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GSIR WORKING PAPERS

Economic Development & Policy Series EDP06-7

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May 2006

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Abstract

There have been some studies on the measurement of tax progressivity since the innovative works of Suits (1977) and Kakwani (1977). These measurements essentially rely on the idea of the Lorenz distribution of income and tax burden and the Gini concentration of inequality. Instead of such a traditional idea, this paper proposes a new measure of tax progressivity based on the relative volatility of tax revenue vis-a-vis income. The advantage of our approach is to make it possible to assess the degree of tax progressivity and to do international comparisons without any specific information about the distribution of the income and tax burden. All we need is macro data, which is a lot easier to obtain than micro data. This paper also discusses some international comparisons using the new measurement.

* The authors are grateful to seminar participants at the 2006 Public Choice Society Meeting in New Orleans, Louisiana.

1 Introduction

In the discussion of alternative tax systems, economists have been particularly concerned with the optimal degree of tax progressivity and/or regressivity. The literature on the optimal tax structures is relatively large.[1] A number of questions arise in the debate, such as which marginal tax rate and which degree of tax progressivity delivers the maximum welfare, or the maximum growth rate to the economy. However, a related issue that has not been extensively explored is how we measure tax progressivity. It is quite intuitive, for example, that consumption taxes are likely to be regressive due to the fact that the savings rate tends to be higher among the rich. The income tax, on the other hand, is usually designed as a progressive tax, with higher tax rates for brackets of higher income. But the question is how progressive or regressive is the entire tax system of a country. To answer this question, we need an appropriate index of tax progressivity/regressivity.

Two pioneer contributions on the measurement of tax progressivity are the works of Suits (1977) and Kakwani (1977).[2] Essentially, these authors rely on the concepts of the Lorenz distribution of income and the Gini concentration of inequality. The techniques are similar to standard assessments of income inequality. The Suits index computes the Gini coefficient for a Lorenz curve in which the accumulated percent of tax burden is plotted vertically against the accumulated percent of income on the horizontal axis. The Kakwani index, on the other hand, is calculated using the difference in the Lorenzian income inequality and Lorenzian tax inequality. A comparison between the Suits and the Kakwani indexes is carried out by Formby, Seaks, and Smith (1981). These authors use data of the U.S. tax system for the period 1962-76. Applications of the Suits or Kakwani index can be found extensively in the

[1] For various issues over the tax system, see, e.g., Slemrod (1994), and Li and Sarte (2004). Li and Sarte (2004) discuss the effect of tax progression in conventional endogenous growth model with heterogeneous households. As a relevant study on the 1986 Tax Reform Act in the United States, Feldstein (1995) examines the effect of marginal tax rates on taxable income, and Altig and Carlstrom (1999) investigate the impact of marginal tax rates on income inequality in a computable general equilibrium framework.

[2] As a further earlier study on tax progression, Musgrave and Thin (1948) compare the inequality of the before-tax and after-tax income distributions to arrive at a single measure of tax progression, and Slitor (1948) also discusses ways of measuring tax progressivity.

literature. For example, Sarte (1997) elaborates a dynamic stochastic general equilibrium model of an economy with heterogenous agents to explain the relation between progressive tax and income inequality. He computes the Suits index of tax progressivity predicted by the model, under different sets of parameter values.

Refinements to the tax progressivity index have been proposed by Hayes, Lambert, and Slottje (1995) and Stroup (2005). Hayes, Lambert, and Slottje (1995) propose an algorithm to compute the effective income tax progression by application to the U.S. tax system for the period 1950-87 when taxes are related not only to money income but also to other non-income characteristics. Stroup (2005) explores a simple index from a similar idea of Lorenz curves and computes an annual index for the United States for the period that goes from 1980 to 2000.

In this paper we propose a different way of assessing tax progressivity. We use neither Lorenz curves nor Gini coefficients. Our new measure of tax progressivity is the relative proportional standard deviation of tax revenue vis-a-vis the proportional standard deviation of income. The more volatile tax revenues relative to the volatility of incomes are, the more progressive the tax system is. The intuition is simple. Suppose, for example, that the business cycle is moving up towards its peak, and income is increasing. If the taxation is progressive, one can expect tax revenues to raise more than proportionately with income. Thinking in terms of a system with progressive tax brackets, a period of fast economic growth brings larger fractions of income to the brackets with higher tax rates, and the growth of the tax revenue should outpace the growth of income. A similar mechanism takes place in recessions. Hence, aggregate fluctuations of tax revenues relative to aggregate fluctuations of incomes are a crucial piece of information about the degree of tax progressivity. The background logic of our new index may be related to the concept of tax elasticity, which is the elasticity of the tax paid with respect to the income.[3]

[3]Kakwani (1977) states that a measure of tax progressivity should show the deviation of a given tax system from proportinality. Noticing that the tax elasticity is unity for proportional taxes, tax progressivity can be captured by the magnitude of the difference of the tax elasticity from unity. Based on this argument, traditional indices are typically calculated using the characteristics of the income and tax burden distributions

Tax systems consist of various taxes, such as income tax, corporate tax, and sales tax, with extremely complicated structures. The advantage of our new tax progressivity index is that it is much easier to compute than traditional indexes. One reason is that the micro data required in the traditional approach is costlier to obtain than the macro data required by our method. Indeed, with our new volatility-based index, we can assess tax progressivity *without any information of the income and tax burden distributions*. All we need is aggregate, time series data. This might be particularly relevant for less-developed countries, where data on the income and tax burden distributions are typically unavailable. An important contribution of our method is to allow international comparisons of tax progressivity between those countries.

Furthermore, it should be noted that we focus on tax progressivity in a purely aggregate level. The income and tax burden distributions within an economy are not considered at all. Also, we do not tackle issues such as the relation between the tax system and the inequalities of the income and tax burden; neither the macroeconomic consequences of the tax system (such as economic growth and development). Constructing an index of tax progressivity from aggregate data is a valuable tool to analyze the tax system, although we admit that our proposed index is not able to capture important distributional issues. The remainder of the paper is organized as follows. In section 2 we show that tax progressivity is closely connected with the volatility of tax revenues relative to the volatility of incomes. In section 3 we calculate the volatility index for a group of developed countries. Section 4 concludes the paper.

2 A New Index of Tax Progressivity

Tax progressivity has always been measured with an index that requires costly information about the income and tax burden distributions. The objective of this paper is to construct a new index of tax progressivity/regressivity that can be computed without such information. Our new index is based on the relative volatility of aggregate tax revenues to aggregate

in an economy as a whole.

incomes. More precisely, the tax progressivity index for a country in period t is given by:

$$\gamma_t \equiv \frac{\hat{\sigma}_{T,t}}{\hat{\sigma}_{Y,t}}, \tag{1}$$

where $\hat{\sigma}_{T,t}$ is the proportional standard deviation of the tax revenue in period t, and $\hat{\sigma}_{Y,t}$ is the proportional standard deviation of the income in period t. The proportional standard deviation is defined by the standard deviation divided by the mean. The important aspect is that time series on aggregate income and aggregate tax revenue are the only information required to build the index.

It is now shown how our new index γ_t is related to the conventional definition of the tax system. We define by $\tau_t(y_t)$ the tax revenue function in period t, where y_t represents the national income in period t. Letting $r_t(y_t)$ denote the average tax rate in period t, the tax revenue function can be written by:

$$\tau_t(y_t) = r_t(y_t)y_t.$$

It is said that the average tax system is progressive if the tax rate is increasing in the income ($r_t'(y_t) > 0$), proportional if the average tax rate is independent of the income ($r_t'(y_t) = 0$), and regressive if the average tax rate is decreasing in the income ($r_t'(y_t) < 0$). The sign of the derivative of $r_t(y_t)$ decides whether the tax system entails progressivity or regressivity. Although our definition of the tax system is based on the aggregate level, it is consistent with the conventional approach in studies on tax progression, such as Musgrave and Thin (1948).[4]

To examine the relationship between the tax system defined above and the volatilities of income and tax revenue in their aggregate level, we assume that the income y_t is a random

[4] According to the definition of the tax system in the work of Musgrave and Thin (1948), the tax system is progressive where the average rate of tax rises when moving up the income scale (the marginal tax rate exceeds the average rate); and regressive where the average rate falls with the rising income (the average tax rate lies below the average rate). In this study, the average tax rate is $r(y)$ and the marginal tax rate is $\tau'(y) = r(y) + yr'(y)$. Thus, the tax system is progressive if $r(y) < \tau'(Y)$ or $r'(y) > 0$ and regressive if $r(y) > \tau'(Y)$ or $r'(y) < 0$.

variable according to some distribution function with mean $E(y_t) = \mu_t$ and variance $V(y_t) = \sigma_t^2$. The proportional variance of income and tax revenue in period t are respectively given by:

$$\hat{\sigma}_{Y,t}^2 = \frac{V(y_t)}{[E(y_t)]^2} = \frac{\sigma_t^2}{\mu_t^2} \quad \text{and} \quad \hat{\sigma}_{T,t}^2 = \frac{V(\tau_t(y_t))}{[E(\tau_t(y_t))]^2}. \tag{2}$$

Then, we obtain the following result:

Lemma 1 *If the tax system is progressive, the proportional variance of tax revenues is higher than that of incomes. In contrast, if the tax system is regressive, the proportional variance of tax revenues is smaller than that of incomes. Moreover, if the tax system is proportional, the proportional variance of tax revenues equals that of incomes.*

Proof of Lemma 1 Consider the tax revenue function $\tau_t(y_t) = r_t(y_t)y_t$. Taking the Taylor expansion of the tax revenue function around $y_t = \mu_t$ yields:

$$\tau_t(y_t) - \tau_t(\mu_t) \cong [r_t(\mu_t) + \mu_t r_t'(\mu_t)](y_t - \mu_t).$$

Applying the expectation operator and taking the variance in this equation, we obtain:

$$E(\tau_t(y_t)) = \tau_t(\mu_t) = r_t(\mu_t)\mu_t;$$
$$V(\tau_t(y_t)) = [r_t(\mu_t) + \mu_t r_t'(\mu_t)]^2\sigma_t^2.$$

Using equations (2) and the above equations, we obtain the proportional variance of tax revenues:

$$\hat{\sigma}_{T,t}^2 = \frac{V(\tau_t(y_t))}{[E(\tau_t(y_t))]^2} = \frac{[r_t(\mu_t) + \mu_t r_t'(\mu_t)]^2\sigma_t^2}{[r_t(\mu_t)\mu_t]^2} = \hat{\sigma}_{Y,t}^2\left[1 + \frac{\mu_t r_t'(\mu_t)}{r_t(\mu_t)}\right]^2. \tag{3}$$

Thus, it must hold that $\hat{\sigma}_{T,t}^2 > \hat{\sigma}_{Y,t}^2$ if $r_t'(\mu_t) > 0$, and $\hat{\sigma}_{T,t}^2 < \hat{\sigma}_{Y,t}^2$ if $r_t'(\mu_t) < 0$. □

The result is quite intuitive and important for our discussion. The tax revenue is more (less) volatile than the income under progressive (regressive) tax system. Using equation (1) and Lemma 1, the value of the tax progressivity index depends on the tax system as follows:

Proposition 1 *The tax progressivity index is less than unity if the tax system is regressive, equal to unity if proportional, and more than unity if progressive, i.e.,* $\gamma_t \lesseqgtr 1$ *if* $r_t'(y_t) \lesseqgtr 0$.

In addition to the classification of the tax system into progressive, regressive and proportional taxation, it is also essential that our new index captures the degree of tax progressivity or regressivity. To consider that, we define the degree of progressivity/regressivity of the tax system by the absolute value of

$$\epsilon_t(\mu_t) \equiv \frac{\mu_t r_t'(\mu_t)}{r_t(\mu_t)}. \tag{4}$$

The sign of $\epsilon_t(\mu_t)$ decides whether the tax system is progressive or regressive so that the system is progressive if $\epsilon_t(\mu_t) > 0$ and regressive if $\epsilon_t(\mu_t) < 0$. The value of $\epsilon_t(\mu_t)$ represents the elasticity of the average tax rate $r_t(\mu_t)$ with respect to the expected income μ_t. Notice that this measure relates to progression or regression at a point in the expected income. This specification of the degree of tax progressivity is consistent with the discussion of the relation between the elasticity and tax progressivity in Kakwani (1977).[5] By equations (1), (3) and (4), the tax progressivity index defined by the proportional variance of tax revenues relative to the proportional variance of income in period t is represented by:

$$\gamma_t(\mu_t) \equiv \gamma_t = \frac{\hat{\sigma}_{T,t}}{\hat{\sigma}_{Y,t}} = 1 + \epsilon_t(\mu_t).$$

Then, assuming that $\epsilon_t(\mu_t) > -1$, the following result is obtained:

Proposition 2 *If the tax system is progressive, the tax progressivity index is monotone increasing in the degree of tax progressivity. In contrast, if the tax system is regressive, the*

[5] Kakwani (1977) argues that the tax system is progressive if the elasticity of the tax paid with respect to the income exceeds unity and regressive if the elasticity is less than unity. The elasticity of the tax paid with respect to the income is described by $\frac{d\tau}{dy} = 1 + \frac{y}{r}\frac{dr}{y} = 1 + \epsilon(y)$. Evaluating the elasticity at the expected income μ yields the result that the tax system is progressive if $\epsilon(\mu) > 0$ and regressive if $\epsilon(\mu) < 0$.

index is monotone decreasing in the degree of tax regressivity. Moreover, if the tax system is proportional, the index equals unity.

This result implies that the tax progressivity index based on the relative volatility of tax revenue vis-a-vis income is reflected by the degree of tax progressivity or regressivity. This volatility-based index is computable using a time series of aggregate income and aggregate tax revenue without any micro data related to their distributions.

In the discussion of tax progressivity measures it is important to define which tax is being studied. The conventional Suits and the Kakwani indexes are designed mainly to study the progressivity of income taxes. However, the existence of various taxes such as income tax, corporate tax, and consumption tax, makes the entire tax system very complex. The advantage of our volatility-based index is that it can be applied to any type of taxes, in particular, to the entire tax system. Thus, one can use our index to study, for example, whether corporate taxes are more progressive in the U.S. than they are in Europe, or whether the overall American tax system is more or less progressive than, say, its Japanese counterpart. This volatility-based approach might make it easier to do international comparisons. We believe that our method would be very useful to assess the tax progressivity of an economy as a whole, at least as a first approximation of the tax system. Furthermore, it might allow assessments of tax progressivity in less-developed countries where micro data is not available.

3 Computing the Index of Tax Progressivity

In this section we calculate our volatility-based index for nine industrialized economies: Japan, the U.S., Canada, France, Italy, Germany, UK, Australia, and South Korea. We use the aggregate data on tax revenues and gross domestic product (GDP) from the IMF's International Financial Statistics. For the sake of completeness, we also use aggregate consumption and aggregate investment, and calculate their respective standard deviations. All the data is expressed in terms of domestic currency and deflated with each country's GDP deflator.

Aggregate consumption is just the standard household consumption expenditure of national accounts, which includes consumption of durable as well as non-durable goods. Investment is obtained by the summation of the gross fixed capital formation and changes in inventories. The government revenue is on a cash basis, and comprises all nonrepayable government receipts, whether requited or unrequited, other than grants. It refers to the central government, excluding state and local governments. Hence, our aggregate revenue series includes all types of taxes accruing to the central government.

We take quarterly data, which is logged and filtered using the Hodrick-Prescott procedure. The period of time covered varies according to the availability of data for each country.[6] The HP filter is a standard procedure in the business cycle literature that eliminates the low frequencies of the series (that could be interpreted as trends). That prevents, for example, finding a high standard deviation for a series that is very smooth on the business cycle frequencies, but grows with a steep upward trend, captured by an extremely low frequency. We then calculate the proportional standard deviations of the government revenue, consumption, investment and output. The relative proportional standard deviation of government revenue with respect to output is our measure of tax progressivity.

We split the available time series in periods as close as possible to ten years each. There are two reasons for that. First, the time length of our sample varies from country to country. We want to avoid comparing standard deviations between series with large differences in the number of observations (for example, more than 150 observations for UK against less than 80 for Canada). Second, we want to capture changes in tax policy. There may be intertemporal changes in the degree of tax progressivity in those countries. By dividing the data in periods of ten years we may, for example, examine whether taxes in Australia are becoming more or less progressive in the recent decades.

Tables 1 to 9 present the proportional standard deviations of government revenue, invest-

[6] The lenghts of time covered are the following. Australia: from 1965Q1 to 1999Q1; Canada: from 1976Q1 to 1995Q3; France: from 1970Q1 to 1998Q4; Germany: from 1966Q1 to 2003Q4; Italy: from 1980Q1 to 2005Q2; Japan: from 1960Q1 to 1980Q2; Korea: from 1973Q2 to 1999Q4; United Kingdom: from 1960Q1 to 1998Q1; United States: from 1968Q1 to 1990Q4 and from 1994Q1 to 2005Q3.

ment, consumption and output, for the nine aforementioned economies. The tables confirm some of the stylized facts about the economic cycle: investment is more volatile than output, which tends to be more volatile than consumption. The proportional standard deviations of investment are typically two to seven times higher than the proportional standard deviations of output. The only exception is Japan (see Table 9), where investment was only slightly more volatile than output in the 60s and the 70s. In most countries, output fluctuates more than consumption. Exceptions are France, Italy and Germany (see Tables 3, 4 and 5). In intertemporal macroeconomic models with households maximizing convex preferences, it must be the case that consumption is smoother than output. A possible explanation for those exceptions is that the national accounts data of consumption typically includes the consumption of durable goods, which sometimes resembles more investment series, and is certainly a lot more volatile than the consumption of nondurables.

In most countries government revenues are highly volatile. With the exception of Korea, we find that the proportional standard deviation of tax revenues is higher than the proportional standard deviation of investment. This high volatility suggests that taxes are progressive mostly everywhere. The standard deviation of tax revenues relative to income is higher than the unity in eight of the nine economies analyzed. Only Korea has an evidence of a regressive tax structure in the 70s and 80s, as can be seen in Table 6. Nonetheless, it was reverted to a progressive tax scheme in the 90s.

Furthermore, by looking at the evolution of the tax revenue volatility through the decades, one can verify that large changes take place in some countries. The evidence of Table 1, for example, strongly suggests that Australia is sharply reducing its degree of tax progressivity. Government revenues were twenty three times more volatile than output back in the period 1964-1974. In the period 1985-1999, this difference was reduced to roughly ten times. Other countries like Germany, Italy, Korea, the U.S., and Japan experienced the inverse. As can be seen in Table 8, tax revenues in the U.S. were seven times more volatile than output in the period 1968-1979. In the last ten years we found that tax revenues are fourteen times more volatile than output, suggesting a movement towards a more progressive tax structure.[7]

4 Conclusion

Tax progressivity has been a key issue in the economics profession. The debate has emphasized the role played by tax progressivity and its implications on welfare and growth. On the other hand, few contributions have been made on the measurement of tax progressivity. The conventional wisdom tells us that some taxes are progressive but others are regressive. What interests us is to assess the degree of progressivity of the entire tax structure.

In this paper we proposed a method for assessing tax progressivity that departs from the traditional approach of using Lorenz Curves and Gini Coefficients (see, e.g., Kakwani (1977) and Suits (1977)). Our method is based on the fact that the more progressive a tax is, the more volatile the tax revenue will be relative to the income. The greatest advantage of this volatility-based index is that we do not need any information about the income or the tax distribution. This kind of micro data is hard and costly, or sometimes impossible to obtain. Hence, it becomes practically impossible to assess tax progressivity in less-developed countries with the traditional indexes. Our volatility-based methodology provides a reasonable assessment of tax progressivity with very few data requirements. The volatility index of tax progressivity can be computed with only two aggregate series: the tax revenue and the domestic output.

We applied our method to a group of nine industrialized economies. We are able to rank these economies according to their degree of tax progressivity. The result implied that Italy has a sharp tax progression, while Japan and Korea have a relatively small tax progression in the past. Moving beyond this static picture, we are able to verify how tax progressivity evolves over time in each of the nine countries analyzed. We found that in some countries such as Germany the tax system is becoming considerably more progressive, whereas in countries such

[7] Much has been said about the regressive character of the Bush administration's recent tax cuts. Notice that our time frame mingles part of the Clinton and the Bush administrations. An interesting exercise would be to isolate the Bush term, and compare the relative volatility of tax revenues for both administrations.

as Australia it is becoming less progressive. Various interesting extensions of this research can be possible by applying our new index, for example, perhaps, first time assessments of tax progressivity in developing economies.

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Table 1
Australia: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Variable: Tax Revenues	Investment	Consumption	Output
1965/Q1 to 1974/Q4	(%)	0.325	0.054	0.001	0.014
	Relative to Output	23.009	3.827	0.702	1
1975/Q1 to 1984/Q4	(%)	0.241	0.068	0.009	0.016
	Relative to Output	14.743	4.144	0.524	1
1985/Q1 to 1999/Q4	(%)	0.136	0.069	0.008	0.013
	Relative to Output	10.413	5.280	0.623	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.

Table 2
Canada: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Variable: Tax Revenues	Investment	Consumption	Output
1972/Q2 to 1984/Q4	(%)	0.082	0.086	0.014	0.017
	Relative to Output	4.768	5.000	0.799	1
1985/Q1 to 1995/Q3	(%)	0.069	0.062	0.009	0.017
	Relative to Output	4.045	3.638	0.503	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.

Table 3

France: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Tax Revenues	Investment	Consumption	Output
1970/Q1 to 1979/Q4	(%)	0.103	0.048	0.018	0.012
	Relative to Output	8.847	4.139	1.567	1
1980/Q1 to 1989/Q4	(%)	0.072	0.031	0.010	0.006
	Relative to Output	11.541	4.908	1.571	1
1990/Q1 to 1998/Q4	(%)	0.059	0.045	0.007	0.006
	Relative to Output	9.582	7.310	1.155	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.

Table 4

Germany: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Tax Revenues	Investment	Consumption	Output
1966/Q1 to 1974/Q4	(%)	0.065	0.076	0.014	0.020
	Relative to Output	3.184	3.719	0.709	1
1975/Q1 to 1984/Q4	(%)	0.067	0.061	0.012	0.013
	Relative to Output	4.956	4.531	0.856	1
1985/Q1 to 1994/Q4	(%)	0.068	0.062	0.036	0.027
	Relative to Output	2.549	2.296	1.352	
1995/Q1 to 2003/Q4	(%)	0.101	0.043	0.012	0.008
	Relative to Output	12.049	5.154	1.297	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.

Table 5
Italy: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Tax Revenues	Investment	Consumption	Output
1980/Q1 to 1989/Q4	(%)	0.207	0.042	0.009	0.007
	Relative to Output	30.519	6.159	1.313	1
1990/Q1 to 1999/Q4	(%)	0.187	0.048	0.011	0.009
	Relative to Output	21.405	5.489	1.205	1
2000/Q1 to 2005/Q2	(%)	0.252	0.020	0.005	0.004
	Relative to Output	60.348	4.892	1.290	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.

Table 6
Korea: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Tax Revenues	Investment	Consumption	Output
1973/Q2 to 1979/Q4	(%)	0.110	0.671	0.045	0.168
	Relative to Output	0.651	3.985	0.568	1
1980/Q1 to 1989/Q4	(%)	0.076	0.285	0.055	0.110
	Relative to Output	0.696	2.597	0.500	1
1990/Q1 to 1999/Q4	(%)	0.120	0.207	0.040	0.070
	Relative to Output	1.716	2.951	0.266	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.

Table 7
United Kingdom: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Tax Revenues	Investment	Consumption	Output
		Variable			
1960/Q1 to 1969/Q4	(%)	0.246	0.076	0.024	0.025
	Relative to Output	9.981	3.060	0.957	1
1970/Q1 to 1979/Q4	(%)	0.116	0.084	0.032	0.032
	Relative to Output	3.593	2.597	0.999	1
1980/Q1 to 1989/Q4	(%)	0.125	0.075	0.027	0.027
	Relative to Output	4.591	2.744	0.985	1
1990/Q1 to 1998/Q1	(%)	0.080	0.061	0.029	0.029
	Relative to Output	2.751	2.094	0.991	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.

Table 8
United States: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Tax Revenues	Investment	Consumption	Output
		Variable			
1968/Q1 to 1979/Q4	(%)	0.128	0.061	0.013	0.017
	Relative to Output	7.328	3.523	0.721	1
1980/Q1 to 1990/Q4	(%)	0.104	0.061	0.013	0.016
	Relative to Output	6.377	3.746	0.799	1
1994/Q1 to 2005/Q3	(%)	0.136	0.041	0.008	0.010
	Relative to Output	14.108	4.218	0.834	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.

Table 9
Japan: Standard Deviations of Macroeconomic Variables

	Standard Deviation	Variable: Tax Revenues	Investment	Consumption	Output
1960/Q1 to 1969/Q4	(%)	0.131	0.121	0.102	0.104
	Relative to Output	1.257	1.159	0.979	1
1970/Q1 to 1980/Q2	(%)	0.298	0.082	0.069	0.067
	Relative to Output	4.434	1.214	1.022	1

Note: Based on quarterly data from IMF's International Financial Statistics. The data were measured in domestic currency values of the last period in the sample and then logged. All series were Hodrick-Prescott filtered. Output is given by the GDP, investment by the Gross Fixed Capital Formation plus change in inventories.