Population Pressures, Migration, and the Returns to Human Capital and Land

Insights from Indonesia

Yanyan Liu
Futoshi Yamauchi

The World Bank
Development Research Group
Agriculture and Rural Development Team
February 2014
Abstract

Rapid population growth in many developing countries has raised concerns regarding food security and household welfare. To understand the consequences of population growth in a general equilibrium setting, this paper examines the dynamics of population density and its impacts on household outcomes. The analysis uses panel data from Indonesia combined with district-level demographic data. Historically, Indonesia has adapted to land constraints through a mix of agricultural intensification, expansion of the land frontier, and nonfarm diversification, with public policies playing a role in catalyzing all of these responses. In contemporary Indonesia, the paper finds that human capital determines the effect of increased population density on per capita household consumption expenditure. On the one hand, the effect of population density is positive if the average educational attainment is high (above junior high school), while it is negative otherwise. On the other hand, farmers with larger holdings maintain their advantage in farming regardless of population density. The paper concludes with some potential lessons for African countries from Indonesia's more successful rural development experiences.

This paper is a product of the Agriculture and Rural Development Team, Development Research Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at fyamauchi@worldbank.org.
Population Pressures, Migration, and the Returns to Human Capital and Land

Insights from Indonesia

Yanyan Liu and Futoshi Yamauchi

Keywords: Population Growth, Migration, Income Growth, Education, Landholding, Rural economy, Indonesia

JEL Classifications: J24, O15, Q12, Q15

1 Yanyan Liu, International Food Policy Research Institute, 2033 K Street, NW, Washington, DC 20006; Email: y.liu@cgiar.org. Futoshi Yamauchi (Corresponding author), World Bank, 1818 H Street, NW, Washington, DC 20433; Email: fyamauchi@worldbank.org. We would like to thank Fabrizio Bresciani, Thom Jayne, Derek Headey, William Martin, Keijiro Otsuka, participants in the IFPRI–Michigan State University workshop, and the referees of the journal for useful comments. We are especially grateful to Derek Headey for his detailed suggestions to improve Section 2. Remaining errors are the authors’.
1. INTRODUCTION

Economic growth is often accompanied by social mobility. Migration to high-growth centers promises a pathway out of poverty by improving economic returns on human capital investments (see, for example, Harris and Todaro 1970; Foster and Rosenzweig 2008; Yamauchi 2004). Thus, population pressures on farmland in rural areas can be relaxed through labor movement to urban sectors, an idea that contrasts with the argument centering around poverty traps driven by population growth (Malthus 1826). Population pressures, if not released through the migration process and absorbed into nonagricultural sectors, can alter relative factor prices, which induce technological and institutional innovations (Hayami and Ruttan 1985) and intensification in agricultural production to accommodate the pressures (Boserup 1965, 1981). Therefore, the issue of population density in agrarian economies cannot be analyzed apart from the dynamics of nonagricultural sectors, that is, more generally, the country’s development stage.

High population density can certainly have negative effects through increased population pressures on scarce resources such as farmland, but higher densities can also be associated with higher intensity of economic activities through agglomeration economies (Fujita, Krugman, and Venables 1999; Krugman 1996). The concentration of economic activities in cities is a manifestation of these agglomeration economies. Even in rural areas, high population density can support the evolution of nonfarm industries, often closely linked to urban markets. More generally, whether increased population density exhibits positive or negative effects depends on the magnitude of demand-driven migration inflows versus supply-driven natural growth. In this paper, we examine the relationships between population density and rural households’

---

2 Labor shortage is becoming a serious issue in agriculture in many Asian countries. Using country-level panel data, Otsuka, Liu, and Yamauchi (2013) recently showed evidence that increased real wages due to labor shortage causes a decline of land productivity among small farmers and of self-sufficiency at the country level. Yamauchi (2012) showed household-level evidence from Indonesia to support the hypothesis that rising real wages led large farmers to introduce machines, diverging productivity between large and small farmers.

3 See Geertz (1963) for an early study of Indonesia.
consumption, income, and labor allocation dynamics using two unique datasets from Indonesia, involving household panel data and village census data.

Population growth in a particular area is endogenous, depending upon both natural increase and on migration decisions. The natural increase of a population is a consequence of fertility and mortality dynamics (see Schultz 2008 for a review).\(^4\) Migration can also play an important role in determining population growth in an area. Large migration from rural to urban areas not only reduces population pressures in the rural areas but can contribute to industrialization by supplying low-cost labor to urban sectors, as argued centrally by Lewis (1954). Improved transportation between rural areas and urban centers supports greater mobility of labor.

Indonesia provides an interesting empirical context. With its combination of high- and low-density areas, the country is in some regards structurally similar to many African countries. High-density areas are concentrated in the island of Java, whereas other islands, such as Kalimantan, Sulawesi, and Sumatra, have lower densities. Having already achieved a Green Revolution mainly in rice production (concentrated in Java), Indonesia today is at a relatively advanced stage of structural transformation, in which human capital formation and migration out of agriculture are central to the transformation of the economy. More recently, an overall increase in real wages has been encouraging the labor migration and promoting mechanization to substitute for labor in agriculture, mostly among large farmers who can further increase their operational farm size (Yamauchi 2012).

\(^4\) For example, an increase in returns to schooling weakens the incentive to have a large number of children, reducing the fertility rate through the quality–quantity tradeoff (Becker and Lewis 1973). Reduced mortality is more closely related to the development of modern medical science, although there are transition dynamics in mortality, with a decline in the number of vulnerable very young children tending to reduce the crude death rate in early stages of the transition.
Our data show that about 13 percent of the residents aged 15–25 in the sample households in 2000 migrated out of their villages by 2007, and most of these were relatively educated. In addition, we found that although urban areas have much higher population density, they still attract people from rural areas, thus perpetuating urbanization.\(^5\)

The analysis pays particular attention to the distributional impacts of population growth. Increased population density in the local economy can have heterogeneous impacts on households if it alters returns to human and physical capital.\(^6\) If entry into the urban labor market is easier for educated workers, households with more education will choose to move away from agriculture (see, for example, Fafchamps and Shilpi 2003, 2005). With higher demand for skills, returns to schooling rise in urban sectors, but the inflow of migrants can intensify competition in the labor market, which may ultimately decrease wages and, thereby, the returns to schooling.

Population growth in rural and urban areas can also have diverse impacts on agriculture. For some farmers, population growth can potentially increase agricultural profitability because it increases demand for agricultural commodities and decreases wage rates for agricultural labor. In this case, the returns to farmland may increase, which serves to keep such farmers in agricultural production. In contrast, landless households may be worse off particularly due to wage erosion (if migration to nonagricultural sectors is limited).

To empirically analyze the dynamic effects of population growth at the household level, we must combine, by household and village locations, both household and spatial panel data over a long span of time with sufficiently large changes in population. In this paper, we capture the

---

\(^5\) The above process creates food security problems in urban areas if it solely depends on rural agricultural production, and it can change terms of trade between rural and urban sectors, likely increasing farm incomes.

\(^6\) Yamauchi, et al. (2011) analyzed income dynamics and labor transition to nonagriculture using Indonesian household panel data from 1995 to 2007. They showed that improved road quality at the subdistrict level significantly increased returns to schooling, especially among those who had completed high school. In contrast, returns to farmland did not change.
change in population density using subdistrict panel data (constructed from the Indonesia village census) to explain its impacts on household decisions.

The paper is structured as follows. Section 2 discusses Indonesia’s structural transformation from a historical perspective. Section 3 describes the data that we use in the analysis. Section 4 discusses our empirical strategy to analyze population growth, migration, and household outcomes. Section 5 summarizes our empirical results. Section 6 provides concluding remarks.

2. BACKGROUND

Drawing on Indonesia’s historical experiences starting in the 1960s, this section clarifies the empirical setting for our econometric analysis that uses data collected after 2000. Moreover, our efforts to integrate historical overviews and empirical findings help us to visualize lessons that we hope to derive from the Indonesia case study for today’s problems in African countries.

Prior to its relatively successful transformation, Indonesia bore many similarities to a number of African countries. First, like many African countries, Indonesia’s rural population is highly concentrated. The island of Java, accounting for merely 9% of the country’s total land mass, hosts 60% of its population. Thus, Indonesia has areas of extremely high density in Java, the most densely populated regions in the world, and areas of land abundance in the outer islands such as Kalimantan and Sumatra. And as in Africa today, land constraints raised Malthusian

---

7 Due to the coexistence of land scarce and abundant areas, both the surplus labor theory (Lewis, 1954) and the vent for surplus theory (Myint, 1965, 1971) are relevant to Indonesia. Hayami (2004) provides a good account of Indonesia’s agrarian conditions from ecological and historical perspectives. He summarizes as “the ‘vent-for-surplus' theory focused on the development of ‘empty land' with low population density, large unused tracts and abundant natural resources, typically found in Southeast Asia and East Africa at the onset of Western colonization [Note, however, that Thailand was never colonized—thanks to Rama V—but had a similar experience]. When these economies had been integrated into international trade, their natural resources (previously of no value to indigenous people) acquired market value, since they could be used to produce primary commodities of high demand in the West. In this way, previously 'unused' resources became the source of economic development.”
concerns in Java, where the term “agricultural involution” was first coined (Geertz 1963). Second, Indonesia started out very poor and overwhelmingly agrarian. In 1967 sixty percent of Indonesia’s population lived below the $1 per day poverty line, and 80 percent of the population was rural. But unlike most African countries, Indonesia was able to reduce poverty over several decades. In 2010 only 18 percent lived below the $1.25 per day poverty line (World Bank 1990; World Bank 2012). Finally, Indonesia’s economy started out as a traditional agrarian economy, combined with a modern sector in the oil and plantation sectors, with only a small industrial base. But unlike Africa, Indonesia managed to sustain a successful industrialization process over several decades, and its economy is now dominated by industry and services rather than agriculture. Compared with Africa, Indonesia is therefore at a relatively advanced stage of structural transformation.

How did Indonesia achieve this successful transformation, particularly in rural areas? Reviews of Indonesia’s experience emphasize agricultural development (Falcon 2013; Hayami 2003), social policies on education, family planning (World Bank 1993), infrastructure (Yamauchi et al. 2011), and successful industrialization strategies (Hall 1997). Table 1 lends support to all of these ingredients. Economic growth was relatively rapid and sustained, and clearly involved a sizeable increase in the share of industrial output. Remarkable changes were observed in rice yields in the 1970s largely due to the Green Revolution, which contributed to food security in the population (Hayami, 2004). Agricultural land areas had not changed significantly over decades. The share of the rural population, the gross secondary-school enrollment rate and the crude birth rate have been clearly correlated, especially since 1980. The above observations indicate that an increase in agricultural productivity dramatically started in the 1970s, driven by the Green Revolution, followed by social dynamics in which a decline in
the birth rate (thus, likely, population growth) and an expansion of public education, and an acceleration in industrial output. All of these factors likely played important roles in facilitating a smooth transition from agriculture to non-agriculture.

First, as observed above and in many other Asian countries, the Green Revolution played a central role to secure food availability and reduce rural poverty. The realization of Green Revolution considerably increased land productivity, improved food security, and reduced poverty. As we discuss below, Indonesia introduced several important policies, as a package, which contributed to the successful realization of the Green Revolution, and the Suharto regime consistently emphasized agricultural development during its entire existence (Falcon 2013), particularly in the wake of the disastrous food price inflation in the late 1960s.

New agricultural technologies, especially modern variety seeds, were successfully introduced through partnership with the International Rice Research Institute in the Philippines (IRRI, 2012). The series of modern varieties from the IRRI, clearly evidenced in the diffusion of IR36, significantly contributed to the mitigation of food insecurity problems, which established the era of the Green Revolution in Indonesian (rice) agriculture. Hayami (2003, Table 2.3) reports remarkable increases in agricultural productivity. Starting as the benchmark index of 100 in the 1961-65 period, total agricultural production has increased up to 309 in the 1991-95 period. Per farm worker and hectar productions reached 232 and 263 in the 1991-95 period, respectively.

According to Hansen (1972), the government in the 1960s attempted to introduce new technologies through non-market approaches by distributing homogeneous and uniform packets of modified seeds, fertilizer and pesticide. The effort soon turned out to be a failure. The strategy then switched to a more flexible market-based approach by providing subsidies and allowing farmers to choose the inputs in the 1970s. This was accompanied with a focus on rural credit and
financial intermediation. It is noteworthy that the fast adoption of new technologies can be largely attributed to the long history of intensive crop cultivation, especially in Java. The long history of intensive crop cultivation is a missing factor in many African countries, where low population density allowed low-input shifting cultivation models to persist much longer (Binswanger and Pingali 1988).

Second, the government imposed a series of policies to stabilize the macro-economy and food prices, which provided a favorable environment for farmers. BULOG, the national logistics command, acted as a major instrument for price stabilization (Timmer, 1989, 1996; Falcon 2013). Through BULOG, an integrated set of warehouses was erected across the whole country, which assured regular rice supplies and reduced the seasonal volatility of rice prices. International trade was also used to stabilize the rice price across seasons and years.

In addition to agriculture, the Suharto regime emphasized rural development more generally (World Bank 1993). The government’s public rural investments focused on irrigation, roads, education and health service deliveries. This not only directly increased land and labor productivity but also reduced transaction costs and transportation costs of production inputs and outputs, which resulted in higher allocative efficiency in rural economies (Yamauchi et al, 2011). As Table 1 shows, the crude birth rate substantially declined over time, which significantly reduced the pre-existing population pressures on agricultural land. In particular, local clinics established in rural communities were important to penetrate family planning into rural households to alter their reproduction behavior (Table 1). Moreover, the government’s large-scale intervention to build public schools in the early 1970s (the New Era regime) helped the rural poor to become educated at a rapid pace, which is clearly observed in the increased gross enrollment rate in the secondary school education (Table 1).
The emphasis on rural education is likely to have been an increasingly important factor over time, as our empirical evidence reported below suggests. If rural households are increasingly constrained by physical capital in the form of land, human capital accumulation will be an essential means of successful transformation. In theory, investment in human capital also facilitates demographic transition by increasing the per-child economic value (thus increasing the cost of having an additional child) and increased the probability of obtaining jobs in non-agricultural sectors, often through migration to urban sectors, as knowledge and skills required in those industries significantly differ from those in agricultural production.8

Figure 1a demonstrates a positive trend of years of schooling completed over cohorts. The generation of school age when the intervention started experienced better opportunities to study in school, which is clearly reflected in the sharp increase in years of schooling completed. Next, Figure 1b shows the relationship between years of schooling completed and the probability of engaging in full-time non-agricultural occupations among rural residents. In the graph, the probability clearly increases at and after the completion of secondary school education. Therefore, the rural population in Indonesia has attained more schooling rather quickly over cohorts, which created the possibility of entering (or starting) non-agricultural economic activities.9

In addition to education, the other crucially important driver of economic transformation was likely to have been successful industrial strategies (World Bank 1993; Hill 1997). Indonesia’s abundance of labor relative to land (at least in Java and some other densely populated islands) created a comparative advantage in light manufacturing. However, Indonesia

---

8 The analysis that starts in the next section will focus on the effects of human capital accumulation.
9 Yamauchi, et al. (2008, Figures 4.7 and 4.8) and World Development Report 2009 (World Bank, 2008; Figure 2.1, citing Yamauchi, et al. 2008) show from Indonesia that improved road networks, which support higher speed transportation and allocative efficiency in local economies, helped new non-farm industries to evolve in rural areas.
faced a typical African problem of a natural resource “curse”, particularly the twin threats of Dutch Disease and political capture. Unlike similarly-structured economies such as Nigeria, however, Indonesia was able to channel the natural resource surplus into productive public investments including public education, as well as to achieve macroeconomic stability between the economic and political crises of 1966-67 and 1997-98. Though this macroeconomic stability created a favorable environment for business investments, including foreign direct investments, it was clearly the growth of light labor-intensive manufacturing – such as textiles and garments, food processing, etc. – and service industries that created the jobs that were able to pull rural people off the farm.

Finally, like many African countries, Indonesia experimented with large-scale rural-rural resettlement programs. This involved directly relocating rural people from densely populated Java to outer islands such as Kalimantan, Sulawesi and Sumatra in the so-called the trans-migration (transmigrasi) program (World Bank, 2012). But like most programs in Africa and elsewhere (Kinsey and Binswanger 1993), these programs were not typically effective since agro-ecological conditions in most of the outer islands significantly differ from that of Java, thus making it difficult for the migrant farmers from Java to rely on the labor intensive methods to which they were accustomed. Overall this policy was unsuccessful, and resulted in large scale return-migration.10

To sum up, Indonesia in the 1960s had many characteristics that were similar to many African economies, particularly its significant differences in agricultural endowments between Java and other islands, and its combination of a traditional agrarian economy with relative

10 On the other hand, the more laissez-faire migration into the booming oil palm sector probably did help alleviate land constraints to some extent. This sector employed around 3.2 million people by the mid 2000s (Sheil, et al., 2009) However, the long-term sustainability of such a boom observed in the oil palm sector highly depends on its world price. It is also an urgent concern that the expansion of the oil palm production is a cause for large scale deforestations in Kalimantan and Sumatra.
natural resource abundance. The country has seen well-balanced policy packages under the strong political leadership during the Suharto regime, particularly the introduction of high-yielding varieties in rice production and successful oil palm expansion, large-scale investments in human capital, and successful industrial strategies. Though these factors seemingly took place in somewhat sequential phases, they all contributed to reducing population pressures on agricultural land. In this way the country avoided the dire “agricultural involution” predictions from the 1960s (Geertz 1963) and reached a more advanced stage of structural transformation. In the remainder of the paper we focus more on Indonesia’s current and more advanced stage of economic transformation in rural areas, particularly the under-research area of out-migration from rural areas.

3. DATA

Our data are from three sources: (1) the 2000 and 2007 Indonesia Family Life Survey (IFLS), (2) village censuses from the 2000 and 2006 rounds of Village Potential Statistics (PODES), and (3) online climate data. A prominent feature of the IFLS is that it attempted to track and interview individuals who had moved and split off from their original households (Strauss et al. 2009). The IFLS 2000 survey interviewed 5,410 rural households from 13 provinces, and the 2007 survey re-interviewed 5,059 of the households from the 2000 rural sample and their split households.\(^{11}\) The household questionnaire of the IFLS contains information on household demographics, income, consumption, and assets including landholdings. Based on this information, we constructed our key dependent variables: per capita consumption expenditure, income shares of

\(^{11}\) IFLS has both rural and urban samples. We use only its rural sample as defined in the 2000 round for the purpose of this study.
wages and farming, and landholdings. We also identified the individuals who left the surveyed households from 2000 to 2007 due to schooling, work, marriage, and so on.

PODES 2000 and 2006 are village censuses that provide information on population; area; key geographic characteristics; and infrastructure of transportation, education, health, finance, and communication. From the online climate data, we generated average annual total rainfall from 1961 to 2011 and share of area belonging to each of the four agroecological zones (warm/semiarid, warm/subhumid, warm/humid, and cool/humid) at the district level. We used these variables to capture agricultural potential.

Based on the data described above, we constructed four samples: (1) a subdistrict sample for analysis on population dynamics, (2) two household samples to analyze effects of population density on household decision making, and (3) an individual sample to look at migration behavior.

The PODES 2000 database had 4,038 subdistricts from 26 provinces, while PODES 2006 included 5,358 subdistricts from 31 provinces, due to splits of administrative units between 2000 and 2006. Tables 2 and 3 report population density averaged over districts and over subdistricts, respectively, for rural and urban areas in 2000 and 2006. The proportion of villages classified as urban has increased from 10.86% to 17.57% in the period of 2000 to 2006. More villages are categorized as urban in 2006. Although average population density over districts decreased slightly in rural areas from 2000 to 2006, most likely due to the above mentioned compositional change, it increased by 77 persons per square kilometer in urban areas during the same period. Averaged over subdistricts, population density increased in both rural and urban areas, with a higher magnitude in urban areas even though the initial average population density in urban areas

---

12 The rainfall data are from Climate Research Unit, University of East Anglia 2012. The data on area of agroecological zones are from FAO 2012.
was more than seven times that in rural areas.\textsuperscript{13} Thus, there was significant urbanization in Indonesia over the period 2000–06.

Before merging PODES 2000 with 2006, we aggregated the data at the subdistrict level for the two rounds separately. The variables were averaged over villages using population as weights. We then aggregated the split subdistricts in 2006 to make them consistent with the original subdistricts in 2000. We were able to merge 3,608 original subdistricts between the two rounds.\textsuperscript{14} We then merged the panel subdistricts with the district-level agricultural potential data (long-term rainfall and agroecological zones) by district name. In total, some 3,128 subdistricts were merged successfully.

For the two household samples, we merged the IFLS household panel with the PODES panel at the subdistrict level because we could identify only subdistricts in the IFLS. Of the original 5,059 households tracked, a total of 758 households could not be merged with the PODES data, so these were dropped from the sample. We then dropped 994 households that had moved from the villages where they lived in 2000 before the 2007 survey. From the remaining 3,307 households, we further dropped 622 households who were either from non-original villages or had incorrect village identifiers. This data cleaning and restriction procedure led to a final sample of 2,685 rural households from the 2000 IFLS.

For our first household sample (Sample 1), we aggregated the original households from 2000 and the split households from 2007. We defined a split household as a newly sampled household in 2007 headed by a child of someone who was a household head in 2000 and residing in the same village with the original household. Our second household sample (Sample 2) kept

\textsuperscript{13} In Tables 1 and 2, we report simple averages of population density over districts and subdistricts, respectively. Therefore, the inconsistencies between the two tables could be potentially because we applied different weights (proportional to the inverse of the area of the location).

\textsuperscript{14} Merging of PODES in different rounds required a tedious process of identifying provinces, districts, and subdistricts. We also attempted to identify by their names villages in each subdistrict that could be merged. As a result of this process, about 8.07 percent of the 2000 villages were merged with 2006 villages.
the original households in the main household sample, but we aggregated all the migrant and split households with their original households in 2007. We defined a migrant household as a new household in 2007 with at least one member who had moved from an original household from the 2000 sample but did not meet the definition of a split household. Appendix Table A.1 summarizes key characteristics of the households in 2000 and 2007 for both samples.

The individual sample includes all the members aged 15–60 from the 2,685 original rural households from the 2000 survey (used in our two household samples). We defined migrants as individuals who had moved from the original households and left their original villages between the two rounds. Appendix Table A.2 reports the migration rate by age cohort. Among the original household members aged 15–60, 5.5 percent were migrants, defined as individuals who split off from their original households and left their original villages between the two rounds.

4. EMPIRICAL FRAMEWORK

In the analysis of household welfare, we estimate the following equation on consumption growth and change in nonagricultural income shares using household fixed effects and location-specific trends:

\[ y_{it} = \alpha_i + \beta_1 z_{(i)} + \beta_2 x_{it} + \beta_3 z_{(i)} \times x_{it} + m_{it} \beta_4 + \sum_{(i)} D_{(i)} \times t \gamma + \varepsilon_{it}, \]

where \( y_{it} \) is a household welfare indicator (consumption, income shares, landholding, land profitability) for household \( i \) in period \( t \), and \( t = 0 \) (year 2000) or 1 (year 2007); \( \alpha_i \) is household fixed effects; \( z_{(i)} \) is population density at the subdistrict level for household \( i \); \( x_{it} \) is household \( i \)'s endowment such as education and land owned; \( m_{it} \) refers to other household explanatory variables (such as household size, number of members aged 18–60, and so on); \( D_{(i)} \) is a location (province or village) dummy; \( t \) is year dummies; and \( \varepsilon_{it} \) is an error term. We
control for province- and village-specific trends, respectively, in two specifications. We note that when village-specific trends are controlled, the term $\beta_1 z(i)$ on the right-hand side of equation (1) is absorbed into the village-specific trends and cannot be identified. The parameters of interest are $\beta_1$, $\beta_2$, and $\beta_3$. The parameter $\beta_2$ captures returns to schooling and farm landholdings. The parameters $\beta_1$ and $\beta_3$ attempt to capture heterogeneous effects of local population density on the household endowment.

We use aggregate consumption expenditure and incomes from (1) both original and split households who lived in their original village in 2007, and (2) these same households plus migrant households who lived away from the original villages in 2007. In Sample 1, therefore, our results will be robust to household split–related attrition bias potentially arising from endogenous household splits as long as they stay in the same village. Sample 2, which includes migrant households, further corrects attrition bias directly related to migration selectivity.

One of our key research questions is how population density affects household landholdings and farm profitability. To investigate this question, we estimate the following empirical model:

$$\Delta l_i = \alpha_h + \beta_1 \Delta z(i) + \beta_2 \Delta z(i) \times D_{(Java)} + \Delta x_i \beta_3 + x_i^0 \beta_4 + \epsilon_i ,$$  

where $\Delta l_i$ is change in landholdings and farm profitability by household $i$, $\Delta z(i)$ is change in population density for the subdistrict of household $i$, $D_{(Java)}$ is a dummy variable indicating whether the household is located in a Java province, and $x_i$ are some household demographic variables. We include both the initial values and the changes of $x_i$. We also control for province dummies, $\alpha_h$, in the regression. We interact $\Delta z(i)$ with $D_{(Java)}$ to allow for the population density effects to differ between Java and non-Java provinces.
In the analysis we are equally attentive to two important dynamic processes: (1) population density dynamics and (2) migration behavior. To analyze population density dynamics, we aggregate population at the subdistrict level based on village census data from 2000 and 2006 (see details in Section 3). We estimate
\[
\Delta z_k = \beta_0 + \beta_1 s_k^0 + x_k \beta_1 + q_k^0 \beta_2 + \epsilon_k,
\]
where \(\Delta z_k\) is change in population density from 2000 to 2006 for subdistrict \(k\), \(s_k^0\) is share of urban population in the subdistrict in 2000, \(x_k\) is agroecological conditions to capture agricultural potentials, \(q_k^0\) is a vector of socioeconomic and infrastructure conditions in 2000, and \(\epsilon_k\) is an error term. We include the initial proportion of population residing in urban clusters in the subdistrict to see how urbanization attracts further population inflows. If urban communities are expanding in the subdistrict, we expect a positive effect of the initial urbanization level on population density change. We also control for the initial agroecological conditions and initial socioeconomic and infrastructure conditions.

Individual migration behavior is also analyzed in the period from 2000 to 2007. We estimate a probit model and a linear probability model. For the probit model, we estimate
\[
y_{hi}^* = \alpha_h + x_{hi} \beta + \epsilon_{hi},
\]
where \(y_{hi}^*\) is the underlying latent variable for the migration decision of individual \(i\) located in province \(h\); \(\alpha_h\) is a provincial dummy; and \(x_{hi}\) is a vector of control variables including gender, years of schooling, age, and the interaction of years of schooling and age. For the linear probability model, the dependent variable is the dummy variable indicating migration. Instead of using provincial dummies, we use village and household fixed effects, separately, in the linear model.
The results from equation (4) are potentially important when we interpret household outcome regressions. In the household analysis, we use two household samples (with and without migrant households). The distinction between the two samples can be nonrandom, so the omission of migrant households may create bias in the estimation. In equation (4), we investigate the effects of individual characteristics observed in the initial period to know what types of individuals tend to subsequently migrate out of their villages.

5. EMPIRICAL RESULTS

In this section we summarize empirical results on population density change, individual migration behavior, and household outcomes.

5.1 Population Growth

Table 4 shows determinants of population density change over the period 2000–06. Column 1 shows only the effect of the initial urbanization level, measured by the share of population residing in urban areas in the subdistrict. Column 2 adds agroecological factors, and finally Column 3 includes socioeconomic and infrastructure factors in the specification. In Column 4, we add the interaction between the share of urban population and provincial capital population size.

\[\text{For example, if the educated are likely to migrate to cities for better employment opportunities, observed returns to education in the household panel analysis may go down over time if we do not include migrants in the sample. Higher population growth in the region, if it is associated with fast growth of the local economy, may appear to decrease returns to education if the educated tend to move out of rural areas.}\]

\[\text{Though we attempt to explain changes in population density in this sub-section, we will not endogenize population density change in the household outcome equations. In the latter, we use panel data with household fixed effects to estimate the effect of population density change on household outcomes. In a seminal work in the context of agricultural development, Binswanger, Khandker and Rozensweig (1993) attempted to endogenize population density by variations in urban distance and agroecological endowments in their outcome equations. In our case, the initial urbanization and annual rainfall significantly explains changes in population density.}\]
As shown in Tables 2 and 3, we observe that populations move to urban areas over time. The observation is confirmed in Column 1. The initial urbanization level has a significant positive effect on subsequent change in population density. Thus, population is more concentrated into urbanized areas where population density is initially high, which perpetuates the process of urbanization. The result remains robust in Columns 2 and 3, where agroecological, socioeconomic, and infrastructure factors are controlled. Note that annual rainfall significantly explains changes in population density.

In Column 4, we introduce provincial capital population size by interacting it with the share of urban population. That is, our interest is to know how the initial urbanization effect is affected by the degree of provincial urbanization. The results confirm that the presence of large cities in a province matters little to explain dynamics of local population density.

This finding suggests that total population increases may not put large pressures on rural households’ scarce resources such as farmland because migration to urban sectors seems to mitigate these pressures.

In Column 2, we find that less rainfall and less land under warm/semiarid or warm/subhumid conditions contribute to increasing population density. Column 3 shows that the proportion of women who are fertile and the presence of a junior high school in the initial period are positively related to a subsequent change in population density, while a hilly location and greater distance to a regency office show the opposite effect.

To check the robustness of the above results, we also use local population growth (differenced log density) in Columns 5–8. The key results on the initial urbanization level and agroecological conditions remain robust. Though some results of the socioeconomic and infrastructure conditions change, we observe that the effects of the presence of a junior high
school and of a greater proportion of fertile women remain the same. Interestingly, the percentage of households who have experienced natural disasters in the past three years and illness due to epidemic in the past year have significant negative effects on local population growth.

5.2 Migration

Determinants of individual migration decisions are shown in Table 5. For the purpose of describing key demographic characteristics of migrants, we check the effects of schooling, age, and gender with province, community, and household dummies (Columns 1–3, respectively). In all specifications, we have qualitatively similar results: The more educated, males, and young people tend to migrate. Interestingly, the role of education is significantly largest among the young. Since we choose rural communities in the analysis, many of the migrants head to urban areas. The above findings are in line with those of Yamauchi and Dewina (2009), who used a different panel dataset from rural Indonesia.

5.3 Consumption and Income Shares: Returns to Education and Land

In this subsection, we show estimation results on household consumption (per capita consumption expenditure) and on income shares (the shares of wages and of farm activity in income). Consumption expenditure measures the overall welfare of the household, while the share of wages versus farm activities in income captures the degree to which households depend on the labor market or on farm activities.

We aggregated the original households and their split households who stayed in the same community (Columns 1, 3, and 5 in Tables 6 and 7) and, in addition, added migrant households
who moved out of their community (Columns 2, 4, and 6 in Tables 6 and 7). The second approach, including migrant households in the sample, is intended to correct migration-related attrition bias in the estimates. For example, if the educated tend to move to urban sectors (away from their subdistricts), the education effect is biased because many educated household members are out of the village in 2007.

Table 6 shows the estimation results with province-specific trends. As explained, we can compare two types of household sample constructions, covering only original and split households (Columns 1, 3, and 5), or including migrant households too (Columns 2, 4, and 6). First, changes in population density have a significantly negative effect on per capita consumption over the period 2000–07. Interestingly, the effect is mitigated if the average level of schooling in the household is higher, and it becomes positive if the average years of schooling are greater than junior high school level.17

Second, when only original and split households are used, population density increases the share of wages in income, and the effect is smaller if the average years of schooling are higher. However, if we include migrant households, the population density effect disappears, and schooling instead significantly increases the share of wages in income. Since population density change and migration propensity are closely related, the inclusion of migrant households in the sample tends to reduce the effect of population density. The educated have a higher propensity to migrate out, contributing to wage incomes in their original households.

Third, for Sample 1, landholdings have a positive effect on per capita consumption expenditure. However, for Sample 2 (after the correction of selection bias due to migration), the

---

17 The effect of schooling is potentially biased upward in the above results due to a correlation between consumption (income) shocks and schooling investments in children. However, the correlation could be small in cross sections since we are using the average years of schooling, that is, stock of human capital. Interestingly the direct effect of schooling stock is insignificant in many specifications. In contrast, the effect of schooling could be biased downward in farm landholding equations since, in the first differenced form, schooling investments (i.e., change in the average years of schooling) can be positively correlated with the initial period income shocks that may increase the size of landholdings in the initial period.
effect of landholding on consumption becomes smaller and statistically insignificant, which suggests that smallholders are not worse off than their counterparts with larger holdings. In terms of income share from wages, landholdings have a significantly negative effect, but this effect is mitigated if population density increases in the area. Instead, in this latter case, greater landholdings significantly increase the share of farm activities in income.

In Table 7, we use village-specific trends to see how change in population density alters returns to schooling and land. Note that, based on our analysis of population dynamics and the decision to migrate (Tables 4 and 5), an increase in population density at the subdistrict level indicates that the area has some urban clusters that attract population inflows. This implies that the inflow of population disproportionately includes many educated and young people. Potentially this change intensifies competition among skilled labor in the labor market.

First, in per capita consumption expenditure, we find a significantly positive effect of the population density interaction with schooling (Columns 1 and 2 of Table 7). Landholding tends to increase per capita consumption expenditure either linearly or through population density. Second, in contrast to Table 5, an increase in population density decreases the effect of schooling on the share of wages in income, though the schooling effect itself tends toward positive (Column 4). Third, landholding significantly decreases the share of wages in income while increasing that of farm activity. Interestingly, higher population density mitigates the negative effect of landholding on the share of wages in income, which is consistent with Table 6.18 In sum, an increase in population density raises returns to schooling and to land, measured in per

18 The differences between Tables 4 and 5 can possibly be attributed to a potential bias that may arise from a correlation, within a village, between household-level unobserved time-variant shocks and a change in household characteristics, such as landholding and the average years of schooling. For instance, a negative farm income shock in the initial period may increase the share of wage incomes in 2000 and induce migration and land sales over the period 2000–07, which would decrease both landholding and average years of schooling in 2007. At the same time, income would recover, so the change in consumption expenditure would tend to be higher. The share of wages (farm activities) in income tends to decrease (increase). In this case, we would expect downward bias in the estimated effects of schooling and landholding.
capita consumption expenditure, but returns to schooling (land) decrease (increase) in the share of wages in income. Increased population density seems to imply more competition in the local labor market, rather than augmenting returns to skills.

5.4 Land Expansions and Profitability

Table 8 shows regression results on changes in farm landholding at the household level. The independent variables include change in population density, differentiated by Java and non-Java regions, and other explanatory variables such as female headship, age of the household head, average years of schooling among members aged 18–60, household size, and the number of members aged 18–60. The estimation uses changes in total area of owned land (Column 1) and that of cultivated land (Column 2). The effect of change in population density could be potentially different between Java and non-Java islands since, as observed, access to cities, labor market conditions, land endowments and values, and returns to schooling and land are significantly different.

The results suggest that a change in population density significantly decreases land owned for non-Java provinces only, but does not affect land cultivated for either Java and non-Java provinces. Since the sample covers original and split households, land split among household members within the village is not the issue, but out-migrants who inherited land may rent it out to the family members who cultivate in the village. Thus, rental market and arrangements function to absorb the effects of population density, not affecting land cultivated. Higher population density, if associated with higher density of economic activities, may also increase land conversion for commercial use.
Table 9 uses farm income per hectare of farmland owned or cultivated as a measure of farm profitability. This measure includes farm-related incomes other than cropping, such as livestock. Land can also be used as collateral for financing investments that increase farm incomes at a subsequent stage. Column 1 uses land owned as the denominator for farm profitability. An increase in population density significantly reduces farm profitability, but the effect is almost nil in Java. Column 2 uses land cultivated, but we do not see any significant effects for either Java or non-Java provinces. The results are consistent with those of Table 8, which higher population density seems to decrease land owned, probably through land conversion for commercial or residential uses.

6. CONCLUSIONS
This paper examined the dynamics of population density and its impacts on household outcomes using panel data from Indonesia. We found that population density is higher in urban areas, and is increasing over time to perpetuate urbanization. Migration to urban areas is large, so population pressures on rural land can be mitigated through migration. The analysis showed that the young and the educated tend to migrate from rural communities.

The effect of increased population density on per capita household consumption expenditure could be either positive or negative, depending on human capital in the household. The effect is positive if the average educational attainment is high (above junior high school), while it is negative otherwise. On the other hand, farm landholding discourages transition to non-agriculture, measured by the share of wages in income. Larger farmers keep their advantage in agriculture. Thus, human capital (education) and landholding play important roles in determining the impacts of increased population density on household welfare and labor allocation.
Landholding and farm profitability also change in response to increased population density. Interestingly, land owned decreases but land cultivated is not affected, which implies that farm households maintain farm activities regardless of altered ownership. Farm profitability per hectare of land owned decreases only outside Java.

Our findings suggest a few important general lessons from Indonesia’s experiences. The historical overview in Section 2 informs us that agricultural intensifications certainly contributed to reducing rural poverty in the context of Indonesia, especially in Java, but the scope of this option seems rather limited nowadays. In contrast, such technological innovations have not been exhausted in today’s African countries, where modernizing agricultural technologies including the introduction of modern varieties in major crops is considered to be one of the most important steps to solve food security and rural poverty problems.

To go a few steps ahead, our findings offer two important implications. First, the evidence highlights the importance of human capital investments at an early stage of a country’s development. As observed in East Asian countries such as Japan; the Republic of Korea; Taiwan, China; and recently China, the accumulation of human capital is a critical factor that determines the possibility of escaping from high-population-density traps. Indonesia made a large effort to construct public schools from 1973/74 to 1978/79 (see Duflo 2001), which dramatically increased educational attainment, especially in the rural population.

Second, migration and urbanization play important roles in absorbing rural population. More recently, the development of nonagricultural sectors offers higher-productivity activities to the labor force, and our evidence supports a positive role of human capital in the dynamic process. Successful industrialization that reallocates labor into more productive activities, through rural-urban migration as well as evolution of nonfarm industries in rural areas, is a
common phenomenon largely observed in most of growing Asia. Farm households can diversify their income sources to capture the benefits of industrialization through increased non-farm employment in rural areas and/or urban migration (and remittances). Here Indonesia’s successful industrialization has been absorbing labor from labor-intensive agriculture, in contrast to the trans-migration policy that aimed to relocate labor to land abundant non-Java rural areas.

The situation is largely different in many parts of Africa, where increased population pressures can still directly reduce (per capita) operational landholding and farm household welfare. Whether increased population can be absorbed in productive sectors or not differentiates our results and those from Africa. The development of nonagricultural sectors and the rapid accumulation of human capital, both observed not only in Indonesia but many other Asian countries, characterize our results that support a positive role, in the general equilibrium setting, that population density can have, especially when the population is well educated.
REFERENCES

Akiyama, T., Growth of the Agricultural Sector: Are There Peculiarities with Southeast Asia, Chapter 3 in Akiyama, T. and D. Larson, eds. Rural Development and Agricultural Growth in Indonesia, the Philippines and Thailand, Asia Pacific Press.

Becker, G., and H. Lewis. 1973. “On the Interaction between the Quantity and Quality of Children.” Journal of Political Economy 81 (2, part 2): S279–S288.

Binswanger, H., Pingali, P., 1988. Technological Priorities for Farming in Sub-Saharan Africa. The World Bank Research Observer 3, 81-98.

Binswanger, H.P., Khandker, S.R., and M.R. Rosenzweig, 1993. "How Infrastructure and Financial Institutions affect Agricultural Output and Investment in India." Journal of Development Economics, 41: 337-366.

Boserup, E. 1965. The Conditions of Agricultural Growth. New York: Aldine Publishing Co.

________, 1981. Population and Technological Change: A Study of Long-Term Change. Chicago: University of Chicago Press.

Climatic Research Unit, University of East Anglia. 2012. Precipitation (5°×5° and 0.5°×3.75° gridded versions). Accessed on September 15. http://www.cru.uea.ac.uk/cru/data/precip/.

Duflo, E. 2001. “Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment.” American Economic Review 91:795–813.

Fafchamp, M., and F. Shilpi. 2003. “Spatial Division of Labor in Nepal.” Journal of Development Studies 39:23–66.

________. 2005. “Cities and Specialization: Evidence from South Asia.” Economic Journal 115: 477–504.

Falcon, W.P., 2013, Food Security for the Poorest Billion: Policy Lessons from Indonesia, Chapter 2, in R. L. Naylor, ed., The Evolving Sphere of Food Security, FAO (Food and Agricultural Organization). 2012. Global Agro-Ecological Zones. Accessed July 15, 2012. http://www.fao.org/nr/gaez/en/.

Foster, A. D., and M. R. Rosenzweig. 2008. “Economic Development and the Decline of Agricultural Employment.” In Handbook of Development Economics. Vol. 4, edited by P. Schultz and J. Strauss, 3051–3084. Amsterdam: Elsevier.

Fujita, M., P. Krugman, and A. Venables. 1999. The Spatial Economy. Cambridge, MA, US: MIT Press.

Geertz, C. 1963. Agricultural Involution: The Process of Ecological Change in Indonesia. Association of Asian Studies Monographs and Papers No. 11. Berkeley, CA, US: University of California Press.

Hansen, G.E. 1972. “Indonesia’s Green Revolution: The Abandonment of a Non-Market Strategy toward Change.” Asian Survey 12:: 932-946.

Harris, J. R., and M. P. Todaro. 1970. “Migration, Unemployment and Development: A Two-Sector Analysis.” American Economic Review 60:126–142.

Hayami, Y., 2004, “Ecological and Historical Perspecyive on Agricultural Development in Southeast Asia.” Chapter 2 in Akiyama, T. and D. Larson eds Rural Development and Agricultural Growth in Indonesia, the Philippines and Thailand, Asia Pacific Press.

Hayami, Y., and V. W. Ruttan. 1985. Agricultural Development: An International Perspective, 2nd ed. Baltimore: Johns Hopkins University Press.

Hill, H. 1997. Indonesia’s Industrial Transformation. Singapore: Institute of Southeast Asian Studies.

International Rice Research Institute, 2012, IRRI and Indonesia, IRRI, Los Banos, Philippines.

Kinsey, B.H., Binswanger, H.P., 1993. Characteristics and performance of resettlement programs: A review. World Development 21, 1477-1494.

Krugman, P. 1996. The Self-Organizing Economy. Cambridge, MA, US: Blackwell.

Lewis, W. A. 1954. “Economic Development with Unlimited Supplies of Labour.” Manchester School 28:139–191.
Malthus, R. 1826. *An Essay on the Principle of Population*, 6th ed. London: John Murray.

Myint, H. 1965. *The Economics of Developing Countries*, Praeger, New York

---------. 1971. *Economic Theory and Underdeveloped Countries*, Oxford University Press, New York.

Otsuka, K., Y. Liu, and F. Yamauchi. 2013. “Factor Endowments, Wage Growth, and Changing Food Self-Sufficiency: Evidence from Country-Level Panel Data.” *American Journal of Agricultural Economics*, forthcoming.

Schultz, T. P. 2008. “Population Policies, Fertility, Women’s Human Capital, and Child Quality.” In *Handbook of Development Economics*. Vol. 4, edited by P. Schultz and J. Strauss, 3249–3304. Amsterdam: Elsevier.

Sheil, D., Casson, A., Meijaard, E., van Noordwijk, M., Gaskell, J., Sunderland-Groves, J., Wertz, K., and M. Kanninen, 2009, *The impacts and opportunities of oil palm in Southeast Asia: What do we know and what do we need to know?*, Center for International Forestry Research (CIFOR), Bogor, Indonesia

Strauss J., F. Witoelar, B. Sikoki, and A. M. Wattie. 2009. *The Fourth Wave of the Indonesia Family Life Survey: Overview and Field Report, Volume 1*. Rand Labor and Population Working Paper WR-675/1-NIA/NICHD. Santa Monica, CA, US: Rand Corporation.

Timmer, P., 1989, *Food Price Policy: The Rationale for Government Intervention*. *Food Policy*, 4: 7-27.

---------. 1996, *Does BULOG Stabilize Rice Prices in Indonesia? Should it try?* *Bulletin of Indonesian Economic Studies*, 32: 45-74.

World-Bank, 1993. *The East Asian miracle: economic growth and public policy*. Oxford University Press, New York.

---------. 2008, *World Development Report 2009: Reshaping Economic Geography*, World Bank, Washington DC.

World Bank Independent Evaluation Group, 2012, *Transmigration in Indonesia*, Washington, D.C.

Yamauchi, F. 2004. “Are Experience and Schooling Complementary? Evidence from Migrants’ Assimilation in the Bangkok Labor Market.” *Journal of Development Economics* 74:489–513.

_______. 2008, Intergenerational Mobility, Schooling, and the Transformation of Agrarian Society: Evidence from Indonesia, Manuscript, International Food Policy Research Institute, Washington DC.,

_______. 2012. “Wage Growth, Landholding and Mechanization in Agriculture: Evidence from Indonesia” Manuscript, World Bank, Washington, DC.

Yamauchi, F., M. Muto, R.Dewina and S. Sumaryanto, 2008, Spatial Networks, Incentives and the Dynamics of Village Economy: Evidence from Indonesian Villages. Chapter 4 In Huang, Y and A.M. Bocchi, eds. *Reshaping Economic Geography in East Asia*, World Bank, Washington DC.

Yamauchi, F., and R. Dewina. 2009. “Human Capital, Mobility, and Income Dynamics: Evidence from Indonesia.” Mimeo, International Food Policy Research Institute, Washington, DC.

Yamauchi, F., M. Muto, S. Chowdhury, R. Dewina, and S. Sumaryanto. 2011. “Are Schooling and Roads Complementary? Evidence from Income Dynamics in Rural Indonesia.” *World Development* 39:2232–2244.
### Table 1 Key economic and social indicators in Indonesia, 1961-2010

| Year | 1961 | 1965 | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 |
|------|------|------|------|------|------|------|------|------|------|------|------|
| Real per capita GDP (USD) | 208 | 196 | 233 | 300 | 460 | 592 | 799 | 773 | 915 | 1144 |     |
| Annual growth rate | -1.5 | 3.6 | 5.2 | 5.4 | 3.4 | 5.2 | 6.2 | -0.7 | 3.4 | 4.6 |     |
| Industry (% GDP) | 16.3 | 12.6 | 18.7 | 33.5 | 41.7 | 35.8 | 39.1 | 41.8 | 45.9 | 46.5 | 47.0 |
| Annual growth rate | -4.6 | 9.7 | 15.8 | 4.9 | -2.8 | 1.8 | 1.4 | 2.0 | 0.3 | 0.2 |     |
| Rice yield (ton/ha) | 1.94 | 1.95 | 2.62 | 2.90 | 3.63 | 4.35 | 4.74 | 4.79 | 4.85 | 5.04 | 5.53 |
| Annual growth rate | 0.1 | 6.1 | 2.0 | 4.6 | 3.7 | 1.8 | 0.2 | 0.2 | 0.8 | 1.9 |     |
| Agricultural land area (0,000,000 square km) | 4.06 | 4.05 | 4.04 | 4.02 | 4.00 | 4.17 | 4.74 | 4.44 | 4.80 | 5.18 | 5.76 |
| Annual growth rate | -0.1 | -0.1 | -0.1 | -0.1 | 0.9 | 2.6 | -1.3 | 1.6 | 1.5 | 2.1 |     |
| Total population (000,000) | 95.1 | 104.0 | 117.0 | 131.3 | 146.6 | 162.3 | 177.4 | 191.5 | 205.3 | 219.2 | 232.5 |
| Annual growth rate | 2.3 | 2.4 | 2.4 | 2.2 | 2.1 | 1.8 | 1.5 | 1.5 | 1.3 | 1.2 |     |
| Share of rural population (%) | 85.2 | 84.2 | 82.9 | 80.7 | 77.9 | 73.9 | 69.4 | 64.4 | 58.0 | 51.9 | 46.3 |
| Annual growth rate | -0.3 | -0.3 | -0.5 | -0.7 | -1.0 | -1.2 | -1.5 | -2.1 | -2.1 | -2.2 |     |
| Crude birth rate (1/1000) | 44.3 | 42.8 | 40.1 | 36.7 | 33.4 | 29.6 | 25.9 | 23.0 | 21.4 | 20.1 | 18.2 |
| Annual growth rate | -0.9 | -1.3 | -1.8 | -1.8 | -2.4 | -2.7 | -2.3 | -1.4 | -1.2 | -2.0 |     |
| Gross secondary school enrollment rate (%) | -- | -- | 17.5 | 21.1 | 27.4 | 39.0 | 48.0 | 49.4 | 52.8 | 60.6 | 77.2 |
| Annual growth rate | -- | -- | -- | 3.9 | 5.3 | 7.3 | 4.2 | 0.6 | 1.3 | 2.8 | 4.9 |

Sources: FAOSTAT and WB indicators. Annual growth rates are averaged over the past five years based on authors’ calculation.
### Table 2: Average population density over districts, 2000 and 2006

|       | Total | Rural | Urban |
|-------|-------|-------|-------|
| 2000  | 8.68  | 3.30  | 16.93 |
| 2006  | 10.05 | 3.19  | 17.70 |

Source: Self-calculation from PODES 2000 and 2006.
Note: Density expressed as 100 people per square kilometer

### Table 3: Average population density over subdistricts, 2000 and 2006

|       | Total | Rural | Urban |
|-------|-------|-------|-------|
| 2000  | 10.07 | 3.60  | 26.28 |
| 2006  | 12.55 | 4.76  | 29.08 |

Source: Self-calculation from PODES 2000 and 2006.
Note: Density expressed as 100 people per square kilometer.
Table 4: Determinants of population density change from 2000 to 2006

|                                    | (1)      | (2)      | (3)      | (4)      | (5)      | (6)      | (7)      | (8)      |
|------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Share of urban population          | 5364.8***| 6691.6***| 3302.3** | 3085.4** | 0.0476***| 0.0634***| 0.0453** | 0.0372*  |
|                                    | (8.26)   | (9.36)   | (2.41)   | (2.23)   | (4.28)   | (5.75)   | (2.14)   | (1.71)   |
| Share of urban population X        | 10.16    |          | 0.0476***| 0.0634***| 0.0453** | 0.0372*  |          | 0.0228   |
| Provincial capital population      | (1.09)   |          | (4.28)   | (5.75)   | (2.14)   | (1.71)   |          | (1.50)   |
| Average annual total rainfall      | -168.8***| -161.0***| -161.1***| -0.00202***| -0.00207***| -0.00208***|          |          |
| (mm)                               | (-4.30)  | (-4.10)  | (-4.10)  | (-3.33)  | (-3.43)  | (-3.43)  |          |          |
| Square of average annual total     | 0.307*** | 0.299*** | 0.299*** | 0.00000383***| 0.00000399***| 0.00000399***|          |          |
| rainfall                           | (3.74)   | (3.65)   | (3.65)   | (3.03)   | (3.16)   | (3.16)   |          |          |
| Share of total area belonging to   | -9057.0  | -11926.2**| -11888.7**| -0.0553  | -0.140   | -0.139   |          |          |
| warm/semiarid                      | (-1.56)  | (-2.05)  | (-2.04)  | (-1.56)  | (-1.56)  | (-1.55)  |          |          |
| Share of total area belonging to   | -7030.9  | -8400.5* | -8454.0* | -0.114   | -0.167** | -0.168** |          |          |
| warm/subhumid                      | (-1.39)  | (-1.65)  | (-1.66)  | (-1.45)  | (-2.13)  | (-2.15)  |          |          |
| Share of total area belonging to   | -2775.2  | -4775.9  | -4766.4  | -0.0759  | -0.130*  | -0.131*  |          |          |
| warm/humid                         | (-0.56)  | (-0.97)  | (-0.97)  | (-1.00)  | (-1.71)  | (-1.72)  |          |          |
| Percent of households in           | -1470.3  | -1426.1  | -1426.1  | 0.0135   | 0.0144   |          |          |          |
| communities on shore               | (-1.35)  | (-1.31)  | (-1.31)  | (0.81)   | (0.86)   |          |          |          |
| Percent of households in           | -1408.6  | -1374.5  | -1374.5  | -0.0234  | -0.0224  |          |          |          |
| communities in valley              | (-1.00)  | (-0.98)  | (-0.98)  | (-1.08)  | (-1.03)  |          |          |          |
| Percent of households in           | -1822.2**| -1731.1**| -1731.1**| -0.00832| -0.00628 |          |          |          |
| communities in hill area           | (-2.30)  | (-2.17)  | (-2.17)  | (-0.68)  | (-0.51)  |          |          |          |
| Average distance to                | 8.496    | 8.087    | 8.087    | -0.0000358 | -0.0000457 |          |          |          |
| subregency office                  | (1.60)   | (1.52)   | (1.52)   | (-0.44)  | (-0.56)  |          |          |          |
| Average distance to regency        | -5.122** | -5.155** | -5.155** | -0.0000492 | -0.0000500 |          |          |          |
| office                             | (-2.09)  | (-2.10)  | (-2.10)  | (-1.30)  | (-1.32)  |          |          |          |
| Percent of fertile women           | 19151.0***| 19515.3***| 19515.3***| 0.278*** | 0.283*** |          |          |          |
|                                    | (3.19)   | (3.25)   | (3.25)   | (3.01)   | (3.06)   |          |          |          |
| Percent of households who are      | 7187.6   | 6874.5   | 6874.5   | 0.204    | 0.200    |          |          |          |
| family planning acceptors          | (0.62)   | (0.59)   | (0.59)   | (1.13)   | (1.11)   |          |          |          |
| Number of disasters in past 3      | -318.0   | -310.6   | -310.6   | -0.00684*| -0.00660*|          |          |          |
| years                              | (-1.39)  | (-1.36)  | (-1.36)  | (-1.94)  | (-1.87)  |          |          |          |
| Percent of households in communities with a river crossover | -1236.7 | -1312.7 | -0.00565 | -0.00706 |
| Percent of households in communities with a primary school | -3999.2 | -3788.3 | -0.195*** | -0.189*** |
| Percent of households in communities with a junior high school | 4854.2*** | 4795.6*** | 0.0483** | 0.0473** |
| Percent of households in communities with a mosque | 1542.0 | 1750.6 | 0.0415* | 0.0465** |
| Percent of households in communities with a hospital | 1181.0 | 1061.8 | 0.0380** | 0.0352* |
| Percent of households in communities with an epidemic during past year | -1059.5 | -1089.6 | -0.0379*** | -0.0385*** |
| Percent of households in communities that can only travel by sea/river or air | -766.0 | -922.8 | -0.00640 | -0.00990 |
| Percent of households in communities with asphalt/concrete/cone block road | 96.53 | 51.88 | 0.00377 | 0.00288 |
| Percent of households in communities with public telephone available | 1078.0 | 1258.3 | -0.00723 | -0.00363 |
| Percent of households having telephones | 4849.2 | 4407.9 | -0.0127 | -0.0201 |
| Percent of households having televisions | 439.8 | 434.2 | -0.00205 | -0.00189 |
| Percent of households having satellite antennas | -7587.2 | -6653.0 | 0.0310 | 0.0532 |
| Provincial dummies | No | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Number of observations | 3607 | 3128 | 3128 | 3128 | 3607 | 3128 | 3128 | 3128 |

Sources: Estimation from subdistrict samples from PODES 2000 and 2006.
Notes: t-statistics in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01. In models (1) – (4), the dependent variable is difference of population density; capital city population is demeaned value of population (in 10000) in the capital city of the province. In models (5)-(8), the dependent variable is difference of log population density; capital city population is demeaned value of log population in the capital city of the province.
Table 5: Determinants of individual migration decisions

|                      | (1)            | (2)            | (3)            | (4)            | (5)            | (6)            |
|----------------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                      | Probit model   | LPM            | LPM            | Probit model   | LPM            | LPM            |
| Years of schooling   | 0.0872***      | 0.0173***      | 0.0154***      | 0.120***       | 0.0194***      | 0.0122**       |
|                      | (3.06)         | (6.35)         | (4.30)         | (3.63)         | (5.05)         | (2.25)         |
| Age                  | -0.0338***     | -0.00105*      | -0.00176**     | -0.0313***     | -0.00197**     | -0.00373***    |
|                      | (-4.37)        | (-1.87)        | (-2.43)        | (-3.27)        | (-2.08)        | (-2.86)        |
| Years of schooling x | -0.00223**     | -0.000475***   | -0.000453***   | -0.00371***    | -0.000599***   | -0.000428**    |
|                      | (-2.16)        | (-6.06)        | (-4.55)        | (-2.94)        | (-4.83)        | (-2.47)        |
| Female               | -0.0500        | -0.00871       | -0.0131**      | -0.0700        | -0.0104        | -0.0196**      |
|                      | (-0.92)        | (-1.49)        | (-1.98)        | (-1.25)        | (-1.54)        | (-2.53)        |
| FE/dummies           |                |                |                |                |                |                |
| Province             |                |                |                |                |                |                |
| Community            |                |                |                |                |                |                |
| Household            |                |                |                |                |                |                |
| Number of observations | 6,383         | 6,383          | 6,383          | 5,415          | 5,415          | 5,415          |

Sources: Estimation from individual samples from IFLS 2000 and 2007.
Notes: LPM = linear probability model; FE = fixed effects.
t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Mean partial effects are reported for probit model
Table 6: Regression results of household outcomes, household fixed effects with province-specific trends

|                                | (1) Consumption expenditure | (2) Share of wages in income | (3) Share of farm activities in income |
|--------------------------------|----------------------------|------------------------------|---------------------------------------|
|                                | Sample 1  | Sample 2  | Sample 1  | Sample 2  | Sample 1  | Sample 2  |
| Population density             | -13,867.5*** | -15,869.0*** | 0.00924*** | 0.00430 | -0.00498 | -0.00115 |
|                                | (-2.25)   | (-2.65)   | (2.34)    | (1.16)   | (-1.60)   | (-0.39)   |
| Average years of schooling for members aged 18–60 | -8,396.3  | -3,043.1  | 0.00685  | 0.0169*** | -0.000359 | -0.00896 |
|                                | (-1.12)   | (-0.44)   | (1.06)    | (2.73)   | (-0.06)   | (-1.50)   |
| Population density x average years of schooling for members aged 18–60 | 1,538.4* | 1,695.8** | -0.000841** | -0.000472 | 0.000421 | 0.000159 |
|                                | (1.93)    | (2.34)    | (-2.06)   | (-1.35)  | (1.15)    | (0.47)    |
| Total land owned (ha)          | 14,033.0*** | 6,370.1  | -0.0232* | -0.0243*** | 0.0214* | 0.0224*** |
|                                | (2.36)    | (0.65)    | (-1.88)   | (-4.11)  | (1.94)    | (3.17)    |
| Population density x total land owned | 104.5  | 117.0  | 0.000491*** | 0.000203** | 0.0000258 | -0.000915 |
|                                | (0.71)    | (0.98)    | (2.37)    | (2.20)   | (0.15)    | (-0.85)   |
| Household size                 | -47,651.1*** | -35,559.2*** | -0.00219 | -0.00776 | -0.00900 | -0.00218 |
|                                | (-7.84)   | (-7.40)   | (-0.26)   | (-1.04)  | (-1.21)   | (-0.33)   |
| Number of members aged 18–60   | 28,538.5*** | 44,633.5*** | 0.0339** | 0.0296** | -0.0127 | -0.0277** |
|                                | (2.85)    | (4.87)    | (2.38)    | (2.23)   | (-0.96)   | (-2.33)   |
| Number of school-age children (7–18 years old) | 2,774.2  | 3,820.5  | -0.00630 | -0.0112 | 0.00584 | 0.00318 |
|                                | (0.43)    | (0.61)    | (-0.64)   | (-1.23)  | (0.65)    | (0.38)    |
| Average age of members aged 18–60 | 1,457.5 | 688.9  | -0.00373** | -0.000901 | 0.00249* | 0.00136 |
|                                | (1.33)    | (0.59)    | (-2.51)   | (-0.58)  | (1.73)    | (0.93)    |
| Number of female adults        | -9,101.9 | -15,449.9 | -0.0288 | -0.0101 | 0.00805 | 0.0195 |
|                                | (-0.61)   | (-1.12)   | (-1.44)   | (-0.55)  | (0.42)    | (1.08)    |
| Number of observations         | 4,659  | 4,686  | 4,564  | 4,635  | 4,564  | 4,635  |

Sources: Estimation from household samples from IFLS 2000 and 2007.

Notes: Sample 1 refers to the sample with original and split households; Sample 2 refers to the sample with original, split, and migrant households; t-statistics in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01.
Table 7: Regression results of household outcomes, household fixed effects with community-specific trends

|                                               | (1)                      | (2)                      | (3)                      | (4)                      | (5)                      | (6)                      |
|-----------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|                                               | Sample 1   | Sample 2   | Sample 1   | Sample 2   | Sample 1   | Sample 2   |
| Average years of schooling for members aged 18–60 | -7,363.7    | -1,800.6    | 0.00395    | 0.0146     | 0.00480    | -0.00594    |
|                                               | (-0.98)     | (-0.26)     | (0.62)     | (2.32)     | (0.77)     | (-1.01)     |
| Population density x average years of schooling for members aged 18–60 | 1,484.9*     | 1,677.1**   | -0.000986*  | -0.00630*  | 0.000310   | 0.000117    |
|                                               | (1.77)      | (2.20)      | (-2.46)    | (-1.77)    | (0.81)     | (0.33)      |
| Total land owned (ha)                         | 13,647.0**  | 6,477.6     | -0.0278**  | -0.0263*** | 0.0224**   | 0.0222***   |
|                                               | (2.40)      | (0.72)      | (-2.26)    | (-4.21)    | (2.08)     | (3.01)      |
| Population density x total land owned         | 279.8       | 201.3*      | 0.000469*  | 0.000246** | 0.000768   | -0.00109    |
|                                               | (1.30)      | (1.79)      | (2.11)     | (2.47)     | (0.40)     | (-0.93)     |
| Household size                                | -50,506.0***| -37,232.5***| -0.00245   | -0.00602   | -0.00775   | -0.00359    |
|                                               | (-8.18)     | (-7.67)     | (-0.29)    | (-0.79)    | (-1.06)    | (-0.55)     |
| Number of members aged 18–60                  | 28,442.8*** | 46,023.2*** | 0.0378***  | 0.0285***  | -0.0169    | -0.0254**   |
|                                               | (2.75)      | (4.96)      | (2.90)     | (2.16)     | (-1.29)    | (-2.22)     |
| Number of school-age children (7–18 years old)| 4,370.6     | 3,958.3     | -0.00809   | -0.0127    | 0.00431    | 0.00304     |
|                                               | (0.67)      | (0.63)      | (-0.81)    | (-1.39)    | (0.49)     | (0.37)      |
| Average age of members aged 18–60             | 982.8       | 532.6       | -0.00387***| -0.000954  | 0.00325**  | 0.00156     |
|                                               | (0.92)      | (0.47)      | (-2.58)    | (-0.61)    | (2.25)     | (1.08)      |
| Number of female adults                       | -3,322.9    | -16,196.4   | -0.0335*   | -0.00884   | 0.0139     | 0.0184      |
|                                               | (-0.23)     | (-1.18)     | (-1.68)    | (-0.49)    | (0.72)     | (1.06)      |
| Number of observations                        | 4,659       | 4,686       | 4,564      | 4,635      | 4,564      | 4,635       |

Sources: Estimation from household samples from IFLS 2000 and 2007.

Notes: Sample 1 refers to the sample with original and split households; Sample 2 refers to the sample with original, split, and migrant households; t-statistics in parentheses; *p < 0.10, **p < 0.05, ***p < 0.01.
Table 8: Changes in farm landholding at the household level

|                                | (1) Change in land owned (ha) | (2) Change in land cultivated (ha) |
|--------------------------------|-------------------------------|------------------------------------|
| Change in population density   | -0.0156***                    | -0.000467                          |
|                                | (-8.83)                       | (-0.16)                            |
| Change in population density x if Java | 0.00914                       | 0.00220                            |
|                                | (1.27)                        | (0.19)                             |
| If female-headed household     | 0.0433                        | 0.0681                             |
|                                | (0.57)                        | (1.19)                             |
| Age of household head          | -0.00343*                     | -0.00222                           |
|                                | (-1.69)                       | (-1.15)                            |
| Initial average years of schooling for members aged 18–60 | -0.0103                        | 0.00910                            |
|                                | (-1.17)                       | (1.30)                             |
| Initial household size         | 0.0151                        | -0.0171                            |
|                                | (0.59)                        | (-0.71)                            |
| Initial number of members aged 18–60 | -0.00284                      | 0.0273                             |
|                                | (-0.08)                       | (0.79)                             |
| Change in average years of schooling for members aged 18–60 | -0.0218                        | -0.00851                           |
|                                | (-1.15)                       | (-0.83)                            |
| Change in household size       | 0.0457*                       | 0.0535**                           |
|                                | (1.70)                        | (2.34)                             |
| Change in number of members aged 18–60 | 0.0836*                      | 0.0264                             |
|                                | (1.82)                        | (1.17)                             |
| Province dummies               | Yes                           | Yes                                |
| Number of observations         | 2,210                         | 2,169                              |

Source: Estimation from household samples from IFLS 2000 and 2007.
Notes: t-statistics in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01.
Table 9: Farm profitability

|                          | (1) Change in log farm income per ha owned | (2) Change in log farm income per ha cultivated |
|--------------------------|------------------------------------------|-----------------------------------------------|
| Change in population density | -0.151*** (3.90)                          | -0.00216 (-0.08)                              |
| Change in population density x if Java | 0.143*** (3.33)                          | -0.0283 (-0.89)                              |
| If female-headed household | 0.214 (0.83)                             | -0.0386 (-0.17)                              |
| Age of household head    | 0.0105* (1.79)                           | 0.00595 (1.22)                               |
| Initial average years of schooling for members aged 18–60 | 0.0219 (0.76)                          | -0.0321 (-1.28)                              |
| Initial household size   | 0.0238 (0.40)                            | 0.0321 (0.62)                                |
| Initial number of members aged 18–60 | -0.0547 (-0.67)                      | 0.0199 (0.25)                                |
| Change in average years of schooling for members aged 18–60 | -0.0239 (-0.69)                      | -0.0306 (-1.04)                              |
| Change in household size | 0.0130 (0.29)                            | 0.0159 (0.34)                                |
| Change in number of members aged 18–60 | -0.110 (-1.51)                       | -0.0444 (-0.59)                              |
| Province dummies         | Yes                                     | Yes                                           |
| Number of observations   | 761                                     | 989                                           |

Source: Estimation from household samples from IFLS 2000 and 2007.
Notes: t-statistics in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01.
Figure 1a Years of schooling over cohorts in 2007

Sources: Yamauchi (2008). Data: IMDG 2007 Survey (International Food Policy Research Institute and Japan International Cooperation Agency)

Figure 1b Probability of engaging in non-agricultural fulltime works

Sources: Yamauchi (2008). Data: IMDG 2007 Survey (International Food Policy Research Institute and Japan International Cooperation Agency)
## APPENDIX

### Table A.1: Summary statistics of sample households, 2000 and 2007

| Variable                              | 2000     | Std. dev. | 2007 (original + split) | Std. dev. | 2007 (original + split + migrant) | Std. dev. |
|---------------------------------------|----------|-----------|--------------------------|-----------|------------------------------------|-----------|
| Per capita consumption expenditure    | 188,792  | 229,297   | 411,896                  | 314,050   | 426,898                            | 309,833   |
| Income share of wages                 | 0.32     | 0.4       | 0.34                     | 0.4       | 0.38                               | 0.39      |
| Income share of farming               | 0.35     | 0.4       | 0.39                     | 0.4       | 0.35                               | 0.38      |
| Area of land owned (ha)               | 0.49     | 1.38      | 0.32                     | 0.80      | 0.39                               | 1.30      |
| Area of land cultivated (ha)          | 0.47     | 1.30      | 0.33                     | 0.87      | 0.40                               | 1.23      |
| Average years of schooling of members aged 18–60 | 6.71     | 2.89      | 7.33                     | 3.04      | 7.44                               | 3.02      |
| Household size                        | 5.32     | 2.28      | 6.36                     | 2.92      | 7.61                               | 4.3       |
| Number of members aged 18–60          | 3.02     | 1.56      | 3.76                     | 2.08      | 4.55                               | 2.97      |
| Number of school-age members (aged 7–18) | 1.3      | 1.24      | 1.22                     | 1.14      | 1.43                               | 1.42      |

Source: Self calculation from household sample from IFLS 2000 and 2007.

### Table A.2: Individual migration rate by age cohort

| Age cohort | Migration rate |
|------------|----------------|
| 15–25      | 13.0%          |
| 25–35      | 3.0%           |
| 35–45      | 1.6%           |
| 45–60      | 0.8%           |
| 15–60      | 5.5%           |

Source: Self calculation from household sample from IFLS 2000 and 2007.