



De-agriculturalization as a result of productivity growth in agriculture

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ABSTRACT

This paper explores the secular decline in the employment share in agriculture as a result of productivity growth in the agricultural sector. I study an equation that states that employment share in agriculture is determined by the subsistence constraint and productivity in agriculture. Given the calibrated value for subsistence level of consumption in agriculture, labor productivity in this sector implies a share of employment in agriculture in the model that turns out to be very close to the data for a variety of countries between 1963 and 2005.

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1. Introduction

One of the most firmly established empirical generalizations in economics relates to the secular decline of the agricultural population and labor force and agriculture's share in national income in the course of economic development (Johnston, 1970; Barrett et al., 2010; Gollin, 2010). Especially, decline in agricultural employment in early stages of development is well-established. The share of agriculture in total employment, which was initially very large, has undergone a continuous decline throughout the entire path of economic development. For example, agricultural employment share in the United States fell from about 74% in 1800 to about 2% in 2000 (Dennis and İscan, 2009). What prompts such a decline of employment share in agriculture?

This paper argues that a simple characterization, that is that employment share in agriculture is determined solely by the subsistence constraint and productivity in agriculture, explains most of the decline in agricultural employment share in the last four–five decades for several countries around the world. Historically, there are two competing views to explain the secular decline in agricultural employment share: (1) labor push, and (2) labor pull (Matsuyama, 2008; Alvarez-Cuadrado and Poschke, 2011). The labor push hypothesis states that improvements in

agricultural technology combined with the fact that the income elasticity of demand for food is less than one—as implied by Engel's law—release labor from agriculture (Nurkse, 1970; Gollin et al., 2002, 2007). The labor pull hypothesis states that improvements in industrial technology attract labor out of agriculture, i.e., faster productivity growth in the modern sector (or relative stagnation in the traditional sector) induces more workers to abandon the traditional sector (Lewis, 1954; Harris and Todaro, 1970; Hansen and Prescott, 2002).

This paper focuses on a particular channel asking the question of to what extent agricultural productivity growth combined with the subsistence level of consumption in agriculture may explain the reallocation of labor out of agriculture. The motivation for this paper comes from the results of Alvarez-Cuadrado and Poschke (2011). They study de-agriculturalization in 12 industrialized countries since the 19th century providing empirical evidence on the relative importance of the push and pull hypotheses.¹ They argue that productivity improvements in the non-agricultural sector were the main driver of structural change (movements of resources out of the agricultural sector) before 1960. After that, the evidence indicates productivity changes in agriculture as the driver of change.

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¹ The countries are Belgium, Canada, Finland, France, Germany, Japan, the Netherlands, South Korea, Spain, Sweden, the United Kingdom, and the United States.

The quantitative analysis presented in Alvarez-Cuadrado and Poschke (2011) is based on the historical data of the employment share in agriculture and the evolution of the price of non-agricultural relative to agricultural goods. However, there is no comparison of the data with the predicted employment share in agriculture. For example, one cannot assess to what extent productivity growth in agriculture alone could explain the changes in agricultural employment share observed in the last four–five decades. This paper tries to fill this gap comparing the model-predicted (employment share in agriculture is determined by the subsistence constraint and productivity in agriculture in the model) employment share in agriculture and the actual data using the Groningen Growth and Development Centre (GGDC) 10-sector database.

Alvarez-Cuadrado and Poschke (2011) study the countries that complete the process of structural change (countries with current employment share in agriculture of less than 10%). The GGDC database provides data on a variety of countries, i.e., there are rich OECD countries with less than 10% of employment share in agriculture and there are some countries in Latin America and in Asia with more than 20% of employment share in agriculture in the last year of the sample period. Therefore, examining the role of agricultural productivity growth (and isolating all other possible variables) in generating declines in employment share in agriculture over time for a variety of countries is important to generalize the argument.

The approach to model employment share in agriculture is related to the multi-sector general equilibrium models of Duarte and Restuccia (2007, 2010), Üngör (2011) and the references therein. The idea is that technological progress in agriculture, combined with the subsistence level of consumption in agriculture, would cause structural change, with the economy shifting from a preponderance of agricultural production to marginalization of the same sector (Laitner, 2000; Stokey, 2001; Gollin et al., 2002, 2007; Lagakos and Waugh, 2012). I calibrate the subsistence term to match the share of employment in agriculture in the United States in the initial period. The calibrated economy restricts the level of labor productivity in agriculture relative to that in the United States for the first year. Then, I use data on the growth rates of agricultural labor productivity to construct the time series for agricultural productivity for each country. In other words, countries differ only in productivity (both level and growth rate); preferences are taken to be identical across countries.

The results suggest that given the calibrated value for subsistence level of consumption in agriculture, labor productivity in this sector implies a share of employment in agriculture in the model that turns out to be very close to the data for a variety of countries between 1963 and 2005. In addition, the results are informative considering the diversity among nations and the variety that is so characteristic of agriculture that could possibly limit the validity of a condensed, general treatment. This paper contributes to an already large literature focusing on the determinants of structural transformation across countries and over time (see Duarte and Restuccia, 2010 and the references therein) and it is complementary to Alvarez-Cuadrado and Poschke (2011). The findings suggest that higher agricultural productivity increases the speed of the declines in agricultural employment share. This paper also contributes to the literature that emphasizes that there are wide differences in agricultural productivity across countries and across time, and these differences appear to be important in understanding relative development levels (Restuccia et al., 2008; Vollrath, 2009; Gollin et al., 2012).

The paper is organized as follows. Section 2 presents the equation of interest providing a discussion and intuition of the argument. Section 3 presents the quantitative analysis and Section 4 concludes.

2. The equation of interest

I study the following equation that states that employment share in agriculture is determined by the subsistence constraint and productivity in agriculture²:

$$N_{A,t} = \bar{A}/\theta_{A,t}. \quad (1)$$

Here $N_{A,t}$ is the employment share in agriculture at time t , $\bar{A}$ is the subsistence level of consumption in agriculture, and $\theta_{A,t}$ denotes the level of productivity in agriculture at time t . Employment share in agriculture is negatively correlated with productivity in this sector (and it is independent of productivity in other sectors). Preferences to support Eq. (1) would mean that agriculture is not only a subsistence good with minimum requirement of $\bar{A}$, but also would mean that $\bar{A}$ is a satiation point.

Unlike other goods, agricultural products are consumed at the subsistence level: one needs to consume some specific amount of these goods, not more, not less. Increases in the level of agricultural productivity push labor out of the agricultural sector, since the same amount of agricultural goods can be produced with lower levels of employment. Any labor not needed to produce the subsistence units of agricultural output will flow into the non-agricultural sector, regardless of productivity levels in that sector. Historically, increasing per-capita incomes were not only associated with a strong decline in the employment share in agriculture but also with a strongly declining budget share for food, the latter relationship being known as Engel's law. Here I use it to refer to structural change driven by nonlinear income effects that influence demand for agricultural good (Foellmi and Zweimüller, 2008; İşcan, 2010).

3. Quantitative analysis

3.1. Data and calibration

I study 23 countries and the data are from the GGDC 10-sector database.³ It includes annual data on value added at constant prices (in local currency units) for Asia (India, Japan, Korea, Taiwan, Thailand), Latin America (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, Venezuela), and the OECD countries (West Germany, Denmark, Spain, France, Italy, Netherlands, Sweden, United Kingdom, United States) as well as data on persons employed, which allows the derivation of labor productivity (value added per worker) series (Timmer and de Vries, 2007). The sample period covers annual data from 1963 to 2005.⁴

The calibration strategy follows Duarte and Restuccia (2007, 2010). First, I normalize labor productivity level in agriculture to 1 for the initial year in the United States. Then, I calibrate the subsistence term in agriculture, $\bar{A}$, to match the share of

² See Duarte and Restuccia (2007, 2010), Üngör (2011) and the references therein for an explicit formulation of this statement in multi-sector general equilibrium models. In words, labor is the sole production factor, and labor productivity can differ across sectors and time. The per-period utility in Duarte and Restuccia (2007) and Üngör (2011) is given by $U(A_t, C_t) = \bar{A} + \log(C_t)$. The instantaneous utility is defined over the agricultural good (A_t) and the composite consumption good (C_t). Solution for the agricultural employment share implies that $N_{A,t} = \bar{A}/\theta_{A,t}$. On the other hand, Duarte and Restuccia (2010) study the per-period utility as $U(A_t, C_t) = a \log(A_t - \bar{A}) + (1 - a) \log(C_t)$. Solution in this case, ignoring the possibility of an exogenous endowment of non-agricultural goods, implies that $N_{A,t} = (1 - a) \frac{\bar{A}}{\theta_{A,t}} + a$, where a denotes the weight of agricultural goods in preferences.

³ <http://www.rug.nl/research/ggdc/data/10-sector-database>.

⁴ I choose 1963 as the initial year to include as many countries as possible. The last year of data for India is 2004, for Bolivia and Japan is 2003, and for West Germany is 1991.

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