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Abstract
The classical liberal belief is trade, which economically benefits countries, creates ties binding the interests of countries and reduces conflict. While the vast majority of the empirical literature supports this view, recent research questions these findings by also considering the reciprocal relationship between trade and conflict. If conflict also influences trade, then trade is an endogenous right hand side regressor and previous estimates which ignore this are inconsistent. This article determines when one uses appropriate instruments for the endogenous regressors that trade reduces conflict and conflict reduces trade. Failure to use such instruments results in inconsistent estimates and can lead to the spurious conclusion that trade increases conflict. The lesson is the use of inappropriate instruments can be worse than not using them at all.

Introduction

There is a theoretical difference of opinion between classical liberals, Marxists, and realists as to the effect of trade on conflict between countries. Empirically though there has been less debate, with the vast majority of research finding trade reduces conflict. Policymakers today also agree, frequently citing trade as a cause of peace. For example, the US trade representative Susan Schwab (2008: 6), in the President's 2008 Trade Policy Agenda, noted growth of intra-regional trade in Central America has strengthened peace in the region. Therefore when new research findings demonstrate the contrary, one may be quick to dismiss the findings as a mere anomaly or statistical artifact of little concern. Given the difference in effect suggested by theory, one should view empirical challenges to the liberal peace as potentially significant. The validity of which depends on the reliability of the estimates and the assumptions made. For in the end, we are interested in understanding the true underlying causes of conflict.

Most of the international relations literature that examines the relationship between trade and conflict has focused on the empirical effects trade has on conflict. More recently, attention has been drawn to the reciprocal relationship. The belief is conflict also influences the volume of bilateral trade. If true, then there would be a simultaneous relationship between trade and conflict. The implication is previous results, which failed to control for the endogeneity of trade, would be inconsistent, causing one to wonder about the true effect of trade on conflict. Towards this end, our contribution in this paper is to estimate models of trade and conflict controlling for endogeneity, where we focus on the importance of choosing instruments both relevant and exogenous to produce consistent results. The results here show trade has a negative and significant effect on conflict, and conflict has a negative and significant effect on trade when appropriate instruments are used.

Typical Model of Conflict

The typical empirical model of conflict examines whether pairs of countries engage in militarized disputes, as defined by the Correlates of War (COW) project. In some cases, researchers examine directed dyads, which allow one to distinguish which country initiates conflict. For observations of non-directed dyads the model specification is of the form:

$$Conflict_{i,t} = \gamma_0 + \gamma_1 Trade_{i,t} + W_1\delta_1 + u_{1i,t} \tag{1}$$

where the vector W_1 contains exogenous, observed factors, which influence the willingness and ability to use conflict among dyads (i) at time (t). Factors such as whether the dyad shares an alliance, border, or political regime type and others that measure the dyad's military capabilities, their interests, and the distance that separates them.[1] As noted, recent interest has focused on the effects that trade has on conflict. The classical liberal point of view advanced by Kant is that trade brings dissimilar people together and binds their interests due to the mutual benefits generated by trade. These shared interests form interdependence between countries that is said to inhibit conflict. Polachek (1980) was the first to formally incorporate these ideas into a model relating trade to conflict. In his expected utility model, Polachek (1980) and subsequent coauthors (Polachek, Robst, & Chang, 1999; Robst, Polachek, & Chang, 2007) assume that the level of trade directly increases the cost of conflict. Their empirical tests of the model indicate trade increases cooperative events and decreases conflict between

[1] Bremer (1992) provides a nice discussion.

countries. Further empirical estimates (Oneal & Russett, 1997, 1999; Russett & Oneal, 2001) of equation 1 using various specifications, time periods, and pairs of countries have predominantly found trade reduces conflict.[2]

Two recent studies (Keshk, Pollins, & Reuveny, 2004; Kim & Rousseau, 2005) though cast doubt as to trade's pacific effect on conflict by questioning whether trade is an exogenous variable on the right hand side of equation 1. Each set of authors posit that conflict also influences trade. This notion itself is not new. Supporters of the liberal peace assume it is the decrease in trade, caused by conflict, which inhibits trading partners from engaging in conflict. Conflict or political instability more generally, creates an uncertain environment for economic agents. Uncertainty, caused by social or political instability reduces investment (Alesina & Perotti, 1996; Feng, 2001; Rodrik, 1991). The potential for physical and human capital to be displaced or destroyed by conflict reduces their productivity and the incentive to invest. The result is capital flight, whereby resources are either moved abroad to a safer environment or into industries in the uncertain environment that require low investment and are more speculative (Feng, 2001). Countries in conflict are thus less able to specialize in industries where they have a comparative advantage and are likely to trade less. Trade between enemies may also generate security concerns, which limits trade during periods of conflict. Several studies (Anderton & Carter, 2001; Athanassiou & Kollias, 2002; Mansfield, 1994; Polins, 1989a 1989b) have shown that conflict can inhibit trade between countries.

Equation 2 represents a generic model specification of bilateral trade between a pair of countries (i) at time (t), which is dependent on conflict.

[2] Barbieri (1996, 2002) and Gasiorowski (1986) provide evidence to the contrary that interdependence increases conflict, while Beck, Katz, & Tucker (1998) and Goenner (2004) find no statistical relation between the two.

$$Trade_{i,t} = \beta_0 + \beta_1 Conflict_{i,t} + W_2\delta_2 + u_{2i,t} \quad (2)$$

Vector W_2 contains exogenous observed factors, which influence trade, such as those found in the gravity model (Bergstrand, 1985; Tinbergen, 1962). The specification typically controls for the mass of the two countries within each dyad and factors, such as distance, which create resistance to trade. Other factors that influence resistance to trade, including shared membership in trade blocs, adjacency, and common language, may also be included (Frankel, 1997). Variables describing political factors and institutions, such as whether the pair of countries are both democratic (Bliss & Russett, 1998, Morrow, Siverson, & Tabares, 1998) or share an alliance (Gowa & Mansfield, 1993) have also been included by researchers interested in international relations.

Endogeneity Remedy

If there is a simultaneous relationship between trade and conflict, where trade influences conflict and conflict influences trade, then there is an endogeneous regressor in equations 1 and 2. The concern of Keshk, Pollins, & Reuveny (2004) and Kim & Rousseau (2005) with estimating the conflict model is $u_{1i,t}$ may be correlated with $Trade_{i,t}$, in which case all the coefficients of the estimated model would generally be inconsistent, implying they do not converge to the population estimates as the sample size increases (Wooldridge, 2002: 84). The solution to producing consistent estimates is quite simple in theory. We need to select a variable to serve as an instrument in place of the endogenous right hand side variable that is both relevant and exogenous. Relevance implies the instrumental variable (IV) is partially correlated with the endogenous regressor after controlling for the effects of the other regressors. For the instrument to be exogenous it must not be correlated to the error term. The instrument for trade needs to explain variation in trade (relevance), but have no direct impact on conflict (exogenous), which rules out using variables in W_1 as instruments.

A natural instrument choice would be to use a variable in W_2, which is not contained in W_1. Finding an appropriate instrument to remedy an endogenous regressor though is often a challenge in practice as few variables meet both criteria empirically. This may result in researchers using an instrument, which is only weakly correlated with the endogenous regressor. Stock, Wright, & Yogo (2002) point out in these cases the sampling distributions of IV statistics are in general non-normal, thus point estimates and hypothesis tests are unreliable even with large samples. Further as the instruments become weaker, we are able to explain less variation in the endogenous regressor, which increases the asymptotic variance of the IV estimates resulting in lower precision. Weak instruments though are often used because the more highly correlated the instrument is with the endogenous regressor the less likely the instrument is uncorrelated with the error term (Greene, 1997: 295). If the instrument used is relevant and not exogenous then it can be shown (Stock & Watson, 2003: 372) that IV estimates are inconsistent. Even if the instrument is both relevant and exogenous, IV estimates remain biased and thus should be interpreted with caution because in finite samples the estimates may not converge to their population value. This implies IV should not be used if endogeneity does not exist. When endogeneity is present, IV needs to be applied using appropriate instruments, otherwise it is possible that using an endogenous instrument results in more inconsistent coefficients than those from a model that ignores endogeneity completely.[3]

[3] Wooldridge (2002: 102) shows that the inconsistency of a model with a single endogenous regressor (X) estimated using OLS is $\beta_1^{OLS} \to \beta_1 + \frac{\sigma_u}{\sigma_x} corr(x,u)$, where for the model estimated using 2SLS with an

For now, we will assume trade and conflict are both endogenous and we have identified appropriate instruments Z = (Z_1, Z_2, . . . Z_M) to use for each. Later we will further investigate this empirically. To produce consistent estimates of the linear trade model in equation 2 we use two-stage least squares (2SLS), which is the most efficient IV estimator. In the first-stage we use OLS to regress the endogenous regressor (conflict) on the exogenous variables included in the trade model (constant and W_2) and our instruments (Z). This linear projection generates the linear combination of Z that is the most highly correlated with our endogenous regressor and exists regardless of whether the endogenous regressor or instruments are continuous or discrete.[4] We save the fitted values of conflict from the regression, which are uncorrelated with the error term. In the second-stage we run an OLS regression of trade on a constant and W_2 from equation 2 and the saved fitted values. The coefficient on the fitted value is our IV estimate of conflict's effect on trade.[5]

$$\begin{aligned} &\text{First-Stage OLS:} \quad Conflict_{i,t} = \mu_0 + W_2\varphi_2 + Z\phi + \varepsilon_1 \\ &\text{Second-Stage OLS:} \quad Trade_{i,t} = \beta_0 + \beta_1 \widehat{Conflict}_{i,t} + W_2\delta_2 + u_{2i,t} \end{aligned} \quad (3)$$

Two-stage least squares could also be applied to the conflict model in equation 1 to obtain consistent estimates. If conflict is a binary outcome, as typically found in the literature, then the coefficients, while consistent, represent an average effect. Probit and

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endogenous instrument (Z): $\beta_1^{2SLS} \rightarrow \beta_1 + \frac{\sigma_u}{\sigma_x}\frac{corr(Z,u)}{corr(Z,x)}$. Given u is unobserved we cannot tell which coefficient deviates more from the true value β_1.

[4] Use of a probit or logit model in the first stage should not be used. See Kelejian (1971) and Angrist & Krueger (2001) for further discussion.

[5] The standard errors of this second stage will be incorrect as they are based on the fitted values of conflict rather than the actual values. See Wooldridge (2002: 95) for the correction. Stata's ivreg2 command automatically corrects the standard errors and is used below to produce the estimates of the linear trade model.

logit models though are generally used to restrict predicted values to between zero and one. Rivers & Vuong (1988) have developed a two-stage conditional maximum likelihood (2SCML) procedure to estimate the probit model with a continuous endogenous regressor. In the first-stage we regress the endogenous regressor (trade) on the exogenous variables (constant and W_1) and instruments (Z), where we save the OLS residuals ($\hat{v}_2$). In the second stage we estimate the probit model of conflict on the actual value of trade, the exogenous variables (constant and W_1), and the residuals ($\hat{v}_2$) using maximum likelihood.

$$\begin{aligned} &\text{First - Stage OLS:} \quad Trade_{i,t} = \mu_0 + W_1\phi_1 + Z\psi + \varepsilon_2 \\ &\text{Second - Stage Probit:} \ Conflict_{i,t} = \gamma_0 + \gamma_1 Trade_{i,t} + W_1\delta_1 + \hat{v}_2\theta + u_{1i,t} \end{aligned} \tag{4}$$

A nice feature of Rivers & Vuong's (1988) estimation procedure is it allows us to easily test whether trade is endogenous in the conflict equation. We test the null hypothesis that trade is exogenous using the t-statistic of the coefficient for theta found from including the residual in the second stage. The test is also nice because its validity does not depend on the normality or homoskedasticity of the error term (Wooldridge, 2002). A more efficient two-stage estimator has been introduced by Newey (1987).[6] Maximum likelihood is also used to estimate the model and will allow for heteroskedasticity. The advantage of maximum likelihood estimation is it is a full information method and will thus be more efficient than Newey's estimator. The negative is the computations may not converge, in which case one can use Newey's (1987) estimator.

Testing whether conflict is endogenous in the linear trade model can be done

[6] The Stata command ivprobit along with the two step option produces Newey's (1987) estimates of the coefficients and their standard errors. Maximum likelihood estimation is performed without this option

using a regression based version of the Hausman (1978) test. Similar to Rivers & Vuong's (1998) test, the first-stage involves regressing the endogenous regressor (conflict) on the exogenous variables (constant and W_2) and instruments (Z). In the second step we regress trade on the exogenous variables, the actual value of conflict, and residuals from the first step. The t-statistic of the residual is used to test the null hypothesis of no endogeneity. A heteroskedasticity robust t-statistic can be used if heteroskedasticity is a concern.

If endogeneity is shown to be present, then one needs to find relevant and exogenous instruments to use IV. Fortunately we can test the strength of the instruments by examining their partial correlation with the endogenous regressor. This is done by regressing the endogenous regressor, whether continuous or not, on the instruments and other exogenous variables in the specification. The strength of the instruments is measured by calculating the F-statistic of whether the coefficients of the instruments are jointly zero. Staiger & Stock's (1997) rule of thumb is an F-statistic less than 10 is an indication of weak instruments. A heteroskedasticity-robust version of the test was also developed by Kleibergen and Paap (2006).

While one is able to test the relevance of an instrument, there is no direct test for its exogeneity. There is, however, an indirect way to test an instrument's exogeneity, but it requires the model to be overidentified, which means we have more instruments than endogenous regressors. With two instruments and one endogenous regressor, we can estimate the linear trade model via 2SLS twice, using each instrument separately. If the estimates are sufficiently dissimilar then we know one or both of the instruments are not exogenous A heteroskedasticity-robust version of this test is also available.[7] For models with a limited dependent variable, Lee (1992) has developed an appropriate test of overidentification, which is implemented in Stata using the overid command after estimating the model using Newey's (1987) procedure.

Empirical Tests of Endogeneity, Relevance, and Exogeneity

Keshk, Pollins & Reuveny (2004) and Kim & Rousseau (2005) (hereafter referred to as KPR and KR respectively) argue failing to account for the endogeneity of trade results in inconsistent estimates of trade's effect on conflict. They therefore each specify a simultaneous model of trade and conflict similar to equations 1 and 2. Both sets of authors control for endogeneity in their system of equations for trade and conflict by using Maddala's (1983: 244-245) two stage estimation procedure.[8] To estimate the coefficients of the trade equation, the first stage uses probit to estimate the reduced form equation of conflict on the exogenous variables and instruments. The instruments used by the procedure to estimate the trade equation are the exogenous variables included in the conflict equation and omitted from the trade equation. In order to estimate the equation, i.e. for it to be identified, there needs to be at least as many instruments as endogenous regressors. This implies the variables in Z_1 must statistically influence conflict and not trade. The second stage uses the fitted value of conflict in place of the actual value in an OLS regression of the trade equation.

$$\text{First-Stage Probit: } Conflict_{i,t} = \mu_0 + W_2\phi_2 + Z_1\varphi + \varepsilon_1, \text{ where } Z_1 = W_1 \not\subset W_2$$

$$\text{Second-Stage OLS: } Trade_{i,t} = \beta_0 + \beta_1 \widehat{Conflict}_{i,t} + W_2\delta_2 + u_{2i,t} \qquad (5)$$

[7] See Wooldridge (2002: 123) for a more complete discussion. Stata command ivreg2 produces the test statistic.
[8] Maddala's estimator is implemented in Stata using the program CDSIMEQ written by Keshk (2003).

Estimation of the conflict equation is similar. In the first stage, OLS is used to find the fitted value of trade from the regression of trade on the exogenous variables in the conflict equation and the relevant instruments. The second stage uses probit to estimate the conflict specification, with the fitted value replacing the actual value of trade.

$$\text{First-Stage OLS: } Trade_{i,t} = \mu_0 + W_1\phi_1 + Z_2\psi + \varepsilon_2, \text{ where } Z_2 = W_2 \not\subset W_1$$
$$\text{Second-Stage Probit: } Conflict_{i,t} = \gamma_0 + \gamma_1 Trade_{i,t} + W_1\delta_1 + u_{1i,t} \quad (6)$$

The procedure is a full information method as the standard errors of the coefficients are adjusted to control for correlation in the errors across equations.

The variables used by KPR (Tables 1 and 2) and KR (Table 3) in their specifications of equations 1 and 2 appear below in Table 1.[9] Both models measure conflict based on whether there was an incidence of militarized conflict. The primary difference in the two models is the measurement of the potentially endogenous variable trade interdependence. KPR use the value of real bilateral trade in natural logs, whereas KR use the natural log of the ratio of bilateral trade to the higher GDP within the dyad. The latter captures the economic interdependence of the so called weakest link (Oneal & Russett, 1997). A negative and significant coefficient for this variable is said to support the classical liberal hypothesis. KPR's specification captures the same effect by including separate measures of bilateral trade and the higher GDP within the dyad.[10] KR's formulation of the trade equation is somewhat problematic, as trade dependence is specified to be a function of typical gravity variables. It is likely that the ratio of bilateral

[9] KR Table 3 specification uses non-directed dyads and COW militarized disputes similar to KPR. KR also analyzed directed dyads involved in international disputes that escalate to force. Hegre, Oneal, & Russett (2010) believe the latter sample is biased as it excludes dyads that did not use force. For this reason and ease of comparison later on we report results using the specification in Table 3.

[10] Increasing trade, holding GDP constant implies trade dependence increases. Thus a negative coefficient on trade supports the liberal hypothesis that trade reduces conflict. KPR's treatment is preferable because the impact of conflict on the ratios of bilateral trade to GDP is not clear. For example, interdependence could remain the same if bilateral trade and GDP both decline as a result of conflict.

trade to GDP is influenced by factors other than those that influence only the level of trade. Also noteworthy is that KPR control for temporal dynamics in their conflict and trade specifications by using lagged values of the endogenous variables. KR instead control for temporal dynamics in their conflict specification using the standard framework, which includes the previous years of peace and corresponding cubic spline. Other minor differences exist in their selection and measurement of variables.[11]

[Insert Table 1 about here]

Controlling for endogeneity, both sets of authors find that trade increases conflict, with Kim & Rousseau's result strongly significant (p-value < .001).[12] For KPR's specification, increasing conflict significantly reduces bilateral trade (p-value .02), whereas with KR's specification increasing conflict increases trade dependence (p-value = .26). Both sets of coefficients and robust standard errors appear in columns 1 and 2 of Tables 1a and 1b. We replicate the results of KPR, but the results of KR are altered when using the correct values of major power status, lower democracy score, peace years, and spline variables. KR's conclusion that trade increases conflict is no longer significant. These mixed findings may cause one to question whether the classical liberal understanding of trade and conflict was right. It may though be the case that these results, which control for endogeneity are still inconsistent.

Keshk, Reuveny, & Pollins (2010) have reexamined their model's robustness to

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[11] Interestingly, a review of the data used by KR in their analysis revealed six of the variables in their conflict equation did not equal the values from their sources (Oneal, 2003; Oneal, Russett, & Berbaum, 2003). The correlation between Oneal, Russett, & Berbaum's (2003) measure of major dyads and KR is .36. The problem is KR's dataset misses a number of major dyads, one of many examples being Canada and the United States. Further the previous years of peace and the corresponding cubic spline are each negatively correlated with their actual values. For the entire 1920-1992 period KR report the previous years of peace between Canada and the United States to be 0, with the actual value ranging from 0 to 54 when using Oneal's (2003) code to generate the value. The lower democracy score was also incorrectly classified for 40,582 observations where one of the country's values was missing in the dyad.

[12] The p-value for KPR's specification is .27

several modifications, which include the treatment of distance and contiguity, size, and fatal versus all MIDs. Their findings show that the effect of trade on conflict is sensitive to minor modifications of the specification and generally upholds their earlier conclusion that trade does not reduce conflict.[13] Recent research by Hegre, Oneal, & Russett (2010) has also questioned the sensitivity of KPR and KR's results to their specifications. Adding the log of distance to KPR's conflict specification, Hegre, Oneal, & Russett find trade significantly reduces conflict, contrary to KPR's positive and insignificant result. The questions of interest is why might these results be sensitive to seemingly minor changes in specification and what is the real effect of trade on conflict.

Full information methods, such as Maddala's (1983) two-step estimator, require the entire system to be correctly specified in order to produce consistent estimates. This implies the variables excluded from the conflict equation and included in the trade equation must influence trade and have no statistical effect on conflict otherwise the model is misspecified. There must also be no omitted variables. The advantage of using a limited information procedure, such as two stage least squares (2SLS) is that it does not require the entire system to be correctly specified in order to produce consistent estimates. Therefore as Wooldridge (2002: 222) notes the results are more robust to model misspecification. From a practical standpoint this allows researchers interested in conflict to focus on factors that lead to disputes, without the need to estimate elaborate trade models. A single-equation approach also allows us to more easily test the appropriateness of our instruments. The disadvantage is full information methods are asymptotically more efficient in cases where the system is correctly specified.

[13] Of the 36 specifications they consider, there was a positive and significant relationship between trade and conflict for 8, negative and significant relationship for 8, and not significant relationship for 18.

In columns 3 and 4 of Tables 1a and 1b we report single equation estimates from KPR and KR specifications. Maximum likelihood estimation was used to estimate both conflict models and two stage least squares was used to estimate both trade model specifications. Coefficients and robust standard errors for the single equation estimates appear in columns 3 and 4 of Tables 1a and 1b, next to the results from Maddala's estimation procedure. The results for the most part are quite similar across both sets of estimates. Interestingly, the single equation results of KR's trade model indicate trade significantly increases conflict. The issue is whether these coefficients are consistent, as this depends crucially on the validity of the instruments.

[Insert Tables 1a and 1b about here]

Estimation using instrumental variables techniques should only be used in the presence of an endogenous regressor. We use a heteroskedasticity robust version of the Hausman test to determine whether conflict is endogeneous in either of the single model specifications of trade. Clustering on dyad, we find conflict is endogenous in both KPR and KR's trade specifications. The cluster robust t-statistics are 2.09 and -3.45, which are both significant at the 5% level. The next step is to test whether the instruments for conflict are relevant by evaluating the correlation between the instruments and the endogenous regressor. The cluster-robust F-statistic for KPR's specification (60.4) and KR (23.9) are both above 10, which indicate the instruments are indeed relevant. Both trade specifications are overidentified so the endogeneity of the instruments can be tested. Hansen's J statistic is 708 with 5 degrees of freedom for KPR's specification. We strongly reject the null that the instruments are exogenous. Similarly, the statistic of KR's specification is 300 and the null is strongly rejected. Neither set of instruments are exogenous, thus both sets of trade equation estimates are inconsistent.

To test whether trade is endogenous in the conflict equation we use Rivers and Vuong's two-stage procedure outlined above in equation 4. The results indicate trade is indeed endogenous in both equations. The t-statistic on theta is -4.99 for KPR's specification and -14.18 for KR. First-stage F-tests are applied to test the instruments' relevance. In both models the instruments are highly relevant. KPR's specification has an F-statistic of 130,000, while the F-statistic of KR is 31043. Lee's (1992) overidentification test is used to test the exogeneity of the instruments. In both cases we find that the null hypothesis of exogenous instruments is strongly rejected. The coefficient estimates of the trade and conflict equations in Tables 1a and 1b are inconsistent.

Overidentification tests reveal the instruments suggested by KPR and KR's models are not all exogenous. The test though does not reveal which particular instruments are endogenous. Theory may help us identify suspects and suggest alternatives. For example, both authors' models include contiguity as an instrument of trade. Contiguity is exogenous in the trade equation only if it has no direct effect on trade. Contiguity and distance though are typically both included by economists to estimate the gravity model of trade.[14] Distance differs from contiguity as it measures the separation between two points, whereas contiguity takes into account borders. Mexico and the United States share a border of approximately 2000 miles, yet the distance between them is 916 miles. Compare this to the United States and Belize, which are not

[14] Contiguity and distance are both used in the earliest application of the gravity model to trade (Tinbergen, 1962), in its theoretical development (Bergstrand, 1985), and in the most influential recent empirical studies (Anderson & van Wincoop, 2003; Baier & Bergstrand, 2007, Rose, 2004, Subramanian & Wei, 2007).

contiguous yet are separated by only 889 miles. If Belize were the same size as Mexico, we would not expect higher trade by the US with Belize than with Mexico. As Frankel (1997: 71) discusses sharing a border is an important part of North American trade as parts are trucked across borders, where they are assembled, and are then sent back as final goods. Contiguity is thus likely to have a direct impact on trade and is an inappropriate instrument. Other instruments for conflict are also suspect. Capability ratio, for example, is based in part on the population of the countries within the dyad, which is a factor known to directly influence trade. The higher real GDP used by KPR is possibly problematic for the same reason. The instruments for trade are based on the sizes of population and GDP, both of which may impact conflict in a direct fashion similar to the capability ratio.

In the analysis below we identify specifications and instruments for conflict and trade, where the instruments are shown to be relevant and exogenous. We focus our attention only on models that control for trade and not trade dependence. As noted earlier, we prefer the former as the gravity model explains bilateral trade and it is theoretically unclear what the effect of conflict on trade dependence might be. Control variables for each specification are drawn from those used by KPR and KR. The conflict model's specification includes allies, major power dyads, contiguity, log of distance, the slower growth rate of GDP within the dyad, log of the capability ratio, lower democracy score within the dyad, and peace years with the corresponding cubic splines. Original data from Oneal (2003) and Oneal, Russett, & Berbaum (2003) was used for most of the variables, except for bilateral trade, GDP growth, and higher GDP within the dyad, where we used KPR's data. The trade model's specifications consists of the variables included in the most basic gravity model, along with the potentially endogenous regressor conflict, the democracy score of the least democratic country within the dyad, and allies. The basic controls include the log of the product of GDPs, log of the product of populations, log of distance, and contiguity. Data for each was drawn from Oneal, Russett, & Berbaum (2003) except for bilateral trade, which was from KPR.

As noted, it is often a challenge to find an instrumental variable that is correlated with the endogenous regressor and yet has no direct effect on the dependent variable. To add to the level of difficulty, one needs more instruments than endogenous regressors to be able to test whether the instruments are actually exogenous. With a single endogenous regressor, we would ideally identify at least two instruments to estimate each specification. A benefit of the single equation approach used here is that we can focus on the appropriate specification and estimation of one model without simultaneously worrying about the other.

Many of the variables in the gravity model (size & distance) are also likely to influence conflict, thus we appeal to trade theory to determine whether other appropriate variables exist. The Heckscher Ohlin theory of trade developed by Nobel Laureate Bertil Ohlin and Eli Heckscher explains that cross-country differences in relative factor endowments cause countries to specialize and thus trade. Therefore the model predicts that countries with large differences in relative endowments would trade more ceteris paribus. The theory has been used (Deardorff, 1997) to derive the gravity model framework. We use the asymmetry of the dyad's land to population ratio to measure the difference in relative endowments, which is the absolute value of the difference between the two ratios.[15] The other instrument used is a lagged version of the endogenous regressor. Here we use the lagged value of bilateral trade, which is a predetermined variable at time t. As Cameron & Trivedi (2005: 106) discuss use of a lagged value is a common strategy in application of IV to panel data.

Similar to the models of conflict, we use a lagged version of the endogenous regressor as an instrument in the models of bilateral trade. We draw on theory to determine an additional variable. In theory, a measure of the dyad's relative military strength could be a good instrument for conflict in our models of trade, as military capabilities are unlikely to directly influence bilateral trade flows. Conflict models typically control for the relative strength within a dyad using the COW capability index (Singer, 1987), which is based on a country's total population, urban population, energy consumption, military personnel, military expenditures, and production of iron and steel. Total population and urban population though both directly influence trade, with urban population influencing a country's ability to achieve economies of scale in production. The capability ratio is thus potentially endogenous. Of the five other components, the factor least correlated with total population is the amount of military expenditures.[16] Therefore we propose relative military expenditures within each dyad as an instrument for conflict. The measure used is the natural log of the ratio of the higher expenditure to that of the lower for each dyad. Overidentification tests will reveal whether both sets of instruments are relevant and exogenous.

[15] Population data for 1950-1992 are from the Penn World Tables version 6.1. Land area for each country is from the World Bank's World Development Indicators dataset for the period 1961-1992 and is from the United Nations for the period 1950-1960. The latter dataset is reported in 5 year intervals beginning in 1950. None of the countries in our sample changed size between 1950 and 1960, so the value for 1950 was used throughout this period.

[16] The correlation between total population and military expenditures is .28 for the period 1816-1992.

[Insert Table 2 about Here]

The results appearing in Table 2, show that trade has a negative and significant effect on conflict. Our instruments for trade, the asymmetry of relative factor endowments and the lagged value of trade are both relevant and exogenous. Further, we find that conflict has a negative and significant effect on trade, when using the lagged value of conflict and ratio of military expenditures as instruments. These instruments are also both relevant and exogenous. The use of appropriate instruments results in consistent estimates that provide additional support to the liberal peace, while controlling for the potential endogeneity of trade and conflict.

We also considered the robustness of our results to a few minor changes in the conflict model's specification. Modifications also considered by Hegre, Oneal, & Russett (2010) and Keshk, Reuveny, & Polins (2010). The first modification is to determine the impact of including both contiguity and distance in the conflict equation. Keshk, Reuveny, & Polins believe both measures should not be used and remove distance from their specification. Dropping distance from the specification, we find trade reduces conflict, though the effect is not significant.[17] Our instruments though are no longer relevant or exogenous. Omitting distance leads to correlation between the instruments and the error term. If one instead omits contiguity, trade reduces conflict (p-value .054) and the instruments are in this case appropriate. Hegre, Oneal, & Russett (2010) argue that major power status is an inadequate measure of size and they instead prefer to add both countries GDPs separately. Adding both countries GDP's to the original specification, trade still significantly reduces conflict and the instruments are appropriate. Omitting major power status and using the two GDPs does not alter this result. Another

[17] Results for the following discussion appear in a web-appendix.

idea put forward by Hegre, Oneal, & Russett (2010) is shared membership in preferential trade agreements (PTA) may serve to explain trade and not influence conflict. Theoretically, it would seem that economic ties and military ties might be potentially related and thus not an appropriate instrument. Recent research by Baier and Bergstrand (2007) also suggests countries endogenously select into trade agreements, which may possibly be correlated to the level of trade. Despite this potential, we added PTA membership to our list of instruments and re-estimated our model. Again trade was found to significantly reduce conflict and interestingly the instruments were exogenous.

Discussion and Conclusion

Existence of an unobserved variable, which influences a dyad's preferences for trade and conflict, or a simultaneous relationship where trade and conflict each influence the other, can both lead to model specifications with an endogenous regressor. In either case, estimating a model of trade using OLS or a model of conflict using probit will lead to inconsistent estimates where the sign and size of the coefficients may be unreliable. The often used remedy is to use instrumental variables in the place of the endogenous regressor. Estimation requires the model to be identified, which means the instruments are both relevant and exogenous. The model specifications used by KPR and KR used instruments which were strong, but not exogenous. Use of endogenous instruments implies the IV coefficients of the models are also inconsistent. We were able to identify relevant and exogenous instruments for both trade and conflict. Using appropriate instruments we found that trade significantly reduces conflict and conflict reduces trade, which supports the liberal peace proposition.

Researchers who are concerned with the effects of a potentially endogenous regressor need to tread carefully. Correcting for endogeneity incorrectly can be as bad if not worse than ignoring it entirely. As discussed earlier, estimating a conflict model with an endogenous regressor using probit produces inconsistent estimates as does estimating the model using endogenous instruments. It is possible that IV estimates with endogenous instruments will be even more inconsistent than those that ignore endogeneity. Table 3 compares the estimates of trade's effect on conflict when we use exogenous instruments, ignore endogeneity and use probit, and use endogenous instruments (factor asymmetry and product of the dyad's real GDPs). The consistent estimate is negative and significant as is the probit estimate, whereas the IV estimate with endogenous instruments is positive. The inconsistent IV estimate deviates more from the consistent estimate than the inconsistent probit estimate. Another point to keep in mind is that even our consistent estimator is still biased. Consistency is an asymptotic property, thus IV estimates may show bias in finite samples. This implies in finite samples it is possible that our "consistent" estimates differ more from the true value than estimates that ignore endogeneity.

[Insert Table 3 about Here]

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Table 1a: Specification of Keshk, Pollins, & Reuveny's Model

	SEQ		Single Equation	
		Robust		Robust
Conflict Equation	Coefficient	Std. Error	Coefficient	Std. Error
LN Bilateral Trade	0.0063	0.0057	0.0069	0.0057
Lag of conflict	1.9632**	0.0875	1.9615**	0.0874
Trend of dependence (H)	-45.2697	32.4459	-44.2317	31.8372
Growth rate (L)	-0.0091*	0.0045	-0.0087	0.0045
LN of democracy score (L)	-0.1305**	0.0222	-0.1300**	0.0221
Allies	0.0116	0.0724	0.0129	0.0724
LN Capability ratio	-0.0002	0.0003	-0.0002	0.0003
Contiguity	1.2175**	0.0729	1.2116**	0.0735
LN Real GDP (H)	0.0974**	0.0228	0.0963**	0.0226
Constant	-4.6959**	0.3943	-4.6768**	0.3934
n	143792		143792	
Endogeneity T-Statistic			-4.99	p-value < .001
Relevance F-Statistic			130000	p-value < .001
Lee Overidentification Statistic			213	p-value < .001

	SEQ		Single Equation	
		Robust		Robust
Trade Equation	Coefficient	Std. Error	Coefficient	Std. Error
Conflict	-0.0438*	0.0189	-0.6739**	0.1536
Lag of Trade	0.8991**	0.0019	0.8990**	0.0019
LN Real GDP (A)	0.2296**	0.0064	0.2305**	0.0063
LN Real GDP (B)	0.2339**	0.0061	0.2338**	0.0061
LN Population (A)	-0.0470**	0.0074	-0.0542**	0.0060
LN Population (B)	-0.0812**	0.0052	-0.0829**	0.0051
LN of Distance	-0.2459**	0.0095	-0.2391**	0.0077
LN of Democracy score (L)	0.0500**	0.0054	0.0538**	0.0051
Allies	0.0128	0.0145	0.0093	0.0143
Constant	-4.2531**	0.1152	-4.1040**	0.1035
n	143792		143792	
Endogeneity T-Statistic			2.09	p-value .037
Relevance F-Statistic			60.37	p-value < .001
Hansen Overidentification Statistic			708	p-value < .001

(H) and (L) denote higher or lower value within the dyad is used; LN denotes the natural log is used.
(A) and (B) denote each country separately within the dyad.
**p-value < .01; *p-value < .05

Table 1b: Specification of Kim & Rousseau's Model

	SEQ		Single Equation	
		Robust		Robust
Conflict Equation	Coefficient	Std. Error	Coefficient	Std. Error
Trade Dependence	0.0765**	0.0086	0.0692**	0.0072
Democracy score (L)	-0.0388**	0.0042	-0.0364**	0.0038
LN of capability ratio	-0.0465**	0.0166	-0.0455**	0.0159
Allies	0.0235	0.0603	0.0233	0.0568
Contiguity	0.8666**	0.0613	0.8232**	0.0620
LN of distance	-0.0218	0.0295	-0.0213	0.0283
Major Power	0.3805**	0.0659	0.3639**	0.0648
Peace Years	-0.1629**	0.0137	-0.1532**	0.0122
Spline 1	-1.1E-03**	1.6E-04	-1.0E-03**	1.5E-04
Spline 2	5.9E-04**	1.1E-04	5.5E-04**	1.0E-04
Spline 3	-4.1E-05*	2.0E-05	-3.9E-05*	1.9E-05
Constant	-1.2311**	0.1864	-1.1850**	0.1744
n	261609		261609	
Endogeneity T-Statistic			-14.18	p-value < .001
Relevance F-Statistic			31043	p-value < .001
Lee Overidentification Statistic			129.5	p-value < .001

	SEQ		Single Equation	
		Robust		Robust
Trade Equation	Coefficient	Std. Error	Coefficient	Std. Error
Conflict	0.0995	0.0875	10.1894**	3.6307
Democracy score (L)	0.1547**	0.0057	0.1565**	0.0058
Allies	-0.1402	0.1088	-0.1191	0.1124
LN of distance	-2.1021**	0.0615	-2.0913**	0.0607
LN of Real GDP	1.5930**	0.0260	1.6279**	0.0267
LN of Population	-0.7090**	0.0351	-0.7314**	0.0343
Constant	-36.2176**	0.7483	-37.5499**	0.7805
n	261609		261609	
Endogeneity T-Statistic			-3.45	p-value = .001
Relevance F-Statistic			23.91	p-value < .001
Hansen Overidentification Statistic			300.2	p-value < .001

(H) and (L) denote higher or lower value within the dyad is used
LN denotes the natural log is used.
**p-value < .01; *p-value < .05

Table 2: Conflict and Trade Specifications with Relevant and Exogenous Instruments

	Conflict Equation	
	Coefficient	Robust Std. Error
LN Bilateral Trade	-0.0401*	0.0160
Democracy score (L)	-0.0110*	0.0055
Growth rate (L)	-0.0121*	0.0054
LN of capability ratio	-0.1680**	0.0317
Allies	-0.0360	0.0745
Contiguity	0.9832**	0.0756
LN of distance	-0.2895**	0.0515
Major Power	0.3867**	0.0856
Peace Years	-0.1742**	0.0172
Spline 1	-0.0010**	0.0002
Spline 2	0.0005**	0.0001
Spline 3	-1.0E-05	2.6E-05
LN Real GDP (H)	0.2776**	0.0556
Constant	-4.2669**	0.6124
n	119508	
Endogeneity T-Statistic	1.73	p-value = 0.083
Relevance F-Statistic	15.92	p-value< .001
Lee Overidentification Statistic	0.518	p-value = .47

	Trade Equation	
	Coefficient	Robust Std. Error
Conflict	-5.6322**	1.0522
LN of Real GDP	2.3107**	0.0276
LN of Population	-0.8473**	0.0327
LN of distance	-2.0675**	0.0526
Contiguity	1.5654**	0.1662
Democracy score (L)	0.0927**	0.0056
Allies	0.2018	0.1093
Constant	-41.2391	0.7756
n	140872	
Endogeneity T-Statistic	5.35	p-value< .001
Relevance F-Statistic	46.62	p-value< .001
Hansen Overidentification Statistic	< .001	p-value = .99

(H) and (L) denote higher or lower value within the dyad is used;
LN denotes the natural log is used.
**p-value < .01; *p-value < .05

Table 3: Comparison of Instrumental Variable and Probit Estimates of Trade's effect on Conflict

	Conflict Equation	
	Coefficient	Robust Std. Error
IV - Strong and Exogenous Instruments	-0.0401	0.0160
Probit	-0.0109	0.0061
IV - Endogenous Instruments	0.0435	0.0278
Relevance F-Statistic	218.6	p-value < .001
Lee Overidentification Statistic	3.974	p-value = .046