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Evidence of growth complementarity between agriculture and industry in developing countries

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ABSTRACT

Using dynamic panel models with data for 62 developing countries, this paper examines whether growth in agriculture elicits growth in manufacturing. For identification, I use population-weighted, average temperature as an instrument for growth in agriculture, exploring exogenous variation in land yields. I find large short-run effects: a one-percentage point increase in growth in agriculture is estimated to raise growth in manufacturing by 0.47–0.56 percentage point (baseline), and 0.28–0.47 percentage point (conservative). Extensions of the empirical model suggest that growth in agriculture benefits the manufacturing sector by improving its domestic terms of trade, by increasing the share of investment and saving in GDP, and by increasing the capacity to import industrial inputs. Together, these findings lend support to the notion that agriculture plays key macroeconomic roles in the industrialization of developing countries by relieving saving, aggregate demand, fiscal, and foreign exchange constraints on the industrial sector.

1. Introduction

There is little doubt that the expansion of industrial activities and their ancillary services characterizes sustained episodes of economic growth in developing countries.[1] But the initial stages of industrialization almost invariably impinge on societies where agriculture accounts for a large share of output and employment.

Several recent studies have underscored the role of agriculture in generating favorable initial conditions for modern economic growth. Their dominant theme is the historical pattern of land ownership and its lasting influence on the distribution of income and education, on the incidence of social conflict, and on the development of institutions of economic and political governance.[2]

And yet, beyond the lasting political-economic influence of agrarian structure, agriculture also plays macroeconomic roles in industrialization. They include providing saving and foreign exchange to finance capital accumulation, as well as a home market for industry (Johnston and Mellor, 1961). Their fulfillment is a key ingredient of successful industrialization, as recognized by Alice Amsden in regard to Taiwan's post-war experience:

> Agriculture managed to produce a food supply sufficient to meet minimum domestic consumption requirements as well as a residual for export. [. . .] Good rice harvests have been a major factor behind price (and real wage) stability. [. . .] Agriculture also managed to provide an important source of demand for Taiwan's industrial

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[1] For recent evidence on the relation between structural change and economic development, see Timmer and Vries (2009), Ocampo et al. (2009), and McMillan and Rodrik (2011).

[2] For recent examples, see Engerman and Sokoloff (2002), Acemoglu et al. (2000, 2005), Galor et al. (2009), and Oyvat (2013).

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> output, particularly chemicals and tools, and a mass market for consumption goods. [. . .] In summary, agriculture in Taiwan gave industrial capital a labor force, a surplus, and foreign exchange. (Amsden, 1979, p. 363)

This paper estimates whether growth in agriculture elicits growth in manufacturing, providing reduced-form evidence of macroeconomic linkages between the two sectors. Using average temperature to identify changes in agricultural supply in 62 developing countries, I estimate that a one percentage point increase in growth in agriculture raises contemporaneous growth in manufacturing by between 0.47 and 0.56 percentage point in the baseline specifications, and by between 0.28 and 0.47 percentage point in more conservative specifications that limit influential observations.

As discussed below, annual variation in temperature is best suited to identify short-run effects. Still, the implied long-run multipliers show that if the average country in the sample were to permanently increase growth in agriculture to 4.4%/year (the average in China during 1961–2006), growth in manufacturing would eventually increase by between 0.95 and 1 percentage points. This effect is substantial, as the sample mean of growth in manufacturing is 4.5%/year.

Estimating the effect of growth in agriculture using country-level data is challenging for two main reasons. First, countries differ along time-constant dimensions, such as natural conditions, that are correlated with growth in agriculture. To address this problem, I control for country fixed effects, using only relative variation within countries to identify the coefficients.

Second, regressions relating growth in the two sectors are likely to run afoul of bias due to reverse causality and omitted time-varying variables. To address these problems, I control for the previous dynamics of growth in manufacturing, and use a population-weighted measure of average annual temperature (from Dell et al., 2012a) as an instrument for growth in agriculture.

A growing body of evidence has shown that annual variation in average temperature is an important determinant of crop yields under the technical and geographical conditions of most developing countries (see section 4). This fact makes my empirical strategy appealing, as it exploits a source of variation in agricultural growth that resembles the effect of yield-increasing innovations – a type of technical change that characterized agricultural development during the early industrialization of Japan and East Asia, and later spread to other countries as part of the 'green revolution'.

This paper joins a growing literature using climate data to identify supply shocks in agriculture (see Dell et al., 2013, for a broad review). It is particularly related to papers that have used this identification strategy to establish causal relations between agricultural growth and broader economic outcomes, such as local urban activity (Henderson et al., 2009), patterns of migration (Brückner, 2012), and industrial growth (Shifa, 2014).

This empirical strategy also assumes that annual variation in average temperature within countries, while exogenously shifting agricultural supply, does not directly affect growth in manufacturing. Section 4 below further discusses the appropriateness of this assumption.

Besides estimating the reduced-form effect of growth in agriculture on growth in manufacturing, I explore a number of potential mechanisms that could explain it. I find that growth in agriculture improves the domestic terms of trade of the non-agricultural sector, increases the share of investment and saving in GDP, increases the capacity to import industrial inputs, and increases average output per worker.

These two contributions lend support to the notion that agriculture plays key macroeconomic roles in the industrialization of developing countries by relieving saving, aggregate demand, fiscal, and foreign exchange constraints on the industrial sector. In particular, they suggest that the assumptions typically required to generate a trade-off between yield-increasing innovations in agriculture and industrial development – such as perfect tradability and full employment – are unlikely to hold in most developing countries, at least in the short to medium run (see Sections 2 and 7 for further discussion).

The paper is organized as follows. Section 2 motivates the question in relation to the existing empirical and theoretical literature. Section 3 describes the dataset and introduces the empirical model. Section 4 discusses the identification strategy and presents the main empirical results of the paper: the effect of growth in agriculture on growth in manufacturing using temperature as an instrumental variable. Section 5 examines the effects of controlling for cross-country heterogeneity along several dimensions – such as the share of agriculture in GDP and the degree of openness to international trade –, as well as several robustness checks; Section 6 examines the impact of agricultural growth on potential channels through which it would enhance industrial growth. Section 7 discusses the main findings, implications, and limitations of the paper. An Appendix provides descriptive statistics and detailed variable definitions.

2. Agricultural development and industrialization

Most of the recent empirical literature consists of reduced-form tests of whether output or productivity growth in agriculture bolster their counterparts in other sectors. To address reverse causality and omitted variable bias, most authors have deployed time series techniques or instrumental variables.

For example, a group of studies has used cointegration and error correction models to estimate long-run sectoral balance relations, followed by an examination of sectoral responses to deviations from this equilibrium. Studies of individual countries have yielded mixed results: Gemmell et al. (2000) found that manufacturing output and productivity in Malaysia were exogenous (in the sense of Granger) to increases in their counterparts in agriculture. By contrast, Kanwar (2000), and Chebbi and Lachaal (2007) found that they responded positively in India and Tunisia. A study of panel cointegration using a sample of 85 countries, however, confirmed the finding of positive responses for the majority of countries in the sample (Tiffin and Irz, 2006).