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IFPRI Discussion Paper 00741

December 2007

Spatial Coordination in Public Good Allocation

Nonparametric Evidence from Decentralized Indonesia

Futoshi Yamauchi, International Food Policy Research Institute
Shyamal Chowdhury, University of Sydney
and
Reno Dewina, International Food Policy Research Institute

Food Consumption and Nutrition Division

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ABSTRACT

This paper examines dynamics in public good accessibility and cross-community inequality in Indonesia, using village-level panel data from 2000 to 2006 from their decentralized public-good allocation system. The introduction of decentralization makes public-good investment dependent on initial local income and endowment, and makes it difficult to coordinate investment decisions across communities. Our analysis also shows that possible strategic interactions among communities connected with transportation infrastructure (externalities) implies spatial divergence. Empirical evidence on education and heath facilities, however, demonstrates that during the decentralized period, (1) accessibility to school has improved and school investments were effectively coordinated over space; (2) hospital access has improved only marginally; but (3) per-capita availability of schools and local medical clinics (*puskesmas*) in the community shows convergence toward low-level equilibria. Despite the coordination in spatial allocation even in the decentralization period (observed in intervillage accessibility), endogenous population mobility and growth partially cancel the benefits of the coordinated efforts in public-good allocation. This point requires further policy attention.

Keywords: public goods, education, health, spatial coordination, poverty dynamics, Indonesia

1. INTRODUCTION

The devolution of political decisionmaking to local governments and communities—so-called decentralization—has been promoted in the area of infrastructure investment. Development aid agencies such as the World Bank also tend to encourage this experimental transition of political power from central governments to local entities in many developing countries (World Bank 2000). In a decentralized regime, local governments and communities are expected to work together to manage their resources and decide the budget allocation. In this simplified picture, well-endowed communities often use their resources well and thus achieve more investment in local public goods, while resource-poor communities have difficulty raising enough funds to invest in local public goods and may thus remain stagnant. For this reason making investment capability dependent on local income and endowments can potentially increase intercommunity inequality.

The issue of coordination failure is potentially important in both centralized and decentralized regimes. First, if small communities decide to investment in public goods independently, it would be difficult for a group of them to coordinate their projects. Second, in reality, both local communities *and* governments are often involved in the decisions on local public-good investments and allocation. Even if the local government tries to coordinate communities' investments across all the communities in their jurisdiction, it is not guaranteed that the investments will be well coordinated to equalize the accessibility and availability of public goods. Third, the central government also allocates budgets to local governments, who coordinate public-good investments in their regions. For example, in Indonesia, villages propose investment project plans to their district, which select good projects and allocate to them not only district but also central government funds that the district has received.

Local coordination becomes especially important in the presence of externalities. For example, since children often commute to schools outside their village, the spatial allocation of schools across villages will be crucial in ensuring accessibility to education. In other words, children can benefit from schools investments in other villages. In this paper, we examine the spatial coordination and allocation issues of public goods such as schools and health facilities in a decentralized regime, using village-census panel data from Indonesia.

In Indonesia, the responsibility for much of government expenditure was decentralized to district governments through fiscal and political decentralization. Two cornerstones of Indonesian decentralization are Law 22/1999 on governance and Law 25/1999 on fiscal relations. Law 22 devolves all governance functions from the center to the regions with the exception of national defence, international relations, justice, police, monetary policy, development planning, religion, and finance. It makes local governments responsible for the provision of health, education, and environmental and infrastructure services. Local governments can also perform any other function not explicitly reserved for the center (Hofman and Kaiser 2006).

Similar to the law on governance, Law 25 on fiscal relations has significantly strengthened local governments' share in government spending. For example, regional governments' expenditure as a share of overall public expenditure increased from about 17 percent in 2000 to more than 30 percent after 2001. In addition, decentralization also reassigned some two-thirds of central civil servants to regional governments, and regional governments now employ more than three-quarters of civil servants (Hofman and Kaiser 2006).

Following the decentralization decision, the central government quickly delegated virtually complete responsibility for urban and rural infrastructure services to local governments (Peterson and Muzzini 2005). The transition was implemented in 2001. In 2002, local governments financed 44.3 percent of transportation development, 21 percent of health and social services, and 16 percent of education development (Eckardt and Shah 2006). Today, even though the central government distributes grant subsidies to local governments, fiscal equalization remains incomplete in large part because the equalization formula is still driven by historical allocations, including wages, and local governments are subject to significant disparities in per capita expenditures (Hofman and Kaiser 2006).

This experiment in Indonesia is unique in two ways. First, the change happened very quickly and applies to a large area. It was in fact imposed on the majority of local communities from above, and they did not have time to prepare for the change before it happened.

Second, local conditions across the country vary greatly, including access to and availability of local public goods. We would therefore expect various responses to decentralization at the community level. For these two reasons, Indonesia gives us a suitable empirical setting in which to investigate how diverse local initial conditions affect the potential to grow during the decentralization period.

Indonesia also provides an invaluable village-census database, which helps us to understand village-level dynamics of public goods such as public education and health facilities. For our research purposes, the village is an appropriate unit of observation since it is the basic unit of consensus-building. Villagers, coordinated by the village office (head), approach local governments at the *kecamatan* (subdistrict) and *kabupaten* (district) level for funding for their projects. We construct panel data from the village census during the decentralization regime to examine possible changes in the way that public-good investments were determined (see Section 4).

The earlier literature on decentralization started with the seminal work of Tiebout (1956), where voter-citizens move costlessly among jurisdictions and chose from them. Tiebout focused on whether a set of competing jurisdictions would provide an efficient allocation of public goods. As we will see, the Indonesian evidence partly supports the Tiebout-style "voting with your feet" argument. One of the omissions of Tiebout's work was that he did not consider "spillovers," which was remedied in Oates (1972). Under an assumption of uniform expenditure, Oates (1972) finds that decentralization is preferable over centralized provision with heterogeneous tastes and no spillovers since local governments can tailor local public goods to local tastes. However, with spillovers and no taste heterogeneity, centralized provision is more efficient.

Recent literature on decentralization has taken two directions. The first studies examine theoretically the various aspects of decentralization impacts, such as the emergence of local elites capturing the bulk of the benefits and the improvements in project efficiency and accountability (see, for example, Bardhan 2002; Bardhan and Mookherjee 2000). Second, empirical studies have also emerged recently that assess both the effect of decentralization and democratization on both public-good investment behavior (see, for example, Chattopadhyay and Duflo 2004; Foster and Rosenzweig 2001) and students' academic achievement where vouchers have been introduced (Angrist et al. 2002). The main interest in the literature is to know the effect of heterogeneous population preferences on local decisionmaking for public investments.[1] We investigate this issue in detail in another paper (Chowdhury, Yamauchi, and Dewina 2007).

Unlike the above papers, we are interested in cross-community (spatial) inequality and the poverty trap. To our knowledge, this paper is the first attempt to assess dynamic implications for inequality, divergence, and convergence across communities. Our main conjecture is that, even if decentralization can improve accountability and efficiency in public-good investment and management, it can also increase cross-community inequality if the government and/or local communities do not coordinate their efforts. This coordination is especially desirable where public goods have externalities across communities. This concern poses a serious question about equity, as investment capacity crucially depends on local income and endowment through the decentralization process.

This paper is organized as follows. The next section sets up a simple model of local decisionmaking on public goods in both decentralized and centralized regimes. We next show that transportation externalities (road development) across communities introduce strategic interactions among communities. The main implication is that decentralization can potentially increase intercommunity inequality because of the failure of communities to coordinate their decisionmaking, whereas the central government is expected to equalize public-good allocation across communities.

Section 3 discusses our empirical approach. We use nonparametric estimation of public-good dynamics, which can flexibly depict possibilities of convergence and divergence processes. Section 4 describes our data and the method we used to construct village-level panel data.

[1] Miguel and Gugerty (2005) investigated the effects of ethnic diversity on local public good management. Ethnic diversity leads to collective action failures by making it diffcult to impose social sanctions.

Section 5 shows our empirical results on dynamics in the availability and accessibility of school and health facilities. We observe an interesting similarity between the two types of local public-good dynamics. We show that communities are converging in a situation in which they have more equal access to primary, junior, and senior school. This trend is slightly weaker in the spatial allocation of hospitals. However, the dynamics of facility availability indicates convergence to low-level equilibria. These two observations can be explained by endogenous population mobility and growth. People move to locations with more per-capita facilities, although new investments are effectively coordinated over space to improve accessibility during the decentralization period. Section 6 shows some evidence that population growth—including both natural and through mobility—is higher in locations with higher per-capita numbers of school and health facilities at the initial stage.

2. MODEL

2.1 Basic Setting

This section sets up the environment in which the community decides public-good investment and allocation. Assume for simplicity that there is one public good. We also assume that the community allocates its resources into consumption and investment and has returns (service) from the public-good investment. For simplicity, assume there is no subsidy from the central government.

The community taxes the residents to raise funds for building the public good. The tax rate is assumed to be unique within the community, and residents have to decide through some mechanism what the rate should be. Before discussing the mechanism, let us describe the individual decision problem. Assume a nondegenerate income distribution in the community. Income y_i is given to individual *i*. With tax rate *t*, the per-capita public good *q* is formed through $q = tE(y)$ if $q \geq g$ (or $t \geq \frac{g}{E(y)}$) where $E(y)$ is the average community income, which is exogenous to each individual in the community, and *g* is the minimum sufficient level of the public good. Assume that $q = 0$ if $tE(y) < g$. Meanwhile, we assume that the above condition holds. We write the utility for a household as

$$V(t; y_i) = u((1-t)y_i) + \beta f(q),$$

where $u(.)$ and $f(.)$ are utility functions for the consumption and public-good service, respectively, and β is the discount factor ($\beta \in (0,1)$). Assume that both utility functions are strictly increasing and concave. Since the problem is single-peaked, the first order condition for agent *i*, $u'(c_i)y_i = \beta E(y) f'(q)$, provides the most preferred tax rate for *i*. In other words, the most-preferred tax rate is determined by

$$MRS(y_i) = \frac{u'(c_i)}{\beta f'(q)} = \frac{E(y)}{y_i}.$$

The relative income position affects the individually most-preferred tax rate. Let $t(y_i)$ denote the tax rate, that is $t(y_i) \equiv \text{argmax}\, V(t; y_i)$. Given the nondegenerate income distribution, we also have a nondegenerate distribution of the most preferred tax rate. The community uses majority voting to decide the community's tax rate. By median voter theorem, the tax rate t^* is equal to

$$t(y^m) = \text{argmax}\, V(t; y^m),$$

where y^m is the median income in the community. In this autarchy case, since community-income level (median, taking into account the distribution) affects investment in public good, the distribution of the community median-income (across communities) will generate the distribution of public-good investment.

Proposition 1

(i) Investment in public good depends on community income level
(ii) Cross-community income distribution generates the distribution (inequality) of public-good investment across communities.

2.2 Multiple Communities

In this section, we open transportation to neighboring communities. We assume *N* communities. Let q_{-k} denote per-capita public good in the other community. Individuals have access to public good in the neighboring community. Accessibility to public good outside one's own community is measured by $\delta \in (0,1)$, and δq_{-k} is the good (or service) accessible for them. Our problem becomes

$$V(t; y_i, q_{-k}) = u((1-t)y_i) + \beta f(q_k + \delta q_{-k}) .$$

In the above, we assume that public good (service) in one's own community is substitutable to that in the other community. This setting creates a free-rider incentive, which leads to underinvestment. Individuals in the community take public good (service) in the other community as exogenous to them.

By median voter theorem, the community's tax rate is $t(y_k^m; q_{-k})$. Therefore,

$$q(q_{-k}) = E(y_k)t(y_k^m, q_{-k}),$$

which is the community's reaction function to q_{-k}. The function $q(q_{-k})$ is negatively sloped, and the slope depends on accessibility parameter δ. The larger δ is, the greater the free-riding incentive is. Thus, the function becomes more negatively sloped.

The Nash equilibrium is defined as (q_k^*, q_{-k}^*) or $(t_k^*, t_{-k}'^*)$, from which both communities have no incentive to deviate. The intersection of the two reaction functions defines the equilibrium:

$$q_k^* = q(q_k^*) = E(y)t(y_k^m, q_{-k}(q_k^*)).$$[2]

Proposition 2

i) In the presence of cross-community transportation ($\delta > 0$), public good in neighboring communities reduces the incentive to invest in public good (free-riding incentive).
(ii) An increase in δ decreases the incentive to invest, which implies divergence in public goods.
(iii) Income inequality across communities generates divergence in public goods.

There are a few remarks on the equilibrium. First, without interdependence between the communities, we confirm again that a higher average (median) community income implies more public good (by a higher tax rate). This creates a wider income inequality between the communities than the central government case (see the next section).

Second, a higher income in the neighboring communities implies a lower incentive to invest because of a free-riding incentive. In other words, the community invests more in public goods if the adjacent community is poor. The interdependence creates a potential free-rider problem. When all communities in a region are poor (cannot afford to invest enough in public good), they are likely to be in a poverty trap, as in the autarchy case.

Third, compared to the autarchy case, we have welfare improvement in the two community cases due to cross-community spillovers. Both communities can save investment in the first period. Thus, opening a road and improving accessibility to the other community will improve the total welfare in both communities.

2.3 Social Planner: Central and Local Governments

In this section we examine the implications in the case where the central or local government taxes income and allocates public goods in communities mutually connected through transportation. Assume

[2] Suppose that q^1 and q^2 are two different public goods. Utility from these services in each community is summarized as $\sum_{j=1,2} f(q_k^j + \delta q_{k'}^j)$. Budget allocation is $q_k^1 + q_k^2 = tE(y_k)$. Reaction function for tax is $t(y_k^m; q_{k'}^1, q_{k'}^2)$. This setting creates the possibility of coordination between the two communities if δ is sufficiently large. Since marginal returns from the service are assumed to be the same in the two public goods, they have an incentive to equalize the marginal returns from these goods.

However, the minimum sufficiency condition imposes that $tE(y_k) \geq 2g$ in both communities if they invest in both. In some income range, it is easy to show that $q_k^1 = t(y_k^m; 0, q_{k'}^2)E(y_k)$ and $q_{k'}^2 = t(y_{k'}^m; q_k^1, 0)E(y_{k'})$ are Nash equilibrium. Multiplicity of public goods with spatial substitutability may generate the multiplicity of equilibria: poverty-trap and coordination equilibria if the minimum investment requirement for the multiple goods cannot be met singly in each community.

that the government can tax communities differently and allocate different amounts of public good to communities. Define the resource constraint as

$$\sum_k t_k \sum_i y_{ik} = \sum_k n_k q_k ,$$

where superscript k denotes community and n_k is community k's population. Assume $n = n_k$ for all k.

The government maximizes the sum of utilities in N communities:

$$\max \sum_{k=1}^{N} \sum_i u((1-t_k) y_{ik}) + \beta \sum_{k=1}^{N} nf(q_k + \delta q_{-k}) ,$$

subject to

$$\sum_{k=1}^{N} t_k \sum_i y_{ik} = \sum_{k=1}^{N} nq_k .$$

The first order conditions for t_k and q_k are, respectively,

$$-\sum_i y_{ik} u'(c_{ik}) + \lambda \sum_i y_{ik} = 0$$

$$\beta nf'(q_k + \delta q_{-k}) + \beta \sum_{k' \neq k} nf'(q_{k'} + \delta q_{-k'}) - \lambda n = 0$$

for all k. The latter set of conditions gives q^* for all k. Therefore, the government guarantees equal access to public good in each community, no matter what the income level is. From the former set, we have the following condition:

$$\lambda = \sum_i \left(\frac{y_{ik}}{\sum_i y_{ik}} \right) u'(c_{ik})$$

for all k. The weighted average of marginal utilities (with relative income as a weight) is equalized between the two communities. This condition implies that the government taxes rich communities more (that is, the government can also distribute subsidies to communities if a unique tax rate is imposed on all communities).

Proposition 3

(i) Under centralization, the government progressively taxes communities and allocates public goods equally across communities.
(ii) Local spillovers (q substitution through transportation) do not change the above result, although it affects investment level.

We have some remarks. First, with centralization, the allocation of public goods is equalized across communities. In the process of decentralization, however, the income inequality across communities generates the inequality in public good investment. Depending on how public goods are related across neighboring communities (substitutable or complementary), the income and endowment levels of neighboring communities have a negative or positive effect on the incentive to invest in public good. The latter case may induce spatial poverty traps.

Second, spatial correlation has implications on local inequality and dynamics of public investment. For example, negative spatial correlation increases local inequality in the availability of public good. This factor does not necessarily increase local inequality in accessibility because in this situation, they can easily access public goods in other communities.[3] Therefore, it is important to distinguish between availability and accessibility when assessing the impact of decentralization on inequality.

Positive spatial correlation of public-good investments in a region, generated from the spatial complementarities (as discussed in Appendix A), may induce multiple equilibria (one of which could be poverty trap). In this case, local inequality may not increase through decentralization since public-good investments are positively correlated among communities.

Third, note that in Section 2.3, we discussed centralized coordination in which the central authority decides resource allocation across communities. This is one form of cross-community coordination. In Section 2.2, we discussed the possibility of noncentralized coordination in a noncooperative game setting. Empirically we also cannot identify the funding source of public investments but can only observe changes in public infrastructure. Although the interpretation of coordinated investments differs between the above two stories, we have to set this issue aside as a possible limitation in our empirical work.

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[3] However, we do not have data on time costs required to reach the nearest public good in some other communities.

3. EMPIRICAL APPROACH

To assess community-level public-good dynamics, we use a nonparametric approach, and a local polynomial smoothing estimation. This approach is flexible to capture (possibly non-linear) relationships between current community-level public good or accessibility and the next period.

Figures 1 and 2 illustrate the possibilities of multiple equilibria: poverty trap, threshold, and stable high-level equilibrium. Figures 1a and 1b show the dynamics of public good availability, for example, the number of facilities per capita. Given the initial level, the number of facilities per capita will increase (decrease) if the dynamic curve is above (below) the 45 degree line. Figure 1a describes convergence to a low-level x_* (poverty trap). In contrast, Figure 1b shows sustainable growth in x_t if the initial level is above the threshold.

Accessibility is measured and interpreted in a different way. We show distance to the nearest facility outside the community if there is no facility in the community. Since a long distance means that the facility is not easily accessible, the area below the 45-degree line (that is the distance is getting shorter over time) implies convergence. Figure 2a shows a possibility that intercommunity inequality becomes larger over time. Remote areas are neglected in this case. Figure 2b describes intercommunity convergence.

Note that in the analysis of distance (accessibility), we only examine villages with no facility, that is, those villages that are underdeveloped in the sense that they have no public infrastructure in the initial condition.

Coordination success and failure also correspond to the above figures. If public goods are allocated effectively over space (across communities), they should improve accessibility in neighboring communities too. Such coordination can fail when spatial allocation is not well designed. In the period of decentralization, if neighboring communities do not coordinate among themselves, it may increase inequality in accessibility.

In decentralization, however, we have a more fundamental prediction, that is, low-income (low-endowment) communities suffer from a lack of resources to invest in public goods. Thus, we predict that divergence patterns are more likely to be observed in decentralization that lacks the coordination of the central or local governments.

The above method potentially fails to capture spatial variations in the timings of decentralization implementation, and to differentiate cases by the length of period exposed in the decentralization process. As discussed in the introduction, this paper does not attempt to strictly compare centralized and decentralized regimes.

Figure 1. Per-capita availability

Figure 1a.

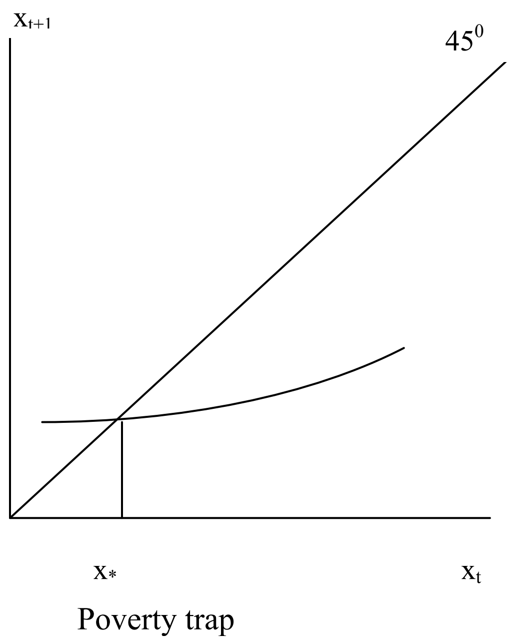


Figure 1b.

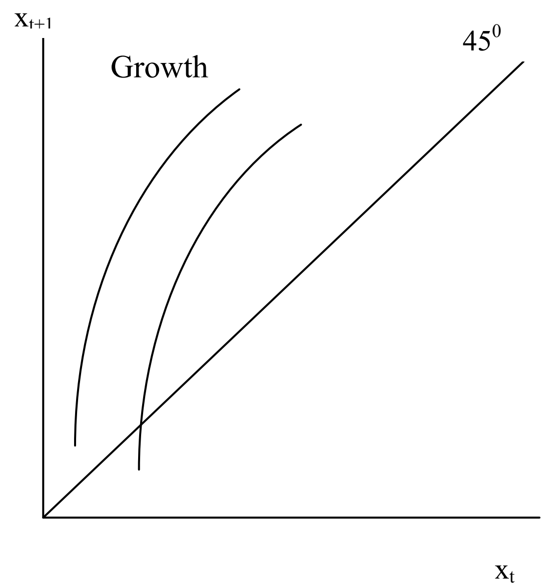


Figure 2. Accessibility

Figure 2a.

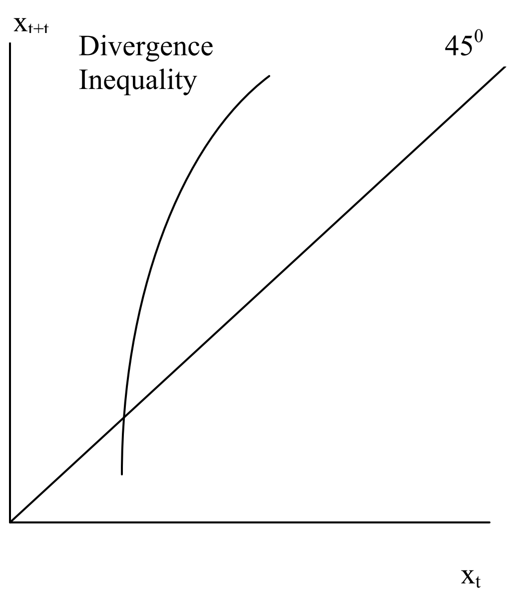
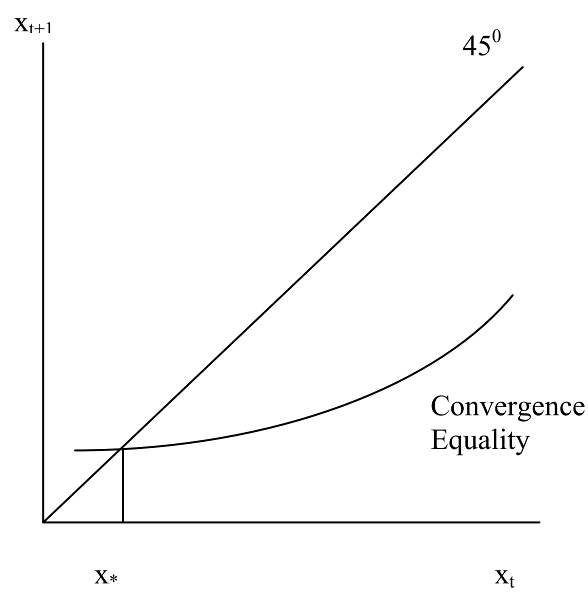


Figure 2b.



4. DATA

We use the Indonesian village census (PODES) for 2000 and 2006. Each round covered all villages in the country, collecting information on various village characteristics. We matched the 2000 and 2006 rounds by village, (1) recovering provinces, districts, and subdistricts from codes that have changed from round to round; (2) sorting out merge and split patterns at the subdistrict level, and (3) constructing unique codes for these administrative units. At the village level, we used village names to match, so where village names changed, some observations were missed (along with their splits). During this process about 80.7 percent of the 2000 villages were merged between 2000 and 2006, based on the 2000 village sample.

The village census collects detailed information on education and public-health facilities in all rounds. On education, it asks how many schools there are of different types (primary, junior secondary, senior secondary, and higher), which are public or private, and the distance to the nearest school if the village has no school. On health facility, it collects information on the number of different types of health facility (hospital, maternity house, medical clinic [*poliklinik*], community health center [*puskesmas*], and so on) and the distance to the nearest health facility if the village has none itself.

In the analysis, we use the per-capita number of facility and the distance to the nearest facility to measure the availability and accessibility of education and health public goods (services), respectively. Note that the per-capita number of facilities may change because of population mobility, even if the absolute number of facilities does not change.

It is important to note that the capacities of schools and health facilities could be different across villages. For example, even if the per-capita number of schools is low, those schools could themselves be large. However, the situation in many villages is different from that of towns and cities, in that schools are usually small in rural areas. It is also important to note that high schools are, on average, larger than primary schools. In the nonparametric analysis below, therefore, we have to allow certain errors in the measurement of per-capita facility availability.

Distance to the nearest facility (if the village has no facility) can measure the accessibility to public goods as well as intercommunity coordination success and failure. Allocation in other villages changes the distance, so the spatial distribution of public goods (services) could have implications for accessibility.

5. EMPIRICAL RESULTS

This section reports empirical findings on education and health facilities during the 2000–2006 period. The analysis investigates dynamic changes in (1) accessibility and (2) within-village availability of these facilities in the decentralization period. We cover all provinces in Indonesia, which provides sufficient variations in local endowment and economic conditions.

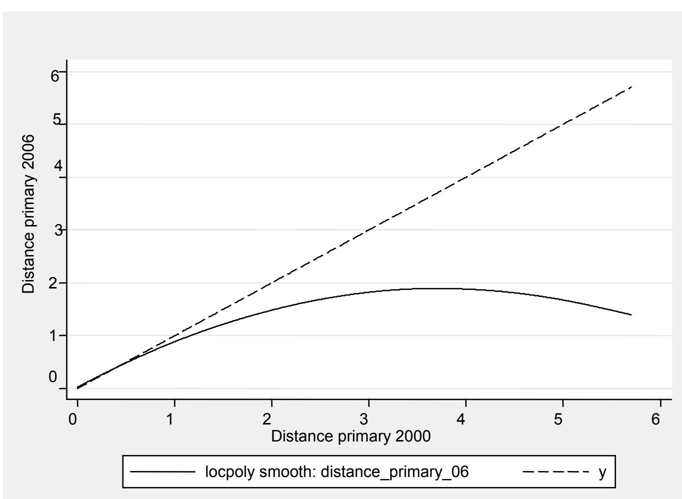
5.1 Schools

5.1.1 Accessibility: Underdeveloped villages

We report nonparametric regression results on the village dynamics of education public goods. The analysis examines dynamic changes in the access (distance) to the nearest primary school, junior high school, and senior high school among villages without schools.

In the analysis of distance to the nearest school, 6 and 50 kilometers were chosen as the maximum distance to primary and high schools, respectively, after carefully examining the skewed distributions (see Appendix B Tables B.1 to B.3 for the number of schools and percentage distributions). Figure 3 depicts the dynamic changes in the distance to the nearest primary school. Generally, accessibility dynamics show convergence patterns. Convergence seems to be quite visible for villages in terms of distance to the nearest school.

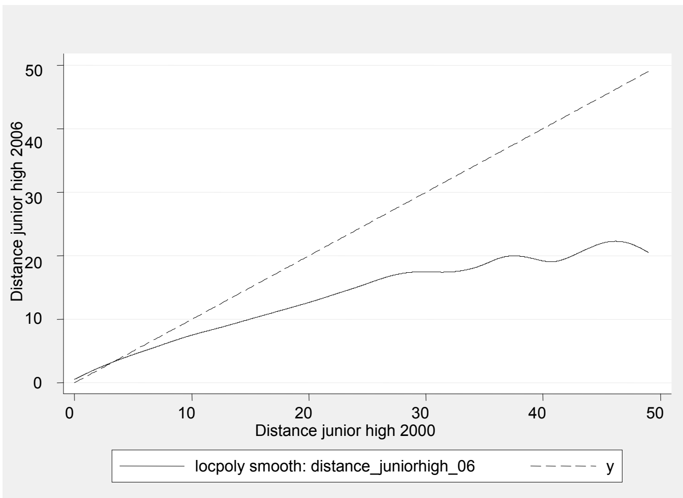
Figure 3. Dynamics: Distance to primary school, 2000-2006



However, caution must be exercised in generalizing this finding, as the sample we used in this analysis is only about 8 percent of the total villages. In other words, more than 90 percent of villages have at least one primary school.

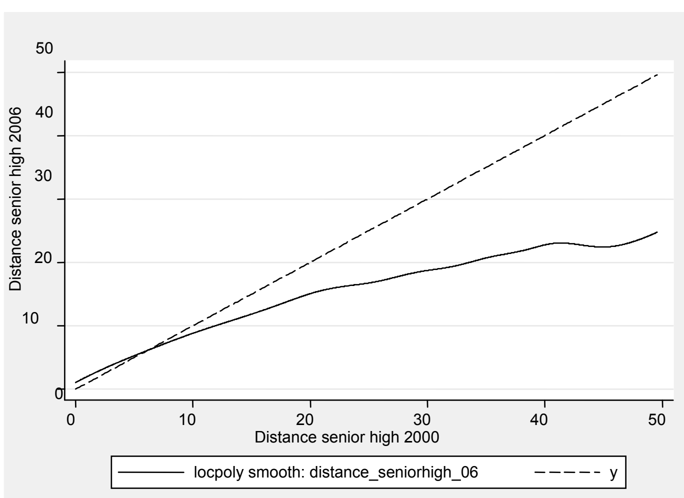
Figure 4 shows dynamic changes in the distance from the village to the nearest junior high school. The curve has shifted downward. The convergence pattern is steady through decentralization, which appears to be against our initial prediction. It seems that the incentive to secure the accessibility of education has been strengthened. In other words, coordination appears to be quite successful even in the decentralization period.

Figure 4. Dynamics: Distance to junior high school, 2000-2006



Dynamic change in the distance to the nearest senior high school from the village is shown in Figure 5. The previous finding becomes even clearer in this case. The concavity of this dynamic correspondence implies that distance is converging to zero

Figure 5. Dynamics: Distance to senior high school, 2000-2006



5.1.2 Availability: More developed villages

Next we analyze the availability of school capital in the village, by computing per capita number of schools (that is, number of schools divided by village population). Figure 6 shows changes in the per capita availability of public primary schools. The graph indicates a convergence pattern in which the per capita number is moving toward an equilibrium level. There is a similar finding in Figures 7 and 8, which show the dynamics of public junior and senior secondary schools.

Figure 6. Dynamics: Number of primary schools, 2000-2006

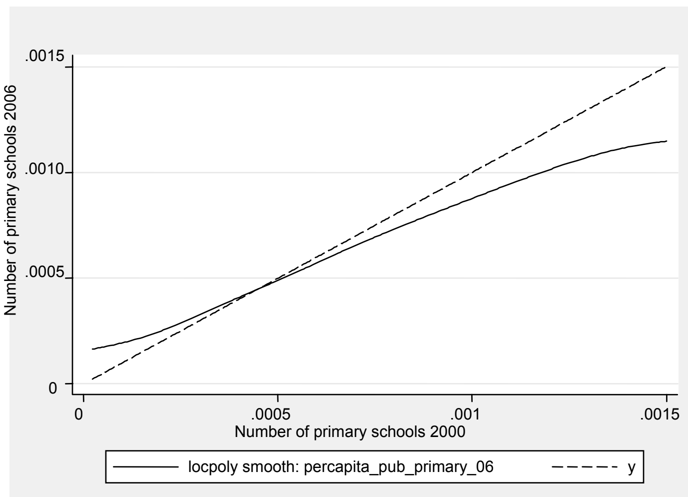


Figure 7. Dynamics: Number of junior high schools, 2000-2006

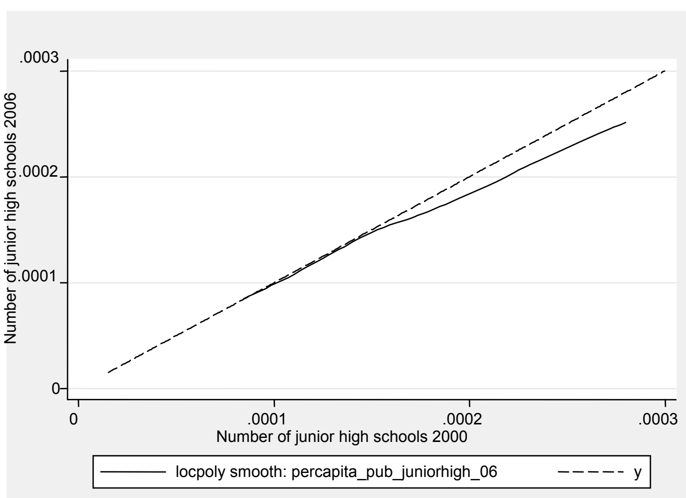
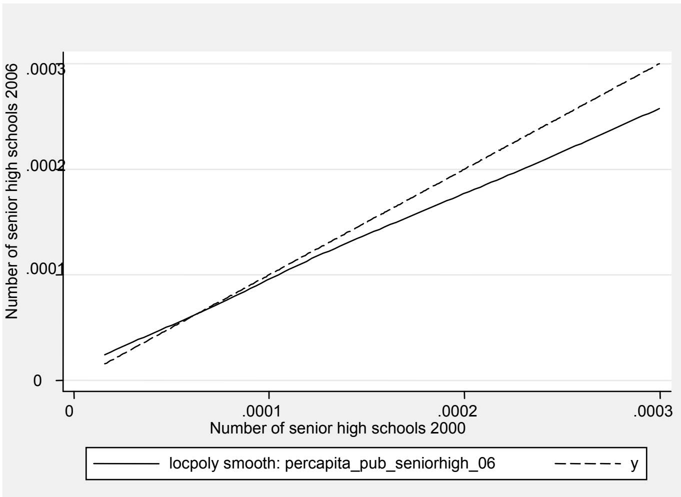


Figure 8. Dynamics: Number of senior high schools, 2000-2006



All these graphs demonstrate convergence to a low-level state. This is possible when populations endogenously move toward better communities or better-off communities have higher population growth, unless schools were destroyed in natural disasters.

Dynamics in accessibility shows convergence to a more equal and better situation (that is, building new schools in relatively remote areas), whereas dynamics in availability exhibits convergence to a more equal but a low-level state, the so-called poverty trap. Even though spatial allocation seems to become more equal, endogenous population mobility or population growth seems to worsen the distribution, measured by per-capita number of school facilities in the village. In Section 6, we show some evidence to support this hypothesis.

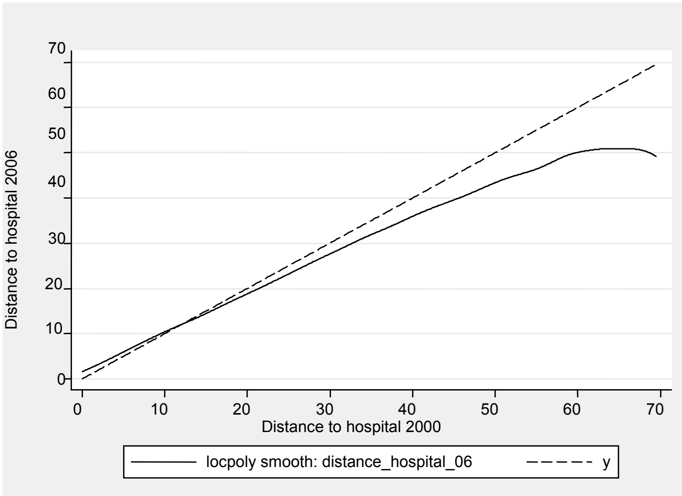
5.2 Health Facilities

In this section, we illustrate the dynamics of health-facility public goods during the decentralization period. For this purpose we have chosen "distance to the nearest hospital" to investigate the accessibility and the per capita number of *puskesmas* (health centers) (both integrated health centers and supported/small *puskesmas*). In 2000, most villages had no hospital,[4] and nearly 40 percent of villages had at least one *puskesmas*. The maximum distance to a hospital in the following analysis is set at 70 kilometers.

Figure 9 shows dynamic changes in accessibility to a hospital in the decentralization period (2000-2006), which supports convergence toward a more equal spatial distribution.

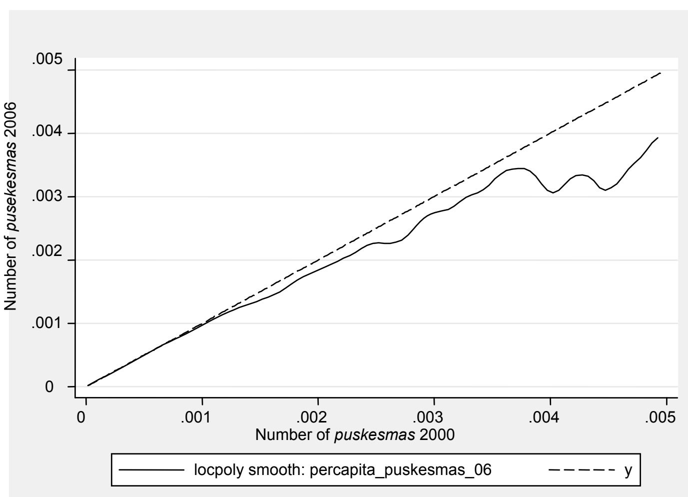
[4] In the 1996 PODES, the information on distance is only available for hospitals, thus we cannot analyze changes in distance for health facilities other than hospitals.

Figure 9. Dynamics: Distance to hospital, 2000-2006



The dynamics of the per capita availability of *puskesmas* is investigated in Figure 10. Although unstable curves (zig-zags) show up among villages with relatively large per capita numbers of *puskesmas*, the curves are located a little below the 45-degree line, which implies convergence to a low-level equilibrium over time.

Figure 10. Number of *puskesmas*, 2000-2006



As observed with the education figures, we see a qualitative difference between health facility availability and accessibility. Dynamics in accessibility show convergence to a situation with more equal accessibility, whereas dynamics in availability show convergence to a more equal but worse-off situation (poverty trap). Even though spatial allocation seems to be getting more equal, endogenous population mobility seems to worsen the per capita availability of health facilities in the village (see Section 6).

5.3 Java and Non-Java

We also investigated dynamic patterns on the island of Java: Jakarta, West Java, Banten, Central Java, Yogyakarta, and East Java provinces. This region is thought to be more developed than the other regions in terms of economic activity and accessibility/availability of public infrastructure such as school and health facilities. Another clear characteristic of this island is a high population density, which, on average, decreases per-capita availability of school and health facilities.

Briefly, first, in general, the accessibility dynamics are faster in Java. Second, the per capita availability is, on average, much lower in Java than in the other regions because of the high population density in Java, but we do not observe significant differences in the dynamic changes between Java and non-Java regions.

6. POPULATION GROWTH: IS THIS A KEY?

In this section we show some evidence about population growth in the period 2000–2006. Our nonparametric analysis in the previous sections demonstrated that the per-capita availability of school and health facilities has been deteriorating in general, except in some very disadvantaged areas. This finding contrasts with our findings on the dynamics of spatial accessibility, which shows that in villages with no school or health facility, the average distance to the nearest school and/or health facility has decreased over time.

To explain this gap, our conjecture rests on population dynamics. If population grows faster—either through natural growth or movement into areas endowed with more facilities than others—it is possible that the per capita measure of facility availability could worsen. In other words, local population is endogenously responding to infrastructure (in this paper, school and health facilities) to crowd it out.

Table 1 shows regression results using the PODES data in 2000 and 2006. We include district-level fixed effects to control local trends in population growth as well as facility availability. In other words, we suppose that population is moving across villages within a district. This procedure also controls region-specific natural population growth. Interestingly, population growth is significantly and positively responding to three out of four infrastructure measures: junior high schools, senior high schools, and *puskesmas*. Since we controlled the district-level average changes, we can interpret this result as showing that population is moving from less-endowed to well-endowed villages. In particular, the effect of senior high schools is large.

Table 1. Population growth against the initial infrastructure condition
(Dependent: village-level population growth in 2000-2006)

	Primary school	**Junior high school**	**Senior high school**	***Puskesmas***
Infrastructure – Per-capita numbers in 2000	**(1)**	**(2)**	**(3)**	**(4)**
Infrastructure variable	5.9095	15.168	31.775	12.947
	(1.33)	(3.38)	(4.02)	(3.04)
District fixed effects	Yes	Yes	Yes	Yes
Number of observations	55,495	55,495	55,495	55,495
R-squared (within)	0.0013	0.0003	0.0004	0.0004

Note: The numbers in parentheses are absolute t-values, using robust standard errors with district clusters.

7. CONCLUSION

We showed that accessibility to school has been improving among villages without schools. This trend is steady through decentralization in the spatial allocation of primary, junior, and senior high schools, but weaker in the hospital allocation.

However, the dynamics of per capita facility availability demonstrates the convergence to a low-level equilibrium. Among villages with school and health facilities, the per-capita number has been decreasing, probably due to the dynamic mobility of the population toward better-off communities.

This contrast, shown in the above two dimensions, may suggest that the spatial allocation of these public goods appears to be coordinated during the decentralization period but the endogenous mobility of population partially cancels out the benefits from this coordination effort. Policy attention is required to this point.

APPENDIX A

Public goods in a region can be not only substitutable but also complementary in a different context. A typical example is road construction. If a road is not connected to roads in the neighboring villages, economic returns are small.

A similar point is true also in education and health. In education, for example, building new schools in neighboring communities makes existing schools less crowded, which improves the quality of and increases returns to schooling. Second, the availability of schools at the secondary level is likely to improve the progression rate from the primary to secondary levels among children in the community. The first point is also relevant to health facilities.

Suppose that $G(Q)$ affects the marginal returns from own public good, where

$$Q = \sum_{k=1}^{N} q_k .$$

Assume that $G(Q)$ and $G'(Q)$ are small if Q is sufficiently small, but $G'(Q) > 0$. For the sake of our discussion, we assume that $\delta = 0$ in this section. The objective function is

$$V(y_i; q_k, q_{-k}) = u((1-t)y_i) + \beta G(q_k + Q_{-k}) f(q_k).$$

First order condition for the median income voter provides

$$MRS(y_k^m) = \frac{u'((1-t)y_k^m)}{\partial V(y_i; q_k, q_{-k})/\partial q_k} = \frac{E(y_k)}{y_k^m},$$

where

$$\partial V(y_i; q_k, q_{-k})/\partial q_k = \beta\left[G(q_k + Q_{-k}) f'(q_k) + G'(q_k + Q_{-k}) f(q_k)\right].$$

Under the above condition, a sufficiently small Q likely reduces the individually most-preferred tax rate, since the marginal rate of substitution becomes large. Reaction function is defined as

$$q(Q_{-k}) = E(y_k) t(y_k^m, Q_{-k}).$$

If $G(Q)$ and $G'(Q)$ are both near zero for sufficiently small Q (that is, local convexity) and the marginal utility is bounded from below,

$$t(y_k^m, 0) = 0,$$

that is, communities can be stagnant in poverty-trap Nash equilibrium.

It is interesting to point out that substitutability and complementarity imply observationally distinct predictions. With substitutability, more infrastructure in neighboring communities leads to less investment in the community. With complementarity, it is opposite: more infrastructure in the neighborhood leads to more investment in the community.

APPENDIX B: TABLES

Table B.1. Distance to the nearest primary school, 2000-2006 (kilometers)

	Year 2006				
Year 2000	**0**	**0 < x < 2**	**2 <= x < 4**	**4 <= x < 6**	**Total**
0	49,538	418	158	63	50,177
	(98.73)	(0.83)	(0.31)	(0.13)	(100.00)
0 < x < 2	535	2,246	394	73	3,248
	(16.47)	(69.15)	(12.13)	(2.25)	(100.00)
2 <= x < 4	176	378	393	61	1,008
	(17.46)	(37.50)	(38.99)	(6.05)	(100.00)
4 <= x < 6	86	67	63	67	283
	(30.39)	(23.67)	(22.26)	(23.67)	(100.00)
Total	50,335	3,109	1,008	264	54,716
	(91.99)	(5.68)	(1.84)	(0.48)	(100.00)

Note: Numbers in parentheses are row percentages.

Table B.2. Distance to the nearest junior secondary school, 2000-2006 (kilometers)

	Year 2006						
Year 2000	**0**	**0 < x < 10**	**10 <= x < 20**	**20 <= x < 30**	**30 <= x < 40**	**40 <= x < 50**	**Total**
0	15,570	1,559	135	38	16	7	17,325
	(89.87)	(9.00)	(0.78)	(0.22)	(0.09)	(0.04)	(100.00)
0 < x < 10	2,865	26,667	1,033	140	51	25	30,781
	(9.31)	(86.63)	(3.36)	(0.45)	(0.17)	(0.08)	(100.00)
10 <= x < 20	514	1,590	1,507	198	49	35	3,893
	(13.20)	(40.84)	(38.71)	(5.09)	(1.29)	(0.90)	(100.00)
20 <= x < 30	153	289	263	295	88	36	1,124
	(13.61)	(25.71)	(23.40)	(26.25)	(26.25)	(7.83)	(100.00)
30 <= x < 40	65	119	96	66	139	27	512
	(12.70)	(23.24)	(18.75)	(12.89)	(27.15)	(5.27)	(100.00)
40 <= x < 50	51	54	69	43	37	69	323
	(15.79)	(16.72)	(21.36)	(13.31)	(11.46)	(21.36)	(100.00)
Total	19,218	20,278	3,103	780	380	199	53,958
	(35.62)	(56.11)	(5.75)	(1.45)	(0.70)	(0.37)	(100.00)

Note: Numbers in parentheses are row percentages.

Table B.3. Distance to the nearest senior secondary school, 2000-2006 (kilometers)

	Year 2006						
Year 2000	**0**	**0 < x < 10**	**10 <= x < 20**	**20 <= x < 30**	**30 <= x < 40**	**40 <= x < 50**	**Total**
0	5,641 (77.42)	1,490 (20.45)	121 (1.66)	19 (0.26)	13 (0.18)	2 (0.03)	7,286 (100.00)
0 < x < 10	1,632 (5.56)	25,529 (86.60)	1,957 (6.64)	239 (0.81)	82 (0.28)	41 (0.14)	29,480 (100.00)
10 <= x < 20	484 (5.50)	3,119 (35.46)	4,467 (50.79)	557 (6.33)	111 (1.26)	57 (0.65)	8,795 (100.00)
20 <=x < 30	197 (6.09)	799 (24.69)	826 (25.53)	1,094 (33.81)	247 (7.63)	73 (2.26)	3,236 (100.00)
30 <= x < 40	95 (6.32)	365 (24.28)	283 (18.83)	260 (17.30)	402 (26.75)	98 (6.52)	1,503 (100.00)
40 <= x < 50	64 (7.49)	177 (20.70)	145 (16.96)	122 (14.27)	126 (14.74)	221 (25.85)	855 (100.00)
Total	8,113 (15.86)	31,479 (61.54)	7,799 (15.25)	2,291 (4.48)	981 (1.92)	492 (0.96)	51,155 (100.00)

Note: Numbers in parentheses are row percentages.

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