W test for normal data (residuals)		0.61387
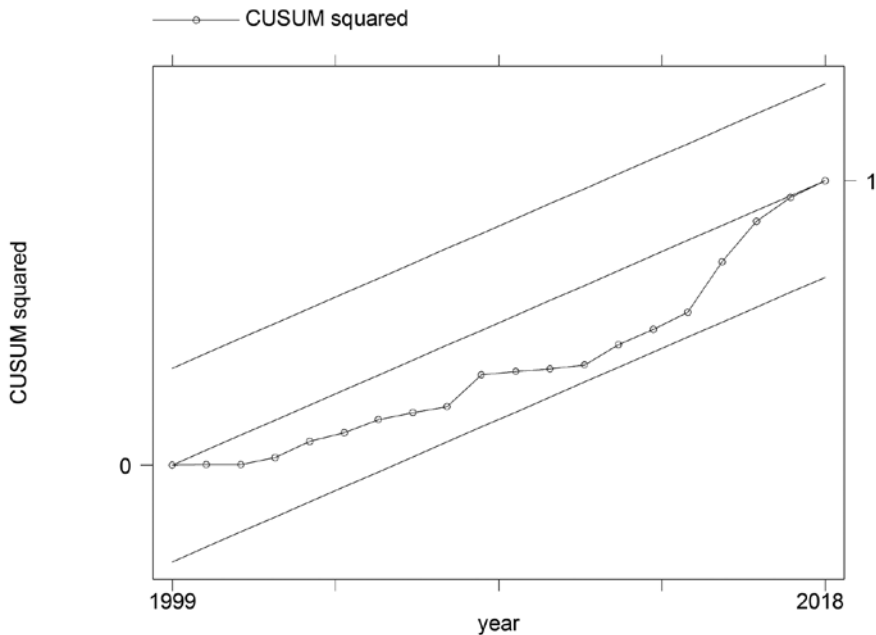
H_0: no level relationship							F = 14.952	t = −6.617
	10 % I(0)	10 % I(1)	5 % I(0)	5 % I(1)	2.5 % I(0)	2.5 % I(1)	1 % I(0)	1 % I(1)
F	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36
T	−2.57	−3.21	−2.86	−3.53	−3.13	−3.80	−3.43	−4.10

Source: Pesaran et al. (2001). ARDL Bounds Test. Critical values from Pesaran et al. (2001). For export demand function.

ADF test results

H_0: unit root is present in a time series sample

variable	ADF statistics (levels)	ADF statistics (first differences)	Critical value 1 %	MacKinnon approximate p-value for $Z(t)$	Order of integration
Log_termsoftrade	−3.093	—	−3.00	0.0271	I(0)
Log_GDP_World	−0.938	−4.240	−3.75	0.0006	I(1)
Log_export_volume	−0.947	−3.715	−3.00	0.0039	I(1)

Bound test on cointegration between GDP growth rate and export growth rate

Pesaran/Shin/Smith (2001) ARDL Bounds Test

H0: no levels relationship F = 5.365 t = −2.924

Critical Values (0.1–0.01), F-statistic, Case 3

| [I_0] [I_1] | [I_0] [I_1] | [I_0] [I_1] | [I_0] [I_1]

| L_1 L_1 | L_05 L_05 | L_025 L_025 | L_01 L_01

------+---------------+---------------+---------------+---------------

k_1 | 4.04 4.78 | 4.94 5.73 | 5.77 6.68 | 6.84 7.84

accept if F < critical value for I(0) regressors

reject if F > critical value for I(1) regressors

Critical Values (0.1–0.01), t-statistic, Case 3

| [I_0] [I_1] | [I_0] [I_1] | [I_0] [I_1] | [I_0] [I_1]

| L_1 L_1 | L_05 L_05 | L_025 L_025 | L_01 L_01

------+---------------+---------------+---------------+---------------

k_1 | -2.57 -2.91 | -2.86 -3.22 | -3.13 -3.50 | -3.43 -3.82

accept if t > critical value for I(0) regressors

reject if t < critical value for I(1) regressors

Validation of Thirlwall's law

	"Weak" form	"Weak" form with terms of trade effect	"Strong" form	"Strong" form with terms of trade effect
GDP growth real	0.547 (0.490)	0.501 (0.474)	0.586[*] (0.214)	0.540[*] (0.204)
Constant	0.026 (0.021)	0.028 (0.021)	0.018 (0.009)	0.020[*] (0.009)

[*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$

10. Conclusions

This study tries to validate assumptions of Thirlwall's law and illustrates its implication for Poland. Furthermore, a rarely used "strong" form of Thirlwall's law is tested.

The assumption that the relative prices do not influence trade performance of Poland does not hold, therefore, the influence of terms of trade was considered and BOP constrained growth rate was calculated with and without terms of trade effect. For the "strong" form of Thirlwall's law, the existence of correlation between growth of income of Poland and the rest of the world was tested. The existence of cointegration between rates of growth of export and GDP is tested as a main idea of growth model based on export. After verifying all assumptions of the model hold, ARDL cointegration approach

and error correction model are applied to estimate income elasticities. Further, statistical equality of growth rates of predicted and real GDP was tested to validate Thirlwall's law, and it supports the importance of external imbalances for Polish economy for the period between 1995 and 2018. Both "weak" and "strong" forms of Thirlwall's law are valid. These findings coincide with the results of most works on validity of Thirlwall's law. Although, if any of proposed assumptions of the model are violated in these works, it could lead to misleading results. Unexpected result is positive signs of income elasticity in import demand function in the long run, although in the short run the sign is negative as expected. Possible explanation is that imported goods are highly necessary for Poland. Furthermore, findings of this work supports insignificance of relative prices on economic growth, although it has significant impact on demand functions.

This study recommends for countries constrained by external demand to implement policies that will improve the growth rate of export to raise the economic growth rate. Productivity may be encouraged in the home country through subsidies as an import substitution strategy to lower income elasticity of import in industries, which solely rely on import.

Verified cointegration between export growth rates could be useful to policymakers in Poland. In order to achieve sustainable GDP growth rate, the government should help to the exporting firms. Especially, sectors with comparative advantage at producing goods should be supported. Export promotion policies should be introduced, for example, preferential credits. Policies that focus on increasing export and import substitution also develop supply-side factors.

It should be noted that validity of Thirlwall's law in one more country highlights the importance of external imbalances for the rest of the world.

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