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The Simultaneous Equations Model of Unemployment and Tariffs: A Panel Data Analysis of the EU

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Abstract: This paper investigates the direction of the unemployment and tariffs relationship, paying a great attention to the simultaneity problem. To solve this problem in the unemployment equation, we obtain the estimates by constructing the simultaneous equations model; considering the direct and indirect influence through tariffs applied by a country. We developed a two-equation simultaneous equations model with two endogenous variables, the unemployment rate and tariffs applied by a country. The proper tests and the model estimation results are obtained using EU 28 countries panel data that cover the period 2009-2018.The results shows the existence of a two-way (bi-directional) relationship between unemployment and tariffs applied to the imports of the EU. This relationship is inversely running from tariffs applied by the EU to unemployment rate however, it is positive when running in the opposite direction (from unemployment to tariffs applied by the EU).

Keywords: Unemployment, Tariffs, Simultaneity, Simultaneous Equations Model, Order condition, Rank condition.

1. Introduction

> *"There are situations where there is a two-way flow of influence among economic variables; that is, one economic variable affects another economic variable (s) and is, in turn, affected by it (them)". (Gujarati, 1995, 633)*

What is the direction of the relationship (if exists) between unemployment and tariffs? Simultaneity problem arises when trying to answer this question. Simultaneity problem is shaped by the economic variables interdependence. It is a fact that, in economic system, everything is linked to everything else. In this case, a simultaneous equations model (SEM) should be used to indicate the relationship between two endogenous variables. Dealing with the simultaneity problem, Van de Berg and Lewer (2007) assured that simultaneous equations model, a set of linear simultaneous equations, is the most attractive approach that captures the two-way (simultaneous) relationships among the variables of the model.

Ignoring the simultaneity problem, some empirical studies failed to decide most of relationships among economic variables. This is because a single equation is used which causes simultaneity bias. While the single equation model indicates that a dependent variable is a function of an independent one (or ones), a one-way relationship, the simultaneous equations model considers a two-way relationship between two jointly dependent variables. The simultaneous equations model is featured by the appearance of a variable as regressand in one equation and a regressor in the other one of the system.

This paper, empirically, attempts to investigate the existence of a simultaneous relationship between unemployment and tariffs. The relationship between both variables, specifically unemployment and trade, is introduced theoretically and verified empirically.

Lowering the costs of production; trade liberalization allows the foreign producers to out-compete domestic ones. And as a consequence this may lead to less domestic output and fewer domestic jobs (for more details see, Stolper and Samuelson, 1941; Davidson *et al.*, 1999; Moore and Ranjan, 2005; Felbermayr *et al.*, 2009; Felbermayr *et al.*, 2013).

Also, it is argued that trade liberalization may enlarge the export markets, following-on an increase in the domestic products demand, production and jobs. It is notable that trade liberalization and unemployment relationship studies, empirically, interested in the existence and the sign of this relationship. Belenkiy and Riker (2015) assured that, based on some reviewed theoretical models, the theory do not provide a general prophecy for the positive or negative influence of both international trade and trade liberalization on aggregate unemployment in a country.

Moreover, they found that the link between trade and aggregate unemployment is complex and ambiguous. Some empirical studies are based on causality test, relying on a single equation (for more details see Negem, 2015). However, to the best of my knowledge, no study focused on the simultaneity of unemployment and tariffs by using simultaneous equations model to estimate the mentioned relationship.

Trying to find out the simultaneous relationship between unemployment and tariffs, a contribution is offered by estimating the simultaneous equations model. Representing the best case of trade liberalization, from my point of view, the European Union panel data are used to estimate our model for the period 2009-2018 (witnessed a continuous decline in the unemployment weighted average from 9% in 2009 to 7.3% in 2018 increased sharply in between to reach 11.9% in 2013 (*www.statista.com*). This paper remainder is organized as follows: section 2 presents some related literature. Then, section 3 presents the methodology, clarifying the simultaneous equations model: the model specification, the model identification, the reduced form of the simultaneous equations model of Unemployment and Tariffs, and finally, the unit root test. Section 4 introduces the results of the stationarity testing and the reduced form estimating with indicating the retrieving process to get the structural equations. Section 5 concludes.

2. Literature Review

Tariffs raise employment (Stopler and Samuelson, 1941). They were the first, to the best of my knowledge, who alert to this issue. Their assumptions to analyze the trade liberalization and unemployment relationship, in perfectly competitive world, are: two production factors (labour and capital), two goods, with importing labour intensive goods. Under the above assumptions, Stopler and Samuelson (1941) argued that protection will increase the rate of nominal wage with a greater percentage than that of the imported good.

Over many years ago, studies, theoretically and empirically, paid more attention to this relationship and modelled unemployment as a consequence of time consuming job search formalized by job search theory (for more details see, Davidson *et al.*, 1999; Moore and Ranjan, 2005; Hasan *et al.*, 2010; Helpman *et al.*, 2010; Mitra and Ranjan, 2010; Felbermayr *et al.*, 2013; Negem, 2015). The insight of the relationship investigation is that as a result of imperfect information of the labour market, the frictional unemployment appears and persists in the long run.

Davidson *et al.* (1999) incorporated, theoretically, equilibrium job search into a model of international trade to model unemployment, comparing their conclusions with the results of full employment models. Arguing that some traditional results are excessively narrow and do not take a broad view to models with unemployment. They show that their model allows addressing some issues which the traditional model can not hold. Also, their model shows that search frictions in the labour market can affect job creation and destruction.

The model has predicted that the trade between a relatively capital-abundant large country and a smaller relatively labour country results in a low unemployment rate in the large country with more efficient labour market. Davidson and Matusz (2004) analyzed, empirically, Davidson *et al.* (1999) theoretical model. Their empirical results obtained are unswerving with the Dvidson *et al.*'s theoretical predictions.

On the analysis the trade liberalization and unemployment relationship, like the work of Davidson *et al.* (1999), Moore and Ranjan (2005), theoretically, assumed the existence of two factors, but here, they are skilled and unskilled labour, and two countries with different relative factor endowments to specify their model of trade and equilibrium job search. They concluded that trade openness, by increasing the skill intensive goods relative price, lowers the unemployment rate (raises the real wage) of skilled workers and raises the unemployment rate (lowers the real wage) of unskilled workers simultaneously.

In this regard and based on the rise of low-skilled unemployment rate relative to high-skilled workers in Switzerland, empirically, Mohler *et al.* (2018) tried to investigate the relationship between international trade and unemployment. They used a panel data analysis of the Swiss manufacturing sector for the period 1991-2008. No strong evidence is found for the positive impact of international trade on the possibility of individuals to become unemployed, especially, low-skilled ones.

The Year 2010 witnessed a growing interest of the trade liberalization and unemployment relationship. Hasan *et al.* (2010), applying on India case, used a theoretical framework by incorporating trade and search generated unemployment. They used state- and industry- level data on unemployment rates and trade protection. A little evidence is found to support the view that with trade liberalization, unemployment increases. Their finding supports the unemployment falling with trade liberalization view. The analysis of state-level shows a decline of urban unemployment. Moreover, the analysis of industry-level shows that the workers in this level are less to become unemployed with greater trade protection reductions.

Mitra and Ranjan (2010) constructed a general equilibrium model to investigate the influence of offshoring on the unemployment rate. This model has two sectors where unemployment is caused by search frictions. Based on labour mobility, the main conclusion is that offshoring raises the wage and reduces sectoral unemployment. They explained this as a result of enhancing productivity (reducing cost) influence. The negative relative price influence becomes stronger once modifying the model for labour immobility across sectors, counteracting the positive influence of productivity resulting in an increase in unemployment.

Based on assumptions of two sectors, one produces homogenous commodities and the other produces heterogeneous ones, and two countries, Helpman and Itskhoki (2010) incorporated job search and equilibrium unemployment into the models of international trade. They tried to investigate labour market rigidities and trade impediments interaction in shaping welfare, productivity, trade flows, and unemployment. They conclude that lower labour market frictions do not certify lower unemployment, and both unemployment and welfare can be raised as a result of falling the frictions of labour market and costs of trade.

By extending the work of Helpman and Itskhoki (2010), Helpman *et al.* (2010) added job-differences in worker ability. They argue that low ability workers are screened out by the firms to improve their employees. In a closed economy, where the absence of international trade, they predict that the sectoral wages distribution inequality increases in firm productivity and work ability dispersions and the opening of this closed economy to trade amplifies composition differences of workforce. Concerning the issue of interest, they predict that this opening has an indistinct influence on the rate of sectoral unemployment.

Using panel data of OECD20 countries, Felbermayr *et al.* (2013) tried to estimate a two-country Armingtonian trade with frictions on the products and labour market. They conclude foreign institutions affect domestic unemployment by 10% of the influence of domestic ones. Also, they conclude that wage flexibility lowers the size of unemployment spillovers and finally, international trade expanding reduces the unemployment rates.

Investigating the direction of tariffs and unemployment relationship, Negem (2015) constructed a four-variable system to conduct the causality test framed within error correction model. She derived the model under estimation relied on incorporating search-generated unemployment theory into a model of international trade shown in the works of Hasan *et al.* (2010) and Dutt *et al.* (2008). Unemployment is used as a dependent variable and tariffs applied to the EU imports and exports, and finally, trade flow as explanatory ones. Using a panel data analysis of the EU agricultural sector, for the period 2000-2010, the model estimation confirms that a one-way causality between unemployment and tariffs is detected; this is for the full sample. The richest group panel of the EU shows a two-way or bi directional causality between unemployment and tariffs.

Regarding the estimation of the simultaneous equations models to investigate the relationship of unemployment and tariff, it is worth notable that most of them focused on the international trade and economic growth relationship (for more details see, Salvatore, 1983; Esfahani, 1991; Sprout and Weaver, 1993; Frankel *et al.*, 1996; Negem, 2017). Only, a test of tariff endogeneity was applied using the United States data in 1985. In the light of job search theory, Lancaster (1983) tried to analyze the survey data on unemployment and wages. The study findings are inconsistent with search theory.

It is obvious that a very little attention is paid to examine the tariffs and unemployment relationship using a simultaneous equations model. To overcome this shortage in the literature, we contribute to this relationship by constructing a simultaneous equations model and apply using the EU panel data.

3. Methodology

3.1. The Simultaneous Equations Model

3.1.1. The Model Specification

By considering the simultaneity problem, this paper tries to investigate the relationship between unemployment and tariffs. The model specification in the context of a simultaneous equations model is, mainly, relied on a theoretical framework of incorporating search-generated unemployment into a model of international trade shown in the works of Hasan *et al.* (2010), Dutt *et al.* (2008), and Negem (2015). Inflation and real wage are added, as explanatory variables, to the unemployment equation on the base of Phillips (1958) work, proposing an inverse relationship between wage changes and unemployment. Phillips's work was extended by Samuelson and Solow (1960) to reflect the inverse relationship between inflation (rather than wage changes) and unemployment in the short run. Trade flows and tariffs applied by trading partners are added to the simultaneous tariffs equation. The trade flows, represented by *(Export+ import)/GDP*, measure the effect of underlying trade policy instruments. Based on what is stated above, we specify our model under estimation as follows:

$$U = f(TAR_{EU}, INF, W)$$
$$TAR = f(U, TAR_{TP}, TF)$$

Based on the foregoing two functions, a simultaneous equations model is developed to capture the unemployment and tariffs relationship with taking the simultaneity problem into account. The model under estimation is specified as a two equations model:

$$U_{it} = \partial_0 + \partial_1 TAR_{EU} + \partial_2 INF_{it} + \partial_3 W_{it} + \upsilon_{1it} \quad (1)$$

$$TAR_{EU} = \delta_0 + \delta_1 U_{it} + \delta_2 TAR_{TPit} + \delta_3 TF_{it} + \upsilon_{2it} \quad (2)$$

Where,

U is unemployment rate, TAR_{EU} is the tariff imposed by the EU to imports of its trading partners, INF is inflation rate, W is the real wage rate, TAR_{TP} is the tariff imposed to the European Union exports by its trading partners, TF, represented by (exports+imports)/GDP, is the trade flows, υ is independently distributed error term, t is the period from 2009 to 2018 and i is for a country.

3.1.2. The Model Identification

It is said that a specific equation is identified if we can obtain numerical estimates of the structural equation parameters from the coefficients of the estimated reduced form (for more details, see Gujarati, 1995). Two conditions are used to identify individual equation. The first is called order condition. It is necessary but not sufficient for identification and tells us that the considered equation is exactly, over, or under identified. The identifiabiliy condition $N - n \geq m - 1$ is checked. Where N is the number of exogenous, or predetermined, variables in the model including the model intercepts, n is the number of exogenous variables in an equation including intercept of under consideration equation, and m is the number of endogenous, or jointly dependent, variables in a given equation (Gujarati, 1995). We might get one of three cases.

N-n= m-1, the structural equation is exactly identified.

N-n> m-1, the structural equation is over-identified.

N-n< m-1, the structural equation is under-identified.

In our system, for the first equation,

$$U_{it} = \partial_0 + \partial_1 TAR_{EU} + \partial_2 INF_{it} + \partial_3 W_{it} + \upsilon_{1it} \tag{1}$$

N= 6 n= 3 m= 2

Applying the order condition where *N-n≥m-1*, it is found that 6-3>2-1 which means that this equation is over-identified.

For the second equation,

$$TAR_{EU} = \delta_0 + \delta_1 U_{it} + \delta_2 TAR_{TPit} + \delta_3 TF_{it} + \upsilon_{2it} \tag{2}$$

N= 6 n= 3 m= 2

By applying the order condition where *N-n≥m-1* it is found that 6-3>2-1 which means that this equation is over-identified as well.

As each of the above equations is over identified, it can be concluded that it is possible to retrieve more than one structural coefficient from the reduced form of the equation in the model. As mentioned, the order condition of identification is necessary but not sufficient; so the second one that is the rank condition must be applied. It is both necessary and sufficient for identification problem. The model is defined by the matrix rank which should have a dimension *(M-1) (M-1),* where *M* is the number of endogenous variables in the model (for more details, see Negem 2008,). The expected results of applying order and rank conditions can be summarized as follows (Gujarati, 1995):

a) If N-n> m-1(order condition) and the rank of the matrix is M-1, the equation is over-identified.
b) If N-n= m-1 (order condition) and the rank of the matrix is M-1, the equation is exactly identified.
c) If N-n<m-1 (order condition) and the rank of the matrix is less than M-1, the equation is under- identified.

Gujarati (2003, 752) summarizes several steps to apply the rank condition. First, the system should be written down in a tabular form. Second, we should strike out the coefficients of the row where the equation under consideration appears. The next is to strike out the columns corresponding to those coefficients in the previous step which are nonzero. The entries left in the table will give only the coefficients of the variables included in the system but not in the equation under consideration. Then all possible matrixes will be formed from these entries, like X, of order M-1 and finally, the corresponding determinants should be obtained, which have to be unequal to zero.

As the model is:

$$U_{it} = \partial_0 + \partial_1 TAR_{EU} + \partial_2 INF_{it} + \partial_3 W_{it} + \upsilon_{1it} \tag{1}$$

$$TAR_{EU} = \delta_0 + \delta_1 U_{it} + \delta_2 TAR_{TPit} + \delta_3 TF_{it} + \upsilon_{2it} \tag{2}$$

so,

	constant	U_{it}	TAR_{EU}	INF_i	W_{it}	TAR_{TP}	TF_{it}
U_{it}	-	1	-	-	-	0	0
TAR_{EU}	-	-	1	0	0	-	-

The matrix of coefficients missing from each of the above equations is:

For the U_{it} equation: $X_1 = -\delta_2 \neq 0$ or $-\delta_3 \neq 0$

For the TAR_{EU} equation: $X_2 = -\partial_2 \neq 0$ or $-\partial_3 \neq 0$

Thus the structural coefficients can be retrieved from the reduced form coefficients since the rank condition allows each of the above equations to be identified.

3.1.3. The reduced form of the simultaneous equations model of Unemployment and Tariffs

As indicated, our model is specified as follows:

$$U_{it} = \partial_0 + \partial_1 TAR_{EU} + \partial_2 INF_{it} + \partial_3 W_{it} + \upsilon_{1it} \tag{1}$$

$$TAR_{EU} = \delta_0 + \delta_1 U_{it} + \delta_2 TAR_{TPit} + \delta_3 TF_{it} + \upsilon_{2it} \quad (2)$$

The model solution can be obtained by substituting TAR_{EU} in equation 1 by the second equation. So,

$$U_{it} = \partial_0 + \partial_1 (\delta_0 + \delta_1 U_{it} + \delta_2 TAR_{TP\,it} + \delta_3 TF_{it}) + \partial_2 INF_{it} + \partial_3 W_{it} + \upsilon_{1it}$$

$$U_{it} = \partial_0 + \partial_1\delta_0 + \partial_1\delta_1 U_{it} + \partial_1\delta_2 \; TAR_{TP\,it} + \partial_1\delta_3 \; TF_{it} + \partial_2 \; INF_{it} + \partial_3 \; W_{it} + \upsilon_{1it}$$

By putting $\partial_1\delta_1 \; U_{it}$ on the left side.

$$U_{it} - \partial_1\delta_1 U_{it} = \partial_0 + \partial_1\delta_0 + \partial_1\delta_2 \; TAR_{TP\,it} + \partial_1\delta_3 \; TF_{it} + \partial_2 \; INF_{it} + \partial_3 \; W_{it} + \upsilon_{1it}$$

By taking a common factor U_{it} .

$$U_{it} (1 - \partial_1\delta_1) = \partial_0 + \partial_1\delta_0 + \partial_1\delta_2 \; TAR_{TP\,it} + \partial_1\delta_3 \; TF_{it} + \partial_2 \; INF_{it} + \partial_3 \; W_{it} + \upsilon_{1it}$$

Dividing both equation sides by $(1 - \partial_1\delta_1)$

$$\text{a}U_{it} = (\partial_0 + \partial_1\delta_0)/(1 - \partial_1\delta_1) + (\partial_1\delta_2 /(1 - \partial_1\delta_1))^* \; TAR_{TP\,it} + (\partial_1\delta_3 /(1 - \partial_1\delta_1))^* TF_{it}$$
$$+(\partial_2 / (1 - \partial_1\delta_1))^* INF_{it} +(\partial_3 / (1 - \partial_1\delta_1))^* W_{it} \; +(1/ (1 - \partial_1\delta_1))^* \upsilon_{1it}$$

So, the reduced form for U_{it} is:

$$U_{it} = \Pi_{10} + \Pi_{11} + \Pi_{12}\,\mathrm{TF}_{it} + \Pi_{13}\mathrm{INF}_{it} + \Pi_{14}\,\mathrm{W}_{it} + \mu_{1it}$$

where,

$\Pi_{10} = (\partial_0 + \partial_1\partial_0)/(1 - \partial 1\delta_1)$ $\qquad$ $\Pi_{11} = \partial_1\delta_2 / (1 - \partial_1\delta_1)$

$\Pi_{12} = \partial_1\delta_3/(1 - \partial_1\delta_1)$ $\qquad$ $\Pi_{13} = \partial_2/(1 - \partial_1\delta_1)$

$\Pi_{14} = \partial_3/(1 - \partial_1\delta_1)$

$$TAR_{EU} = \delta_0 + \delta_1(\partial_0 + \partial_1 TAR_{EU} + \partial_2 INF_{it} + \partial_3 W_{it}) + \delta_2 TAR_{TPit} + \delta_3 TF_{it} + \upsilon_{2it}$$

So,

$$TAR_{EU} = \delta_0 + \partial_0\delta_1 + \partial_1\delta_1 TAR_{EU} + \partial_2\delta_1\alpha_2 INF_{it} + \partial_3\delta_1 W_{it} + \delta_2 TAR_{TPit} + \delta_3 TF_{it} + \upsilon_{2it}$$

By putting $\partial_1\delta_1 \; TAR_{EU}$ on the left side and taking a common factor,

$$TAR_{EU}(1 - \partial_1\delta_1) = \delta_0 + \partial_0\delta_1 + \partial_2\delta_1 INF_{it} + \partial_3\delta_1 W_{it} + \delta_2 TAR_{TPit} + \delta_3 TF_{it} + \upsilon_{2it}$$

Dividing both equation sides by $(1 - \partial_1\delta_1)$,

$$TAR_{EU} = (\delta_0 + \partial_0\delta_1)/(1 - \partial_1\delta_1) + (\partial_2\delta_1 /(1 - \partial_1\delta_1)) * INF_{it} + (\partial_3\delta_1 /(1 - \partial_1\delta_1)) * W_{it} +$$
$$(\delta_2 /(1 - \partial_1\delta_1)) * TAR_{TPit} + (\delta_3 /(1 - \partial_1\delta_1)) * TF_{it} + (1/(1 - \partial_1\delta_1)) * \upsilon_{2it}$$

Rearranging the variables, we get the following equation,

$$TAR_{EU} = (\delta_0 + \partial_0\delta_1)/(1-\partial_1\delta_1) + (\delta_2/(1-\partial_1\delta_1)) * TAR_{TPit} + (\delta_3/(1-\partial_1\delta_1)) * TF_{it} + (\partial_2\delta_1/(1-\partial_1\delta_1)) * INF_{it} + (\partial_3\delta_1/(1-\partial_1\delta_1)) * W_{it} + (1/(1-\partial_1\delta_1)) * \upsilon_{2it}$$

Then the reduced form for equation 2 is:

$$TAR_{EU} = \Pi_{20} + \Pi_{21} + \Pi_{22}\mathrm{TF}_{it} + \Pi_{23}\mathrm{INF}_{it} + \Pi_{24}\mathrm{W}_{it} + \mu_{2it}$$

where,

$\Pi_{20} = (\delta_0 + \partial_0\delta_1)/(1-\partial_1\delta_1)$ $\quad$ $\Pi_{21} = \delta_2/(1-\partial_1\delta_1)$

$\Pi_{22} = \delta_3/(1-\partial_1\delta_1)$ $\quad$ $\Pi_{23} = \partial_2\delta_1/(1-\partial_1\delta_1)$

$\Pi_{24} = \partial_3\delta_1/(1-\partial_1\delta_1)$

The model of unemployment and tariffs presented above has four exogenous variables and its reduced form is written as:

$$U_{it} = \Pi_{10} + \Pi_{11} + \Pi_{12}\mathrm{TF}_{it} + \Pi_{13}\mathrm{INF}_{it} + \Pi_{14}\mathrm{W}_{it} + \mu_{1it}$$

$$TAR_{EU} = \Pi_{20} + \Pi_{21} + \Pi_{22}\mathrm{TF}_{it} + \Pi_{23}\mathrm{INF}_{it} + \Pi_{24}\mathrm{W}_{it} + \mu_{2it}$$

Both μ_{1it} and μ_{2it} represent composite error terms.

3.2. Unit root test

For stationarity, the IPS test is used (Im, Pesaran and Shin's, 1998). This test of panel unit root technique allows for heterogeneity in both intercepts and the slope coefficients. The IPS statistic is the individual ADF statistics average computed as t-bar statistics. By regressing each variable on a time dummies set and taking the residuals, any common time effects are removed and the correlation risk across countries is reduced (for more details, see Negem, 2015).

4. Data and empirical results of the simultaneous equations model.

To estimate the simultaneous equations model of unemployment and tariffs, this paper uses panel data of the European Union. A panel of 10-year average for the period 2009-2018 is created. Our sample includes 28 countries and their trading partners, indicated in appendix 1, both the members and non-members in the European Union. The main variables of interest are unemployment rate (*U*), tariffs applied to the imports of the EU (TAR_{EU}), inflation rate (*INF*), real wage rate (*W*), tariffs applied to the EU exports by its trading partners (TAR_{TP}), and finally, trade flow (*TF*).

Our estimation depends on some database shown as follows: International Financial Statistics-IMF elibrary and European Commission available at *www.ec.europa.eu/index_en.htm*, World Development Indicators (WDI) and International Trade Centre available at *www.intracen.org/itc/*

market-info-tools/trade-statistics/, International labour organization available at *ilostat.ilo.org* and WORLD FACTBOOK ARCHIVES (The World Factbook, 2009-2018) available at *cia.gov* are useful to get the data of unemployment, inflation and wage rates. Also, the above databases are useful to get exports, imports and GDP to calculate trade flows represented by (Exports+Imports)/GDP. Data for tariffs both applied by the EU and applied by the EU trading partners (as the computed weighted average of bilateral applied tariffs) are obtained using eurostat available at ec.europa.eu, database of Integrated Tariff European Community (TARIC), and World Integrated Trade Solution (WITS). Data for tariffs and wages are obtained for the agriculture, plantations, and other rural sectors. To overcome the problem of the existence of a number of zeros in the tariff vectors, we estimate our model by computing natural logarithm of *(1+TAR)* for both TAR_{EU} and TAR_{TP}.

Give Win, Pc-Give is used to obtain the results of the proper tests and the simultaneous equations model estimation. It begins by testing for unit root. Then, we estimate our simultaneous equations model. Three-stage least squares (3SLS) technique is used to estimate our model. It is a general method to get consistent estimates and overcome the endogeneity of any causing variable. Some independent variables may be endogenous ones such as *W*, *TF*, and *INF*. The results obtained are analyzed as follows:

4.1. Unit Root test results

The order of integration, first, is tested in all model variables series to check whether unit root exists in the data or not. As mentioned, IPS test is conducted in level and first difference. In real quantities, all variables are expressed. Table 1 presented the unit root test results:

Table 1
Unit Root results for Full Sample (2009-2018)

variables	*Average ADF*	
	Level	*First Difference*
U	-3.59*	-7.38*
TAR_{EU}	-2.46*	-4.96*
INF	-2.99*	-5.09*
W	- 3.54*	-6.27*
TAR_{TP}	-1.95	-3.71*
TF	-2.78*	-4.58*

Notes: (1) All data used are in logarithmic form.
(2) * indicates significance at 1%level.

The IPS test results shown in table 1 on the level form reject the null of non-stationarity except for TAR_{TP}; however they do reject the null for all variables as first differenced become stationary at the 1% significance level. This means the mentioned variable is integrated of order one, I (1), i.e. it has a stochastic trend and as a consequence we can not reject the null hypothesis of the unit root existence for the level form. However, as first differenced, all variables are stationary, i.e. they are integrated of order zero, I (0), at 1% significance.

4.2. Regression Results

Table 2 reports the estimated coefficients of the reduced form.

Table 2
The Reduced form Estimates

The reduced form coefficient		*The reduced form estimated coefficient*	*t-statistics*
For U equation			
Π_{10}	(constant)	-0.3782*	-4.432
Π_{11}	(TAR_{TP})	-0.1522*	-3.647
Π_{12}	(TF)	0.0076*	-5.894
Π_{13}	(INF)	-0.1634*	6.587
Π_{14}	(W)	-0.0723*	-3.645
R^2		0.69	
For TAR_{EU} equation			
Π_{20}	(constant)	0.4536*	-2.934
Π_{21}	(TAR_{TP})	0.8224*	2.872
Π_{22}	(TF)	0.0017*	-5.632
Π_{23}	(INF)	-0.1836*	-2.985
Π_{24}	(W)	-0.0023*	-2.783
R^2		0.54	

Note: * indicates significance at 1%level.

Shown in table 2, R^2 for *U* equation indicates that the Regressors explain 69% of the variations in the dependent variable. Similarly, R^2 for TAR_{EU} equation shows that a reasonable proportion, 54%, of the variations is explained by the Regressors (explanatory variables. To obtain the parameters of the structural equations 1 and 2, the reduced form estimates (estimated coefficients) are retrieved. For the retrieving process, see appendix 2.

Table 3
Retrieved parameters for the regression of the Full Sample

Regressors	*parameters*	*Equation 1 for U*	*Equation 2 for TAR_{EU}*
constant	∂_0	-0.291	
TAR_{EU}	∂_1	-0.185	
INF	∂_2	-0.164	
W	∂_3	-0.071	
constant	δ_0		0.459
U	δ_1		0.032
TAR_{TP}	δ_2		0.817
TF	δ_3		0.002

Table 3 reports the retrieved parameters gotten from the estimates of the reduced form shown in table 2. Our data analysis relies on elasticities since we estimated all variables in logarithmic form. This means if $\ln U = \partial_0 + \partial_1 \ln TAR_{EU}$ here, ∂_1, -0.185 = $\dfrac{\Delta U / U}{\Delta TAR_{EU} / TAR_{EU}}$. As a consequence of the significance of the reduced form estimates at 1% level, the parameters retrieved are statistically significant. To apply panel data, the over identified restrictions are used for instrumental (exogenous) variables estimation. This is to avoid the over identification problem. Hence, our results analysis relies on these retrieved parameters. The null hypothesis of residuals homoschedasticity is accepted by the White test. Based on Hausman's test, it is indicated that the fixed effect model is statistically preferable to the error-components model (for more details, see appendix 3).

Both columns 3 and 4 in table 3 present the retrieved parameters for $U and TAR_{EU}$ equations. On one hand, column 3 presents the retrieved parameters for equation 1 where *U* is the endogenous (dependent) variable. It shows that tariffs applied to the European imports, TAR_{EU}, inflation rate, *INF*, and real wage, *W*, have inverse relationships with unemployment rate (*U*). TAR_{EU} looks to have greater influence than the other two variables. On the other hand, column 4 presents the retrieved parameters for equation 2 where TAR_{EU} represents the endogenous variable. All have positive signs, meaning the positive relationships between, on one hand, unemployment rate, *U*, tariffs applied by the EU trading partners, TAR_{TP}, and trade flow,

TF, and tariffs applied by EU, TAR_{EU} on the other hand. TAR_{TP} has a greater effect. It is obvious that a bi-directional relationship is detected between U and TAR_{EU} . δ_1 Coefficient implies that a 1% increase in U leads to a 0.032 increase in tariffs applied by EU (TAR_{EU}). It is less than the inverse effect of TAR_{EU} on unemployment, U, which is -0.185 shown in the first equation.

5. Concluding Remarks

Our paper addresses the simultaneity problem of the unemployment and tariffs relationship. It tries to indicate the direction of this relationship using the simultaneous equations model. This paper contributes to the literature by considering the simultaneity problem that represents an important quantitative aspect when investigating the unemployment and tariffs relationship. Applying on the EU countries, a two-equation simultaneous equations model is conducted. The two endogenous variables are unemployment rate (U) and tariffs applied by the EU to its imports (TAR_{EU}). The first equation of our model states that unemployment rate is determined by tariffs applied to the EU imports, inflation rate, and real wage rate. The second one states that tariff applied to the EU imports is determined by unemployment rate, tariffs applied to the EU exports by its trading partners, and trade flows.

We estimated our model the 3SLS method using EU panel data for the period 2009-2018. The results obtained, for the full sample, found a bi-directional relationship between unemployment and tariffs levied by the EU to its imports. An inverse effect runs from tariffs levied by the EU to unemployment; however, it is a positive effect running from unemployment to tariffs levied by the EU. Also, both inflation and wage rates have inverse influence on unemployment. To recommend, by operating on some of the previous variables, exogenous, (as policy instruments) the EU governments can try to increase inflation rate or wage rate to reduce unemployment.

Appendix 1
EU and its Trading Partners

Ser.	*Country*	*Exports-partners*	*Imports-partners*
1	Austria	Germany and US	Germany and Switzerland Netherlands and US
2	Belgium	Germany and US	Russia and Turkey
3	Bulgaria	Germany and Turkey	Russia and China
4	Croatia	Bosnia and Herzegovina, and Serbia	Israel and China
5	Cyprus	UK and Germany	China and Russia
6	Czech Republic	Germany and Slovakia	Norway and China
7	Denmark	US and Norway	Russia and China
8	Estonia	Sweden and Russia	Russia and Sweden
9	Finland	US and Russia	Germany and China
10	France	Germany and US	China and Russia
11	Germany	US and China	Russia and China
12	Greece	Turkey and Italy	Russia and China
13	Hungary	Germany and France	UK and US
14	Ireland	US and UK	China and France
15	Italy	Germany and US	Russia and Lithuania
16	Latvia	Russia and Lithuania	Russia and Germany
17	Lithuania	Russia and Belarus	US and China
18	Luxembourg	Germany and Belgium	Italy and UK
19	Malta	Singapore and Hong Kong	China and Russia
20	Netherlands	Germany and France	Russia and China
21	Poland	Russia and UK	Spain and Angola
22	Portugal	Angola and US	Germany and Russia
23	Romania	Turkey and Germany	Russia and South Korea
24	Slovakia	Germany and Hungary	China and Germany
25	Slovenia	Russia and Croatia	Germany and China
26	Spain	France and Italy	China and Russia
27	Sweden	Norway and US	China and US
28	United Kingdom	Switzerland and US	

Appendix 2
The Retrieving Process of the Reduced Form Estimated Coefficients

To simplify, one parameter is considered for the results analysis.

To obtain ∂_1:

$\partial_1 = \Pi_{11} / \Pi_{21} = -0.1522/0.8224 = -0.185$

To obtain δ_1:

$\delta_1 = \Pi_{24} / \Pi_{14} = 0.0023 / 0.0723 = 0.032$

To obtain ∂_2:

$\Pi_{13} = \partial_2 / (1 - \partial_1\delta_1)$ so, $-0.1634 = \partial_2$ / (1- 0.185*0.032) so, $-0.1634 = \partial_2$ / (1-0.006)

$0.1634 = 0.994 * \partial_2$

$\partial_2 = -0.164$

To obtain ∂_3:

$\Pi_{24} = \partial_3\delta_1 / (1 - \partial_1\delta_1)$ so, $-0.0023 = \partial_3 * 0.032/0.994$

$-0.032\ \partial_3 = 0.00228$ so, $\partial_3 = -0.071$
To obtain δ_2:
$\Pi_{21} = \delta_2 / (1 - \partial_1\delta_1)$
$0.8224 = \delta_2/0.994$ so, $\delta_2 = 0.817$
To obtain δ_3:
$\Pi_{22} = \delta_3 / (1 - \partial_1\delta_1)$
$0.0017 = \delta_3/0.994$ so, $\delta_3 = 0.002$
To obtain ∂_0 and ∂_0:
$\Pi_{10} = (\partial_0 + \partial_1\delta_0) / (1 - \partial_1\delta_1)$ $\Pi_{20} = (\delta_0 + \partial_0\delta_1) / (1 - \partial_1\delta_1)$
$-0.3782 = (\partial_0 + (-0.185)^* \delta_0) / 0.994$
$-0.376 = \partial_0 - 0.185\ \delta 0$ (1)
$\Pi_{20} = (\delta 0 + \partial_0\delta_1) / (1 - \partial_1\delta_1)$
$0.4536 = (\delta_0 + \partial_0 {}^*0.032)/0.994$
$0.4508 = 0.032\ \partial_0 + \delta_0$ (2)
By putting both equations (1) and (2) together
$-0.376 = \partial_0 - 0.185\ \delta_0$ (1)
$0.4508 = 0.032\ \partial_0 + \delta_0$ (2)
By multiplying equation (2) by 0.185
$0.083 = 0.006\ \partial_0 + 0.185\ \delta_0$ and adding to equation (1)
$-0.293 = 1.006\ \partial_0$ so, $\partial_0 = -0.291$
Replacing the value of ∂_0 in equation (1) we can obtain the value of δ_0
$-0.376 = -0.291 - 0.185\ \delta_0$
$-0.085 = -0.185\ \delta_0$ so, $\delta_0 = 0.459$

Appendix 3
The Results of Hausman and White tests

For Hausman's specification test:

The null hypothesis, H_0: the model is correctly specified

The alternative hypothesis, H_1: the model is mis specified

To test for model mis specification, The Hausman test is the Hausman F-statistic. It is used for the comparison between two-stage least squares (2SLS) and (3SLS) for an estimators class for which 3SLS is asymptotically efficient to determine, when applying panel data, whether we use fixed or random effects models. It is noted that this paper uses 3SLS to estimate the simultaneous equations model of unemployment and tariffs. The following table indicates the results of Hausman test.

	Equation	
	U	
	TAR_{EU}	
Hausman test	1.68	1.43

Here, we use Hausman's test as a kind of Wald χ^2 test.

With k-1 freedom degrees.

k is the NO. of regressors.

White's test:

White's test is a test for heteroscedasticity. It is used to establish whether the residual variance of a variable in a regression model is constant (homoscedasticity exists) (White, 1980). We test this constant variance by regressing the squared residuals from a regression model onto the regressors, then inspecting R^2 (Negem, 2017). The following table indicates the results of White test.

	Equation	
	U	TAR_{EU}
White test	17.2	16.8

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