A Semiparametric Analysis of the Role of Inequality, Investment, and Government Expenditure in Economic Growth

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Abstract

The relationship between inequality, investment, and government expenditure and their impact on economic growth in a panel of countries is empirically analyzed via a fixed effects, semiparametric model. The analysis demonstrates that the marginal impact of inequality on growth is highly nonlinear, and depends critically on both the levels of investment and government expenditure. In the absence of adequate investment and/or government expenditure, higher inequality promotes growth. However, when investment and/or government expenditure is substantial, higher inequality may actually reduce growth. Apart from the impact on the relationship between inequality and growth, it appears that government expenditure and investment have important direct, nonlinear effects on growth. Moreover, there appears to be an important but limited role for government, which hinges critically on the size of investment.

Keywords: Economic Growth, Inequality, Government Expenditure, Investment

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1 Introduction

Does the distribution of income have any real effect on the rate of economic growth? The answer to this question has important implications for public policy, efficiency, and social welfare. So far, many empirical investigations have sought to answer this question. Virtually all of these studies, however, have used completely linear (cross sectional or panel) models. As a result, the current literature predicts that the impact of a marginal increase in inequality on economic growth is always either harmful, beneficial or neutral (e.g., see Alesina and Rodrik (1994), Forbes (2000), and Barro (2000)). This paper shows that in the context of a more flexible, semiparametric model, inequality can promote, retard or have no impact on growth. Before elaborating further on the results of this paper, it is important to place them within the context of the existing literature.

The debate swirling around income inequality and economic growth is a relatively recent development. Prior to the early 1990s, income inequality was couched in terms of its relationship with the *level* of economic development (i.e., the level of GDP). Kuznets (1955) kicked-off this debate by hypothesizing that during the course of development, income inequality first rises and later falls (i.e., the Kuznets Hypothesis). That is to say, increasing GDP causes inequality to rise during the first stages of development, and then causes it to fall as the economy reaches maturity.

However, as the broader topic of growth began to experience resurgence in the literature in the early 1990s, research into variables thought to influence growth became popular. As such, research into the long-run theoretical and empirical link between the level of GDP and inequality was shifted to the short-run relationship between the rate of economic growth and income inequality. An important departure, however, from the original research agenda (i.e., between inequality and GDP) is the hypothesis that inequality causes changes in the rate of economic growth.

In 1994, two important papers investigating the empirical relationship between economic growth and income inequality were published: Persson and Tabellini, and Alesina and Rodrik. Both papers built cross-sectional models where the long-run growth rate over the time period in question (20 to 25 years) was explained by a set of variables measured at the beginning of the time period. Despite differences in variable definitions and

conditioning variables, both papers reached similar conclusions: initial income inequality is harmful to subsequent, long-run economic growth.[1] Several other papers, seeking to improve upon the basic models employed above, were published in the mid 1990s with similar results (see Clarke (1995) and Alesina and Perotti (1996)). However, this empirical regularity was seriously challenged by the introduction of the Deininger and Squire (1996) panel dataset on income inequality.

Making use of the Deininger and Squire (1996) panel data set, several papers examined the relationship between economic growth and inequality using panel data methodology. Unlike the previous empirical literature, which delivered a more or less consistent, negative relationship between inequality and growth, the following panel studies' results vary widely.

In his investigation of the relationship between income inequality and subsequent economic growth, Barro (2000) estimated a random effects panel system and found that the coefficient on inequality was approximately equal to zero. In other words, there is no unconditional relationship between economic growth rates and inequality. Exploring this relationship further, however, Barro found that inequality promoted growth in wealthier nations (nations with per-capita GDP in excess of $2,070 1985 U.S. dollars), and reduced growth in poorer nations (nations with per capita GDP below the foregoing threshold).

Published at about the same time as Barro's paper, Forbes (2000) employed a fixed effects panel model and found a positive and statistically significant relationship between growth and inequality. Her model, which is very similar to Perotti (1996), covers five-year periods from 1966 to 1995 (i.e., six periods), where growth is averaged and the other variables take beginning of period values. Although the paper makes an important improvement by employing a fixed effects panel, it uses a much simpler (albeit more parsimonious) set of conditioning variables. More to the point, Forbes' model does not include a policy variable representing government spending, investment in primary education, conditional convergence, inflation or capital investment.[2]

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[1] The first empirical papers investigating the link between income inequality and economic growth supported the predictions of the theoretical papers written roughly during the same era (see Greenwood and Jovanovic (1990), Bertola (1993), Galor and Zeira (1993), Perotti (1993), Benabou (1996), Alesina and Perotti (1996)).
[2] In addition to Forbes, Li and Zou (1998) demonstrated a positive empirical relationship between inequality and growth using a fixed effects, 5-year panel variant of Alesina and Rodrik (1994).

The semiparametric relationship between economic growth and income inequality has been more or less left unexplored. To date, Banerjee and Duflo (2000) is one of the few papers that has done work in this area. However, the overwhelming thrust of their paper deals with *changes* in lagged inequality and its relationship with subsequent economic growth. More specifically, they employ a random effects, semiparametric model in which growth is a function of a set of beginning of period conditioning variables (similar to those used in Barro (2000)), and changes in inequality between the base period and the previous period, which enters via the semiparametric function.

They find that changes in inequality (in either direction), reduce economic growth. To the extent that the *level* of inequality is related to subsequent short-run economic growth, Banerjee and Duflo assert the following (pg. 17):

> *We conclude that inequality, lagged one period, is negatively correlated with growth in countries in the range where it is not too large (below 0.40), and, in particular, outside Latin America. Note that results are sensitive to the lag structure: We found no relationship whatsoever between base-period inequality and growth.*

This paper's model (see section 3) differs with Banerjee and Duflo (2000) in three crucial ways. First, the current model, like the literature before it, does not consider how changes in inequality impact economic growth. Second, the current model uses semiparametric methodology to allow the coefficient on inequality and the intercept to vary (depending on the levels of investment and government expenditure). And third, the current model is a fixed effects panel.

As a result of this more flexible specification, it will be shown (depending upon the simultaneous levels of investment and government expenditure), that inequality can either promote growth (consistent with Forbes (2000), among others), reduce growth (consistent with Alesina and Rodrik (1994), among others), or have no impact on growth (consistent with Barro (2000), among others). More specifically, in the absence of high levels of investment and/or government expenditure (as a fraction of GDP), higher inequality tends to be growth promoting. However, when levels of investment and government expenditure are substantial, higher levels of income inequality tend to retard growth. In either scenario, there are ranges of investment and/or government expenditure in which higher levels of inequality are growth neutral.

Section 2 will provide a brief summary of the evolution of the empirical methodology and data used to evaluate the relationship between economic growth and inequality. Section 3 will introduce a new, more general semiparametric model, and provide estimates of said model. Section 4 will explore the model in greater detail and seek to reconcile differences between the existing literature and the new model. Section 5 will conclude.

2 Data Set and Initial Model Estimation

2.1 Data Set

Conforming to Barro (2000), Forbes (2000), *et. al.*, this paper makes use of the Deininger and Squire dataset. The remaining dataset values were acquired from various sources, including the Penn World tables, World Bank Development Indicators, the Barro/Lee dataset, etc. A complete listing of the data sources is provided in Appendix A. Throughout the rest of the paper, the dependent variable will consist of 5-year growth rates, whereas the independent variables will consist of beginning of period values or period averages. The panel consists of 246 observations, with a total of 29 nations in the panel, and observations per nation ranging from a low of 3 to a high of 26. A complete listing of these nations and the years included is provided in Appendix B.

2.2 Initial Model Estimation

Before diving directly into the results of the final model (described in detail in Section 3), a short exposition of the properties (and deficiencies) of the basic linear (parametric) and semiparametric models is helpful. As a first step in this analysis, let us examine the relationship between the fixed effects residuals from a Barro-style growth model with inequality entering linearly:[3]

$$gr_{it+5} = \alpha_i + \eta_t + \beta_1 y_{it} + \beta_2 gini_{it} + X_{it}B + \varepsilon_{it+5} \tag{2.1}$$

where the variables are defined as follows:

[3] The Hausman specification test on the linear panel model strongly rejects the random effects specification at any standard level of significance. The Hausman test statistic equals 67.95, which easily exceeds the 1% critical value of 20.09. Therefore, the fixed-effects specification is used for the remainder of the paper.

gr_{it+5}	growth rate of country i between period t and t+5
y_{it}	the natural log of per capita national product
X_{it}	the remaining set of (Barro) conditioning variables (less democracy and rule-of-law)
$gini_{it}$	the gini coefficient for country i during period t
α_i	invariant, nation specific (fixed) effect
η_t	time period dummy

A graph of the residuals from this model (sorted by their corresponding gini coefficient (from low to high)) is provided in Figure 1 (see Appendix C). Clearly, the volatility of these residuals is an increasing function of the level of inequality. Two likely explanations are either 1) nations with higher inequality experience greater volatility in their growth rates (i.e. growth rates display heteroscedasticity) or 2) there is a more complicated, nonlinear relationship between growth and inequality that has been neglected. Assuming for the moment that the latter explanation is correct, one can clearly show that a nonlinear correspondence exists between inequality and growth.

By splitting the residuals into two groups (values greater than and less than zero respectively) and running separate linear regressions on each, it appears that a sideways "U" is present in the residuals (see Figure 2).[4] However, because this bivariate relationship takes the form of a correspondence, neither parametric nor standard nonparametric methodologies can be used to estimate this bivariate relationship over the entire sample. Indeed, this is demonstrated by the fact that a simple neglected nonlinearity test (conditioning on the gini coefficient) failed to detect any neglected nonlinearity.[5] This helps to explain why Banerjee and Duflo (2000) only found a downward sloping, almost linear relationship between growth and lagged inequality (where inequality entered the model semiparametrically). All of these factors suggest that a more flexible semiparametric model capable of conditionally estimating correspondence relations is needed. To test this hypothesis, a Fan-Ullah (1999) Test was utilized in which the expectation of the residuals was taken over three variables: government expenditure, investment, and the gini coefficient. This test rejected the null

[4] For example, if the residuals where standard normally distributed, one would expect that both the unconditional and conditional mean of the residuals (based on the level of inequality) would be equal to 0.674 (for the residuals greater than zero), and - 0.674 (for the residuals less than zero) respectively.
[5] The Fan-Ullah (1999) Test failed to reject the null hypothesis of no neglected nonlinearity at any standard level of significance.

hypothesis of no neglected nonlinearity at any standard level of significance.[6] The next section of this paper will examine a model which incorporates this nonlinearity.

3 More General Semiparametric Model and Estimation

3.1 The Model

The remainder of the paper focuses on the following more general, semiparametric fixed effects panel model:

$$gr_{it+5} = \alpha_i + \eta_t + \beta_1 y_{it} + a\left(gov_{it}, inv_{it}\right) + b(gov_{it}, inv_{it}) \cdot gini_{it} + X_{it}B + \varepsilon_{it+5} \tag{3.1}$$

where the variables are defined as follows:

gr_{it+5}	growth of country i between period t and t+5
y_{it}	the natural log of per capita national product
gov_{it}	government expenditure as a percentage of national product (G/Y)
inv_{it}	gross investment as a percentage of national product (I/Y)
X_{it}	the remaining set of (Barro) conditioning variables (less government, investment, democracy, and rule-of-law)
$gini_{it}$	the gini coefficient for country i during period t
α_i	invariant, nation specific (fixed) effect
η_t	time period dummy

3.2 Estimation Methodology

Equation (3.1) was estimated via a semiparametric, instrumental variable (IV) procedure. The first step of this procedure is to calculate the expected value of equation (3.1) conditional on government expenditure, investment, and inequality (i.e. $gov_{it}, inv_{it}, gini_{it}$). Next, these expected values are subtracted from their corresponding unconditional values in equation (3.1), thereby yielding the following equation:

$$gr^*_{it+5} = \alpha^*_i + \eta^*_t + \beta_1 y^*_{it} + X^*_{it}B + \varepsilon_{it+5} \tag{3.2}$$

where "star" superscripts denote deviations from conditional means. The model has been reduced to a simple dynamic fixed effect panel. Utilizing one-period lags of the right-hand

[6] The conditional expectation of the residuals took the form: $E\left[\hat{\varepsilon}_{it+5} \middle| gov_{it}, inv_{it}, gini_{it}\right] = \alpha(gov_{it}, inv_{it}) + \beta(gov_{it}, inv_{it}) \cdot gini_{it}$. The Fan-Ullah (1999) (t-test) statistic was 5.52, which clearly surpasses the 5% critical value of 1.96.

side regressors as instruments, equation (3.2) can be consistently estimated via IV methodology. Because the reduced model (3.2) is just identified, the coefficients are given by:

$$\begin{pmatrix} \hat{\alpha}_{IV}^{*} & \hat{\eta}_{IV}^{*} & \hat{\beta}_{1,IV} & \hat{B}_{IV} \end{pmatrix}' = \left(W^{*\prime} Z^{*} \right)^{-1} W^{*\prime} gr^{*} \tag{3.3}$$

where Z is the matrix of all the regressors in (3.2) and W is the matrix of corresponding instruments. Using the IV coefficients from (3.3), subtract the linear terms from both sides of (3.1):

$$gr_{it+5}^{**} \equiv gr_{it+5} - \hat{\alpha}_i - \hat{\eta}_t - \hat{\beta}_1 y_{it} - X_{it}\hat{B} = a\left(gov_{it}, inv_{it}\right) + b(gov_{it}, inv_{it}) \cdot gini_{it} + u_{it+5} \tag{3.4}$$

Equation (3.4) can be estimated nonparametrically by solving the following minimization problem:

$$\min_{a,b} \left\{ \sum_{i=1}^{N} \sum_{j=1}^{T_i} \left[\left(gr_{ij+5}^{**} - a(gov, inv) - b(gov, inv) \cdot gini_{ij} \right)^2 \cdot K\left(\frac{gov_{ij} - gov}{h_1}, \frac{inv_{ij} - inv}{h_2} \right) \right] \right\} \tag{3.5}$$

where the solution to the foregoing problem is given by:

$$\begin{pmatrix} \hat{a}(gov, inv) \\ \hat{b}(gov, inv) \end{pmatrix} = \left(\Psi' \bar{K} \Psi \right)^{-1} \Psi' \bar{K} gr^{**} \tag{3.6}$$

$$\Psi = \begin{pmatrix} 1 & gini \end{pmatrix} \tag{3.7}$$

$$\bar{K} = diag\left(K\left(\frac{gov_{11} - gov}{h_1}, \frac{inv_{11} - inv}{h_2} \right) \quad \cdots \quad K\left(\frac{gov_{NT_N} - gov}{h_1}, \frac{inv_{NT_N} - inv}{h_2} \right) \right) \tag{3.8}$$

$$K\left(\frac{gov_{it} - gov}{h_1}, \frac{inv_{it} - inv}{h_2} \right) = \left(\frac{1}{2\pi} \exp\left(-\frac{1}{2}\left(\frac{gov_{it} - gov}{h_1} \right)^2 - \frac{1}{2}\left(\frac{inv_{it} - inv}{h_2} \right)^2 \right) \right) \tag{3.9}$$

The function $a(gov, inv)$ is interpreted as the expected value of growth (net of all other factors) conditional on government expenditure and investment, while $b(gov, inv)$ is interpreted as the marginal impact on growth of a small increase in the level of inequality (i.e. $b(gov, inv) = \frac{\partial gr_{it+5}^{**}}{\partial gini_{it}}$). Both of these functions are estimated and analyzed in the following sections.

3.3 Estimation Results: Inequality and Growth

Using the foregoing procedure, the model (3.1) was estimated. It appears that the neglected nonlinearity detected in the previous section has been accounted for. A plot of the residuals from model (3.1), ranked by the gini coefficient is provided in Figure 3. No obvious structure with regard to inequality appears to remain. Now, we will turn out attention to the individual components of model (3.1).

In order to examine the impact of government spending alone on $b(gov, inv)$, one must fix the value of investment. But, one must not forget that the value of $b(gov, \overline{inv})$ hinges critically on the fixed value of investment ($\overline{inv}$) chosen. Likewise, one faces the same challenges when seeking to examine the impact of investment spending alone on $b(gov, inv)$. In order to address these issues, government spending and investment were individually fixed at their (from lowest to highest) twentieth and eightieth percentiles. The plots of $\hat{b}(gov, \overline{inv})$ are provided in Figures 4 and 5.[7]

Clearly, for relatively low levels of investment (the twentieth percentile), an increase in inequality is associated with higher growth. However, as government expenditures increase, the benefits of higher inequality steadily decline. Moreover, as government expenditure approaches 19% to 20% of GDP, higher inequality actually reduces economic growth. For higher levels of investment (eightieth percentile), an increase in inequality is universally associated with higher growth.

One possible interpretation of these results stems from the credit market constraint argument. To elucidate why this may be the case, let's digress for a moment and examine the relationship between government expenditures and education, and investment and education. Figure 6 is a scatter-plot of government expenditure versus the primary education completion rate (as a percentage of the adult population aged 15 and above) with a simple regression line added. Although the correlation is low, it is still broadly true that higher levels of government expenditure are associated with higher levels of primary education.

A similar picture emerges when examining the relationship between investment and the primary education completion rate. Figure 7 is a scatter-plot of investment versus the primary education completion rate with a simple regression line added. As with government

[7] In both Figures 3 and 4, the lowest and highest 10% of observations (with respect to government expenditure) have been trimmed from the graphs. In addition, all confidence intervals are 95% confidence intervals.

expenditure, one can clearly see that higher levels of investment are associated with higher levels of primary education.[8]

More formally, this relationship can be examined within the context of a simple, panel data model:

$$ed_{it} = \alpha_i + m(gov_{it}, inv_{it}) + u_{it} \tag{3.10}$$

where ed_{it} is the primary education completing rate, α_i is the nation-specific fixed effect, m(•) is a continuous function ($m : \mathbb{R}_+^2 \to \mathbb{R}$), gov_{it} is government expenditure, inv_{it} is aggregate public and private investment, and u_{it} is distributed i.i.d. $(0, \sigma_u^2)$. The foregoing model, estimated semiparametrically, explains about 60% of the variation in the primary education completion rate.[9] Despite this good fit, the relationship between government expenditure, investment, and levels of primary education appears to be highly nonlinear. However, broadly speaking, education levels are higher when government expenditures are higher. With regard to investment, education levels initially fall when investment rises, but later increase with investment when investment levels are more substantial. A three-dimensional plot of $\hat{m}(gov_{it}, inv_{it})$ is provided in Figure 8.

Taking all of these points together, one possible interpretation of the plots of $\hat{b}(gov, i\overline{n}v)$ (Figures 4 and 5) is that in nations with relatively low levels of investment, levels of education tend to be lower. In the absence of government procurement or subsidization, an increase in inequality is necessary to provide a subset of the population with enough income to acquire an education. As government expenditure rises (and hence the level of education), both the need for and benefit derived from higher inequality is reduced. If government expenditure is quite large, and presumably access to education quite easy, an increase in inequality may actually reduce levels of education, and hence overall growth. However, in nations with very high levels of investment (i.e. those with investment in the ninetieth percentile), credit market constraints are, by-and-large, a non-issue. Thus, an increase in inequality would only achieve to move the poorest segments of society below the

[8] The same relationship also holds for government expenditure versus years of secondary and higher education, and investment versus years of secondary and higher education.

[9] The model has a pseudo goodness of fit ($\tilde{R}^2$) of 0.7879, which implies that the corresponding "true" parametric model, if it were known, has a traditional goodness of fit (R^2) of approximately 0.60 (see Chambers (2003)).

necessary income threshold to finance their education. However, as government expenditure rises and thus access to education eases, the impact of additional inequality is reduced. In order to examine the relationship between changes in inequality and investment, government expenditure must be held constant.

The plots of $\hat{b}(\overline{gov}, inv)$ are displayed in Figures 9 and 10. As investment moves from low to moderately high levels, the marginal impact of additional inequality rises and then declines in nations with lower levels of government expenditure (i.e. twentieth percentile). In nations with high levels of government expenditure, the marginal impact of additional inequality initially declines and then rises over low to moderately high levels of investment. One possible explanation for this phenomenon is that in nations with relatively low levels of government expenditure and low levels of investment, agents find it very difficult to finance their education. Therefore, higher inequality places enough income in a select group of agents, thereby promoting more education (and hence growth). As investment rises, credit market constraints begin to diminish and the benefits of greater inequality diminish as well.

In nations with high levels of government expenditure and low levels of investment, greater inequality reduces growth, in large part because access to education is already prevalent (i.e. greater inequality only serves to make education less attainable). However, as investment rises, credit market constraints diminish thereby offsetting the impact of higher inequality (i.e. easier access to credit markets allow individuals with an otherwise smaller share of total income to afford an education). An alternative way of representing these relationships is through a three-dimensional graph, which is provided in Figure 11.

3.4 Estimation Results: Government Expenditure, Investment, and Growth

The estimates of $\hat{a}(gov, \overline{inv})$ and $\hat{a}(\overline{gov}, inv)$ from model (3.1) provide a glimpse of the relationship between government expenditure, investment, and growth. Plots of these are provided in Figures 12 to 15.

Figures 12 and 13 seem to suggest that there is an important but limited role for government. In nations with relatively low levels of investment, higher levels of government

expenditure seem to universally raise growth rates. However, in nations with moderate to high levels of investment, government is only of limited value. That is, when government expenditures exceed approximately 17% of GDP, greater government expenditures tend to retard growth. Although investment is fixed in these exercises, this reduction in growth may be reflective of a crowding-out effect.

Figures 14 and 15 are reflective of the fact that higher investment appears to reduce education levels (when investment is low) and then augments them (when investment is high). These declines/increases in human capital accumulation appear to, in turn, reduce/increase the economic growth rate.

4 New Results in Perspective

The results of this paper, while similar in some ways to the existing literature, provide a number of new and original findings. Like Barro, this paper finds more than one growth-inequality regime. However, unlike Barro, the multiplicity of regimes is much greater and the dynamics of this model do not hinge on national income. This, however, does not imply that Barro was incorrect to partition his sample by income. Because he used a much broader sample, which included 20 sub-Saharan African nations (which generally have high inequality and low growth), the dynamics of his data set could differ. Moreover, Barro's model is more temporally aggregated (he used 10-year rather than 5-year growth periods), which has been shown (in linear models) to generate a more robust, negative relationship between inequality and growth. Finally, Barro employed a random effects model, whereas Forbes (2000), Li and Zou (1998), and myself have used fixed-effects models. It appears that the use of fixed effects models has the effect of yielding a positive estimated relationship between inequality and growth in linear panel models (see Forbes (2000)). However, in the context of this model and dataset, the random effects specification appears to be inappropriate (as noted in footnote 3).

It also appears that the principle results of this paper do not rely upon the remaining conditioning variables. To demonstrate this, the following fixed-effect, semiparametric model, void of any of Barro's conditioning variables and time period effects was estimated:

$$gr_{it+5} = \alpha_i + a(gov_{it}, inv_{it}) + b(gov_{it}, inv_{it}) \cdot gini_{it} + \varepsilon_{it+5} \tag{4.1}$$

The graphs of both $\hat{b}(gov, i\overline{n}v)$ and $\hat{b}(g\overline{o}v, inv)$ are provided in Figures 17 and 18 respectively. Clearly, the dynamics exhibited in both of these figures are consistent with the stylized facts discussed above, thereby implying that the main results of this paper appear to be robust.

Overall, the coefficient estimates of the remaining (linear) variables from model (3.1) seem consistent with those reported by Barro (2000) and Forbes (2000). Table 1 below reports the estimated coefficients from these models.

The current model and Barro's model agree (in terms of the sign of the coefficients) on conditional convergence and the importance of education, trade, and inflation. However, they disagree on the impact of fertility. This latter disagreement, however, is surprising given that most economists would expect higher birth rates to retard economic performance.

In Barro's paper, interestingly, when fertility is omitted, the coefficient on inequality becomes significantly negative, whereas when included the coefficient on inequality becomes insignificant. Barro informally investigated this link by treating fertility as a dependent variable, and used inequality, log GDP, and other factors as independent variables. He found that greater inequality predicts higher rates of fertility.

A possible problem with this exercise lies in the fact that fertility has a significant time trend (i.e. fertility rates decline systematically over the sample).

Therefore, the measured relationship between fertility and any other variable may be spurious (i.e. the extraneous impact of time on fertility and any other variable may drive any measured correlation). A plot of the fertility series of several nations is provided in Figure 19 to show this time trend.

Moreover, because fertility and inequality are correlated, when the nonlinear relationship between inequality and growth is conditioned for, the remaining relationship between fertility and economic growth may not be negative.

Throughout this paper, the credit market constraint argument has been used to help explain the behavior of model (3.1). As such, one may wonder if the political economy

argument could help explain the relationship between growth, inequality, government expenditure, and investment. The answer to this question appears to be no.[10]

In the traditional political economy argument, it is posited that higher inequality leads to greater social unrest and instability, which in turn reduces domestic investment (because investors must be compensated for the resulting increased risk of default, equilibrium interest rates rise and equilibrium investment falls). Lower domestic investment, in turn, reduces the rate of economic growth. However, this argument is not totally consistent with the facts.

It appears that greater stability is associated with higher predicted rates of economic growth. Figure 20 plots the scatter diagram of the rule of law index against in-sample values of $\hat{a}(gov, inv)$. There appears to be a strong positive relationship between the two series, thus implying that more stable nations have higher predicted rates of economic growth. Thus, the political economy argument that stability is growth promoting appears to be supported by the data. However, an important question remains: is inequality the catalyst for changes in political stability? This appears to be the point where the political economy argument is less supported by the data. It appears that the relationship between inequality and political instability is non monotonic (i.e. the correlation between these variables is neither exclusively positive nor negative). Instead, it appears that the relationship between inequality and political instability is driven by or is a reflection of the Kuznets Hypothesis. Figure 21 is a scatter diagram of the rule of law index versus contemporaneous levels of log per-capita GDP. There is a clear, positive relationship between these variables (i.e. nations that are more stable appear to produce more per-capita output). Therefore, if one accepts the Kuznets Hypothesis to be a stylized fact, one would expect an inverted U-shaped relationship between the rule of law index and income inequality. Indeed, Figure 22 displays just such a relationship. Because a negative relationship between inequality and instability only appears to exist in nations that are already fairly stable, the political economy argument can, at best, only explain a limited amount of the dynamics between growth, inequality, government expenditure, and investment.

5 Conclusion

[10] It should be pointed out that the measure of political instability used in this exercise (the rule of law index) varies very little within each nation. As such, the omission of a proxy for political instability is inconsequencial because model (3.1) employs fix effects, and hence accounts for any nation-specific heterogeneity.

Past empirical investigations of the relationship between economic growth and inequality have yielded a broad set of results, including no relationship, and negative, and positive relationships. Although models, empirical methodology, and datasets have steadily improved, the empirical unit of interest was always a single, invariant coefficient on inequality (which entered the various models linearly). This paper finds, however, significant evidence to suggest that the relationship between economic growth and inequality is quite complicated, and hinges critically on both the levels of government expenditure and investment. Moreover, while the estimated relationships may be consistent with a number of economic forces and phenomena, it appears that the interplay between imperfect credit markets and government subsidization of the acquisition of human capital helps drive the observed relationship between government expenditure, investment, and inequality.

With regard to the impact of government expenditure directly on the growth rate, the results seem to suggest that there is an important but limited role for government. In nations with relatively low levels of investment, higher levels of government expenditure seem to universally raise growth rates. However, in nations with moderate to high levels of investment, government is only of limited value. Finally, the results may also reflect the existence of two steady state growth rates, and hence two associated levels of investment, which could explain why some nations experience greater growth rates.

Appendix A

The data have been collected from the following sources:

Variable	**Source**
Real GDP per capita (chain weighted)	Penn World (Mark 5.6)
Investment to GDP ratio	Penn World (Mark 5.6)
Government expenditure to GDP ratio	World Bank Development Indicators (2001)
Inflation rate	World Bank Development Indicators (2001)
Fertility rate	World Bank Development Indicators (2001)
Growth rate of terms of trade	World Bank Development Indicators (2001)
Primary education completion rate	Barro (Barro/Lee Dataset)
Gini coefficient	World Bank (Deininger & Squire Dataset)
Rule-of-Law Index	E. Duflo (originally constructed by Barro)

Appendix B

The nations and time periods used in the paper are listed below:

Nation	Observations	Dates
Australia	8	1968-69,1976,1978-79,1981,1985-1986
Brazil	5	1982-83,1985-1987
Canada	14	1969,1971,1973-75,1979,1981-87
Chile	9	1971,1980-1987
Colombia	5	1970-72,1974,1978
Costa Rica	8	1969,1971,1977,1979,1981-1983,1986
Denmark	3	1976,1981,1987
Spain	6	1973,1975,1980,1985-1987
Finland	11	1966,1971,1977-1984,1987
France	5	1965,1970,1975,1979,1984
United Kingdom	26	1962-1987
Indonesia	8	1967,1970,1976,1978,1980-81,1984,1987
India	5	1973,1977,1983,1986-87
Italy	12	1975-1984,1986-87
Japan	20	1963-65,1967-82,1985
Korea, Rep.	7	1969-1971,1976,1980,1982,1985
Sri Lanka	6	1970,1973,1979-1981,1987
Mexico	4	1968,1975,1977,1984
Malaysia	5	1973,1976,1979,1984,1987
Netherlands	9	1975,1977,1979,1981-83,1985-87
Norway	7	1967,1973,1976,1979,1984-86
Pakistan	6	1970-71,1979,1985-87
Peru	5	1962,1971-72,1981,1986
Philippines	3	1965,1971,1985
Sweden	11	1967,1975-76,1980-87
Thailand	4	1969,1975,1981,1986
Trinidad and Tobago	3	1971,1976,1981
United States	26	1962-1987
Venezuela, RB	5	1977-79,1981,1987

Appendix C

Figure 1

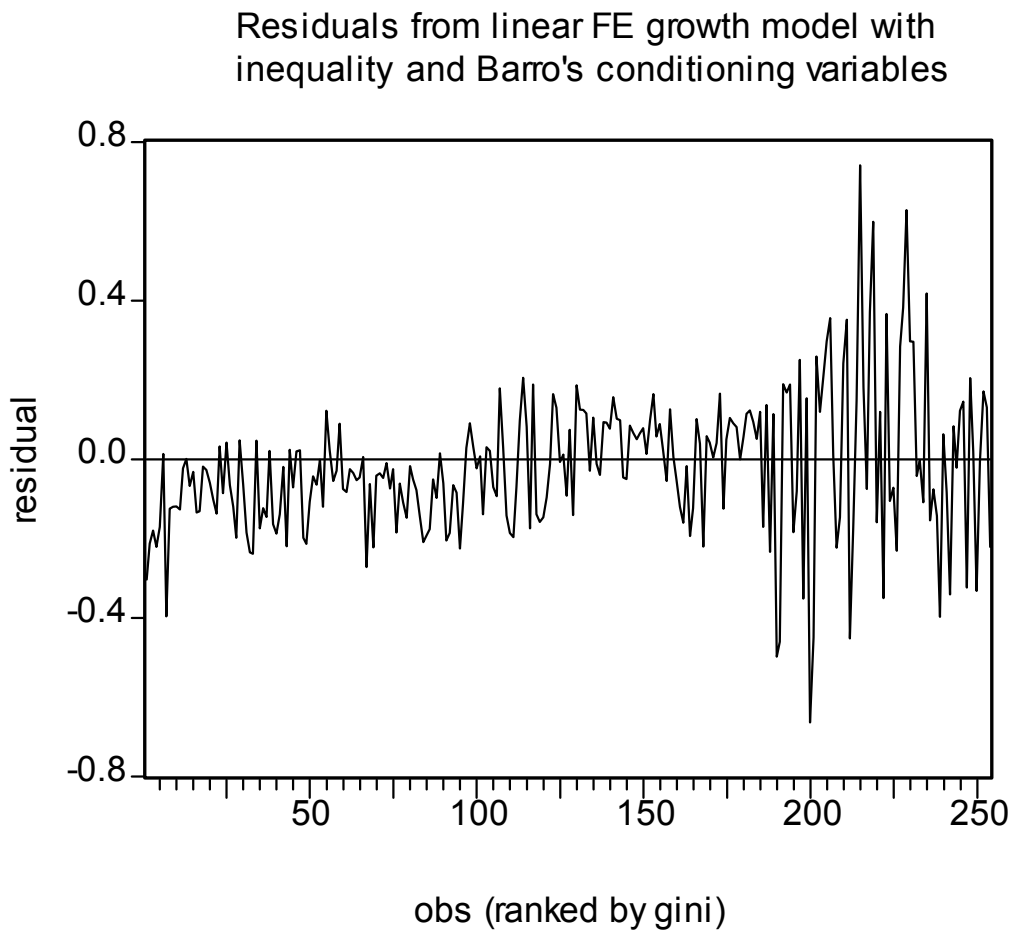


Figure 2

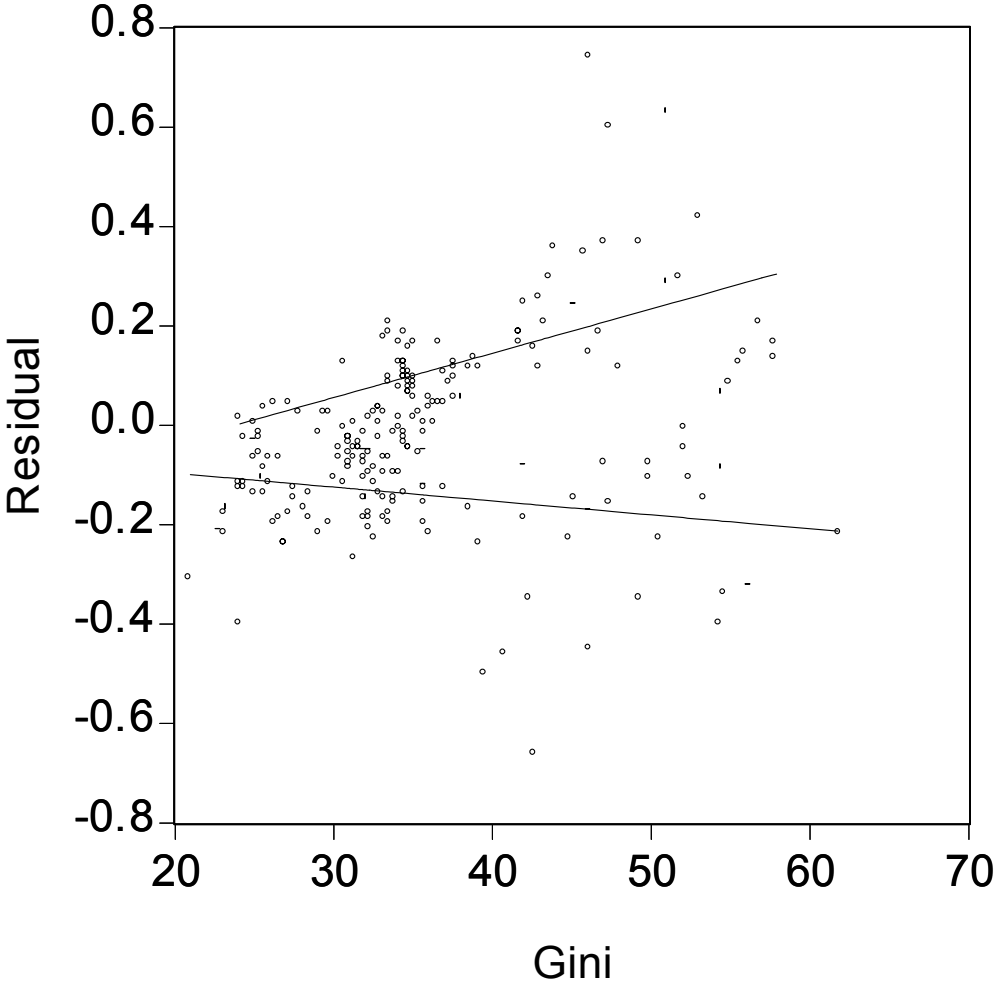


Figure 3

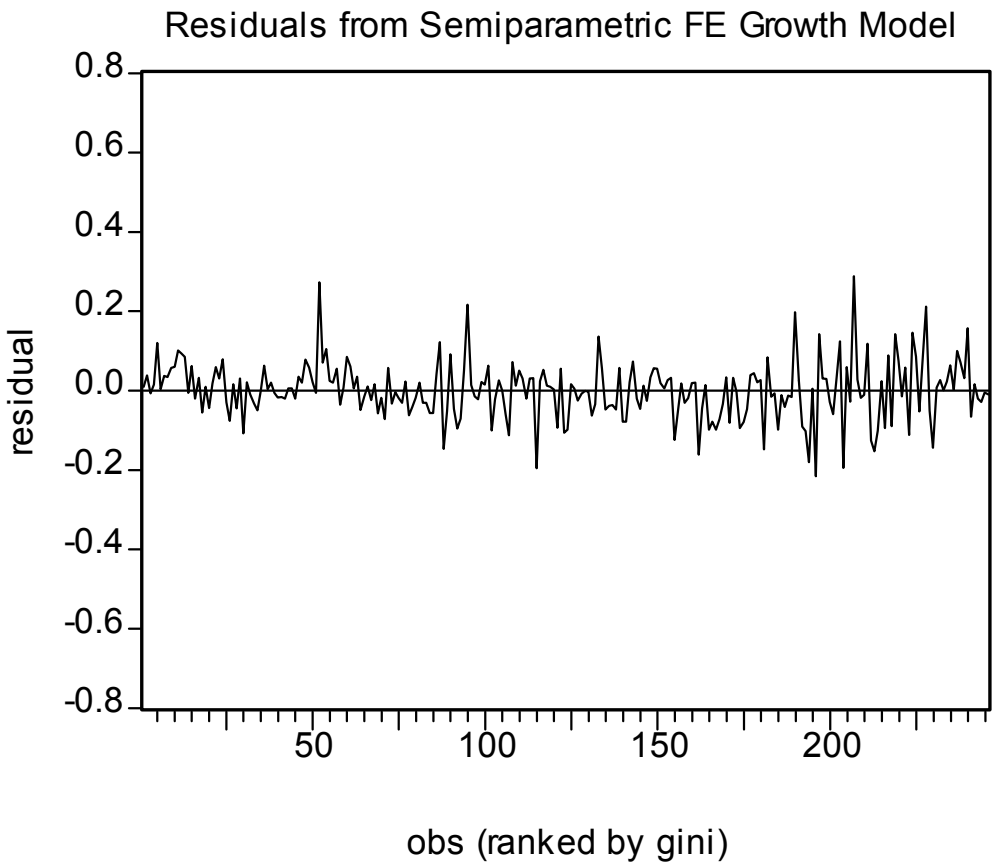

Residuals from Semiparametric FE Growth Model
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
residual
50
100
150
200
obs (ranked by gini)

Figure 4

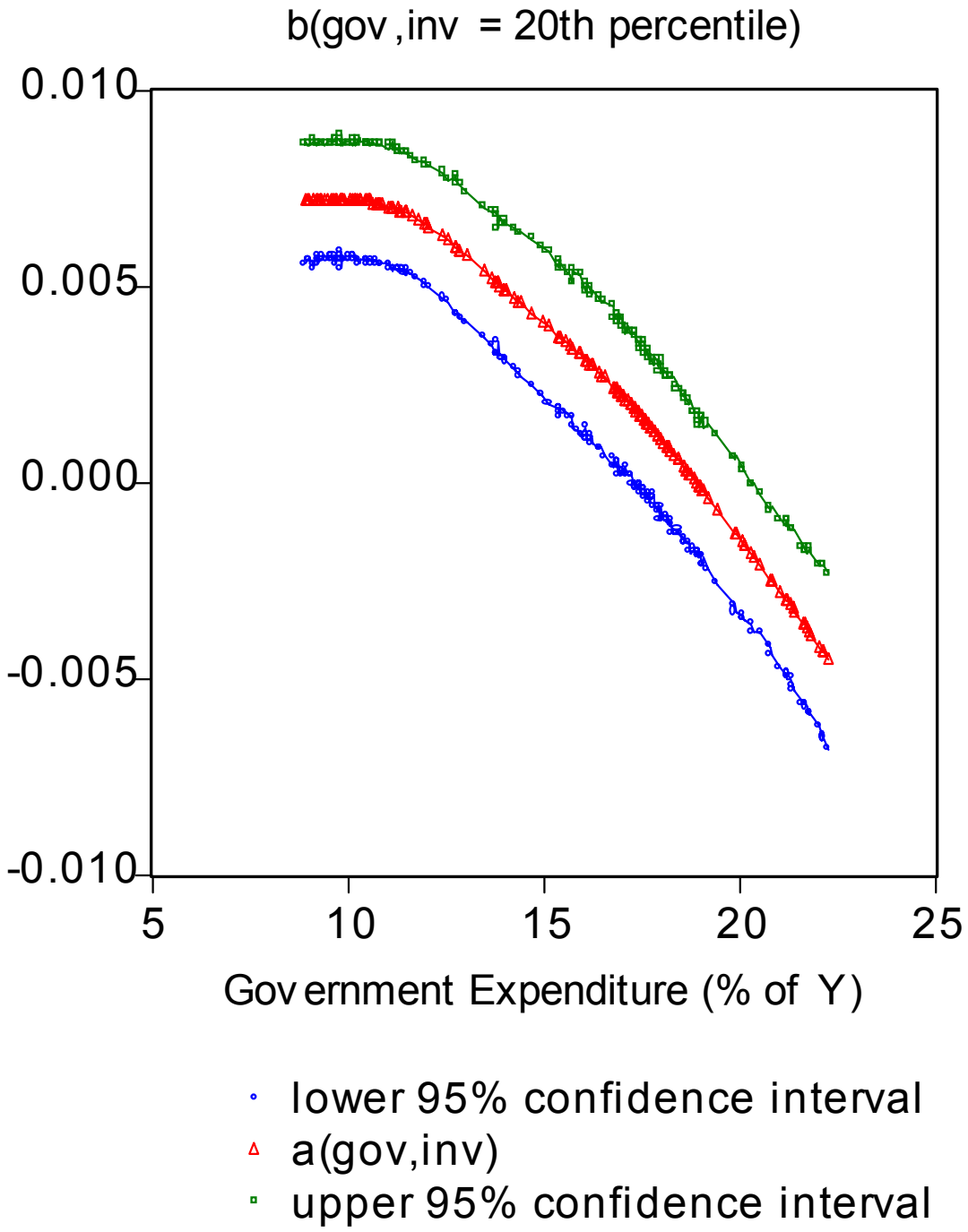

b(gov ,inv = 20th percentile)
0.010
0.005
0.000
-0.005
-0.010
5
10
15
20
25
Government Expenditure (% of Y)
lower 95% confidence interval
a(gov,inv)
upper 95% confidence interval

Figure 5

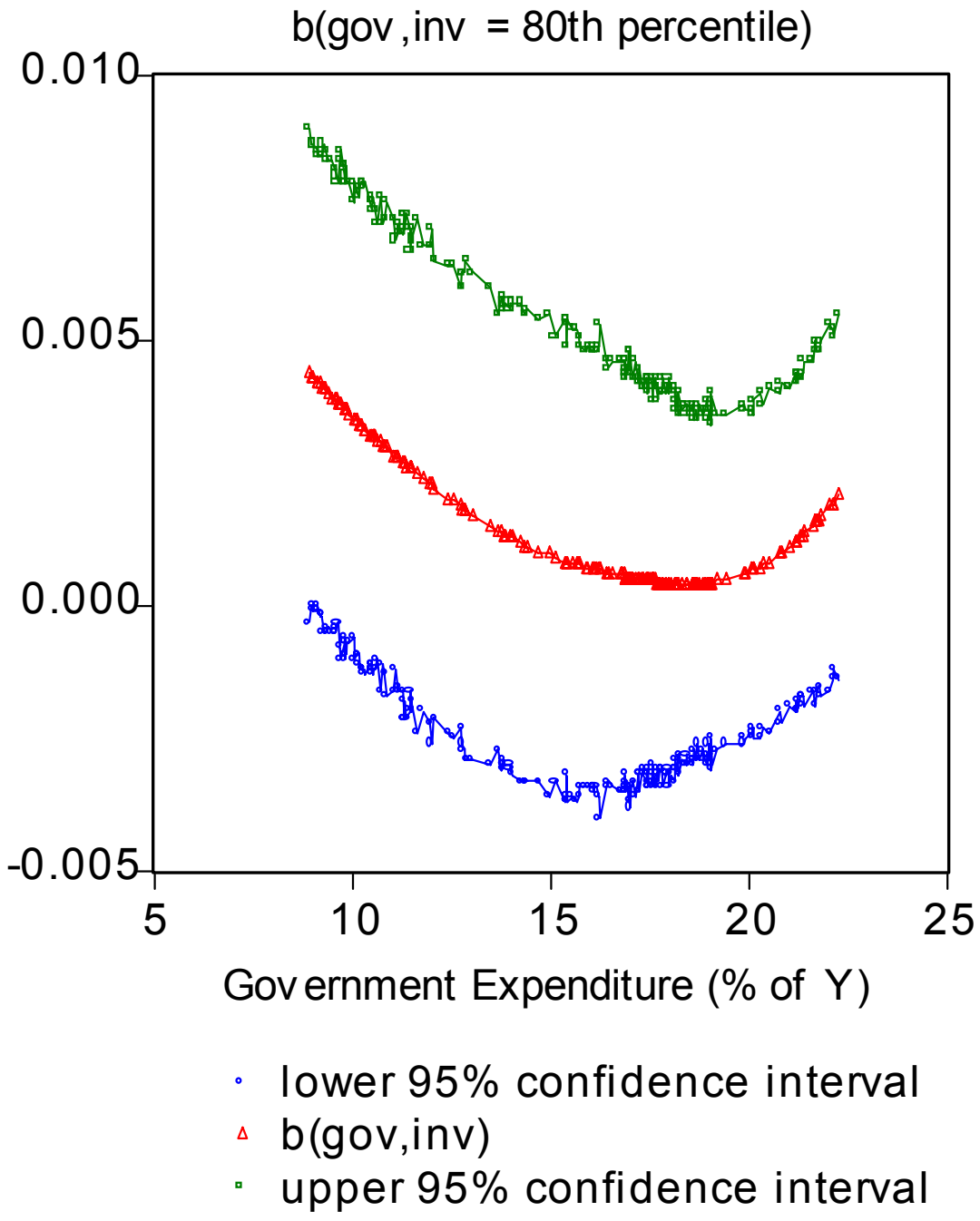

b(gov ,inv = 80th percentile)
0.010
0.005
0.000
-0.005
5
10
15
20
25
Government Expenditure (% of Y)
lower 95% confidence interval
b(gov,inv)
upper 95% confidence interval

Figure 6

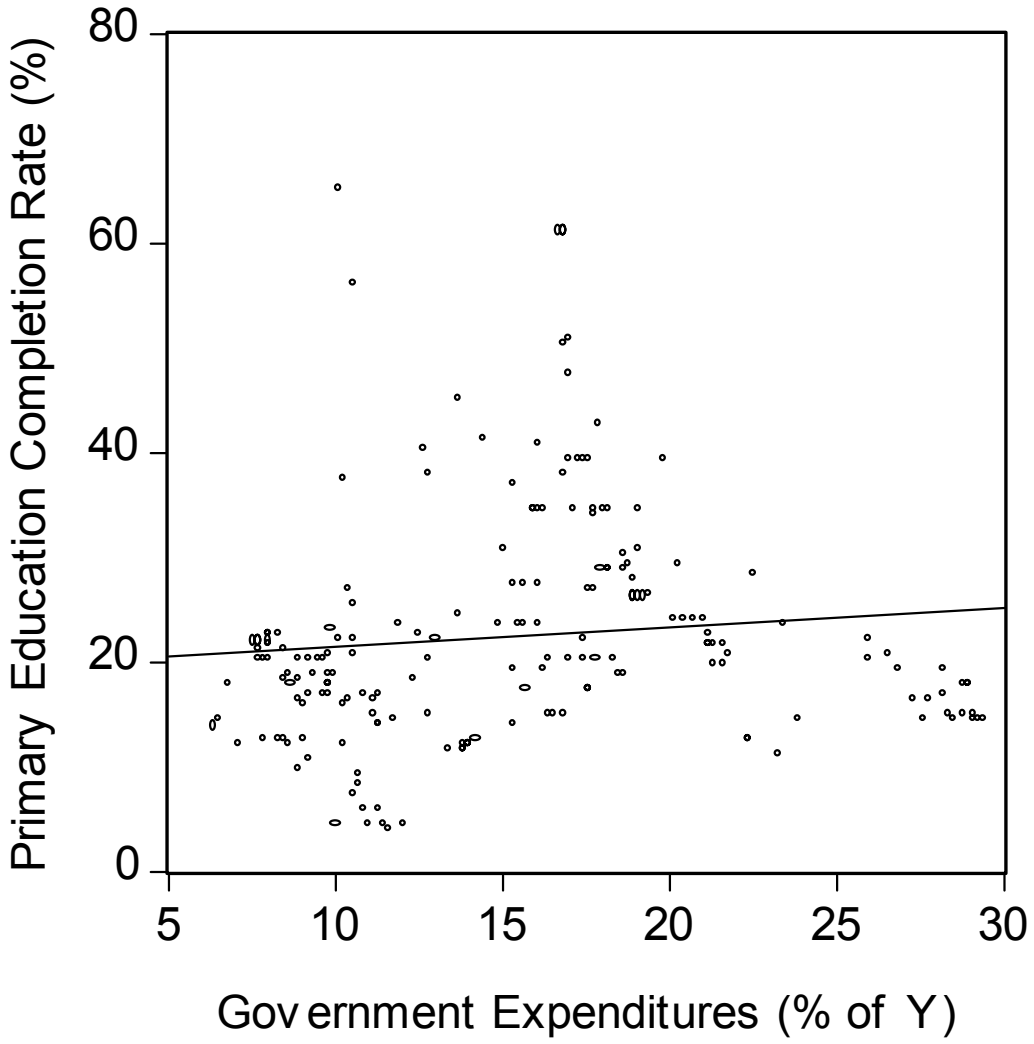

Primary Education Completion Rate (%)
80
60
40
20
0
5
10
15
20
25
30
Government Expenditures (% of Y)

Figure 7

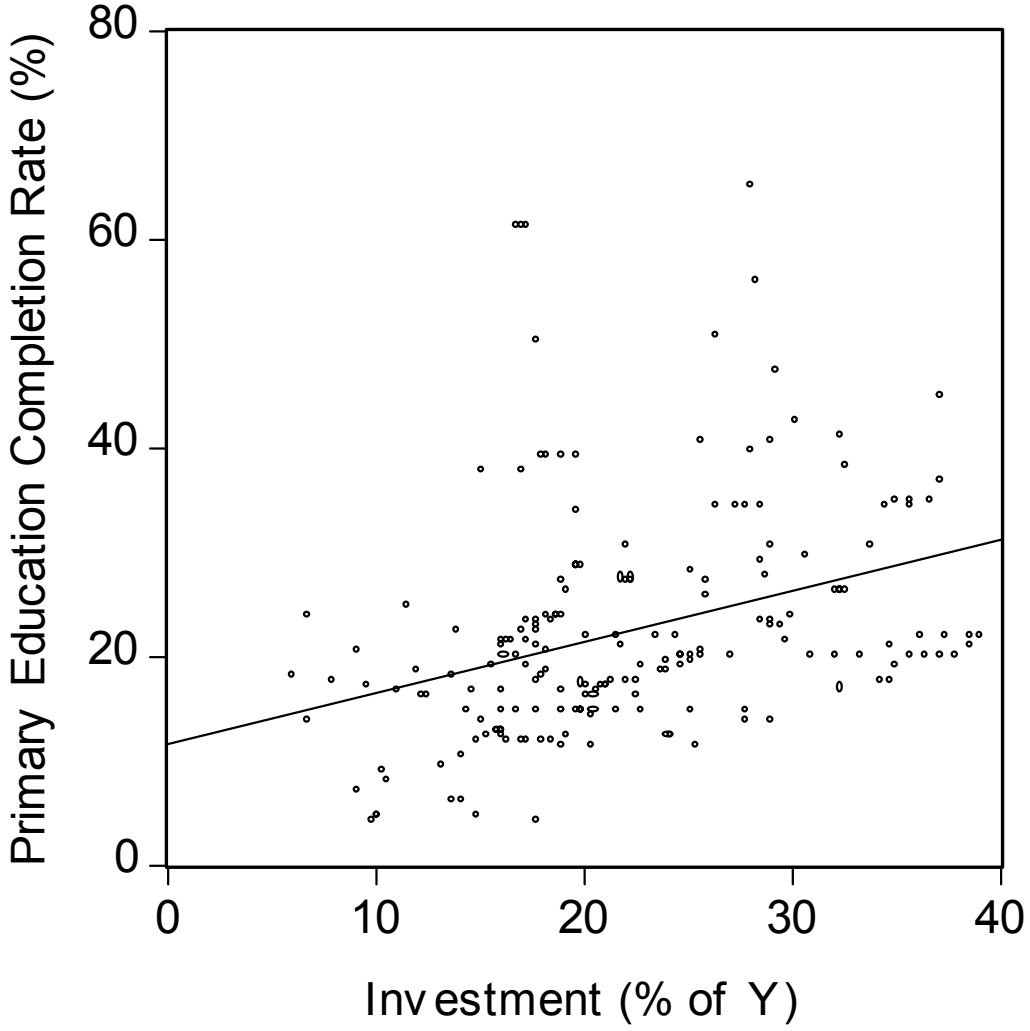

Primary Education Completion Rate (%)
80
60
40
20
0
0
10
20
30
40
Investment (% of Y)

Figure 8

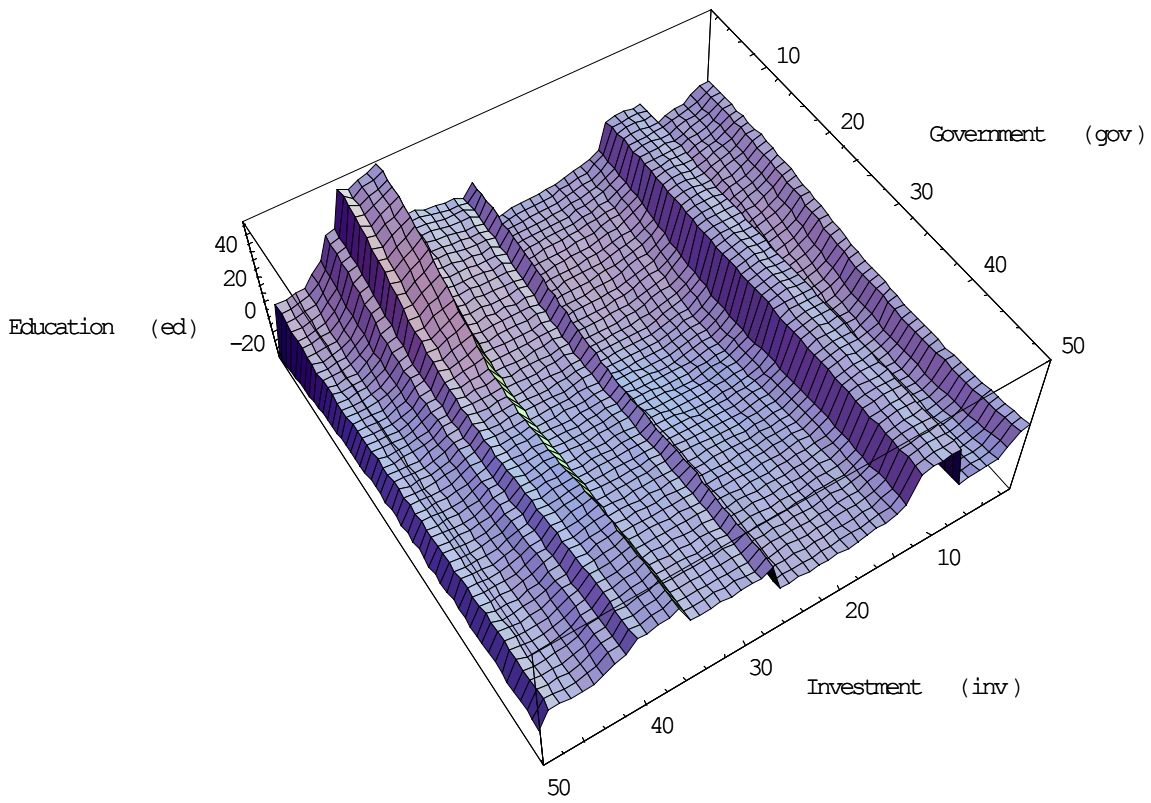

Education (ed)
40
20
0
-20
Government (gov)
10
20
30
40
50
Investment (inv)
10
20
30
40
50

Figure 9

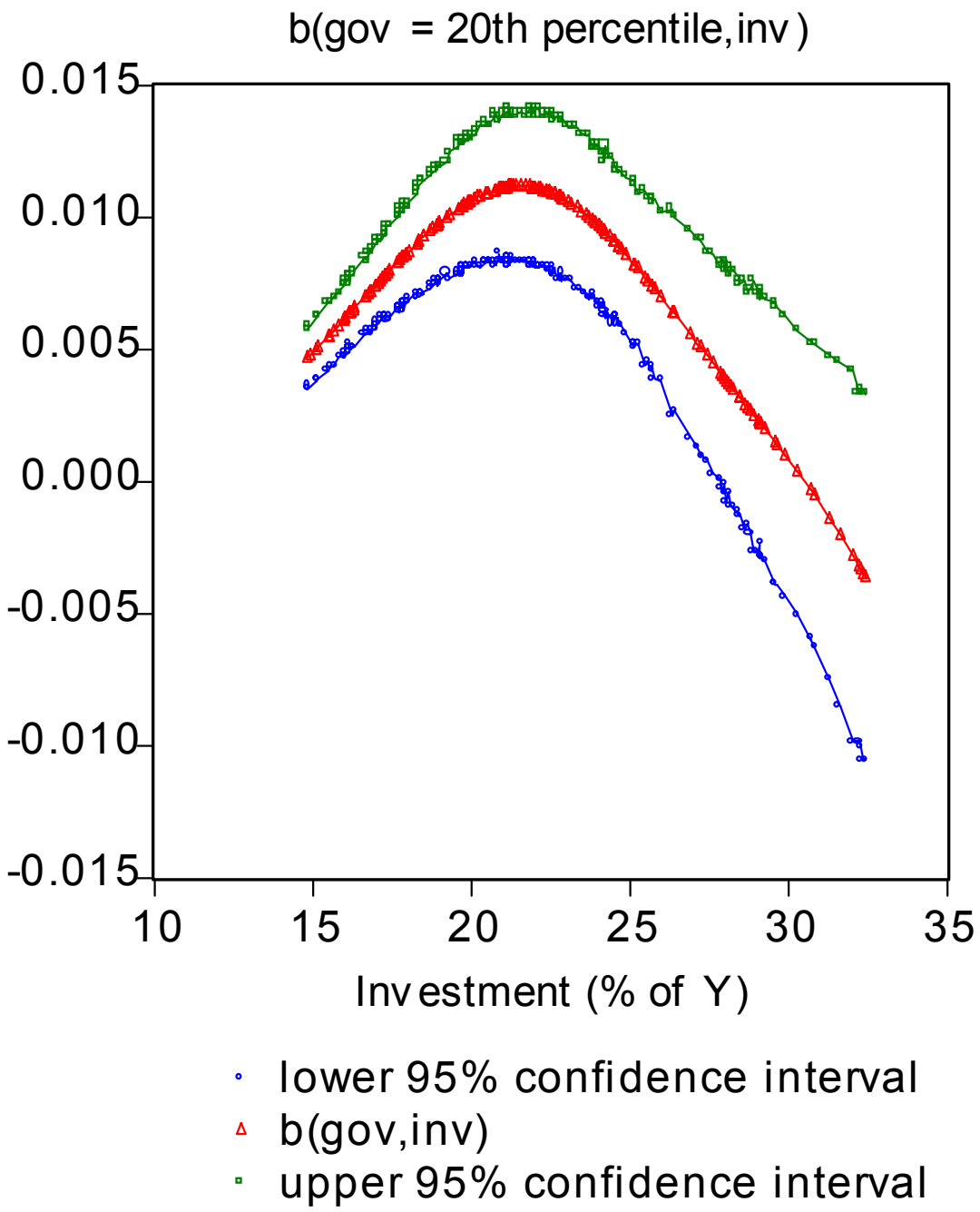

b(gov = 20th percentile,inv)
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
10
15
20
25
30
35
Investment (% of Y)
lower 95% confidence interval
b(gov,inv)
upper 95% confidence interval

Figure 10

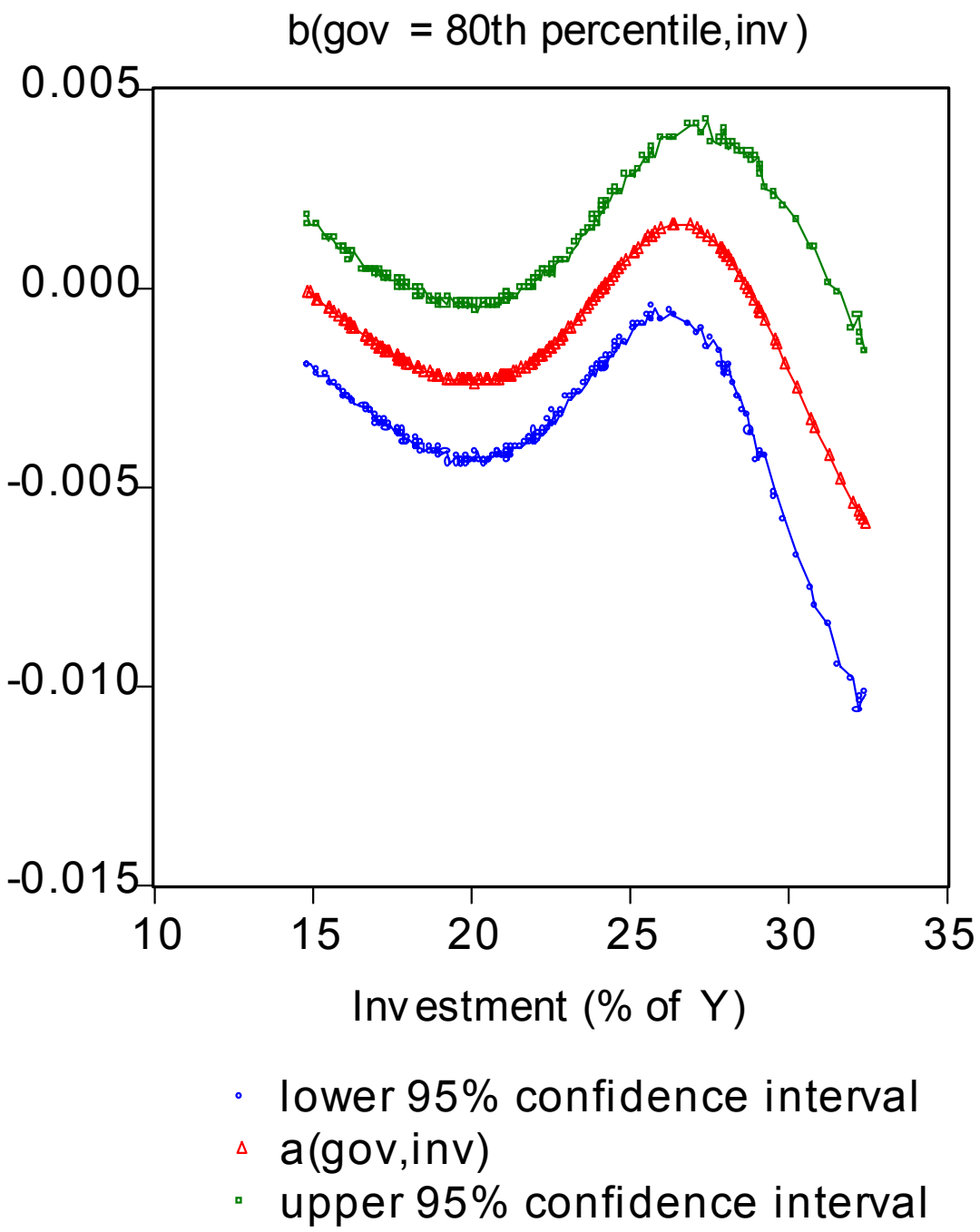

b(gov = 80th percentile,inv)
0.005
0.000
-0.005
-0.010
-0.015
10
15
20
25
30
35
Investment (% of Y)
lower 95% confidence interval
a(gov,inv)
upper 95% confidence interval

Figure 11

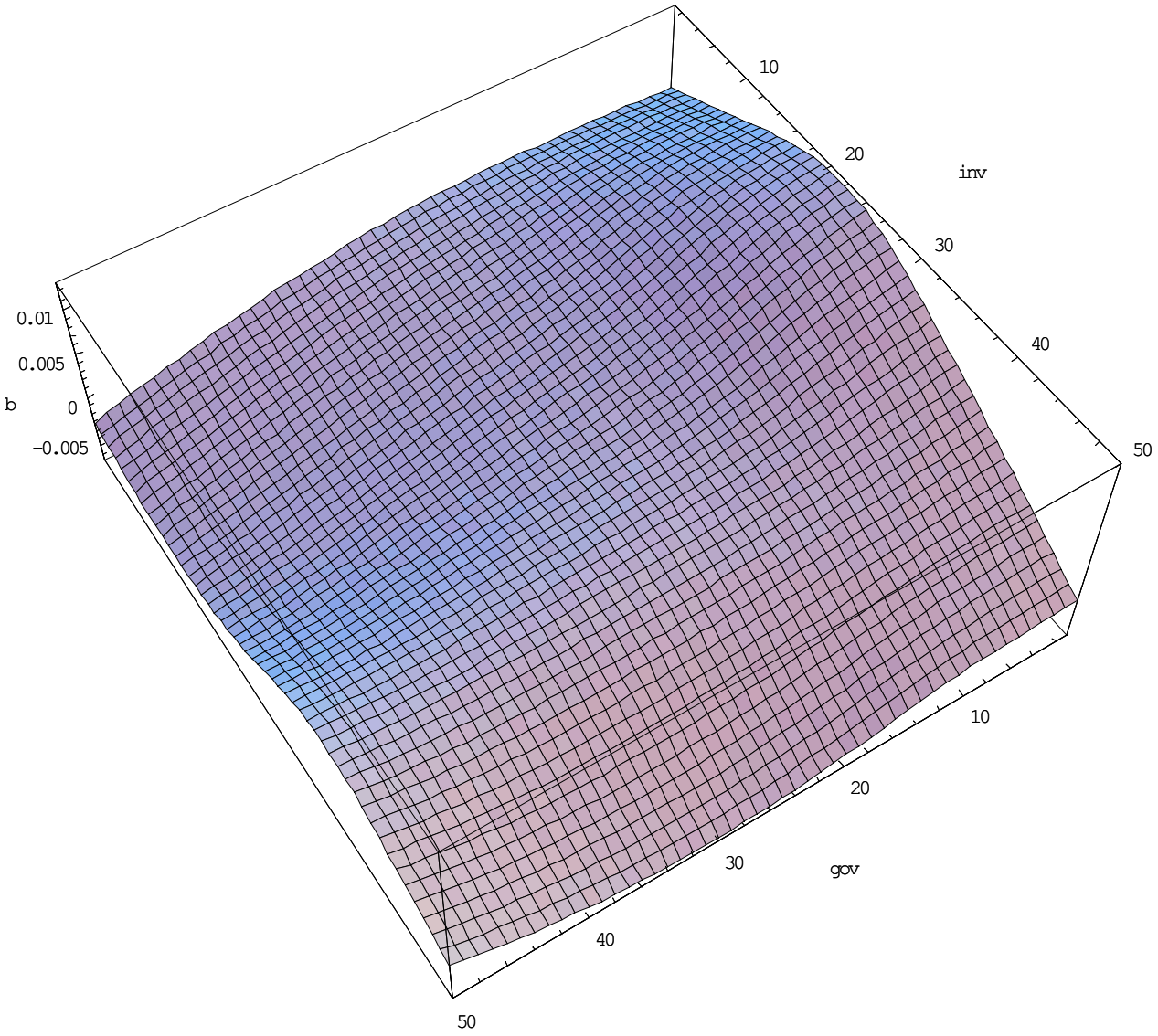


Figure 12

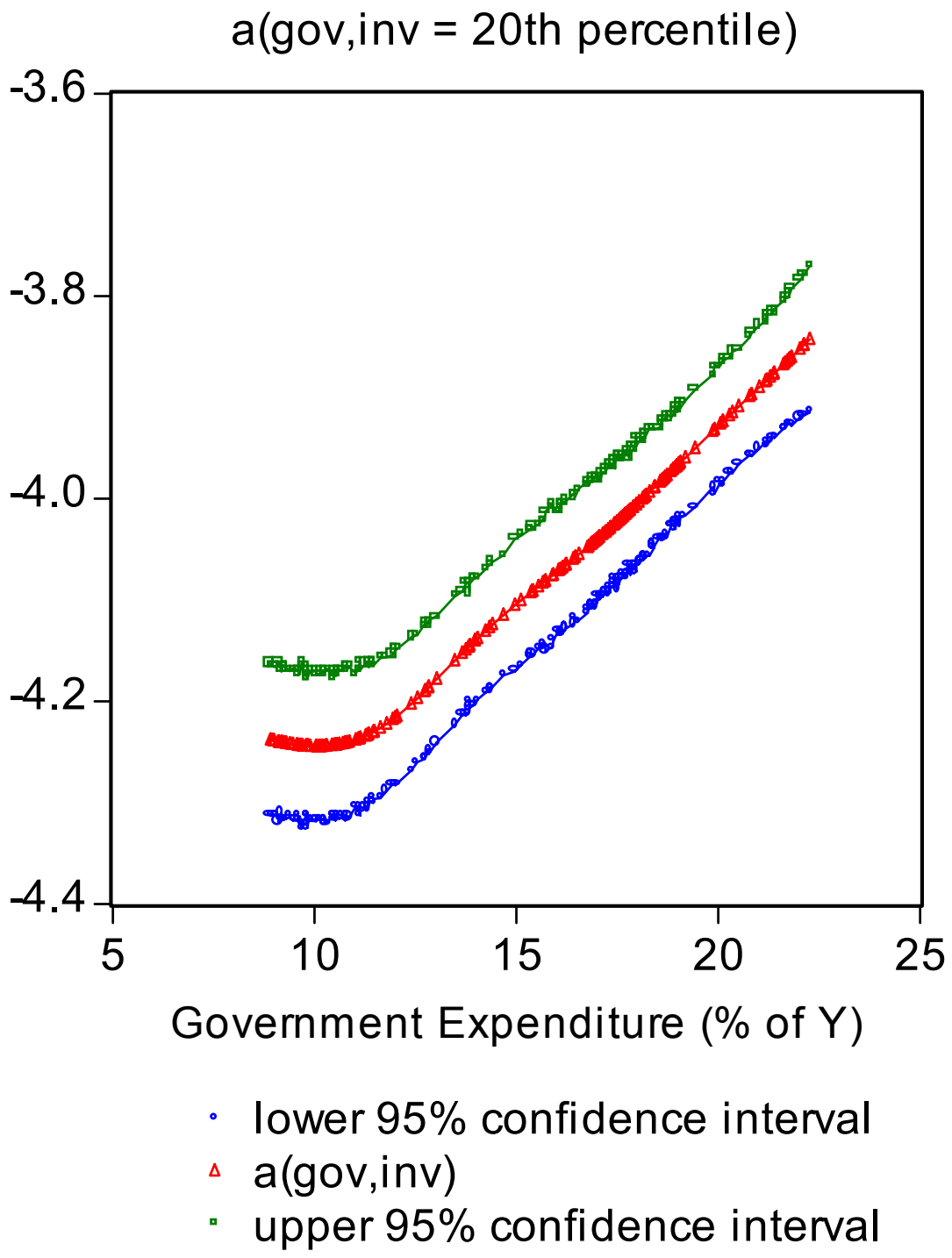

a(gov,inv = 20th percentile)
-3.6
-3.8
-4.0
-4.2
-4.4
5
10
15
20
25
Government Expenditure (% of Y)
lower 95% confidence interval
a(gov,inv)
upper 95% confidence interval

Figure 13

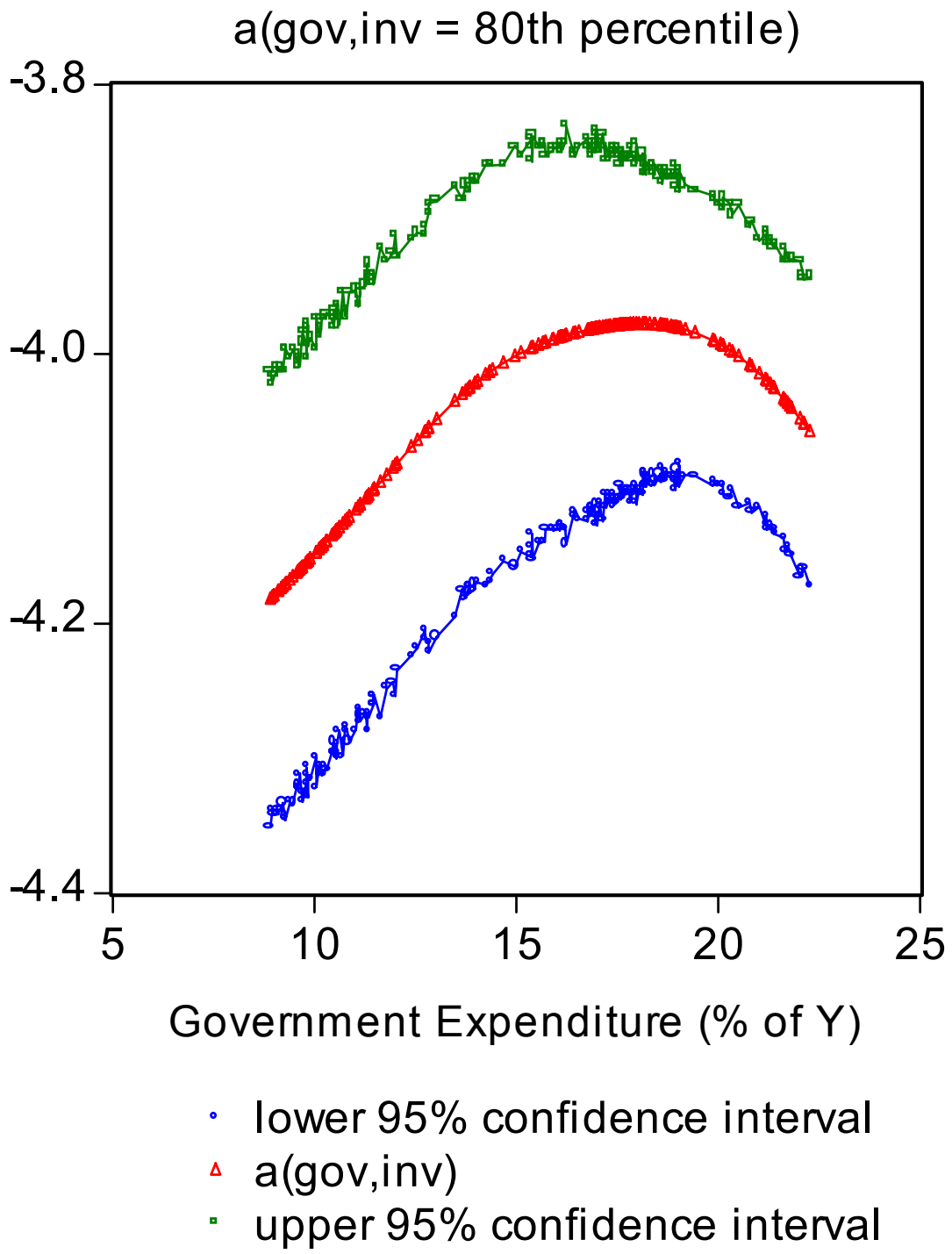

a(gov,inv = 80th percentile)
-3.8
-4.0
-4.2
-4.4
5
10
15
20
25
Government Expenditure (% of Y)
lower 95% confidence interval
a(gov,inv)
upper 95% confidence interval

Figure 14

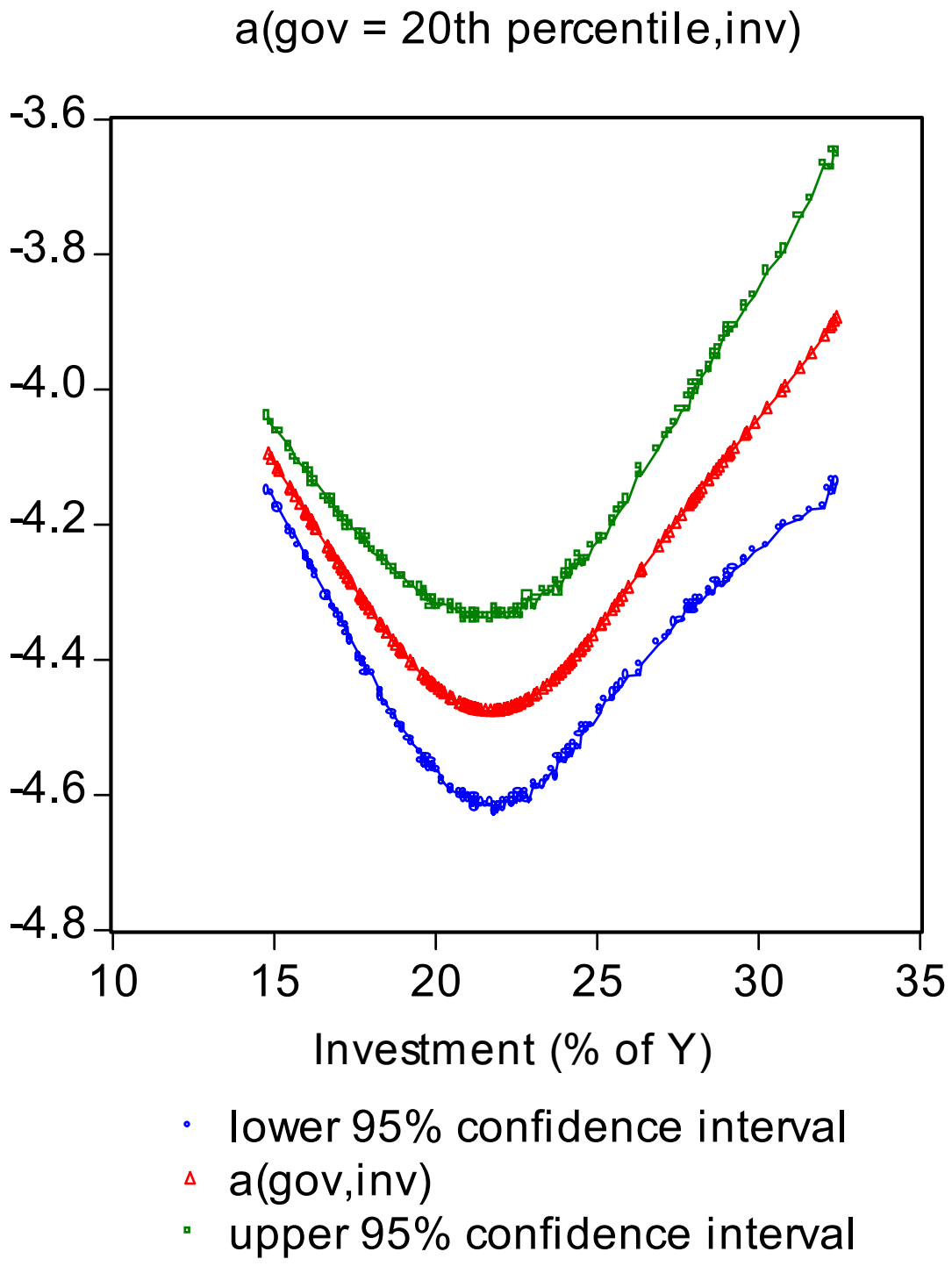

a(gov = 20th percentile,inv)
-3.6
-3.8
-4.0
-4.2
-4.4
-4.6
-4.8
10
15
20
25
30
35
Investment (% of Y)
lower 95% confidence interval
a(gov,inv)
upper 95% confidence interval

Figure 15

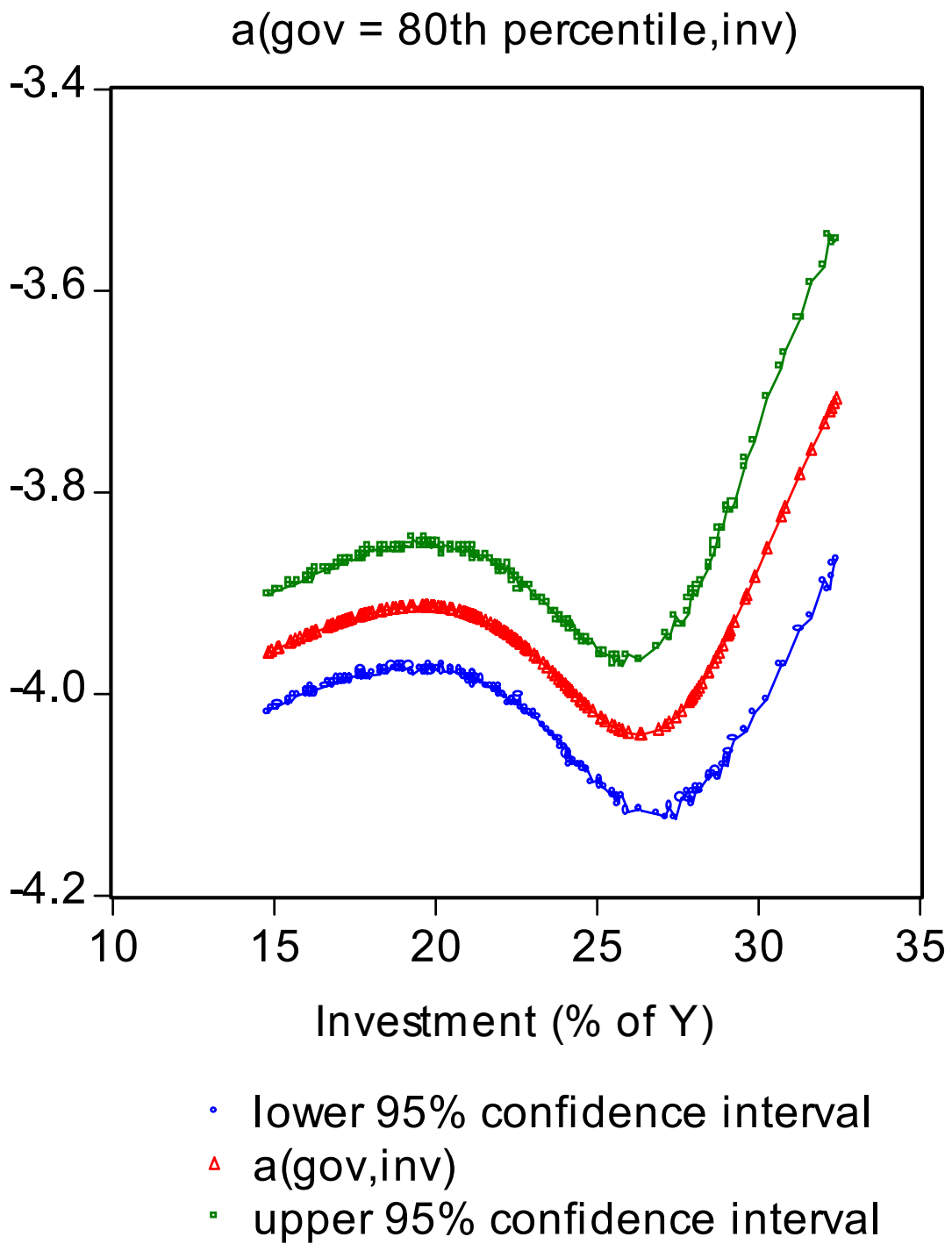

a(gov = 80th percentile,inv)
-3.4
-3.6
-3.8
-4.0
-4.2
10
15
20
25
30
35
Investment (% of Y)
lower 95% confidence interval
a(gov,inv)
upper 95% confidence interval

Figure 16

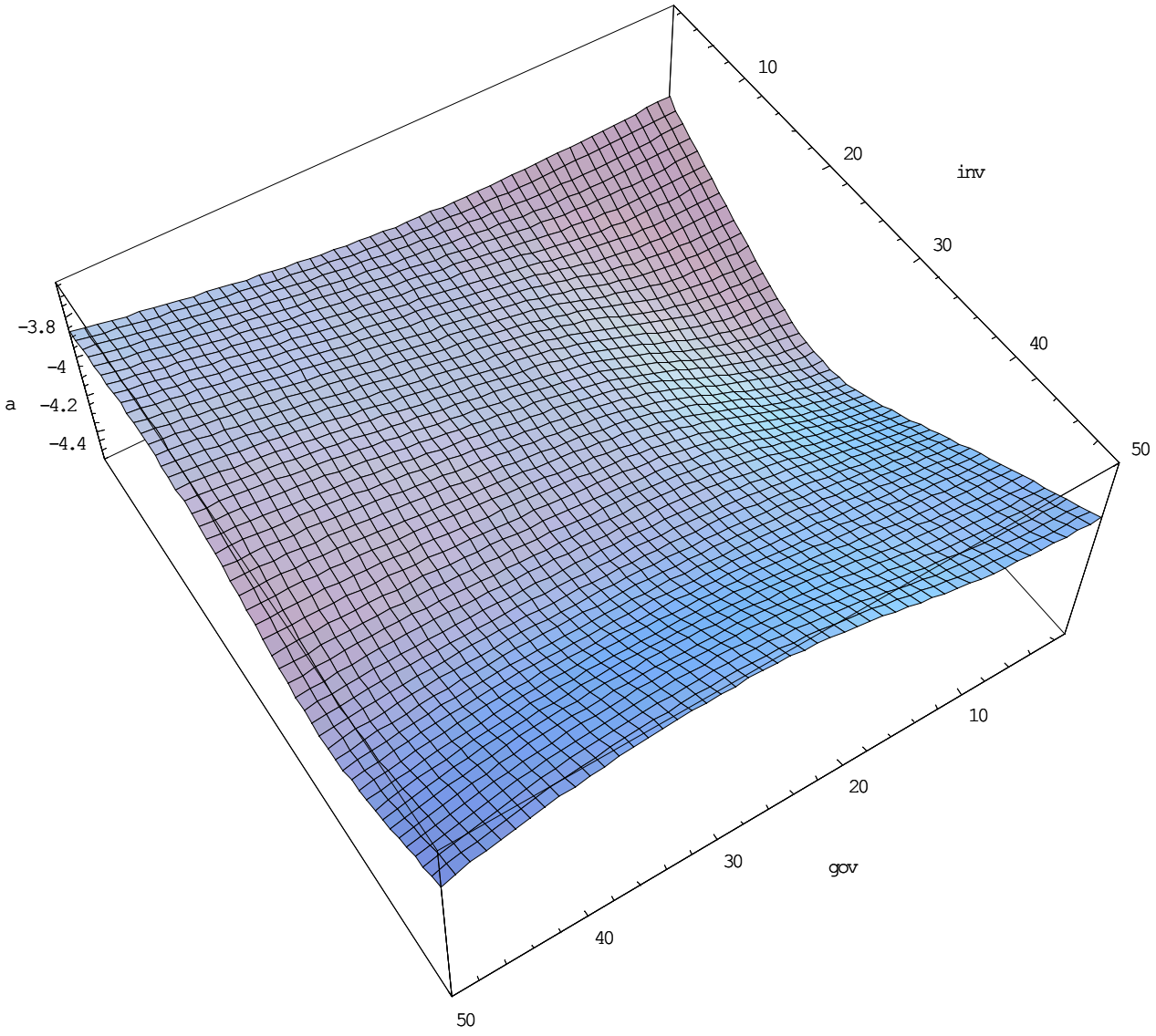


Figure 17

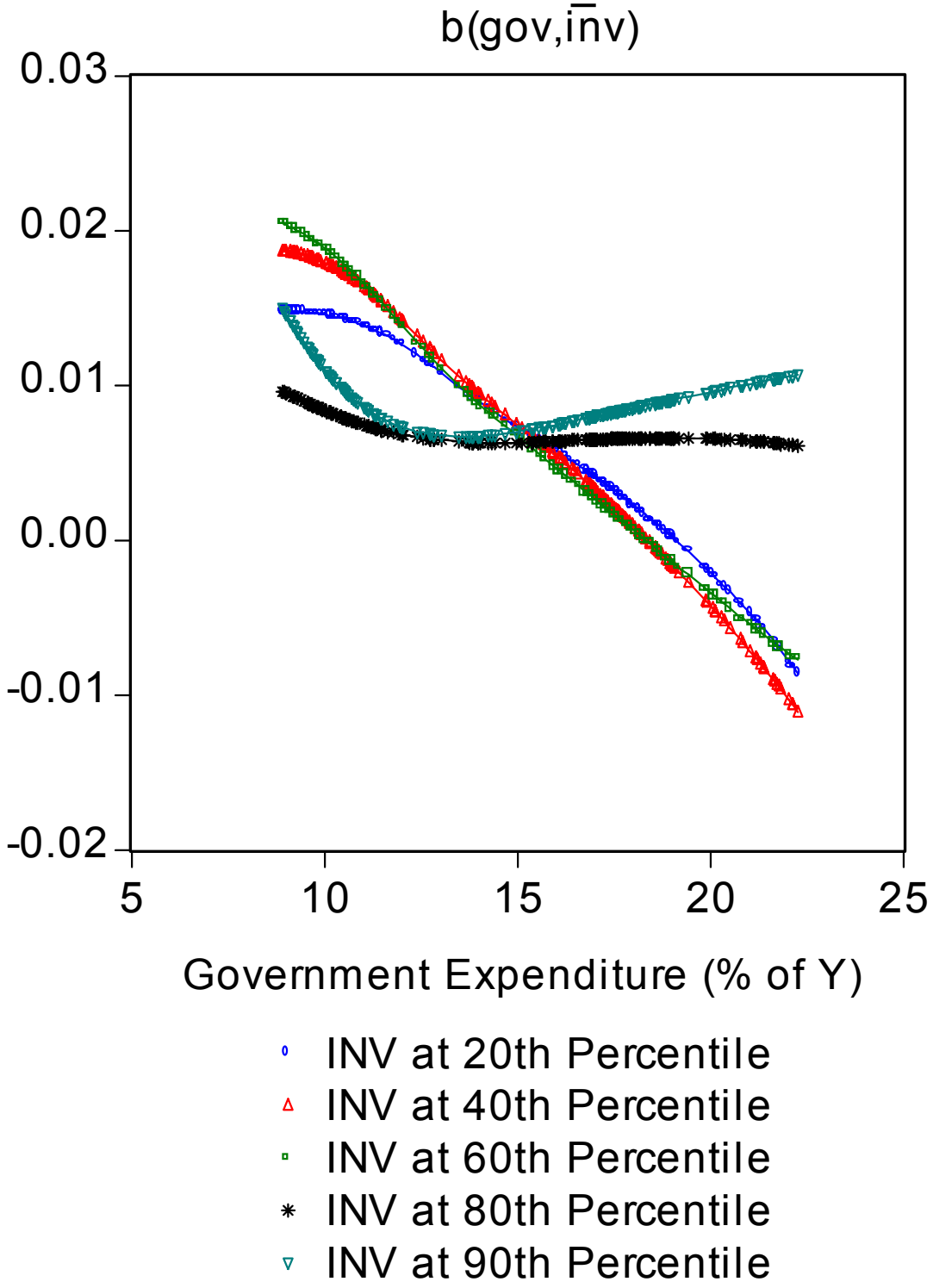

b(gov,inv)
0.03
0.02
0.01
0.00
-0.01
-0.02
5
10
15
20
25
Government Expenditure (% of Y)
INV at 20th Percentile
INV at 40th Percentile
INV at 60th Percentile
INV at 80th Percentile
INV at 90th Percentile

Figure 18

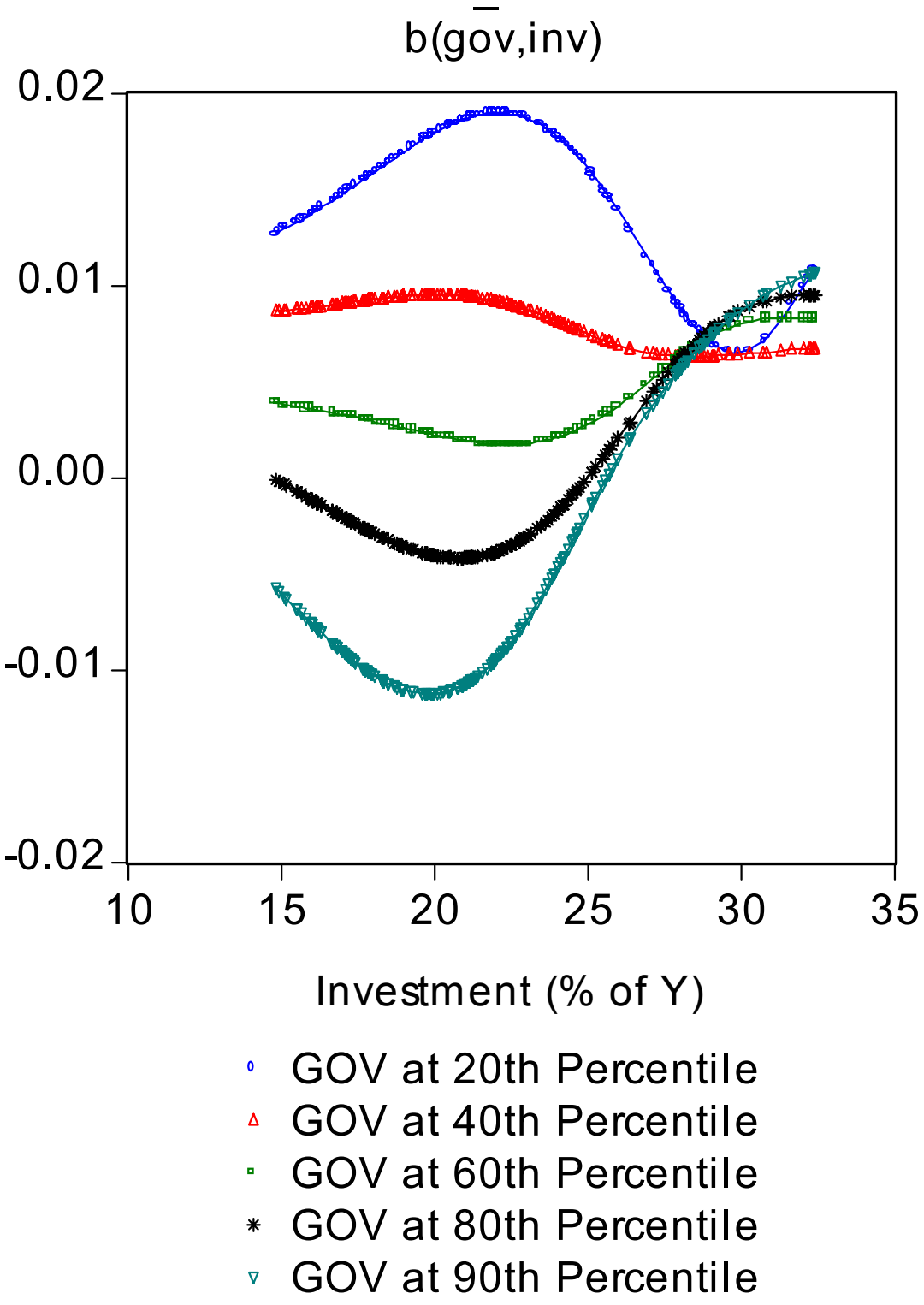

b(gov,inv)
0.02
0.01
0.00
-0.01
-0.02
10
15
20
25
30
35
Investment (% of Y)
GOV at 20th Percentile
GOV at 40th Percentile
GOV at 60th Percentile
GOV at 80th Percentile
GOV at 90th Percentile

Figure 19

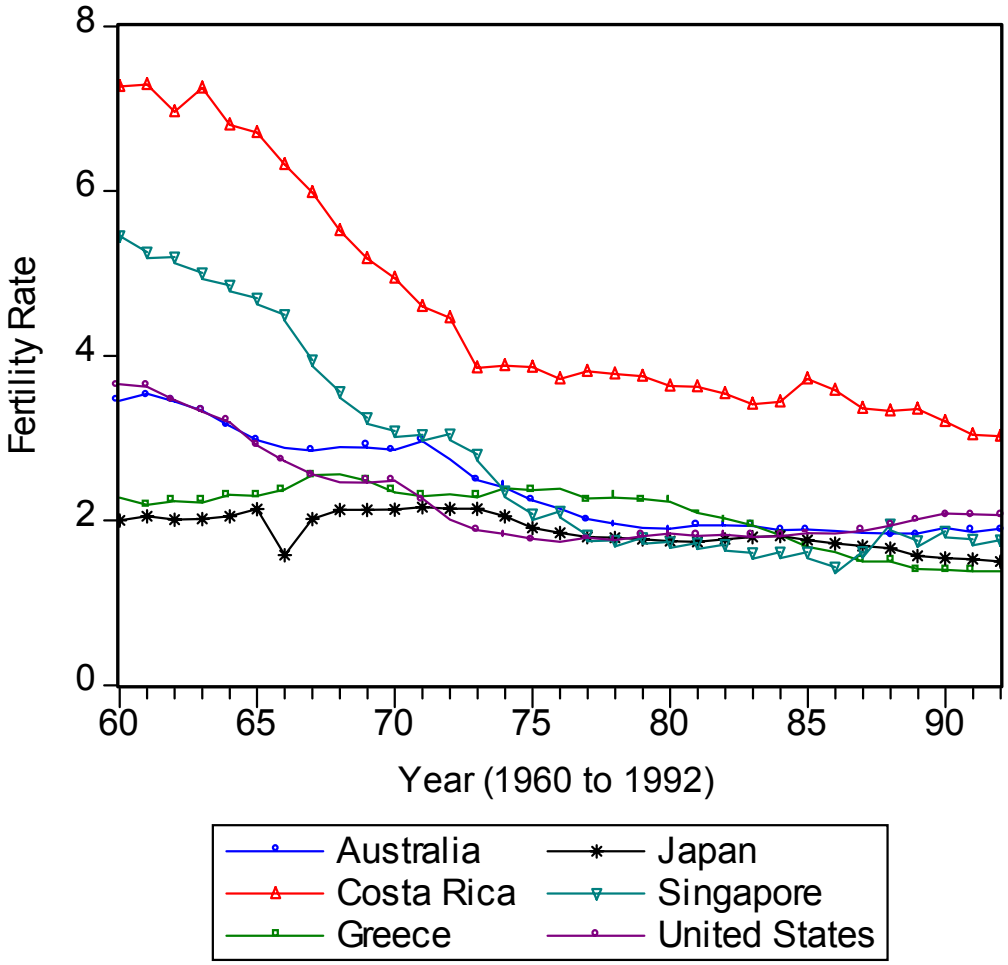

8
6
4
2
0
Fertility Rate
60
65
70
75
80
85
90
Year (1960 to 1992)
Australia
Japan
Costa Rica
Singapore
Greece
United States

Figure 20

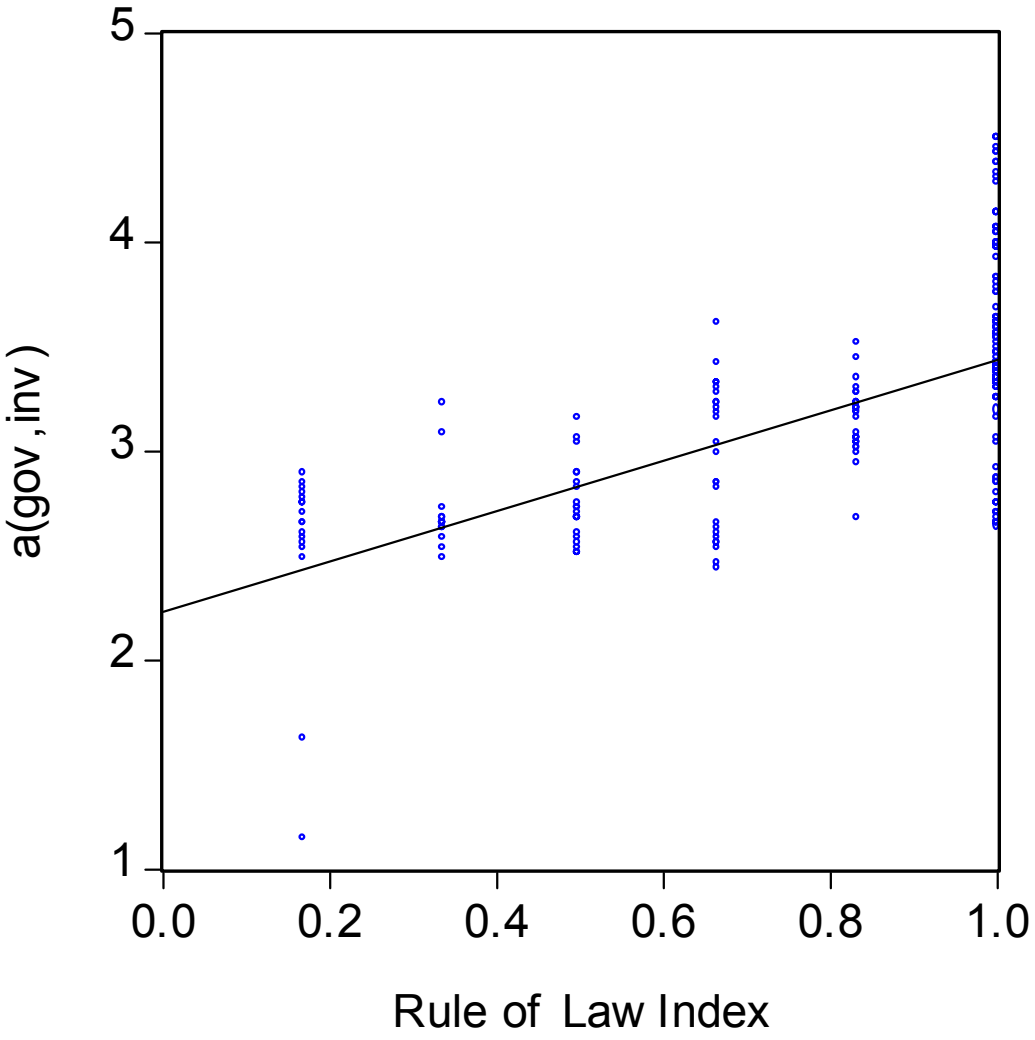


Figure 21

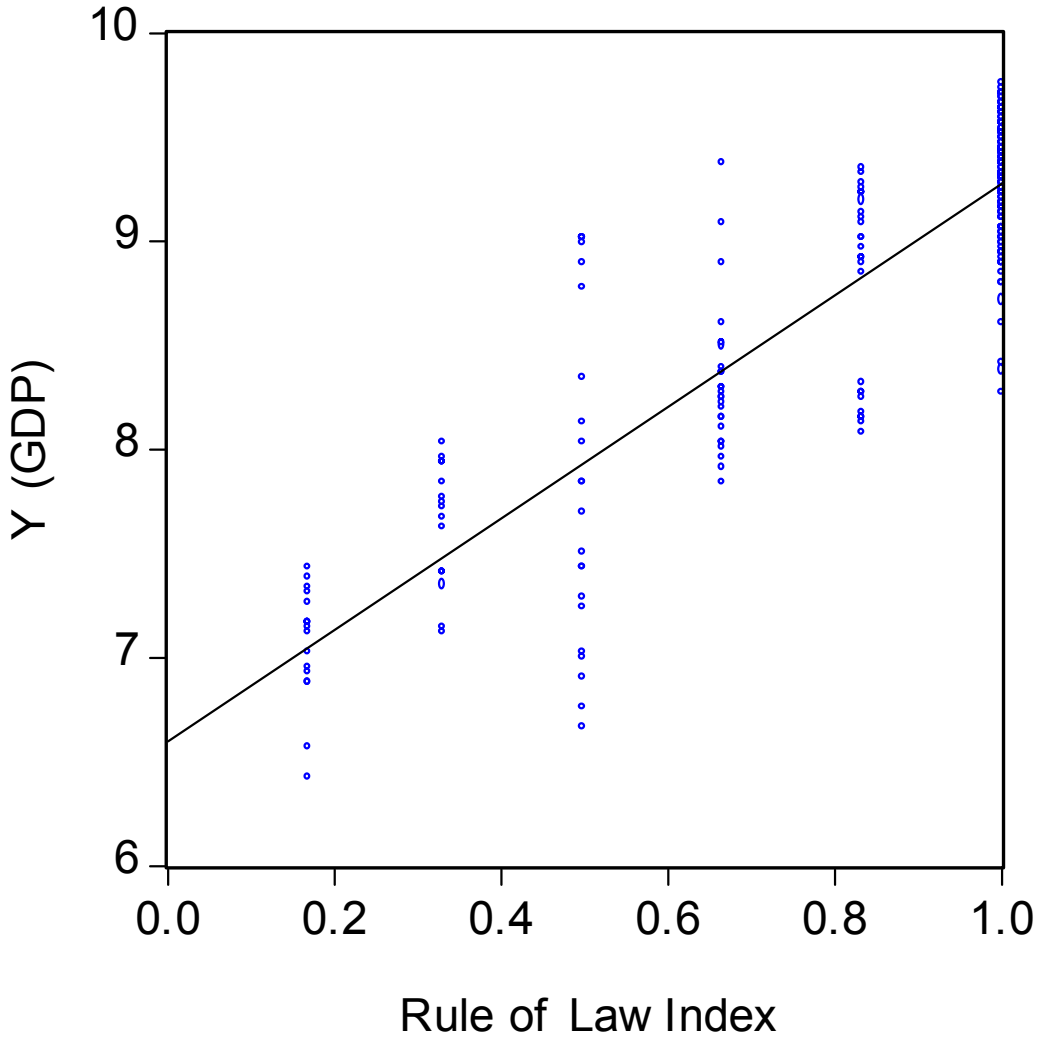
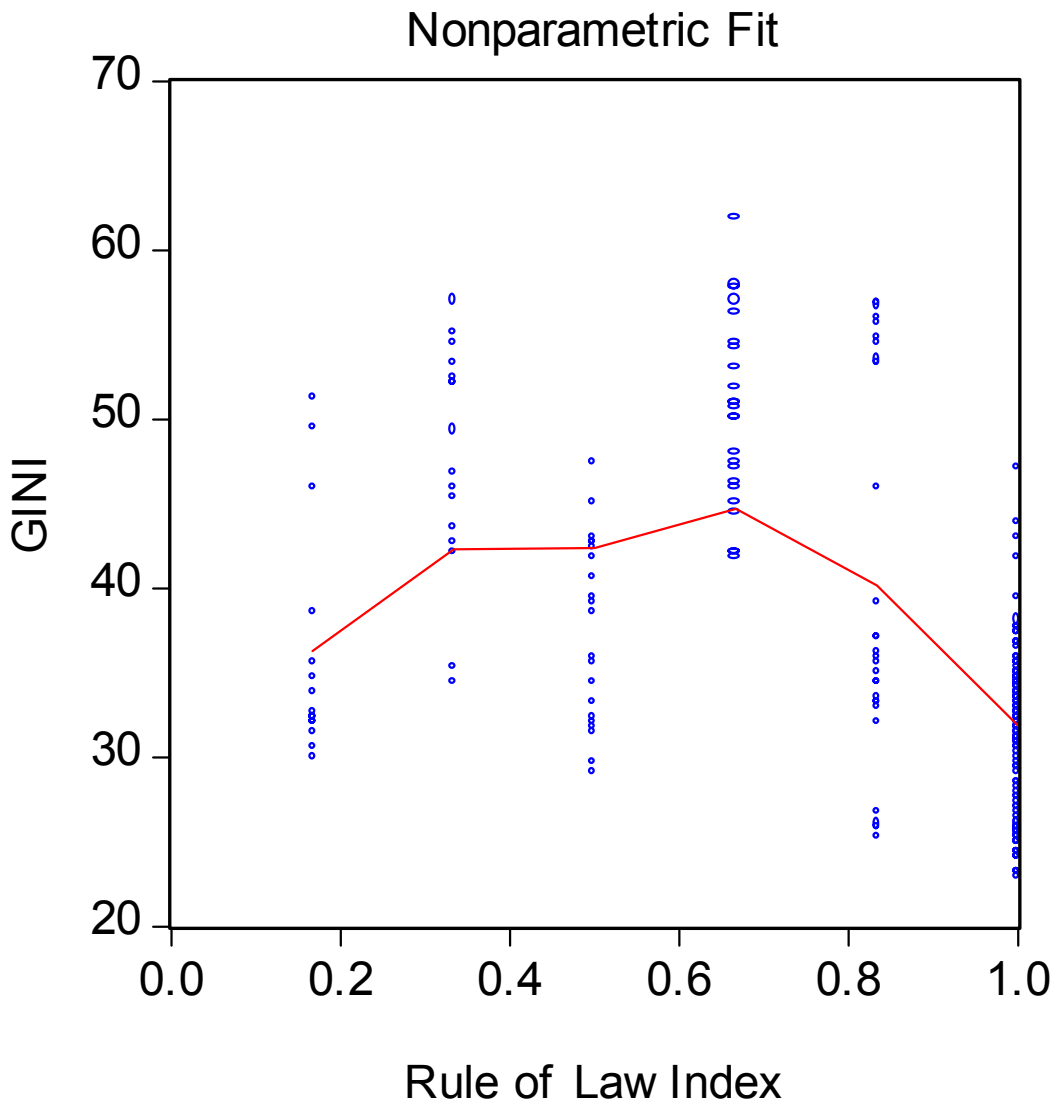


Figure 22


Nonparametric Fit
70
60
50
40
30
20
GINI
0.0
0.2
0.4
0.6
0.8
1.0
Rule of Law Index

Appendix D

Table 1

Independent Variable	Barro (2000) 3SLS	Forbes (2000) FE-GMM	Semi-Parametric FE-IV[1]	Semi-Parametric FE-IV[1]
log(per capita GDP)	0.101	-0.47	1.4246	1.4089
	(0.030)	(0.008)	(0.2757)	(0.2568)
log(per capita GDP) squared	-0.0081	---	-0.1149	-0.1139
	(0.0019)		(0.0161)	(0.0151)
Government consumption/GDP	-0.153	----	----	
	(0.027)			
Years of schooling	0.0066	---	----	
	(0.0017)			
Education completion rate	---	---	0.0005	
			(0.0005)	
Years of secondary education	---	---	----	
Years of higher education	---	---	----	
Years of male education	---	-0.008	----	
		(0.022)		
Years of female education	---	0.074	----	
		(0.018)		
log(total fertility rate)	-0.0303	---	0.0475	0.043
	(0.0054)		(0.0077)	(0.0076)
Growth rate of terms of trade	0.122	---	0.1332	0.1156
	(0.035)		(0.4522)	(0.4535)
Investment/GDP	0.062	---	---	
	(0.022)			
Inflation Rate	-0.014	---	-0.0023	-0.0023
	(0.009)		(0.0005)	(0.0004)

standard errors in parenthesis
1 - robust standard errors

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