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The impact of trade on growth in the Great Lakes states

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Abstract

Recently, public debate has re-emerged about whether the U.S. has benefited from global trade and trade agreements. We contribute to the debate about the impact of trade on growth, using a natural experiment particular to the Great Lakes region of the United States. Shipping activity in the Great Lakes is sensitive to cyclical fluctuations in water levels, which in turn is primarily driven by natural phenomena such as rainfall, snowfall, and drought. This connection allows us to use data on Great Lakes water levels to identify the causal impact of trade on economic growth, overcoming methodological challenges due to the endogenous relationship between these two variables. We conduct an instrumental variables analysis and show that a 1% increase in trade is associated with a 5bp to 8.5bp increase in the growth rate of state GDP, on average. Our results confirm that shocks to trade policy which negatively disrupt international commerce can have real adverse consequences for the strength of the domestic economy.

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1 Introduction

Recent shifts in the political rhetoric about international trade has led to the re-emergence of perennial questions about what, if any, are the benefits of trade and of trade agreements, such as the North American Free Trade Agreement (NAFTA), for the United States.

In this article, we contribute to the renewed debate by offering new evidence on the causal link between trade and growth in a case study of the U.S. states bordering the Great Lakes. International commerce by states bordering the Great Lakes can vary according to cyclical fluctuations in the water levels of the lakes, offering a unique natural experiment that allows us to overcome methodological challenges in identifying the growth effect of foreign trade. This link between economic activity and natural phenomena has been described in public media; for example, according to a 2017 USA TODAY article, “For shipping and ports on the Great Lakes, the high-water levels are generally beneficial. Deeper water enables shippers to carry heavier loads. It’s more economical for the shippers and it means more product moves through the port, generating a larger economic impact on communities.” (Haen 2017) This anecdotal evidence suggests that Great Lakes water levels could be a prime candidate as an instrumental variable for foreign trade.

This article is most similar to previous literature that tries to isolate the impact of trade on growth, such as Frankel and Romer (1999), Dollar and Kraay (2003), Lee, Ricci, and Rigobon (2004), and Brückner and Lederman (2012). Much of this literature seeks to identify appropriate instrumental variables that can be used to identify the causal growth effect of international trade; for instance, in the papers mentioned above, geographic distance, lags of economic openness, heteroscedasticity, and rainfall are used as instrumental variables for analyzing trade, respectively. Notably, Feyrer further extended the methodology by leveraging time-variation in distance to study the causal impact of trade on income: Feyrer (2009) constructed a time-varying geographic instrument based on the observation that improvements in aircraft technology shorten the effective distance between trading partners. In a second work, Feyrer (2009) exploited the 1967-1975 closing of the Suez Canal due to the outbreak of war as a natural experiment during which sea distance between trading partners temporarily increased if the countries had previously used the canal as the shortest shipping route.

In this article, we explore the suitability of using publicly available Great Lakes water level data as an instrument for international trade. We present econometric evidence showing that lake levels satisfy the requirements of an instrumental variable: namely that they are correlated with the endogenous trade variable, while being uncorrelated with the error term in the regression of GDP growth. Our findings highlight the application of new data to shed light on the familiar question of the growth effect of trade.

The structure of this article proceeds as follows: in the next section, we describe our methodology, including the natural experiment that allows us to identify the causal relationship between trade and growth; Section 3 describes our data; Section 4 presents our main empirical findings, and Section 5 offers concluding remarks.

2 Methodology

To identify the impact of trade on growth, our basic estimation framework is the panel regression equation:

$$\Delta y_{it} = \alpha + \beta \Delta k_{it} + \gamma \Delta l_{it} + \delta \Delta trade_{it} + \theta X_{it} + \varepsilon_{it} \quad (1)$$

Where y, k, and l refer to the logarithm of real gross domestic product (GDP), capital stock, and labor force, respectively. $Trade$ is some measure of international trade, in logs, discussed below. GDP, capital, labor, and trade variables are differenced, which converts them into growth rates. X refers to a vector of control variables which include fixed effects for state and time. Indexes i and t refer to state, and quarter of observation, respectively. ε_{it} is a residual term which captures all determinants of output not included in the other variables, and represents the growth rate of total factor productivity (TFP). This specification is based on the neoclassical production function and is commonly used in empirical studies of the relationship between foreign trade and economic growth. As described in van den Berg (1996), "this specification is not only convenient in that data to proxy the variables is readily available for most countries, but it is also theoretically justified" by various economic models of growth and international trade.

In this paper, we consider six different measures of foreign trade: state-level imports from Canada, exports to Canada, total trade (the sum of imports and exports) with Canada, as well as total imports from the world, exports to the world, and total trade with the world. Canada was chosen in particular because its proximity to the Great Lakes suggested a tighter link between Great Lake water levels and bilateral Canadian-U.S. trade. We consider the impact of actual trade flows rather than normalizing trade by GDP (referred to in the literature as the "trade share" or "trade openness") which is the approach in Frankel & Romer (1999) and Brückner & Lederman (2012), among others. As Feyrer (2009) notes, using the trade share as an independent variable makes interpretation of the coefficient problematic because trade share is a function of GDP and thus GDP appears on both the left and right sides of the regression.

Estimating equation (1) is not straightforward due to the presence of endogeneity: international trade and economic growth are simultaneously determined, and each one causes the other. Figure 1 illustrates this relationship, illustrating the economic theories by which these variables are determined by each other. Under these conditions, a standard, ordinary least squares (OLS) regression would yield biased and inconsistent estimates of the effect of the independent variables on the dependent variable. Consistent estimation of equation (1) is possible through an instrumental variables (IV) approach, where additional variables ("instruments") are used to identify a causal effect. A proper instrument must satisfy two criteria: (1) the instrument must be uncorrelated with the error term ε_{it} (TFP), and (2) it must be highly correlated with the endogenous variable ($trade_{it}$). Based on these properties, variation in the instrument can be used to identify the impact of the endogenous variable on the outcome.

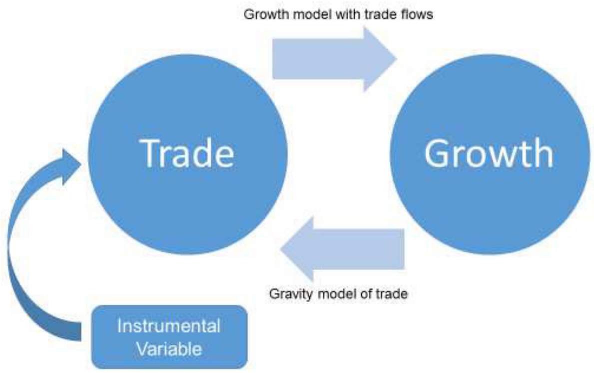

Figure 1: Endogenous relationship between trade and growth

In this article, we look at the impact of foreign trade on economic growth among a set of states bordering the Great Lakes, and whom are members of legally binding interstate compact to manage the shared use of Great Lakes water, known as the Great Lakes Compact.[1] A key feature of Great Lakes states' economies allows for an interesting natural experiment enabling an IV analysis to identify the causal impact of trade on growth. Namely, goods shipping is sensitive to the water levels of the Great Lakes. In 2013, the New York Times reported that "drought and other factors have created historically low water marks for the Great Lakes, putting the $34 billion Great Lakes-St. Lawrence Seaway shipping industry in peril, a situation that could send ominous ripples throughout the economy." (Schwartz 2013) The same article goes on to describe how to cope with low water levels, "shipowners have had to lighten the loads on their boats, making hauling less efficient and profitable." (Schwartz 2013) According to the New York Times, "the most recent causes of low water were mild winters…which left too little snow to feed the lakes, traditionally the `largest source of water to the Great Lakes…..' The ability of humans to fix the situation is limited, said Mr. Nevin of the International Joint Commission. `We can't make it rain.'" (Schwartz 2013)

We argue that the water levels of the Great Lakes are an attractive IV for trade between the Great Lakes states and foreign countries. When it comes to the first requirement that lake levels are uncorrelated with TFP, we use the fact that lake levels are largely determined by exogenous meteorological phenomena; the NYT article notes that human intervention is largely unable to affect the weather and lake levels. Therefore, any correlation between lake levels and TFP in the data is likely to be driven by random fluctuations rather than a meaningful underlying relationship. Furthermore, based on the qualitative evidence provided above, insufficient water levels can affect the volume and value of maritime trade passing through the Great Lakes, fulfilling the second requirement that lake levels and trade levels be correlated.

[1] The Great Lakes-St. Lawrence River Basin Water Resources Compact details how member states cooperate to manage and protect the Great Lakes-St. Lawrence River Basin, and provides a framework for each State to enact programs and laws protecting the Basin. More information available on www.glscompactcouncil.org.

A second, important element of our estimation strategy involves correcting the standard errors of the estimated regression model to allow for proper statistical inference. Angrist and Pischke (2009) describe Moulton's finding that conventional standard errors can become increasingly misleading as residual correlation within clusters—intraclass correlation—increases (Moulton 1986). Using cluster-robust standard errors (Liang and Zeger 1986) allows consistent estimation of standard errors under the assumption that the number of clusters approaches infinity, but cluster-robust standard errors are inconsistent with a fixed number of groups, which is the case in our dataset where there are only eight states. Although Hansen (2007) showed that cluster standard errors performs reasonably well even for as few as 10 clusters, we choose to implement a correction to account for this finite-sample bias. One potential solution is a procedure called bias-reduced linearization (BRL), which inflates residuals in order to reduce bias, paired with using a small-sample correction to conduct statistical inference (Bell and McCaffrey 2002). In this paper, we employ Pustejovsky and Tipton's generalization of this approach, which allows for an arbitrary number of fixed effects (Pustejovsky and Tipton 2016). Using this correction allows for valid statistical inference despite the limited number of states in the sample.

3 Data

To take advantage of the natural experiment outlined in the methodology above, we employ the data sources described below. We construct a quarterly dataset spanning 2008-2016, combining available data from the U.S. Census Bureau and the U.S. Army Corps of Engineers, among other sources. Based on the limited number of years in the sample, conducting the analysis at quarterly frequency increased the number of observations in the data and allowed us to take advantage of not only cross-state, but also within-year fluctuations in trade, growth, and lake levels to identify the causal impact of trade on growth.

Gross Domestic Product (GDP)

Quarterly data on GDP by state and industry are from the Bureau of Economic Analysis (BEA) regional economic accounts, seasonally adjusted and represented in millions of chained 2009 U.S. dollars. Data were available from 2005Q1 to 2017Q2.

Imports, Exports, and Total Trade

Data on imports and exports by state (in current USD) are taken from the U.S. Census Bureau's USA Trade Online database, which contains monthly data on imports and exports from 2008 onwards. Import and export data were aggregated to quarterly frequency, and represented in 2009 U.S. dollars by deflating with the Consumer Price Index (total, all items for the United States) available from the OECD (2016). Total trade is calculated as the sum of imports and exports in each quarter.

Great Lakes Water Levels

We use water levels in the Great Lakes as instrumental variables for international trade. Data on water levels are from the U.S. Army Corps of Engineers, which provides monthly mean water levels from 1918 through 2016 for all of the Great Lakes including Lake St. Clair. These data in metric units and are aggregated to quarterly frequency by taking averages.

Labor

Labor input is captured as total employment by state in the private sector, following the approach in Cardarelli and Lusinyan (2015). Seasonally adjusted monthly data on the total number of private sector employees (in thousands) are pulled from the Bureau of Labor Statistics Current Employment Statistics database. Data were available from January 2000 to December 2017. The data are aggregated to the quarterly frequency by taking the quarterly average.

Capital

There is no official data on capital stock or services for U.S. states. To construct a quarterly, state-level series on capital stock, we follow the approach of Garofalo and Yamarik (2002) and Yamarik (2013). This approach involves apportioning annual national capital stock estimates at the industry-level to the states using annual industry-level income data. We take the BEA's annual estimates of the national capital stock at the industry-level (in billions of chained 2009 dollars), and divide it up among states according to their output share in the industry. Industry-level capital stock estimates by state are then summed to create a state-level total capital stock series. The data were available annually from 1999-2016,

This approach has been used elsewhere in the literature as well, such as by Sharma, Sylwester and Margono (2007), Cardarelli and Lusinyan (2015) and Blanco, Gu and Prieger (2016), with the implied capital stock series showing high correlation with alternative estimates of capital stock such as those constructed by Turner, et al. (2007). Additionally, Cardarelli and Lusinyan (2015) show that aggregated total factor productivity (TFP) measures based off of this method of calculating capital stocks are highly correlated to national TFP estimates produced by various sources, including the BLS, while the state-level TFP measures are correlated with several state-level alternatives used in the growth literature as well.

After following the Garofalo and Yamarik (2002) approach to generate an annual series for capital stock by state, we use the proportional Denton method to interpolate the annual series into a quarterly capital stock series. This method uses a high-frequency (quarterly) indicator series to temporally disaggregate the low-frequency (annual) series, imposing the constraint that the interpolated series aggregates back to the original totals. The proportional Denton method is recommended by the IMF as "relatively simple, robust, and well suited for large-scale applications" (Bloem, Dippelsman and Mæhle 2001, 98). In our baseline results, we use quarterly state-level GDP as the high-frequency benchmark for interpolating the annual capital stock series, motivated by the following economic reasons:

1. Kaldor (1957) documented a stylized fact that the ratio of capital to output remains roughly constant in the long-run.
2. Business cycle models attempt to capture the stylized fact of positive investment correlation with output in response to short-run economic shocks (Plosser 1989). All else equal, higher investment should lead to higher capital stock (for example, standard business cycle models have a constant ratio of investment-to-capital in the steady state), and the standard real business cycle model indeed features positive co-movement of output and capital at business cycle frequency (King and Rebelo 1999).

3. King and Rebelo (1999) note that empirically the volatility of capital stock is much lower than that of output, and that capital appears to be essentially acyclical, with a low correlation with output over the business cycle. Using output as a benchmark for quarterly capital means we are *more likely* to find a strong relationship between capital and output, and *less likely* to find that other things, such as international trade, contribute to growth after accounting for capital. Thus, our methodology is biased against our main hypothesis and will yield conservative results.[2]

4 Results

Before describing the results of our IV analysis, we first test whether water levels in the Great Lakes should be directly incorporated into the production function. This is related to the first IV requirement that the instrument must be uncorrelated with the error term in equation (1). In particular, if Great Lake water levels have explanatory power for GDP, then in equation (1) the influence of lake levels would fall in the error term ε_{it}; lake levels would then be correlated with the error term—a violation of a key IV assumption. Table 1 shows our results for regressing output on labor, capital, and water levels of each of the Great Lakes. We ran five separate regressions for each state corresponding to each of the lake level series in our dataset. Coefficient estimates were obtained using a seemingly unrelated regressions model, as described in Greene (2008). The last row of the table is a pooled estimate of the effect of lake levels on production, restricting estimated coefficients to be the same across all states. Table 1 shows that changes in lake levels do not have a statistically significant effect on changes in state GDP, with the possible exception of Lake Ontario for New York state, where the coefficient is significant at the 10% level. The pooled effect across all eight states in the dataset is largely insignificant. This finding, along with the rationale explained in the previous section, gives us more confidence that lake levels can be considered a properly excluded instrument.

[2] As a robustness check to the sensitivity of our results to using GDP as to benchmark the quarterly capital stock, we calculate an alternative capital series which evenly distributes the annual capital stock across all quarters, without the use of a high-frequency benchmark. Our results remain similar, both qualitatively and on the basis of statistical significance.

Table 1: Coefficients on lake levels in production function regression					
	Erie	Michigan-Huron	Ontario	St. Clair	Superior
Illinois	2.132	0.805	0.738	1.898	-2.245
	(1.526)	(2.198)	(0.575)	(1.581)	(3.621)
Indiana	-0.835	-1.592	-0.346	-2.033	-1.146
	(1.500)	(2.099)	(0.549)	(1.519)	(3.540)
Michigan	-0.254	-1.308	-0.002	-1.980	-6.663
	(1.590)	(2.227)	(0.592)	(1.618)	(3.601)
Minnesota	-1.143	0.912	0.011	-1.406	3.445
	(1.561)	(2.191)	(0.588)	(1.601)	(3.621)
New York	-2.053	-1.833	-1.370+	-1.753	0.886
	(2.190)	(3.058)	(0.778)	(2.258)	(5.221)
Ohio	-0.166	-0.986	-0.193	-1.414	0.538
	(1.309)	(1.828)	(0.480)	(1.351)	(3.100)
Pennsylvania	-1.362	1.182	-0.116	-0.908	3.822
	(1.357)	(1.948)	(0.511)	(1.408)	(3.178)
Wisconsin	0.145	1.268	0.404	-0.400	0.181
	(1.379)	(1.913)	(0.502)	(1.423)	(3.293)
Pooled	-0.340	0.491	-0.001	-0.717	-0.085
	(1.012)	(1.417)	(0.374)	(0.492)	(0.972)
Note: Standard errors reported in parentheses. Each regression conducted on 35 quarterly observations spanning full sample period of 2008Q2-2016Q4.					
+ p < 0.10, * p < 0.05, ** 0 < 0.01, *** p < 0.001					

Table 2 presents our key results. Table 2 shows a positive, statistically significant effect of trade on growth, an effect that is robust to the different measures of trade that we consider. For example, Column 1 indicates that a 1% increase in the growth rate of imports from Canada is associated with a 5.1 basis point (bp) increase in GDP growth in the Great Lakes states, on average, an effect that is significant at the 1% level. Across all different measures of trade, the growth effect varies from about 5 bp in the case of imports from Canada, to about 8.5 bp in the case of exports to Canada. As we conjectured earlier, we also identify a strong, statistically significant contribution of capital accumulation to growth: a 1% increase in capital stocks is associated with a growth rate that is about 45 bp higher. Labor force growth is also found to have a statistically significant effect in four columns. As we note earlier, the construction of the capital stock series may have introduced attenuation bias on the other coefficients, so the insignificant labor coefficient in columns 2 and 3 are not necessarily a cause for concern. Importantly, despite this attenuation bias, we continue to find a statistically significant growth effect from increased foreign trade.

The second section of the table reports various diagnostics tests for the estimated regression models. The weak instruments test reports an F statistic of the first stage regression of the endogenous variable (trade) on the instruments (lake levels). According to Bound, Jaeger and

Baker (1995), "F statistics close to 1 should be cause for concern." Table 2 shows that the first-stage F statistics are all greater than 1, and the F tests reject the null hypothesis that the instruments are uncorrelated with trade, indicating that we satisfy the second IV requirement. The Wu-Hausman test is a test for whether IV was truly necessary. It compares the IV coefficients to coefficients from an ordinary least squares estimation to test the null hypothesis that the OLS estimator is consistent and fully efficient. We reject this null hypothesis in all specifications, suggesting that the use of IV is appropriate and leads to consistent estimates of the effect of trade on growth. The Sargan test is a statistical test of the null hypothesis (and key IV requirement) that the instrumental variables are uncorrelated with the error process. Baum, Schaffer and Stillman (2003) note that Hansen's J test (in the following row, modified to account for state clustering) performs better under heteroskedasticity. Table 2 shows that we are unable to reject the null hypothesis of no correlation at a standard 5% rejection level, although we do weakly reject the null at the 10% level. In light of our reasoning about the plausible exogeneity of Great Lakes levels and the quantitative results in Table 1, and because the Hansen J test is known to have low power as the set of excluded instruments increases (Baum, Schaffer and Stillman 2003), we argue that these test results do not cast strong doubt on the validity of our approach.[3]

The third section of Table 2 presents various measures of goodness-of-fit for the model. The Wald test strongly rejects the null hypothesis that our independent variables jointly have no explanatory power. The adjusted R-squared measure indicates that our model explains over half the variability in states' GDP growth rates.

[3] Hoxby and Paserman (1998) show that standard overidentification tests (such as the conventional Sargan and Hansen tests) are biased towards over-rejecting their null hypothesis in the presence of intra-cluster correlation, which exists in our dataset.

Table 2: IV estimates of the effect of trade on growth in Great Lakes states						
	Trade measure					
	Imports from Canada	Exports to Canada	Total trade with Canada	Imports from World	Exports to World	Total trade with World
Trade measure	0.051**	0.084**	0.062**	0.051**	0.060*	0.055*
	(0.020)	(0.017)	(0.020)	(0.014)	(0.023)	(0.016)
Capital	0.456***	0.456***	0.454***	0.440***	0.467***	0.450***
	(0.056)	(0.059)	(0.058)	(0.053)	(0.061)	(0.057)
Labor	0.396	0.187	0.322	0.532**	0.497**	0.510**
	(0.201)	(0.115)	(0.172)	(0.127)	(0.124)	(0.111)
Weak instruments	4.836***	3.316**	6.296***	10.173***	8.312***	13.651***
df	5, 251	5, 252	5, 253	5, 254	5, 254	5, 254
Wu-Hausman	13.264***	13.472***	13.247***	6.983**	8.307**	6.694**
df	1, 253	1, 254	1, 255	1, 256	1, 257	1, 257
Sargan test	2.660	2.949	2.773	8.677+	7.987+	8.799+
df	4	4	4	4	4	4
Hansen's J	8.000+	8.000+	8.000+	8.000+	8.000+	8.000+
df	4	4	4	4	4	4
Wald test	25.212***	21.480***	27.383***	33.492***	31.675***	34.712***
df	21, 258	21, 258	21, 258	21, 258	21, 258	21, 258
Adjusted R^2	0.597	0.527	0.629	0.699	0.681	0.709
Root MSE	0.008	0.008	0.007	0.007	0.007	0.007
Note: Standard errors reported in parentheses. Small-sample correction used for inference.						
Standard errors robust to cluster (state)-level heteroskedasticity and autocorrelation.						
All specifications include intercept and country, year, and quarter fixed effects (not shown).						
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001						

Our estimated impact for the growth effect of trade has less variance than, but remains within the range of, some existing cross-country studies. van den Berg (1996) looks at a sample of five Asian countries and finds that the growth elasticity of trade varies between -41bp and +23bp. Feyrer (2009) finds in a cross-country study of over 60 countries that the effect of trade on growth varies between 46bp and 78bp. In contrast, our estimated effect is much more modest, which is perhaps due to the conservative bias stemming from the calculation of the capital stock measure in the regression. However, our estimates remain positive and statistically significant, in accord with the results in much of the literature that trade has a growth-boosting effect.

5 Conclusion

Our results show that for the Great Lakes states, trade matters for growth. An increase in foreign trade growth causes higher domestic GDP growth rates—a robust, statistically significant result. This finding confirms that shocks to trade policy which negatively disrupt international commerce can have real adverse consequences for the strength of the domestic economy.

Additionally, by introducing how data on Great Lake water levels can serve as an instrument for foreign trade, we lay the groundwork for future econometric studies to explore this connection between economic activity and the natural environment.

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