Stockholm
University

Essays on growth, political economy and development

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ISSN 0346-6892
ISBN 978-91-7447-689-7

Printed in Sweden by PrintCenter US-AB, Stockholm 2013

Distributor: Institute for International Economic Studies

Dedicated to my parents.

Acknowledgments

I began the PhD study at Stockholm University with high excitement hoping to learn a wide set of fascinating tools to analyze many intriguing economic issues. It has indeed been a very exiting and wonderful experience to learn and apply those tools at one of the top PhD programs. I am deeply thankful to the Economics Department and the IIES for offering me such an opportunity.

Per Krusell and Jakob Svensson, I am immensely grateful for your supervision. You always had the time whenever I needed your support. Under your supervision, I have been guided to learn experimenting with my thoughts and developing my own research. I sincerely feel that you took a very good care of me! Thank you very much for your patience, your attention to my study and your precious time.

Thanks to their kindness, I always felt very easy to knock at the door of the IIES faculty members. I am very grateful for your help. I also thank Philippe Aghion and Paul Klein for their useful advices and feedbacks on my research.

I thank Annika, Christina, Hanna, Ingela and Åsa for your administrative support – it couldn't have been more friendly.

I thank Daron Acemoglu for sponsoring my visit to the MIT Economics Department where I had the opportunity to learn from many leading economists in a vibrate research environment. Despite your extremely busy schedule, you always got the time to give me your advices on my work. I am truly grateful for your generous support and supervision during my stay at the MIT.

I also thank James Robinson for many of the useful advices and interesting discussions.

As I look for the next stage in my career, I depart from the PhD program with the memory of many nice colleagues in the program whose friendship I cherished. The first year course works wouldn't have been as much fun if it were not for the friendly teamwork with Andualem, Christian, Claudia and Elena. Bei and Pamela, traveling with you was a lot of fun and thanks for the wonderful friendship. I also thank you Pamela for taking care of the thesis printing while I am away.

Daniel, I enjoyed your friendship and benefited from your advices. You generously wanted me to learn from your experience in the job market and advised me on many things. It was very useful. Thanks a lot.

Kiflu, it was really nice to have you in Stockholm. I enjoyed many of our chats and I am grateful for you gave me useful information during the earlier days of my PhD study.

Hannes and Niels-Jakob, I enjoyed many of our conversations while sharing the office with you. I am very glad to have you as my office mates and I will certainly miss our time together. Thanks for the good times.

My dear wife, you have gone through the emotional ups and downs of my PhD journey. Your deep love, kind care and generous support took away much of my stress during the PhD study. Thank you very much!

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Chapter 1

Introduction

This thesis consists of three articles that study important issues on economic growth, development and political economy.

The first chapter presents a model to analyze the implication of global human capital flows for catch-up by developing countries. Development of the model is motivated by the salient empirical pattern in the East Asian "miracle": a large increase in output and factor accumulation (both human and physical capital) despite only a modest increase in TFP as documented by Young (1992, 1995). A novel element of the model is a global market for education that allows for human capital transfer from frontier to developing economies. This assumption is motivated by the fact that, during the technological catch-up of countries like Korea and Taiwan, domestic universities usually relied on graduates of Western universities to provide advanced training in science and engineering. Using plausible parameter values from the literature and the data, calibration of the model suggests that the human capital transfer channel can indeed amplify substantially the impact of a TFP increase in a developing economy, providing a rationale for the observed empirical pattern.

The second chapter provides both a theoretical and empirical analysis of the political economy of urban bias in dictatorial regimes – a phenomenon where governments in many developing countries are biased against the rural residents in provision of public goods. This bias is highlighted as one of the most important policy obstacles to poverty reduction since a vast majority of the poorest households depend on farming for their livelihood. Previous literature on the political economy of urban bias emphasizes the role of disproportionate political power by urban residents as a driving force of urban bias. One of the explanations for the relatively weak political power of rural residents is the “group action logic" forwarded by Olson (1971), where a larger size of the agricultural labor force is argued to weaken farmerst' lobbying ability by worsening the free-riding problem (Olson, 1986). Information advantage by urban residents is also argued as an alternative explanation for the disproportionate political power by urban residents (Majumdar et al. (2004)).

A novel result of the model presented in this chapter is that urban bias can emerge in predominantly agrarian economies even if there is *no* bias in political power toward urban residents. The empirical evidence from a recently compiled country-level panel dataset on agricultural taxes/subsidies is consistent with the prediction of the model.

Finally, the third chapter takes an empirical look at the impact of agricultural growth on manufacturing growth. The role of agricultural development for industrialization is central both to many theories of economic development and policy. The link between agriculture and manufacturing sectors is interesting for several reasons. First, agriculture typically constitutes a dominant portion of the economies in developing countries. For example, at least half of the total labor force is engaged in agriculture in nearly half of the low and lower middle income countries (see Figure 4.1). Second, as has been experienced by the East Asian economies, growth in the manufacturing sector can make an important difference in the growth prospect of a developing country (Page, 2012). Thus, the extent to which agricultural development should be seen as an integral part of industrialization policies partly depends on the expected impact of agricultural growth on manufacturing growth. The link between agricultural development and manufacturing growth also underlies several models of structural change (e.g., Harris and Todaro, 1970, Matsuyama, 1992, Gollin et al., 2002).

However, empirically assessing the impact of agricultural growth on manufacturing growth has remained illusive because of endogeneity concerns. This chapter attempts to address the identification challenge. 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 from the instrumental variable estimations show that agricultural growth has a significant positive impact on manufacturing growth, and the impact is larger than what is suggested by the OLS estimates. I discuss the empirical implications for agricultural policies, efficiency of the manufacturing sector, and for the role of agricultural growth in

Africa's industrialization

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Chapter 2

Economic growth and trade in human capital*

***Abstract**: A salient empirical pattern in the East Asian "miracle" is a large increase in output and factor accumulation (both human and physical capital)* despite *only a modest increase in TFP. I present a simple model of growth and economic catch-up that provides a possible explanation. A novel element of the model is a global market for education that allows for human capital transfer from frontier to developing economies. This assumption is motivated by the fact that, during the technological catch-up of countries like Korea and Taiwan, domestic universities usually relied on graduates of Western universities to provide advanced training in science and engineering. Calibration of the model using plausible parameter values from the literature and the data suggests that the human capital transfer*

*I thank Philippe Aghion, John Hassler, Boyan Jovanovic, Paul Klein, Per Krusell, Conny Olovsson, Jakob Svensson and participants in the macro study group at the IIES, the Development Workshop group at Gothenburg University and the SUDWEc 2012 conference for helpful feedback. I also thank Christina Lönnblad for proof-reading.

channel can amplify substantially the impact of a TFP increase in a catching-up economy, providing a rationale for the observed empirical pattern.

2.1 Introduction

Over the past decades, several East Asian economies have narrowed their income gaps to developed economies through rapid growth – a phenomenon that Lucas (1993) referred to as a “miracle” since it lifted millions out of poverty within a relatively short period. A salient empirical pattern in the East Asian experience is a large increase in output and factor accumulation (both human and physical capital) despite only a modest increase in TFP, as documented by Young (1992, 1995), Collins and Bosworth (1996) and Kim and Lawrence (1994). This pattern appears to contradict the standard notion that growth is fundamentally driven by productivity improvement. For example, Collins and Bosworth (1996) argue that the main lessons of East Asia’s success “come not from identifying which policies best promote TFP growth, but how countries can achieve and sustain high rates of saving and investment”. Ventura’s model of growth through a high savings rate, rather than through higher productivity growth, is also motivated by this empirical pattern (Ventura, 1997).

In this paper, I propose a simple model of growth and catch-up that offers an alternative explanation for why catching-up economies may experience a large increase in output and factor accumulation despite a small increase in TFP. I will use the model to discuss whether catch-up led by a large increase in factor accumulation is consistent with the standard notion that TFP is the fundamental driver. A novel element of the model is a global education market that allows for the possibility of human capital transfer from frontier to developing economies. In the model, those who received an advanced education in frontier economies (such as science and engineering professors trained in the West) can train students in developing economies, provided that the students have sufficient incentives to pay for the cost of education.

Using foreign graduates to accumulate domestic human capital is often argued to have played an important role in the technological catch-up of countries like Taiwan, Korea and Japan (Mazzoleni, 2008). After the Meji restoration in the late 19th century, Japan relied heavily on foreign scientists to train its domestic students with the ambition of catching-up with the West in science and technology. The entire faculty in Japan's first engineering college, namely the Imperial College of Engineering, consisted of British scientists (Mazzoleni, 2008). A large number of Japanese also went abroad to study in the West and later returned and engaged in training Japanese students at domestic colleges in Japan (Nakayama, 1989).

Korea and Taiwan also used foreign graduates (mainly from the US) to provide advanced training at their colleges. For example, the Korea Advanced Institute of Science and Technology (KAIST), which primarily focused on supplying skilled workers who were needed to advance the Korean industrial sector, mainly employed foreign-trained professors from the US as a means of transferring technological knowledge to domestic students. Hsieh (1989) reports that the shares of the faculty that had obtained their degree abroad at the two leading universities in Taiwan, National Tsing Hua University and National Taiwan University, were 84% and 74%, respectively. This is also partly reflected in a relatively large presence of Taiwanese students in US colleges (see Figure 1).

In this paper, I present a simple framework to analyze the interaction between catch-up by a developing country and the transfer of human capital via import of teachers, as illustrated in the above examples. In the model, output is a function of physical capital, human capital (supplied by skilled workers), raw labor (supplied by unskilled workers) and the level of TFP. I assume that the acquisition of human capital involves an investment of time both by the teacher and the student. Teaching is done by skilled individuals who can also engage in the production of goods as skilled workers. The teachers are assumed to be heterogeneous with respect to the level of their human capital (i.e., their quality). Students will then choose from a menu of teachers with different levels of quality. Students taught by high-quality teachers will have a higher level of human capital upon graduation. Although high-quality teachers are preferable to low-quality ones, they are more expensive because the wage a teacher receives from teaching should be weakly higher than her earnings from working in the production sector as a skilled worker. Hence, students face the trade-off between the quality and cost of education.

In addition to domestic graduates, the menu of teachers also includes graduates from the frontier economy so that human capital accumulation is not constrained by the domestic stock of human capital. This assumption allows for possibilities such as graduates from

US universities teaching at universities in Taiwan. Thus, the menu of teachers is only constrained by the level of human capital in the frontier economy. A developing economy may then narrow its gap to the frontier economy when individuals in the former have sufficient incentives to pay the cost of importing high-quality teachers from the frontier economy.

The main outcome of the model is that a developing economy may experience a large increase in output in response to a relatively small increase in TFP. It is this prediction of the model that provides a possible explanation for the large increase in output and factor accumulation in catching-up economies, despite a relatively small increase in TFP. By definition, a higher TFP implies a higher level of efficiency in the economy whereby a given stock of human and physical capital results in a higher level of output. Thus, the TFP improvements will also increase the productivity of human capital. For the purpose of this discussion (even though it is not necessary), it is intuitive to think of the TFP increase as an outcome of policy/institutional reforms that remove distortions in the economy – factors that Hall and Jones (1999) emphasize as major drivers of productivity differences across countries. Examples of such reforms could be improved tax codes, more secure property rights and a better provision of public infrastructure. The increase in the productivity of human capital (due to the productivity improvement) increases the demand for high-quality education in the developing economy. This will lead to a rise in wages for high-quality teachers. As a result, foreign residents with higher human capital will be induced to come home and teach at domestic universities, leading to an increase in the domestic level of human capital. Since physical capital and human capital are complements, the increase in human capital, in turn, increases the marginal product of physical capital, which bolsters the accumulation of physical capital. It is due to this chain of complementarity, first from a TFP increase to human capital flows and then to physical capital accumulation, that a small increase in TFP of a catching-up economy leads to a relatively large increase in output.

There is an important asymmetry with regard to the impact of a TFP increase in a frontier versus a developing economy. Compared to the frontier economy, the developing economy may experience a relatively large increase in output in response to a given TFP increase because the possibility of human capital transfer can have a substantial impact on the human capital stock of the developing economy. Such a transfer of human capital is naturally absent in the frontier economy, as it is already at the edge of the knowledge frontier. Hence, a "miraculous" growth in a catching-up economy can be an outcome of the interaction between productivity improvements (e.g., due to improved business climates) and the flow of human capital from the frontier economy. Thus, the large increase in output is fundamentally induced by a potentially marginal improvement in TFP, but catalyzed by the transfer of human capital.

Using parameter values from the literature and data, I simulate the model to quantify the extent to which the possibility of human capital transfer amplifies the effect of an exogenous increase in the TFP of a developing economy. As a first step in the calibration exercise, I solve for the balanced growth path (i.e., the long-run equilibrium) of a model with two-countries – a developed and a developing economy. On the balanced growth path, the *relative* levels of TFP, output and human capital between the developing and developed economy remain the same, i.e., both economies grow at the same rate. This is a standard result shared by a large class of multi-country growth models (e.g.,Parente and Prescott, 1994; Acemoglu and Ventura, 2002; Damsgaard and Krusell, 2010).

I calibrate the impact of a TFP increase under two scenarios. In the first scenario, the developing economy has access to the global education market whereas in the second scenario, it does not have access. The first scenario implies a higher level of income in the new steady state because the TFP increase induces a human capital transfer. Then, the output difference between the new steady states (after the TFP increase) under the two scenarios is the contribution of human capital transfer in augmenting the TFP impact. In one of the calibrations, I consider a case where the initial income of the developing country is just 8% of the frontier. This roughly corresponds to Taiwan's income relative to that of the US in the early 1950s (or China's relative income in the early 1990s). Then, I calibrate the steady state impact of a permanent and exogenous increase in the level of the developing economy's TFP relative to the frontier. I consider a TFP increase that is large enough so that, in the new steady state and with the possibility of human capital transfer, the income of the developing economy becomes 70% of the frontier. Once more, this roughly corresponds to the substantial catch-up experienced by Taiwan in the course of half a century. Then, I re-calibrate the model assuming the same level of TFP increase but *without* the possibility of human capital transfer. Under a set of plausible parameter values, the steady state with the possibility of human capital transfer is found to be twice as large as the scenario without the human capital transfer. This implies that half of the output increase observed in an economy experiencing such a catch-up could plausibly come from the human capital transfer. Under a more conservative choice of parameter values, the contribution of human capital transfer can be about 30% of the total increase in output.

The next section presents the related literature. Section 3 describes the environment of the model. Section 4 derives the equilibrium under the assumption of no human capital transaction across the border. In section 5, the equilibrium with human capital trade is analyzed. The final section concludes the paper.

2.2 Related literature

This paper builds on the existing models of human capital. A common assumption in the existing models of human capital accumulation and growth is that the future levels of human capital depend on the current stock of human capital in the economy [see, e.g., Lucas (1988); Bils and Klenow (2000); Jovanovic and Nyarko (1995) and Park (1997)]. This assumption is reasonable to the extent that the knowledge frontier is constrained by the current stock of human capital in the economy due to, say, the quality of the teachers currently available in the economy. This seems plausible for countries on the knowledge frontier, such as the US, that primarily rely on domestic graduates to train their students. However, countries that are behind the knowledge frontier may instead use foreign graduates with more advanced knowledge to train domestic students. Hence, the current level of human capital may not be the only determinant of the future level of human capital. The contribution of my model is to account for the possibility of such human capital transfer.

Young (1992, 1995) investigates the quantitative contribution of factor accumulation and productivity improvement for the rapid growth of the Asian economies. Young finds that the growth is largely driven by factor accumulation rather than productivity growth. Collins and Bosworth (1996) and Kim and Lawrence (1994) report similar results that emphasize the contribution of factor accumulation as opposed to productivity improvement for the rapid growth of Asian economies. This paper is consistent with those empirical findings in the sense that it provides a possible explanation as to why we may observe a large increase in output and factor accumulation along with a potentially small increase in productivity.

This study is also related to the literature on cross-country income distribution and endogenous growth models. As noted by Acemoglu and Ventura (2002), a key feature of the endogenous growth models is technological spillover where the global technology frontier is shared by all countries, albeit with some delay [see, e.g., Howitt (2000); Parente and Prescott (1994); Damsgaard and Krusell (2010)]. I consider a specific channel for the transfer of technological knowledge from the frontier economy. Those who have the knowledge can engage in "selling" their human capital to residents across the borders as long as there are sufficient incentives. It is this particular channel that enables a relatively small improvement in overall productivity (due to factors such as improved policies and institutions) to have a substantial impact on output. Moreover, the model in this paper shares the standard result in the endogenous growth models that countries experience the same steady-state growth rates (i.e., a balanced growth path) although they may differ in income level.

I consider a simple learning technology where education involves an opportunity cost of time, as is the case in the standard human capital models such as Ben-Porath (1967) and Stokey (1991). Thus, I abstract from other forms of learning which are potentially important. Park (1997) models on-the-job learning where the old train the young at the job. Hence, learning occurs while producing and it does not necessarily involve an opportunity cost of time. Learning-by-doing is also another means of human capital accumulation which I do not incorporate in this paper [see, e.g., Arrow (1962); Krugman (1987); Lucas (1988); Stokey (1988); Parente (1994)].

2.3 Environment of the model

We consider a world with two countries: a large developed and a small developing economy. The economy in each country has two sectors – the production and the human capital sector. Firms produce goods in the production sector. In the human capital sector, schools provide training to young individuals who choose to study.

Regarding factor mobility and market structure, we assume that (i) both the schools and the firms face perfectly competitive *domestic* markets for products and factors, (ii) the markets for goods and physical capital are fully globalized, and (iii) labor is immobile across borders *except* that schools in the developing economy can import teachers from the frontier economy at an internationally competitive wage rate.[1] Time is discrete and infinite, $t \in \{0, 1, 2, \dots\}$.

The next two subsections present details of the model environment. For the sake of brevity, we drop country and individual indices unless they are necessary.

2.3.1 Demography, preferences and endowment

The framework is that of the standard overlapping generations model where current generations care about their offspring, as in Becker and Barro (1988). Each individual lives for two periods – as young and old. Each country is populated by a continuum of infinitely-lived dynasties of households. We assume that each household has 1 unit of young and 1 unit of old (i.e., a fertility rate of 1). The total number of households in each economy is normalized to mass 1. Denote the consumption of an individual born in period t while young and old, respectively, by c_t^y and c_t^o. The household's utility is given by

$$E_t U_t = E_t \{u_t + \beta U_{t+1}\} \tag{2.1}$$

where u_t denotes the utility from current consumption by current members of the household. Let the household's total consumption be denoted by $c_t = \left(c_t^y + c_{t-1}^o\right)$. We assume that the household's in-

[1]In addition to teachers, we can also allow for the possibility of importing skilled workers by the developing economy. The conclusions do not change.

stantaneous utility, u_t, is logarithmic in c_t,

$$u_t = \log c_t \tag{2.2}$$

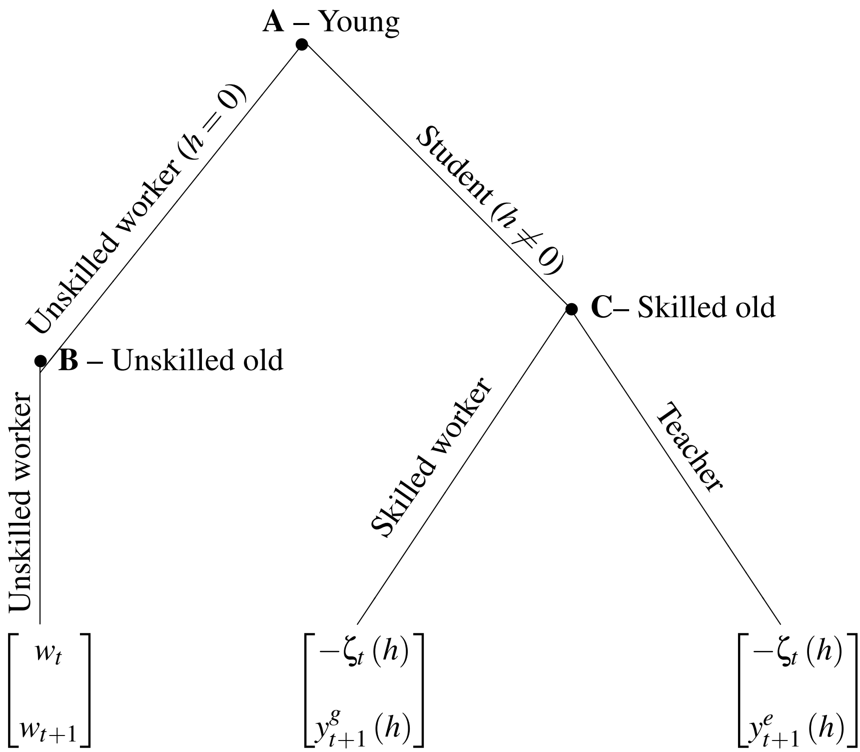
Note that the utility function (2.2) is a version of the standard utility function for the agent with an infinite-horizon. Inserting (2.2) into (2.1) and iterating forward (starting from $t = 0$), (2.1) becomes

$$E_0 U_0 = E_0 \sum_{t=0}^{\infty} \beta^t u_t = E_0 \sum_{t=0}^{\infty} \beta^t \log c_t \tag{2.3}$$

The household's earnings depend on the human capital investment and career choices of its members. This is illustrated in Figure 2.1. The vectors at the bottom of the tree display the earnings/costs associated with each career path that an individual may choose. The first row in the vector shows the earnings/costs while young and the second row shows earnings while old. While young (node A), each individual chooses whether to work or invest in human capital (i.e., study). Those who have studied while young become skilled when old (node C) while the rest will remain unskilled (node B). Students also choose among various levels of education quality, measured here by the quantity of human capital h that they acquire upon graduation. We will see that, in equilibrium, the tuition fee is increasing in h. So the students choose from the menu of education quality taking into account the trade-off between quality and cost – high-quality education is more costly.

When old, skilled individuals choose between working in the goods sector (as skilled workers) or in the human capital sector (as

Figure 2.1: Choices on career and human capital investment



teachers). Thus, teaching is assumed to be done only by skilled individuals.

Unskilled individuals work in both periods and earn wage w_t and w_{t+1} in the first and second period, respectively. Those who study while young give up their current wage from working as unskilled workers. Moreover, they pay tuition fees to the schools, denoted by $\zeta(h)$. The earnings of skilled individuals depend on the quality of the education they received while young and the sectors they work in. If a skilled individual with human capital of h chooses to work in the goods sector, she will earn $y^g(h)$ while she would earn $y^e(h)$ from working as a teacher.

We also allow for the possibility that some of the individuals that acquire human capital may not be able to transfer their human capital to the future generation. This friction is meant to capture possibilities such as a gradual obsolescence of some of the currently useful knowledge. This is similar in spirit to Mankiw et al. (1992) where they assume a positive depreciation rate for human capital. As will be shown later, the size of this friction is relevant to the quantitative fit of the model. The expected benefit from investing in human capital partly depends on the possibility of selling one's knowledge to the future generation (by working as a teacher). Thus, a higher level of the friction can negatively affect the value of investing in human capital.

We model the friction by assuming that, when old, each individual is hit by a fully insurable shock with probability $\psi \in (0,1)$. Skilled individuals who receive the shock can only work in the goods sector whereas those who do not receive the shock are free to choose between working in either sector. Thus, a fraction $\psi \in (0,1)$ of the skilled individuals cannot work as teachers since, for example, their skills become obsolete upon their death.

Let $\varepsilon_t \in \{0,1\}$ be an indicator variable for whether the individual has received the shock. The earning by an individual with human capital h, denoted by $y_t(h|\varepsilon)$, is contingent both on h and ε. Skilled individuals that have not received the shock would earn the maximum of $\{y_t^e(h), y_t^g(h)\}$ since they can choose between teaching and working in the goods sector. Those who have received the shock would earn $y_t^g(h)$. The shock has no bearing on the career choice of unskilled individuals: $y_t(0|0) = y_t(0|1) = w_t$.

The household chooses the optimal sequence of consumption $\{c_t\}_{t=0}^{\infty}$, asset holdings $\{a_{t+1}(\varepsilon_{t+1})\}_{t=0}^{\infty}$, and human capital investment $\{h_{t+1}\}_{t=0}^{\infty}$ to maximize (2.1) and subject to the budget constraint:

$$a_t(\varepsilon_t) + y_t(h_t|\varepsilon_t) + w_t\left(1 - \mathbf{1}_{h_{t+1}>0}\right) \geq$$
$$c_t(\varepsilon_t) + \mathbf{1}_{h_{t+1}>0}\zeta_t(h_{t+1}) + \sum_{\varepsilon_{t+1}} p_t(\varepsilon_{t+1})\, a_{t+1}(\varepsilon_{t+1}), \quad \forall \varepsilon_t \qquad (2.4)$$

$$\lim_{t\to\infty} \sum_{\varepsilon_{t+1}} p_t(\varepsilon_{t+1})\, a_{t+1}(\varepsilon_{t+1}) \geq 0 \qquad (2.5)$$

where $p_t(\varepsilon_{t+1})$ is the price of an asset (in terms of period t goods) that pays 1 unit of goods in period $t+1$ if the state is ε_{t+1}, and $\mathbf{1}_{h_{t+1}>0}$ is an indicator function that takes the value of 1 if the young individual in the household invests in human capital and 0 otherwise.

The stock of human capital in the economy at a given point in time depends on the number of skilled individuals and the quality of their skills which, in turn, is determined by past investments in human capital. Let the number of skilled individuals among the currently old population be given by $\phi_t \in (0,1)$ and the composition of their quality by $\Gamma_t(\sigma_t)$, a probability measure on $(\Omega_t, \mathcal{F}_t)$ where

$$\Omega_t = \left\{h_{j,t} : h_{j,t} > 0\right\} \qquad (2.6)$$

$\mathcal{F}_t$ is the associated Borel σ-algebra and $h_{j,t}$ is the human capital of the old in household $j \in [0,1]$. So $\Gamma_t(\sigma_t)$ is the distribution of human capital among the skilled old individuals.

We define the country's total stock of human capital in period t, denoted by $\bar{H}_t$, as

$$\bar{H}_t = \phi_t \int h d\Gamma_t(h)$$

It is increasing in the quantity and quality of skilled individuals.

2.3.2 The goods and the human capital sectors

In the production sector, output is a function of raw (unskilled) labor, human capital, physical capital and the level of TFP. In addition, we also allow for the possibility that the total stock of human capital in the economy may have a positive externality on the productivity of the goods sector.[2] The production function closely follows that of Mankiw et al. (1992):

$$Y_t = F(H_t, L_t, \bar{H}_t) = A_t K_t^{\alpha} H_t^{\omega} L_t^{1-\alpha-\omega} \bar{H}_t^{\gamma} \tag{2.7}$$

where H_t and L_t, respectively, denote the total amount of human capital and unskilled labor employed by the representative firm. $\gamma \geq 0$ captures the externality effect of the total stock of human capital in the economy. A_t is an exogenously given level of TFP in the economy and it can differ across countries. The production function satisfies the standard concavity assumptions: $\alpha + \omega \in (0,1)$ and $\alpha, \omega > 0$.

[2]Alternative explanations for the potential externalities of human capital include complementarity among skills and technology adoption that require the availability of skilled workers on a large scale [see, e.g., Lucas (1988); Bils and Klenow (2000); Jones (2011)].

The capital stock evolves according to

$$K_{t+1} = (1-\delta)\,K_t + I_t$$

where I_t is investment in period t and δ is the depreciation rate.

We consider a competitive market with a representative firm. Taking wages and the interest rate as given, the firm employs physical capital, human capital and unskilled labor with the objective of maximizing its profit:

$$\max_{H_t, L_t, K_t \geq 0} A_t K_t^{\alpha} H_t^{\omega} L_t^{1-\alpha-\omega} \bar{H}_t^{\gamma} - (r_t+\delta)\,K_t - W_t^L L_t - W_t^H H_t \tag{2.8}$$

W_t^H is the wage for a unit of human capital and W_t^L is the wage for a unit of unskilled labor. H_t is the sum of each skilled worker's human capital that is employed by the firm. L_t is the total number of unskilled workers hired by the firm. The firm's first-order conditions are given by

$$K_t : \alpha A_t K_t^{\alpha-1} H_t^{\omega} L_t^{1-\alpha-\omega} \bar{H}_t^{\gamma} = r_t + \delta \tag{2.9}$$

$$L_t : (1-\alpha-\omega)\,A K_t^{\alpha} H_t^{\omega} L_t^{-\alpha} \bar{H}_t^{\gamma} = W_t^L \tag{2.10}$$

$$H_t : \omega A_t K_t^{\alpha} H_t^{\omega-1} L_t^{1-\alpha-\omega} \bar{H}_t^{\gamma} = W_t^H \tag{2.11}$$

In the human capital sector, we assume that schools need two types of inputs to provide training to their students: teachers and material inputs. Examples of the material inputs could be buildings, computers, administrative services, etc. The amount of human capital that a student acquires upon graduation depends positively on the quality of her teacher – high-quality teachers produce high-quality graduates. The relationship between the student's human capital, h', and her teacher's human capital, h, is given by:

$$h' = \eta h^{1-\kappa} \bar{H}^{\kappa}, \quad \eta > 0, \kappa \in [0,1] \tag{2.12}$$

where κ measures the externality of aggregate human capital on the productivity of the human capital sector. In the absence of such an externality, $\kappa = 0$.

We fix the student-to-teacher ratio to $\theta > 0$, i.e., a teacher can teach θ number of students. Thus, when it comes to teacher's input, we are effectively assuming that improving the quality of teachers is the only margin to improve education quality (as opposed to increasing the number of teachers). Let $X_t(h')$ denote the amount of material input that a school needs to graduate a student with a human capital of h'. Then, the total cost for the school of training a student to acquire h' level of human capital is given by

$$\chi_t(h') = \frac{1}{\theta} y_t^e(h) + X_t(h') \tag{2.13}$$

where h is given by (2.12). The cost is decreasing in the student-to-teacher ratio. If a school in the developing country imports a teacher from the developed country, $y_t^e(h)$ is given by the market wage for the foreign teacher in the developed country.

To further simplify the analysis, we assume that the material cost is a fixed fraction $v \in (0,1)$ of the total cost:

$$X_t\left(h'\right) = \nu\chi_t\left(h'\right)$$

Combining with (2.13), $\chi_t\left(h'\right)$ becomes:

$$\chi_t\left(h'\right) = \frac{1}{(1-\nu)\theta} y_t^e(h) \tag{2.14}$$

We consider a representative school that maximizes its profit. Let Ω' be the set of all feasible levels of human capital that the school can provide to the students. If we abstract from the cross-border trade in teachers (i.e., assume that each economy relies on the supply of its own teachers), Ω_t' would be given by

$$\Omega_t' = \left\{h' : h' = h^{1-\kappa}\bar{H}_t^{\kappa} \text{ and } h \in \Omega_t\right\} \tag{2.15a}$$

where Ω_t is the set of the human capital levels of domestic skilled individuals [see equations (2.6) and (2.12)]. If we instead allow the developing economy to import teachers from the developed economy, the menu of human capital that the schools can provide would be

$$\Omega_t' = \left\{h' : h' = h^{1-\kappa}\bar{H}_t^{\kappa} \text{ and } h \in \Omega_t \cup \Omega_{f,t}\right\} \tag{2.15b}$$

where $\Omega_{f,t}$ is the set of the human capital levels of skilled individuals in the developed economy. So the possibility of importing teachers expands the menu of education quality from (2.15a) to (2.15b).

To maximize its profit, the school chooses the supply of trainings for each level of education quality h',

$$\max_{S \in \bar{S}_t} \int \left[\zeta_t\left(h'\right) - \chi_t\left(h'\right)\right] dS\left(h'\right) \tag{2.16}$$

where $\bar{S}_t$ is the set of all probability measures on $(\mathcal{H}_t, \mathcal{F}_t')$ such that $\Omega_t' \subset \mathcal{H}_t \subset \mathbb{R}^+$ and $\mathcal{F}_t'$ is the associated Borel $\sigma-$algebra.

2.4 The balanced growth equilibrium

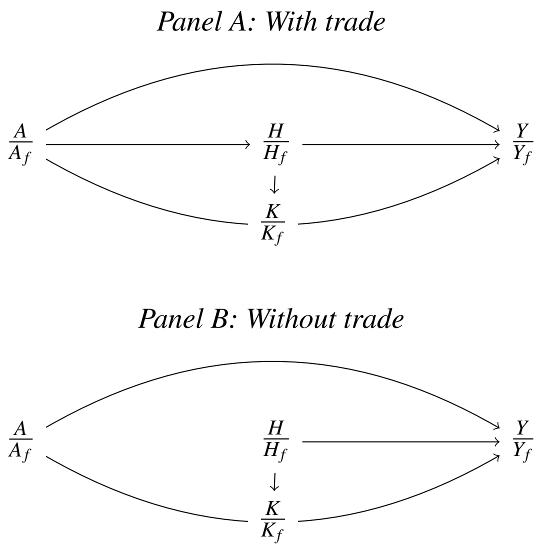
The focus of our analysis is the long-run. Thus, we look at the balanced growth equilibrium (BGE) – an equilibrium where all variables grow at a constant rate and the distribution of human capital normalized by the accumulated growth, given as $\hat{h} = h_t(1+g_h)^{-t}$, is stationary. In this section, I prove the existence of the BGE and characterize it. However, before embarking on the formal analysis of the BGE, it is worthwhile to briefly describe the main intuitions that characterize the BGE.

Along the BGE, there can be a persistent gap between the frontier and the developing economy in the levels of output, the stock of human capital and physical capital. We will see that the output gap is fundamentally determined by the TFP gap. This happens because the TFP gap affects output through two channels: (i) directly via the production function and (ii) indirectly through factor accumulation (both human and physical capital). The latter channel is due to the fact that the demand for factor accumulation depends on the TFP.

In each country, a fixed fraction $\phi \in (0,1)$ of young individuals invest in human capital. This fraction is sustained because, within each country, the equilibrium trade-offs between skill-premiums and tuition fees are such that the young individuals are indifferent between becoming skilled or not. However, skilled individuals in the frontier economy can be of better quality (i.e., they have a higher level of human capital). Thus, the difference in the human capital stock between the frontier and developing economies is driven by the differences in the quality of skilled individuals (rather than the quantity). We will see that, in the developing economy, the difference between equilibrium tuition fees for education provided by foreign teachers and domestic teachers is such that the students are indifferent between the two. Hence, the quality gap in human capital is sustained because of the low demand for human capital in the developing economy (caused by the low TFP) to finance the import of teachers from the frontier economy.

As a first step in solving the BGE, in the next sub-section, I solve for the BGE of an economy without trade in human capital, corresponding to Ω' given by (2.15a). Then, in sub-section 2.4.2, I will extend the solutions for the scenario where there is trade in human capital, corresponding to Ω' given by (2.15b). Figure 2.2 illustrates the main difference in the BGE outcomes between the open and closed human capital market. In the open case, the gap in the BGE human capital is a function of the TFP gap due to the integrated market for education. However, in the closed case, the gap in the human capital stock is independent of the TFP gap. Instead, it is determined by history through the human capital accumulation equation (2.12).

Figure 2.2: Gaps with and without human capital trade



2.4.1 The BGE in a closed market for human capital

In equilibrium, (i) households maximize their utility, (ii) firms and schools maximize their profit, and (ii) the markets for goods, education and labor clear. The following definition presents the equilibrium conditions. The skilled individuals' occupational choice between teaching and working is denoted by the indicator variable $\mu_j \in \{0 = working, 1 = teaching\}$.

Definition 1. *A competitive equilibrium is the distributions of* c_t, h_t, μ_t *and* a_t *across households, the employment of* K_t, L_t *and* H_t *by the firm, the supply of training by the school* $S_t(h)$*, prices* W_t^L, r_t*,* W_t^H*,* $y_t^e(h)$ *and* $\zeta_t(h)$*, and net import of goods* M_t *such that*

- *the households maximize (2.1) subject to the budget constraint (2.4),*

- *the market for goods clears,*

$$Y_t + M_t = I_t + \int_0^1 c_{j,t} dj$$

- K_t, L_t *and* H_t *solve the firm's problem (2.8),*

- *the demand for unskilled workers equals the supply,*

$$L_t = 1 - \phi_{t+1} + 1 - \phi_t$$

- *the market for human capital in the production sector clears,*

$$H_t = \int_0^1 h_{j,t} \left(1 - \mu_{j,t}\right) dj$$

- Γ_{t+1} *solves the school's problem (2.16),*

$$S_t(h) = \Gamma_{t+1}(h)$$

- *the market for teachers clears,*

$$S_t(h') = \Gamma_t(h|\mu = 1)$$

The resources to provide for investment and aggregate consumption come from the sum of domestic output and net import. Total unskilled labor consists of the unskilled old, $1-\phi_t$, and the young who do not attend school, $1-\phi_{t+1}$. The total stock of human capital supplied to the goods sector equals the sum of the human capital of skilled individuals who are not engaged in teaching (i.e., $\mu_j = 0$). The composition of the quality of training currently offered by schools, $S_t(h)$, determines the quality composition of the skilled labor force in the next period, $\Gamma_{t+1}(h)$. Finally, the distribution of education quality is determined by the distribution of the quality of teacher's supply, $\Gamma_t(h|\mu = 1)$.

The BGE requires $\hat{h} = h_t(1+g_h)^{-t}$ – the distribution of human capital normalized by the accumulated growth – to be stationary. This will be satisfied if, for all $\sigma_t \in \mathcal{F}_t$ and $\sigma_{t+1} = \{h : h = \eta h_t^{1-\kappa} \bar{H}_t^{\kappa}$ and $h_t \in \sigma_t\}$,

$$\Gamma_{t+1}(\sigma_{t+1}) = \Gamma_t(\sigma_t) \tag{2.17}$$

An intuitive interpretation of the above definition is that a constant fraction of the skilled individuals from each level of human capital engage in teaching so that the distribution of human capital across households features a stable pattern over time.

Lemma 1 (Singleton)**.** *If $\kappa = 0$, Ω_t is a singleton in the equilibrium. Moreover, if $\kappa > 0$ and (2.17) is satisfied, Ω_t converges to a singleton.*

Proof. See Appendix A. □

Given that Ω_t is either a singleton or must converge to a singleton in the stationary equilibrium, I focus on the equilibrium with a singleton Ω_t. The following proposition states such an equilibrium.

Proposition 1 (BGE). *The economy has a stationary equilibrium with singleton Ω_t. In this equilibrium, a constant fraction $\phi \in (0,1)$ of young individuals invest in human capital in every period where*

$$\phi = \frac{\omega 2\left[\beta - \frac{1}{(1-\nu)\theta}\right]}{(1-\alpha-\omega)\left(\frac{\theta-1}{\theta}\right)(1+\beta) + \omega 2\left[\beta - \frac{1}{(1-\nu)\theta}\right]} \tag{2.18}$$

Moreover, the growth rates of the human capital stock H_t and output Y_t are given by

$$g_h \equiv \frac{h_{t+1}}{h_t} = \eta\phi^{\kappa} \tag{2.19}$$

$$g_y \equiv \frac{Y_{t+1}}{Y_t} = g_a^{\frac{1}{1-\alpha}} g_h^{\frac{(\omega+\gamma)\alpha}{1-\alpha}} g_h^{1-\alpha+\gamma} \tag{2.20}$$

Proof. See Appendix B. □

Growth is driven by a perpetual accumulation of human capital and TFP growth. Since Ω_t is a singleton, in each period, all old skilled individuals have the same level of human capital, i.e., $h_{j,t} = h_t \forall j$.

The share of the young population that invest in human capital is decreasing in the tuition fee. This effect is reflected through the term $[(1-\nu)\theta]^{-1}$ in (2.18). The equilibrium tuition fee is given by

$$\frac{1}{(1-\nu)\theta} y_t^e(h_t)$$

where $y_t^e(h)$ is the equilibrium teacher's wage. By increasing the skill premium, the elasticity of income with respect to human capital, ω, does also increase ϕ. A higher β means more willingness to postpone consumption, leading to a higher ϕ.

Note also that ϕ is independent of the TFP level – a result from the assumption of factor-neutral TFP. Similarly, γ does not enter ϕ due to the factor-neutrality of the human capital externality.

The total stock of human capital in the country is given by

$$\bar{H}_t = \phi h_t \tag{2.21}$$

A fraction $1/\theta$ of the ϕ individuals who are skilled engage in teaching. The total stock of human capital used for the production of goods is given by

$$H_t = \left(1 - \frac{1}{\theta}\right)\bar{H}_t$$

A constant fraction $1-\phi$ of young and old individuals work as unskilled workers. The total supply of unskilled labor thus equals $2(1-\phi)$. Given r_t, we can solve for W_t^L and W_t^H using firms' first-order conditions (2.9), (2.10) and (2.11):

$$W^L{}_t = B_L A_t^{\frac{1}{1-\alpha}} \bar{H}_t^{\frac{\gamma+\omega}{1-\alpha}} \tag{2.22}$$

$$W_t^H = B_H A_t^{\frac{1}{1-\alpha}} \bar{H}_t^{\frac{\gamma-(1-\omega-\alpha)}{1-\alpha}} \tag{2.23}$$

where

$$B_L \equiv (1-\alpha-\omega)\left[\left(\frac{\alpha}{r+\delta}\right)^{\alpha}\left(\frac{\theta}{L(\theta-1)}\right)^{\omega}\right]^{\frac{1}{1-\alpha}}$$

$$B_H \equiv \omega\left[\left(\frac{\alpha}{r+\delta}\right)^{\alpha}\left(\frac{\theta L}{\theta-1}\right)^{(1-\omega-\alpha)}\right]^{\frac{1}{1-\alpha}}$$

W_t^L is always increasing in $\bar{H}_t$. The term $-(1-\omega-\alpha)$ in (2.23) captures the diminishing return for human capital as the stock of human capital increases. This effect is partly offset by the externality term γ.

Since W_t^H is the wage per unit of human capital, the earning by skilled individuals working in the goods sector, $y^g(h_t)$, is given by

$$y_t^g(h_t) = h_t W_t^H$$

Moreover, skilled individuals are indifferent between teaching and working in the goods sector, $y_t^g(h_t) = y_t^e(h_t)$.

The firm's demand for physical capital, from (2.9), is

$$K_t = \left(\frac{\alpha A_t H_t^{\omega} L_t^{1-\alpha-\omega} \bar{H}_t^{\gamma}}{r_t+\delta}\right)^{\frac{1}{1-\alpha}}$$

Inserting this into (2.7) and using the fact that $L = 2(1-\phi)$, we get output as a function of TFP and the aggregate human capital stock:

$$Y_t = B_y A_t^{\frac{1}{1-\alpha}} \bar{H}_t^{\frac{\gamma+\omega}{1-\alpha}} \tag{2.24}$$

where

$$B_y = \left[\left(\frac{\alpha}{r+\delta} \right)^{\alpha} [2(1-\phi)]^{1-\alpha-\omega} \left(\frac{\theta-1}{\theta} \right)^{-\omega} \right]^{\frac{1}{1-\alpha}}$$

The elasticity of aggregate output with respect to the human capital stock depends on the direct effect of human capital on output [captured by the term $\gamma + \omega$ in (2.24)] and the indirect effect through physical capital accumulation induced by the human capital stock [captured by the term $1-\alpha$ in (2.24)].

2.4.2 Equilibrium in an open market for human capital

We now allow for the possibility of human capital transfer from the frontier to the developing economy – by assuming that schools in the developing economy can import teachers from the frontier economy. We assume that the frontier economy has a higher level of TFP, $A_{f,t} > A_t$. The gap in the human capital stock is endogenous.

Solving for the BGE with the possibility of human capital trade can be seen as a two-stage procedure. First, we solve for the BGE of the closed economies, a task that we have accomplished in the previous sub-section. Second, we solve for the gap in the human capital stock such that the students in the developing economy are indifferent between receiving their training from foreign versus domestic teachers. This condition implies that the gap in the human capital stock that we solve for can be sustained as a BGE outcome where the education is entirely provided by domestic teachers (due to the students' indifference). Given such a gap in the human capital stock, the BGE with the possibility of human capital trade is effectively similar to the BGE without such a possibility. Hence, the sole implication of the human capital trade is to ensure that the gap in the human capital stock is consistent with the demand for education in the developing economy.

Definition 2 below extends the equilibrium condition to incorporate indifference of the students in the developing country between foreign and domestic teachers. If a young individual decides to acquire h_{t+1} level of human capital, the present value of her next period income, denoted by $V_t(h_{t+1})$, is given by

$$V_t(h_{t+1}) = \sum_{\varepsilon_{t+1} \in \{0,1\}} p_t(\varepsilon_{t+1}) y_{t+1}(h_{t+1}|\varepsilon_{t+1}) \tag{2.25}$$

The expected earnings are contingent on human capital h_{t+1} and the realization of the shock ε_{t+1}, against which the individual can insure. Let $h_{f,t}$ and h_t denote the level of human capital by skilled individuals in the frontier and the developing economy, respectively. The equilibrium with the possibility of human capital trade is defined as follows.

Definition 2. *With an open market for human capital, the developing economy is said to be in equilibrium if, in addition to the conditions stated in the above definition (Definition 1), the following condition* *is satisfied:*

$$V_t(\tilde{h}_{t+1}) - \zeta_t\left(\tilde{h}_{t+1}\right) = V_t\left(h_{t+1}\right) - \zeta_t\left(h_{t+1}\right) \tag{2.26}$$

where $\tilde{h}_{t+1} = \eta h_{f,t}^{1-\kappa}\bar{H}_t^{\kappa}$ *and* $h_{t+1} = \eta h_t^{1-\kappa}\bar{H}_t^{\kappa}$.

Inserting (2.14) into (2.26),

$$V_t(\tilde{h}_{t+1}) - \frac{\theta}{1-\nu}y_t^e\left(h_{f,t}\right) = V_t\left(h_{t+1}\right) - \frac{\theta}{1-\nu}y_t^e\left(h_t\right)$$

Since $\tilde{h}_{t+1} > h_{t+1}$, receiving training from the frontier teachers leads to higher earnings [i.e., $V_t(\tilde{h}_{t+1}) > V_t\left(h_{t+1}\right)$]. On other hand, the tuition fee is higher for high-quality teachers, $\zeta_t\left(\tilde{h}_{t+1}\right) > \zeta_t\left(h_{t+1}\right)$. Thus, individuals investing in human capital face the trade-off between quality and cost. The above condition states that, in equilibrium, they should be indifferent.

To simplify the analysis, we further assume that the developing economy is a small economy so that the flow of factors from the frontier to the developing economy does not affect the total stocks in the frontier economy. Moreover, we take as given the fact that the frontier is in a BGE. Thus, the BGE gap in human capital is determined by the condition (2.26). Otherwise, the equilibrium of the open economy is similar to that of the closed one. A constant fraction ϕ, given by equation (2.18), of individuals invest in human capital. Skilled individuals earn the same amount from teaching and working in the production sector, $y_t^e\left(h_t\right) = W_t^H h_t$and $y_t^e\left(h_{f,t}\right) = W_{f,t}^H h_{f,t}$ where

$$W_{f,t}^H = B_H A_{f,t}^{\frac{1}{1-\alpha}} \bar{H}_{f,t}^{\frac{\gamma-(1-\omega-\alpha)}{1-\alpha}} \tag{2.27}$$

Moreover, $V_t(h_{t+1})$ is the discounted value of the wage earnings in the next period for the skilled worker, $\left(h_{t+1}W^H_{t+1}\right)/R_{t+1}$. Inserting these values into (2.26) and rearranging,

$$y^e_t\left(h_{f,t}\right) = W^H_t h_t + \frac{1-\nu}{\theta}\left(V_t(\tilde{h}_{t+1}) - \frac{W^H_{t+1}h_{t+1}}{R_{t+1}}\right) \tag{2.28}$$

A no-arbitrage condition between state-contingent assets and the risk-free asset implies:

$$p_t(1) = \frac{\psi}{R_{t+1}} \tag{2.29}$$

$$p_t(0) = \frac{1-\psi}{R_{t+1}} \tag{2.30}$$

Combining (2.28) with (2.25), iterating forward, and using (2.30) and (2.29) for asset prices, we get

$$V_t\left(\tilde{h}_{t+1}\right) = V_t(h_{t+1})\,Q\left(\frac{h_{f,t}}{h_t}\right) \tag{2.31}$$

where

$$Q\left(\frac{h_{f,t}}{h_t}\right) \equiv \sum_{s=0}^{\infty} q^s\left\{\psi\left(\left[\frac{h_{f,t}}{h_t}\right]^{1-\kappa}\right)^{s+1} + \Phi\right\} \tag{2.32}$$

$$q \equiv \frac{1-\psi}{R}(1-\nu)\theta g_y$$

$$\Phi \equiv (1-\psi)\frac{R\theta-(1-\nu)\,g_y}{R\theta}$$

$Q\left(h_{f,t}/h_t\right)$ is the factor by which the value of having a frontier teacher exceeds that of having a domestic teacher. When $h_{f,t} = h_t$, $Q\left(h_{f,t}/h_t\right) = Q(1) = 1$ – home teachers are equally valued as foreign graduates as long as they have the same level of human capital.[3] Note that $Q\left(h_{f,t}/h_t\right)$ is increasing in $h_{f,t}$.

$V_t\left(\tilde{h}_{t+1}\right)$ exceeds $V_t\left(h_{t+1}\right)$ by a factor of $Q\left(h_{f,t}, h_t\right)$.

The infinite summation captures the fact that the value of acquired human capital depends on the returns that future generations receive since human capital is transferred from one generation to the other. A higher ψ means that a skilled individual is less likely to be able to transfer human capital to future generations, lowering the discount factor q. The cost of transferring knowledge to the future generation, captured by the inverse of the tuition fee term $\theta(1-\nu)$, also lowers q.

To finally derive the BGE gap in the human capital stock, we first insert (2.31) into (2.28):

$$y_t^e\left(h_{f,t}\right) = W_t h_t + \frac{1-\nu}{\theta}\left(V_t\left(h_{t+1}\right) Q\left(h_{f,t}, h_t\right) - \frac{W_{t+1}h_{t+1}}{R}\right)$$

Note that $V_t\left(h_{t+1}\right) = W_{t+1}h_{t+1}/R_{t+1}$. From the BGE growth rates, we have $W_{t+1}h_{t+1} = g_y W_t h_t$ [see equations (2.19), (2.20) and (2.23)]. Using $y_t^e\left(h_{f,t}\right) = W_{f,t}h_{f,t}$, the above equation becomes

$$W_{f,t}h_{f,t} = W_t h_t \left[1 + \frac{1-\nu}{\theta}\frac{g_h}{R}\left[\left(Q\left(h_{f,t}, h_t\right) - 1\right)\right]\right] \tag{2.33}$$

Using the values for W_t and $W_{f,t}$ from equations (2.23) and (2.27),

[3] $Q(1) = \sum_{s=0}^{\infty} q^s \{\psi + \Sigma\} = \frac{\psi+\Sigma}{1-q} = \frac{1-q}{1-q} = 1.$

and combining this with (2.33), the BGE gap in the human capital stock is given by

$$\left(\frac{\bar{H}_f}{\bar{H}}\right)^{\frac{\gamma+\omega}{1-\alpha}}\left\{\frac{g}{R}\left[Q\left(\frac{\bar{H}_f}{\bar{H}}\right)-1\right]+\frac{1}{(1-\nu)\theta}\right\}=\frac{1}{(1-\nu)\theta}\left(\frac{A}{A_f}\right)^{\frac{-1}{1-\alpha}} \tag{2.34a}$$

The gap in the human capital stock is a function of the TFP gap. From (2.24), the BGE output gap is given by

$$\frac{Y}{Y_f}=\left(\frac{A}{A_f}\right)^{\frac{1}{1-\alpha}}\left(\frac{\bar{H}}{\bar{H}_f}\right)^{\frac{\gamma+\omega}{1-\alpha}} \tag{2.34b}$$

The TFP gap determines the output gap through two channels: directly via the production function (2.34b) and indirectly via the human capital gap (2.34a).

An appealingly simple feature of the model is that, given the parameter values, equations (2.34a) and (2.34b) can be used to back-out the TFP and human capital stock gaps implied by a given gap in output. We will exploit this feature in the next calibration exercise.

2.5 Calibration: Impact of a TFP increase

This section presents the calibration exercise. Using parameter values from the literature and data, I simulate the model to quantitatively assess the extent to which the possibility of human capital transfer can amplify the effect of an exogenous increase in the TFP of a developing economy. Such a TFP increase can be considered as an outcome of a large scale institutional/policy reform that arguably improves the efficiency of resource use in the economy. An example of such a reform could be China's decision to open up its economy for the private sector in the early 1980s that triggered the later growth.

2.5.1 Choice of parameter values

Using a similar two-period OLG model of human capital investment, Mayr and Peri (2008) consider a total working life of 40 years so that each period represents 20 years, which I follow in this exercise. In the literature, the standard annualized value for the discount factor β is 0.98. The share of capital, α, is set to one-third. Among the 1,311 higher education institutions that provided data to *U.S. News* in 2010, the average faculty-to-student ratio, θ, is 14.8 (U.S, 2011). Estimates by Acemoglu and Angrist (2000) suggest a 2% externality of aggregate human capital, implying $\gamma = 0.02$. A similar value is assumed for the externality parameter in the human capital sector, $\kappa = 0.02$. Based on the evidence by the U.S (1996) and Kendrick (1976), Bils and Klenow (2000) argue that students' and teachers' time constitutes 90% of the cost of education, the remaining 10% being the cost for material. This jointly implies that $\nu = 0.4$ and $\phi = 0.42$. The US per capita GDP grew by an average of 2.27% per year over the period 1960 – 1990 (Heston et al., 2012).[4] To match the calibrated steady-state growth with that of long-run US growth, η is set to 1.52. Following Mankiw et al. (1992), we experiment with the calibration for ω in the interval between a third and one-half.

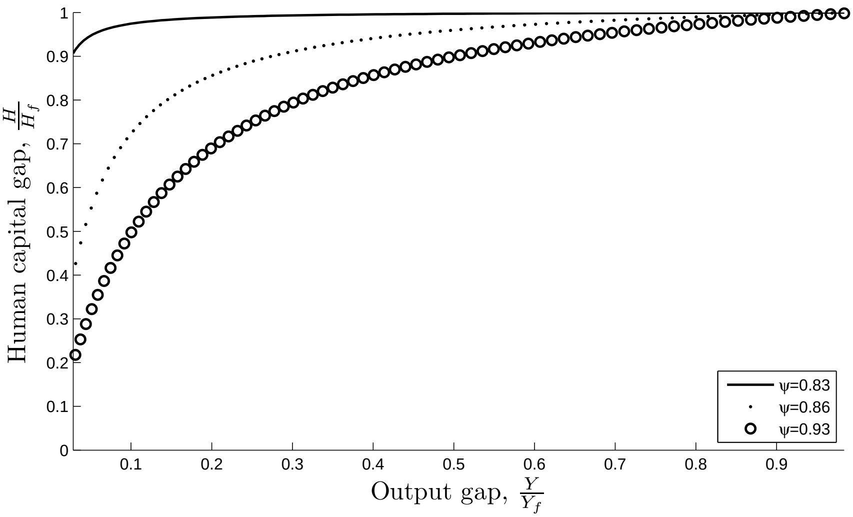
[4]The growth rate computed as the slope of log GDP on time, i.e., $\log Y_t = 0.0227 \times \textit{year} + \textit{constant}$.

Table 2.1: Parameter values

Parameter	value	Note
α	0.33	Match captial share to one-third
β	0.98	Annualized value
γ, κ	0.02	Acemoglu and Angrist (2000)
ν	0.4	Bils and Klenow (2000)
η	1.52	Match U.S. growth
θ	14.8	U.S, 2011

We are left with the parameter for the friction in the inter-generational transfer of human capital, ψ. The value of ψ is set to the inverse of θ so that the BGE number of skilled individuals that can engage in teaching, $(1-\psi)\phi$, equals the number of teachers required in the economy, ϕ/θ. The calibrated relationship between the output gap and the human capital gap appears to be more realistic for this value of ψ. Figure 2.3 plots the human capital gap against the output gap calibrated from the model for three values of ψ. We see that, for the smaller values of ψ, the curves are very steep toward the origin and almost flat otherwise. In the case of $\psi = 0.83$, even a poor country with a 90% output gap will have almost no gap in human capital. The explanation follows from the fact that a decrease in ψ implies an increase in the value of human capital, an effect captured in the expression for Q where an increase ψ increases the discount factor q [see equation (2.32)]. We get a relatively smoother relationship for $\psi = 0.93$ and I use this value in the calibrations. Table 2.1 summarizes the parameter values and the sources.

Figure 2.3: Human capital and output gap



2.5.2 Human capital transfer and amplification of a TFP increase

We calibrate the BGE impact of a permanent shift in the TFP gap. We assume that the two economies have been on the BGE prior to the TFP shift – the TFP and human capital gap are such that the students in the developing economy are indifferent between importing teachers or not. This assumption is needed to net out the impact of human capital transfer in amplifying the impact of a TFP increase because, given this condition, there will not be any import of human capital without a TFP increase. The entire human capital transfer has to be induced by the TFP increase. In terms of the figure below, the assumption about the initial level of the human capital of the developing economy is such that output is the same in scenarios II and IV. The amount by which output in scenario I exceeds output in scenario III will be the contribution of human capital transfer in amplifying the impact of TFP.

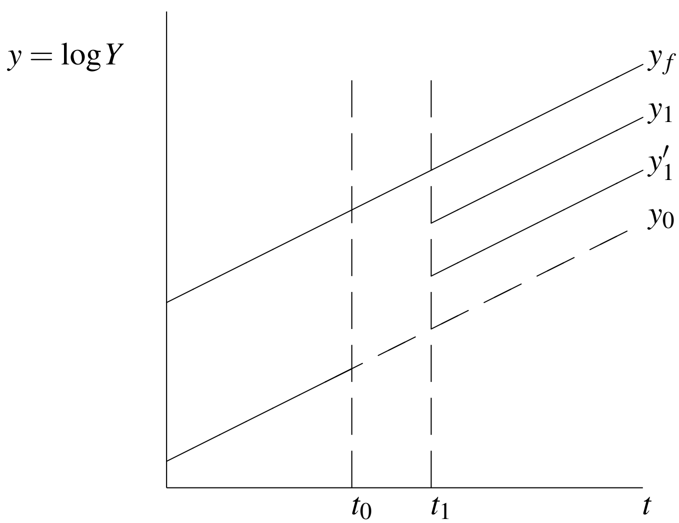
		Change in $\frac{A}{A_f}$	
		Increase	No change
Possibility of HC transfer	Yes	I	II
	No	III	IV

Figure 2.4 illustrates the paths of output under the four scenarios. The shift in the TFP gap happens at time t_0. Prior the shift, the two economies are assumed to be on the BGE. The output of the frontier economy, y_f, remains above that of the developing economy, (y_0), while both economies grow at the same rate.

When there is a shift in the relative level of the TFP of the developing economy (scenarios I and III), we assume that the economy will have returned to the BGE in period t_1. The graph y_0 captures scenarios II and IV. The graphs y_1 and y_1' capture, respectively, scenarios I and III. The difference between y_1 and y_1' on the new balanced growth path is the contribution of human capital transfer.

As a first experiment, let us consider a developing country whose initial income is just 8% of the frontier economy, i.e., an output gap of 92 percentage points. This roughly corresponds to Taiwan's income relative to that of the US in the early 1950s (or China's relative income in the early 1990s). Then, given the parameter values, the output and human capital stock of the developing economy implied by the BGE conditions (2.34a) and (2.34b) will be 31 and 36 of the frontier, respectively. We now experiment with a TFP increase that is large enough so that, in the new BGE and *with* the possibility of human capital transfer (i.e., scenario I), the income in the developing economy becomes 70% of that in the frontier economy. Once more, this roughly corresponds to the large catch-up experienced by Taiwan in the course of half a century. The first row in Table 2.2 shows the sources of this increase as implied by the BGE conditions.

Figure 2.4: Impact of a TFP increase with and without human capital transfer



The first procedure in the calibration exercise is to back out the TFP gap on the new BGE. Given the parameter values and assuming that $Y/Y_f = 0.7$, the value of A/A_f implied by the BGE conditions is 0.94. Then, we ask: what would be the new output level if we had the TFP increase but shut down the human capital transfer? This output level, reported in the last column, is 33.6%, implying that the relative output without a human capital transfer would have increased by a factor of only 4.2 (instead of 8.8). Thus, the human capital transfer contributes a factor of 2.1. Assuming a period of 50 years and a 2.08% steady state growth rate in the frontier economy, the contribution of human capital transfer for the increase in the absolute (instead of the relative) level of output would be 52% – nearly half of the output increase comes from the human capital transfer.

Table 2.2: Contributions of productivity increase and human capital transfer

		The contribution of:		
	Output rise	Productivity increase	Human cap. transfer	Counter-factual $\frac{Y}{Y_f} \times 100$
(A)	8% → 70% (↑ by 8.8×)	4.2	2.1	33.6%
(B)	10% → 60% (↑ by 6×)	3.3	1.8	33.0%

The second row in Table 2.2 presents a similar exercise for an economy that starts out with an initial relative income of 10% and moves to a new BGE with a relative income of 60%, experiencing a six-fold increase in relative income. This roughly corresponds to the level of increase experienced by South Korea over the last fifty years. In this case, the contributions of the TFP increase and the human capital transfer are factors of 3.3 and 1.8, respectively. Once more, considering a 50 year period with a 2.08% annual growth rate in the frontier economy, about 45% of the increase in the absolute level of output are due to the human capital transfer.

The extent to which a TFP increase is amplified by the human capital transfer depends on the initial conditions. Figure 2.5 shows this non-linearity. On the horizontal axis, we have the initial TFP gaps. We assume that the economies are on the BGE so that the TFP gaps translate into gaps in output and the human capital stock according to the BGE conditions (2.34b) and (2.34a). On the vertical axis, we have the contribution of human capital transfer if the developing economy experiences a 10 percentage point increase in its TFP relative to that of the developed economy. As the economy gets closer to the frontier, this contribution falls consistently. This non-linearity is the fundamental reason why a developing economy may experience a disproportionate effect from a TFP increase. All else equal, countries that are further behind the frontier will experience a higher level of increase in output and factor accumulation for a given level of TFP increase. This result is consistent with the fact that the TFP increases observed by the East Asian economies are not exceptionally high compared to those experienced by relatively more industrialized countries such as Italy. However, the observed increase in output and factor accumulation is much higher in the East Asian economies (Young, 1995).

Figure 2.5: Contribution of human capital transfer in response to a 10 pp ↑ in $\frac{A}{A_f}$

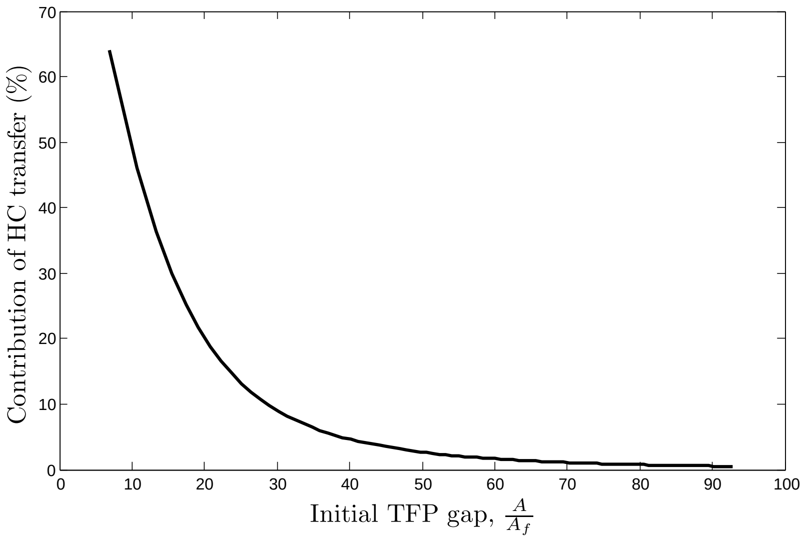


Table 2.3 presents the sensitivity of the results to ω. The calibration is done for the economy that experienced a shift from 8% of initial output to 70%. When ω is one-half, the contribution of the human capital transfer is about 52%. As ω falls, the contribution of human capital transfer also decreases. This follows from the fact that lower values of ω imply that human capital is less important in the production function. When ω is set to one-third, the lowest value that Mankiw et al. (1992) consider, the contribution of human capital transfer is about 40%. The contribution will fall to about 32% if we further lower ω to a quarter, a relatively conservative value.

Table 2.3: Sensitivity to ω

ω	Contribution of human capital transfer to output gain (percent)
$\frac{1}{2}$	52.2
$\frac{1}{3}$	39.5
$\frac{1}{4}$	31.8

2.6 Concluding remarks

Why do emerging economies experience a very rapid growth? Building on Lucas (1988), this paper provides an alternative framework to analyze the mechanics of catch-up in per capita income. This is done by taking into account the possibility that knowledge transfer from frontier economies may play an important role. In particular, I endogenize the possibility that foreign residents with a higher level of human capital may play a crucial role in knowledge transfer, thereby facilitating the catch-up.

A novel result of the model is that a relatively small improvement in the overall productivity of the economy, e.g., due to institutional reforms such as more efficient trade policies and more secure property rights, may lead to a substantial increase in output. The reforms may result in small changes in measured overall productivity (such as TFP measures). However, with the possibility of human capital transfer, the impact on output could be substantially larger. The model in this paper thus provides a framework that is consistent with the empirical observation that the Asian miracle happened with a relatively modest increase in overall productivity along with a large increase in factor accumulation (Young, 1995).

Modern production activities involve sophisticated knowledge. The sphere of such knowledge ranges from technical skills on the specifics of producing a particular good to skills in the organization and management of firms. The diffusion of such knowledge occurs via various forms of learning and is influenced by the incentives for learning. In this paper, I considered a simple learning technology – teachers teach students and are paid for that. I abstracted from other forms of learning which are likely to be very important. Thus, exploring the various channels through which human capital flows across borders, and the incentives that shape the flow, is a promising research avenue for understanding the phenomenon of rapid growth in emerging economies. An example in this direction is Alvarez et al. (2011) who study the cross-border flow of ideas as a by-product of the interaction in international trade.

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A Appendix

A.1 Proof of Lemma (Singleton)

When $\kappa > 0$

Suppose that $h_{t,i} \in \Omega_t$. Then, by definition of the stationary equilibrium, $h_{t+1,i} \in \Omega_{t+1}$ where

$$h_{t+1,i} = \eta h_{t,i}^{1-\kappa} \bar{H}_t^{\kappa}$$

Iterating forward,

$$h_{t+T,i} = h_{t,i}^{(1-\kappa)^T} \prod_{n=0}^{T-1} \eta^{(1-\kappa)^n} \bar{H}_{t+n}^{\kappa(1-\kappa)^n}$$

If $\kappa \in (0,1)$, $\lim_{T\to\infty} (1-\kappa)^T = 0$. Hence, for any $h_{t,i} > 0$,

$$\lim_{T\to\infty} h_{t,i}^{(1-\kappa)^T} = 1$$

This means that, for any $h_{t,i} \in \Omega_t$, the limit of $h_{t+T,i}$ in the above expression is independent of $h_{t,i}$ and converges to $\prod_{n=0}^{T-1} \left(\eta^{(1-\kappa)^n} \bar{H}_{t+n}^{\kappa(1-\kappa)^n} \right)$. Thus, Ω converges to a singleton.

When $\kappa = 0$

When $\kappa = 0$, Ω_t is a singleton for the stationary equilibrium. We prove this by contradiction.

Take any $h_t, \bar{h}_t \in \Omega_t$ with $\bar{h}_t > h_t$. In the stationary equilibrium, individuals should be indifferent between having the two levels of human capital:

$$\frac{W_{t+1}\bar{h}_{t+1}}{R} - \frac{1}{(1-\nu)\theta}W_t\bar{h}_t = \frac{W_{t+1}h_{t+1}}{R} - \frac{1}{(1-\nu)\theta}W_t h_t$$

where $\bar{h}_{t+1} = \eta\bar{h}_t$ and $h_{t+1} = \eta h_t$. Combining with $W_{t+1}h_{t+1}/(W_t h_t) = g_y$,

$$W_t\bar{h}_t\left(\frac{g_y}{R} - \frac{1}{(1-\nu)\theta}\right) = W_t h_t\left(\frac{g_y}{R} - \frac{1}{(1-\nu)\theta}\right)$$

which is a contradiction (since $\bar{h}_t > h_t$)

A.2 Proof of proposition (BGE)

Skilled individuals are indifferent between working in the goods sector and teaching: $y_t^e(h) = y_t^g(h) = W_t^H h_t$. Young individuals should be indifferent between becoming skilled or not:

$$\frac{W_{t+1}^H h_{t+1}}{R_{t+1}} - \frac{1}{(1-\nu)\theta}W_t^H h_t = W_t^L + \frac{W_{t+1}^L}{R_{t+1}}$$

Along the BGP, all the variables grow at constant rates:

$$\left(\frac{g_{w,h}g_h}{R} - \frac{1}{(1-\nu)\theta}\right)W_t^H h_t = W_t^L\left(1 + \frac{g_{w,l}g_h}{R}\right)$$

where $g_{w,h}, g_{w,l}$ and g_h are the BGP growth rates of W^H, W^L and h, respectively. We conjecture that $R = \beta g_c$, where g_c denotes consumption gross growth rate. From the budget constraint, $g_c = g_{w,l} =$

$g_{w,h}g_h$. Inserting this into the above expression,

$$\frac{W_t^H h_t}{W_t^L} = \frac{1+\beta}{\beta - \frac{1}{(1-\nu)\theta}} \tag{2.35}$$

Getting back to the firms FOCs () and (), we get

$$\frac{W_t^H h_t}{W_t^L} = \frac{\omega A_t K_t^{\alpha} L_t^{1-\alpha-\omega} H_t^{\omega-1} \bar{H}_t^{\gamma} h_t}{(1-\alpha-\omega) A_t K_t^{\alpha} L_t^{-\alpha-\omega} H_t^{\omega} \bar{H}_t^{\gamma}}$$

If a fixed fraction ϕ of young individuals invest in human capital,

$$\frac{W_t^H h_t}{W_t^L} = \frac{\omega 2 (1-\phi)}{(1-\alpha-\omega)\phi\left(1-\frac{1}{\theta}\right)}$$

Combining with (2.35),

$$\phi = \frac{\omega 2\left[\beta - \frac{1}{(1-\nu)\theta}\right]}{(1-\alpha-\omega)\left(\frac{\theta-1}{\theta}\right)(1+\beta) + \omega 2\left[\beta - \frac{1}{(1-\nu)\theta}\right]}$$

Chapter 3

The dual policy in the dual economy - the political economy of urban bias in dictatorial regimes*

Abstract: *In many developing countries, public resource allocation is often biased against the rural population. Since a vast majority of the poor live in rural areas, the bias is highlighted as one of the most important institutional factors contributing to poverty. This pa-*

*I am very grateful to Daron Acemoglu, Camilo Garcia, John Hassler, Per Krusell, Masayuki Kudamatsu, James Robinson, Bernie Zaaruka and Dilan Ölcer for their helpful comments. I would also like to thank participants in the spring 2010 political economy workshop organized by the Department of Government at Harvard University and participants in the development economics lunch seminar organized by the Economics Department at MIT. The paper has also benefited substantially from comments by Maitreesh Ghatak and two anonymous referees. I thank Christina Lönnblad for the proofreading.

per develops a dynamic political economy model of urban bias in a dictatorial regime. A novel result of the model is that urban bias can emerge in predominantly agrarian economies even if there is no *bias in political power toward urban residents. The empirical evidence from a recently compiled country-level panel dataset on agricultural taxes/subsidies is consistent with the prediction of the model.*

3.1 Introduction

One of the major policy features that characterize many developing countries is a heavy bias against the rural population. This bias is highlighted as one of the most important policy obstacles to poverty reduction as a vast majority of the poorest households depend on farming for their livelihood. According to the *Rural Poverty Report* 2011, “1.4 billion people continue to live in extreme poverty, struggling to survive on less than US $1.25 a day. More than two thirds of them reside in rural areas of developing countries." The bias was first articulated by Lipton and he coined the term “urban bias" in his influential book *Why Poor People Stay Poor: Urban Bias in World Development* [Lipton, 1977]. Lipton identified such a systematic bias against rural residents as the single most important source of deprivation for the majority of the poor across the world. Moreover, Bates (1984) provides extensive accounts of various tax instruments that governments use to extract resources from the rural sector. For example, government-owned marketing boards with monopsony power buy export products from peasants at administratively set low prices, sell those products at prevailing world prices, and pocket the surplus. Bates (1984) also shows how governments in Sub-Saharan Africa manipulated exchange rates against exportable farm products and used other domestic policies to suppress the prices of agricultural products (particularly food) in the domestic market. More recently, Bezemer and Headey (2008) single out urban bias as “the largest institutional impediment to growth and poverty reduction in the world’s poorest countries."

This paper presents a model to shed some light on the political economy mechanism driving the bias. It also provides empirical support for the main prediction of the model. As previous studies of urban bias have shown that the bias is primarily a feature of non-democratic regimes [e.g. see Ades and Glaeser, 1995], the focus in this paper is on dictatorial regimes. One of the main regime features that characterize a dictatorial regime is the role of intra-elite conflict in power transfer [Lizzeri and Persico, 2004]. In many dictatorial regimes, conflicts within the ruling elite are major sources of threat to political power. Citizens may also play a role in those conflicts. For example, citizens can support certain factions within the ruling circle. On the other hand, regime insiders may use popular sentiments against the current leader to come into power. It is not unusual for regime insiders to capitalize on citizens’ dissatisfaction to justify coups d’état against leaders (Bates, 1984; Wiseman, 1986). The model combines these features in a dynamic setting.

I derive a testable prediction regarding political incentives and economic structure as defined by the relative size of different sectors in the economy. A novel result of the model is that anti-agricultural biases can emerge in predominantly agrarian economies even if there is no bias in political power between urban and rural citizens.

In the political game, it is assumed that the insider can stage a coup and take over power with the support of either the rural or the urban residents. To avert a coup, the leader has two options: either to bribe the insider or to lower the taxes to citizens so that they do not provide any support for the insider. Urban residents are said to be politically more powerful the higher is the probability that the insider needs their support to overthrow the leader. Urban bias is then defined as the expected tax rate on the rural residents relative to the expected tax rate on urban residents.

I show that relative tax rate becomes higher when the share of output by the rural sector is larger. The reason is that, as the relative size of agriculture increases, appeasing the rural population may require giving up a large amount of rent. And the leader reverts to bribing the insider whenever the insider needs the support of the rural residents. On the other hand, whenever the insider needs the support of the urban residents, the leader prefers to lower taxes on urban residents rather than bribing the insider. Using a recently compiled country-level panel dataset on taxation of the agricultural sector (see Anderson and Valenzuela, 2008), I show that the empirical evidence is consistent with the prediction of the model.

Previous literature on the political economy of urban bias emphasizes the role of disproportionate political power by urban residents as a driving force of urban bias.[1] A common explanation follows the “collective action logic" forwarded by Olson (1971), where a larger

[1] Swinnen (2010) provides a detailed review of the literature.

size of the agricultural labor force is argued to weaken farmers' lobbying ability by worsening the free-riding problem (Olson, 1986). This explanation is motivated by what appears to be a general pattern that poorer countries, which tend have a larger share of their labor force in the agricultural sector, tend to tax agriculture while rich countries subsidize agriculture (Bale and Lutz, 1981; Honma and Hayami, 1986; Krueger et al., 1988).

The informational advantage for urban residents is argued to be an alternative explanation for urban bias. Using a voting model with imperfect information, Majumdar et al. (2004) show how an informational advantage for urban residents can lead to a disproportionate political influence of urban residents. Ades and Glaeser (1995) emphasize differences in regime types as a source of differences in political power between urban and rural residents. They argue that dictatorships favor urban residents since urban residents are assumed to have a higher political power in dictatorships than in democracies. In this paper, I expand on this idea. Specifically, I show that the extent to which dictatorships are biased toward the urban sector varies substantially depending on the relative size of the rural economy. A key finding of the paper is that dictatorship may feature urban bias in predominantly agrarian economies even if there is no bias in political power between urban and rural residents.

The remainder of this paper proceeds as follows. The model is presented in Section 3.2. This is followed by an analysis of the equilibrium outcomes in Section 3.3. Section 3.4 looks at correlates of agricultural policies and economic structure under different regime types to examine the major prediction of the model. The final section presents concluding remarks.

3.2 The model

3.2.1 Setup: players, strategies and timing

Consider a dynamic game among various groups within a society. Specifically, assume that there are four groups of players: an incumbent leader (denoted by L), a regime insider (denoted by I), a continuum of urban citizens (denoted by U) and a continuum of rural citizens (denoted by R).

Political influences are carried out through non-democratic means. The leader's objective is to maximize his rent (taxes collected) from the output produced by the citizens. While doing so, however, he faces certain constraints depending on the relative political strength of each group within society. The main constraint is the threat that he faces from his own insider.

There are two states of the world, denoted by $q \in \{q_u, q_r\}$. In order to overthrow the leader, the insider needs the support of R if the state is q_r. He needs the support of U if the state is q_u.[2]

If the leader is overthrown, there is uncertainty regarding the relative political power of each group in the future (i.e. the state of the world may change). Such uncertainties are typically the case following political uprisings in weakly institutionalized states. Following

[2]The main results do not change if more states are allowed for. For example, we can consider two additional states – the insider can overthrow the leader by himself (with no support) and the insider can overthrow the leader with the support of *either* U or R.

Besley and Kudamatsu (2007) and Padro-I-Miquel (2007), the uncertainty is captured by random changes in the state variable q whenever there is a change in power (i.e. leader overthrow). In each period, assume that y_u and y_r quantities of output are produced by the urban and rural sectors, respectively.

The timing of the game and the strategies by each player are as follows:

Step 1 At time $t = 0$ (the initial period), nature randomly selects a leader and an insider from the citizens, and determines the type of the state $q_t \in \{q_u, q_r\}$ according to the probability distribution $p(q_u) = p_u > 0$ and $p(q_r) = p_r = 1 - p_u > 0$.

Step 2 All players observe the state of the world q_t.

Step 3 The leader announces tax rates on both sectors $\tau'_{u,t}, \tau'_{r,t} \in [0, \bar{\tau}]$ for some $\bar{\tau} \in [0, 1)$, and the share of the rent to be given to the insider $\delta'_t(\tau'_{u,t} y_u + \tau'_{r,t} y_r)$, with $\delta'_t \in [0, 1]$.[3]

Step 4 The insider proposes whether to overthrow the leader and, if so, whether to do it with the support of U or R. Denote the insider's strategy by $\psi_t = (\psi_{u,t}, \psi_{r,t}) \in \Psi \equiv \{0, 1\} \times \{0, 1\}$. We have $\psi_u = 1$ ($\psi_r = 1$) if the insider calls for support from the urban (rural) citizens; otherwise, $\psi_u = 0$ ($\psi_r = 0$).

[3]The assumption that $\bar{\tau} < 1$ is a reduced form for non-political constraints faced by the leader. One such constraint is what is called the "dead-weight loss" where the actual revenue for the leader from a tax rate of τ will be $\tau - \alpha\frac{\tau^2}{2}$ for some $\alpha > 0$; see Meltzer and Richard (1981). The other constraint is what Acemoglu (2005) calls "economic power" of citizens where citizens can hide their output and evade taxes albeit at certain costs (such as resorting to informal activities which may give them lower returns) if the taxes are too high.

Step 5 Citizens decide whether to offer support for the insider's call: $z_{u,t}, z_{r,t} \in \{0,1\}$. Following Acemoglu and Robinson (2006), I assume that participating in a revolution to overthrow an incumbent is a costly activity. Hence, if $z_{s,t} = 1$ for $s \in \{u,r\}$ (i.e. if citizens participate in an overthrow), it costs them γy_s for some $\gamma > 0$.[4]

Step 6 If the leader is not overthrown, $q_{t+1} = q_t$, $\tau_{u,t} = \tau'_{u,t}$, $\tau_{r,t} = \tau'_{r,t}$ and $\delta_t = \delta'_t$; and the game continues from Step 2 in period $t+1$.

Step 7 If the leader is overthrown, $\tau_{u,t} = \tau_{r,t} = 0$. The leader gets 0 in the future.[5] q_{t+1} takes either of the values with probabilities p_u and p_r. In period $t+1$, the game continues from Step 2 with the insider as a new leader and a randomly selected citizen as an insider. This assumption implies that an insider who overthrows a leader and takes over power will face similar rivalry from his own insider. Leaders change, but the political regime remains the same.

The payoffs for player j, denoted by V^j, are the discounted sum of instantaneous consumptions C_t^j:

$$V^j = \sum_{t=0}^{\infty} \beta^t C_t^j$$

[4]The sequence between Steps 4 and 5 is not necessary for the conclusion on tax rates. The equilibrium tax rates will still be the same even if we interchange Step 5 and Step 4.

[5]An interpretation could be that he loses everything after having been purged.

where

$$C_t^j = \begin{cases} (1-\delta_t)(\tau_{u,t}y_u + \tau_{r,t}y_r), & \text{if } j \text{ is a leader in period } t. \\ \delta_t(\tau_{u,t}y_u + \tau_{r,t}y_r), & \text{if } j \text{ is an insider in period } t. \\ (1-\tau_{s,t} - z_{s,t}\gamma)y_s, s \in \{u, r\}, & \text{if } j \text{ is an ordinary citizen.} \end{cases}$$

The difference between probabilities p_u and p_r reflects the relative power of the two groups, U and R. A higher p_u, for example, implies that it is more likely that urban residents become important political constituencies for rival groups within the ruling circle (i.e. the leader and the insider). The opposite is true for a higher p_r.[6]

Finally, note that the distinction between urban versus rural groups is based on two main assumptions: the leader can impose separate tax rates on each sector and he needs to lower the taxes for the whole group in order to win the support of the group. Thus, to the extent that these two assumptions are realistic, the implications of the model can be relevant for analyzing policy biases among other types of groups as well.

[6] Although γ is assumed to be the same for both U and R, in reality, it could also vary across U and R depending on the political tools available to the groups. Among many others, Ades and Glaeser (1995) and Bates (1984), for example, argue that urban residents tend to have better access to influence due to factors such as physical proximity to power centers, better access to information, and better ability to organize. In this model, the purpose of assuming a similar γ for U and R is to focus on the impact of economic structure on urban bias in spite of similar γs for urban and rural residents.

3.2.2 Equilibrium

The equilibrium concept used in this analysis is a pure strategy Markov Perfect Equilibrium (henceforth MPE). The appealing feature of MPE is its analytical simplicity. Within each period, players play a subgame perfect equilibrium. Along the equilibrium path, equilibrium strategies are functions of the state variable q. The following definition presents a precise equilibrium concept used in this analysis.

Definition 3. *The MPE of this game is a set of the value functions* $\{V_i(q) : i \in \{U,R,I,L\}\}$*; strategy by the leader* $(\tau_u, \tau_r, \delta)(q)$*; strategy by citizens* $z_u(q)$ *and* $z_r(q)$*; and strategy by the current insider* $\psi(q)$ *such that:*

- *Given* $(z_r, z_u, \psi)(q)$*,* $(\tau_u, \tau_r, \delta)(q)$ *and* $V_L(q)$ *solve*

$$V_L(q) = \max_{\tau_u, \tau_r \in [0,\bar{\tau}]; \delta \in [0,1]} \left\{ C_L\Big(\tau_u, \tau_u, \delta, (z_u, z_r, \psi)(q), q\Big) + \beta \mathbb{E} V_L(q') \right\}$$

- *Given* $(z_r, \tau_u, \tau_r, \delta, \psi)(q)$*,* $z_u(q)$ *and* $V_U(q)$ *solve*

$$V_U(q) = \max_{z_u \in \{0,1\}} \left\{ C_U\Big(z_u, (z_r, \tau_u, \tau_r, \delta, \psi)(q), q\Big) + \beta \mathbb{E} V_U(q') \right\}$$

- *Given* $(z_u, \tau_u, \tau_r, \delta, \psi)(q)$*,* $z_r(q)$ *and* $V_R(q)$ *solve*

$$V_R(q) = \max_{z_r \in \{0,1\}} \left\{ C_R\Big(z_r, (z_u, \tau_u, \tau_r, \delta, \psi)(q), q\Big) + \beta \mathbb{E} V_R(q') \right\}$$

• *Given* $(z_u, z_r, \tau_u, \tau_r, \delta)(q)$, $\psi(q)$ *and* $V_I(q)$ *solve*

$$V_I(q) = \max_{\psi \in \Psi} \left\{ C_I\Big(\psi, (z_r, z_u, \tau_u, \tau_r, \delta)(q), q\Big) + \beta \mathbb{E} V_I(q') \right\}$$

The political constraint faced by the leader is binding only when $\gamma < \bar{\tau}$, and we assume this throughout the analysis.[7] Depending on the parameter values of the model, we will see that there are four cases with unique equilibrium tax rates in each case. These cases correspond to the leader's decision with regard to the group he wants to appease. The leader adopts one of the following four strategies:

Case 1. Irrespective of the state of the world, impose the maximum tax rate $\bar{\tau}$ on both U and R, and rely on the insider's support for survival.

Case 2. Lower τ_u if $q = q_u$ and lower τ_r if $q = q_r$, i.e. rely on the support of either U or R that can provide support for the insider.

Case 3. Lower τ_u when $q = q_u$ but impose $\tau_r = \bar{\tau}$ when $q = q_r$, i.e. rely on the support of U when $q = q_u$ and on the insider's support when $q = q_r$.

Case 4. Lower τ_r when $q = q_r$ but impose $\tau_u = \bar{\tau}$ when $q = q_u$, i.e. rely on the support of R when $q = q_r$ and on the insider's support when $q = q_u$.

What factors affect the leader's choice among the above four strategies? The following proposition states the assumptions needed

[7] If $\gamma \geq \bar{\tau}$, the political constraint becomes irrelevant and the equilibrium tax rates are always equal to $\bar{\tau}$.

to sustain each of the above four cases as the MPE outcome of the game.

Proposition 2. *Assume that, for $n,m \in \{r,u\}$ and $n \neq m$, either of the four sets of assumptions (A1-A4) is satisfied.*

$$\frac{\bar{\tau}}{1+\beta}\left(1-\beta\frac{y_m}{y_n}\right) \geq \gamma \tag{A1}$$

$$(1-\beta)\,\bar{\tau}-\bar{\tau}\beta\frac{y_m}{y_n} \leq \tau_m^* \tag{A2}$$

$$c_u - b_u\frac{y_r}{y_u} \leq \tau_u^* \leq a_u\frac{y_r}{y_u} - \bar{\tau} \tag{A3}$$

$$c_r - b_r\frac{y_u}{y_r} \leq \tau_r^* \leq a_r\frac{y_u}{y_r} - \bar{\tau} \tag{A4}$$

where

$$a_n = \left(\frac{1+\beta p_m}{p_n\beta}\,(\bar{\tau}-\gamma)-2\bar{\tau}\right) \tag{3.1}$$

$$b_n = \frac{\beta\,(1-\beta)\,\bar{\tau}}{1-\beta^2 p_m}$$

$$c_n = \frac{\bar{\tau}\,[1-\beta\,(1-\beta p_m)]}{1-\beta^2 p_m}$$

$$\tau_m^* = \frac{1}{1-\beta p_m}(\gamma-\gamma\beta+\beta\bar{\tau}-\beta p_m\bar{\tau}) \tag{3.2}$$

Then, the leader's MPE strategy is such that Case 1 prevails if assumption A1 is satisfied. Similarly, either of Cases 2,3 or 4 prevail if either of the assumptions A2, A3 or A4, respectively, is satisfied.

An important factor that determines the leader's strategy is the relative size of the sectors. Note that Case 3 features urban bias in the sense that the leader lowers the urban tax rate whenever urban support is relevant (i.e. when $q = q_u$) but he does not lower the rural tax rate when rural support is relevant (i.e. $q = q_r$). Case 3 is likely to occur when the relative size of agriculture becomes larger. This is captured by assumption A3 that is needed to sustain Case 3 as an MPE outcome. Note that b_u (on the LHS of A3) is always positive. Moreover, if $a_u > 0$, assumption A3 can always be satisfied for a large enough y_r/y_u. The main intuition behind this result is that, when the relative size of agriculture increases, appeasing the rural population may require giving up a large amount of rent. Instead of lowering the taxes on the rural population to win their support, the leader prefers imposing the maximum tax rate on the rural population and rely on the insider's support.[8]

Figure 3.1: Size of the agricultural sector and the leader's strategy

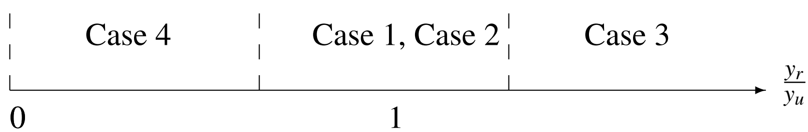


Figure 3.1 illustrates the relationship between the relative size of agriculture and the leader's strategy. When the two sectors are

[8] a_u is more likely to be positive as $\bar{\tau} - \gamma$ becomes larger (see equation 3.1). γ is the citizens' cost for providing support for the insider, imposing an upper bound on the tax rate that the leader can set without inciting the citizen's support for the insider. $\bar{\tau}$ is the maximum feasible tax rate if the leader reverts to bribing the insider (instead of lowering the taxes for the citizens). Hence, the extra amount of rent that the leader collects if he reverts to relying on the insider's support is increasing in $\bar{\tau} - \gamma$. For a_u to be positive, the extra rent must be large enough so that the leader chooses to rely on the insider's support when the share of agriculture increases.

relatively equal (i.e., when y_r/y_u is in the neighborhood of 1), we are more likely to have Case 1 and/or Case 2. Case 3 is more likely to occur for higher values of y_r/y_u whereas the oppose holds for Case 4.

We now turn to the equilibrium tax rates, the insider's share of the rent and the strategies by all players. Lets define V_3 and V_4 as follows.

$$V_3 \equiv p_u\left(\tau_u^* y_u + \bar{\tau} y_r\right) + p_r \bar{\tau}\left(y_u + y_r\right)$$
$$V_4 \equiv p_u \bar{\tau}\left(y_u + y_r\right) + p_r\left(\bar{\tau} y_u + \tau_r^* y_r\right)$$

where τ_u^* and τ_r^* are given by (3.2). We will that V_3 and V_4 denote the expected total amount of rents (before the states are realized) collected by the leader under Cases 3 and 4, respectively.

Proposition 3. *Assume that either of the sets of assumptions (A1-A4) is satisfied. Then,*

- *the MPE urban tax rate $\tau_u(q)$ is given by*

$$\tau_u(q) = \begin{cases} \frac{\gamma - \gamma\beta + \beta\bar{\tau} - \beta p_u \bar{\tau}}{1 - \beta p_u} & \textit{if either A2 or A3 holds and } q = q_u. \\ \bar{\tau} & \textit{otherwise.} \end{cases}$$

- *the MPE rural tax rate $\tau_r(q)$ is given by*

$$\tau_r(q) = \begin{cases} \frac{\gamma - \gamma\beta + \beta\bar{\tau} - \beta p_r \bar{\tau}}{1 - \beta p_r} & \textit{if either A2 or A4 holds and } q = q_r. \\ \bar{\tau} & \textit{otherwise.} \end{cases}$$

- *the MPE insider's share* $\delta(q)$ *is given by*

$$\delta(q) = \begin{cases} \frac{\beta}{1+\beta} & \text{if A1 holds.} \\ \frac{\beta}{(1+\beta p_r)} \frac{V_3}{\bar{\tau}(y_u+y_r)} & \text{if A3 holds and } q = q_r. \\ \frac{\beta}{(1+\beta p_u)} \frac{V_4}{\bar{\tau}(y_u+y_r)} & \text{if A4 holds and } q = q_u. \\ 0 & \text{otherwise.} \end{cases}$$

- $\psi_i(q) = z_i(q) = 0$ *for* $i \in \{u, r\}$ *and for all* q.

Proof. See the appendix. □

When the leader prefers to lower taxes to the group of citizens that provide support to the insider needs, he lowers the tax rates to $\tau_u(q_u)$ and $\tau_r(q_r)$ – lower than the maximum level $\bar{\tau}$. Both $\tau_u(q_u)$ and $\tau_r(q_r)$ are increasing in γ.[9] This happens because, as the cost of providing support increases, citizens are less willing to overthrow the leader even if the leader imposes high taxes.

$\tau_u(q_u)$ is decreasing in p_u. This outcome is driven by the uncertainty following a change in the leader – captured by the probabilities p_u and p_r. The group that has political power today may lose its power in the aftermath of the overthrow of a leader. For example, a higher p_u implies that urban residents are less concerned about loosing power in the event of the overthrow of a leader (i.e., there

[9] Taking the derivatives, $\frac{\partial \tau_{r1}}{\partial p_r} = \frac{-\beta(\bar{\tau}-\gamma)(1-\beta)}{[1-\beta(p_r+p_{ur})]^2} < 0$, $\frac{\partial \tau_{u1}}{\partial p_u} = \frac{-\beta(\bar{\tau}-\gamma)(1-\beta)}{[1-\beta(p_u+p_{ur})]^2} < 0$, $\frac{\partial \tau_{u1}}{\partial \gamma} = \frac{1-\beta}{[1-\beta(p_u+p_{ur})]^2} > 0$, $\frac{\partial \tau_{r1}}{\partial \gamma} = \frac{1-\beta}{[1-\beta(p_r+p_{ur})]^2} > 0$, $\frac{\partial \tau_{r1}}{\partial \beta} = \frac{(\bar{\tau}-\gamma)(1-(p_r+p_{ur}))}{[1-\beta(p_r+p_{ur})]^2} > 0$, $\frac{\partial \tau_{u1}}{\partial \beta} = \frac{(\bar{\tau}-\gamma)(1-(p_u+p_{ur}))}{[1-\beta(p_u+p_{ur})]^2} > 0$.

is a higher likelihood that the next state will remain to be q_u in the event of the overthrow of a leader). Thus, they will be less willing to accept higher taxes. Knowing this, the leader imposes a lower tax rate. Similarly, $\tau_r(q_r)$ is decreasing in p_r. $\tau_u(q_u)$ and $\tau_r(q_r)$ are also increasing in β. The more forward-looking citizens are, the more they worry that future political power may slip out of their hands if they overthrow the current leader – a fear upon which the leader can capitalize to impose higher taxes.[10]

In the cases where the leader bribes the insider, the insider's share δ is increasing in two factors: (i) the amount of expected total rent if he were to seize power and (ii) the discount factor. The former sets the value of the outside option for the insider (i.e., overthrowing the leader). A more forward-looking insider would put more weight on future rents if he were to seize power. Thus, he requires a higher share of the current rent not to stage an overthrow.

3.3 Urban bias, political power and dominance of agriculture

The impact of political power (as measured by the probability distribution) depends on which of the four cases prevail and, for a given case, which state of the world we are in. For example, under *Case 1*, a change in p_u has no effect on the equilibrium τ_u. However, under

[10]Such a fear of losing political power is the main mechanism in what Padro-I-Miquel (2007) calls “the politics of fear" where leaders capitalize on citizens' fear of losing power in ethnically divided societies.

Case 3, an increase in p_u decreases the equilibrium τ_u if the state is q_u. Thus, we will consider the expected equilibrium tax rates in order to have a more tractable and comprehensive measure of urban bias. Let $\mathbb{E}\tau_u$ and $\mathbb{E}\tau_r$ be given by

$$\mathbb{E}\tau_u = p_u\tau_u(q_u) + p_r\tau_u(q_r)$$
$$\mathbb{E}\tau_r = p_u\tau_r(q_u) + p_r\tau_r(q_r)$$

$\mathbb{E}\tau_u$ and $\mathbb{E}\tau_u$ are more comprehensive because they do not depend on the actual state.

An increase in p_u decreases $\mathbb{E}\tau_u$ in those cases where urban support is relevant (i.e., Cases 2 and 3). This happens for two reasons. First, $\tau_u(q_u)$ decreases as p_u increases. $\mathbb{E}\tau_u$ also decreases in p_u since $\tau_u(q_u)$ enters additively in the expression for $\mathbb{E}\tau_u$. Second, note that $\tau_u(q_u) \leq \tau_u(q_r)$. An increase in p_u decreases $\mathbb{E}\tau_u$ since a higher p_u means a larger weight for the smaller term in the expression for $\mathbb{E}\tau_u$ and a smaller weight for the larger term. Similarly, an increase in p_r decreases $\mathbb{E}\tau_r$ in the cases where rural support could be relevant (i.e., Cases 2 and 4). The following corollary summarizes these effects.

Corollary 1. $\mathbb{E}\tau_u$ *is decreasing in* p_u *if either of assumptions A2 and A3 holds. Similarly,* $\mathbb{E}\tau_r$ *is decreasing in* p_r *if either of assumptions A2 and A4 holds.*

Proof. See the appendix. □

This proposition is consistent with previous claims that urban bias, among other factors, is driven by disproportionate political power by urban residents (see, e.g., Ades and Glaeser, 1995). According to

Corollary 1, the group with a higher p is likely to get relatively favorable tax rates.

Disproportionate political power by urban residents, however, is not a necessary condition for urban bias to emerge. Urban residents could be more likely to get favorable tax rates if the urban sector is small relative to the rural sector, as we saw in Proposition 2. Such a bias against agriculture can occur *despite* the relative political power of the rural residents (as measured by p_u and p_r). Consider the relative expected tax rates $\mathbb{E}\tau_r/\mathbb{E}\tau_u$ as a measure of bias against agriculture. There is no bias if $\mathbb{E}\tau_r/\mathbb{E}\tau_u = 1$, the bias is against agriculture if $\mathbb{E}\tau_r/\mathbb{E}\tau_u > 1$, and the bias is against the urban sector if $\mathbb{E}\tau_r/\mathbb{E}\tau_u < 1$. We have the following proposition stating the bias that is driven by the mere dominance of agriculture in the economy.

Proposition 4. *Assume that $p_u = p_r = 0.5$, i.e. there is no bias in political power. For large enough y_r/y_u, $\mathbb{E}\tau_r/\mathbb{E}\tau_u \geq 1$. Moreover, for a large enough y_r/y_u, $\mathbb{E}\tau_r/\mathbb{E}\tau_u > 1$ if $(1+\beta p_r)(\bar{\tau}-\gamma)/(p_u\beta)-2\bar{\tau} > 0$.*

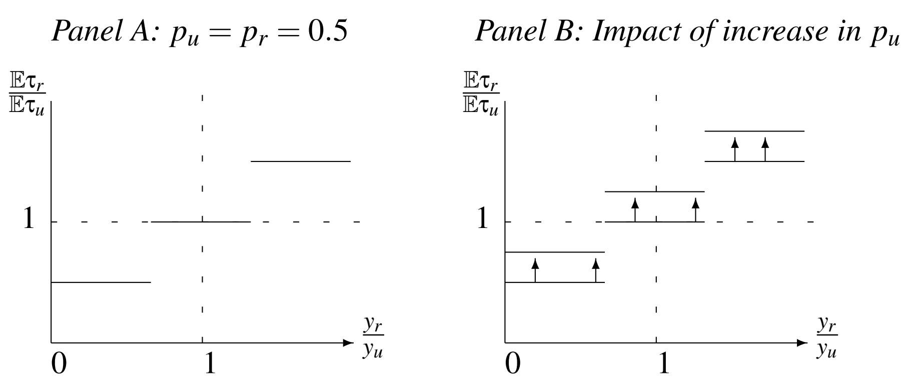
Proof. See the appendix. □

The condition in this proposition simply follows from the assumptions needed to sustain Case 3 as an equilibrium outcome. Note that as $(\bar{\tau}-\gamma)$ becomes larger, the larger will be the extra taxes that the leader can collect when he shifts his strategy from relying on citizens' support to that of bribing the insider.

Figure 3.2 distinguishes the impact of political power and agriculture on urban bias. We have the relative expected tax rate on the vertical axis and the relative size of agriculture on the horizontal axis. In Panel A, it is assumed that there is no bias in political power ($p_u = p_r$). $\mathbb{E}\tau_r/\mathbb{E}\tau_u$ equals one (i.e. there is no urban bias in policy) if the urban and rural sectors are of a relatively equal size (i.e. if y_r/y_u are in the neighborhood of 1). However, as the share of the rural sector increases, $\mathbb{E}\tau_r/\mathbb{E}\tau_u$ shifts to a level above one (i.e. an urban bias will emerge).

Panel B illustrates the impact of political power on urban bias. As p_u increases, $\mathbb{E}\tau_r/\mathbb{E}\tau_u$ shifts upward.

Figure 3.2: Size of the agricultural sector, political power and urban bias



3.4 Empirical evidence

This section takes a look at the data to verify whether the statistical correlates between the share of agriculture in the national economy and observed policies are consistent with Proposition 4. I will first discuss the main variables in the analysis and the data source. Then, I will proceed to the regression analysis.

3.4.1 Data

Rates of Assistance

The two key variables in the analysis are the nominal rate of assistance (NRA) and the relative rates of assistance (RRA) to agriculture. The estimates for NRA and RRA are compiled by a team of researchers under the auspices of the World Bank. The data source is Anderson and Valenzuela (2008).

NRAs measure the subsidies (or taxations) that the agricultural sector receives (or pays) as a result of mainly government-imposed measures. Details of the measurement steps are described in Anderson et al. (2008). For each country in the sample, NRAs are estimated for a variety of agricultural commodities. Then, a weighted average of NRAs for each commodity is taken to estimate overall NRA to the agricultural sector in the country. The nominal rate of assistance that a particular agricultural product i receives, denoted by NRA_i is defined as

$$NRA_i = \frac{D_i}{R_i} - 1 \tag{3.3}$$

where D_i denotes the actual return that a producer of agricultural product i receives while R_i denotes the return that would have prevailed under a free market condition. An agricultural commodity i is said to be subsidized (or taxed) if $NRA_i > 0$ (or $NRA_i < 0$). The subsidies/taxes take various forms such as tariffs on competing imported items, export subsidies/taxes, direct production subsidies/taxes to farmers, exchange rate manipulations, and subsidies/taxes on inputs for production. The overall NRA that the agricultural sector receives is computed as a weighted average of NRAs offered to each commodity.

$$NRA = \sum_i \alpha_i NRA_i \tag{3.4}$$

where α_i is the ratio of the value of commodity i to the value of the country's total agricultural produce. Hence, α_i measures the relative economic importance of commodity i in the country's agricultural sector. For each country included in the sample, the annual time series of NRAs are estimated spanning from 1955 to 2007. For some countries, the time series may not cover the entire period of 1955-2007. A total of 75 countries are included in the estimation. According to Anderson and Valenzuela (2008), the countries together account for 92 percent of the world population and agricultural GDP and 95 percent of total GDP. They also account for more than 85 percent of farm production and employment in each of Africa, Asia, Latin America and the transition economies of Europe and Central Asia.

RRA, on the other hand, measures the net assistance offered to agriculture *relative* to other sectors. It is computed using the formula

$$RRA = \frac{1 + NRA}{1 + NRA_{nonagri}} - 1 \tag{3.5}$$

where $NRA_{nonagri}$ measures the nominal rate of assistance offered to non-agricultural sectors.

Other variables

As a measure of the relative importance (or extent of dominance) of agriculture in the national economy, I use the ratio of value-added by the agricultural sector to total value-added in the whole economy (i.e. the sum of value added by all sectors). The correlation between the share of agricultural value-added in the national economy and the NRA/RRA will be used to study the statistical relationship between agricultural dominance and anti-agricultural policy. Other variables included in the statistical analysis are the ratio of agricultural to non-agricultural population, income from resource extraction, number of conflicts, number of anti-government demonstrations, and government consumption (as a percentage of GDP). The data sources are *World Development Indicators* 2010, Heston et al. (2011), Banks (2001) and Teorell et al. (2011)

Since the model focuses on dictatorial regimes, a measure of political freedom is needed to distinguish regimes that are dictatorial from those that are not. I use the *Freedom in the World* 2010 data that ranks countries as *free*, *partially free* or *not free*.

3.4.2 Estimation Results

Tables 3.1 and 3.2 present fixed-effect panel regression estimates to examine the relationship between the output share of agriculture in the national economy (defined as the ratio of value added by agriculture to total value added in the economy) and rate of assistance. An advantage of the fixed-effect estimate is that it controls for time-invariant factors such as geography and historical legacies. As the mechanisms outlined in the model pertain to non-democratic regimes, the estimations in Tables 3.1 and 3.2 are carried out for non-democratic regimes (labeled *not free* or *partially free* in the Freedom House category). In Table 3.1, the dependent variable is NRA. The dependent variable in Table 3.2 is RRA.

Column (A) in Table 3.1 includes the share of value added in agriculture as the only right-hand-side variable. The dependent variable is NRA. The theoretical model predicts that, in dictatorial regimes, the expected agricultural tax rates are higher in economies with a greater share of agricultural GDP. The estimated coefficient is negative. As the output share of agriculture in the economy increases, countries tend to impose higher tax rates on the agricultural sector, which is consistent with the prediction of the model. A unit increase in the share of agriculture decreases the NRA by almost a proportional amount (0.92).

Columns (B) to (E) verify whether the correlation between the share of agricultural output and NRA disappears if we control for alternative explanations. One such explanation follows from Olson (1971) where, due to a free-riding problem, smaller groups may be more effective at lobbying than larger groups. Applied to agricultural policies, this argument implies that by reducing the lobbying incentive of farmers, an increase in the relative size of the agricultural population may thus have a negative effect on NRA (Olson, 1986; Anderson, 1995). If the agricultural population share is correlated with the agricultural output share (which is true in the data), the observed negative correlation between the agricultural output share and NRAs may also be due to farmers' weaker incentive to lobby. Note that the

Table 3.1: Share of agriculture and NRA in non-democracies

	(A)	(B)	(C)	(D)	(E)
Agri. value added	-0.92^{a}	-0.67^{b}	-0.77^{b}	-0.93^{a}	-0.93^{a}
	(0.26)	(0.31)	(0.30)	(0.33)	(0.32)
Agri/non-Agri pop.		-0.08^{a}	-0.05^{b}	-0.04^{c}	-0.04^{c}
		(0.03)	(0.02)	(0.02)	(0.02)
Energy (% of GNI)			−0.00	−0.00	−0.00
			(0.00)	(0.00)	(0.00)
Mineral(% of GNI)			-0.01^{a}	-0.01^{a}	-0.01^{a}
			(0.00)	(0.00)	(0.00)
Government share			1.14^{b}	1.05^{b}	1.11^{b}
			(0.49)	(0.46)	(0.45)
Manuf. value added				0.54	0.57
				(1.21)	(1.20)
Manuf. square				−3.45	−3.52
				(2.53)	(2.51)
Armed conflicts					−0.02
					(0.02)
Observations	953	789	719	719	719
Countries	44	38	36	36	36
R-Square	0.073	0.122	0.156	0.200	0.204

Robust standard errors clustered by country are in parentheses.
^{c} $p < 0.10$, ^{b} $p < 0.05$, ^{a} $p < 0.01$

collective action logic is a different mechanism to that outlined by the model in this paper. According to the collective action logic, a larger agricultural population share leads to lower NRAs by reducing the political power of farmers (by changing the farmers' incentive to lobby). According to the model in this paper, however, a larger agricultural share leads to lower NRAs by changing the leader's incentive despite the political power of the agricultural population (see Proposition 4). If the observed negative correlation between agricultural output share and NRAs is driven by the collective action logic, the correlation should become insignificant when we control for the agricultural population share. Column (B) in Table 3.1 thus controls for the ratio of agricultural to non-agricultural population. The estimated coefficient is negative and significant, suggesting that the collective action logic is indeed empirically valid. However, the coefficient on the value added share of agriculture is still significantly negative.

Another potential explanation is related to the fiscal capacity of the state (i.e. the ability of the state to mobilize fiscal resources). At the early stage of development, countries may have a lower capacity to collect taxes (see, e.g., Acemoglu, 2005; Besley and Persson, 2010). Such countries may thus have to rely on few agricultural products (particularly tradeable commodities) to raise revenue. Moreover, countries with a higher share of agricultural output may have lower state capacity, since typically, as the economy grows along with higher state capacity, the economy passes through a structural change where the share of agricultural output falls. In order to control for this channel, I make use of two observations in the recent literature on state capacity – (i) countries with a higher fiscal capacity tend to have a larger government share of GDP, and (ii) resource rich countries tend to have a lower fiscal capacity (see Acemoglu, 2005; Besley and Persson, 2010; Besley and Persson, 2011; Sachs and Warner, 1995). Thus, Column (C) controls for two sets of variables: the share of government consumption in GDP and resource income as a percentage of GNI.[11] The estimated effect of the control variables is consistent with this view. Resource availability, as captured by the two variables Energy Income (% of GNI) and Mineral Income (% of GNI), decreases NRA. The government share of GDP (as a proxy for state capacity) has a positive and significant effect. The coefficient on the output share of agriculture still remains significantly negative.

A third potential explanation relates to the role of ideology. In countries with a lower level of industrialization, governments' ambition to develop their manufacturing sector through resource transfer from the agricultural sector is often mentioned as a reason for anti-agricultural policies in many developing countries (Schiff and Valdés, 2002; Krueger, 1996). To control for such an effect, column (D) includes the share of the manufacturing sector in the total value added of the country. Due to the potential non-linearity of this effect, partly because of the non-linearity in the share of the manufacturing sector in the stage of economic transformation, the square term is

[11]The data source for government consumption share is Heston et al. (2011). Resource income data is from World Development Indicators. It includes income from energy and mineral resources. The minerals are bauxite, copper, iron, lead, nickel, phosphate, tin, zinc, gold and silver.

also included. Consistent with this view, the estimated coefficients show that NRAs increase as the share of the manufacturing sector increases (before reaching a maximum). The coefficient on the agricultural output share largely remains unaltered.

Ades and Glaeser (1995) argue that unstable governments tax the rural sector more. The last column (E) accounts for instability by controlling for the number of armed conflicts. The coefficient has the expected sign (is negative), although it is insignificant.[12]

Finally, Table 3.2 reports estimation results with RRA as the dependent variable. NRA and RRA are highly correlated (with a correlation coefficient of 0.97). The estimation results show the positive effect of a higher agricultural output share on relative agricultural tax rates. The coefficient also remains significant when we control for the alternative explanation (columns (B) through (E)).

Corresponding regressions are also carried out for democratic regimes, i.e. regimes that are categorized as *free* by Freedom House. The results are reported in the Appendix. For democratic regimes, the share of agricultural value added does not have a significant effect on NRA. This finding suggests that the relationship between the agricultural output share and anti-agricultural policies is primarily driven by political forces that are typical for non-democratic regimes. The model in this paper provides such a mechanism.

To summarize, the correlation between the output share of agriculture and anti-agricultural policies is consistent with the prediction of the model. Moreover, alternative specifications to verify whether

[12]The result is similar when an alternative measure of instability, namely, the number of anti-government demonstrations from Banks (2001), is controlled for.

Table 3.2: Share of agriculture and RRA in non-democracies

	(A)	(B)	(C)	(D)	(E)
Agri. value added	-1.61^{a}	-0.97^{a}	-1.05^{a}	-1.19^{a}	-1.19^{a}
	(0.31)	(0.34)	(0.34)	(0.42)	(0.42)
Agri/non-Agri pop.		-0.10^{a}	-0.08^{a}	-0.08^{a}	-0.08^{a}
		(0.02)	(0.02)	(0.03)	(0.03)
Energy (% of GNI)			−0.01	-0.01^{b}	-0.01^{b}
			(0.00)	(0.00)	(0.00)
Mineral(% of GNI)			-0.01^{a}	-0.01^{a}	-0.01^{a}
			(0.00)	(0.00)	(0.00)
Government share			1.05^{b}	0.93^{b}	0.93^{b}
			(0.41)	(0.39)	(0.40)
Manuf. value added				1.00	1.00
				(1.33)	(1.33)
Manuf. square				−4.71	−4.71
				(2.83)	(2.84)
Armed conflicts					0.00
					(0.02)
Observations	798	780	712	712	712
Countries	36	35	33	33	33
R-Square	0.163	0.200	0.243	0.289	0.289

Robust standard errors clustered by country are in parentheses.
^{c} $p < 0.10$, ^{b} $p < 0.05$, ^{a} $p < 0.01$

Table 3.3: Share of agriculture and RRA in democracies

	(A)	(B)	(C)	(D)	(E)
Agri. value added	−0.14	−0.34	−0.69	−0.71	−0.70
	(0.80)	(0.65)	(0.64)	(0.62)	(0.62)
Agri/non-Agri pop.		-0.45^{b}	-0.26^{c}	−0.26	−0.24
		(0.18)	(0.15)	(0.22)	(0.23)
Energy income			−0.02	−0.02	−0.02
			(0.02)	(0.02)	(0.02)
Mineral income			-0.03^{c}	-0.04^{c}	-0.04^{c}
			(0.02)	(0.02)	(0.02)
Government share			4.38^{b}	3.40^{b}	3.38^{c}
			(2.07)	(1.68)	(1.68)
Manuf. value added				8.76^{a}	8.84^{a}
				(2.88)	(2.87)
Manuf. square				-21.43^{a}	-21.59^{a}
				(6.48)	(6.45)
Armed conflicts					0.01
					(0.01)
Observations	933	815	812	812	812
Countries	47	45	44	44	44
R-Square	0.000	0.032	0.061	0.106	0.106

Robust standard errors clustered by country are in parentheses.

^{c} $p < 0.10$, ^{b} $p < 0.05$, ^{a} $p < 0.01$

the observed correlation is driven by alternative explanations show that those explanations are relevant and need to be controlled for. However, controlling for those explanations does not nullify the initial result.

3.5 Conclusion

A heavy systematic bias against the rural population, which constitutes the majority of the poor, still remains one of the major policy features that characterize many developing countries. As argued by Bezemer and Headey (2008), the bias remains to be "the largest institutional impediment to growth and poverty reduction in the world's poorest countries."

One may expect the political incentives that perpetuate anti-agricultural policies to respond to changes in economic structure, and the incentives to respond differently in different political environments. This paper develops a formal political economy model to explain urban bias in dictatorial regimes. By identifying the mechanisms that link economic structure with political incentives under dictatorial regimes, the model sheds some light on the impact of economic structure and policy outcomes. In economies with a larger share of agricultural output, the model shows that dictatorial regimes have the incentive to impose higher agricultural tax rates even if there is no bias in political power. The empirical evidence is consistent with the prediction of the model. Alternative empirical specifications suggest that the mechanism outlined in the model complements existing theories of urban bias.

This paper examines the implication of differences in economic structure among dictatorial regimes. Given that urban bias is primarily a feature of dictatorial regimes, and that there is a large heterogeneity among dictatorships with respect to political structures, an important avenue for future research may be to examine the policy implications of such heterogeneity within dictatorships. Besley and Kudamatsu (2007), for example, emphasize the importance of differences between party and autocratic dictatorships. Future research may examine the implication for urban bias of differences in political structure within dictatorial regimes. The large dataset on agricultural taxes and subsidies made available by Anderson and Valenzuela (2008) also provides an opportunity to empirically test alternative theories.

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A Appendix

A.1 Proof of propositions 2 and 3

We follow the usual procedure where we first conjecture that the set of strategies are MPE strategies and then verify the claim.[13]

MPE – Case 1

Note that, when $q = q_u$, urban residents are indifferent between paying the current tax τ_u and participating in an overthrow of the leader (upon the insider's call to do so) if

$$\frac{\beta(1-\tau_u(q_u))}{1-\beta} + 1 - \tau_u = 1 - \gamma + \frac{\beta}{1-\beta}\Big(p_u(1-\tau_u(q_u)) + p_r(1-\bar{\tau})\Big)$$

Under the conjecture, $\tau_i(q_s) = \bar{\tau}$ for all $i, s \in \{r, u\}$. So the above condition becomes

$$\frac{\beta(1-\bar{\tau})}{1-\beta} + 1 - \tau_u = 1 - \gamma + \frac{\beta}{1-\beta}\Big(p_u(1-\bar{\tau}) + p_r(1-\bar{\tau})\Big)$$
$$\tau_u = \gamma$$

By assumption A1, however, the leader is better off increasing the taxes to $\bar{\tau}$ and sharing the rent with the insider. Since the insider gets V_1 in each period, he does not have the incentive to call for an overthrow of the leader.

[13] See, for example, Hassler et al. (2003).

The insider's expected pay-off if he seizes the leadership is

$$\beta \frac{(1-\delta)\,\bar{\tau}\,(y_u+y_r)}{1-\beta}$$

The insider's pay-off if he continues to be an insider is

$$\frac{\delta\bar{\tau}\,(y_u+y_r)}{1-\beta}$$

When $\delta = \beta/(1+\beta)$, the above two pay-offs are equal. Hence, the insider does not have an incentive to stage an overthrow of the leader.

We also need to verify that the leader does not have the incentive to lower taxes to the citizens instead of bribing the insider:

$$\begin{aligned}(1-\delta)\,\bar{\tau}\,(y_u+y_r) &\geq \gamma y_u + \bar{\tau} y_r \\ &\geq \bar{\tau} y_u + \gamma y_r\end{aligned}$$

This condition will be satisfied under assumption A1.

MPE – Case 2, 3 and 4

Given the conjecture under Cases 2 and 3, and when $q = q_u$, urban residents are indifferent between paying the current tax τ_u and participating in an overthrow of the leader (upon the insider's call to do so) if

$$\frac{\beta(1-\tau_u(q_u))}{1-\beta}+1-\tau_u = 1-\gamma+\frac{\beta}{1-\beta}\Big(p_u(1-\tau_u(q_u))+p_r(1-\bar{\tau})\Big)$$
$$\tau_u = \gamma-\frac{\beta}{1-\beta}\Big(p_r(1-\bar{\tau})-(1-p_u)(1-\tau_u(q_u))\Big)$$
$$\tau_u = \gamma+\frac{\beta}{1-\beta}\Big((1-p_u)(\bar{\tau}-\tau_u(q_u))\Big)$$

In equilibrium, $\tau_u = \tau_u(q)$, which implies that $\tau_u = \tau_u^*$ (given by equation (3.2)).

Similarly, under Cases 2 and 4, and when $q = q_r$, rural citizens are indifferent between paying the current tax τ_r and protesting if

$$\frac{\beta(1-\tau_r(q_r))}{1-\beta}+1-\tau_r = 1-\gamma+\frac{\beta}{1-\beta}\Big(p_u(1-\bar{\tau})+p_r(1-\tau_r(q_r))\Big)$$
$$\tau_r = \gamma+\frac{\beta}{1-\beta}\Big((1-p_r)(\bar{\tau}-\tau_r(q_r))\Big)$$

In equilibrium $\tau_r = \tau_r(q)$, which implies that $\tau_r = \tau_r^*$ (given by equation (3.2)).

The leader does not have the incentive to decrease taxes below what is required to keep the urban and rural residents just indifferent between protesting or not (i.e. τ_u^* and τ_r^*).

If the leader increases the tax rates beyond τ_u^* and τ_r^*, he must appease the insider as citizens will support the insider's call for leader change. We verify that either of the assumptions A2, A3 or A4 imply that increasing taxes to $\bar{\tau}$ and sharing the rent with the insider is not optimal for the leader.

Case 2

Given the conjecture under Case 2, the discounted value of the expected future pay-off from remaining an insider is zero. The expected pay-off for the insider from seizing the leadership is:

$$\frac{\beta}{1-\beta}\left[p_u\left(\tau_u^* y_u + \bar{\tau} y_r\right) + p_r\left(\bar{\tau} y_u + \tau_r^* y_r\right)\right]$$

If the leader decides to rely on the insider's support, the insider's share has to be large enough so that he does not stage an overthrow of the leader:

$$\delta\bar{\tau}\left(y_u + y_r\right) = \frac{\beta}{1-\beta}\left[p_u\left(\tau_u^* y_u + \bar{\tau} y_r\right) + p_r\left(\bar{\tau} y_u + \tau_r^* y_r\right)\right]$$

$$\Longrightarrow \delta = \frac{\beta}{1-\beta}\frac{1}{\bar{\tau}\left(y_u + y_r\right)}\left[p_u\left(\tau_u^* y_u + \bar{\tau} y_r\right) + p_r\left(\bar{\tau} y_u + \tau_r^* y_r\right)\right]$$

For the leader to prefer lowering the taxes to the citizens (instead of bribing the insider), we should have:

$$\tau_u^* y_u + \bar{\tau} y_r, \bar{\tau} y_u + \tau_r^* y_r \geq (1-\delta)\,\bar{\tau}\left(y_u + y_r\right)$$

This is satisfied by assumption A2.

Thus, the leader proposes τ_u^* and τ_r^* as his optimal strategy. And knowing that he will not get the support from the citizens, the insider does not have the incentive to call for an overthrow of the leader.

Case 3

The value of seizing power equals

$$\frac{\beta}{1-\beta}\left[p_u\left(\tau_u^* y_u+\bar{\tau} y_r\right)+p_r(1-\delta)\,\bar{\tau}\left(y_u+y_r\right)\right]$$

Given the conjecture, when $q = q_r$, the discounted value of expected pay-offs from remaining an insider is

$$\frac{\delta\bar{\tau}\left(y_u+y_r\right)}{1-\beta}$$

where, according to Proposition 3,

$$\delta=\frac{\beta}{\left(1+\beta p_r\right)\bar{\tau}\left(y_u+y_r\right)}\left[p_u\left(\tau_u^* y_u+\bar{\tau} y_r\right)+p_r\bar{\tau}\left(y_u+y_r\right)\right]$$

Thus, when $q = q_r$, the insider does not have the incentive to overthrow the leader.

Given the conjecture, when $q = q_u$, the discounted value of expected future pay-offs from remaining an insider is zero. If the leader decides to bribe the insider, the leader's offer, denoted by δ_u below, must be large enough to make the insider indifferent between seizing power and receiving the rent today:

$$\delta_u\bar{\tau}\left(y_u+y_r\right)\geq\frac{\beta}{1-\beta}\left[p_u\left(\tau_u^* y_u+\bar{\tau} y_r\right)+p_r(1-\delta)\,\bar{\tau}\left(y_u+y_r\right)\right]$$

$$\Longrightarrow\delta_u\geq\frac{\beta}{1-\beta}\frac{1}{\bar{\tau}\left(y_u+y_r\right)}\left[p_u\left(\tau_u^* y_u+\bar{\tau} y_r\right)+p_r(1-\delta)\,\bar{\tau}\left(y_u+y_r\right)\right]$$

Assumption A3 means that: (i) when $q = q_r$ the leader prefers to offer δ to the insider rather than lowering the rural tax rate to τ_r^* and (ii) when $q = q_u$, the leader prefers lowering the urban tax rate to τ_u^* to offering the insider δ_u.

Case 4

Proving Case 4 follows similar steps as Case 3.

A.2 Proof of Corollary 1

We take the derivatives of $\mathbb{E}\tau_u$ with respect to the probabilities and see whether they are negative or positive.

$$\begin{aligned} 1\mathbb{E}\tau_u &= p_u\tau_u(q_u) + p_r\tau_u(q_r) \\ &= p_u\tau_u(q_u) + (1-p_u)\tau_u(q_r) \\ \implies \frac{d\mathbb{E}\tau_u}{dp_u} &= \tau_u(q_u) + p_u\frac{\partial\tau_u(q_u)}{\partial p_u} - \tau_u(q_r) + (1-p_u)\frac{\partial\tau_u(q_r)}{\partial p_u} \end{aligned}$$

Under Cases 2 and 3, $\tau_u(q_u) = \tau_u^*$ and $\tau_u(q_r) = \bar{\tau}$. Thus,

$$\frac{d\mathbb{E}\tau_u}{dp_u} = \tau_u^* + p_u\frac{\partial\tau_u^*}{\partial p_u} - \bar{\tau} + (1-p_u)\times 0$$

Since $\partial\tau_u^*/\partial p_u = -(1-\beta)\beta(\bar{\tau}-\gamma)/(1-\beta p_u)^2 < 0$,

$$\frac{d\mathbb{E}\tau_u}{dp_u} = p_u\frac{\partial\tau_u^*}{\partial p_u} - 2\bar{\tau} < 0.$$

Similar steps can be followed to prove that $\mathbb{E}\tau_r$ is decreasing in

p_r if either of assumptions A2 and A4 holds.

A.3 Proof of Corollary 1

First, note that if $p_u = p_r$, then $\mathbb{E}\tau_r/\mathbb{E}\tau_u = 1$ under Case 1 and 2. Under Case 3, $\mathbb{E}\tau_r/\mathbb{E}\tau_u > 1$. Under Case 4, $\mathbb{E}\tau_r/\mathbb{E}\tau_u < 1$. So we prove this corollary by proving that given that the condition $(1+\beta p_r)(\bar{\tau}-\gamma) / (p_u\beta) - 2\bar{\tau} > 0$ is satisfied, then assumption A3 is satisfied for a large enough y_r/y_u. This is true because, as y_r/y_u gets arbitrarily large, the LHS of A3 approaches minus infinity and the RHS of A3 approaches positive infinity.

A.4 Regression results for democracies

Table 3.4: Share of agriculture and NRA

	(A)	(B)	(C)	(D)	(E)
Agri. value added	0.53	0.05	−0.11	−0.28	−0.28
	(0.69)	(0.59)	(0.57)	(0.64)	(0.64)
Agri/non-Agri pop.		-0.30^{b}	−0.18	−0.16	−0.17
		(0.11)	(0.15)	(0.25)	(0.28)
Energy income			−0.02	−0.03	−0.03
			(0.03)	(0.03)	(0.03)
Mineral income			-0.04^{b}	-0.05^{b}	-0.05^{b}
			(0.02)	(0.02)	(0.02)
Government cons.			2.82	1.54	1.54
			(1.78)	(1.54)	(1.55)
Manuf. value added				12.70^{b}	12.69^{b}
				(5.16)	(5.21)
Manuf. square				-29.35^{a}	-29.33^{b}
				(10.82)	(10.92)
Armed conflicts					−0.00
					(0.01)
Observations	998	848	844	844	844
Countries	50	45	44	44	44
R-Square	0.002	0.008	0.026	0.084	0.084

Robust standard errors clustered by country are in parentheses.
^{c} $p < 0.10$, ^{b} $p < 0.05$, ^{a} $p < 0.01$

Chapter 4

Does agricultural growth cause manufacturing growth?*

Abstract: *The role of agricultural development for industrialization is central both to several theories of economic development and policy. However, empirically assessing the impact of agricultural growth on manufacturing growth is challenging because of endogeneity concerns. To address the identification challenge, I use random weather variations to instrument agricultural growth. The instrumental variable estimations show that agricultural growth has a significant positive impact on manufacturing growth, and the impact is larger than what is suggested by the OLS estimates. I discuss the empirical implications for agricultural policies, efficiency of the manufacturing sector, and the role of agriculture in Africa's industrialization.*

*I thank Per Krusell, Jakob Svensson and participants in the macro study group at the IIES for helpful feedback. I also thank Christina Lönnblad for proof-reading.

4.1 Introduction

The role of agricultural development for industrialization has been an important issue both in economic theory and development policy for a long period of time, gaining prominence as early as in the 1950s with the seminal work by Lewis (1954). Many developing countries tried to promote industrialization at the expense of agricultural growth through a transfer of resources from their vast agricultural sector to the manufacturing sector by imposing high agricultural taxes and subsidizing the manufacturing sector (Schiff and Valdés, 2002; Krueger, 1996). On the other hand, the development of the manufacturing sector may benefit substantially from agricultural growth due to various potential channels through which agricultural growth may enhance manufacturing growth (e.g., supply of raw materials and increased demand for manufacturing products). Thus, taxing the agricultural sector with the aim of subsidizing the manufacturing sector and promoting industrialization may actually end up reducing manufacturing growth since high taxes on the agricultural sector may discourage agricultural growth, indirectly reducing manufacturing growth. Such a view underlies another policy approach where agricultural development is assumed to be the fundamental driver of industrialization and countries put more emphasis on investing in the agricultural sector (as opposed to imposing high taxes on the agricultural sector).[1]

[1] For example, Ethiopia followed the so-called Agricultural Development Led Industrialization (ADLI) where the development of agriculture is assumed to lead to industrialization and the government provides active support for the agricultural sector in the form of rural infrastructure and extension services.

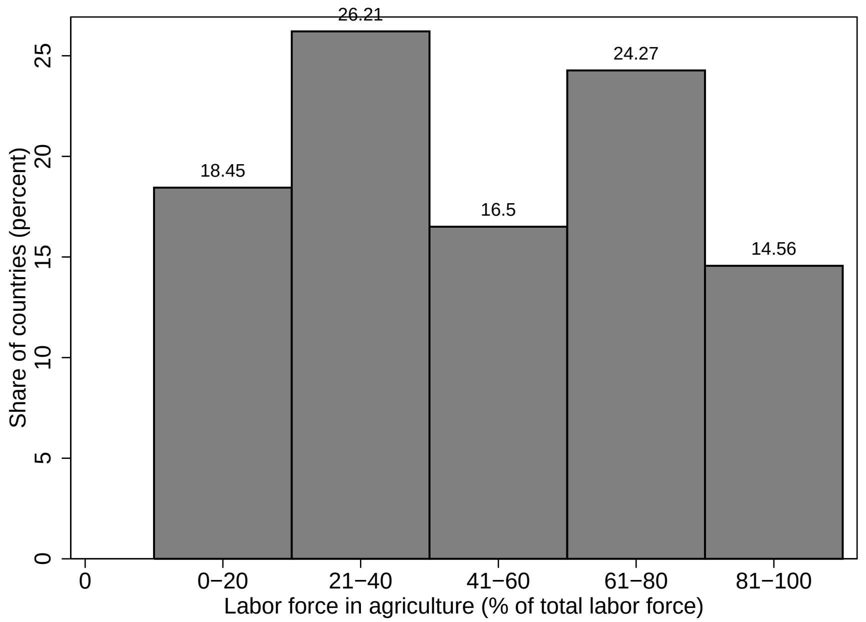
These two divergent policy approaches illustrate the stark choices that countries face regarding resource allocations between the agricultural and the manufacturing sectors in order to speed up industrialization. Central to the two policy prescriptions is the perceived impact of agricultural growth on manufacturing growth. However, empirically identifying the actual impact has been a challenge since the observed correlations between the two growth rates do not necessarily capture the causal effects. In this paper, I attempt to address this challenge by estimating the impact of agricultural growth on manufacturing growth using a reasonably reliable set of instruments.

The focus on manufacturing growth also distinguishes this paper from a number of other empirical studies that examine the impact of agricultural growth: Tiffin and Irz (2006) examine the impact of agricultural growth on overall GDP, Christiaensen et al. (2011) on non-agricultural GDP and poverty rate, and Bruckner (2012) on urbanization in Sub-Saharan Africa. The link between agriculture and manufacturing sectors is interesting for several reasons. First, agriculture typically constitutes a dominant portion of the economies in developing countries. For example, at least half of the total labor force is engaged in agriculture in nearly half of the low and lower middle income countries (see Figure 4.1). Second, as has been experienced by the East Asian economies, growth in the manufacturing sector can make an important difference in the growth prospect of overall GDP in a developing country (Page, 2012). Thus, from a policy prespective, the extent to which agricultural development should be seen as an integral part of industrialization policies partly depends on the expected impact of agricultural growth on manufacturing growth. The link between agricultural development and manufacturing growth also underlies several models of structural change. Murphy et al. (1989) develop a model where an increase in agricultural productivity, by increasing the demand for industrial products, leads to industrialization. The role of agricultural development for generating a market for the manufacturing sector is also noted by earlier works (see, e.g., Nurkse, 1953; Lewis, 1954; Mellor and Johnston, 1961, 1984). The provision of labor for the manufacturing sector is the core element of the seminal work by Lewis (1954) and several other models of structural change (see, e.g., Fleming, 1955; Ranis and Fei, 1961; Jorgenson, 1961; Harris and Todaro, 1970; Matsuyama, 1992; Laitner, 2000, Gollin et al., 2002; Hansen and Prescott, 2002; Lucas, 2004).

Using country-level panel data, I exploit the within-country random variations in the weather (temperature and precipitation) to instrument for within-country variations in agricultural growth. Agriculture is heavily dependent on the weather and this is also visible in the strong correlation between agricultural growth and weather variations in the data. Since the weather variations are independent of factors that may also affect other sectors (like overall economic policies and technological changes), they provide a plausibly exogenous source of variation in agricultural growth – a feature that has recently been exploited by a number of other studies too (e.g., see Bruckner, 2012; Burke and Leigh, 2010; Miguel et al., 2004).

Estimating for the whole sample (covering 127 countries and 2712 observations), I find that the impact on manufacturing growth of a 1 percentage point increase in agricultural growth is within the

Figure 4.1: Distribution of countries by the agricultural labor force in low and low middle income countries, year 2000



The bars plot the share of countries (among the 103 low and lower middle income countries in the sample) according to their agricultural labor force. The first bar plots the share of countries where 0-20 % of the labor force are engaged in agriculture, the second bar plots the share of countries where 20-40 % of their labor force are engaged in agriculture, and so on.

vicinity of 0.4 percentage points. This is nearly twice as large as the OLS estimates, which are around 0.2 percentage points.

The estimates for the whole sample can mask potential heterogeneities across sub-samples. A possible factor that affects the impact of agricultural growth is the efficiency of the manufacturing sector in the reallocation of factors. For example, suppose that agricultural growth affects manufacturing growth through a cheaper (or more abundant) supply of agricultural inputs for the manufacturing sector. Then, whether firms in the manufacturing sector take advantage of the increased supply of agricultural inputs may depend on their efficiency in mobilizing inputs. If there are various constraints that limit the manufacturing sector's efficiency in reallocation of factors, the impact of agricultural growth may be less pronounced. I look at trade closeness as one potential source of such inefficiency. I find that the impact of agricultural growth is larger in economies that are more open to trade, suggesting that the competitiveness of the manufacturing sector is indeed important for translating agricultural growth into a higher growth in the manufacturing sector.

Another potential source of heterogeneity could be policies toward the agricultural vis-à-vis the manufacturing sector. A number of countries adopted state-led industrialization policies that relied on taxing the agricultural sector to subsidize the manufacturing sector (Schiff and Valdés, 2002; Krueger, 1996). On the one hand, these policies can be expected to amplify the impact of agricultural growth through state-led resource transfer. On the other hand, the policies can encourage inefficiency in the manufacturing sector through the subsidies. Using data on tax rates on the agricultural sector relative to tax rates on other sectors as a proxy for the extent of state-led resource extraction from the agricultural sector, I examine if those policies have indeed led to a higher impact of agricultural growth. I do not find evidence of such an effect.

I also look at the impact of agricultural growth for the Sub-Saharan Africa (SSA) sub-sample to see the extent to which SSA's low agricultural growth explains the poor performance in the manufacturing sector. Separate regressions for SSA confirm that the coefficient for the impact of agricultural growth is more or less the same (around 0.4). SSA is an interesting sub-sample because, compared to the high performing East Asian and Pacific (EAP) region, SSA experienced low growth rates both in the manufacturing and agricultural sectors. During 1965-2000, the growth rate of manufacturing output was nearly 10% per year in EAP while it was only 3.7% in SSA, implying a gap of 6.3 percentage points in manufacturing growth rates between EAP and SSA. Similarly, agricultural output per worker grew by an average of 3.2% per annum in EAP while it remained stagnant at 0.2% per annum in SSA. Given that the coefficient for the impact of agricultural growth on manufacturing growth is in the vicinity of 0.4, the 3 percentage point gap in agricultural productivity growth between the two regions implies a 1.2 percentage point gap in the manufacturing growth rate. Thus, the gap in agricultural growth between the two regions would explain about one-fifth of the 6.3 percentage point gap in manufacturing growth.

Although the use of reasonably exogenous instruments is an appealing element of the estimates in this paper, we have to bear in mind that weather variations are essentially short-run variations. Thus, the impact of such short-run variations could differ from long-term shifts in productivity due to, say, improved seed varieties or shifts in government policies. Hence, the estimated impacts in this paper are more likely to come from short-run effects such as increased consumption demand for manufacturing products (due to improved farm incomes) and a more abundant supply of agricultural inputs than from long-run effects like the release of labor from agriculture to manufacturing. This will also be confirmed by the insignificance of the lagged terms in the instrumental variable estimations.

The next section presents the data. It will be followed by discussion of the empirical results. Section 4.4 concludes.

4.2 Data

Table 4.1 presents summary statistics of the variables included in the analysis. Data on both agricultural growth and manufacturing growth is available for 3407 observations (from 161) countries during the period 1960-2000. The year 2000 is the latest year for which weather data is available. Agriculture value added includes the sum of value added in the sectors corresponding to 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 source for precipitation and temperature data is Mitchell et al. (2004). The rest of the variables listed in Table 4.1 will be included as control variables in the regression analysis. The data on agricultural growth, manufacturing growth, population growth, and

and mineral and energy depletions as a percentage of GNI is from the *World Development Indicators* by the World Bank.[2] Data on the number of anti-government demonstrations (the variable "Protests") is from Data Bank International. The level of democracy (variable "Democracy"), ranging from -10 for the least democratic to 10 for the most democratic regimes, is the polity2 variable in the Polity IV dataset. The data on the share of the agricultural labor force is from the World Resource Institute. Agricultural and manufacturing growth rates for the whole sample are 2.6% and 4.6% per annum, respectively. The whole sample consists of diverse groups of countries.[3]. This indeed masks substantial heterogeneity across subsamples. Five highly-performing East Asian economies (HPEA) – namely, Cambodia, China, Indonesia, Malaysia and Thailand – experienced a rapid industrialization during the sample period with 10.7% annual growth in the manufacturing value added. On the other hand, Sub-Saharan Africa (SSA) experienced a relatively slow growth in the manufacturing sector despite having a substantial room for further industrialization (as measured by the low level of industrialization in 1970). The manufacturing growth gap between SSA and HPEA economies is also somehow mirrored in the agricultural growth gap. Annual agricultural growth averaged at 4% per annum in HPEA, which exceeds that of Sub-Saharan Africa (SSA) by 0.6

[2]Accessed at http://databank.worldbank.org/data/views/variableselection/select variables.aspx?source= world-development-indicators on February 26, 2012.

[3]In the whole sample, 18% of the observations are from high income groups (according to the World Bank classification). The shares of observations from upper middle income, lower middle income and low income countries are 35%, 29% and 19%, respectively.

Table 4.1: Summary Statistics

Variable	**Mean**	**SD**	**Obs.**	**Countries**
Agricultural growth (%)				
Whole sample	2.6	9.3	3407	161
SSA	2.9	11.0	896	38
EA	3.5	4.0	152	5
Manufacturing growth (%)				
Whole sample	4.6	10.9	3407	161
SSA	4.5	12.4	896	38
EA	10.7	7.7	152	5
Manufacturing (% of GDP)				
Whole sample	15.7	7.9	3112	157
SSA 1970	10.3	5.1	24	24
SSA 2000	11.1	7.0	41	41
HPEA 1970	18.1	10.7	4	4
HPEA 2000	28.2	6.7	5	5
Agriculture labor force (%)				
Whole sample	44.2	27.0	3241	154
SSA 1970	78.6	15.3	44	44
SSA 2000	63.9	20.9	45	45
HPEA 1970	71.3	11.3	5	5
HPEA 2000	52.0	20.5	5	5
Population growth (%)				
Whole sample	1.9	1.3	3407	161
SSA	2.7	1.2	896	38
HPEA	2.1	0.6	152	5
Protests	0.6	1.8	2854	134
Democracy	0.6	7.3	2829	132
Energy depletion	3.3	8.0	2554	131
Mineral depletion	1.0	2.9	2554	131
Precipitation	1221.5	806.2	2905	134
Temperature	20.2	7.2	2905	134

percentage points. Compared to SSA, EA experienced a larger reduction in the agricultural labor force (as a share of the total labor force) and a slower population growth. Thus, the higher agricultural output growth in EA is largely driven by increased output per worker (i.e., the growth happened despite a relatively slower growth in the agricultural labor force).[4]

Note also that HPEA started out with a higher share of the manufacturing sector (at 18.1% of the GDP) in 1970, as compared to SSA whose manufacturing value added was only 10.3%. The manufacturing sector continued to keep a relatively small share in SSA until the year 2000 while it increased substantially in EA, constituting nearly one-third of the GDP in the year 2000.

4.3 Empirical Results

4.3.1 Partial correlations

The regression model under consideration is

$$Manu\_g_{i,t} = \sum_{l=0}^{L} \beta_l Agri\_g_{i,t-l} + \Gamma X_{i,t} + \alpha_i + \alpha_t + \varepsilon_{i,t} \qquad (4.1)$$

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 $\varepsilon_{i,t}$ are control variables, year dummy and country dummy,

[4]Note that the calculated figures are not weighted by the relative size of each observation. Thus, the means reported here, for example, are not meant to calculate the mean values at the regional level.

respectively.

Table 4.2 presents the partial correlation between growth in agricultural and manufacturing output. Columns labeled (FE) control for country-fixed effects while the other columns report ordinary least square (OLS) estimates. The fixed-effect estimates have the advantage of controlling for country-specific factors that do not vary over time such as geography, initial conditions, historical legacies, etc. For example, we noticed in the descriptive statistics that, compared to Sub-Saharan Africa, the initial level of industrialization was substantially larger in the high-performing East Asian economies. Such differences would be accounted for by country-specific dummies in the fixed-effect regressions. The last four columns control for four lags of agricultural growth. Each regression is estimated with and without year dummies. We notice a few patters in the data. Current and lagged agricultural growth are significantly correlated with manufacturing growth. The correlation is the highest with current growth in agriculture and falls for further lags. The third and fourth lags are more or less insignificant. The correlation with current agriculture increases as we control for lags. This is because current agricultural growth is negatively correlated with lagged agricultural growth in the data (with a correlation coefficient of -0.19). Hence, dropping the lag term reduces the coefficient on current agricultural growth if the lag term is positively correlated with manufacturing growth, which is the case here. The inclusion of year dummies seems to slightly slow down the correlation between agricultural growth and manufacturing growth, suggesting that part of the correlation is driven by global trends in both manufacturing and agricultural growth. The

Table 4.2: Partial correlation between manufacturing and agricultural growth (without controls)

	OLS				FE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Agri_g$	0.17[a]	0.15[a]	0.20[a]	0.18[a]	0.15[a]	0.14[a]	0.20[a]	0.19[a]
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)
L.$Agri_g$			0.12[a]	0.11[a]			0.13[a]	0.12[a]
			(0.03)	(0.03)			(0.03)	(0.03)
L2.$Agri_g$			0.08[a]	0.06[b]			0.08[a]	0.07[b]
			(0.03)	(0.03)			(0.03)	(0.03)
L3.$Agri_g$			0.03	0.02			0.03	0.02
			(0.03)	(0.03)			(0.03)	(0.03)
L4.$Agri_g$			0.06[b]	0.05[b]			0.05[c]	0.05[c]
			(0.02)	(0.02)			(0.03)	(0.03)
Year	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	3407	3407	2977	2977	3407	3406	2977	2971
Countries					161	160	159	153
R-square	0.02	0.02	0.04	0.03	0.02	0.01	0.04	0.03

The dependent variable is manufacturing growth. The right-hand-side variables are agricultural growth ($Agri_g$) and its four lags. The first four columns present the OLS estimates while the last four columns present the fixed-effect estimates. Robust standard errors clustered by country are in parentheses.

[a] significant at the 1 percent level.

[b] significant at the 5 percent level.

[c] significant at the 10 percent level.

fixed effect and OLS estimations give more or less the same coefficients, probably due to the fact that a large part of the variations in the data is driven by within-country changes (rather than between-country changes).

Table 4.3 includes the estimation results controlling for a wide variety of control variables. Both agricultural growth and manufacturing growth could be jointly affected by a number of factors. Availability of labor could be one of those factors. The population growth rate and the share of agricultural labor force are meant to control for growth in the total labor force and changes in its composition. We observe that manufacturing growth is positively correlated with population growth and the share of agricultural labor force. Another set of factors that could affect both agricultural and manufacturing growth rates are policies and institutions. There is some empirical evidence that large income shocks are associated with political protests, violence and democratization (e.g., see Burke and Leigh, 2010, Miguel et al., 2004, and Brückner and Ciccone, 2011). Thus, I also control for the number of anti-government demonstrations and the level of democracy.

An abundance of natural resources can also reduce both agricultural and manufacturing growth through the classic Dutch-disease effect and the potential erosion of institutional quality (Sachs and Warner, 1995a). The negative coefficients on the two measures of natural resource abundance – the share of mineral depletion and energy depletion in Gross National Income – are consistent with this story.

Including the control variables seems to reduce the coefficients on

Table 4.3: Impact of agricultural growth (partial correlations)

Dependent var:	OLS				FE			
Manu. growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Agri_g$	0.15^a	0.14^a	0.16^a	0.15^a	0.13^a	0.12^a	0.16^a	0.15^a
	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
L.$Agri_g$			0.12^a	0.11^a			0.12^a	0.11^a
			(0.04)	(0.04)			(0.04)	(0.04)
L2.$Agri_g$			0.07^c	0.06^c			0.06	0.05
			(0.04)	(0.04)			(0.03)	(0.03)
L3.$Agri_g$			0.05^c	0.04			0.03	0.02
			(0.03)	(0.03)			(0.03)	(0.03)
L4.$Agri_g$			0.06^b	0.05^b			0.04	0.04
			(0.02)	(0.02)			(0.02)	(0.02)
Agri. labor	0.02	0.02	0.02	0.02	0.20^a	0.18^b	0.19^a	0.17^b
	(0.02)	(0.02)	(0.02)	(0.02)	(0.06)	(0.08)	(0.06)	(0.07)
Pop. growth	0.63^b	0.55^c	0.19	0.15	0.57	0.65^c	0.40	0.49
	(0.31)	(0.31)	(0.35)	(0.36)	(0.46)	(0.37)	(0.48)	(0.39)
Protests	−0.12	−0.13	−0.11	−0.12	-0.33^b	-0.31^b	-0.32^b	-0.31^b
	(0.19)	(0.19)	(0.19)	(0.18)	(0.14)	(0.13)	(0.14)	(0.13)
Democracy	−0.03	−0.01	−0.03	−0.01	0.07	0.04	0.09	0.06
	(0.05)	(0.05)	(0.05)	(0.05)	(0.07)	(0.07)	(0.07)	(0.07)
Energy	-0.07^c	-0.07^c	−0.04	−0.04	0.01	0.02	0.01	0.02
	(0.04)	(0.04)	(0.03)	(0.03)	(0.06)	(0.06)	(0.07)	(0.07)
Mineral	-0.17^b	-0.26^a	-0.18^b	-0.26^a	−0.11	−0.15	−0.07	−0.11
	(0.08)	(0.08)	(0.09)	(0.08)	(0.16)	(0.15)	(0.16)	(0.15)
Year	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	2479	2479	2298	2298	2479	2478	2298	2292
Countries					128	127	127	121
Rsquare	0.04	0.03	0.05	0.04	0.03	0.02	0.05	0.04

The RHS variables are agricultural growth ($Agri_g$), its lags and the controls. Columns (1)-(4) are OLS estimates while columns (5)-(8) are fixed-effect estimates. Standard errors are clustered by country. ^{c} $p < 0.10$, ^{b} $p < 0.05$, ^{a} $p < 0.01$.

current agricultural growth by 0.03-0.05 percentage points. The coefficient on the second lag also becomes insignificant. This suggests that part of the correlation between agricultural and manufacturing growth is indeed a reflection of co-movements driven by other variables that jointly affect both agricultural and manufacturing growth. In the presence of other variables that are not controlled for in the regressions and that can jointly affect both agricultural and manufacturing growth, the estimated coefficients may not be consistent due to the classical omitted variable problem.

OLS estimates of β_l's in equation (4.1) can potentially be inconsistent for several reasons. Technically speaking, such a bias can occur if the error term $\varepsilon_{i,t}$ is correlated with $Agri\_g_{i,t-l}$.

One potential source of bias is reverse causality, whereby manufacturing growth affects agricultural growth (instead of the other way round). For example, a higher manufacturing growth can lead to an increased demand for agricultural goods and a more abundant (or cheaper) supply of inputs from the manufacturing sector to the agricultural sector. In the presence of such reverse-causality, the partial correlations may over-estimate the impact of agricultural growth. On the other hand, the partial correlations may under-estimate the impact of agricultural growth if manufacturing growth has a negative impact on agricultural growth. For example, growth in the manufacturing sector may go hand in hand with a structural transformation where labor resources are moved from the agricultural sector to the manufacturing sector, as in Lewis (1954).

Another plausible source of bias in the ordinary regressions is the possibility that the observed correlation between manufacturing and agricultural growth is driven by a set of other factors that cause both variables to co-move, but that are not included in the regression. The fall in the estimated agricultural growth as we control for more variables shows that this is a relevant concern in our estimation (see Tables 4.2 and 4.3). Even though such a bias could theoretically be handled by controlling for all relevant variables, it is not a practical option due to data constraints.

Yet a further source of bias is measurement error in the agricultural growth data. This is of particularly concern for developing countries where the data quality is likely to be less reliable.

The instrumental variable estimation reported in the next section addresses the potential bias in the above regressions.

4.3.2 Instrumental variable estimates

Main results

In order to address the concern that ordinary regressions are likely to suffer from various sources of bias, I estimate equation (4.1) instrumenting agricultural growth by variations in the weather. The first-stage regression is

$$\begin{aligned} Agri\_g_{i,t} = & \psi_1 Prec_{i,t} + \psi_2 Prec_{i,t-1} + \pi Temp_{i,t} + \\ & \Phi X_{i,t} + \theta_i + \theta_t + \mu_{i,t} \end{aligned} \tag{4.2}$$

where $Prec_{i,t}$ and $Temp_{i,t}$ are measures of precipitation and temperature. Following Burke and Leigh (2010), $Prec_{i,t}$ is the annual percentage change in precipitation and $Temp_{i,t}$ measures the annual change in temperature[5]. ψ's are expected to have a positive sign whereas π is expected to be negative.

For the instrumental variable estimation to give a consistent estimate, two identifying assumptions must be satisfied:(i) the weather variations are relevant instruments (i.e., they are correlated with $Agri\_g_{i,t}$) , and (ii) the weather variations are exogenous (i.e., they are not correlated with the error term $\varepsilon_{i,t}$). As we will see, the first assumption is satisfied since there is quite a strong correlation between variations in the weather and agricultural output. This is not surprising given the heavy dependence of agriculture on the weather.

The exogeneity of weather variations is also a fairly plausible assumption since changes in temperature and precipitation do not depend on the overall economic environment that may affect both agricultural and manufacturing growth (such as macro policies, institutions, price movements, etc). Unlike agriculture, the manufacturing sector is not directly dependent on the weather. Hence, the effect of weather variations on the manufacturing sector can plausibly be argued to come through the agricultural sector. However, one A potential concern, however, is that large changes in the weather (like heavy rains) may also affect manufacturing growth by flooding and damaging roads, for example. To address this concern, observations with extreme variations in precipitation (i.e., observations with more than a 50% change in precipitation) are excluded from the regressions

[5]Following Burke and Leigh (2010), the temperature change is multiplied by -1 if the 1960-70 average temperature is below 12° Celsius because an increase in temperature can be conducive for agriculture in cold areas.

with the precipitation instrument.

Table 4.4 summarizes the first-stage regressions for a wide variety of alternative specifications. In Panel A, the only instruments we have are perception growth and its lag. Panel B only has the temperature instrument while Panel C includes all instruments. The estimations are done with the inclusion/exclusion of country-fixed effects, year dummies and control variables. The first four columns do not include the control variables while the last four columns do. Columns labeled "FE" control for country-specific fixed effects while those labeled "OLS" do not. In all specifications, precipitation growth has a large and statistically significant effect on agricultural growth. A one percentage point increase in current (lag) precipitation growth increases agricultural growth by about seven (four) percentage points. The first four columns of Panel A also show that precipitation variations alone explain 2% of the variation in agricultural growth.

The temperature instrument also has a large and statistically significant effect on agricultural growth. A unit increase in the temperature instrument decreases agricultural growth by about 2 percentage points. The first four columns in Panel B show that one percent of the variation in agricultural growth is explained by the variation in the temperature instrument. The coefficients in Panel C are slightly slower than those in Panels A and B. Otherwise, in all specifications, the coefficients on the instruments are by and large remarkably stable.

Panel A of Table 4.5 presents the estimated impact of agricultural growth using the instrumental variables and without including the controls. In the first four columns, the precipitation and temperature

Table 4.4: First stage (agricultural growth and weather)

Dependent var:	OLS				FE			
Agri. growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Precipitation instrument								
$Precip_{i,t}$	7.97^a	7.54^a	8.21^a	7.67^a	7.97^a	7.52^a	8.29^a	7.69^a
	(1.93)	(1.86)	(2.08)	(1.97)	(2.00)	(1.88)	(2.18)	(2.00)
$Precip_{i,t-1}$	4.43^a	4.15^a	3.96^a	3.72^b	4.58^a	4.29^a	4.20^a	3.91^b
	(1.40)	(1.46)	(1.45)	(1.51)	(1.46)	(1.49)	(1.54)	(1.56)
Obs.	2713	2713	2343	2343	2713	2712	2343	2342
Countries					128	127	123	122
F	10.04	9.04	9.93	10.01	9.61	8.89	4.72	5.78
Rsquare	0.02	0.02	0.04	0.04	0.02	0.02	0.03	0.02
Panel B: Temperature instrument								
$Temp_{i,t}$	-2.00^a	-1.96^a	-2.17^a	-2.17^a	-2.15^a	-2.10^a	-2.25^a	-2.26^a
	(0.42)	(0.45)	(0.47)	(0.51)	(0.44)	(0.46)	(0.50)	(0.52)
Obs.	2905	2905	2479	2479	2905	2904	2479	2478
Countries					134	133	128	127
F	22.18	18.36	9.82	8.65	23.56	20.25	5.74	6.03
Rsquare	0.01	0.01	0.03	0.03	0.01	0.01	0.02	0.02
Panel C: Both instruments								
$Precip_{i,t}$	7.05^a	6.68^a	7.11^a	6.64^a	6.91^a	6.53^a	7.10^a	6.57^a
	(1.88)	(1.82)	(2.01)	(1.91)	(1.95)	(1.83)	(2.10)	(1.94)
$Precip_{i,t-1}$	4.03^a	3.84^a	3.56^b	3.39^b	4.11^a	3.92^a	3.76^b	3.55^b
	(1.38)	(1.42)	(1.40)	(1.45)	(1.43)	(1.44)	(1.49)	(1.50)
$Temp_{i,t}$	-1.51^a	-1.48^a	-1.66^a	-1.69^a	-1.69^a	-1.65^a	-1.75^a	-1.80^a
	(0.37)	(0.41)	(0.41)	(0.45)	(0.39)	(0.42)	(0.43)	(0.46)
Obs.	2713	2713	2343	2343	2713	2712	2343	2342
Countries					128	127	123	122
F	9.59	8.35	9.27	8.95	9.67	8.68	5.37	6.26
Rsquare	0.03	0.02	0.05	0.04	0.03	0.03	0.04	0.03
Year	No	Yes	No	Yes	No	Yes	No	Yes
Controls	No	No	Yes	Yes	No	No	Yes	Yes

$Precip_{i,t}$ and $Temp_{i,t}$ are the precipitation and temperature instruments, respectively. See Table 4.5 for the list of controls. ^{c} $p < 0.10$, ^{b} $p < 0.05$, ^{a} $p < 0.01$.

instruments are included separately whereas in the last two columns, all instruments are included in the regression. The F-stat from the first-stage regression indicates that temperature is the strongest instrument. The p-values of the Hansen J statistics do not to reject the exogeneity of the instruments. The estimated impact of agricultural growth is also fairly stable with respect to alternative instruments. According to the results in Panel A of Table 4.5, a one percentage point increase in agricultural growth increases manufacturing growth by 0.38 - 0.48 percentage points. Note that these estimates are substantially larger than those from the ordinary regressions, where the estimated coefficients are in the range of 0.14-0.2 (see Tables 4.2 and 4.3). This suggests that the endogeneity sources that may cause a downward bias in the ordinary regressions (such as classical measurement error) tend to outweigh those that may cause an upward bias.

Panel II of Table 4.5 reports the estimation results with the control variables. The sample size now drops slightly due to missing observations for some of the control variables. We observe that the coefficients are quite robust to the inclusion of the control variables. The stability of coefficients for the inclusion/exclusion of alternative instruments and control variables is quite comforting since it gives further credence to the exogeneity of the instruments.

Table 4.6 includes both the first and second lags as control variables. Controlling for further lags makes inference difficult because the inclusion of the lags somehow happens to substantially lower the F-stat. Remember also that only the current and first lag of agricultural growth happen to be significant in the ordinary regressions with

Table 4.5: Impact of agricultural growth: IV estimates

	Instrument					
Dependent var:	Precipitation		Temperature		Both	
Manu. growth	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Without controls					
$Agri_g$	0.38^c	0.46^b	0.43^a	0.48^a	0.39^b	0.45^b
	(0.21)	(0.23)	(0.16)	(0.17)	(0.17)	(0.18)
Observations	2712	2712	2904	2904	2712	2712
Countries	127	127	133	133	127	127
F-stat of 1st stage	10.08	8.89	24.70	20.25	10.15	8.68
P-value of Hansen J	0.52	0.69			0.80	0.92
	Panel B: With controls					
$Agri_g$	0.41^c	0.48^c	0.42^a	0.44^a	0.41^b	0.46^b
	(0.22)	(0.25)	(0.16)	(0.17)	(0.17)	(0.18)
Agri. labor	0.17^a	0.14^c	0.19^a	0.16^b	0.17^a	0.14^c
	(0.05)	(0.08)	(0.05)	(0.08)	(0.05)	(0.08)
Pop. growth	0.46	0.49	0.38	0.43	0.46	0.51
	(0.47)	(0.41)	(0.46)	(0.39)	(0.46)	(0.38)
Protests	-0.34^b	-0.33^b	-0.31^b	-0.31^b	-0.34^b	-0.33^b
	(0.14)	(0.14)	(0.13)	(0.13)	(0.14)	(0.14)
Democracy	0.06	0.03	0.07	0.05	0.06	0.03
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Energy (% of GNI)	0.03	0.02	0.02	0.01	0.03	0.02
	(0.06)	(0.07)	(0.06)	(0.07)	(0.06)	(0.07)
Mineral (% of GNI)	−0.05	−0.08	−0.06	−0.10	−0.05	−0.08
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.14)
Observations	2342	2342	2478	2478	2342	2342
Countries	122	122	127	127	122	122
1st stage F-stat	9.29	8.13	21.52	18.65	8.93	8.07
Hansen J P-val	0.45	0.62			0.75	0.84
Year dummy	No	Yes	No	Yes	No	Yes

$Agri_g$ is agricultural growth. Columns (1)-(4) include the precipitation and the temperature instruments separately. Columns (5) and (6) include both instruments. Standard errors clustered by country. ^{c} $p < 0.10$, ^{b} $p < 0.05$, ^{a} $p < 0.01$.

control variables and country fixed effects (see the last two columns in Table 4.3). Current agricultural growth remains significant and the coefficients are more or less similar to those without controlling for the lags. It is also interesting that the first lag of agricultural growth, which is significant in the ordinary regressions (see Tables 4.2 and 4.3), is no longer significant. A potential reason is that the correlation in the ordinary regressions is spurious. It could also be due to the nature of the instruments. Weather variations are typically short-lived and they are not expected to last long. Thus, we are effectively estimating the impact of short-lived variations in agricultural growth that do not alter the expectations about future productivity. Sub-Saharan Africa (SSA) is a particularly interesting sub-sample. First, it is heavily dependent on agriculture – over two-thirds of the population live in rural areas. Second, despite the availability of a vast and cheap labor force in SSA, the kind of low-skill manufacturing growth experienced by the East Asian countries did not happen in SSA. The share of manufacturing value added in SSA's GDP is stagnant at the level of the 1970s. Third, parallel to the dismal performance in the manufacturing sector, SSA experienced the least growth in agricultural per-capita incomes as compared to many other regions. [6]

Table 4.7 presents the estimates of only the SSA sub-sample. The estimates are reported for alternative sets of instruments. The first three columns do not include the control variables while the last three columns do. The estimated impact of agricultural growth for the SSA sub-sample is more or less similar to the one for the whole sample.

[6] World Development Report 2008, World Bank, pp. 53

Table 4.6: Lagged effects

	Instrument					
	Precipitation		Temperature		Both	
	(1)	(2)	(3)	(4)	(5)	(6)
$Agri_g$	0.42^c	0.33	0.45^a	0.49^a	0.45^b	0.40^b
	(0.25)	(0.26)	(0.16)	(0.16)	(0.18)	(0.20)
L.$Agri_g$	−0.22	−0.31	0.13	0.11	−0.15	−0.24
	(0.24)	(0.30)	(0.20)	(0.18)	(0.17)	(0.21)
L2.$Agri_g$	−0.27	−0.44	0.14	0.04	−0.19	−0.28
	(0.25)	(0.28)	(0.19)	(0.17)	(0.17)	(0.19)
Observations	2515	2206	2350	2725	2515	2206
Countries	123	119	126	131	123	119
F-stat of 1st stage	1.99	1.48	3.92	4.88	2.64	2.27
P-value of Hansen J	0.47	0.41			0.50	0.25
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	No	No	Yes

The dependent variable is manufacturing growth. The right-hand-side variables are agricultural growth ($Agri_g$), its two lags and the control variables. Columns (1)-(4) include the precipitation and temperature instruments separately. Columns (5) and (6) include both instruments. Robust standard errors clustered by country are in parentheses. See Table 4.5 for the list of controls. ^{c} $p < 0.10$, ^{b} $p < 0.05$, ^{a} $p < 0.01$.

This is somewhat surprising given that agriculture constitutes a relatively larger share of the SSA economy. Thus, a percentage point increase in SSA's agricultural growth can be expected to have a larger impact. The next section presents some empirical insight as to why a larger share of agriculture may not always translate into a higher impact of agricultural growth. During 1965-2000, the growth rate

Table 4.7: Impact of agricultural growth in SSA

	Instrument					
	Precipitation		Temperature		Both	
	(1)	(2)	(3)	(4)	(5)	(6)
Agri_g	0.34	0.43	0.53^b	0.47^b	0.43^c	0.46^c
	(0.29)	(0.32)	(0.26)	(0.22)	(0.25)	(0.26)
Controls	No	Yes	No	Yes	No	Yes
Observations	808	746	874	776	808	746
Countries	35	35	37	36	35	35
1st stage F-stat	7.73	7.90	15.15	16.52	9.29	10.76
Hansen J p-val	0.60	0.49			0.64	0.78

This table presents the instrumental variable estimation results for the Sub-Saharan Africa sample. The dependent variable is manufacturing growth. The variable $Agri_g$ is agricultural growth. The first four columns include the precipitation instruments [columns (1) and (2)] and the temperature instrument [columns (3) and (4)] separately. The last two columns include both instruments. See Table 4.5 for the list of controls. Robust standard errors clustered by country are in parentheses.
[a] significant at the 1 percent level.
[b] significant at the 5 percent level.
[c] significant at the 10 percent level.

of manufacturing output was nearly 10% per year in EAP while it was only 3.7% in SSA, implying a gap of 6.3 percentage points in the manufacturing growth rates between EAP and SSA. Similarly, agricultural output per worker grew by an average of 3.2% per annum in EAP while it remained stagnant at 0.2% per annum in SSA. Given that the coefficient for the impact of agricultural growth on manufacturing growth is in the vicinity of 0.4, the 3 percentage point gap in agricultural productivity growth between the two regions implies a 1.2 percentage point gap in the manufacturing growth rate. Thus, the gap in agricultural growth between the two regions would explain about one-fifth of the 6.3 percentage point gap in manufacturing growth.

Impact of agricultural growth, competitiveness and agricultural taxation

Competitiveness

A possible factor that affects the impact of agricultural growth is the efficiency of the manufacturing sector in the reallocation of factors. It has become increasingly evident that inefficiencies in factor reallocation are important determinants of total factor productivity (Hsieh and Klenow, 2009). For example, one potential channel through which agricultural growth affects manufacturing growth is a cheaper (or more abundant) supply of agricultural inputs for the manufacturing sector. Then, whether firms in the manufacturing sector take advantage of the increased supply of agricultural inputs may depend on their efficiency in mobilizing inputs. If there are various constraints that limit the efficiency of the manufacturing sector in the reallocation of factors, the impact of agricultural growth may be less pronounced. I look at trade closeness as one potential source of such inefficiency. Trade openness can drive out less efficient firms and reallocate resources to more efficient ones through increased competition (Melitz, 2003). Thus, in more open economies, the manufacturing sector can be expected to be relatively more efficient in responding to agricultural productivity.

Table 4.8 presents the estimation results for two subgroups that differ in trade openness. The first four columns categorize the countries based on the Sachs and Warner (1995b) dichotomous trade policy openness indicator for the 1990s.[7] We see that the impact of agricultural growth is relatively large and significant in open economies whereas it is small and insignificant (or marginal significant) in closed economies. The estimation is also robust for including the control variables. The last four columns consider the average trade share of GDP during the 1990s as an alternative indicator of openness. In the "High trade" columns, the observations include countries whose trade share exceeded the median level while the rest are included in "Low Trade" columns. We observe that the impact of agricultural growth is larger and more significant in the "High trade" countries while it is lower and insignificant in the "Low Trade" countries. To summarize, the impact of agricultural growth is larger in economies that are more open to trade, suggesting that the competitiveness of the manufacturing sector is indeed important for translating agricultural growth into more success in the manufacturing sector.

[7] The open-close categorization data is from Wacziarg and Welch (2003).

Table 4.8: Trade openness and the impact of agricultural growth

	Sachs-Warner				Trade as a share of GDP			
	Close		Open		Low		High	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Agri_g	0.26	0.21[c]	0.43[b]	0.46[b]	0.21	0.16	0.62[b]	0.65[b]
	(0.18)	(0.12)	(0.20)	(0.19)	(0.14)	(0.13)	(0.30)	(0.32)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	642	543	1820	1607	1358	1156	1354	1186
Countries	29	27	81	81	56	54	71	68
1st stage F-stat	4.60	5.13	4.97	4.68	6.26	5.79	3.51	3.36
Hansen J P-val	0.26	0.38	0.68	0.99	0.70	0.66	0.58	0.52

This table compares the impact of agricultural growth in countries that are more open to trade vis-à-vis in those that are less open. The dependent variable is manufacturing growth. The variable $Agri_g$ is agricultural growth. The first four columns categorize the countries based on the Sachs and Warner (1995b) dichotomous trade policy openness indicator for the 1990s. In columns (1) and (2), we include countries that are categorized as "Close" while Columns (3) and (4) include countries that are categorized as "Open". The last four columns consider the average trade share of GDP during the 1990s as an alternative indicator of openness. In the “High trade” columns, the observations include countries whose trade share exceeded the median level while the rest are included in “Low Trade” columns. In all of the regressions, we include both the temperature and precipitation instruments. See Table 4.5 for the list of controls. Robust standard errors clustered by country are in parentheses.
[c] $p < 0.10$, [b] $p < 0.05$, [a] $p < 0.01$.

Agricultural taxation

The role of agriculture is one of the controversial issues in industrialization policies of developing countries (Singer, 1950; Prebischb, 1959; Mellor and Johnston, 1984; World Bank 1982). A number of countries adopted state-led industrialization policies that relied on taxing the agricultural sector to subsidize the manufacturing sector, leading to policies that are biased against agriculture and favor the urban sectors.[8] On the one hand, these policies can be expected to amplify the impact of agricultural growth through state-led resource transfer. On the other hand, the subsidies provided to the manufacturing sector can exacerbate inefficiencies in the manufacturing sector. The policies are also controversial, not least because agricultural taxes target the rural population where the vast majority of the poor in the world live (Bezemer and Headey, 2008).

Table 4.9 presents an empirical comparison of the impact of agricultural growth across two groups of countries, categorized based on state-led transfers to the agricultural sector *relative* to transfers to other sectors. The first two columns of Table 4.9 report the regression results for countries that adopted a relatively less favorable policy toward agriculture, while the last four columns report the regression results for countries that adopted a relatively more favorable policy toward agriculture. The objective here is to examine if the impact of agricultural growth is indeed higher in countries where the state transfered more resources from agricultural to non-agricultural sec-

[8]For the political economy explanations of the origin of urban bias, see Lipton (1977), Bates (1984), Ades and Glaeser (1995), Majumdar et al. (2004) and Shifa (2011).

tors. The categorization of countries (into more or less favorable poli-

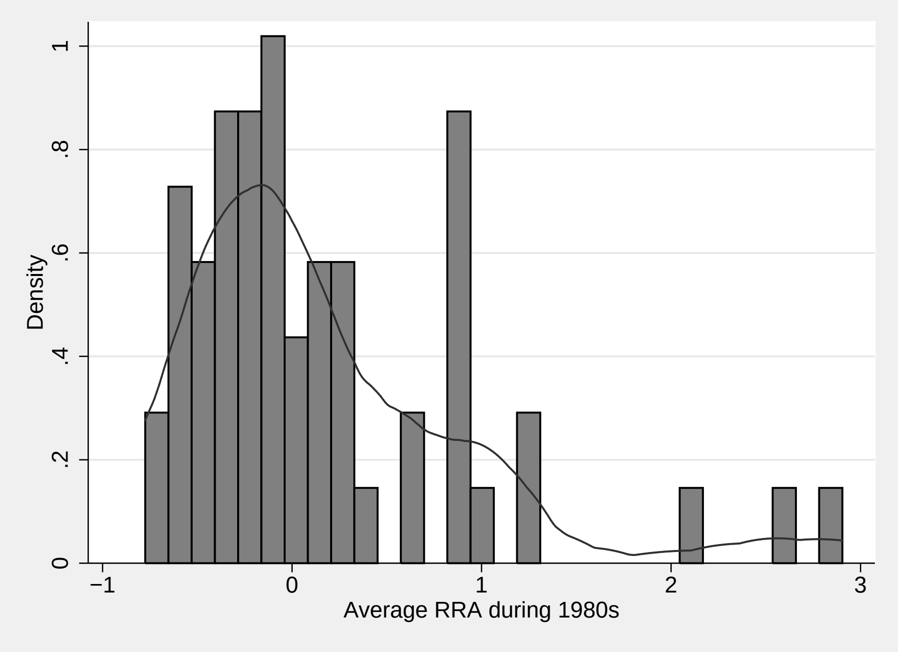
Table 4.9: Agricultural policy and the impact of agricultural growth

	Taxes on the agricultural sector					
	High		Low		Low	
	(1)	(2)	(3)	(4)	(5)	(6)
Agri_g	0.47^c	0.41^b	0.36^c	0.36^c	0.49^b	0.46^b
	(0.24)	(0.16)	(0.21)	(0.19)	(0.22)	(0.20)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes
Observations	635	566	615	541	525	460
Countries	23	23	24	24	21	21
1st stage F-stat	2.99	3.70	10.43	8.43	7.69	6.96
F-stat of 1st stage	2.99	3.63	10.43	8.64	7.69	7.08

This table compares the impact of agricultural growth in countries that imposed high taxes on agriculture [columns (1) and (2)] vis-à-vis in those that imposed low taxes [columns (3) - (6)]. The dependent variable is manufacturing growth. The variable $Agri_g$ is agricultural growth. The last two columns exclude Switzerland, Norway and Korea from the "Low" sample. In all of the regressions, we use the temperature instrument. See Table 4.5 for the list of controls. Robust standard errors clustered by country are in parentheses.
[a] significant at the 1 percent level.
[b] significant at the 5 percent level.
[c] significant at the 10 percent level.

cies to agriculture) is based on the country-level panel data provided by Anderson and Valenzuela (2008) on the *relative rate of assistance* to agriculture (RRA) – a measure for the amount of transfers by the state to agriculture relative to transfers to other sectors. The transfers may occur in the form of trade protections, input price subsidies, output price setting, etc. Formally, the RRA measures the amount of transfers to agriculture as a share of the total value of agricultural output *relative to* the amount of transfers to non-agricultural sectors as a share of the total value of non-agricultural output. Figure 4.2 plots the distribution of the average RRA during the 1980s for 56 countries. The RRA value of zero implies that agriculture received the same rate of assistance as the non-agricultural sectors. Values above zero imply that agriculture received more assistance than the non-agricultural sector. The right-most three observations that provided the highest subsidy to agriculture are Switzerland, Norway and Korea. The first two columns of Table 4.9 report the regression results for countries whose average RRA during the 1980s was below the median level. The third and fourth columns report the regression results for countries whose average RRA during the 1980s was above the median level. We observe that those countries that extracted relatively more resources from agriculture (the first two columns) do not seem to have experienced any higher impact of agricultural growth. The last two columns exclude Switzerland, Norway and Korea from the list of high RRA countries. In fact, once we exclude those three countries, the impact of agricultural growth appears to be higher in countries where the state extracted less resources from agriculture. By and large, the results do not provide support for the claim that state-led resource extraction from the agricultural sector has led to a higher impact of agricultural growth.

Figure 4.2: The average relative rate of assistance to agriculture during the 1980s



This graph plots the distribution of the average relative rate of assistance to agriculture during the 1980s for 56 countries.

4.4 Conclusion

The role of agricultural development for industrialization has been an important issue both in economic theory and development policy. However, empirically identifying the actual impact has been a challenge since observed correlations between the two growth rates do not necessarily capture the causal effects. In this paper, I attempt to address this challenge by estimating the impact of agricultural growth on manufacturing growth using random variations in the weather as a set of instruments. I find that the impact on manufacturing growth of a 1 percentage point increase in agricultural growth is within the vicinity of 0.4 percentage points. This is nearly twice as large as the OLS estimates, which are around 0.2 percentage points.

The impact of agricultural growth is larger in economies that are more open to trade, suggesting that the competitiveness of the manufacturing sector is indeed important for translating agricultural growth into more success in the manufacturing sector.

A number of countries adopted state-led industrialization policies that relied on taxing the agricultural sector to subsidize the manufacturing sector. On the one hand, these policies can be expected to amplify the impact of agricultural growth through state-led resource transfer. On the other hand, the policies can encourage inefficiency in the manufacturing sector through the subsidies. I examine if those policies have indeed led to a higher impact of agricultural growth. I do not find evidence of such an effect.

I also look at the impact of agricultural growth for the Sub-Saharan Africa (SSA) sub-sample to see to what extent SSA's low agricultural growth explains the poor performance in the manufacturing sector. SSA is an interesting sub-sample because, compared to the high performing East Asian and Pacific (EAP) region, SSA experienced low growth rates both in the manufacturing and agricultural sectors. The gap in agricultural growth between the two regions explains about one-fifth of the 6.3 percentage point gap in manufacturing growth.

A final caveat is in order. The literature identifies several potential mechanisms through which agricultural growth can affect the manufacturing sector. Although the use of reasonably exogenous instruments is an appealing element of the estimates in this paper, some of the mechanisms outlined in the literature are unlikely to be captured in my estimates. Weather variations are essentially short-run variations. The impact of such short-run variations could differ from long-term shifts in productivity due to, say, improved seed varieties or shifts in government policies. Thus, the estimated impacts in this paper are more likely to come from short-run effects like increased consumption demand for manufacturing products (due to improved farm incomes) and a more abundant supply of agricultural inputs than from long-run effects like the release of labor from agriculture to manufacturing. This is also confirmed by the insignificance of the lagged terms in the instrumental variable estimation.

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