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Abstract

The recent U.S. trade policy shift has reignited interest about the macroeconomic effects of import tariffs. This paper examines the impacts of import tariff shocks on U.S. macroeconomic performance using quarterly data from 1989-2017. Relying upon the estimation of structural VAR model with sign restrictions, the results suggest that tariff shocks on net-imported vital intermediate input, such as steel, trigger stagflationary tendencies as characterized by short-run increase in inflation and unemployment and decline in real output.

Keywords: import tariff shocks, steel, stagflation, structural VAR

JEL Classification: F1; F14; C3

1 Introduction

Stagflation may be defined as a condition of simultaneous price inflation and unemployment (McConnell, 1978). Since the 1970s oil shocks, there has been a strong belief that energy crises are the most important element that accelerate and intensify the tendency towards stagflation (Branson and Rotemberg 1979; Bruno and Sachs 1985; Blinder and Rudd 2008; Burbige and Harrison 1984; Harkness 1982; Malinvaud 1977; Hill 1980; Leduc and Sill 2004; Mork Olsen and Mysen 1994; Peterson 1980).[1] Consequently, not very much work have been done to examine other possible sources of stagflation. The exceptions are Gilbert and Hendryson (1975), Barsky and Kilian (2002), and Kilian (2010). Gilbert and Hendryson (1975) identify overtaxation as the cause of stagflation whereas Barsky and Kilian (2002) and Kilian (2010) emphasized monetary conditions as the cause of stagflation.

The recent trade policy shift in the United States (U.S.) –particulary, the 2018 steel tariffs– has reignited interest about the impact of protectionist-leaning trade policies on inflation, output, and unemployment. Thus, the objective of this paper is to examine the macroeconomic effects of the steel import tariffs on the U.S. economy. More specifically, whether tariffs on steel could generate stagflationary tendencies.

The paper's contribution to the trade literature is two-fold. One, the paper is the first attempt towards modeling import tariff shocks using sign-restricted structural VAR model. In particular, it defines and and structurally identifies steel tariff shocks alongside other macroeconomic shocks such as inflation, output, and unemployment. Two, the study provides detailed analysis of the short-run macroeconomic effects of the tariff shocks using impulse response functions.

The remainder of the paper is organized as follows. Section 2 contains a discussion on modeling the effects of import tariffs on the macroeconomy. Section 3 lays out the empirical model. Section 4 operationalizes the empirical model using quarterly data on the U.S. economy from 1989-2017. A discussion of the results is also contained in Section 4. The paper ends with few concluding remarks in Section 5.

2 Modeling the macroeconomic effects of tariffs

Tariff is tax levied on imported goods. It can be specific tariff when placed on each unit of imported good or ad valorem tariff when calculated as a percentage of the value of the imported good. Tariff, whether specific or ad valorem, increases the price of the imported good. A question of principal interest in this paper relates to whether steel tariffs generate stagflationary pressures, i.e., coexistence of inflation and unemployment in the country imposing the tariff. In other words, do stagflationary tendencies arise when a country imposes tariff on a vital intermediate input such as steel?

Many advanced economies, like the U.S., are net importers of steel. In addition, the steel-consuming industries constitute an integral part of these economies. As a result, a tariff-driven increase in domestic steel prices increases cost of production for steel-consuming industries which span a wide range of manufacturing sectors including fabricated metal products, machinery and equipment, and transportation equipment and parts. Companies in these sectors often produce parts that are used to make products ranging from cars, appliances, to lawn-mower blades. Steel consumers also include chemical manufacturers, who use steel products extensively for storage and transportation of the products they manufacture; petroleum refinery companies and their contractors, who use steel pipe and oil field equipment to drill for and transport petroleum and natural gas; tire manufacturers, which put steel belts and beads in tires for safety and durability; and nonresidential construction companies, who use a variety of steel products to build offices, bridges, and roads (Francois and Baughman 2003).

Following a steel tariff-driven increased cost of production, steel-consuming industries can react to the increased cost in either or both of the two following ways. They can attempt to pass the increased steel costs to consumers by raising prices. To the extent that they succeed, price inflation will result. Steel-consuming industries can also attempt to minimize the increased steel costs by cutting back production. To the extent that they succeed, unemployment will result. Consequently, the combined effect of the tariff-driven steel price increase is to generate unemployment and inflationary tendencies in the economy imposing the tariff.

For the purpose of illustrating the tariff-driven stagflation hypothesis, the study specifies the following steel price function for a net-steel importing country:

$$P = f(C, P_m) \quad [1]$$

$$P_m = \phi(t) \quad [2]$$

where P denotes steel price in the country, C denotes the cost of steel production, P_m is the price of imported steel, and t is the steel tariff rate. Holding C constant, the relationship between P and t can be expressed as:

$$P(t) = f(Pm) = f((t)) \quad [3]$$

From [3], taking the derivative of P with respect to t yields:

$$\frac{\delta P}{\delta t}(t) = \frac{\delta f}{\delta P_m}(\phi(t)).\frac{\delta \phi}{\delta t}(t) \quad [4]$$

where $\frac{\delta f}{\delta P_m}(\phi(t))$ measures the effect of changes in the price of imported steel P_m on domestic steel price P at tariff rate t, and $\frac{\delta \phi}{\delta t}(t)$ measures the effect of changes in steel tariff rate t on the price of imported steel P_m. Since tariff rate t and the price of imported steel P_m are positively related, then $\frac{\delta f}{\delta P_m}(\phi(t)) > 0$ and $\frac{\delta \phi}{\delta t}(t) > 0$. Thus from [4]:

$$\frac{\delta P}{\delta t}(t) > 0 \quad [5]$$

indicating the tariff-driven increase in domestic steel price.

What is the impact of the tariff-driven steel price increase on inflation and unemployment? As noted earlier, the increase in steel price raises the cost of production of steel-consuming industries. Depending on the reaction of the steel-consuming industries, price inflation and/or unemployment will result. To delineate the effect of tariff-driven steel price increase on inflation, the following inflation function is specified:

$$\pi = g(P, \mathbf{Z}) \quad [6]$$

where π is the average price level, P as before denotes steel price in the country, and $\boldsymbol{Z}$ is a set of control variables which may include real GDP, interest rate, wage rate, budget deficit, and energy prices. Abstracting from the variables in $\boldsymbol{Z}$, [6] can be simplified as:

$$\pi = g(P) \quad [7]$$

Assuming t directly affects P such that:

$$P = \vartheta(t) \quad [8]$$

then combining [7] and [8] yields:

$$\pi(t) = g(\vartheta(t)) \quad [9]$$

From [9], taking the derivative of π w.r.t. t yields:

$$\frac{\delta \pi}{\delta t}(t) = \frac{\delta g}{\delta P}(\vartheta(t)).\frac{\delta \vartheta}{\delta t}(t) \quad [10]$$

where $\frac{\delta g}{\delta P}(\vartheta(t))$ measures the effect of changes in domestic steel price P on inflation at tariff rate t, and $\frac{\delta\vartheta}{\delta t}(t)$ measures the impact of changes in tariff rate t on domestic steel price P. Since t and P are positively related, then $\frac{\delta g}{\delta P}(\vartheta(t)) > 0$ and $\frac{\delta\vartheta}{\delta t}(t) > 0$. Thus from [10]:

$$\frac{\delta\pi}{\delta t}(t) > 0 \qquad [11]$$

[11] indicates the tariff-induced inflation.

Similarly unemployment, u, in the economy can be represented as follows:

$$u = h(P, \mathbf{Z}) \qquad [12]$$

where P and $\boldsymbol{Z}$ are as defined before. Again, abstracting from the variables in $\boldsymbol{Z}$, [12] can be rewritten as:

$$u = h(P) \qquad [13]$$

Assuming tariff directly affects domestic steel price, invoking [8] and combining it with [13] yields:

$$u(t) = h(\vartheta(t)) \qquad [14]$$

From [14], taking the derivative of u w.r.t. t yields:

$$\frac{\delta u}{\delta t}(t) = \frac{\delta h}{\delta P}(\vartheta(t)).\frac{\delta\vartheta}{\delta t}(t) \qquad [15]$$

where $\frac{\delta h}{\delta P}(\vartheta(t))$ measures the effect of changes in domestic steel price P on unemployment u at tariff rate t, and $\frac{\delta\vartheta}{\delta t}(t)$ measures the effect of changes in tariff rate t on domestic steel price P. Here, while $\frac{\delta\vartheta}{\delta t}(t) > 0$, $\frac{\delta h}{\delta P}(\vartheta(t))$ could be negative or positive depending on the net effect of the job-creation and job-shedding tendencies of the steel tariff. $\frac{\delta h}{\delta P}(\vartheta(t)) < 0$ if job gains in steel-producing sector of the economy (due to steel tariff-driven increase in domestic steel price) outweighs job losses in steel-consuming sectors of the economy (due to steel tariff-induced increased cost of production). Conversely, $\frac{\delta h}{\delta P}(\vartheta(t)) > 0$ if job losses in steel-consuming sectors of the economy outweighs job gains in the steel-producing sector. Since there is reason to believe the latter scenario to be the case in many advanced net-steel importing economies such as the U.S. where steel-consuming sectors tend to be larger (in terms of output and employment) than the steel-producing sector, then $\frac{\delta h}{\delta P}(\vartheta(t)) > 0$. Together with $\frac{\delta\vartheta}{\delta t}(t) > 0$, from [15]:

$$\frac{\delta u}{\delta t}(t) > 0 \qquad [16]$$

[16] indicates the tariff-induced unemployment.

Equations [11] and [16] summarize the tariff-driven stagflation hypothesis. The next section discusses the empirical model to test the hypothesis.

3 Empirical Model

To test the tariff-driven stagflation hypothesis, the study specifies the following structural VAR model:

$$\mathbf{A}_0\mathbf{y}_t = \sum_{i=1}^{n} \mathbf{A}_i\mathbf{y}_{t-1} + \boldsymbol{\varepsilon}_t \qquad [17]$$

where $\mathbf{y}_t$ denotes a vector time series consisting of inflation rate (INF_t), unemployment rate (UNE_t), real GDP (GDP_t), and tariff rate (TRF_t). The vector ε_t consists of four structural shocks. The first three shocks correspond respectively to the inflation shock, unemployment shock, and output shock common in macroeconomic shocks literature (Barsky Basu Lee 2014; Bernanke Gertler Watson 1997; Burbige and Harrison 1984; Cochrane 1998; Evans 1989; Hamilton, 1983; Kilian 2009; Mountford and Uhlig 2009; Peersman and Van Robays 2009; Ramey 2016; Sims 1980; Uhlig 2005). The study introduces a fourth shock referred to as tariff shock. This shock is associated with unexpected increases in tariff rates (here, steel tariff rate).

To identify the shocks, the study uses the sign restrictions approach of Uhlig (2005) and Mountford and Uhlig (2009) which allows the identification of shocks by directly restricting the signs of their impulse responses. Table 1 shows the sign restrictions for the shocks, each of which is discussed in turn. First, *inflation shock* is an unexpected increase in prices. The study postulates that inflation shock will tend to raise prices and decrease the rate of unemployment (classic Philips curve). However, the effect of this shock on output and steel tariff is unclear. Unexpected increase in prices could be associated with output growth or trigger output decline. Also, it is difficult to identify any automatic response of steel tariff rates following an inflation shock since steel tariff hikes could exacerbate the inflationary pressures. For these reasons, no restrictions are imposed on tariff and output responses to inflation shock. Instead, we let the data determine the signs of these responses. Second, *unemployment shock* is defined as unanticipated increase in unemployed labor and are assumed to be associated with high unemployment rate, low inflation rate, and output decline. The effect of this shock on tariff is unclear although it is likely to trigger calls for targeted tariff increase in the trade-related sectors of the economy. Consequently, no restriction is applied to tariff rate response to unemployment shock. Third, *output shock* is defined as unexpected increases in real output growth driven by economic expansion and are assumed to move inflation and unemployment in opposite directions. However, like inflation and unemployment shocks, the effect of this shock on tariff is not clear hence no restriction is imposed. Finally, *tariff shock* is defined as a sudden increase in tariff (steel tariff) and is assumed to raise inflation and unemployment but may or may not increase real output. This shock is also characterized by a positive co-movement with the steel tariff rates. The price inflation that follows the tariff shock results from steel-consuming industries attempt to pass portions of the increased steel costs to the consumers by marginally raising prices, while the increase in unemployment arises from job-shedding attempts by the steel-consuming industries through production cut-backs. These set identifying restrictions imposed in Table 1 implies a unique response pattern for each structural shock. With this set of restrictions, the study operationalizes the empirical model using quarterly macroeconomic data on the U.S. economy.

Table 1: Sign restrictions

Shock/Variable	Inflation rate	Unemployment rate	Real GDP growth	Steel tariff rate
Inflation shock	+	-		
Unemployment shock	-	+	-	
Output shock	+	-	+	
Tariff shock	+	+		+

Notes: Missing entries mean that no sign restriction is imposed.

4 Understanding the macroeconomic effects of steel tariffs on the U.S. economy

4.1 Data

The study uses quarterly inflation rate, unemployment rate, real GDP growth, and steel tariff rate data from 1989-2017. Table 2 provides summary statistics of the variables. Inflation rate is the average quarterly percent change in the producer price index for all commodities and the consumer price index for all items. Unemployment rate is the quarterly civilian unemployment rate. Real GDP growth is the quarterly percent change in inflation adjusted value of goods and services. Data on producer price index, consumer price index, unemployment rate, and real GDP growth are obtained from the St. Louis Fed FRED website using the series PPIACO, CPIAUCNS, UNRATE, and GDPC1. Steel tariff rate data is obtained from the US International Trade Commission (USITC) Harmonized Tariff Schedule publications. The starting date of the analysis is dictated by the availability of steel tariff rate data. The publication of the Basic Harmonized Tariff Schedule (BHTS) began in 1989. For most years, the BHTS is updated with supplementary and revision publications (referred to as *supplements*, for short). Where supplements available, attempt is made to compare the new presidential proclamation for modification of the tariff rates with previous rates. If the steel tariff rates from the basic publication and the supplements differ, the dates on the publications are used to match the rates with the respective quarter of the year. If the rates do not differ, the original schedule rates are maintained. On few occasions like 1990, only the supplementary publication is available. In that instance, the rates in the supplement is used. In the years missing both the BHTS publication and supplements, the immediately preceding years rates is used. This applies to 1992. The tariff rates are in annual frequency and made up of three major categories: non-alloy steel, stainless steel, and other alloy steel. To obtain quarterly observations of steel tariff rates, the study used the average rate of the three categories in a given year for all four quarters of that year.

Table 2: Summary statistics of variables

	Inflation rate	Unemployment rate	Real GDP growth	Steel tariff rate
Mean	2.36	5.96	2.46	27.42
Median	2.58	5.55	2.64	26.13
Maximum	10.37	9.93	5.27	30.50
Minimum	-7.45	3.90	-4.06	25.67
Std. Dev.	2.88	1.53	1.73	2.03
Skewness	-0.6152	0.9785	-1.3138	0.5526
Kurtosis	4.3983	3.1294	5.7466	1.5636

Notes: Summary statistics are based on quarterly averages for sample period 1989Q1-2017Q12. Inflation rate is the average quarterly percent change in the producer price index for all commodities and the consumer price index for all items. Unemployment is the quarterly civilian unemployment rate. Real GDP growth is the quarterly percent change in inflation adjusted value of the goods and services. Data on producer price index, consumer price index, unemployment rate, and real GDP growth are obtained from the St. Louis Fed FRED website using the series PPIACO, CPIAUCNS, UNRATE, and GDPC1. Steel tariff rate data is obtained from the US International Trade Commission (USITC) Harmonized Tariff Schedule publications and are in annual frequency and made up of three major categories, i.e., non-alloy steel, stainless steel, and other alloy steel. Quarterly steel tariff observations were derived by using the average rate of the three categories in a given year is for all four quarters of that year.

4.2 Empirical results

The structural VAR model in Eq. [17] with the sign restrictions in Table 1 is estimated for the U.S. economy using inflation, unemployment, real GDP, and steel tariff rate data for the sample period 1989Q1-2017Q4. The lag length of two is used according to Hannan-Quinn Criterion (HQC) and Schwarz Information Criterion (SIC) criterion. In Section 4.2.1, we discuss the responses to inflation, unemployment, and output shocks. In Section 4.2.2, we discuss the responses to steel tariff shocks.

4.2.1 Effects of inflation, unemployment, and output shocks

Figures 1, 2, and 3 show the estimated impulse responses of inflation rate, unemployment rate, real output, and steel tariff rate to inflation, unemployment, and output shocks, together with the 16th and 84th percentile error bands. From Figure 1, following an unanticipated increase in prices (positive inflation shock), real output and inflation increase while unemployment declines. The responses of inflation and unemployment is consistent with Philips curve where inflation and unemployment are inversely related. Also, the response of output is in line with the view that rising prices are associated with output expansion (Brock, 1974; Ireland 1994; Sidrauski 1967; Tobin 1965). However, steel tariff rate is not responsive to this shock. This is consistent with the restrictions discussed in Section 3 about the difficulty in identifying any automatic response of steel tariff policy following an inflation shock.

Turning now to unemployment shock. As shown in Figure 2, after an unanticipated increase in unemployment (positive unemployment shock), inflation and real output decline while unemployment rate spikes. The response of output to unemployment shock is in line with Okuns law and supported by empirical findings in Prachowny (1993), Ball Leigh and Loungani (2013), and Huang and Yeh (2013) although others empirical findings such as Lee (2000), Freeman (2001), and Malley and Molana (2008) point to mixed evidence about the inverse relationship between unemployment and output. Also, the inverse response of inflation to unemployment shock is consistent with Philips curve. Interestingly, this shock triggers a small increase in tariff rates which could reflect calls for targeted tariff increase in the trade-related sectors of the economy, such as the steel sector, following periods of rising unemployment.

Regarding output shock, as Figure 3 shows, after periods of unexpected economic expansion (positive output shock), real output increases, inflation rises, and unemployment decreases. However, steel tariff rate is not responsive to this shock which is not surprising as there is no hard-fast rule about trade policy during periods of economic expansion. If any, during good economic times one would expect calls for protectionist trade policy to be rare or on the sidelines, hence no major trade policy shift is likely to take place during periods of unexpected economic expansion.

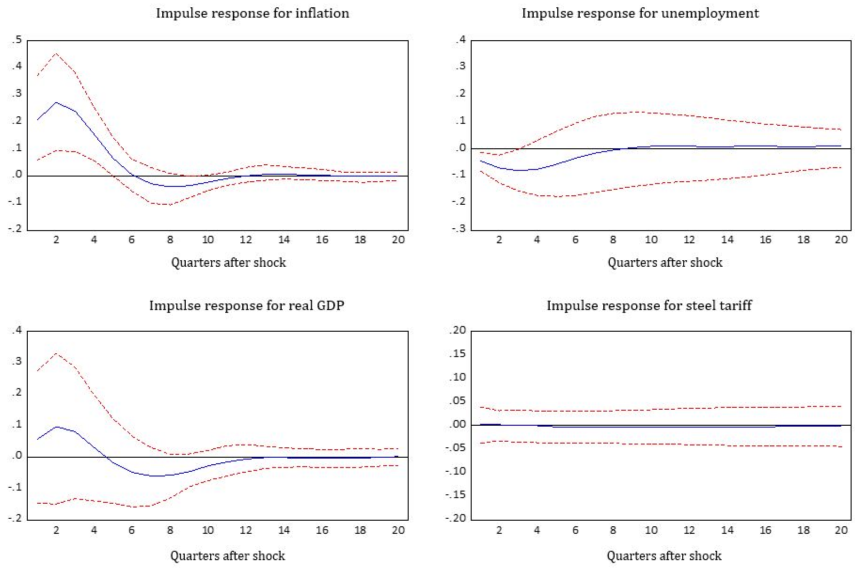

Figure 1. Impulse responses to a positive inflation shock one standard deviation in size

Notes: The solid blue lines are the median impulse responses to a positive inflation shock estimated using the sign-restriction structural VAR approach. That is, the response of inflation rate has been restricted to positive and response of unemployment rate restricted to negative. No restrictions are placed on the responses of real output growth and steel tariff rate. The top row shows the responses of inflation and unemployment. The bottom row shows the responses of real output and steel tariff rate. The dotted red lines are the 16th and 84th percentile error bands.

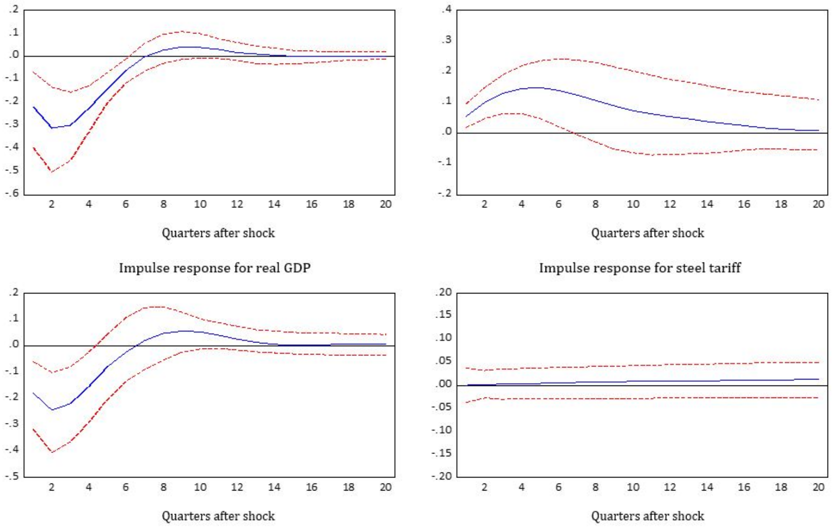

Figure 2. Impulse responses to a positive unemployment shock one standard deviation in size

Notes: The solid blue lines are the median impulse responses to a positive unemployment shock estimated using the sign-restriction structural VAR approach. That is, the responses of inflation rate and real output growth have been restricted to negative and response of unemployment rate restricted to positive. No restriction is placed on the response of steel tariff rate. The top row shows the responses of inflation and unemployment. The bottom row shows the responses of output and steel tariff rate. The dotted red lines are the 16th and 84th percentile error bands.

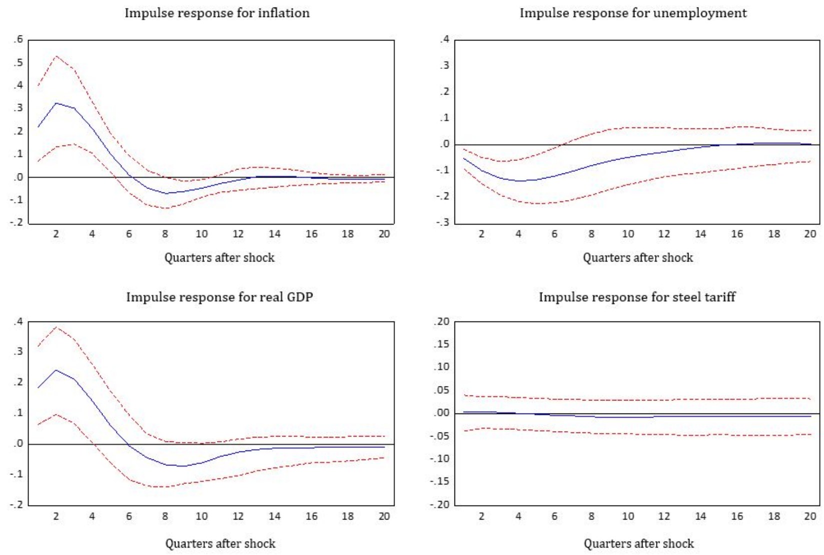

Figure 3. Impulse responses to a positive output shock one standard deviation in size

Notes: The solid blue lines are the median impulse responses to a positive output shock estimated using the sign-restriction structural VAR approach. That is, the responses of inflation rate and real output growth have been restricted to positive and response of unemployment rate restricted to negative. No restriction is placed on the response of steel tariff rate. The top row shows the responses of inflation and unemployment. The bottom row shows the responses of output and steel tariff rate. The dotted red lines are the 16th and 84th percentile error bands.

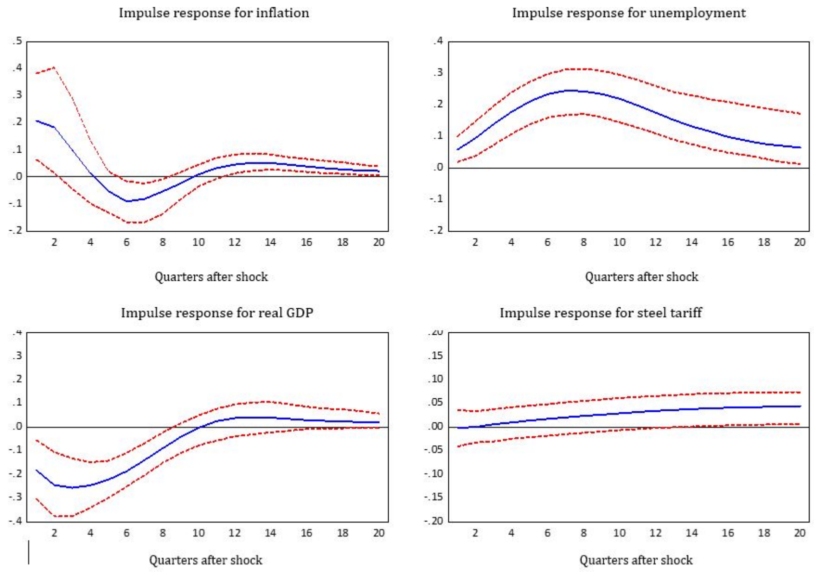

Figure 4. Impulse responses to a positive steel tariff shock one standard deviation in size

Notes: The solid blue lines are the median impulse responses to a positive steel tariff shock estimated using the sign-restriction structural VAR approach. That is, the responses of inflation and unemployment have been restricted to positive and response of steel tariff rate restricted to negative. No restriction is placed on the response of real output. The top row shows the responses of inflation and unemployment. The bottom row shows the responses of output and steel tariff rate. The dotted red lines are the 16th and 84th percentile error bands.

4.2.2 Effects of tariff shocks

Figure 4 shows the estimated impulse responses of inflation, unemployment, output, and steel tariff rate to steel tariff shocks, together with the 16th and 84th percentile error bands. The main results are the following. A positive steel tariff shock triggers an increase in steel tariff rate, a rise in inflation, an increase in unemployment, and a decline in real output. The responses of inflation and unemployment to the steel tariff shock are consistent with the steel tariff-driven stagflation hypothesis. Since steel-consuming industries constitute an integral part of U.S. economy, the price inflation that follows the steel tariff shock could result from steel-consuming industries attempting to pass the increased steel costs to the consumers. The extent to which they succeed in doing so can be inferred from the short-run price elasticity of demand for consumer goods. To determine the economy-wide short-run price elasticity of demand for consumer goods, an autoregressive distributed lag (ARDL) model is estimated with personal consumption expenditures as dependent variable and consumer price index and real disposable personal income as explanatory variables. The estimation yielded a price elasticity of -0.903 indicating that, the short-run demand for consumer goods is inelastic which in turn suggests that steel-consuming industries have a small but a possible window of passing some of its costs to consumers. A price elasticity of -1 or higher would have ruled out this possibility.[2] The finding that tariff shock triggers a rise in inflation is in line with Rassekh and Ranjbar (2014) but contrasts Batra (2003). Rassekh and Ranjbar (2014) find that, in OECD countries, factors such as exchange rate fluctuations and movements in tariff rates that influence import prices tend to be inflationary while Batra (2003) finds that tariffs produce inflation only in nonmarket or dualistic developing economies, but not in advanced economies like the United States. These studies however examined the effects of tariffs in general not steel tariff in particular as in this study.

In the case of unemployment, the increase that follows a tariff shock could reflect job-shedding by the steel-consuming industries as they attempt to minimize the increased steel costs by cutting back production. To examine the short-run effect of steel tariff rate changes on steel-consuming industries employment, an ARDL model that includes a measure of employment in steel-consuming industries as dependent variables and steel tariff rate, steel price index, and effective federal funds rate as dynamic regressors is estimated. It is found that, a 1 percentage point increase in steel tariff rate yields a 0.015% drop in employment in steel-consuming industries.[3] While a growing literature on the relationship between trade and unemployment suggest that in the short-run, openness raises unemployment (Davidson and Matusz 2004; Egger and Kreickemeier 2009; Helpman and Itskhoki 2010; Helpman et al. 2010; Janiak 2006; Mitra and Ranjan 2007; Trefler 2004; Yanikkaya 2013; among others), the finding in this study suggest that unemployment can also result from protectionist trade policies.

Finally, since no sign restriction is imposed on real output response to tariff shock, the real output decline following steel tariff shock could result from the combined effects of rising unemployment and inflation as stagflationary periods tend to coincide with output decline (Barsky and Kilian 2002; Blinder and Rudd 2008; Bruno and Sachs 1985; Kendrick 1981; Kilian 2010; Olson 1982; Peterson 1980).

4.3 Robustness checks

The study checked the results for robustness to changes in the lag length, to the exclusion of constant terms in the VAR, and to changes in the order in which the shocks are established.[4] The main results of the paper – that steel tariff shocks trigger an increase in steel tariff rate, a rise in inflation, an increase in unemployment, and a decline in real output – are invariant to these changes. However, some things do change across specifications in changing the lag length, in particular, the behavior of the response of inflation to steel tariff shock. For lags 3, as in the main estimated model with two lags, after an immediate increase in inflation rate following steel tariff shock, the rate does not increase beyond 0.05% six quarters into the shock, but for lags 5 and 6 it does.

5 Conclusion

This paper investigates the macroeconomic effects of import tariff shocks. A tariff-driven stagflation hypothesis is presented. The structural VAR identification approach with sign restrictions is utilized to test the hypothesis using quarterly data on the U.S. economy from 1989-2017. Results indicate that tariff shocks on vital intermediate input, such as steel, trigger short-run stagflationary tendencies as characterized by increase inflation and unemployment and decline in real output. At a more general level, the analysis presented in this paper suggests that tariff shocks on net-imported vital intermediate input generate short-run macroeconomic instability. In addition, the study provides a timely contribution to the literature by opening up a new window to modeling the impacts of import tariff shocks; a novel approach where simple sign-restricted VAR can be utilized to identify tariff shocks and their impacts examined using impulse response functions.

Obviously, there are some limitations to the study. For instance, the effects of steel tariffs on inflation, unemployment, and output is not contemporaneous as it takes time for the tariff shock to cause movements in these variables. This delayed response issue could be addressed by using a recursive VAR identification system but that system is most suitable for monthly data. However, because the estimation of sign restriction identification systems begins by fitting a recursive system to generate a set of base shocks that are uncorrelated, which are then used to form new shocks upon which random draws of impulse responses with the correct signs are estimated, the delayed response problem is attenuated and evidence of which is found in the case of unemployment in Figure 4, where the response of unemployment to steel tariff shock exhibits a slight delay before peaking about the sixth quarter.

Furthermore, there is the multiple models problem common to sign restriction identification system, i.e., the existence of many models with identified parameters that provide the same fit to the data. Consequently, one has to search for structural models which satisfy the sign restrictions among all structural models consistent with the reduced form model. A standard solution to this problem (as implemented in this paper) is to summarize the information on the set of impulse responses satisfying the sign restrictions and report the measures of central tendency and the magnitude of the spread of responses such as the minimum, maximum and mean (or median).

Finally, another concern is the multiple shocks problem. Indeed, the inclusion of other macroeconomic variables in the structural VAR model (Eq. [17]) like interest rate, exchange rate, energy prices, financial market expectations, and so forth could also generate additional shocks to be examined. Thus, there are potentially several other shocks that the study could have accounted for. This latter limitation could possibly be overcome in future work that experiment with incremental additions of other macroeconomic variables which may generate very interesting results and make the discourse on macroeconomic impacts of import tariff shocks richer.

Notes

[1] Other studies that emphasize the oil shocks channel to stagflation include Cologni and Manera 2008, Dogrul and Soytas 2010, Jimnez-Rodrguez and Sanchez 2005, Sachs 1982, and Santini 1985.

[2] The ARDL model is estimated using quarterly personal consumption expenditures, consumer price index for all items, and real disposable personal income data from 1989-2017. Personal consumption expenditures data is obtained from the U.S. Bureau of Economic Analysis National Income Accounts. Consumer price index and real disposable personal income data are retrieved from the St. Louis Fed FRED website, using the series CPIAUCNS and A229RX0. The model has personal consumption expenditures (in units) as dependent variable and consumer price index and real disposable personal income as dynamic regressors. The dynamic regressors respectively capture the price and income elasticities. We found a short-run price elasticity of -0.903 and income elasticity of 0.29 using the Akaike info criterion (AIC) and Hannan-Quinn criterion (HQC) lag selection criteria. The Schwarz criterion (SIC) yielded an income elasticity of 0.38 and a statistically insignificant price elasticity. Cointegration is found among variables in all estimated models. Results are summarized in Table A1 in the Appendix. The ARDL modeling approach has become increasingly popular in estimating elasticities due to the new approach developed by Pesaran and Shin (1999) and Pesaran Shin and Smith (2001). The model is a general dynamic specification which uses the lags of the dependent variable and the lagged and contemporaneous values of the explanatory variable through which the short-run effects can be directly estimated (Gosh 2009, Pesaran Shin and Smith 2001; von Arnim and Prabheesh 2013).

[3] The reported short-run elasticity of steel-consuming industries employment to steel tariff rate changes of -0.015 is based on the results from the AIC lag selection criterion. The HQC and SIC lag selection criteria yielded elasticity of -0.022 and

-0.035 respectively. The models are estimated using quarterly data from 1990-2017. Results are summarized in Table A2 in the Appendix. Steel consuming industries employment data is obtained from the BLS Quarterly Census of Employment and Wages (QCEW) database. Our definition of steel-consuming industries includes NAICS 2362, 237, 238, 32411, 325, 326211, 332, 333, 335, and 336 (Nonresidential building construction, Heavy and civil engineering construction, Specialty trade contractors, Petroleum refineries, Chemical manufacturing, Tire manufacturing except retreading, Fabricated metal product manufacturing, Industrial machinery manufacturing, Electrical equipment and appliance manufacturing, and Transportation equipment manufacturing). Steel tariff rate data is obtained from the U.S. International Trade Commission Basic Harmonized Tariff Schedule publications. Data on steel price index (average of cold rolled sheet PPI and hot rolled steel PPI) is retrieved from the St. Louis FRED database using series WPU101707 and WPU101703. Effective federal funds data is also retrieved from FRED database using series FEDFUNDS.

[4] We re-estimated the VAR model with lag lengths 3, 5, and 6, without constant terms, and by changing the ordering of the variables to identify the shocks.

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Appendix

Table A1: Short-run elasticity estimates for consumer goods demand from ARDL model
Dependent variable: LN(PCE)
Error Correction Model Regression

	AIC ARDL(4,4,2)		HQC ARDL(4,4,2)		SIC ARDL(2,0,2)	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
$\Delta LN(PCE(-1))$	0.1769	0.037	0.1769	0.037	0.2011	0.025*
$\Delta LN(PCE(-2))$	0.0380	0.676	0.0380	0.676		
$\Delta LN(PCE(-3))$	0.2209	0.017	0.2209	0.017		
$\Delta LN(CPI)$	0.2685	0.133	0.2685	0.133		
$\Delta LN(CPI(-1))$	-0.6008	0.001*	-0.6008	0.001*		
$\Delta LN(CPI(-2))$	0.4201	0.019*	0.4201	0.019*		
$\Delta LN(CPI(-3))$	-0.7225	0.000*	-0.7225	0.000*		
$\Delta LN(RDPI)$	0.1087	0.305	0.1087	0.305	0.2014	0.052
$\Delta LN(RDPI(-1))$	0.2930	0.009*	0.2930	0.009*	0.3848	0.000*
$CointEq(-1)$	-0.1082	0.000*	-0.1082	0.000*	-0.1197	0.006*

Notes: PCE denotes personal consumption expenditures (units purchased), CPI is consumer price index (all items), and RDPI is real disposable personal income. CPI and RDPI respectively capture price and income elasticities. Akaike info criterion (AIC), Hannan-Quinn criterion (HQC), and Schwarz criterion (SIC) are the lag selection criteria. Elasticity estimates based on Error Correction Model regression. The models are estimated using quarterly data from 1989-2017. * denotes 5% level of significance. Cointegration is found among variables in all three models. Adjusted R_2: AIC ARDL(4,2,2) = 0.28; HQC ARDL(4,2,2) = 0.33; SIC ARDL(4,2,2) = 0.16 Durbin-Watson statistic: AIC ARDL(4,2,2) = 2.04; HQC ARDL(4,2,2) = 2.04; SIC ARDL(4,2,2) = 2.03

Table A2: Short-run elasticity estimates for steel-consuming industries employment
Dependent variable: LN(SCIE)
Error Correction Model Regression

	AIC ARDL(3,2,2,4)		HQC ARDL(3,2,1,4)		SIC ARDL(3,2,1,0)	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
$\Delta LN(SCIE(-1))$	0.0126	0.878	0.0423	0.589	0.0988	0.236
$\Delta LN(SCIE(-2))$	-0.3637	0.000*	-0.3583	0.000*	-0.2759	0.001*
$\Delta(STR)$	0.0553	0.001*	0.0529	0.002*		
$\Delta(STR(-1))$	-0.07034	0.000*	-0.0755	0.000*	0.0487	0.010*
$\Delta LN(SPI)$	0.0692	0.126	0.1091	0.009*	-0.0842	0.000*
$\Delta LN(SPI(-1))$	0.0748	0.106			0.10807	0.012*
$\Delta(EFFR)$	0.0011	0.894	0.0001	0.987		
$\Delta(EFFR(-1))$	0.0191	0.042*	0.0207	0.028*		
$\Delta(EFFR(-2))$	-0.0234	0.014*	-0.0239	0.013*		
$\Delta(EFFR(-3))$	0.0267	0.001*	0.0264	0.001*		
$CointEq(-1)$	-0.0217	0.084	-0.0064	0.056	-0.1108	0.010*

Notes: SCIE denotes steel-consuming industries employment, STR is steel tariff rate, SPI is steel price index, and EFFR is effective federal funds rate. Akaike info criterion (AIC), Hannan-Quinn criterion (HQC), and Schwarz criterion (SIC) are the lag selection criteria. Elasticity estimates based on Error Correction Model regression. The models are estimated using quarterly data from 1990-2017. * denotes 5% level of significance. Cointegration is found among variables in all three models. Adjusted R_2: AIC ARDL(3,2,2,4) = 0.47; HQC ARDL(3,2,1,4) = 0.46; SIC ARDL(3,2,1,0) = 0.39 Durbin-Watson statistic: AIC ARDL(3,2,2,4) = 2.27; HQC ARDL(3,2,1,4) = 2.35; SIC ARDL(3,2,1,0) = 2.11