WP/18/117

IMF Working Paper

Sharp Instrument: A Stab at Identifying the Causes of Economic Growth

By Reda Cherif, Fuad Hasanov, and Lichen Wang

INTERNATIONAL MONETARY FUND

IMF Working Paper

Institute for Capacity Development

Sharp Instrument: A Stab at Identifying the Causes of Economic Growth

Prepared by Reda Cherif, Fuad Hasanov, and Lichen Wang[1]

Authorized for distribution by Ralph Chami

May 2018

Abstract

We shed new light on the determinants of growth by tackling the blunt and weak instrument problems in the empirical growth literature. As an instrument for each endogenous variable, we propose average values of the same variable in neighboring countries. This method has the advantage of producing variable-specific and time-varying—namely, "sharp"—and strong instruments. We find that export sophistication is the only robust determinant of growth among standard growth determinants such as human capital, trade, financial development, and institutions. Our results suggest that other growth determinants may be important to the extent they help improve export sophistication.

JEL Classification Numbers: O47, C26, C23

Keywords: Economic growth, Export sophistication, Productivity, Weak instrument

Author's E-Mail Address: acherif@imf.org, fhasanov@imf.org, lw2cb@virginia.edu

[1] We are grateful to Andy Berg, Ray Brooks, Ralph Chami, Metodij Hadzi-Vaskov, Sam Ouliaris, and Valerie Ramey for valuable comments and discussions.

CONTENTS PAGE

TABLES

FIGURES

I. Introduction

Determining the causes of economic growth is the grail sought by a large empirical growth literature. To understand the causes of economic growth, what is sought is not an exhaustive list of growth drivers—which is probably unfathomable—but rather a brief list of key determinants of growth. However, uncovering key factors of growth is hard in practice. Data have measurement errors; there are too many growth drivers to consider compared to data available; and causation is hard to distinguish from correlation. In this paper, we attempt to tackle one of the key problems in the empirical growth literature, namely, the causation vs. correlation—or endogeneity—problem, in determining the key causes of growth in a cross-country setting.

The standard technique used in the literature to tackle the endogeneity problem is to use an instrumental variable (IV) estimation. This technique relies on finding an instrumental variable outside the model that is both relatively strongly correlated with the endogenous variable of interest (instrument's strength) and at the same time uncorrelated with the residual or innovation term of the growth regression (instrument's validity). Many growth studies seem to suffer from a violation of one or both of these two conditions. Bazzi and Clemens (2013) showed that some prominent growth studies focus on different determinants of growth while using the same instrumental variables. As a result, they collectively suffer from the "blunt instrument" problem. In this case, at least one of the instrumental variable estimations must be invalid and possibly all could be invalid.

Over the last two to three decades, the number of determinants of growth explored in the literature grew much faster than the stock of instrumental variables available, which makes tackling the blunt instrument issue crucial. For example, population size was used as an instrument in a myriad of growth regressions to instrument for different endogenous variables such as trade (Spolaore and Wacziarg 2005), international aid (Rajan and Subramanian 2008) or export sophistication (Hausmann, Hwang, and Rodrik 2007) without necessarily controlling for other studies' explanatory variables.[2] Moreover, even when the instrument does not suffer from the "bluntness" problem, it could be weak, producing estimates that could misinform the reader about the true effects on growth.[3] It is not an exaggeration to say that thanks to Bazzi and Clemens (2013) we know that we may not know much about key growth determinants from instrumental variable growth regressions. We suggest a way to address their criticism.

In this paper we revisit the study of the main determinants of growth while avoiding the blunt and weak instrument problems. Our instrumentation technique consists in using, as an instrument for each endogenous variable, the average of the same variable in the neighboring marine and land countries. The instruments we propose have the advantage of being variable-specific and time-varying—namely, "sharp"—and the method produces strong instruments. The relatively strong correlations of growth determinants between a country and its neighbors suggest that geographic proximity can lead to imitation in trade openness, quality of institutions, education,

---

[2] Bazzi and Clemens (2013) also argue that even when multiple instruments are used for the same endogenous variable, in many cases population contains all the relevant information and other instruments are weak.

[3] Kraay (2015), following the approach suggested in Bazzi and Clemens (2013), finds a similar weak instrument problem in several studies of growth and inequality. A recent study by Berg et. al. (forthcoming) on growth and inequality uses a variety of robustness checks to address this problem.

financial development, and other policies. Moreover, we show evidence that the spillover effect from neighbors or time-invariant country features do not affect our main conclusions.

We find that export sophistication is the only robustly significant determinant of growth among the standard determinants such as human capital, trade, financial development, and institutions. Moreover, in the presence of export sophistication, other standard growth determinants mostly become statistically insignificant. One potential implication of our result is that improvements in human capital, trade, financial development or institutions would raise economic growth to the extent that they contribute to increasing export sophistication. We also show evidence that export orientation of domestic production, as opposed to domestic production per se or specialization in manufacturing, is critical.

In their seminal paper, Hausmann, Hwang, and Rodrik (2007) proposed a measure of export sophistication and argued that it was a key causal factor of growth. The measure is based on the weighted average of the degree of sophistication of the goods exported, which is measured by the average GDP per capita of all the countries exporting such a good. Replicating Hausmann, Hwang, and Rodrik (2007), Bazzi and Clemens (2013), show that in addition to the blunt instrument problem of using the population variable as an instrument for export sophistication, the problem of weak instruments could not be readily dismissed in the estimation. In this paper, we first recalculate the export sophistication variable, extending it to 2014. Then we not only resurrect the result of Hausmann, Hwang, and Rodrik (2007), but also show that export sophistication is the only robust variable when the standard factors of growth are included in the regression and the averages of variables in the neighboring countries are used as instruments. Moreover, we propose other proxies for export sophistication such as real manufacturing exports per capita or the share of manufacturing exports in total exports of goods and find broadly similar results.

II. Export Sophistication and Growth: Measurement and Stylized Facts

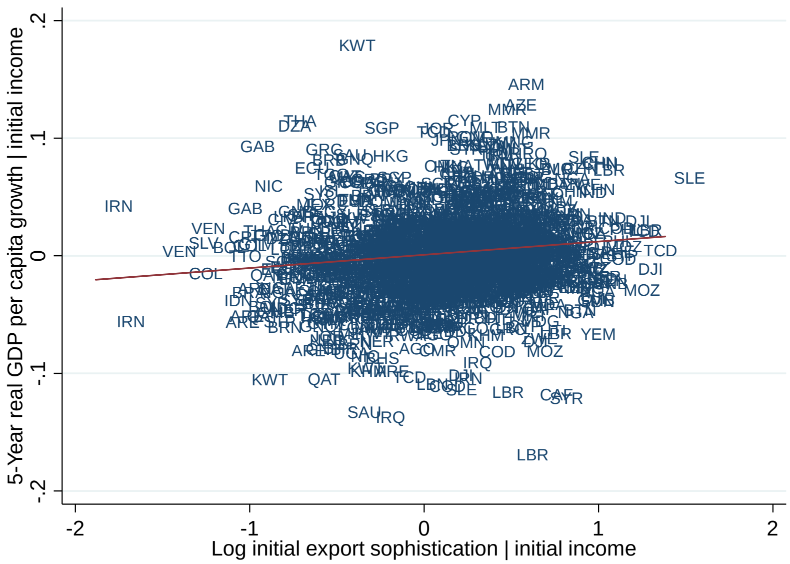
As the experience of many oil-exporting countries shows, in the absence of improvement in export sophistication, economic growth is fleeting (Cherif and Hasanov 2016). Although many oil exporters have grown for periods of time on the back of large oil income flows, sustained growth has not materialized as productivity growth has been stagnant or even negative. The authors argue that the main source of productivity gains stems from the production of sophisticated tradable goods, which in turn could be proxied by the degree of sophistication of exports. This type of production and exports have been lacking in many oil exporters.

Export sophistication has a strong positive association with the 5-year ahead real GDP per capita growth controlling for the level of initial GDP per capita (Figure 1).[4] The level of sophistication of each good is measured as the weighted average of real GDP per capita of all countries that export that good—a proxy for the level of sophistication. If a good is typically exported by rich countries (poor countries), it will have a high (low) sophistication level. Export sophistication

[4] The plot represents the residuals of the pooled OLS regression of growth on the initial logarithm of real GDP per capita vs. the residuals of the pooled regression of export sophistication on the initial logarithm of real GDP per capita. The slope of the fitted line should be equal to the coefficient of export sophistication in the pooled growth regression controlling for initial income. The plot excludes a few outliers with 5-year growth rates over 20 percent.

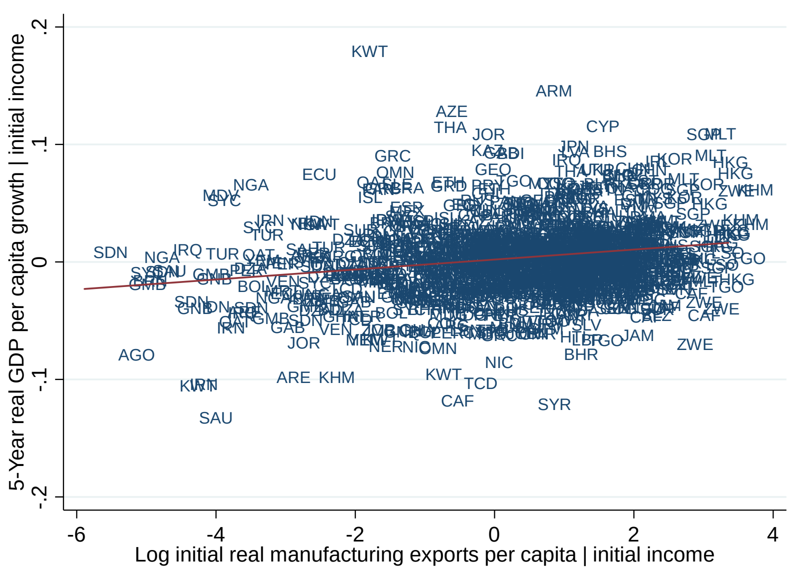
(EXPY in Hausmann, Hwang, and Rodrik 2007) is defined as the export-share weighted average of sophistication levels of the country's export basket.

Figure 1. Log Initial Export Sophistication vs. 5-Year Ahead Log Real GDP per Capita Growth Conditional on Initial Real GDP per Capita



We also use alternative proxies of export sophistication such as the share of manufacturing in goods' exports and real manufacturing exports per capita. Both measures have high coefficients of correlation with EXPY, about 60 and 75 percent, respectively. These measures have also a strong positive correlation with the 5-year ahead real GDP per capita growth controlling for the level of initial real GDP per capita (Figure 2).

Figure 2. Log Real Manufacturing Exports per Capita vs. 5-Year Ahead Log Real GDP per Capita Growth Conditional on Initial Real GDP per Capita



In a macro setting, finding valid and strong instruments is not a straightforward task and the GMM estimation, using country's own lagged variables, should bypass this problem (and in theory could help avoid the blunt instrument issue). Unfortunately, many of these instruments turn out to be weak, especially when using a smaller number of instruments. Bazzi and Clemens (2013) show that several of the seminal papers they examine do not survive the opening of the GMM's "black box," to use their term. In particular, the authors analyze the excludability of the country size (population and area) instrument and examine the instrument validity (e.g. using the test of Hahn, Ham, and Moon 2011), perform various tests of underidentification of the instrument set and tests of weak instruments (e.g. using Kleibergen-Paap and Cragg-Donald test statistics), and use estimation methods robust to weak instruments (e.g. a testing procedure using Kleibergen 2002). Interestingly, the only determinant of growth, which seemed to broadly survive their comprehensive analysis, is the export sophistication variable of Hausmann, Hwang, and Rodrik (2007). However, even in this case, the regressions do not pass all the tests. Weak instrument tests fail in the case of smaller or "collapsed" number of instruments, and the validity of the population variable is questioned. However, the weak-instrument robust confidence set estimation indicates that the export sophistication variable has a positive and statistically significant effect.

In the following section, we study the standard determinants of growth put forth by the literature in addition to export sophistication—human capital, quality of institutions, trade openness, financial development, foreign direct investment (FDI), saving rates, investment, government size, and the Gini coefficient. We use real GDP per capita for 1960-2014 from the Penn World Tables 9.0 (Feenstra, Inklaar, and Timmer 2015). Years of schooling come from Barro and Lee (2013).

Export sophistication data (EXPY) of Hausmann, Hwang, and Rodrik (2007) are computed using the World Trade Flows data (Feenstra and Romalis 2014) for 1962-2014. We also compute a structural EXPY measure—S-EXPY—which discounts the high share of commodity exports of high-income commodity exporters correcting the artificially high EXPY of commodity exporters (see Appendix for details).

The following variables are taken from the World Bank's World Development Indicators (WDI): trade (exports plus imports, percent of GDP) as a measure of trade openness, domestic credit to the private sector (percent of GDP) as a measure of financial development, manufacturing exports (in constant USD and percent of GDP), manufacturing production (real value added in local currency and percent of GDP), FDI (percent of GDP), government consumption (percent of GDP) as a measure of government size, and gross fixed capital formation (percent of GDP). The national saving rate is taken from the IMF's World Economic Outlook database, and the Gini coefficient is from SWIID v4. The law and order indicator, measuring the strength and impartiality of the legal system and the assessment of popular observance of the law, is used as a proxy of the quality of institutions and is taken from International Country Risk Guide's (ICRG) database (the data start in 1984). We also use a corruption indicator from the same source.

III. SHARP VS. BLUNT INSTRUMENT

In this section, we describe our instrumental variable methodology. Finding valid and strong instruments in the cross-country setting is challenging. As argued by Bazzi and Clemens (2013), many papers use the same instruments such as population and area for different variables. In addition, these instruments suffer from validity and possibly weak instrument problems. To illustrate the blunt instrument problem, suppose that growth could be (potentially) explained by two factors x and x' such that:

$$y = a + bx + cx' + e''$$

Let us assume that two studies use growth regressions (A) and (B) which have the following forms:

$$(A): y = a + bx + e$$
$$(B): y = a + cx' + e'$$

Let us suppose that one study uses (A) and instrumental variable z, and a second study uses (B) while relying on the same instrumental variable z. Assuming that z is a valid instrument in both (A) and (B) and that x and/or x' are significant determinants of growth, is problematic. Indeed, (A) could be re-written as $y = a + bx + (cx' + e'')$, while (B) could be re-written as $y = a + cx' + (bx + e'')$. If x' is correlated with z, then the latter is also correlated with the error term of (A), and the same logic applies to (B). In other words, at least one of the studies relies on an invalid instrumental variable (and it could be the case for both).

To remedy the "blunt" instrument problem, we propose the "sharp" instrument solution. Our method instruments for variables of a country with the average values of these variables in its neighboring countries. The advantage of this IV method is that it generates variable-specific instruments and can be applied to a wide range of explanatory variables thus bypassing the problem of blunt instruments described above. We also test for the strength of our instruments (correlation with the variables for which they are instruments).

We argue that using the average of a variable in neighboring countries as an instrument is likely to satisfy the exclusion restriction from the growth equation (validity of instruments) while at the same time, it should be correlated with the country's explanatory variable. The exclusion restriction requires that the innovation or error term in the growth regression be uncorrelated with the instruments for explanatory variables—the average values of those variables in neighboring countries. If the validity assumption holds, the country's growth is affected by neighbors' variables only through the country's own variables.

In contrast, some papers studying neighbor spillover effects use neighbors' variables directly in the growth regressions. Chua (1993) and Ades and Chua (1993) show that various practices and traits that are unfavorable to growth could spill over from neighboring countries and add simple averages of the neighbors' variables in the growth regression. Easterly and Levine (1998) control for the neighbors' growth weighted by GDP in the growth regression and instrument it with the averages of the neighbors' growth regressors.

Growth and its determinants in neighboring countries could be related in several ways. We propose different methods and controls to verify that our instruments are not invalid due to some unaccounted correlation with the residuals of the growth regression. Governments, firms and households in neighboring countries could imitate each other because of regional competition, common languages, or cultural proximity.[5] In particular, Bahar, Hausmann, and Hidalgo (2014) show that a country is more likely to export a product if its neighbor is exporting it. This type of effect would explain the strength of our instrument without invalidating it.

A country could be affected by spillovers from its neighbors mostly, but not exclusively, through trade and finance. Being close to a country that is growing fast could encourage FDI and technological transfers as was the case in East Asia's "Tigers."[6] We offer several types of robustness checks to verify that our instrument remains valid (see the next section). First, we control for the average real GDP per capita or real GDP in neighboring countries as a proxy for the spillover effect. Second, we modify the weighting of the instrument to mitigate a potential violation of the exclusion restriction of instruments based on simple averages. We use the median of variables of neighboring countries and the weighted average of variables of neighbors, in which weights are inversely proportional to real GDP. The median neighbor is less likely to be the main trading partner of a country, while the weights based on the inverse of real GDP mitigate the impact of large neighbors on the construction of instruments. This weighting scheme is inversely related to the size, a key predictor of trade links in the gravity model, assigning a smaller weight to bigger neighbors.

Neighboring countries in general share common "fixed" traits such as geography and climate, which are likely to affect growth. This could invalidate our instruments if not accounted for. We use latitude, ethnic fractionalization, and a dummy for Sub-Saharan Africa to control for some of these features. We also run a fixed effect IV regression. If we properly control for spillovers, common traits and major growth determinants, the country's growth innovations should not be correlated with neighbors' variables, thus satisfying the exclusion restriction.

IV. EMPIRICAL RESULTS

Running ordinary least squares (OLS) and fixed effects (FE) regressions (Table1), we find that many standard growth determinants are correlated with the growth rate. Regressing growth on initial log real GDP per capita and export sophistication and controlling for each standard determinant of growth separately (columns 1-5) yields mostly highly statistically significant coefficients (law and order is, however, not statistically significant) with the expected signs except for private sector credit. The coefficient on private sector credit is negative but this could be due to potential nonlinearities in the finance-growth nexus found in the literature (e.g. Arcand, Berkes, and Panizza 2015 and Demetriadis and Rousseau 2016). Increasing private credit could

---

[5] Rivalry with neighbors could explain a mimetic behavior similar to the "derby" rivalry between locals competing in a sporting contest.

[6] Typically, emerging and low-income countries have strong trade and financial links with advanced countries or large emerging markets, which are remote. Meanwhile, a developing economy is usually surrounded by other developing economies with little trade and financial links. In the absence of such links, it is plausible that there is no spillover effect from neighboring countries.

be correlated with higher vulnerabilities, financial instability and lower growth (e.g. Popov 2014 and Levine, Lin, and Xie 2016).

The coefficient estimates for export sophistication we find when including more controls, are consistent with the relationship shown in Figure 1. A 10 percent increase in export sophistication is associated with about 0.2-0.3 percent increase in the annual growth rate. The regression with all variables (columns 6-7) also yields statistically significant coefficients with the expected signs for all the variables. The same regressions with fixed effects result in a similar statistically significant estimate on export sophistication as in OLS regressions (columns 8-11). However, adding law and order reduces the sample size substantially and makes the export sophistication parameter statistically insignificant (columns 12-14). These regressions, however, show us correlations between growth and standard growth determinants and to infer causality, we turn to instrumental variable estimations.

Table 1. Growth and Export Sophistication: OLS and Fixed Effects (5-Year Panel)

Dependent variable: 5-year ave. annual growth rate	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) FE	(9) FE	(10) FE	(11) FE	(12) FE	(13) FE	(14) FE
Log export sophistication	0.027***	0.024***	0.027***	0.029***	0.029***		0.024***	0.022***	0.020***	0.026***	0.024***	0.012		0.008
	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)		(0.005)	(0.006)	(0.005)	(0.006)	(0.006)	(0.010)		(0.010)
Log real GDP per capita	-0.010***	-0.015***	-0.012***	-0.010***	-0.012***	-0.010***	-0.015***	-0.044***	-0.050***	-0.052***	-0.049***	-0.097***	-0.072***	-0.070***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.006)	(0.008)	(0.006)	(0.005)	(0.023)	(0.012)	(0.012)
Years of schooling		0.003***				0.004***	0.004***		-0.003				-0.003	-0.002
		(0.001)				(0.001)	(0.001)		(0.002)				(0.002)	(0.002)
Trade (% of GDP)			0.017***			0.005**	0.004**			0.037**			0.010	0.014**
			(0.005)			(0.002)	(0.002)			(0.015)			(0.008)	(0.007)
Credit to private sector (% of GDP)				-0.007**		-0.010***	-0.013***				-0.010*		-0.028***	-0.028***
				(0.003)		(0.003)	(0.003)				(0.005)		(0.005)	(0.005)
Law and order					0.001	0.003***	0.002**					-0.000	0.004**	0.004**
					(0.001)	(0.001)	(0.001)					(0.002)	(0.002)	(0.002)
Observations	1,592	1,226	1,376	1,333	748	609	601	1,592	1,226	1,376	1,333	748	609	601
Adjusted R-squared	0.082	0.136	0.118	0.092	0.088	0.119	0.159	0.156	0.216	0.207	0.211	0.284	0.301	0.300
\# of countries								171	137	168	167	134	117	117

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Using an instrumental variable estimation, based on the average of variables of neighboring countries as an instrument for each explanatory variable, we find that export sophistication is the key determinant of growth (Table 2). A 10 percent increase in export sophistication, measured by EXPY, increases the average annual growth rate in the next 5 years by about 0.6-0.7 percent. This result, namely the statistical significance and the magnitude of the coefficient on export sophistication, is robust across most estimations and is about as robust as the initial real GDP per capita.[7] The coefficient obtained is two to three times larger than the coefficient in OLS or FE regressions suggesting a large downward bias. In column 1, real GDP per capita is assumed to be exogenous, while it is not assumed to be exogenous in column 2. In each case, our instruments are simple averages of the instrumented variables of the country's neighbors. For instance, the value of the instrument for export sophistication for Mexico is the average of export

[7] All estimations include a constant and time dummies (not shown). In this specification, fixed effects are subsumed into the error term. This assumes that the fixed effect is uncorrelated with our instruments' set of neighbors' variables. It is a less restrictive assumption than assuming it is uncorrelated with the country's own lagged variables or its differences (as in the GMM estimation). Hahn, Ham, and Moon's (2011) test suggests that in GMM-LEV estimation incorporating a country's lagged variables and neighbors' variables as instruments, the instrument set of neighbors' variables is valid.

sophistication of Mexico's neighbors i.e. Belize, Cuba, Guatemala, Honduras, and the U.S. In both specifications, tests for weak instruments suggest that the instruments are strong. The conditional likelihood ratio (CLR) confidence set of Moreira (2003), which is robust to the weak-instrumentation of one endogenous variable (column 1), indicates that the coefficient on export sophistication is in the range of 0.06 to 0.09. We find that the coefficient estimates stay within this range as we add more variables to the regression (columns 3-5) and increase to about 0.1-0.15 in other specifications (columns 6-9).

Table 2. Growth and Export Sophistication: IV Estimation (5-Year Panel)

Dependent var.: 5-year ave. annual growth rate	(1) IV	(2) IV	(3) IV	(4) IV	(5) IV	(6) IV	(7) IV	(8) IV	(9) IV-FE
Log export sophistication	0.072***	0.063***	0.065***	0.074***	0.077***	0.105***		0.148***	0.154**
	(0.009)	(0.009)	(0.013)	(0.013)	(0.012)	(0.028)		(0.055)	(0.070)
Log real GDP per capita	-0.024***	-0.020***	-0.024***	-0.024***	-0.023***	-0.021***	-0.007*	-0.026***	-0.116***
	(0.003)	(0.003)	(0.004)	(0.005)	(0.003)	(0.006)	(0.004)	(0.008)	(0.043)
Years of schooling			0.001				0.004**	-0.003	0.057
			(0.001)				(0.002)	(0.004)	(0.046)
Trade (% of GDP)				-0.017			-0.006	-0.047	
				(0.013)			(0.011)	(0.032)	
Credit to private sector (% of GDP)					-0.023*		-0.001	-0.003	
					(0.013)		(0.013)	(0.023)	
Law and order						-0.016**	0.001	-0.013*	
						(0.006)	(0.003)	(0.007)	
Observations	1,590	1,590	1,216	1,369	1,319	748	606	598	983
\# of endogenous variables	1	2	3	3	3	3	5	6	3
\# of instruments	13	13	13	14	14	9	11	12	14
\# of excluded instruments	1	2	3	3	3	3	5	6	6
Cragg-Donald F stat	347.0	136.2	40.7	12.9	37.9	9.6	4.4	0.8	1.4
Kleibergen-Paap F stat	267.5	104.8	38.4	10.8	24.8	7.7	2.5	1.0	1.3
Kleibergen-Paap LM test p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11
H_0: t-test size>10% (p-value) | KP	0.00	0.00	0.00	0.17	0.00	0.47	1.00	1.00	1.00
H_0: t-test size>25% (p-value) | KP	0.00	0.00	0.00	0.00	0.00	0.01	0.79	1.00	0.99
H_0: t-test size>10% (p-value) | CD	0.00	0.00	0.00	0.07	0.00	0.26	1.00	1.00	1.00
H_0: t-test size>25% (p-value) | CD	0.00	0.00	0.00	0.00	0.00	0.00	0.33	1.00	0.99
H_0: t-test rel-bias>10% (p-value) | KP	0.00	0.00	0.00	0.00	0.00	0.04	0.95	1.00	1.00
H_0: t-test rel-bias>30% (p-value) | KP	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.94	0.88
H_0: t-test rel-bias>10% (p-value) | CD	0.00	0.00	0.00	0.00	0.00	0.01	0.68	1.00	1.00
H_0: t-test rel-bias>30% (p-value) | CD	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.97	0.85
Hansen J-test p-value									0.17
Lower CLR bound	0.06								
Upper CLR bound	0.09								
H0: Beta_EXPY=0 | CLR p-value	0.00								

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Controlling for other determinants of growth (one at a time) such as human capital, law and order, trade, and financial development do not much affect the coefficient or significance of export sophistication or initial income (columns 3-6). All variables are considered endogenous and are instrumented using the average values of those variables in neighboring countries. Years of schooling and trade are not statistically significant (columns 3-4). The effects of credit and law and order are negative (columns 4-6), albeit at lower significance levels than those for export sophistication or initial income. The negative IV coefficient on credit is also obtained in OLS and FE regressions. The negative coefficient on law and order is more surprising, especially since the coefficient in OLS and FE regressions, is positive. One potential explanation is that it could also exhibit some nonlinearities similar to the private credit variable. In addition, this regression exhibits a potential weak instrument problem. Kleibergen-Paap (KP) Wald statistic is much smaller, and the null hypothesis that the actual size of the t-test of the coefficients equal zero at the 5 percent level is greater than 10 percent cannot be rejected (but is rejected if the size is greater than 25 percent). The tests for weak instruments in other estimations suggest that the instruments are not weak.

In the IV regression with all the determinants of growth while excluding export sophistication (column 7), only years of schooling and initial income remain significant although the coefficient on initial income drops sharply. With export sophistication (column 8), years of schooling becomes insignificant; law and order has a negative coefficient at 10 percent significance level; and export sophistication and initial income are strongly significant with a larger coefficient of 0.15 on export sophistication. In these two regressions, we no longer obtain favorable statistics for strong instruments.[8] It is likely that including several endogenous explanatory variables in the growth regression results in the weak instrument problem as endogenous variables and instruments are probably all correlated with each other resulting in weak identification. Nonetheless, the coefficient on export sophistication is statistically significant at 1 percent level in this specification as well. Since the effect of years of schooling in the regression without export sophistication is statistically significant and has a meaningful sign, we specify our baseline regression with initial income, years of schooling and export sophistication. Lastly, we add fixed effects to this specification and confirm our previous finding that export sophistication remains statistically significant and robust with a positive and relatively large effect on growth. However, the fixed effects IV regression, in which the equation is differenced and the dependent variable is the change in the growth rate, has the weak instrument problem as well. This suggests that it is harder to predict endogenous variables that are growth rates rather than levels using neighbors' variables as instruments.

V. ROBUSTNESS

We experiment with alternative proxies of export sophistication—manufacturing exports as a share of goods' exports and real manufacturing exports per capita (in logs). Using our baseline regression, we find that both the share of manufacturing exports and real manufacturing exports per capita have all significant and positive coefficients (Table 3, columns 2 and 4). Including both EXPY and another measure of manufacturing exports results in quasi-multicollinearity and insignificant coefficients (columns 3 and 5). The weak instrument tests show that the regressions with both measures are plagued with the weak instrument problem.

Adding a control for manufacturing production, we find that export sophistication seems to be more important than manufacturing production in affecting growth. Manufacturing value added as a share of GDP is statistically significant in the regression with EXPY (columns 6-7) but real manufacturing value added per capita (in logs) is not statistically significant (columns 8-9). However, with other proxies for export sophistication, manufacturing value added as a share of GDP is no longer statistically significant while the coefficient of log real manufacturing value added per capita is negative, which seems to pick up the effect of the initial income variable

---

[8] Since the reported test statistics are based on 2-3 endogenous variables from Stock and Yogo (2005), and we have a total of 6 endogenous variables, the thresholds used are relatively conservative.

(columns 10-11). Export sophistication proxies have positive and statistically significant estimates in all regressions. This suggests that export orientation is important in the growth process and that producing manufacturing, and potentially sophisticated, goods without exporting them may not be sufficient to increase long-run growth.

Table 3. Other Measures of Export Sophistication: IV Estimation (5-Year Panel)

Dependent var.: 5-year ave. annual growth rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Log export sophistication	0.065***		0.053		0.209		0.063***		0.083***		
	(0.013)		(0.051)		(0.830)		(0.021)		(0.020)		
Log real GDP per capita	-0.024***	-0.012***	-0.026*	-0.027***	-0.025***	-0.003	-0.023***	-0.002	-0.029**	-0.013***	-0.005
	(0.004)	(0.003)	(0.014)	(0.005)	(0.009)	(0.004)	(0.008)	(0.009)	(0.013)	(0.003)	(0.009)
Years of schooling	0.001	0.004***	0.003**	0.001	0.008	-0.003	-0.003	0.003	0.002	0.003*	0.004*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.028)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
Manufactures exports (% of merchandise exports)		0.000***	-0.000							0.000***	
		(0.000)	(0.000)							(0.000)	
Log real manufacturing exports per capita				0.012***	-0.034						0.012***
				(0.003)	(0.180)						(0.004)
Manufacturing value added (% of GDP)						0.004***	0.003**			0.001	
						(0.002)	(0.001)			(0.001)	
Log real manufacturing value added per capita								-0.004	-0.003		-0.022**
								(0.008)	(0.009)		(0.011)
Observations	1,216	947	947	946	946	828	799	799	770	671	651
\# of endogenous variables	3	3	4	3	4	3	4	3	4	4	4
\# of instruments	13	13	14	13	14	13	14	13	14	14	14
\# of excluded instruments	3	3	4	3	4	3	4	3	4	4	4
Cragg-Donald F stat	40.7	109.7	2.6	13.0	0.0	6.0	5.1	13.1	6.6	5.9	5.5
Kleibergen-Paap F stat	38.4	100.0	1.7	11.6	0.0	4.9	4.0	15.1	5.7	4.0	5.9
Kleibergen-Paap LM test p-value	0.000	0.000	0.013	0.000	0.800	0.000	0.000	0.000	0.000	0.000	0.000
H_0: t-test size>10% (p-value) | KP	0.000	0.000	1.000	0.117	1.000	0.822	0.996	0.021	0.968	0.996	0.961
H_0: t-test size>25% (p-value) | KP	0.000	0.000	0.822	0.000	1.000	0.077	0.286	0.000	0.080	0.289	0.067
H_0: t-test size>10% (p-value) | CD	0.000	0.000	1.000	0.062	1.000	0.689	0.982	0.060	0.931	0.962	0.974
H_0: t-test size>25% (p-value) | CD	0.000	0.000	0.607	0.000	1.000	0.031	0.125	0.000	0.038	0.069	0.093
H_0: t-test rel-bias>10% (p-value) | KP	0.000	0.000	0.960	0.002	1.000	0.247	0.608	0.000	0.288	0.611	0.256
H_0: t-test rel-bias>30% (p-value) | KP	0.000	0.000	0.634	0.000	1.000	0.054	0.122	0.000	0.022	0.123	0.017
H_0: t-test rel-bias>10% (p-value) | CD	0.000	0.000	0.865	0.001	1.000	0.132	0.381	0.001	0.176	0.262	0.317
H_0: t-test rel-bias>30% (p-value) | CD	0.000	0.000	0.374	0.000	1.000	0.021	0.040	0.000	0.008	0.018	0.027

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We control for the average logarithm of real GDP (or real GDP per capita) in the neighboring countries to capture directly spillover effects. Doing so should also mitigate a potential violation of the exclusion restriction of our instruments based on the neighbors' variables. As an instrument for neighbors' GDP or GDP per capita, we use the average GDP or GDP per capita in the neighbors' neighbors and use neighbors' lagged real GDP per capita to instrument for the initial income.[9] The spillover effect as measured by neighbors' real GDP per capita is statistically significant at the 10 percent level (Table 4, column 1). Excluding schooling, it becomes statistically insignificant (column 2). The coefficient on EXPY is statistically significant and similar to other estimates. In the baseline regression (Table 4, column 2), the coefficient of the spillover effect as measure by average real GDP of neighbors is positive and strongly significant while EXPY is no longer significant (column 3). However, when we exclude schooling, which is not significant in most of our regressions (see Tables 2-10), including column 3 regression when EXPY is not included, we obtain a positive and statistically significant coefficient on EXPY (column 4).

[9] We exclude the duplicate countries and the country in question for which the instrument is calculated when computing the average logarithm of real GDP or real GDP per capita of neighbors' neighbors.

The coefficient for the spillover effect as measured by real GDP per capita of neighbors is statistically insignificant using median or weighted averages of neighbors for the instruments (columns 5-6 and 9-10). However, the estimates when using real GDP of neighbors as the spillover effect are similar irrespective of the weighting schemes for the instruments used (columns 7-8 and 11-12). The tests show that instruments are not weak when using real GDP as a measure of the spillover effect. Overall, we find that the spillover effect, even if present, does not invalidate our initial finding that export sophistication is a key growth determinant.[10]

Table 4. The Spillover Effect: IV Estimation (5-Year Panel)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent var.: 5-year ave. annual growth rate		Instruments: Average				Instruments: Median				Instruments: Weighted Average		
Log export sophistication	0.084***	0.065***	0.002	0.043**	0.109***	0.066**	0.010	0.057**	0.045***	0.066***	-0.001	0.033*
	(0.019)	(0.015)	(0.016)	(0.020)	(0.032)	(0.027)	(0.016)	(0.024)	(0.012)	(0.015)	(0.016)	(0.019)
Log real GDP per capita	-0.057***	-0.005	-0.016***	-0.018***	-0.080*	0.007	-0.018***	-0.023***	-0.023	-0.029*	-0.019***	-0.017***
	(0.018)	(0.029)	(0.004)	(0.004)	(0.041)	(0.047)	(0.004)	(0.006)	(0.015)	(0.015)	(0.004)	(0.004)
Years of schooling	0.001		0.002*		0.001		0.001		0.003**		0.005***	
	(0.001)		(0.001)		(0.002)		(0.001)		(0.001)		(0.001)	
Log real GDP per capita of neighbors	0.025*	-0.015			0.038	-0.027			0.001	0.005		
	(0.014)	(0.025)			(0.030)	(0.036)			(0.010)	(0.009)		
Log real GDP of neighbors			0.012***	0.005			0.013***	0.005			0.011***	0.007**
			(0.002)	(0.003)			(0.002)	(0.003)			(0.002)	(0.003)
Observations	1,216	1,489	1,216	1,489	1,216	1,489	1,216	1,489	1,216	1,489	1,216	1,489
\# of endogenous variables	4	3	4	3	4	3	4	3	4	3	4	3
\# of instruments	14	13	14	13	14	13	14	13	14	13	14	13
\# of excluded instruments	4	3	4	3	4	3	4	3	4	3	4	3
Cragg-Donald F stat	4.1	3.2	18.7	17.8	1.0	1.1	18.8	15.6	2.8	7.8	20.3	22.6
Kleibergen-Paap F stat	3.8	2.4	16.7	15.3	0.9	0.8	17.1	12.9	2.6	7.0	17.2	18.9
Kleibergen-Paap LM test p-value	0.00	0.01	0.00	0.00	0.06	0.11	0.00	0.00	0.00	0.00	0.00	0.00
H_0: t-test size>10% (p-value) | KP	1.00	0.98	0.05	0.02	1.00	1.00	0.04	0.06	1.00	0.56	0.04	0.00
H_0: t-test size>25% (p-value) | KP	0.32	0.42	0.00	0.00	0.96	0.85	0.00	0.00	0.59	0.01	0.00	0.00
H_0: t-test size>10% (p-value) | CD	1.00	0.96	0.02	0.00	1.00	1.00	0.02	0.02	1.00	0.46	0.01	0.00
H_0: t-test size>25% (p-value) | CD	0.27	0.27	0.00	0.00	0.94	0.78	0.00	0.00	0.55	0.01	0.00	0.00
H_0: t-test rel-bias>10% (p-value) | KP	0.64	0.70	0.00	0.00	0.99	0.96	0.00	0.00	0.85	0.07	0.00	0.00
H_0: t-test rel-bias>30% (p-value) | KP	0.14	0.36	0.00	0.00	0.88	0.81	0.00	0.00	0.36	0.01	0.00	0.00
H_0: t-test rel-bias>10% (p-value) | CD	0.59	0.54	0.00	0.00	0.99	0.93	0.00	0.00	0.83	0.04	0.00	0.00
H_0: t-test rel-bias>30% (p-value) | CD	0.11	0.21	0.00	0.00	0.84	0.73	0.00	0.00	0.32	0.00	0.00	0.00

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Further, we explore other potential explanatory variables in the baseline regression and examine the robustness of our results (Table 5). We add such variables as investment to GDP ratio, the national saving rate, FDI, government consumption, the Gini coefficient, and corruption (columns 3-9). The coefficient on export sophistication varies in the range of 0.05-0.08 and is statistically significant in line with the previous results. However, some of these regressions suffer from the weak instrument problem. We also include a measure of export sophistication from the IMF's Ding and Hadzi-Vaskov (2017) that results in a robust and positive estimate which is even larger than in previous regressions (column 2).[11] Another measure of EXPY we use—structural EXPY, or S-EXPY which corrects for the share of commodities in exports—also produces a strong and positive coefficient although it is two to three times smaller in magnitude (column 1).

[10] The results with other proxies for export sophistication are broadly the same. We also control for the growth rates of neighbors in the previous 5-year period, but obtain statistically insignificant results and weak instruments. Regression results are not included in Table 4 and are available upon request.

[11] The same study also computes a standardized EXPY but it is highly correlated with the original EXPY and produces similar results (with a coefficient closer to our estimates).

Table 5. Robustness: IV Estimation (5-Year Panel)

Dependent var.: 5-year ave. annual growth rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log export sophistication			0.061**	0.067***	0.078***	0.053***	0.098***	0.079***	0.055***
			(0.024)	(0.018)	(0.020)	(0.012)	(0.022)	(0.020)	(0.017)
Log real GDP per capita	-0.010***	-0.024***	-0.026***	-0.027***	-0.027***	-0.021***	-0.042***	-0.020***	-0.029***
	(0.002)	(0.006)	(0.005)	(0.004)	(0.006)	(0.005)	(0.008)	(0.005)	(0.008)
Years of schooling	0.000	0.008***	0.002	0.001	0.002	0.002	0.004**	0.001	0.001
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Log structural export sophistication, S-EXPY	0.022***								
	(0.004)								
Log export sophistication (Ding and Hadzi-Vaskov)		0.443***							
		(0.147)							
Gross fixed capital formation (% of GDP)			0.000						
			(0.001)						
National saving rate (% of GDP)				0.000					
				(0.000)					
Foreign direct investment (% of GDP)					-0.487*				
					(0.291)				
Government consumption (% of GDP)						-0.001			
						(0.001)			
Gini coefficient (net)							0.001**		
							(0.000)		
Corruption								-0.010***	
								(0.003)	
Ethnic fractionalization									0.000*
									(0.000)
Latitude									0.000
									(0.000)
Sub-Saharan Africa dummy									-0.036***
									(0.007)
Observations	1,216	1,200	1,004	1,047	936	1,052	716	675	980
\# of endogenous variables	3	3	4	4	4	4	4	4	5
\# of instruments	13	13	14	14	13	14	14	10	16
\# of excluded instruments	3	3	4	4	4	4	4	4	5
Cragg-Donald F stat	88.0	23.2	3.2	11.0	0.2	22.8	11.3	16.5	15.2
Kleibergen-Paap F stat	88.4	17.2	2.6	5.1	0.8	19.4	6.9	16.5	13.5
Kleibergen-Paap LM test p-value	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
H_0: t-test size>10% (p-value) | KP	0.00	0.01	1.00	0.98	1.00	0.01	0.92	0.06	0.51
H_0: t-test size>25% (p-value) | KP	0.00	0.00	0.61	0.13	0.97	0.00	0.03	0.00	0.00
H_0: t-test size>10% (p-value) | CD	0.00	0.00	1.00	0.49	1.00	0.00	0.45	0.06	0.31
H_0: t-test size>25% (p-value) | CD	0.00	0.00	0.45	0.00	1.00	0.00	0.00	0.00	0.00
H_0: t-test rel-bias>10% (p-value) | KP	0.00	0.00	0.87	0.39	1.00	0.00	0.15	0.00	0.00
H_0: t-test rel-bias>30% (p-value) | KP	0.00	0.00	0.38	0.04	0.91	0.00	0.01	0.00	0.00
H_0: t-test rel-bias>10% (p-value) | CD	0.00	0.00	0.76	0.01	1.00	0.00	0.01	0.00	0.00
H_0: t-test rel-bias>30% (p-value) | CD	0.00	0.00	0.24	0.00	0.99	0.00	0.00	0.00	0.00

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We also use the GMM methodology using our sharp instrument as an additional instrument in the regression. By doing so, we are revisiting the main specification of Hausmann, Hwang, and Rodrik (2007). We present our results in Table 6 (constant and time dummies are not shown). The standard GMM instruments are two lags of the explanatory variables (levels in the difference equation, DIF) and one lagged difference of the variables in the level equation (LEV). We add the neighbor's averages of the same explanatory variables assumed exogenous (that is, IV instruments) in the GMM setting (implying the difference of the variables in the difference equation and the levels of variables in the level equation). We also experiment with using sharp instruments as GMM instruments and excluding standard GMM instruments from the first stage. Export sophistication has a highly significant and positive coefficient in all specifications. Moreover, the magnitude of the coefficient remains relatively stable around 0.05-0.1 and is similar to that found in IV regressions.

Table 6. GMM-System Estimation (5-Year Panel)

	(1)	(2)	(3)	(4)	(5)
Dependent var.: 5-year ave. annual growth rate	Own variable 2-4 period lags, GMM instr	Neighbor averages, IV instr	Neighbor averages and 1-period lags, IV instr	Neighbor averages and 1-2 period lags, GMM instr	Neighbor averages and 2-4 period lags, GMM instr
Log export sophistication	0.052***	0.059***	0.084***	0.111***	0.098**
	(0.018)	(0.022)	(0.026)	(0.033)	(0.042)
Log real GDP per capita	-0.027**	-0.022***	-0.029***	-0.030***	-0.017**
	(0.011)	(0.006)	(0.007)	(0.011)	(0.008)
Years of schooling	0.008***	0.001	0.000	-0.003	-0.005
	(0.003)	(0.002)	(0.002)	(0.004)	(0.005)
\# of observations	1226	1216	1119	1226	1226
\# of countries	137	136	136	137	137
\# of instruments	22	13	15	19	22
\# of overidentifying restrictions	9	0	1	6	9
Hansen J-test p-value	0.146	.	0.005	0.025	0.012

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Comparing the GMM estimation of the difference equation and the level equation, we find favorable test statistics using the level equation specification. The GMM-LEV estimator that uses smaller or "collapsed" number of instruments (Table 7, column 7) than the usual GMM estimator (Table 7, column 6) does not suffer from the weak instrument problem and produces a positive and statistically significant coefficient on EXPY, similar to the IV estimates. Using own explanatory variables and sharp instruments as GMM instruments results in the weak instrument problem (columns 8-9). However, it seems strong identification comes from using sharp instruments as IV instruments (column 10). The J-test (column 7) suggests that overidentifying restrictions are not valid, but using Hahn, Ham, and Moon (2011) test for instrument validity, we find that the instruments based on the neighbors' averages are valid (p-value of about 0.7). In the difference equation specification (columns 1-5), the tests for weak instruments suggest that the instruments are weak. The coefficient on the initial log real GDP per capita is statistically significant and has the usual negative sign. However, the coefficient on schooling becomes negative and is statistically significant in a few estimations (columns 1-3). The identification seems to come from sharp instruments used as IV instruments (column 5) in which the coefficient on EXPY is statistically significant at 10 percent. However, the weak instrument problem is present in this specification as well. These results indicate that it is the cross-country variation stemming from the level equation estimation rather than the time series variation in the difference equation estimation that produces parameter identification and favorable test statistics.[12]

[12] If we assume fixed effects are correlated with the neighbors' variables, then to get rid of fixed effects, the equation needs to be differenced (similar to GMM's difference equation estimation). However, the time series variation does not produce robust estimates of the parameters and the differenced variables result in the weak instrument problem. Table 2, column 9, and Table 4, column 12, show estimations considering fixed effects. The coefficient on export sophistication is similar to that in other estimations.

Table 7. Dissecting GMM (5-Year Panel)

Dependent var.: 5-year ave. annual growth rate	(1) DIF Own vars, GMM instr + Neighbor averages, IV instr	(2) DIF-Collapse Own vars, GMM instr + Neighbor averages, IV instr	(3) DIF-Collapse Own vars, GMM instr	(4) DIF-Collapse Neighbor averages 1-2 period lags, GMM instr	(5) DIF-Collapse Neighbor averages 1-2 period lags, IV instr	(6) LEV Own vars, GMM instr + Neighbor averages, IV instr	(7) LEV-Collapse Own vars, GMM instr + Neighbor averages, IV instr	(8) LEV-Collapse Own vars, GMM instr	(9) LEV-Collapse Neighbor averages, GMM instr	(10) LEV-Collapse Neighbor averages, IV instr
Log export sophistication						0.036***	0.038***	0.068	0.228***	0.065***
						(0.011)	(0.011)	(0.068)	(0.077)	(0.013)
Log real GDP per capita						-0.018***	-0.018***	-0.126	-0.052***	-0.024***
						(0.004)	(0.004)	(0.121)	(0.018)	(0.004)
Years of schooling						0.003***	0.003***	0.044	-0.018	0.001
						(0.001)	(0.001)	(0.039)	(0.014)	(0.001)
Differenced log export sophistication	0.021	0.057*	0.039	-0.067	0.173*					
	(0.019)	(0.030)	(0.057)	(0.103)	(0.093)					
Differenced log real GDP per capita	-0.142***	-0.110***	-0.193***	-0.060*	-0.126**					
	(0.025)	(0.033)	(0.048)	(0.034)	(0.052)					
Differenced years of schooling	-0.037***	-0.056**	-0.111***	-0.055	0.060					
	(0.013)	(0.029)	(0.034)	(0.043)	(0.060)					
Observations	1,080	1,080	1,089	944	944	1,216	1,216	1,226	1,080	1,216
\# of endogenous variables	3	3	3	3	3	3	3	3	3	3
\# of instruments	75	21	18	14	14	37	16	13	12	13
\# of excluded instruments	66	12	9	6	6	27	6	3	3	3
Cragg-Donald F stat	1.9	1.8	1.5	1.2	0.9	9.7	39.0	0.5	2.3	40.7
Kleibergen-Paap F stat	2.5	1.7	1.6	1.5	0.9	10.4	36.8	0.3	2.5	38.4
Kleibergen-Paap LM test p-value	0.01	0.03	0.06	0.09	0.23	0.00	0.00	0.32	0.01	0.00
C-stat (p-value)	0.00	0.03	.	.	.	0.00	0.00	.	.	.
Hansen J-test p-value	0.00	0.03	0.47	0.31	0.52	0.00	0.00	.	.	.
H_0: t-test size>10% (p-value) | KP	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.98	0.00
H_0: t-test size>25% (p-value) | KP	1.00	1.00	1.00	0.99	1.00	1.00	0.00	0.97	0.40	0.00
H_0: t-test size>10% (p-value) | CD	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.99	0.00
H_0: t-test size>25% (p-value) | CD	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.94	0.46	0.00
H_0: t-test rel-bias>10% (p-value) | KP	1.00	1.00	1.00	1.00	1.00	0.10	0.00	0.99	0.68	0.00
H_0: t-test rel-bias>30% (p-value) | KP	0.97	0.93	0.89	0.82	0.96	0.00	0.00	0.95	0.33	0.00
H_0: t-test rel-bias>10% (p-value) | CD	1.00	1.00	1.00	1.00	1.00	0.25	0.00	0.99	0.73	0.00
H_0: t-test rel-bias>30% (p-value) | CD	1.00	0.91	0.93	0.91	0.95	0.00	0.00	0.92	0.39	0.00

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Using the instrument set of the previous section, in which the neighbors' averages are used, and the 10-year panel regressions, we find that export sophistication is statistically significant in most estimations (Table 8). The coefficients are similar in magnitude and the tests for weak instruments suggest that in several estimations, the instruments are as strong as in the 5-year panel case.

As an additional test of the instruments' validity, we perform the same estimations—IV using 5-year panels—with the instrument set that uses the median of and the weighted mean (with weights equal to the inverse of real GDP) of the neighbors' variables. The results are broadly unchanged compared to the instrument set based on simple averages (Tables 9-10). This shows that our results, tests and coefficients, are mostly robust to changing the aggregation method for the instrument calculation. Using the weights of the inverse of real GDP for our instruments allows us to further reduce the effect of the size of the country's neighbors on the country of interest. Even though the weak instrument tests are not favorable in a few estimations, the overall conclusion remains the same (Table 10). Export sophistication is still a key determinant in growth regressions.

Table 8. IV Estimation (10-Year Panel)

Dependent var.: 10-year ave. annual growth rate	(1) IV	(2) IV	(3) IV	(4) IV	(5) IV	(6) IV	(7) IV	(8) IV	(9) IV-FE
Log export sophistication	0.085***	0.074***	0.061***	0.091***	0.081***	0.142**		0.225	0.020
	(0.013)	(0.013)	(0.016)	(0.024)	(0.020)	(0.062)		(0.180)	(0.052)
Log real GDP per capita	-0.030***	-0.026***	-0.027***	-0.030***	-0.024***	-0.032***	-0.007	-0.035	-0.062**
	(0.005)	(0.005)	(0.005)	(0.009)	(0.005)	(0.012)	(0.005)	(0.022)	(0.026)
Years of schooling			0.002				0.003	-0.009	-0.000
			(0.001)				(0.002)	(0.014)	(0.034)
Trade (% of GDP)				-0.042**			-0.015	-0.096	
				(0.021)			(0.019)	(0.112)	
Credit to private sector (% of GDP)					-0.033		0.017	0.014	
					(0.025)		(0.018)	(0.044)	
Law and order						-0.021	-0.002	-0.026	
						(0.013)	(0.004)	(0.021)	
Observations	724	724	596	627	618	365	306	301	363
\# of endogenous variables	1	2	3	3	3	3	5	6	3
\# of instruments	7	7	8	8	8	6	8	9	9
\# of excluded instruments	1	2	3	3	3	3	5	6	6
Cragg-Donald F stat	147.6	53.3	20.8	6.3	19.3	2.5	1.5	0.2	0.4
Kleibergen-Paap F stat	103.7	38.9	17.9	4.8	11.3	2.2	0.9	0.2	0.4
Kleibergen-Paap LM test p-value	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.28	0.66
H_0: t-test size>10% (p-value) | KP	0.00	0.00	0.00	0.83	0.13	0.99	1.00	1.00	1.00
H_0: t-test size>25% (p-value) | KP	0.00	0.00	0.00	0.08	0.00	0.48	0.99	1.00	1.00
H_0: t-test size>10% (p-value) | CD	0.00	0.00	0.00	0.66	0.00	0.98	1.00	1.00	1.00
H_0: t-test size>25% (p-value) | CD	0.00	0.00	0.00	0.03	0.00	0.40	0.95	1.00	1.00
H_0: t-test rel-bias>10% (p-value) | KP	0.00	0.00	0.00	0.26	0.00	0.75	1.00	1.00	1.00
H_0: t-test rel-bias>30% (p-value) | KP	0.00	0.00	0.00	0.06	0.00	0.41	0.93	1.00	1.00
H_0: t-test rel-bias>10% (p-value) | CD	0.00	0.00	0.00	0.11	0.00	0.68	0.99	1.00	1.00
H_0: t-test rel-bias>30% (p-value) | CD	0.00	0.00	0.00	0.02	0.00	0.33	0.76	1.00	1.00
Hansen J-test p-value	.	.	.	.	.	.	.	.	0.11
Lower CLR bound	0.06								
Upper CLR bound	0.12								
H0: Beta_EXPY=0 | CLR p-value	0.00								

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9. IV Estimation, Instrument Set: Median (5-Year Panel)

Dependent var.: 5-year ave. annual growth rate	(1) IV	(2) IV	(3) IV	(4) IV	(5) IV	(6) IV	(7) IV	(8) IV	(9) IV-FE
Log export sophistication	0.076***	0.078***	0.076***	0.082***	0.082***	0.122***		0.116***	0.108
	(0.010)	(0.011)	(0.013)	(0.014)	(0.013)	(0.032)		(0.030)	(0.067)
Log real GDP per capita	-0.025***	-0.026***	-0.028***	-0.029***	-0.025***	-0.025***	-0.005	-0.025***	-0.109**
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.007)	(0.005)	(0.006)	(0.043)
Years of schooling			0.001				0.003	-0.001	-0.007
			(0.001)				(0.002)	(0.003)	(0.037)
Trade (% of GDP)				-0.003			-0.016	-0.022	
				(0.011)			(0.012)	(0.016)	
Credit to private sector (% of GDP)					-0.021*		0.004	-0.006	
					(0.013)		(0.014)	(0.016)	
Law and order						-0.018**	0.001	-0.009*	
						(0.007)	(0.003)	(0.005)	
Observations	1,590	1,590	1,216	1,369	1,319	748	606	598	983
\# of endogenous variables	1	2	3	3	3	3	5	6	3
\# of instruments	13	13	13	14	14	9	11	12	14
\# of excluded instruments	1	2	3	3	3	3	5	6	6
Cragg-Donald F stat	313.1	100.7	43.3	17.7	40.1	8.3	4.4	2.3	1.4
Kleibergen-Paap F stat	232.7	71.0	39.3	14.5	23.9	6.9	2.4	2.3	1.3
Kleibergen-Paap LM test p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
H_0: t-test size>10% (p-value) | KP	0.00	0.00	0.00	0.03	0.00	0.57	1.00	1.00	1.00
H_0: t-test size>25% (p-value) | KP	0.00	0.00	0.00	0.00	0.00	0.01	0.82	0.92	0.99
H_0: t-test size>10% (p-value) | CD	0.00	0.00	0.00	0.00	0.00	0.39	1.00	1.00	1.00
H_0: t-test size>25% (p-value) | CD	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.93	0.99
H_0: t-test rel-bias>10% (p-value) | KP	0.00	0.00	0.00	0.00	0.00	0.08	0.96	0.99	1.00
H_0: t-test rel-bias>30% (p-value) | KP	0.00	0.00	0.00	0.00	0.00	0.01	0.48	0.53	0.87
H_0: t-test rel-bias>10% (p-value) | CD	0.00	0.00	0.00	0.00	0.00	0.03	0.69	0.99	1.00
H_0: t-test rel-bias>30% (p-value) | CD	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.55	0.85
Hansen J-test p-value	.	.	.	.	.	.	.	.	0.10
Lower CLR bound	0.06								
Upper CLR bound	0.09								
H0: Beta_EXPY=0 | CLR p-value	0.00								

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10. IV Estimation, Instrument Set: Weighted Mean (5-Year Panel)

Dependent var.: 5-year ave. annual growth rate	(1) IV	(2) IV	(3) IV	(4) IV	(5) IV	(6) IV	(7) IV	(8) IV	(9) IV-FE
Log export sophistication	0.062***	0.055***	0.031**	0.060***	0.072***	0.077**		0.269	0.157**
	(0.010)	(0.011)	(0.013)	(0.020)	(0.016)	(0.036)		(0.444)	(0.072)
Log real GDP per capita	-0.021***	-0.018***	-0.015***	-0.015**	-0.020***	-0.013**	0.004	-0.009	-0.135**
	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)	(0.006)	(0.011)	(0.026)	(0.059)
Years of schooling			0.003**				0.000	-0.024	0.082
			(0.001)				(0.004)	(0.052)	(0.085)
Trade (% of GDP)				-0.059			-0.047	-0.215	
				(0.046)			(0.050)	(0.443)	
Credit to private sector (% of GDP)					-0.027**		-0.008	0.111	
					(0.014)		(0.025)	(0.246)	
Law and order						-0.013*	0.004	-0.033	
						(0.008)	(0.006)	(0.061)	
Observations	1,590	1,590	1,216	1,369	1,319	748	606	598	983
\# of endogenous variables	1	2	3	3	3	3	5	6	3
\# of instruments	13	13	13	14	14	9	11	12	14
\# of excluded instruments	1	2	3	3	3	3	5	6	6
Cragg-Donald F stat	260.4	95.7	38.0	1.6	29.6	4.4	0.6	0.0	1.0
Kleibergen-Paap F stat	192.8	72.8	33.9	1.5	20.5	3.3	0.4	0.0	1.1
Kleibergen-Paap LM test p-value	0.00	0.00	0.00	0.03	0.00	0.00	0.18	0.60	0.13
H_0: t-test size>10% (p-value) | KP	0.00	0.00	0.00	1.00	0.00	0.95	1.00	1.00	1.00
H_0: t-test size>25% (p-value) | KP	0.00	0.00	0.00	0.67	0.00	0.25	1.00	1.00	1.00
H_0: t-test size>10% (p-value) | CD	0.00	0.00	0.00	1.00	0.00	0.87	1.00	1.00	1.00
H_0: t-test size>25% (p-value) | CD	0.00	0.00	0.00	0.62	0.00	0.12	1.00	1.00	1.00
H_0: t-test rel-bias>10% (p-value) | KP	0.00	0.00	0.00	0.88	0.00	0.52	1.00	1.00	1.00
H_0: t-test rel-bias>30% (p-value) | KP	0.00	0.00	0.00	0.61	0.00	0.20	0.99	1.00	0.92
H_0: t-test rel-bias>10% (p-value) | CD	0.00	0.00	0.00	0.85	0.00	0.32	1.00	1.00	1.00
H_0: t-test rel-bias>30% (p-value) | CD	0.00	0.00	0.00	0.56	0.00	0.08	0.98	1.00	0.94
Hansen J-test p-value	.	.	.	.	.	.	.	.	0.02
Lower CLR bound	0.04								
Upper CLR bound	0.08								
H0: Beta_EXPY=0 | CLR p-value	0.00								

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VI. CONCLUSION

This paper explores the determinants of growth based on an instrumental variable technique that introduces “sharp” instruments and is immune to the “blunt instrument” problem. Each standard factor of growth is instrumented by its average in the neighboring countries. We show that export sophistication—whether proxied by EXPY, the share of manufacturing exports in goods’ exports, or real manufacturing exports per capita—stands out as an important and robust determinant of growth. This is further confirmed by verifying the strength of the “sharp” instruments and opening up the GMM “black box”, as argued by Bazzi and Clemens (2013). Although standard growth determinants are not robust in the regressions, they may be important to the extent they help improve export sophistication.

The technique we propose could be applied to other empirical studies suffering from the blunt instrument problem. It offers a variable-specific, dynamic and plausibly valid instrument for as many variables as needed. The striking result in our study is that overall, the instruments passed the instrument strength tests. Correlations among neighboring countries’ variables suggest that mimetic forces could be at play, where economic agents learn from across the borders in formal and informal ways. It suggests that competition with immediate neighbors is a potent factor in the diffusion of technologies and policies. Perhaps a “pioneer” country, far away from advanced nations, could achieve high sustained growth, and eventually, others in its region may follow suit benefitting from spillovers and from its experience in terms of policies.

Our key empirical finding could have implications for the design of development strategies. If indeed export sophistication is the main engine of growth, the priorities of developing countries should focus on the expansion of the tradable sector and its sophistication rather than relying solely on providing an "enabling environment" in which a sophisticated export sector would spontaneously emerge by itself. Further constrained by the lack of skills and resources, developing countries may need to pursue a purpose-specific set of policies to develop tradable sophisticated sectors.

REFERENCES

Ades, A. and H. Chua, 1993. "Thy Neighbour's Curse: Regional Instability and Economic Growth," Mimeo.

Aghion, Philippe, and Peter Howitt, 1992. "A Model of Growth Through Creative Destruction," *Econometrica* 60: 323–351.

Arcand, J. L., E. Berkes, and U. Panizza, 2015. "Too Much Finance?" *Journal of Economic Growth* 20(2): 105-148.

Bahar, Dany, Ricardo Hausmann, and Cesar Hidalgo, 2014. "Neighbors and the Evolution of the Comparative Advantage of Nations: Evidence of International Knowledge Diffusion?" *Journal of International Economics* 92(1): 111-123.

Barro, Robert and Jong-Wha Lee, 2013. "A New Data Set of Educational Attainment in the World, 1950-2010," *Journal of Development Economics* 104: 184-198.

Bazzi, Samuel and Michael A. Clemens, 2013. "Blunt Instruments: Avoiding Common Pitfalls in Identifying the Causes of Economic Growth," *American Economic Journal: Macroeconomics* 5(2): 152-86.

Berg, Andrew, Jonathan D. Ostry, Charalambos G. Tsangarides, and Yorbol Yakhshilikov, forthcoming. "Redistribution, Inequality, and Growth: New Evidence" *Journal of Economic Growth*.

Chua, H., 1993. "Regional Spillovers and Economic Growth," Center Discussion Paper No. 700, Economic Growth Center, Yale University.

Demetriades, P. and P. Rousseau, 2016. "The Changing Face of Financial Development." *Economics Letters* 141(C): 87-90.

Ding, X. and M. Hadzi-Vaskov, 2017. "Composition of Trade in Latin America and the Caribbean," IMF Working Paper 17/42.

Easterly, William and Levine, Ross, 1998. "Troubles with the Neighbours: Africa's Problem, Africa's Opportunity," *Journal of African Economies* 7(1): 120-142.

Feenstra, R., R. Inklaar and M. P. Timmer, 2015. "The Next Generation of the Penn World Table," *American Economic Review* 105(10): 3150-3182. Available for download at www.ggdc.net/pwt.

Feenstra, R. and J. Romalis, 2014. "International Prices and Endogenous Quality," *The Quarterly Journal of Economics* 129(2): 477-527.

Hahn, Jinyong, John C. Ham, and Hyungsik Roger Moon, 2011. "The Hausman Test and Weak Instruments," *Journal of Econometrics* 160(2): 289–99.

Hausmann, Ricardo, Jason Hwang, and Dani Rodrik, 2007. "What You Export Matters," *Journal of Economic Growth* 12(1): 1-25.

Jarreau, Joachim and Sandra Poncet, 2012. "Export Sophistication and Economic Growth: Evidence from China," *Journal of Development Economics* 97(2): 281-292.

Kleibergen, F., 2002. "Pivotal Statistics for Testing Structural Parameters in Instrumental Variables Regression," *Econometrica* 70(5): 1781-1803.

Kraay, Aart, 2015. "Weak Instruments in Growth Regressions: Implications for Recent Cross-Country Evidence on Inequality and Growth," World Bank Policy Research Working Paper 7494.

Levine, R., C. Lin and W. Xie, 2016. "Spare Tire? Stock Markets, Banking Crises, and Economic Recoveries," *Journal of Financial Economics* 120(1): 81-101.

Lucas, Robert Jr., 1988. "On the mechanics of economic development," *Journal of Monetary Economics* 22(1): 3-42.

Lucas, Robert Jr., 1993. "Making a Miracle," *Econometrica*, 61(2): 251-272.

Moreira, Marcelo J. 2003. "A Conditional Likelihood Ratio Test for Structural Models," *Econometrica* 71(4): 1027–48.

Popov, A., 2014. "Credit Constraints, Equity Market Liberalization, and Growth Rate Asymmetry." *Journal of Development Economics* 107(C): 202-214.

Rajan, R. and A. Subramanian, 2008. "Aid and Growth: What Does the Cross-country Evidence Really Show?" *Review of Economics and Statistics* 90(4): 643-665.

Rebelo, Sergio, 1991. "Long-Run Policy Analysis and Long-Run Growth," *Journal of Political Economy* 99(3): 500-521.

Rodrik, Dani, 2011. "Unconditional Convergence," NBER Working Papers 17546, National Bureau of Economic Research.

Romer, Paul M, 1986. "Increasing Returns and Long-run Growth," *Journal of Political Economy* 94(5): 1002-37.

Solow, Robert (1956). "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics* 70: 65-94.

Spolaore, E. and R. Wacziarg, 2005. “Borders and Growth,” *Journal of Economic Growth* 10(4): 331-386.

Stock, James H., and Motohiro Yogo. 2005. “Testing for Weak Instruments in Linear IV Regression,” in *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, edited by Donald W. K. Andrews and James H. Stock, New York: Cambridge University Press: 80–108.

Sun, Xiaonan and Junjie Hong, 2011. “Exports, Ownership and Firm Productivity: Evidence from China,” *World Economy* 34(7): 1199-1215.

Swan, T. W., 1956. “Economic Growth and Capital Accumulation,” *The Economic Record* 32(2): 334-361.

APPENDIX

Following Hausmann, Hwang, and Rodrik (2007), we use the index $PRODY_l$ to measure the productivity associated with product *l* (a weighted average of real GDP per capita in PPP constant dollars weighted by export shares of product *l* in country j across all countries exporting product *l*), and compute the sophistication index level of the country j's exports using $EXPY_j$ (a weighted average of PRODY weighted by export shares of country j across all products exported):

$$PRODY_l = \sum_j \frac{\left(\frac{x_{jl}}{X_j}\right)}{\sum_j \left(\frac{x_{jl}}{X_j}\right)} Y_j$$

$$EXPY_j = \sum_l \frac{x_{jl}}{X_j} \cdot PRODY_l$$

Our trade data source is from the United Nations Commodity Trade Statistics Database (COMTRADE). We used Feenstra and Romalis's (2014) codes (available on Feenstra's website) to convert the COMTRADE trade data to the World Trade Flow databases based on 4-digit standard international trade classification (SITC rev.2). The per-capita real GDP data are from the Penn World Tables 9.0, covering 182 countries. The sample coverage is from 1962 to 2014.

In addition to the standard EXPY index, we also construct an adjusted index, that is, structural EXPY, or S-EXPY. It excludes all small islands and economies with population less than 2 million.[13] More important, we scale down each country's per-capita real GDP by the share of primary commodities, precious stones and non-monetary gold in the total export basket.[14] We find that without any adjustments, commodity exporters in the sample have unexpectedly high levels of export sophistication. For instance, exports of Nigeria and Venezuela have massive shares of petroleum-related commodities, which have also been the major export components of the Gulf oil producers. Therefore, values of PRODY for these products tend to be high and as a result, drive up the values of EXPY for these countries. Taking these factors into account, we recalculate the PRODY_S and S-EXPY in such a way that countries with lower export shares in non-primary goods are assigned lower weights in the calculation of PRODY:

$$PRODY\_S_l = \sum_j \frac{\left(\frac{x_{jl}}{X_j}\right)}{\sum_j \left(\frac{x_{jl}}{X_j}\right)} Y_j \cdot (1 - Commodity\_Share_j)$$

$$S - EXPY_j = \sum_l \frac{x_{jl}}{X_j} \cdot PRODY\_S_l$$

---

[13] Small islands and economies are identified using the United Nations publication "Standard Country or Area Codes for Statistical Use."
[14] The definition is by category A11 in UNCTAD product groupings and composition (SITC Rev. 3).