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Does aggregation hide the harmful effects of inequality on growth?

Martin Ravallion[1,*]

Development Research Group, World Bank, 1818 H Street NW, Washington DC, 20433, USA

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Abstract

Aggregation can severely bias conventional tests of whether inequality impedes growth. A micro growth model estimated on farm-household data for rural China indicates that asset inequality in the area of residence has a harmful external effect on consumption growth. The effect is lost in a regional growth regression. © 1998 Elsevier Science S.A. All rights reserved.

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1. Introduction

The theory underlying regressions for consumption growth is usually some variant of the well known Cass–Koopmans–Ramsey model. Given constant returns to scale, we can model each unit of the economy as jointly consuming and producing. Call this unit a ''farm-household''. Also assume the existence of borrowing constraints, such that capital cannot move freely between farm-households.[2] (This does not seem unreasonable in many settings, including underdeveloped rural economies.) With other standard assumptions, the consumption growth rate for the farm-household will then depend positively on the marginal product of the farm-household's own capital, which is a decreasing function of the amount of own capital.

Such a model can be extended to allow external effects of inequality within a country or region on the marginal product of the farm-household's own capital, and hence its consumption growth. Such effects could arise when private investments, or technological innovations which promote growth, generate positive externalities within some geographic area, and the extent of such investments (and hence of the external benefits) depend on the extent of inequality in access to capital and technology. The political-economy of local policy-making might also mean that inequality matters to growth at the micro level.[3]

*Corresponding author. Tel.: +1-202-473-6859; Fax: +1-202-522-1153; E-mail: mravallion@worldbank.org

[1] The findings, interpretations, and conclusions of this paper are those of the author, and should not be attributed to the World Bank, its Executive Directors, or the countries they represent.

[2] For an exposition of the open economy Ramsey model with imperfect capital markets see Barro and Sala-i-Martin, 1995 (chapter 3).

[3] Bruno et al. (1998) review various arguments linking growth and distribution.

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Growth regressions using country-level data have recently been used to test for effects of inequality on growth.[4] However, aggregate data may have little or no power to reveal such effects. The problem is that, given the nonlinearities involved, the aggregation process itself can create spurious effects of inequality on growth. A simple parameterized consumption growth model can illustrate the problem. The following section discusses the model in general terms, while Section 3 estimates its parameters using household-level panel data for rural China. Section 4 concludes.

2. An illustrative empirical growth model

Consider the following specification for testing the effects of asset inequality on consumption growth using aggregate data:

$$\Delta \ln M(\mathbf{C}_{iT}) = \alpha + \beta I(\mathbf{K}_{i0}) + \gamma \ln M(\mathbf{K}_{i0}) + \pi'\mathbf{X}_i + \nu_i \quad (i = 1,..,n) \tag{1}$$

where $\mathbf{C}_{it}$ is a N_{it}-vector of the consumptions of households in geographic area i at date t ($t=0$, T), $M(\mathbf{C}_{iT})$ is the mean consumption in i at date T, $\Delta \ln M(\mathbf{C}_{iT}) \equiv \ln M(\mathbf{C}_{iT}) - \ln M(\mathbf{C}_{i0})$ is the rate of consumption growth from date 0 to T, $\mathbf{K}_{i0}$ is a N_{i0}-vector of the assets held by households in i at the base date 0 (so the j'th element of the vector $\mathbf{K}_{i0}$ is the initial capital stock of household j, K_{ij0}), $I(\mathbf{K}_{i0})$ is an index of asset inequality in i at date 0, $M(\mathbf{K}_{i0})$ is the mean asset holding in i at date 0, $\mathbf{X}_i$ is a vector of other explanatory variables, and ν_i is an error term.

There are a number of possible inequality measures satisfying the usual transfer principle. For analytic convenience, I shall assume that inequality is measured by the mean log deviation of the initial capital stock within each area, i.e.,

$$I(\mathbf{K}_{i0}) = \ln M(\mathbf{K}_{i0}) - M(\ln \mathbf{K}_{i0}) \tag{2}$$

where $\mathbf{ln\ K}_{i0}$ is a N_{i0}-vector with j'th element $\ln K_{ij0}$. $I(.)$ is a member of the well-known Generalized Entropy class of additively decomposable inequality measures (Theil, 1967).[5]

Eq. (1) does not distinguish an external effect of inequality on growth at the micro level from an effect which can arise solely through the process of aggregation. It is readily verified that the micro-level model underlying (1) can be written in the form:

$$\Delta \ln C_{ijT} = \alpha + \delta I(\mathbf{K}_{i0}) + \gamma_1 \ln K_{ij0} + \gamma_2 \ln M(\mathbf{K}_{i0}) + \pi'\mathbf{X}_i + \epsilon_{ij} \tag{3}$$

for household j $(=1,...,N_i)$ in area i at date T. In terms of (1), $\beta = \delta - \gamma_1$, $\gamma = \gamma_1 + \gamma_2$, while the aggregate error term is $\nu_i = I(\mathbf{C}_{iT}) - I(\mathbf{C}_{i0}) + \epsilon_i$, where $I(\mathbf{C}_{it})$ ($t=0$, T) is defined analogously to Eq. (2). To verify that (3) aggregates exactly to (1) under these conditions, take the mean of (3) across all j in area i and substitute Eq. (2). But note that the mean of the growth rates in consumption does not equal the growth rate in mean consumption, as in Eq. (1); to obtain the latter one must also add a term

[4]Some studies have suggested that higher inequality results in lower subsequent rates of growth (Persson and Tabellini, 1994; Alesina and Rodrik, 1994; Clarke, 1995; Deininger and Squire, 1996; Larrain and Vergara, 1997). Some studies have reported no significant effect (Fishlow, 1995; Brandolini and Rossi, 1998). On the potential implications for poverty reduction see Ravallion (1997).

[5]The fact that different studies have used different measures should not matter greatly to the point of this paper, since it can be safely assumed that any two theoretically defensible measures of inequality defined on the distribution of a given variable will be highly correlated with each other.

for the change in the inequality of consumption, noting that the observed rate of growth in aggregate data is $\Delta \ln M(\mathbf{C}_{iT}) = \Delta M(\mathbf{lnC}_{iT}) + \Delta I(\mathbf{C}_{iT})$.

Thus the impact of asset inequality on aggregate growth has two components: the underlying external effect (δ) and the aggregation effect ($-\gamma_1$) stemming from the effect of own capital on the rate of growth. Suppose that there is a negative external effect of higher inequality on growth and that the marginal product of own capital is diminishing, implying conditional convergence. Then the micro external effect and the aggregation effect will work in opposite directions. If the changes in consumption inequality are white noise, then an OLS regression based on (1) will underestimate the harmful effect of inequality on growth.

Notice that if one is willing to assume that there are no spatial externalities with respect to wealth ($\gamma_2 = 0$) then δ can be identified from the aggregate growth regression as $\beta + \gamma$. However, it is unclear why there would be spatial externalities with respect to inequality but not average wealth.

The fact that $\Delta I(\mathbf{C}_{iT})$ is in the error term of the aggregate growth regression adds a further complication to its interpretation, and introduces the possibility of a spurious negative coefficient on initial inequality in standard aggregate growth regressions. A term for the change in inequality has never (it seems) been included in such regressions, so it must be in the error term, and it may lead to omitted variable bias in the other parameters of interest. For example, suppose that inequality is only weakly serially correlated over the time period used in estimating the growth regression. Then a measure of initial inequality could emerge with a significantly negative sign in the estimated aggregate growth regression because it is correlated with an omitted variable, namely the change in consumption inequality over time. Again, this could arise even when $\delta = 0$.

Combining these observations, two assumptions allow one to infer the effect of inequality on growth from the aggregate growth regression. The first is that there are no underlying spatial externalities with respect to average wealth ($\gamma_2 = 0$); although β will still be a biased estimate of δ under this assumption, the problem can be readily solved since $\delta = \beta + \gamma$. The second assumption is that changes in consumption inequality are white noise. Violations of this assumption might be dealt with by adding a measure of the change in consumption inequality to the aggregate growth regression. Other variables (in $\mathbf{X}$) may be picking this up, thus clouding their interpretation.

The above discussion has focused on a very specific functional form, chosen to sharply illustrate the aggregation bias. The nonlinearity in the underlying micro growth model clearly matters to the extent of aggregation bias. Of course, even when the growth rate is linear in the initial capital stock, a term for the change in inequality will be found in the residual of the usual aggregate growth regression, in which the dependent variable is the growth rate in the overall mean of consumption (or income). More complex forms of nonlinearity, and alternative functional forms for the inequality measure relevant to the micro-level externality, can yield further spurious effects of measured inequality. There must still be a presumption that aggregation alone will create a dependence of growth on the initial distribution of assets, although the nature of that dependence will be less transparent than in the above specification.

3. A test for rural China

To obtain an unbiased estimate of the underlying external effect of inequality without making the two assumptions described in the last section, one needs micro panel data to estimate Eq. (3) directly. This also allows a test for bias in the aggregate growth regression. For that purpose, I shall use a panel of farm-household level data for rural areas in four provinces of southern China, spanning the period 1985–90. The data cover 6651 farm households living in 131 counties.[6] In addition to a comprehensive measure of consumption (including consumption from own farm product, valued at local selling prices), the data include an estimate of physical and financial wealth, including valuations of all fixed productive assets, cash, deposits, housing, grain stock, and consumer durables. The vector $\mathbf{X}$ comprises the proportion of people who are literate in the household (H_{ij0}) and the county (H_{i0}).

The OLS estimate of Eq. (3) is:[7]

$$\Delta \ln C_{ijT} = -0.928 - 0.293 I(\mathbf{K}_{i0}) - 0.119 \ln K_{ij0} + 0.255 \ln M(\mathbf{K}_{i0}) + 0.109 H_{ij0} + 0.013 H_{i0} + \text{residual}$$
$$(-10.27)(-4.20) \qquad (-11.73) \qquad (13.84) \qquad (3.27) \qquad (0.33)$$

In view of the importance of the nonlinearity, I also tested this against a model in which it was the level (not log) of K_{ij0} and $M(\mathbf{K}_{i0})$ which mattered to growth. A nested test firmly rejected this specification in favor of the log model above; K_{ij0} and $M(\mathbf{K}_{i0})$ were neither individually nor jointly significant when added to the above regression (an F-test gave 1.76, significant at only the 18% level), and both $\ln K_{ij0}$ and $\ln M(\mathbf{K}_{i0})$, as well as $I(\mathbf{K}_{i0})$, remained highly significant.

So initial wealth inequality in the county of residence has a significant negative effect on individual consumption growth. There is also a negative effect of own initial wealth on future growth. The implied estimate of β is -0.174 (t-ratio$=-2.38$), which is appreciably lower than the underlying external effect of inequality on consumption growth at household level of -0.293 ($t=-4.20$). There is also a strong external effect of county wealth on individual consumption growth. The aggregate wealth effect ($\gamma_1+\gamma_2$) is positive (0.136, with a t-ratio of 9.26), implying overall divergence, even though there is a diminishing marginal product with respect to own wealth.

If instead one runs the aggregate growth regression (across the 131 counties) based on Eq. (1), then the result is:[8]

$$\Delta \ln M(\mathbf{C}_{iT}) = -0.803 - 0.108 I(\mathbf{K}_{i0}) + 0.116 \ln M(\mathbf{K}_{i0}) + 0.002 H_{i0} + \text{residual}$$
$$(-3.38)(-0.61) \qquad (2.74) \qquad (1.39)$$

The coefficient on initial asset inequality is now much lower in absolute value, and is not significantly different from zero. Indeed, it is even lower than the estimate of β implied by the micro model; the difference is attributable to correlations between $\Delta I(\mathbf{C}_{iT})$ (in the error term) and the other right hand side variables in the aggregate growth regression.

Notice too that an even larger bias in the estimate of δ would arise for these data if one had assumed that there is no external effect of living in an area with lower mean wealth, so as to justify employing the identification condition that $\delta=\beta+\gamma$. Here we have strong spatial externalities of both inequality and mean wealth on growth.

[6] The data are discussed further in Chen and Ravallion (1996) and Ravallion and Jalan (1996).

[7] All t-ratios (in parentheses) in this paper are based on Huber–White standard errors. The R^2 is 0.05. It is not surprising that there is a large unexplained variance in growth rates at the micro level.

[8] The R^2 is 0.14. I also tried estimating the same regression using the mean of the growth rates as the dependent variable. The coefficient on initial asset inequality was -0.154 (t-ratio of 0.86), and otherwise the results were very similar.

4. Conclusions

Spurious inequality effects in an aggregate growth regression can arise when the underlying growth rate at farm-household (or local geographic) level depends on the initial log of some variable at that level, such as the farm-household's capital stock. An inequality index for that variable in an aggregate growth regression will pick up the difference between the mean of its log (which should appear in the aggregate model for consistent aggregation but is rarely available as data) and the log of its mean (as typically available in aggregate data). Indeed, that difference is a well-behaved inequality index in its own right. The error term in the aggregate growth regression will also contain the effect of changes over time in the distribution of the consumption or income variable for which growth rates are measured, further confounding the interpretation of the aggregate growth regression.

To illustrate the direction and magnitude of the bias due to aggregation, I have used a simple empirical model of consumption growth, calibrated to farm-household panel data for rural China. The results suggest that the underlying micro effect of local asset inequality on consumption growth works in the opposite direction to the aggregation effect. The aggregation bias is found to be large. A simple regional growth model suggests a negative coefficient on asset inequality of -0.10 but this is not significantly different from zero. A consistent micro model of consumption growth at the farm-household level indicates a far more harmful effect of asset inequality on consumption growth; indeed, the coefficient on initial inequality is almost three times larger in the micro model, and is highly significant.

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