Does agricultural growth have a causal effect on manufacturing growth?

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Abstract

Though the role of agricultural growth for manufacturing growth has been at the center of the discourse on economic development, empirically identifying the causal effect of agricultural growth on manufacturing growth has remained illusive for the correlation between the two doesn't necessarily imply causality. This paper attempts to overcome the identification problem. Since agriculture is heavily dependent on the weather, random weather variations are used as instruments to identify the causal impact of agricultural growth on manufacturing growth. Results show that agricultural growth has a significant positive impact on manufacturing growth. The impact is higher the higher is agriculture's share in the economy (as measured by GDP and employment share). For example, in an economy with 50% of agricultural GDP, a 1% increase in agricultural output increases manufacturing output by about 1%.

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1 Introduction

The role of agricultural development for industrialization has been a focal issue among economists for a long period of time, gaining prominence as early as the 1950s with Lewis (1954). The empirical fact that overall economic growth has a significant positive correlation with agricultural growth has also been noted [see e.g. *World Development Report*, 1982; Gardner, 2003]. However, identifying the causal effect of agricultural growth on manufacturing growth has remained largely illusive for the correlation between the two doesn't necessarily imply causality. This paper attempts to overcome the problem of identifying causality by using random weather variabilities as instruments. To the best of my knowledge, this is the first paper to use a fairly reliable instrument to identify the causal effect of agricultural growth on

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manufacturing growth. Country-level panel data on agricultural and manufacturing growth rates, measures of precipitation and temperature, and a host of other control variables are used for the estimation. Results show that agricultural growth has a significant positive impact on manufacturing growth. The impact is higher the higher is agriculture's share in the economy (as measure by GDP and employment share). For example, in an economy with 50 % of agricultural GDP, a 1% increase in agricultural output increases manufacturing output by about 1%.

The next section presents a brief overview of the vast literature on this long-standing issue and historical account of policies regarding agriculture's role over the past half-century. It will then be followed by data description, estimation results and conclusion.

2 Literature on agriculture's role and policies

Early views soon after the second world war have been dominated by pessimism against agriculture [see e.g. Schiff and Valds, 2002; Tiffin and Irz, 2006]. Pessimism about the potential of agricultural exports to "lead" economic development is emphasized by Singer (1950) and Prebischb (1959) due to agriculture's perceived reliance on natural resources as inputs than other commodities, weak linkages with the rest of the economy, and inelastic demand both to income and price. Dependence on agricultural export commodities is also argued to expose economies to severe income shocks due to volatile prices in the international market.

Those pessimist economic rationales were also matched by the ambition of newly independent nations that aspired for becoming modern and advanced economies through rapid industrialization. For them, "agrarian society by its very nature was regarded as socially and economically backward, governed by tradition, impervious to market signals, and devoid of links to other sectors that could bring the benefits of progress in agricultural production to the economy as a whole" [Schiff and Valds, 2002]. Agriculture "is the home of traditional people, ways, and living standards – the antithesis of what nation builders in developing countries envisioned for their societies." [Timmer, 1988]. The largely pessimist economic rationales by post-war development economists and the political ambitions of newly independent nations have led to development policies that neglected agricultural development and focused on state-led industrialization programs. Those policies involved large subsidies to the manufacturing sector and taxes against the agricultural sector. The pro-manufacturing programs involved heavy protection for domestic manufacturing through policies such as high tariffs and limited quotas for imported manufacturing goods, over-valued exchange rates for imported inputs and machineries, and lower taxes for domestic manufacturing products. On the other hand, agriculture faced heavy taxations. Those anti-agricultural policies ranged from under-provision of public goods in rural areas to direct price controls to under-cut agricultural commodity prices [see e.g. Braverman and Kanbur, 1987; Jones and Corbridge, 2010; Majumdar et al., 2004; Bezemer and Headey, 2008].

The pessimist views and the policies that undermined agricultural development and sponsored subsidized industrialization, however, have faced challenges as early as the 1960s. After investigating various anecdotal evidences based on historical experiences of industrialized countries, Johnston and Mellor (1961) argued that "in underdeveloped countries, where agriculture accounts for some 40 to 60 per cent of the total national income, the transition from a level of saving and investment that spells stagnation to one permitting a tolerable rate of economic growth cannot be achieved unless agriculture makes a significant net contribution to capital formation in the expanding sectors." Two sets of factors are pointed out as the potential role of agricultural development for the manufacturing sector – market creation and resource provision .

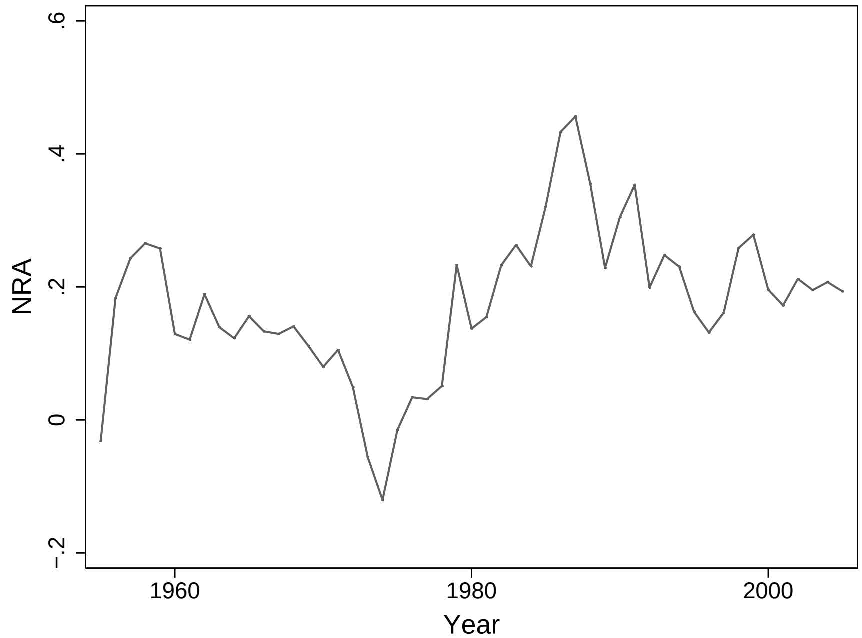
The key role of agricultural development for generating market for the manufacturing sector is noted even by earlier works [see e.g. Rosenstein-Rodan, 1943; Nurkse, 1953; Lewis, 1954; Fleming, 1955]. Johnston and Mellor's work is followed by wave of theoretical and empirical arguments emphasizing agricultural development for overall economic growth and industrialization. Murphy et al. (1989) develop a model of industrialization caused by a large increase in agricultural productivity or by an export boom. Mellor and Johnston (1984) argued in favor of increasing small scale farmers' productivity since the rural demand due to increased farm income fosters "more rapid growth of output and employment in manufacturing and other non-farm sectors." Moreover, modernization of agriculture through increased demand for inputs is argued to further raise demand for manufacturing goods such as tractors, pesticides and fertilizers [Ardeni and Freebairn, 2002; Tiffin and Irz, 2006].

Development of agriculture is also seen as a prerequisite to release resources for industrial development. Provision of labor for the manufacturing sector is the core element of the seminal work by Lewis (1954). Latter works have led to the development of micro founded general equilibrium models that take into account both the demand and supply side interactions between the agriculture and manufacturing sectors. Among them are Harris and Todaro (1970), Matsuyama (1992), Laitner (2000), Gollin et al. (2002), Hansen and Prescott (2002) and Lucas (2004). In addition to releasing labor, agriculture's crucial role in generating investable surplus at the early stage of development is emphasized in those models.

A shift from the early pessimist views toward recognition of positive roles of agricultural development is complemented by political economy arguments against what is termed as "urban bias" following the influential works by Lipton (1977) and Bates (1984). They documented various instances of anti-agricultural policies that are not primarily targeted to promote economic transformation, but meant to serve urban interests at the expense of overall economic efficiency and poverty reduction.

Following the shift in economic perspectives about agriculture coupled with the dismal performance of many state-led industrialization program, agricultural development resurfaced as the single most important issue in development policies during the 1980s. In what has commonly been referred to as the Berg Report (following its lead author), the World Bank emphasized agricultural development as the major element in its annual development report [*World Development Report*, 1982]. Figure (1) portrays this shift in policy. It shows the time path for the average value of net subsidies given to agriculture as a share of total value of agricultural prod-

Figure 1: Average NRA in non high-income countries: 1950-2005



ucts, referred to as the nominal rate of assistance (NRA) to agriculture. The data is from estimates by Anderson and Valenzuela (2008). The NRA includes subsidies and taxes that take various forms of price distortions such as export taxes, import tariffs, domestic input and output price subsidies, and exchange rate manipulations. The average is computed for a cross section of countries that are not classified as high income countries in Anderson and Valenzuela (2008). The clear pattern is that, on average, the net assistance given to agriculture continued to decrease until the early 1980s, getting worse during the 1970s where the net transfers were below zero. The post-1980 experience is that of a radical shift from mostly anti-agricultural policies that imposed heavily distortionary taxes toward a more favorable approach for agriculture.

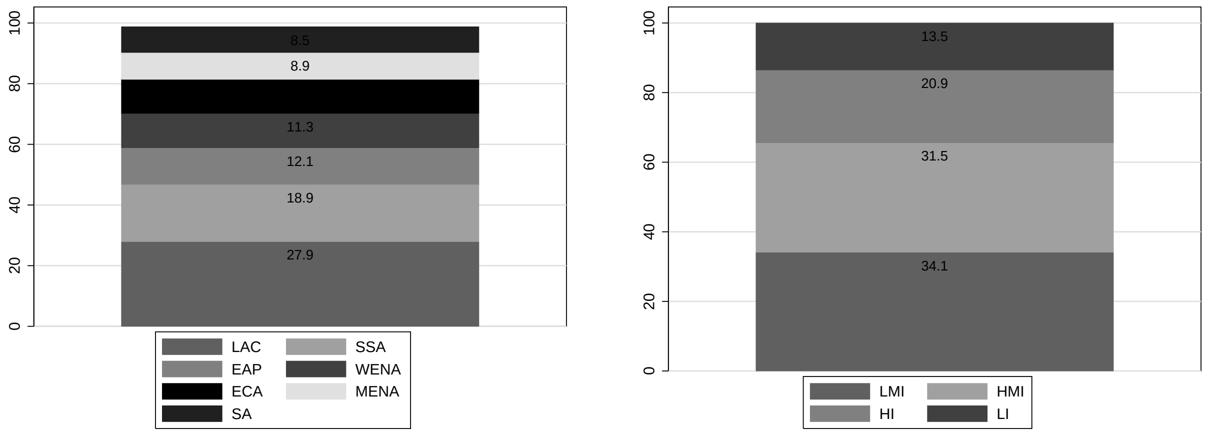
3 Data description and summary statistics

Table (1) presents summary statistics of the variables (mean and standard deviations) along with the data source. The data sources are *World Development Indicators* (2010), Databanks International (DBI), Freedom House, and Mitchell et al. (2004). The key economic variables used in this study are growth rates of agriculture and manufacturing value added. Agriculture value added includes the sum of value added in the sectors forestry, hunting, fishing, as well as cultivation of crops and livestock production. It corresponds to the divisions $1-5$ in the UN's International Standard Industrial Classification (ISIC), revision 3. Manufacturing refers to industries belonging to ISIC divisions $15-37$.

The weather variables are annual precipitation (millimetres) and temperature (°C). The variable "Electric growth" measures annual growth rates of hydroelectric-

Figure 2: Geographic and income groups in the sample

Panel A: Geographic groups Panel B: Income Groups



ity production. The other variables include mineral and energy income as percentage of GNI, exports as percentage of GDP, population growth, index of political freedom and number of anti-government demonstrations. 1618 data points from 93 countries are available for the listed variables. The observations in the data set cover a broad

Table 1: Summary Statistics

Variable	**Mean**	**SD**	**Source**
Agricultural growth %	2.30	8.58	WDI
Manufacturing growth%	4.00	9.95	WDI
Electricity growth	0.04	0.24	WDI
Mineral (as % of GNI)	0.80	2.42	WDI
Energy (as % of GNI)	3.38	7.64	WDI
Exports	29.56	16.85	WDI
Population growth	1.81	1.18	WDI
Protest	0.86	2.10	DBI
Political freedom	3.50	1.99	Freedom House
Temperature	18.52	7.75	Mitchell et al. (2004)
Precipitation	1214.79	787.78	Mitchell et al. (2004)
Number of observations	1618		
Number of countries	93		

category of countries. Figure (2) shows the geographic and economic groups represented in the data. Out of the 1618 observations in the data, the geographic groups Latin America (LAC), Sub-Saharan Africa (SSA), Western Europe and North America (WENA), Middle East and North Africa (MENA), Eastern Europe and Central Asia (ECA), East Asia and Pacific (EAP), and South Asia (SA) respectively represent 30, 19,12,11,11, 9 and 9 percent. Panel B shows the proportion of observations from Low Income (LI), Low and Middle Income (LMI), High Income (HI) and High and Middle Income (HMI) countries.

4 Estimation results

The regression model under consideration is

$$Manu\_g_{i,t} = \beta_1 Agri\_g_{i,t} + \beta_2 Agri\_g_{i,t-1} + \Gamma X_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t} \quad (1)$$

where $Manu\_g_{i,t}$ denotes growth in manufacturing value added in country i, year t. $Agri\_g_{i,t}$ denotes growth in agricultural value added. $X_{i,t}$, α_t and $\epsilon_{i,t}$ are respectively control variables, year dummy and country dummy.

OLS estimates of β_1 and β_2 from equation (1) are inconsistent if the error term $\epsilon_{i,t}$ is correlated with $Manu\_g_{i,t}$ and $Agri\_g_{i,t-1}$. To overcome the endogeneity problem, instrumental variable (IV) estimation is carried out with the following first stage regression

$$Agri\_g_{i,t} = \psi_1 Prec_{i,t} + \psi_2 Prec_{i,t-1} + \pi_1 Temp_{i,t} + \pi_2 Temp_{i,t-1} + \Phi X_{i,t} + \theta_i + \theta_t + \mu_{i,t} \quad (2)$$

where $Prec_{i,t}$ and $Temp_{i,t}$ are measures of precipitation and temperature variations. The identifying assumption is that current and lag weather variations are correlated with $Agri\_g_{i,t}$ but not the error term $\epsilon_{i,t}$. Intuitively, weather variations affect agricultural output with no direct effect on manufacturing output. This is a reasonable assumption given agriculture's heavy dependence on the weather, which is not the case with manufacturing.

We will first take a look at the partial correlations. It will then be followed by discussion of instrumental variable (IV) estimates to verify whether the correlations indeed imply a causal impact of agricultural growth on manufacturing growth. Table (2) presents the partial correlations between manufacturing growth and a host of other variables. The first two columns are OLS regressions and the last two are fixed effect estimates. Manufacturing growth has a significant positive correlation with current and lag of agricultural growth. Growth in hydroelectricity production (weighted by share of electricity production from hydro sources in the total electricity production) and population growth also have a positive correlation. This is expected as both electricity and labor availability are one of the conducive factors for the manufacturing sector. Political instability (as measured by number of anti-government demonstrations) and resource abundance tend to have negative effect on manufacturing growth. The latter is consistent with the resource-curse hypothesis that resource abundance might be bad for overall economic development.

The correlations do not necessarily imply that agricultural growth has a causal effect on manufacturing growth. Unobserved factors may affect both agricultural and manufacturing growth. There might even be a reverse causality [Gardner, 2000]. We will thus take a look the IV estimates.

Table (3) reports the first stage estimates from fixed effect regressions. Agricultural growth is regressed on the instruments along with the other control variables. For the sake of visibility and space, only the coefficients on the instruments are reported. Precipitation growth and temperature changes significantly affect growth in agricultural outputs, where high precipitation and low temperature changes have favorable impact.

Table 2: Partial correlation between manu and agri growth

	(OLS)	(OLS)	(FE)	(FE)
Agriculture growth	0.19***	0.17***	0.17***	0.15***
	(0.05)	(0.05)	(0.05)	(0.05)
Lag agriculture growth	0.15***	0.14***	0.13***	0.11***
	(0.04)	(0.04)	(0.04)	(0.04)
Hydroelectricity growth	0.02*	0.02**	0.02	0.02
	(0.01)	(0.01)	(0.01)	(0.01)
Mineral income (share of GNI)	-0.23**	-0.36***	-0.03	-0.21
	(0.10)	(0.13)	(0.13)	(0.16)
Energy income (share of GNI)	-0.07	-0.07	0.09	0.11
	(0.06)	(0.06)	(0.08)	(0.09)
Exports as a percent of GDP	0.02	0.03	0.04	0.02
	(0.03)	(0.03)	(0.05)	(0.05)
Population Growth	1.03***	1.02***	0.34	0.17
	(0.35)	(0.39)	(0.68)	(0.63)
Anti-government demonstrations	-0.09	-0.08	-0.36**	-0.33**
	(0.21)	(0.21)	(0.16)	(0.16)
Political right	-0.23	-0.27	0.04	-0.09
	(0.20)	(0.21)	(0.26)	(0.24)
Constant	0.02**	0.09***	0.02	0.09***
	(0.01)	(0.02)	(0.02)	(0.03)
Year Dummies	No	Yes	No	Yes
Observations	1607	1607	1607	1607
Countries			93	93
R-Square	0.059	0.106	0.038	0.086

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: First stage, dependent variable: Agriculture growth

	A	B
Precipitation growth	0.06***	0.06***
	(0.02)	(0.02)
Lag precipitation growth	0.03**	0.03*
	(0.01)	(0.01)
Temperature change	-1.89***	-1.97***
	(0.47)	(0.52)
Lag temperature change	-0.71	-0.70
	(0.48)	(0.48)
Year Dummies	No	Yes
Observations	1618	1618
Countries	93	93
R-Square	0.0363	0.0684

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table (4) presents estimation results from the IV regression with country fixed-effects. Coefficient estimates for control variables are not reported for sake of space and visibility. The first column reports estimates for the whole sample. The coefficient on current agricultural growth is positive and significant. Moreover, the impact is larger than what we found from the partial regression estimates in Table (2). The lag agricultural growth, however, is no longer significant, which suggests the correlations we saw in Table (2) between manufacturing growth and lag of agricultural growth are spurious.

The last four columns report estimation results for groups of countries divided by the extent of agriculture's importance in the economy. The countries are divided into high agrarian and low agrarian based on average GDP and employment share of agriculture (in the national economy) during the 1990s. Countries with above the median share are considered as high agrarian while the rest are considered as low agrarian. The 2^{nd} and 3^{rd} columns are for high and low agrarian economies based on employment share of agriculture. The 4^{th} and 5^{th} columns are based on share of agriculture's value added in GDP. The results show that agricultural growth matters only in high agrarian countries. The coefficients in low agrarian countries are insignificant. Lag of agricultural growth doesn't have a significant effect in either group of the countries. The Hansen J statistics confirms the validity of instruments for they lack significant correlation with the error term.

To take a more direct approach toward the link between agriculture's impact on manufacturing and its overall share in the economy, Table (5) reports regression results where agricultural growth rate is interacted with measures of employment and GDP share of agriculture. The average GDP and employment share of agriculture during the 1990s are again used to measure extent of the economy's reliance

Table 4: IV estimates: Impact of agricultural growth on manufacturing growth

	Whole sample	Employment share		GDP share	
		(Low)	(High)	(Low)	(High)
Agriculture growth	0.54**	0.35	0.64**	0.57	0.41**
	(0.22)	(0.29)	(0.26)	(0.37)	(0.18)
Lag agriculture growth	0.12	0.44	0.04	0.07	0.08
	(0.15)	(0.33)	(0.18)	(0.37)	(0.13)
Year Dummies	Yes	Yes	Yes	Yes	Yes
Observations	1600	693	907	791	809
Countries	92	46	46	46	46
Root mean square error	0.10	0.07	0.11	0.10	0.09

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: IV estimates with intereaction

	(A)	(B)
(Agriculture growth)×(GDP share in 1990s)	2.72***	
	(0.78)	
Lag (Agriculture growth)×(GDP share in 1990s)	0.20	
	(0.90)	
(Agriculture growth)×(Labor share in 1990s)		1.01**
		(0.40)
Lag (Agriculture growth)×(Labor share in 1990s)		0.13
		(0.37)
Year Dummies	Yes	Yes
Observations	1570	1600
Countries	90	92
Root mean square error	0.10	0.09

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

on agriculture. In column (A) and (B), growth rate in agriculture value added is interacted with agriculture GDP and employment share, respectively. We see that current agricultural growth has a significant positive effect on manufacturing. The lag of agricultural growth doesn't have significant effect. For example, in an economy where agriculture constitutes 50% of the GDP, a 1% increase in agricultural output leads to a nearly equal percent increase in manufacturing output ($2.72 \times 0.5{=}1.36$). The interaction term with labor share shows that, in economy where agriculture employs 50% of the labor force, a 1% increase in agriculture's value added increases manufacturing value added by about 0.5% ($1.01 \times 0.5 = 0.50$).

Robustness checks have been carried out with alternative measures of agriculture's dominance in the economy. One such measure is the average GDP and employment share of agriculture during the 1980s (in stead of during the 1990s). This results in losing some observations from countries that were formed during early 1990s (particularly former members of the USSR). However, results remained largely the same. Current GDP and employment ratios are also used (in stead of the 10 year averages during the 1990s and 1980s). Again, results remained largely the same. All the sign and significance of the coefficients remained the same. By and large, size of the coefficients haven't shown big difference.

5 Conclusion

Though the role of agricultural growth for manufacturing growth has been at the center of the discourse on economic development, empirically identifying the causal effect of agricultural growth on manufacturing growth has remained illusive for the correlation between the two doesn't necessarily imply causality. This paper attempts to overcome the identification problem. Since agriculture is heavily dependent on the weather, random weather variations are used as instruments to identify the causal impact of agricultural growth on manufacturing growth. Results show that agricultural growth has a significant positive impact on manufacturing growth. The impact is higher the higher is agriculture's share in the economy (as measured by GDP and employment share). For example, in an economy with 50% of agricultural GDP, a 1% increase in agricultural output increases manufacturing output by about 1%. The results are found to be robust to alternative measures of agriculture's dominance in the economy.

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