CIRJE-F-910

On the Decomposition of Regional Stabilization and Redistribution

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December 2013

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Abstract

This study proposes decomposition and estimation methods that can be applied to analyze both regional stabilization and redistribution. The method proposed herein follows the approach taken by Shorrocks (1982), and applies it to per-capita level quantities of the relevant variables rather than the log-linear quantities used by Asdrubali et al. (1996) for regional stabilization and the normalized per-capita quantities used by Bayoumi and Masson (1995) for regional redistribution. I directly calculate the proportional contributions to the decomposition and bootstrap their confidence intervals rather than indirectly obtain them as OLS estimates from the artificial regressions by Asdrubali et al. (1996). I then apply the proposed method to Japanese prefectural accounts data so that we can compare the presented analysis with those in previous studies. Furthermore, I also apply the method to municipal budgetary data in Japan in order to demonstrate its usefulness.

Keywords: Regional stabilization; Regional redistribution; Regional transfers

JEL classification: E6; H7

[*] This study was financially supported by the Grant-in-Aid for Scientific Research (C-23530360) from the JPIS.

1. Introduction

Empirical studies of fiscal federalism have focused on estimating the degree of stabilization and redistribution among subnational regions. In particular, the seminal works of Asdrubali et al. (1996) (ASY hereafter) and Bayoumi and Masson (1995) (BM hereafter) put forward important frameworks on which subsequent studies based their analyses. Both ASY and BM explored the stabilization effect. Specifically, by focusing exclusively on the stabilization effect (or the "risk-sharing effect" in their terminology), the former decomposed it into components that are attributable to a distinct set of economic factors. The stabilization effect formulated by ASY thus represents the proportion of the variance in the growth rate of regional product that is smoothed by adjustments through multiple channels, which typically (but not exclusively) comprise the factor income market, fiscal system, and credit market. This finding shows that shocks to regional product are buffered through those channels before they reach regional consumption. The decomposition by ASY thus quantifies the contributions of these channels to the stabilization effect. Many studies have since adopted the ASY method in order to conduct analogous decompositions for different countries, including Canada (Balli et al. 2012), Sweden (Borge and Matsen 2004), Germany (Buettner 2002, Jüßen 2006, Hepp and von Hagen 2011, 2012), Japan (Doi 2000, Nakakuki and Fujiki 2006, Okabe 2011), China (Du and Rui 2011), Portugal (Ramos and Coimbra 2009), and the United States (Sorensen and Yosha 2000). This method has also been applied to different industrial sectors (Balli et al. 2013a, Demyanyk et al. 2007, Kalemli-Ozcan et al. 2003) and even to different groups of selected countries (Afonso and Furceri 2008, Balli et al. 2011, Balli and Balli 2011, Furceri 2010, Sorensen and Yosha 1998, Volosovych 2013).

Although unnoticed in the literature, the ASY decomposition is a special case of the inequality decomposition proposed by Shorrocks (1982), who considered the following setup. Let x_i be a quantity of a variable for entity i (i = 1, …, n) and x_i^k be its k-th component (k = 1, …, K) of $x_i = \sum_k x_i^k$. The distribution of x_i is thus given by $x = (x_1, \ldots, x_n)$. Shorrocks then showed that, under certain conditions, a variety of inequality indices, including variance var(x) and the square of the coefficient of variation cv(x) = var(x)/E(x) , is decomposed into the proportional contributions, cov(x, x^k)/var(x), such that

$$1=\sum_{k=1}^{K}\frac{\text{cov}(x,x^{k})}{\text{var}(x)}.^{1} \tag{1}$$

Given this decomposition, I highlight two issues that have thus far not been reported in the literature on regional stabilization. First, the ASY decomposition is asymmetrical. Symmetry refers to the independence of a proportional contribution of a given component x^k from any permutations of the whole set of components (x^1, …, x^K). As shown herein, when the order of selecting the channels of stabilization changes, the ASY method indeed yields different quantities, and even different definitions, for the proportional contributions because it fails to satisfy $x_i = \sum_k x_i^k$ with its use of log-transformed variables. Second, the ASY method does not yield what has been defined as the stabilization effect and its proportional contributions for the following reason. The k-th proportional contribution cov(x, x^k)/var(x) is an ordinary least squares (OLS) coefficient from an artificial regression of x^k on x. However, the literature estimates the coefficient by the feasible generalized least squares (FGLS) in order to allow for possible non-spherical errors, or even uses the generalized method of moments (GMM) to allow for endogeneity. Such estimates are therefore clearly different from what was originally defined as cov(x, x^k)/var(x).

However, while ASY studies have only examined regional stabilization, those that have applied the BM method have also considered the redistribution effect. Indeed, BM provided a simple regression analysis that examines how the distribution of long-term regional income changes after regional transfers. Moreover, although the majority of studies that have used the BM framework consider the redistribution effect along with the stabilization effect (Arachi et al. 2010, Decressin 2002, Hepp and von Hagen 2011, Mélitz and Zumer 2002), some authors have focused only on redistribution in specific sectors such as health care (Ferrario and Zanardi 2011) and education (Ferrario and Zanardi 2012). These previous studies have two limitations that must be considered, however. First, they postulate that regional redistribution is a long-run phenomenon and therefore utilize cross-section data on the time-series averages of un-differenced per-capita quantities that are normalized by their national averages. However, this approach simply means that the ratio of per-capita regional product to its national average does

[1] Since var(x) = $\sum_k$cov(x, x^k), the proportional contribution of x^k to var(x) is cov(x, x^k)/var(x) with 1 = $\sum_k$cov(x, x^k)/var(x). Likewise, the proportional contribution of x^k to cv(x)^2 is also cov(x, x^k)/var(x), as $[\text{cv}(x)]^2 = \{[\text{var}(x)]^{1/2}/\ \text{E}(x)\}^2 = \sum_k \text{cov}(x, x^k)/\text{E}(x)^2$ and $[\sum_k \text{cov}(x, x^k)/\text{E}(x)^2]/[\text{cv}(x)]^2 = \text{cov}(x, x^k)/\text{var}(x)$.

not change in the long run, which I argue would be implausible for the type of growth process usually assumed in the related literature. Furthermore, this definition of redistribution is restrictive compared with standard definitions (Boadway and Keen 2000). Second, this formulation of the redistribution effect is not amenable to decomposition. It is thus not so surprising that no studies have yet decomposed the redistribution effect estimated by using the MB method.

Against the background of these issues, this study proposes a decomposition as well as an estimation method that can be applied to analyze both regional stabilization and redistribution. In particular, I take advantage of the per-capita level quantities of the relevant variables rather than the log-linear quantities used by the ASY method to carry out the stabilization analysis, and the normalized per-capita quantities used by the BM method to conduct the regional redistribution analysis. Methodologically, the estimation method proposed herein is based on bootstrapping cov(x, x^k)/var(x), which is directly measured from the calculations of cov(x, x^k) and var(x), rather than indirectly obtained by estimating artificial regressions. This method thereby yields decomposed quantities of both the stabilization and the redistribution effects that are symmetric. In addition, such quantities are calculated as originally defined. I then examine Japanese prefectural accounts data in order to ensure that the presented analysis is comparable to the approaches taken by previous studies that utilize the ASY and/or BM methods. Finally, I apply the proposed method to Japanese municipal budgetary data in order to demonstrate its usefulness.

The remainder of this study is organized as follows. Section 2 describes regional stabilization and explains the potential difficulties faced by the ASY method. In particular, the asymmetry of the proportional contributions is demonstrated by using Japanese prefectural accounts data. I also conduct decompositions on regional stabilization. Section 3 examines regional redistribution. In this section, I summarize the BM analysis by explaining the assumptions behind their estimation model and decompose the regional redistribution effect, which is similar to the decomposition of the stabilization effect. Section 4 then applies the proposed methods to Japanese prefectural accounts data and municipal budgetary data. Section 5 concludes.

2. Regional stabilization

2.1. ASY decomposition

Economic accounting relates product (Y) to income (N), disposable income (D), and consumption (C) through the net outflow of factor incomes (O), net taxes (T), and net savings (S) such that $N \equiv Y - O$, $D \equiv N - T$, and $C \equiv D - S$. ASY utilized these relations to decompose the variance of the growth rate ($\Delta\ln Y$) into parts associated with the changes in O, T, S and C. In particular, ASY quantified the buffering effects of such components on isolating C from shocks to the growth rate. The method starts with the identity:

$$Y \equiv \frac{Y}{Y-O} \cdot \frac{N}{N-T} \cdot \frac{D}{D-S} \cdot C. \tag{2}$$

From (2), ASY obtained an expression:

$$\Delta \ln Y = \Delta \ln\left(\frac{Y}{Y-O}\right) + \Delta \ln\left(\frac{N}{N-T}\right) + \Delta \ln\left(\frac{D}{D-S}\right) + \Delta \ln C. \tag{3}$$

This equation shows that the growth rate is approximated as the sum of the changes in O/Y, T/N, and S/D since $\Delta\ln[x/(x-z)] \approx \Delta z/x$. ASY then showed from (3) that

$$\begin{aligned} 1 = &\frac{\operatorname{cov}\{\Delta \ln Y, \Delta \ln(Y/(Y-O))\}}{\operatorname{var}(\Delta \ln Y)} + \frac{\operatorname{cov}\{\Delta \ln Y, \Delta \ln(N/(N-T))\}}{\operatorname{var}(\Delta \ln Y)} \\ &+ \frac{\operatorname{cov}\{\Delta \ln Y, \Delta \ln(D/(D-S))\}}{\operatorname{var}(\Delta \ln Y)} + \frac{\operatorname{cov}\{\Delta \ln Y, \Delta \ln C\}}{\operatorname{var}(\Delta \ln Y)}. \end{aligned} \tag{4}$$

This equation turns out to be identical with the decomposition (3) by Shorrocks, if both sides of (4) are divided by var($\Delta\ln Y$). ASY then defined the stabilization effect as

$$\begin{aligned} \Psi &= 1 - \frac{\operatorname{cov}\{\Delta \ln Y, \Delta \ln C\}}{\operatorname{var}(\Delta \ln Y)} \\ &= \frac{\operatorname{cov}\{\Delta \ln Y, \Delta \ln[Y/(T-O)]\}}{\operatorname{var}(\Delta \ln Y)} + \frac{\operatorname{cov}\{\Delta \ln Y, \Delta \ln[N/(N-T)]\}}{\operatorname{var}(\Delta \ln Y)} \\ &\quad + \frac{\operatorname{cov}\{\Delta \ln Y, \Delta \ln[D/(D-S)]\}}{\operatorname{var}(\Delta \ln Y)}, \end{aligned} \tag{5}$$

which is obtained from (4) with the proportional contribution of consumption being subtracted from both sides. This equation shows that the stabilization effect Ψ is decomposed into the three proportional contributions of the factor market (O), fiscal system (T), and credit market (S). For example, assume a shock to $\Delta\ln Y$. If it is perfectly buffered before it reaches $\Delta\ln C$, we expect $\text{cov}\{\Delta\ln Y, \Delta\ln C\} = 0$. This is the case when the variations in $\Delta\ln Y$ are perfectly offset by the changes in the three $\Delta\ln[x/(x–z)]$ equations. In other words, shocks to regional product are dissipated before they reach consumption to the extent that these three components adjust in order to absorb such shocks.

2.2. Asymmetry

As noted in the Introduction, two issues regarding the quantification of the stabilization effect (5) have not been reported in the literature. The first of these issues concerns the order of the items (O, T, S) in (3). Note that each of the proportional contributions in (5) takes a different value as the order of the three items that appears in (5) changes. Hence, while their combined value (Ψ) remains the same, the proportional contributions are not 'symmetric.' The ASY decomposition thus fails to satisfy one of the properties, i.e., symmetry, that Shorrocks argued is important when decomposing an index. For example, consider a case of a different order ($T \to S \to O$) with,

$$Y \equiv \frac{Y}{Y-T} \cdot \frac{Y-T}{(Y-T)-S} \cdot \frac{Y-T-S}{(Y-T-S)-O} \cdot C,$$

which then yields the following decomposition of the stabilization effect:

$$\Psi_1 = \frac{\text{cov}\{\Delta\ln Y, \Delta\ln[Y/(Y-T)]\}}{\text{var}(\Delta\ln Y)} + \frac{\text{cov}\{\Delta\ln Y, \Delta\ln[(Y-T)/((Y-T)-S)]\}}{\text{var}(\Delta\ln Y)}$$
$$+ \frac{\text{cov}\{\Delta\ln Y, \Delta\ln[(Y-T-S)/((Y-T-S)-O)]\}}{\text{var}(\Delta\ln Y)}.$$

Note that the first, second, and third contributions are the effects of the fiscal system (T), credit market (S), and factor income market (O), respectively. These contributions are not generally identical to those in (5), while the stabilization effect remains the same, namely $\Psi = \Psi_1$. Further, for this three-component case, there are six sets of decomposed effects based on the following six permutations: $\{(O \to T \to S), (O \to S \to T), (T \to O \to S), (T \to S \to O), (S \to T \to D), (S \to O \to T)\}$.

Nonetheless, although the ASY decomposition clearly does not satisfy the property of symmetry, we might argue that these different orders are unsuitable since the economic accounting process runs according to the manner in which it appears in (2).

After production (Y), people receive their income (N). Once their income is determined, the level of taxation is also determined. Thereafter, people are left with their disposable income (D), on which they decide how much they save (S) and how much they consume (C).

Compelling arguments that dictate the order among the components rarely exist. For example, if Y is *gross* product, we need to add a phase for depreciation in order to yield net quantities. Most studies deduct depreciation from gross product to obtain net product (Sorensen and Yosha 1998, Doi 2000, Alfonso and Furceri 2008, Furceri 2010, Balli and Balli 2011, Balli et al. 2013b). However, we could alternatively deduct depreciation from gross income in order to yield net income, after subtracting net factor income outflow from gross product. Furthermore, the proportional contribution from the fiscal system is often disaggregated into its subcomponents. For example, the US study by ASY decomposed net (federal) taxes into federal direct taxes, unemployment benefits, other federal direct transfers, grants to states, unemployment insurance contributions, corporate income taxes, social security contributions, and other excise taxes. Hepp and von Hagen (2011) also disaggregated net taxes into a set of transfers and taxes at different levels of government in their study of Germany. Moreover, by using cross-country data, Balli et al. (2011) decomposed the net inflow of factor income ($= -O$) into net foreign assets income, net compensation of employees from abroad, and net tax on imports. Doi (2000) similarly decomposed the net inflow of factor income into those of capital income and labor income in his study of Japan. Again, there are no compelling arguments that dictate the order among these components.

2.3. Artificial regressions or data-generating process?

The second issue concerns the way in which we quantify the proportional contributions in (4). While we can obtain them by directly calculating $\text{cov}\{\Delta\ln Y, \Delta\ln[x/(x-z)]\}$, and $\text{var}(\Delta\ln Y)$ for $z = O$, T, and S, we can also do so from a linear regression $\Delta\ln[x/(x-z)] = \alpha + \beta\cdot\Delta\ln Y + u_z$. Note that this is an *artificial regression* whose sole purpose is to obtain $\beta_{OLS} = \text{cov}\{\Delta\ln Y, \Delta\ln[x/(x-z)]\}/\text{var}(\Delta\ln Y)$. Furthermore, the estimator has to be OLS in order to obtain what is defined as in (5). However, the majority of previous studies follow ASY by opting to use FGLS estimates.[2] Some studies even perform an IV estimation (Furceri 2010), which implies that these authors regard what is supposed to be an artificial regression as a data-generating process for the observations of $\Delta\ln[x/(x-z)]$. It is then understandable that they concern non-spherical errors to use FGLS and endogeneity to use IV.[3]

However, neither FGLS nor IV yields the proportional contributions that are defined as in (4), since these estimates are not generally identical to β_{OLS}. For example, recall that the generalized least squares (GLS) estimator is $(\mathbf{X}_z'\mathbf{\Omega}_z^{-1}\mathbf{X}_z)^{-1}\mathbf{X}_z'\mathbf{\Omega}_z^{-1}\mathbf{y}$, where $\mathbf{y}$ is the vector of the dependent variable ($\Delta\ln Y$), $\mathbf{X}_z$ is the matrix of the explanatory variables with two-element row vectors $\{1, \Delta\ln[x/(x-z)]\}$, and $\mathbf{\Omega}_z$ is the variance-covariance matrix for the error term (u_z). If $\mathbf{\Omega}_z$ is unknown but consistently estimated, the estimator is FGLS. Since FGLS estimates are obtained as OLS estimates by regressing $\boldsymbol{\eta}_z'\mathbf{y}$ on $\boldsymbol{\eta}_z'\mathbf{X}_z$, where $\boldsymbol{\eta}_z$ is such that $\boldsymbol{\eta}_z'\boldsymbol{\eta}_z \equiv \mathbf{\Omega}_z^{-1}$, then the FGLS estimate is $\beta_{FGLS} = \mathrm{cov}(y_z, h_z)/\mathrm{var}(y_z)$, where y_z and h_z are the elements of $\boldsymbol{\eta}_z'\mathbf{y}$ and the second column in $\boldsymbol{\eta}_z'\mathbf{X}_z$, respectively. Of course, β_{FGLS} is not generally identical to β_{OLS}.[4] On a related note, when estimated by using non-OLS methods, the estimates for βs do not always add up to unity, meaning that the equality between the first and the other lines in (5) does not always hold.[5]

2.4. Alternative decomposition: variables in level

Since the failure of symmetry originates in the use of the log-differenced variables, I instead propose using unlogged per-capita level variables, which makes the decomposition consistent with the setup presented by Shorrocks (1983). Since $\Delta Y = \Delta C + \Delta O + \Delta T + \Delta S$, (1) allows us to obtain another index of the stabilization effect:

$$\psi = 1 - \frac{\mathrm{cov}(\Delta Y, \Delta C)}{\mathrm{var}(\Delta Y)} = \frac{\mathrm{cov}(\Delta Y, \Delta O)}{\mathrm{var}(\Delta Y)} + \frac{\mathrm{cov}(\Delta Y, \Delta T)}{\mathrm{var}(\Delta Y)} + \frac{\mathrm{cov}(\Delta Y, \Delta S)}{\mathrm{var}(\Delta Y)}. \qquad (6)$$

[2] One exception is Hepp and von Hagen (2012). While also conducting FGLS estimation, Borge and Matsen (2004) based their argument on OLS results.

[3] The dependent variable $\Delta\ln[x/(x-z)]$ should contain those factors that affect the explanatory variable $\Delta\ln Y$, since they are related as components in economic accounting. Furthermore, it is likely that the model may miss variables that both affect $\Delta\ln[x/(x-z)]$ and correlate with $\Delta\ln Y$.

[4] The case against the system GMM is also similarly made given the formula of its estimator.

[5] This was briefly pointed out by Furceri (2010, footnote 9).

The interpretation of (6) is similar to that of (5). Assume that a shock occurs to ΔY, which is then reflected in var(ΔY). If the shock is perfectly offset by the changes in ΔO, ΔT, and ΔS, C would not co-move with Y, namely cov(ΔY, ΔC) = 0. This new index ψ is again decomposed into three contributions that are attributable to the factor market (O), fiscal system (T), and credit market (S). More importantly, however, this index is symmetric.

There are a number of arguments against using level as in (6) in favor of using log as in (5). First, macroeconomic variables such as gross product and consumption are often discussed in percentage terms. Theoretically, economic models often take advantage of isoelastic functions which, along with other assumptions, yield log-linear behavioral equations. Econometrically, the log-transformation is likely to make the variables amenable to the classic assumptions of homoscedasticity and the normal distribution (Mayr and Ulbricht 2007).[6] However, according to Stock and Watson (2011), when choosing between variables in log or level, we should examine whether it makes sense to use them in a particular application. For instance, it may not be sensible to log-transform the variables in the current case because this approach makes the decomposition asymmetric. Furthermore, macroeconomic variables in level are also appropriate in certain circumstance; for example, we may be interested in understanding how much income has increased this year compared with the previous year. In addition, in terms of econometric concerns, the classical assumption may not necessarily be a prerequisite given the recent development of statistical methods.

Second, equation (6) could remove the effect of aggregate shocks. Indeed, another stream of studies of regional stabilization measures the stabilization effect by using coefficient θ from the regression $\Delta c = \theta_0 + \theta \cdot \Delta y + \varepsilon$, where c and y represent consumption and regional product (Bayoumi and Masson 1995, Mélitz and Zumer 2002, Decressin 2002, Arachi et al. 2010, Hepp and von Hagen 2011). In particular, these authors normalize the variables with their national averages in order to eliminate aggregate shocks. However, this normalization may become redundant if we only use cross-section data. Assume that a change in per-capita product is the sum of asymmetric shock ε_{it}^{Y} and aggregate shock τ_t^{Y} ($\Delta Y = \varepsilon_{it}^{Y} + \tau_t^{Y}$). Since ε_{it}^{Y} and τ_t^{Y} are orthogonal, $\mathrm{var}(\Delta Y) = \mathrm{var}(\varepsilon_{it}^{Y}) + \mathrm{var}(\tau_t^{Y})$. In addition, as the aggregate effect is conceived as a

[6] For more on log vs. linear variables, see Ermini and Hendry (2008) and Spanos et al. (2008).

constant (i.e., var(τ_t^Y) = 0) when we examine the year-on-year changes in (6) by using a cross section of regions, we obtain var(ΔY) = var(ε_{it}^Y). In addition, cov(ε_{it}^Y, τ_t^X) = cov(ε_{it}^X, τ_t^Y) = var(τ_t^Y) = var(τ_t^X) = 0 based on cross-section data in a given year. It then follows that cov(ΔY, ΔX) = cov(ε_{it}^Y, ε_{it}^X), where X = O, T, S, and C, showing that (6) is unaffected by the presence of aggregate shocks.

2.5. Estimation method: bootstrapping

If we regard the artificial regression as a DGP, we must then investigate the possible bias in the estimation due to non-spherical errors and/or endogeneity. However, the definition in (6) only presumes the existence of covariance and variance for the set of variables (ΔY, ΔC, ΔO, ΔT, ΔS). Without the knowledge of the specific stochastic processes for these variables, we can simply calculate the sample equivalents for their covariance and variance. However, with this direct calculation, we may not easily obtain an analytical formula of the standard errors for the proportional contributions. By contrast, we can obtain the standard errors of the proportional contributions from the ASY analysis by estimating the artificial regressions. However, we are not sure if its standard errors are appropriate.

I aim to overcome this problem by using the bootstrapping method, a resampling procedure that substitutes the traditional inference based on asymptotic theory. There are two advantages to using the bootstrap for the current analysis. First, since it does not require distributional assumptions, it can reduce bias in inferences when the data are not well behaved and/or when the sample size is small. Second, the bootstrap could yield sampling distributions that are difficult to derive analytically. Given that our statistics are the ratio of the covariance and the variance for the variables whose distributions are unknown, these two advantages thereby allow us to overcome the issues facing our estimation.

2.6. Stabilization: The case of Japanese prefectures

In order to extend previous studies and contribute to the body of knowledge on this topic, I decompose the stabilization effect based on the level-differenced variables and obtain the estimates by bootstrapping the three proportional contributions to the stabilization effect. The data used are derived from the Prefectural Accounts compiled by the Economic and Social Research Institute of the Cabinet Office. Apart from Tokyo, these data have all the necessary economic accounting items for this analysis. Tokyo data are derived from the Tokyo Regional Accounts compiled by the Statistics Division Bureau of the Tokyo Metropolitan Government. All variables are in per-capita terms and deflated by 2000 prices. The data span from FY2001 to FY2009.

In addition to (6) in level, I also calculate (5) for the six cases on an annual basis. Since the difference drops the first observation, the results start in FY2002. Note that I ignore the effect of depreciation by starting with net product in order to make the analysis comparable with previous studies in Japan and minimize the number of log-decomposition cases.

The eight panels in **Figure 1** verify the asymmetry problem in the ASY decomposition and highlight the noticeable differences among the six cases. First, the direction of the fiscal effect is different for FY2002, FY2004, FY2006, and FY2007. Specifically, it is destabilizing for three cases in FY2002 and FY2004 and for two cases in FY2006 and FY2007. Second, the relative sizes of the three channels in a given year are also different in FY2006 and FY2007. In FY2006, the fiscal effect is larger than the factor income effect in Cases 1, 3, and 4, while the opposite is true in the other cases. In FY2007, the fiscal effect is larger than the factor income effect in Case 1. The panels in **Figure 1** also list the decomposed effects based on (6) on the far right. The relative sizes of the three effects in level are similar to those in log. However, the factor market effects in level tend to be larger than or equal to the other six effects in log. In addition, the fiscal effects are smaller in level than they are in log.

Figure 1

Figure 2 shows the changes in the stabilization effect from FY2002 to FY2009, while the panels in **Figure 3** list each of the three effects along with the three types of bootstrapped 95% confidence intervals: normal intervals calculated by using the bootstrapped standard errors, percentile intervals, and bias-corrected intervals. The number of replications is 100,000. From **Figure 2** and the panels in **Figure 3**, we can draw the following four main findings. First, the total stabilization effect is rather large and relatively volatile over time, ranging from 0.793 to 1.000. Second, the credit market contributes the most to the stabilization effect, with the ratios ranging from 0.672 to 0.846. Third, the fiscal system contributes the least and can even be considered to be destabilizing as it has negative values in FY2001–2004 and FY2006–2007, although these volumes were small or even almost nil. Nonetheless, its contribution was relatively large in FY2005 and its effects became noticeable during FY2008–2009 because of the massive fiscal expansion that occurred in the aftermath of the Lehman Brothers bankruptcy. Fourth, the effects of the factor income market are relatively small and almost nil in FY2003.

In summary, regional consumption in Japan was smoothed mainly through saving and borrowing in the credit market. The effects of the fiscal system were negligible and only became noticeable towards the end of the 2000s. We also note that the three types of confidence intervals are almost the same in all three panels in **Figure 3**.

Figures 2 and 3

3. Regional redistribution

3.1. BM measure

As noted earlier, BM provided a framework within which to measure the degree of regional redistribution and this was subsequently adopted by a series of studies (e.g., Decressin 2002, Mélitz and Zumer 2002, Arachi et al. 2010, Ferrario and Zanardi 2011, Hepp and von Hagen 2011). The BM method utilizes a cross section of the period average of un-differenced annual per-capita variables. It further normalizes the variables by using their national averages in order to control the aggregate shock, as in the case for the stabilization analysis. The regression model is typically specified as $x_i^A = \rho_0 + \rho \cdot x_i^B + e_i$, where $x_i^j = \sum_t (X_{it}^j / X_t^j)/T$, $j = B$, and A refers to the variables before and after redistribution. Further, the variables without a subscript i are national averages, T is the number of years in the sample, and e is the error term. The redistribution effect is $1 - \rho$ where $\rho = \mathrm{cov}(x_i^A, x_i^B)/\mathrm{var}(x_i^A)$ when the model is estimated by using OLS.

3.2. A redistribution measure and its decomposition

The BM analysis does not decompose the redistribution effect $1 - \mathrm{cov}(x_i^A, x_i^B)/\mathrm{var}(x_i^A)$ as the ASY analysis does for the stabilization effect because x_i^A and x_i^B are normalized by using different values (i.e., their respective national averages), which automatically violates the conditions for decomposition set out by Shorrocks (1982). Therefore, I propose a measure of the redistribution effect that while similar to the BM measure uses the un-normalized variables 1 − cov(Y, C)/var(Y). This definition again raises the issue of aggregate shocks. However, since this measure uses a cross section of per-capita quantity data, as was the case for the stabilization effect, it also allows for aggregate shocks. This can be shown by assuming that the un-normalized per-capita variable is the sum of an asymmetric element ξ_{it}^{X} and an aggregate element θ_t^X for $X = Y$, O, T, S, C: $X = \xi_{it}^{X} + \theta_t^X$. The logic used for the stabilization effect again shows that aggregate shocks are controlled when analyzed by using a cross section of regional data.

Given the definition above, the redistribution effect is decomposed in exactly the same way as the stabilization effect is. With $Y \equiv C + O + T + S$, (1) again allows us to obtain the following:

$$\phi = 1 - \frac{\mathrm{cov}(Y, C)}{\mathrm{var}(Y)} = \frac{\mathrm{cov}(Y, O)}{\mathrm{var}(Y)} + \frac{\mathrm{cov}(Y, T)}{\mathrm{var}(Y)} + \frac{\mathrm{cov}(Y, S)}{\mathrm{var}(Y)}. \qquad (7)$$

This equation represents a straightforward application of Shorrocks' inequality decomposition. The interpretation of (7) is also similar to that of the stabilization effect. Assume that there is a wide spread in Y, which is reflected in either var(Y) or var(Y)/[E(Y)]^2. If the three variables (O, T, S) take values that offset the dispersion of Y, the association between C and Y would be smaller. In particular, if redistribution through the three channels is perfect, the consumption level would be unrelated to the production level, cov(Y, C) = 0, making the redistribution effect perfect, namely $\phi = 1$. This then shows that, as is the case for the stabilization effect, the redistribution effect is decomposable into parts that are attributed to the income factor market (O), fiscal system (T), and credit market (S). This particular decomposition indeed satisfies the conditions that Shorrocks set out, including symmetry.

3.3. Redistribution as a long-run property?

The BM analysis typically postulates that redistribution is a permanent (or long-run) cross-sectional property. To allow for this characterization, the literature utilizes a single cross-section regression that uses relevant variables averaged over the longest period for which their data are available. By construction, therefore, the redistribution effect is conceptualized as an effect that does not change over time.

While this conceptualization has been well received in the literature, I offer the following alternative view. I use a cross section of single year data in order to measure the regional redistribution effect and examine year-on-year changes in the effect as well as in its components. This may be justified on the following grounds. First, the long-term conceptualization is empirically implausible if we use per-capita level variables. If I continue to use the decomposition $X_{it} = \xi_{it}^X + \theta_t^X$, the long-term view implies that the asymmetric part ξ_{it}^X is further decomposed into a permanent element α_i^X and a transitory element μ_{it}^X so that $X_{it} = \alpha_i^X + \mu_{it}^X + \theta_t^X$. For example, consider regional product Y_{it}. If the period average of Y_{it} approaches the permanent element α_i^Y as the length of period T becomes larger, it follows that $T^{-1}\sum_t \mu_{it}^X \rightarrow 0$ and $T^{-1}\sum_t \theta_t^X \rightarrow 0$ as $T \rightarrow \infty$. In other words, regional product is assumed not to grow in the long-term. This argument also applies partially to the original use of the variables in the BM analysis. If we use the variables normalized with their national averages, we must assume that the ratio of per-capita product to its national average is constant in the long run. However, the findings by recent studies on regional growth and agglomeration suggest this to be implausible.

Second, the long-term concept of redistribution may not be relevant for policymakers. For example, Lambert (2001) defined redistribution as the movement from an old distribution of income to a new one based on an equalization effect, while Boadway and Keen (2000) used the term simply to characterize an unrequited transfer of resources from one to another. Clearly, these definitions do not necessarily require redistribution to be a long-term concept. Furthermore, the inequality decomposition proposed by Shorrocks (1982) should not exclude these definitions of redistribution. In fact, we can measure the effect of a particular redistributive policy by using flow data in a particular year or examining its changes over time.

3.4. Redistribution: The case of Japanese prefectures

In this paper, I measure the redistribution effect by estimating its proportional contributions as in (7). As with the stabilization effect described in Section 2, the estimates are obtained by directly calculating the variance and covariance of the relevant variables and by bootstrapping the proportional contributions. All variables are again in per-capita terms and deflated by 2000 prices, while the data span from FY2002 to FY2009.

Figure 4 shows the changes in the redistribution effect from FY2002 to FY2009, with the proportional contributions from the three channels, while **Figure 5** illustrates each of the contributions with 95% confidence intervals. I bootstrap three types of confidence intervals as before: normal intervals calculated with bootstrapped standard errors, percentile intervals, and bias-corrected intervals. The number of replications is again 100,000. **Figure 4** shows that the total redistribution effect is smaller than the stabilization effect (largest value 0.699), and relatively stable over time (0.641–0.699). The factor income market contributes most to regional redistribution in FY2002–2004 and FY2008–2009, while the credit market does so in FY2003–2007. However, the two decomposed effects are similar in the latter period. The contributions from the fiscal system are always smallest, ranging from 0.121 to 0.203. Further, while the stabilization effect of the fiscal system became noticeable after FY2008, its redistribution effect started to decline in the same period (see Panel B of **Figure 5**).

Given the massive fiscal expansion from FY2008, the recession triggered by the Lehman Brothers bankruptcy may have diminished regional disparities so severely that even this expansion could not counteract the adverse effects. Moreover, while the three types of confidence intervals are similar for the stabilization effect (**Figure 3**), the confidence intervals calculated by using the bootstrapped standard errors are different from the other two in all three panels in **Figure 5**. This finding implies that the covariance-variance ratios for the un-differenced level variables are distributed asymmetrically around the estimated values.

Figures 4 and 5

4. Examples based on municipal budgetary data

4.1. Studies of revenue stabilization and fiscal disparities

The analysis of regional stabilization and redistribution is not limited to economic accounts data. In particular, we can apply the presented analysis to public sector budgetary data in order to shed light on two important policy questions. First, in terms of budget stabilization, volatile tax revenues can prevent governments from effectively planning and sticking to their budgets, although they could borrow and lend to offset such adverse effects. In the short run, an unexpected drop in revenues may inhibit the day-to-day provision of public services. In the longer term, governments typically adopt some form of long-term fiscal target such as achieving primary balance or addressing future expenditure increases caused by the ageing population. Second, in terms of budget redistribution, the equalization (i.e., redistribution) of subnational revenues has been crucial for managing fiscal federalism in many countries, where subnational governments often expect central transfers to mitigate their revenue disparities. Thus, one of the key concerns when designing a system of regional transfers should be its effect on regional revenue disparities.

Given these policy concerns, stabilization and redistribution studies have focused on budgetary data at the subnational government level. For example, Hepp and von Hagen (2011) applied the ASY and BM analysis, as reformulated by Melitz and Zumer (2002), to the tax revenues of *Länders* in Germany. Although using different methods, Boothe (2002), Boadway and Hayashi (2004), and Smart (2004) also utilized provincial budgetary data in order to explore the stabilization effect of Equalization programs in Canada. In addition, a number of studies analyze regional fiscal disparities in various countries (Razin 1998, Tannenwald 1999, 2002, Yu and Tsui 2005, Martinez-Vazquez and Timofeev 2008, Zhao and Hou 2008, Heng 2008, Zhao 2009, Fan et al. 2011, Kyriacou et al. 2013) and explore the effects of interregional redistribution (Tsui 2005, Huang and Chen 2012, Kyriacou and Roca-Sagalés 2013).

4.2. Sample and data

The data considered herein are revenues for 1,746 municipalities in FY2007–2011. This sample excludes a relatively small number of municipalities that merged during the period. All data are drawn from the Annual Report on Municipal Accounts by the Japanese Ministry of Internal Affairs and Communication. Since there are too many accounting items in the municipal accounts to be reasonably handled, I aggregate them into six revenue categories: own revenues (T), Local Allocation Tax (LAT) grants (G_L), categorical grants (G_C), other types of grants (G_O), net borrowing (B), and other non-own revenues (O). Own revenues (T) are the sum of local taxes and other own revenues such as fees and charges. All variables are expressed in per-capita terms. LAT grants (G_L) are the primary general grants disbursed to local governments, while categorical grants (G_C) refer to the combined amount of the Central Government Subsidies and the Prefectural Government Subsidies, both of which are matching and categorical.

4.3. Revenue stabilization

The analysis of revenue stabilization is based on the following identity:

$$E = G_L + G_C + G_O + B + O + T$$

where E is per-capita expenditure. We obtain the stabilization effect and its proportional contributions as

$$\begin{aligned}\psi_R &= 1 - \frac{\operatorname{cov}(\Delta E, \Delta T)}{\operatorname{var}(\Delta E)} \\ &= \frac{\operatorname{cov}(\Delta E, \Delta G_L)}{\operatorname{var}(\Delta E)} + \frac{\operatorname{cov}(\Delta E, \Delta G_C)}{\operatorname{var}(\Delta E)} + \frac{\operatorname{cov}(\Delta E, \Delta G_O)}{\operatorname{var}(\Delta E)} + \frac{\operatorname{cov}(\Delta E, \Delta B)}{\operatorname{var}(\Delta E)} + \frac{\operatorname{cov}(\Delta E, \Delta O)}{\operatorname{var}(\Delta E)}.\end{aligned} \tag{8}$$

Here, by assuming that shocks occur to expenditure (E), we are interested in how each of the four revenue items other than T adjusts in response to shocks in order to ensure that municipal governments do not have to increase their own burdens T to balance their budgets.

Figure 6 and **Figure 7** list (8) and its proportional contributions for FY2008 to FY2009. The panels in **Figure 7** illustrate each of the five proportional contributions separately with the three types of bootstrapped 95% confidence intervals. The number of replications is again 100,000. Their results can be summarized as follows. First, the total stabilization effect is almost perfect, ranging from 0.972 to 1.009 for the four fiscal years, although the effect for FY2011 is slightly destabilizing. Second, the effect of LAT grants is rather small for the latter three years (below 5%). Third, categorical grants and net borrowing switch their relative sizes after 2009, with the former losing importance (0.457 $\rightarrow$ 0.500 $\rightarrow$ 0.144 $\rightarrow$ 0.062) and the latter gaining in terms of its relative effects (0.281 $\rightarrow$ 0.401 $\rightarrow$ 0.794 $\rightarrow$ 0.821). The change in the effects of categorical grants in FY2010 and afterwards is indeed outstanding, reflecting the alteration of regional transfer policy following the advent of a new national ruling party in 2009.

Figures 6 and 7

4.3. Revenue redistribution

Revenue redistribution is based on the following identity:

$$R = G_L + G_C + G_O + B + O + T$$

where R (= E) is total revenue and all variables are in per-capita values. Note that if there are no intergovernmental transfers ($G_L = G_C = G_O = 0$), net borrowing ($B = 0$), or other non-own revenues, all local expenditure is incurred by local residents through T. The redistribution effect and its proportional contributions are thus

$$\begin{aligned} \Psi_R &= 1 - \frac{\mathrm{cov}(T,R)}{\mathrm{var}(T)} \\ &= \frac{\mathrm{cov}(T,G_L)}{\mathrm{var}(T)} + \frac{\mathrm{cov}(T,G_C)}{\mathrm{var}(T)} + \frac{\mathrm{cov}(T,G_O)}{\mathrm{var}(T)} + \frac{\mathrm{cov}(T,B)}{\mathrm{var}(T)} + \frac{\mathrm{cov}(T,O)}{\mathrm{var}(T)}. \end{aligned} \tag{9}$$

We are interested in how the dispersion of the distribution of revenues, say, in terms of variance or the squared coefficient of variations, changes as the three items of intergovernmental grants (G_L, G_C, G_O) and the items of net borrowing (B) and other non-own revenues add to own revenue (T).

Figure 8 and the panels in **Figure 9** calculate (9) and each of its components for FY2008 to FY2009. As before, these panels list each of the five proportional contributions separately with the three types of bootstrapped 95% confidence intervals. The number of replications is again 100,000. The results can be summarized as follows. First, as before, the total redistribution effect is almost perfect (0.980–0.987 over the four years). Second, the effect of LAT grants is the largest except in FY2010 when categorical grants have the largest effect. Third, both the LAT and the categorical grants share a substantial proportion of the redistribution effect (0.781–0.867). Fourth, net borrowing leads to a redistribution effect. This finding is unexpected because we might have expected negative correlations between own revenues and net borrowing since municipalities that have larger tax bases might find it easier to issue municipal bonds.

Figures 8 and 9

5. Concluding remarks

In this paper, I proposed decomposition and estimation methods that can be applied in order to analyze both regional stabilization and redistribution. The decomposition was drawn from the work presented by Shorrocks (1982), although I used per-capita level quantities of the relevant variables rather than the log-linear quantities of the ASY method for regional stabilization and the normalized per-capita quantities of the BM method for regional redistribution. The presented estimation was also based on bootstrapping the proportional contributions whose elements (i.e., variance and covariance) were directly calculated rather than indirectly obtained through artificial regressions. The proposed decomposition yielded the proportional contributions for both the stabilization and the redistribution effects that satisfied the conditions set out by Shorrocks. In the next step, I then analyzed Japanese prefectural accounts data in order to make the presented estimation comparable with those of previous studies that utilize the ASY and/or BM methods. Furthermore, I also applied the method to Japanese municipal budgetary data in order to demonstrate its usefulness.

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Figure 1. The order effects and decompositions

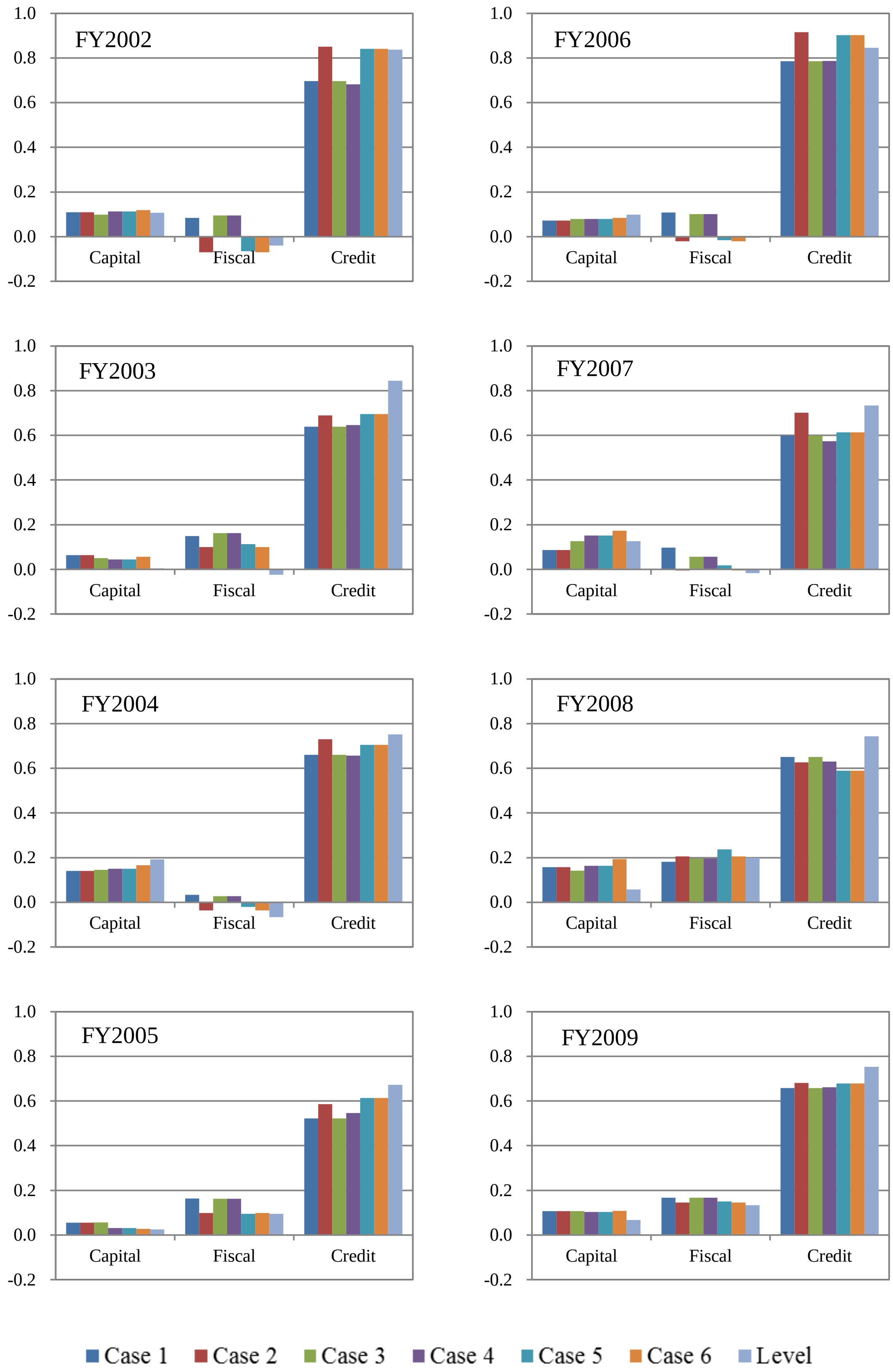

Figure 2. Trends of the stabilization effect

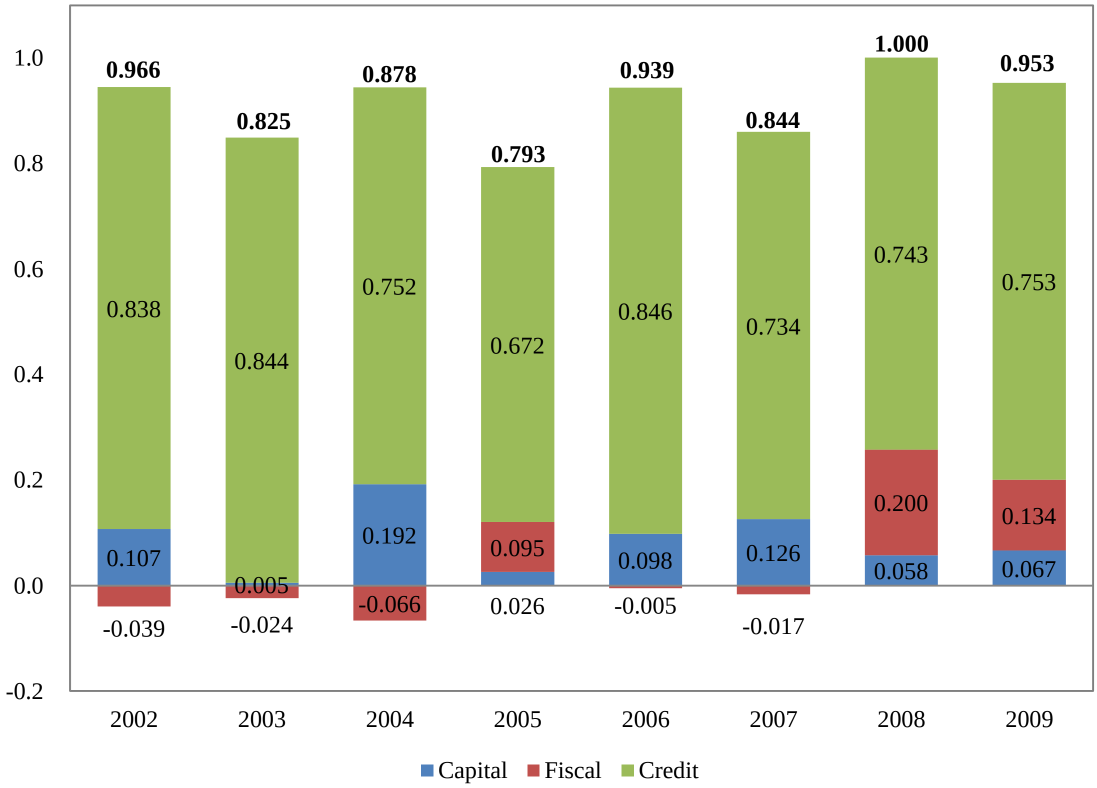

Figure 3. Bootstrapped confidence intervals

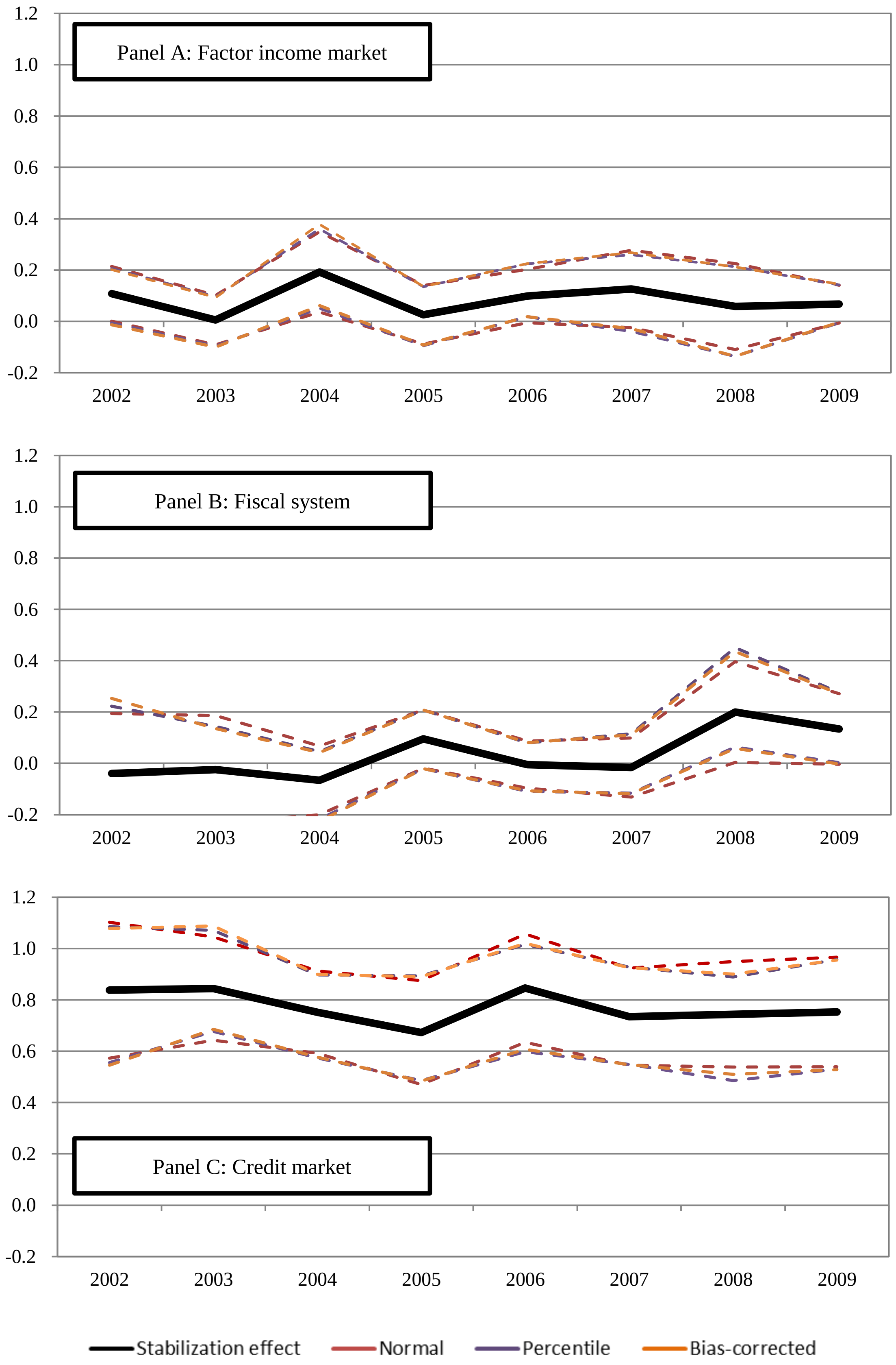

Figure 4. Trends of the redistribution effect

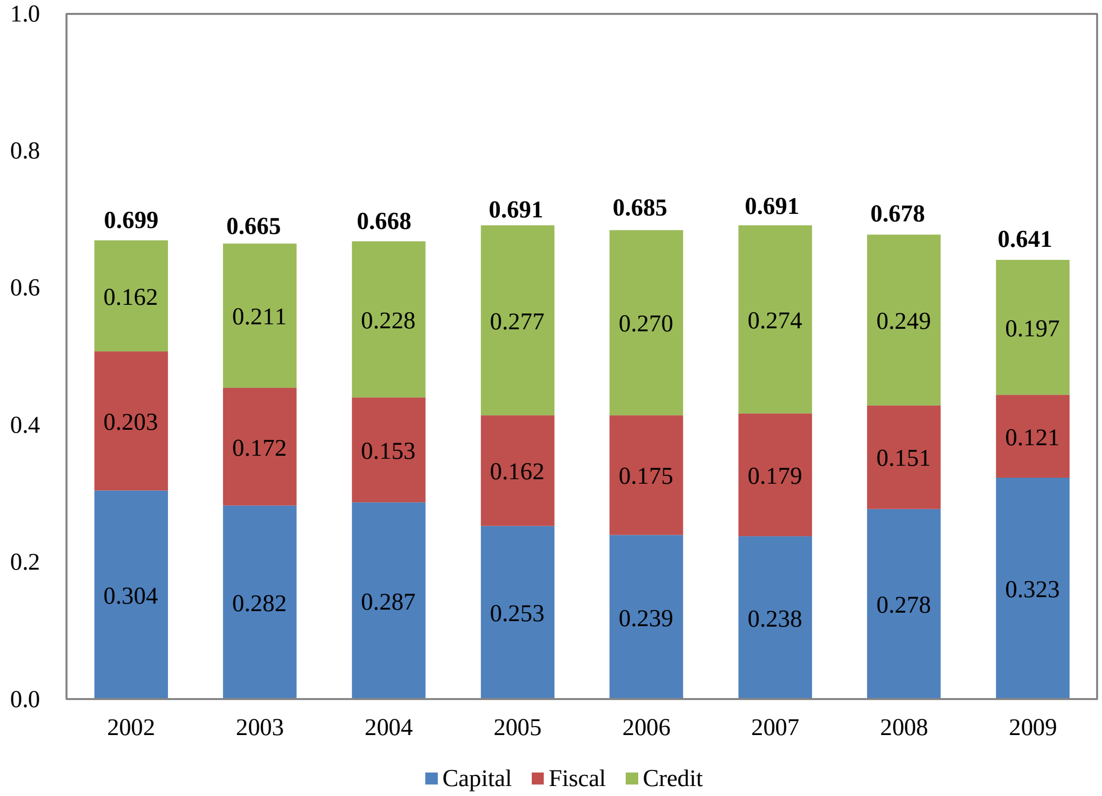

Figure 3. Bootstrapped confidence intervals for the redistribution effect

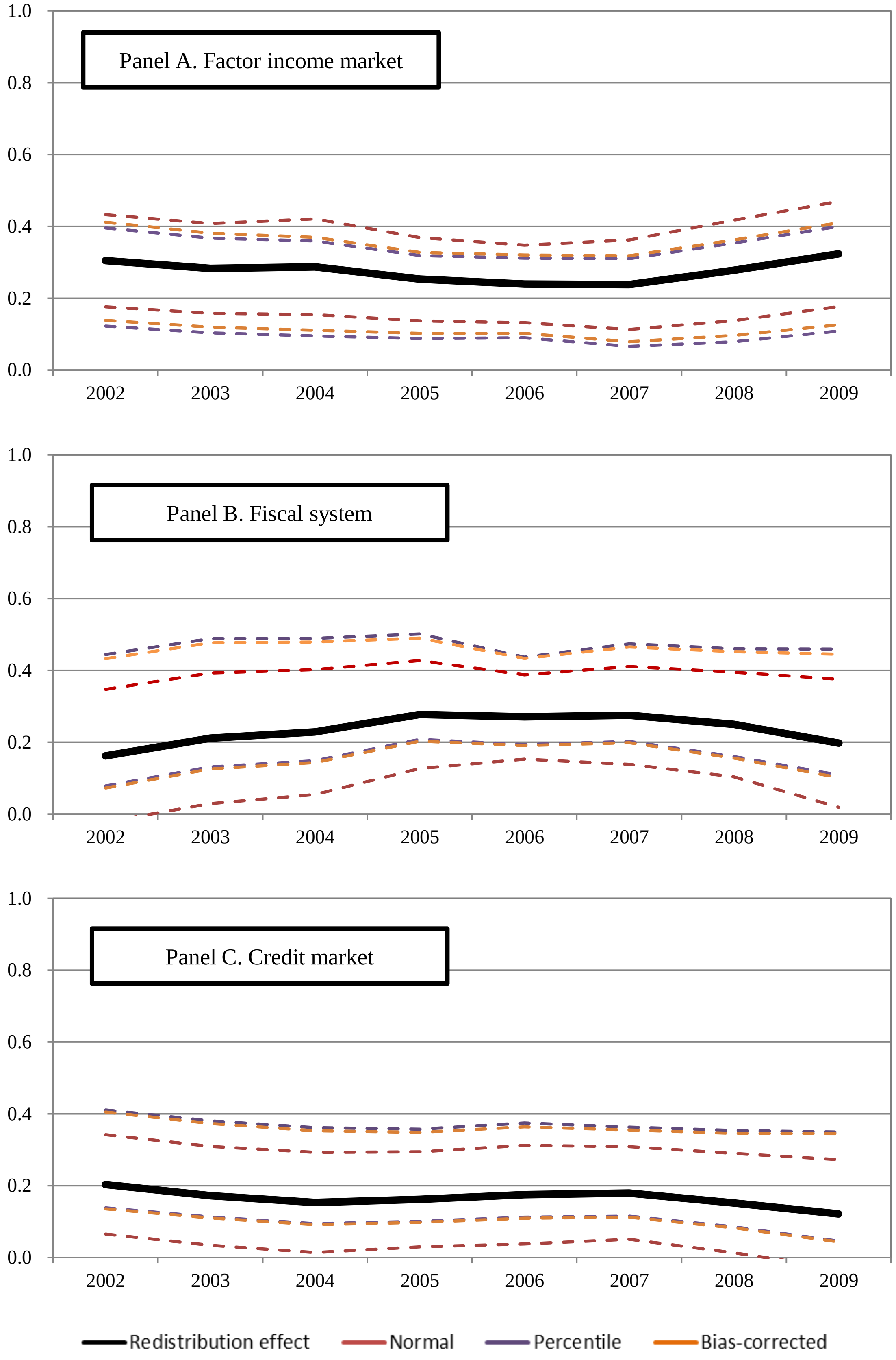

Figure 7. Trends of the revenue stabilization effect

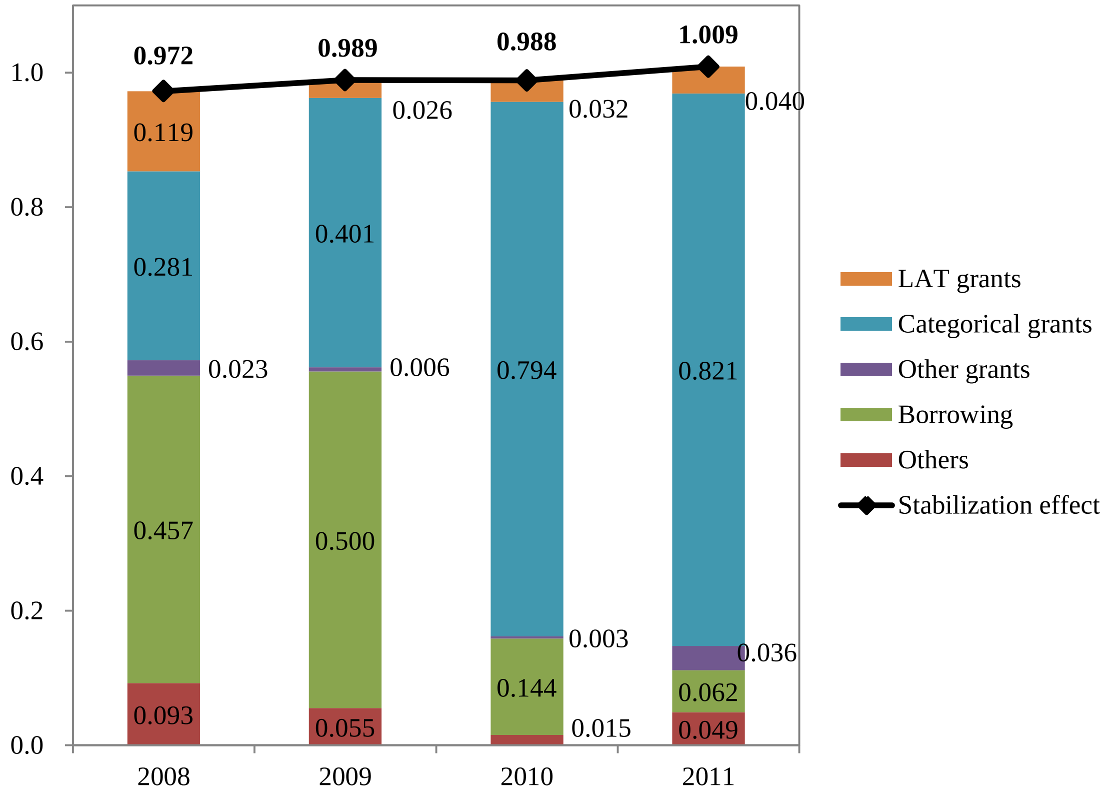

Figure 7 Bootstrapped confidence intervals for the revenue stabilization effect

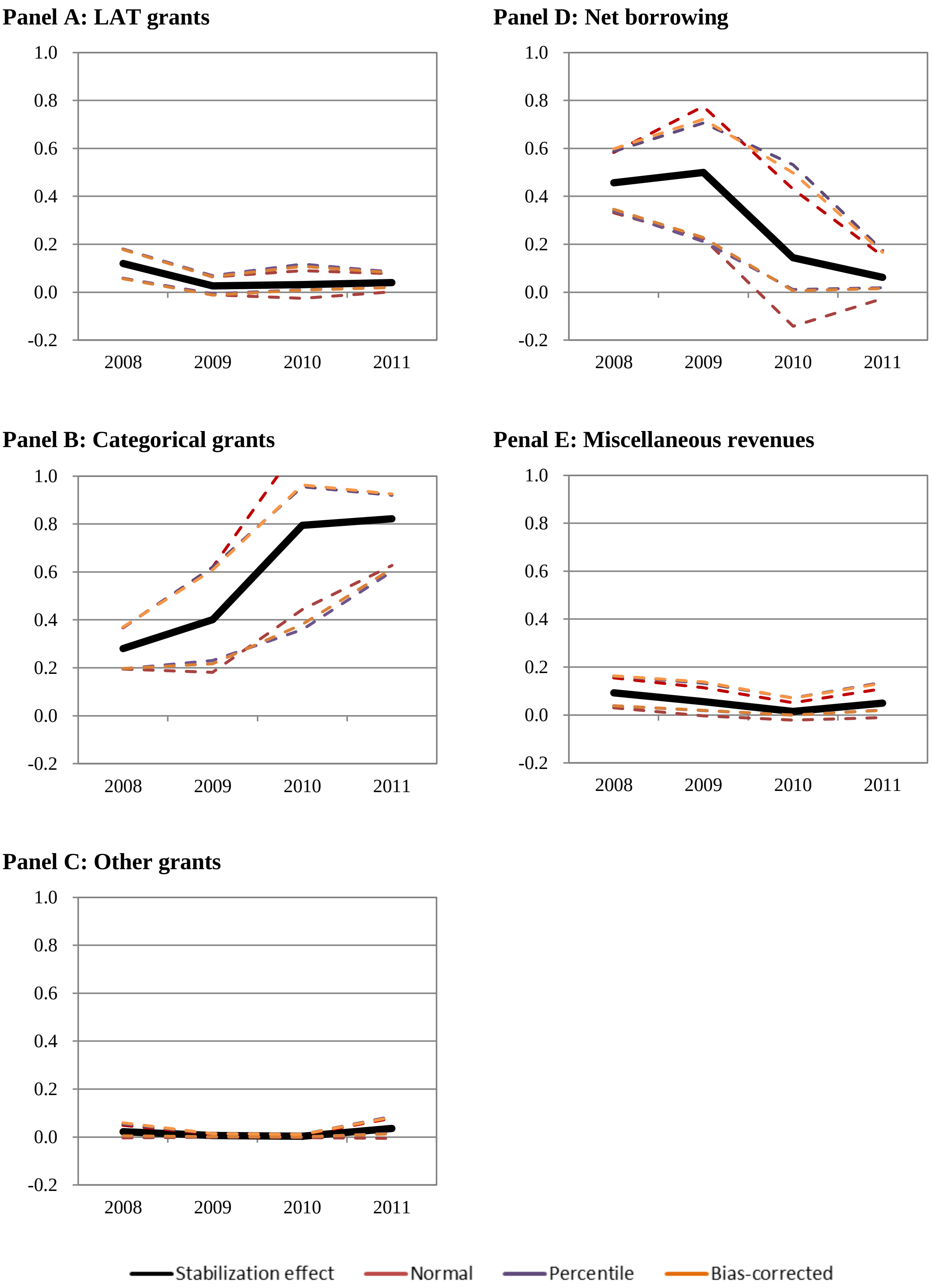

Figure 9. Trends of the revenue redistribution effect

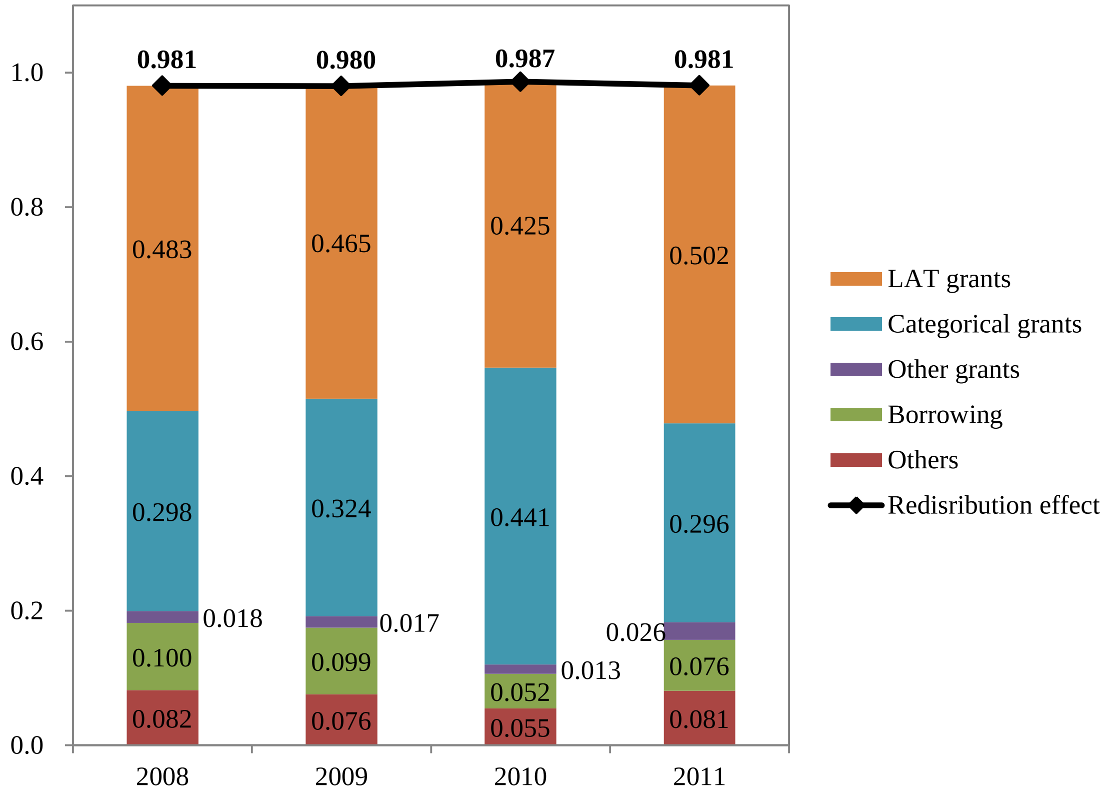

Figure 10. Bootstrapped confidence intervals for the revenue redistribution effect