Government Size and Intersectoral Fluctuation:
An International Panel Analysis *

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Abstract: The association between economic uncertainty and government size has recently become a central policy interest, especially in the open economy context. Using the between-sector variation in income as a new measure of uncertainty, this paper proposes simple models describing the interaction between economic uncertainty and government size in the open economy setting, and provides supportive empirical evidence.

Our empirical results are as follows: (*i*) a greater government reduces sectoral income volatility, and, at the same time, (*ii*) an economy facing higher intersectoral fluctuation has a larger government. However, (*iii*) the government tends to resort to redistributive policies rather than government spending to reduce the uncertainty, while (*iv*) government spending is almost as effective as government subsidies and transfers. The results based on the open economy include: (*v*) for a given external sector-specific shock, intersectoral fluctuation tends to rise when a country becomes more open to international trade.

Key Words: government size, economic uncertainty, openness to trade, intersectoral fluctuation

JEL Classification: H1, H3, H5

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I. Introduction

Economic stabilization has been a major concern for macroeconomists since economic uncertainty can undermine growth potential or entail welfare loss for risk-averse individuals.[1] In principle, individuals can overcome the negative impacts of economic fluctuations through portfolio diversification in capital markets or through transactions in credit markets. However, empirical research finds that market mechanisms do not provide perfect insulation for individuals against economic uncertainty.[2] The finding of imperfect risk sharing through private markets is in general attributed to the fact that contracts for managing individual economic uncertainty are often subject to asymmetric information problems such as moral hazard or adverse selection. This 'market failure' argument suggests that there exists some scope for further income smoothing by government intervention.

The traditional view on the stabilization roles of government has focused on the ability of the tax and transfer system to stabilize disposable income (Sachs and Sala-i-Martin, 1992; von Hagen, 1992; Bayoumi and Mason, 1995). According to simple Keynesian models, fluctuations in gross income can be partially smoothed by cyclical changes in taxes and transfers over business cycles so that disposable income is less volatile than gross income. However, recent empirical studies show that increasing the size of government reduces the volatility of gross income as well as disposable income. The evidence presented by Gali (1994) is indicative of a negative correlation between government size and GDP volatility.[3] In particular, controlling for a possible endogeneity

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[1] Economic stability may affect the long-run performance of an economy. Empirical studies show that more volatile economies in terms of standard deviation of year-on-year growth rates tend to have lower long-run growth rates. In the perspective of endogenous growth theory, the long-run growth rate is determined by investment, which can be negatively impacted by economic uncertainty. Many studies also analyze the welfare cost of business cycles. A partial list of past studies include Tallarini (2000), Beaudry and Pages (2001), Kiley (2003), and Chen (2003).

[2] For the imperfect risk-sharing in the presence of asymmetric income shocks, see Asdrubali, Sorensen, and Yosha (1996). Cochrane (1991) also shows imperfect consumption insurance in his empirical research.

[3] The size of government is measured by the share of government spending in GDP, the share of tax revenue in GDP, or the share of total transfer in GDP. The intensity of gross income volatility is measured by the standard deviation of the log difference of GDP per capita over a certain period of time.

problem, the analysis by Fatas and Mihov (2001) suggests a negative causal relationship from the size of government to the volatility of GDP per capita.

Our study advances the existing literature in two aspects. First, contrary to the existing literature that analyzes the effect of government size on aggregate income volatility, this paper investigates whether government fiscal policy can mitigate 'intersectoral fluctuation,' a measure of uncertainty *at a point in time*. Given that government spending is more stable than any other component of sectoral income, a higher government share in sectoral demand may reduce not only income fluctuation of each sector but also the asymmetry of sectoral income fluctuations.[4]

In this paper, income risk for workers in particular sectors is measured by intersectoral fluctuation of income growth, which is defined as the second moment of the cross-sectional distribution of sectoral labor income growth rates. Compared to the variance of GDP growth rates, intersectoral fluctuation has some advantages because it captures a comparable but different aspect of economic uncertainty. A crucial problem of the variance of GDP growth rates as a measure of economic risks is that it provides information about 'macroeconomic' stability only. It does not tell much about the sector-specific 'microeconomic' risks that individuals in an economy are exposed to, which may be a more important concern for individuals in the context of private or social insurance. Since a substantial portion of sector-specific income shocks can be offset in the process of aggregation, the variance of aggregate income can be small even when sector-specific income risk is high. However, our new statistic, intersectoral fluctuation of income growth, can capture this cross-sectional aspect of income uncertainty by measuring the intensity of sector-specific, asymmetric income risks.

Another advantage in focusing on the sector-specific income risks is that it provides a more solid connection between government size, economic uncertainty, and openness to trade. In his empirical study addressing why more open economies have larger governments, Rodrik (1998) proposes two hypotheses: (*i*) greater exposure to

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[4] This argument requires typical Keynesian assumptions. For example, each sector should face unemployment of resources and the driving force of business cycles is the demand-side (consumption or investment) shocks. Section II will discuss this issue in detail.

external risk increases the total risk to which residents of an economy are exposed, and (*ii*) societies that face more economic uncertainty demand a larger size of government as social insurance. His study provides crucial motivations for this paper. First, if the hypotheses are correct, then the estimated impact of government size on economic uncertainty is subject to a simultaneous equation bias. Second, when we intend to analyze the link between trade openness, economic uncertainty, and government size, we need to be very careful in selecting the proper measure of economic uncertainty. While Rodrik (1998) uses variance of per capita GDP growth rates as a measure of economic uncertainty arising from openness to trade, conventional understanding on this issue is that an economy as a whole is likely to become less volatile when integrated into the world economy. However, we may circumvent this kind of criticism when our empirical analysis uses intersectoral fluctuation as a measure of economic uncertainty. Compared to the variance of GDP growth rates, intersectoral fluctuation is a better measure of economic uncertainty in the context of trade openness because external shocks in an open economy are likely to be sector-specific, and thus sector-specific income risks would be more prominent when an economy is more integrated into international markets.

The above discussion highlights another contribution of the paper. It separates itself from the existing literature by exploring the interactions between government size and intersectoral fluctuation. While existing studies have showed robust causal effects of government spending on various measures of economic uncertainty, they have not explicitly examined the empirical relevance of chosen instruments. Furthermore, there has been no empirical study on the reverse causality: an economy exposed to higher economic uncertainty has a larger government, which is a theoretical argument for why we must use the IV approach. This paper investigates the aforementioned hypotheses in an empirical model using international panel data from OECD countries. To our knowledge, the empirical study conducted here is the first of its kind.[5]

[5] There are three different lines of research that are related to this paper: Gali (1994) and Fatas and Mihov (2001) empirically investigate whether government size plays a stabilization role, Rodrik (1998) and Balle and Vaidya (2002) examine whether openness to trade affects the size of government, and Krebs, Krishna and Maloney (2003) studies the link between openness to trade and individual income risk. However, there

Estimation results show that (*i*) the size of government reduces intersectoral income volatility, and, at the same time, (*ii*) an economy facing higher intersectoral fluctuation has a larger government. However, (*iii*) the government tends to resort to redistributive policies rather than government spending to reduce economic uncertainty, while (*iv*) government spending is almost as effective as government subsidies and transfers. Another interesting result of the paper is that (*v*) intersectoral fluctuation rises when a country becomes more open to international trade, and increases further as an economy is exposed to more intense external shocks. In addition, it is also found that (*vi*) the effect of external shocks on intersectoral fluctuation depends on an economy's openness to trade. Specifically, external shocks increase intersectoral fluctuation in the economies where trade share in GDP is larger than about 50%, while they decrease intersectoral fluctuation in less open economies.

The rest of the paper proceeds as follows. Section II provides the analytical framework for the empirical analysis. Based on the framework, we discuss the theoretical relationship between government size, sector-specific income risks, and openness to trade. The specification and identification of empirical models are also discussed in this section. Section III describes the data that econometric analysis uses, and then presents estimation results. Conclusions are given in Section IV.

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is no literature on the (reverse) causality running from economic uncertainty to government size. This paper analyzes the relationship among government size, economic uncertainty, and trade openness in a unified empirical framework.

II. Theoretical Framework

1. A Simple Keynesian Model

The main interest of this paper is the relationship between government size and sector-specific income risks. For this reason, we focus on the theoretical relationship between these two variables first, and then we discuss some other variables that need to be considered in the empirical specification. There have been a few attempts to conduct a theoretical analysis on the stabilization role of government size. One of the theoretical papers is Gali (1994), which considers the effects of steady-state government spending on GDP volatility. In his stochastic dynamic general equilibrium model, Gali (1994) identifies various effects of government size. Since his analysis is based on a real business cycle model with flexible prices and market clearing, the only way that 'acyclical' government spending can stabilize income is through affecting the optimal behavior of individuals. However, the theoretical relationship proposed by his model is ambiguous, since results are sensitive to parameter values. Moreover, the quantitative importance of government spending would be very small compared to empirical findings, even with the most favorable configuration of parameter values.[6]

To derive simple but clear implications, we adopt a Keynesian approach where the demand side of an economy determines the equilibrium level of income.[7] In the model, income per capita of sector i (y_{it}) is assumed to consist of incomes from the private sector demand and government spending. On average, the private-sector incomes

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[6] According to his simulation, taxes actually work as an automatic destabilizer while government spending is likely to stabilize GDP per capita. The main mechanism through which government spending plays a stabilization role is via its income effect on labor supply. A permanently higher level of government spending will increase the steady state level of labor supply, which reduces the intertemporal elasticity of labor supply when consumers have a log utility function. Therefore, given a technology shock, the magnitude of business cycles is smaller with higher level of government spending. However, the stabilization role of government spending disappears in Galí's model when we assume constant elasticity of labor supply.

[7] As in a simple Keynesian model, we assume the presence of underutilized factors of production. This approach is similar to Rodrik (1998), which relies on the variance-covariance structure of the components of GDP for each country.

grow at the rate of θ, and the shocks to the private-sector income growth rate of sector *i* (ε_{it}) have the following properties: $E(\varepsilon_{it} \mid t) = \mu_t$, $\text{var}(\varepsilon_{it} \mid t) = \sigma_\varepsilon^2$, and $\text{cov}(\varepsilon_{it}, \varepsilon_{jt} \mid t) = 0$ for all *i* and *j*.[8] These assumptions describe the statistical properties of the cross-sectional distribution of private-sector income growth rates. On average, each sector is exposed to a common income shock – the mean of the cross-sectional distribution (μ_t). The intensity of sector-specific income shock is measured by the variance of the sectoral growth rate distribution (σ_ε^2), which indicates how shocks to sectoral income growth rate spread around the common shock. Furthermore, we assume the unconditional properties are such that $E(\varepsilon_{it}) = E(\mu_t) = 0$, $\text{var}(\varepsilon_{it}) = \sigma^2$, and $\text{cov}(\varepsilon_{it}, \varepsilon_{jt}) = 0$ for all *i* and *j*.

The next set of assumptions is on government spending. The government sets the growth rate of its spending equal to the steady state growth rate, θ: $\Delta \ln G_t = \theta$ for all *t*, where *G* is the total government spending. This implies that government spending is "acyclical." we also assume that the government sets the proportion of its spending allocated to sector *i* (α_i) equal to the proportion of sectoral income to aggregate income (γ_i): $\alpha_i \equiv \frac{G_i}{G} = \frac{y_i}{y} \cdot n_i \equiv \gamma_i$,[9] where G_i is the government spending allocated to sector *i*, n_i is the share of sector *i* workers in total workers ($n_i \equiv \frac{N_i}{\sum_{j=1}^{M} N_j}$), N_i is the number of workers in sector *i*, *M* is the number of sectors in this economy, and $y \equiv \sum_{j=1}^{M} n_j \cdot y_j$ is income per capita of this economy.[10] Then, the growth rate of income per capita of sector

[8] The assumption on the covariance structure does not make any difference in the partial relationship between government size and the intensity of intersectoral fluctuation. It was adopted for clarity of exposition.

[9] For example, the government spends *x* percent of the total government spending to sector *i* if sector *i*'s steady state income is *x* percent of the total steady state income of the economy. However, we can still have qualitatively same results with much weaker assumption that the proportion of government spending allocated to sector *i*, $\frac{G_i}{G}$ is constant over time.

[10] For analytical convenience, we assume that the number of workers in each sector is constant over time.

i ($\Delta \ln y_{it}$) can be expressed as the weighted average of incomes that are earned from the private sector and generated from government spending.

$$\Delta \ln y_{it} = (1-\lambda_i)\cdot(\theta+\varepsilon_{it}) + \lambda_i \cdot \theta, \tag{1}$$

where λ_i is the government share in sector i's income, defined as $\frac{G_i}{N_i \cdot y_i}$. These assumptions lead to the following results.[11]

<u>Result 1</u>: The sectoral government share (λ_i) is equal to the aggregate government share (λ) defined as the aggregate government spending over GDP. In our notation, this result can be written as $\lambda_i = \lambda \equiv \frac{G}{\sum_{j=1}^{M} N_j \cdot y_j}$.

<u>Result 2</u>: The growth rate of sector *i's* income is $\Delta \ln y_{it} = \theta + (1-\lambda)\cdot \varepsilon_{it}$. The conditional expectation and variance of sector i's income growth are $E(\Delta \ln y_{it} \mid t) = \theta + (1-\lambda)\cdot \mu_t$ and $\mathrm{var}(\Delta \ln y_{it} \mid t) = (1-\lambda)^2 \cdot \sigma_\varepsilon^2$, respectively.

Next, we define two sample means ($\overline{y}^n$ and $\overline{y}^\gamma$) and two sample variances (s_n^2 and s_γ^2) of income growth rates as follows:

$$\overline{y}_t^n \equiv \sum_{j=1}^{M} n_j \cdot \Delta \ln y_{jt}, \qquad \overline{y}_t^\gamma \equiv \sum_{j=1}^{M} \gamma_j \cdot \Delta \ln y_{jt},$$

$$s_{n,t}^2 \equiv \frac{\sum_{j=1}^{M} n_j \cdot (\Delta \ln y_{jt} - \overline{y}_t^n)^2}{1-\sum_{j=1}^{M} n_j^2}, \qquad s_{\gamma,t}^2 \equiv \frac{\sum_{j=1}^{M} \gamma_j \cdot (\Delta \ln y_{jt} - \overline{y}_t^\gamma)^2}{1-\sum_{j=1}^{M} \gamma_j^2}.$$

[11] Mathematical proof is in Appendix 1.

It should be noted that the employment shares of each sector (n_i) are used as weights in the computation of $\overline{y}^n$ and s_n^2, while the income shares of each sector (γ_i) are used in the computation of $\overline{y}^\gamma$ and s_γ^2.

Result 3: The weighted averages of sectoral income growth rates, $\overline{y}_t^n$ and $\overline{y}_t^\gamma$, are unbiased estimators of the population income growth rate conditional on time t, $E(\Delta \ln y_{it} \mid t)$; $s_{n,t}^2$ and $s_{\gamma,t}^2$ are unbiased estimators of population variance of income growth rate, $\text{var}(\Delta \ln y_{it} \mid t)$.

In our notation, $E(\overline{y}_t^n \mid t) = E(\overline{y}_t^\gamma \mid t) = E(\Delta \ln y_{it} \mid t) = \theta + (1-\lambda)\cdot \mu_t$ and $E(s_{n,t}^2 \mid t) = E(s_{\gamma,t}^2 \mid t) = \text{var}(\Delta \ln y_{it} \mid t) = (1-\lambda)^2 \cdot \sigma_\varepsilon^2$.

Result 4: The unconditional expectation and variance of $\Delta \ln y_{it}$ are $E(\Delta \ln y_{it}) = \theta$ and $\text{var}(\Delta \ln y_{it}) = (1-\lambda)^2 \cdot \sigma^2$, respectively.

Two statistics defined as $\hat{\sigma}_n^2 = \frac{1}{T}\cdot \sum_{t=1}^T s_{n,t}^2$ and $\hat{\sigma}_\gamma^2 = \frac{1}{T}\cdot \sum_{t=1}^T s_{\gamma,t}^2$ are unbiased estimators of $\text{var}(\Delta \ln y_{it})$: $E(\hat{\sigma}_n^2) = E(\hat{\sigma}_\gamma^2) = (1-\lambda)^2 \cdot \sigma^2$.

In this model, the exact definition of intersectoral fluctuation is the conditional variance of sectoral income growth rate, $\text{var}(\Delta \ln y_{it} \mid t)$. Using Result 2, we can derive the stabilization effect of government size. By differentiating $\text{var}(\Delta \ln y_{it} \mid t)$ with respect to λ, we obtain:

$$\frac{\partial\, \text{var}(\Delta \ln y_{it} \mid t)}{\partial \lambda} = -2 \cdot (1-\lambda)\cdot \sigma_\varepsilon^2 < 0\,. \qquad (2)$$

This implies that an economy with a larger government has smaller sectoral income volatility. When the government share in sectoral income is constant, it serves as a symmetric part of sectoral income. For this reason, as government size becomes larger, the symmetric component of sectoral income increases, and thus sectoral income volatility becomes smaller.

On the other hand, the reverse causality can be also discussed using this relationship, while it is not explicitly considered in the previous model. From Result 2, we see that an economy achieves the minimum level of intersectoral fluctuation when the government sets its share equal to 1 ($\lambda = 1$). However, the government will not push the income-risks-minimizing motive to its limit since increasing government size is likely to bring about some real costs.[12] Suppose, for example, government's optimization problem can be expressed as maximizing the value of a linear combination of real activity of the economy, $\Gamma(\lambda)$, and the conditional variance of sectoral income growth rates, $\mathrm{var}(\Delta \ln y_{it} \mid t)$: $V(\lambda; \sigma_\varepsilon^2) = A \cdot \Gamma(\lambda) - B \cdot (1-\lambda)^2 \cdot \sigma_\varepsilon^2$, where A and B are positive and $\Gamma'(\cdot) < 0$. When government maximizes its objective function $V(\lambda; \sigma_\varepsilon^2)$ given the underlying asymmetric income shock σ_ε^2, the optimal size of government (λ^*) satisfies $A \cdot \Gamma'(\lambda^*) + 2 \cdot B \cdot (1-\lambda^*) \cdot \sigma_\varepsilon^2 \equiv 0$ and $\lambda^* \in (0,1)$. Differentiating this optimality condition, we can draw an implication on how the government responds to an increase in the underlying sector-specific income risks σ_ε^2:[13]

$$\frac{d\lambda^*}{d\sigma_\varepsilon^2} = \frac{-2 \cdot B \cdot (1-\lambda^*)}{A \cdot \Gamma''(\lambda^*) - 2 \cdot B \cdot \sigma_\varepsilon^2} > 0\,. \tag{3}$$

[12] There are many studies on the effects of government spending on real activities. In a macroeconomic perspective, distortionary taxes or government-expenditure programs are often pointed out as a primary source of real costs of government. For detail, see Barro (1990, 1991) among others.

[13] The second-order condition suggests that $-\Gamma''(\lambda^*) > -2 \cdot B \cdot \sigma_\varepsilon^2 / A$ should hold. This condition implies that the real marginal benefit of government spending $-\Gamma'(\cdot)$ does not decrease too fast.

This equation shows that the government facing greater sector-specific income risks tends to spend more in equilibrium. In a later section, we will test the implications derived by equations (2) and (3).

While our simple model can deal with the interactions between government size and intersectoral fluctuation well, it does not provide much insight to the case of the open economy due to its simplicity. Perhaps, the underlying relationship between uncertainty and government size would not change, but the extent to which a shock affects sectoral variation in income may intensify in a more open economy. The following subsection offers a simple open economy model, and highlights the importance of openness.

2. Openness to Trade and Intersectoral fluctuation

To examine how openness to trade affects intersectoral fluctuation of labor income growth rates, we compare two economies that are identical except their trade policies. Those economies have two final goods (X_1 and X_2) and one intermediate good (Z). Final goods are domestically produced and consumed while intermediate good cannot be domestically produced.

These economies have two types of workers, and their skills are sector-specific and country-specific. For this reason, labor is immobile across sectors and countries.[14] The number of type 1 workers is N_1, and that of type 2 workers is N_2. In addition, each worker is assumed to live only one period, providing one unit of labor inelastically. The Cobb-Douglas utility function represents the preferences of consumers. The consumer optimization problem is set up as follows.

$$\begin{aligned} &\max_{\{x_{1i}, x_{2i}\}} x_{1i}^{\alpha} \cdot x_{2i}^{1-\alpha} \\ &s.t.\ w_i = x_{1i} + p \cdot x_{2i} \quad for\ i = 1\ and\ 2 \end{aligned} \tag{4}$$

[14] Due to the immobility of labor, factor price (wage) equalization does not hold in this model.

The subscript i indicates the type of workers. w is the labor income, and p is the price of the second final good (X_2). we set the price of the first final good (X_1) equal to unity. From the optimization problem (4), we can derive the following demand functions for two final goods.

$$x_{1i} = \alpha \cdot w_i \ \ and \ \ x_{2i} = \frac{(1-\alpha)\cdot w_i}{p}, \text{ for } i\text{=1 and 2} \tag{5}$$

Each final good is produced with a constant return to scale (CRS) technology. Inputs are intermediate good and labor. The specific production functions are as follows.

$$X_1 = A_1 \cdot Z_1^{\gamma} \cdot L_1^{1-\gamma} \ \text{ and } \ X_2 = A_2 \cdot Z_2^{\beta} \cdot L_2^{1-\beta} \tag{6}$$

A represents the technology level of each sector, and we assume that $A_1 < A_2$ without loss of generality. L is labor, and Z is intermediate good. γ and β are the intermediate good shares in the production of X_1 and X_2, respectively. With the assumption of competitive markets and profit maximization, we can derive the following factor demands.

$$\begin{aligned} &w_1 = (1-\gamma)\cdot A_1 \cdot Z_1^{\gamma} \cdot L_1^{-\gamma} \ \text{ and } \ w_2 = p\cdot(1-\beta)\cdot A_2 \cdot Z_2^{\beta} \cdot L_2^{-\beta} \\ &\varepsilon \cdot p_Z = \gamma \cdot A_1 \cdot Z_1^{\gamma-1} \cdot L_1^{1-\gamma} \ \text{ and } \ \varepsilon \cdot p_Z = p\cdot \beta \cdot A_2 \cdot Z_2^{\beta-1} \cdot L_2^{1-\beta} \end{aligned} \tag{7}$$

w is the wage rate, p is the domestic price of X_2, ε is the nominal exchange rate defined as domestic currency over foreign currency, and p_Z is the international price of intermediate good. It should be noted that the intermediate good is entirely imported, and both sides of each equation are evaluated in domestic currency.

In the next step, we assume that one country (economy **R**) prohibits the international trade of the final good X_1 while there is no restriction to the trade of X_2.

The other country (economy **F**) is assumed to have no trade restriction. Therefore, the equilibrium of economy **R** is described by equations (5), (7), and (8) while that of economy **F** is described by equations (5), (7), and (9).

$$A_1 \cdot Z_1^{\gamma} \cdot L_1^{1-\gamma} = N_1 \cdot x_{11} + N_2 \cdot x_{12}, \; \varepsilon \cdot p_2^W = p, \; L_1 = N_1, \text{ and } L_2 = N_2 \tag{8}$$

$$\varepsilon \cdot p_1^W = 1, \; \varepsilon \cdot p_2^W = p, \; L_1 = N_1, \text{ and } L_2 = N_2 \tag{9}$$

Equations (8) and (9) show the market clearing conditions for the final goods and the labor market clearing conditions.[15]

Closing this model, we assume that these economies have two sources of economic shocks. The first is the technology shocks to A_1 and A_2, and the second is the external shocks to p_1^W, p_2^W, and p_Z. For simplicity, we assume that the productivity levels are stationary, all the random variables follow lognormal distribution, and they are not correlated with each other.

$$\ln A_i \sim N(\mu_{A_i}, \sigma_{A_i}^2) \quad \text{and} \quad \ln p_i^W \sim N(\mu_{p_i^W}, \sigma_{p_i^W}^2) \quad \text{for} \quad i = 1 \text{ and } 2 \text{ and}$$
$$\ln p_Z \sim N(\mu_{p_Z}, \sigma_{p_Z}^2),$$

where μ_Y and σ_Y^2 are mean and variance of the random variable *Y*.

Since we assume that all the exogenous variables are stationary, the percentage deviation of a variable *Y* from its steady state is defined as $\tilde{Y} \equiv \ln Y - E \ln Y$. Following this notion, we can derive the covariance of labor income fluctuations in economy **R** and economy **F**.

$$\text{cov}(\tilde{w}_1^R, \tilde{w}_2^R) = \frac{1-2\cdot\gamma}{(1-\gamma)^3} \cdot \sigma_{A_1}^2 + \left(\frac{\gamma}{1-\gamma}\right)^2 \cdot (1-\delta) \cdot \sigma_{p_2^W}^2 + \left(\frac{\gamma}{1-\gamma}\right)^2 \cdot (1-\delta) \cdot \sigma_{p_Z}^2$$

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[15] The equilibrium of economies **R** and **F** is described in Appendix 2.

$$\mathrm{cov}(\hat{w}_1^F, \hat{w}_2^F) = \frac{-\gamma}{1-\gamma} \cdot \sigma^2_{p_1^w} + \frac{\gamma \cdot \beta}{(1-\gamma)\cdot(1-\beta)} \cdot \sigma^2_{p_Z} \text{ , where } \delta \equiv \frac{\gamma}{1-\gamma} - \frac{\beta}{1-\beta} \qquad (10)$$

<u>Result 5</u>: When the shares of imported factor are similar across sectors ($\gamma \approx \beta$), and they are not greater than 50%, economy **R**'s covariance of labor income fluctuations between sectors is larger than that of economy **F**. At the same time, openness to trade will be higher in economy **F**.

Result 5 indicates that under certain conditions, the economy with trade restriction has stronger co-movement of labor income growth rates and less openness to trade. This implies that less open economy has smaller sectoral labor income volatility.[16] The effect of openness to trade on intersectoral fluctuation primarily results from the differences in price flexibility. As mentioned before, labor is immobile, and therefore wage equalization does not hold in these economies. In this case, another channel through which sector-specific shocks diffuse into the whole economy is the adjustment of final goods prices. In the open economy, the domestic relative price of final goods is fixed at the international relative price. For this reason, sector-specific shocks do not proportionally affect labor incomes, and thus they eventually lead to asymmetric income fluctuations. On the other hand, the economy with trade restriction has more correlated labor income fluctuations between sectors since sector-specific shocks can affect labor income of the other sector through relative (domestic) price adjustment.

Equation (10) also provides some intuitions on how different the effects of external shocks can be in these two economies. In the model, we have three kinds of external shock: shocks to each of two final goods and a shock to the intermediate good. Suppose that the shares of imported factor are similar in two sectors, and they are smaller than 50% in both sectors ($\gamma \approx \beta < 0.5$). In this case, we can see that an increase in the

[16] Actually, the condition that we propose in Result 5 is not the only case that supports the result. Unless the magnitude of shocks is extremely different and/or the intermediate good shares are drastically different in the two sectors, we will have a positive relationship between openness to trade and intersectoral fluctuation.

shock to the intermediate good price ($\sigma^2_{p_Z}$) has a positive effect on the covariance of sectoral income volatility in both economies. Since the intermediate good is used in both sectors, the external shock to the intermediate good price works as a symmetric shock in these economies.[17]

However, the external shocks to final good prices have different effect on intersectoral fluctuation in these economies. As we can see from equation (10), the external shocks to final good prices work as a common shock in economy **R**, while they work as a sector-specific shock in economy **F**. Since domestic price adjustment mechanism works in the economy with trade restriction, favorable (unfavorable) external shocks to X_2 increase (decrease) labor incomes not only in sector 2 but also in sector 1. On the other hand, the external shocks to the price of X_1 boost intersectoral fluctuation in the open economy since they hardly affect the labor income of sector 2.

Result 6: In economy **F**, the import of X_1 increases as sectoral difference in the productivity levels rises.

Another important result of this model is that as sectoral productivity difference increases, production of the final good with lower productivity is more likely to fall short of domestic demand for the good. This finding is analogous to conventional trade theories: economies specialize themselves to the industry where they have comparative advantage. Therefore, the modeled economy imports X_1 due to low productivity in the domestic production. The trade barrier assumed in the model can be rationalized in this situation because many governments regulate international trade in order to protect low-productivity (often called 'infant') industries.[18]

In sum, the model shows that under reasonable conditions, (*i*) the more open an economy is, the larger intersectoral fluctuation, (*ii*) external shocks are likely to decrease

[17] For most of oil-importing countries, oil price shocks are a good example of this type of shocks.
[18] The demand for infant industry protection is greater especially when labor is immobile due to technical reasons.

intersectoral fluctuation in less open economies while they can increase intersectoral fluctuation in more open economies, (*iii*) the trade pattern and policy of an economy can be affected by sectoral difference in the productivity levels, and (*iv*) these tendencies become more prominent as the intermediate good shares, γ and β, get close to zero.

3. The Specification and Identification of Empirical Models

Viewing $\sqrt{\operatorname{var}\left(\Delta \ln y_{it} \mid t\right)}$ as unobservable 'population' intersectoral fluctuation – a macroeconomic measure of sector-specific income risks, we take $s_{n,t}$, the sample standard deviation of sectoral income growth rates, as its unbiased estimator in accordance with Result 3. The baseline equations for intersectoral fluctuation and government expenditure, respectively, are as follows.

$$ASY_{jt} = c_j + y_t + \alpha_1 GOV_{jt} + \alpha_2 OPN_{jt} + \alpha_3 OPN_{jt} \cdot TOT_{jt} + \alpha_4 TOT_{jt} + v_{jt} \tag{11}$$

$$GOV_{jt} = c'_j + y'_t + \beta_1 ASY_{jt} + \beta_2 DEP_{jt} + \beta_3 INC_{jt} + \beta_4 POP_{jt} + \beta_4 LND_{jt} + u_{jt} \tag{12}$$

where subscripts *j* and *t* stand for country and year, respectively;
v and u are the error terms of the system of equations;

$ASY =$ intersectoral fluctuation;	$GOV =$ government size;
$y_t =$ year *t* specific intercept;	$c_j =$ region *j* specific intercept;
$OPN =$ openness to trade;	$TOT =$ terms of trade shock;
$DEP =$ dependency ratio;	$INC =$ log of real GDP per capita;
$POP =$ log of population;	$LND =$ log of land area in square kilometer.

Equation (11) shows the sources of intersectoral fluctuation, *ASY*. As shown in equation (2), the size of government reduces intersectoral fluctuation, and thus we expect the coefficient $\alpha_1 < 0$. Equation (11) also regards openness to trade, external shocks, and their interaction as important determinants of intersectoral fluctuation. As discussed in Section II.2, more open economies have larger intersectoral fluctuation. Moreover, the effect of external shocks on intersectoral fluctuation depends on the openness to trade:

external shocks are likely to decrease sector-specific income risks in less open economies while they can increase the risks in more open economies. For this reason, openness to trade, terms of trade shocks, and their *interaction* are included in the equation. Based on the argument in Section II.2, we expect $\alpha_4 > 0$, $\alpha_5 > 0$ and $\alpha_6 < 0$. The economic interpretation of these coefficients will be further discussed in the next section.

The second equation of our system, equation (12), is an extension to the usual model of the determinants of government size. The main difference is the addition of intersectoral fluctuation due to the theoretical result by equation (3) that governments facing larger intersectoral fluctuation tend to spend more. We thus expect $\beta_1 > 0$. Other variables are those typically considered in the literature. Log of real GDP per capita is included to examine Wagner's law: the demand for government services is income elastic, so that the share of government expenditure is expected to rise with income. There is also a vast political economy literature that studies the determinants of government size. Alesina and Spolaore (1997) suggest that smaller countries will have a larger government as a percentage of GDP because of fixed costs in setting up a government. We measure this using log of population and log of land area in square kilometer. Another explanatory variable is the dependency ratio, defined as the percentage of non-working population in total population. In addition to these explanatory variables, dummy variables are added into both equations (11) and (12) to capture year-specific and region-specific effects.

Our discussion in Section II.2 reveals that the interrelationship between the size of government and intersectoral fluctuation depends on openness to trade. Openness to trade may be an important determinant of intersectoral fluctuation, and, for this reason, a government would implement restrictive trade policies when it wants to reduce economic uncertainty. As a result, not only the size of government but also the extent to which an economy is integrated with the rest of the world is likely to interact with the sector-specific income risks faced by the economy.

There are many studies that suggest how to handle the endogeneity problem of openness to trade, while empirically analyzing the growth effect of openness. Among the various approaches to instrument for trade/GDP ratios, the Frankel and Romer approach

(1996, 1999) is most commonly used in this line of research. Based on a gravity model for bilateral trade flows, they construct the instrument for international trade by projecting bilateral trade flows on geographical characteristics that are “as exogenous a determinant as an economist can ever hope to get.” However, it should be noted that all previous studies that follow the Frankel and Romer approach perform ‘cross-sectional’ analysis. Since geographical characteristics rarely change over time, we can have only cross-section variations from this approach. For this reason, this study that analyzes international panel data should find a new instrumental variable that captures not only cross-section variations but also time series variations of openness to trade.[19]

Along with other exogenous variables in the system of equations, we use sectoral productivity difference as an IV to handle the possible endogeneity of openness to trade, following Result 6 that international trade policy may be affected by sectoral productivity difference. According to conventional trade theories, an economy with higher sectoral productivity difference is better off with more involvement in international trade. Through international trade, the economy specializes in more productive sectors, and as a result, the overall welfare of the economy can be improved. However, trade liberalization does not necessarily lead to welfare improvement if labor mobility of an economy is limited. In such cases, the government may need to protect low-productivity industries by implementing restrictive trade policies. In the presence of opposing impacts on welfare, the actual effect of sectoral productivity difference on the openness to trade should be answered by empirical analysis.[20]

The identification strategy for estimating equations (11) and (12) is that we first attempt to estimate each equation using possible IV’s. If test statistics combined with theory lend support to identification of each of the equations, we then conduct joint 3SLS estimation. As suggested in Sections II.1 and II.2, intersectoral fluctuation, government size, and openness to trade are endogenous variables in the system of equations. These

[19] Lagged measure of openness is often used to resolve the endogeneity problem of openness. However, as Rodrik (1998) mentioned, it does not fully get around this problem.

[20] The first stage regression shows that sectoral productivity difference has a negative effect on openness to trade.

endogenous variables are affected by exogenous variables in direct and indirect ways. For many variables, their exogeneity is unambiguous. For example, reverse feedbacks toward dependency ratio, population, land area, and terms of trade shocks are hardly probable. However, we need more rigorous justification for some other variables such as income level and sectoral productivity difference. We thus do not rely on a particular set of identifying assumptions; rather we begin with an erroneous specification (e.g., OLS), and then examine how corrections using IV's improve the results, followed by the discussion on the validity of identifying assumptions.

Discussion on identifying assumptions: the preferred specification

Many economists have emphasized the role of international trade as a driver of productivity change.[21] According to this view, openness to trade has a positive effect on productivity and income, which implies that we cannot easily rule out the causality running from international trade to income and sectoral productivity difference. On the other hand, Rodrik, Subramanian, and Trebbi (2004) shows that openness to trade is almost always insignificant and often enters the income equation with the "wrong" (i.e., negative) sign, suggesting that the positive effect of trade reported in the previous literature would suffer from an identification problem.[22] Based on the empirical findings of Rodrik et al. (2004), this study rules out such reverse feedbacks.

Another identification assumption is that while the size of government is affected by income level, government size has no simultaneous effect on income level. However, this assumption is inconsistent with our theoretical framework since the main arguments in Section II.1 are based on Keynesian assumptions, which suggest a positive effect of government spending on income level. To resolve this conceptual conflict, this study follows two strategies. The first strategy is based on the assumption that government size

[21] Rodriguez and Rodrik (2001) provide an excellent survey on this issue while maintaining a critical view.
[22] Rodrik et al (2004) control for the quality of institutions using instrumental variables that are recently developed by Acemoglu et al (2001). Their results indicate that the quality of institutions "trumps" everything else. In addition to the insignificance of trade, conventional measures of geography have, at best, weak direct effects on income once institutions are controlled for, although geographic factors have a strong indirect effect by influencing the quality of institutions.

and its fluctuation cannot affect the *trend* component of aggregate income. The expansionary effect of government spending is generally expected when the effective demand falls short of natural (or potential) level of income. For this reason, Keynesian fiscal policies are commonly implemented for the purpose of stabilization, which deals with the second moment of income. Based on this view that government size is irrelevant to the determination of the income trend, this study uses the trend component of real GDP per capita as an income measure, which should rule out the reverse feedback from government size to aggregate income level.[23] However, one may argue that government spending can change the income trend. When technological progress is endogenously determined by private investment, and government spending crowds out such investment, fiscal policy of the government can alter the income trend. As a robust test of the first strategy, we not only check the overidentifying restrictions test result, but also exclude the income variable from the IV's, and see the difference. Usually an arbitrary exclusion causes biases, but we can draw some useful implications in our particular setting.[24]

The last assumption for the identification is that there is no direct relationship between the size of government and openness to trade. However, if globalization deteriorates the income inequality of an economy, more open economy may want to neutralize this negative impact of globalization by increasing government redistribution, which in turn raises government expenditure. Nevertheless, the empirical literature on this issue has found no decisive evidence whether openness to trade increases income inequality or not. Instead, Wei and Wu (2001) find a negative association between openness to trade and inequality. Using the OECD dataset, we examine the plausibility of this relationship by regressing the Gini coefficients of OECD countries on openness to trade. The OLS estimation result shows that the effect of trade openness on income

[23] The trend component of log of real per capita GDP is computed using Hodrick-Prescott Filter with a smoothing parameter of 400.

[24] This exclusion provides an opportunity to check the endogeneity of *INC* and other useful information. First, if *INC* is endogenous, 2SLS estimation of equation (11) with this exclusion will produce different but unbiased estimates. Second, exclusion of a relevant variable causes mis-specification problems in equation (12), but at least the primary variable of interest, ASY, does not seem to be correlated with *INC*. So we can still obtain useful information with the exclusion while checking its validity.

inequality is statistically insignificant and negative, which implies that this possibility is without empirical relevance.[25]

In our preferred specification, equation (11) is identified using sectoral productivity difference (*PRDFF*), population (*POP)*, land area (*LND*), income (*INC*), and dependency ratio (*DEP*). In a similar fashion, equation (12) is identified using sectoral productivity difference (*PRDFF*) and terms of trade shock (*TOT*).[26] The relevance and validity of these instrumental variables are statistically tested in Section III.2.

III. Empirical Analysis

1. Data and the Sample

The novel idea of this paper is to measure economic uncertainty using sector-specific income risks. Using international panel data, we compute intersectoral fluctuation of labor income growth rates as follows:

$$ASY_t = s_{n,t} \equiv \sqrt{\frac{\sum_{j=1}^{M} n_j \cdot (\Delta \ln y_{jt} - \overline{y}_t^n)^2}{1 - \sum_{j=1}^{M} n_j^2}} \, , \qquad (14)$$

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[25] The Gini coefficients are from Government Financial Statistics (2001, IMF). The OLS regression uses 125 observations and it controls year-specific and region-specific effects. A negative coefficient implies that more open economies tend to have more equitable income distribution.

[26] The argument made for the identification of equations (11) and (12) implicitly introduces equation (13) into the system of equations:

$$\begin{aligned} OPN_{it} &= \gamma_0 + \gamma_1 \cdot ASY_{it} + \gamma_2 \cdot yd_t + \gamma_3 \cdot cd_j \\ &\quad + \gamma_4 \cdot POP_{it} + \gamma_5 \cdot LND_{it} + \gamma_6 \cdot INC_{it} + \gamma_7 \cdot PRDFF_{it} + \upsilon_{it} \end{aligned} \qquad (13)$$

where $PRDFF =$ sectoral productivity differences, and υ is error term.

where n_j is the employment share of each sector, $\overline{y}_t^n \equiv \sum_{j=1}^{M} n_j \cdot \Delta \ln y_{jt}$ is the weighted average of labor income growth rate as shown in the previous section. The numerator inside the square root measures the deviation of sectoral labor income growth from its average. The denominator can be interpreted as an industry-concentration index. As the industries are more equal in employment, this index becomes larger. It is designed to parse out the international differences caused by differences in industry-concentration.

The data used to construct this variable is available from the STAN database published by OECD. For the computation of sectoral labor income growth, we first calculate average productivity of each industry by dividing 'value added' by 'total employment.'[27] The labor income growth of each sector is computed using the growth rate of sectoral average labor productivity. By implicitly assuming that the labor share is stable, the growth rate of marginal labor productivity (and labor income) is equal to that of average labor productivity. It should be noted that since the growth rate of labor productivity is a nominal measure, a problem may exist if price levels are significantly different across sectors. Otherwise, intersectoral fluctuation would be a real variable because the effect of price changes on intersectoral fluctuation will be canceled out by subtracting sectoral growth rates from the average. Table 1 describes how the STAN database defines industries. This study involves 17-industry classifications: all 1-digit industries except 'community social and personal services' plus 2-digit industries of manufacturing sector.[28]

[27] Available sectoral employment measures are 'total employment' (all persons engaged in domestic production), 'number of employees' (total employment minus the self-employed and unpaid family workers), 'full-time equivalent' of the previous two measures, and 'total hours worked'. While these five employment measures produce qualitatively the same empirical results, the variations in the sample size are substantial depending on which variable we use. We use 'total employment' as a measure of employment since it provides more observations than any other measure does. The available sectoral output measures are 'gross output at current price', 'value added at current price', and 'quantity indices' for gross output and value added. Like employment data, the choice of sectoral output measure does not make any significant difference in the empirical result. We use 'value added at current price' as a measure of output.

[28] Since 'community social and personal services' are a part of government expenditure, a measure of intersectoral fluctuation excludes them. The study was also performed on 18-industry classifications, which included 'community social and personal services' and on 16-industry classifications, which excluded 'mining and quarrying'. There were no significant differences in the empirical results.

Sectoral productivity difference is defined in a similar fashion. Since sectoral labor productivity level is a nominal measure, the international variations in either price level or exchange rate may exaggerate sectoral labor productivity differences. To counter this problem, we define sectoral productivity difference (*PRDFF*) as the weighted average of deviations in logs of sectoral labor productivity.

$$PRDFF \equiv \sum_{j=1}^{M} n_j \cdot \left(\ln y_{jt} - \ln y_t\right)^2 , \qquad (15)$$

where y_{jt} is the average labor productivity of sector j and y_t is the aggregate labor productivity.[29]

We use three different measures of government size in estimation: the share of government expenditure in GDP, the share of government spending in GDP, and the share of government subsidies and transfers in GDP. By definition, government expenditure is equal to the sum of government spending, subsidies, and transfers. These variables are constructed using the Government Financial Statistics published by the IMF.

Openness to trade is defined as the sum of exports and imports relative to GDP. This variable is available in Penn-World Table 6.1. To construct the shocks to the terms of trade, we first define the terms of trade as the ratio of the export unit value index to the import unit value index. This data is from UN dataset, and it is available from 1980 to 2001. Using the panel observations of the terms of trade, we compute its average annual percentage change over the sample period for each OECD country. Then, the terms of trade shock is defined as the absolute value of the difference between the annual percentage changes in the terms of trade and the average, which implies that we treat the percentage deviations of the terms of trade in a symmetric way.[30] The sources of other variables are as follows: real GDP per capita is from Penn-World Table 6.1, and the

[29] We can reflect the industry-concentration index in the definition of *PRDFF*. However, it does not make any significant difference in the empirical results. It should be noted that the industry-concentration index is not necessary in the definition of *PRDFF* unlike *ASY*. In the construction of *ASY*, one of required conditions is the unbiasedness of *ASY*, which is satisfied by reflecting the concentration index.

[30] The use of the deviation squared does not make any critical difference in the estimation results.

dataset in Bernanke and Gurkaynak (2001) is used for the construction of dependency ratio and population. Land area is available from World Development Indicator published by the World Bank. The full set of variables limits our empirical analysis to 15 out of 21 OECD countries available in the STAN database. These 15 countries are then classified into five groups to assign for regional dummy variables.[31]

As mentioned in Section II.1, the stabilization effect that this study focuses on is not of counter-cyclical fiscal policies but of 'acyclical' government size. To be consistent with the purpose of this study, the sample variations of government size should be mainly driven by cross-sectional variations. To compare the time series variation and the cross-sectional variation of government size, we decompose the total variation of government size (*GOV*) into three parts. When $E\left(GOV_{it}\right)=\mu$ and $E\left(GOV_{it}\,|\,i\right)=\mu_i$,

$$\begin{aligned} \text{var}(GOV_{it}) &= E\left(GOV_{it}-\mu\right)^2 = E\left[\left(GOV_{it}-\mu_i\right)+\left(\mu_i-\mu\right)\right]^2 \\ &= E\left(GOV_{it}-\mu_i\right)^2 + E\left(\mu_i-\mu\right)^2 + 2\cdot E\left[\left(GOV_{it}-\mu_i\right)\cdot\left(\mu_i-\mu\right)\right]. \end{aligned}$$

In this decomposition, $E\left(GOV_{it}-\mu_i\right)^2$ represents the time series variation of government size and $E\left(\mu_i-\mu\right)^2$ stands for the cross-sectional (international) variation of government size.

The sample statistics of government size are summarized in Table 2. The sample covariance, $E\left[\left(GOV_{it}-\mu_i\right)\cdot\left(\mu_i-\mu\right)\right]$ is negligible so that the variance of government size actually consists of time series variation and cross-sectional variation of government size. As we can see from Table 2, more than 90% of total variations of government size result from cross-sectional variation in all three measures of government size. The same computation also shows that the variance of openness to trade is .083, about 95% of which results from cross-sectional variation of openness. The general sample properties can be summarized as follows: (*i*) Subsidies and transfers (TRSF) are more volatile than

[31] This study classifies 15 OECD countries into 5 regional groups: (1) Austria, Belgium, Netherlands, (2) Italy, Spain, (3) Australia, Canada, United Kingdom, United States, (4) Denmark, Finland, Norway, Sweden, (5) Japan, Korea.

government spending (SPND). Both time series and cross-sectional variations are higher in subsidies and transfers. (*ii*) The correlation between TRSF and SPND is positive so that the variance of government expenditure (EXP) is larger than the sum of the variances of TRSF and SPND. (*iii*) Openness to trade is more volatile than any measure of government size. (*iv*) For TRSF, SPND, EXP, and OPN, more than 92% of total variances result from cross-sectional (or international) variation. The contribution of time series variation is no larger than 8% of total variance.

2. Estimation Results

Table 3 summarizes the estimation results, where the measure of government size is the share of government expenditure in GDP. The first four columns report the estimation results of equation (11) and the others summarize the estimation results of equation (12). In these two sets of results, the first columns report OLS estimates, the second and third ones IV estimates, and the last ones 3SLS estimates. Standard errors are reported in parentheses.[32]

The ASY equation

Not surprisingly, the first column of the *ASY* equation shows that the OLS estimate of *EXP* is a small negative number, statistically insignificant at a 5% level. We first correct for the endogeneity of *EXP* by using the set of IV's: *LAND*, *DEP*, *POP*, *INC*. The corrected estimate of *EXP* turns out –0.13, a greater estimate with statistical significance (see the IV1 column). We are, however, concerned with the low overidentifying restrictions test result of *p*-value=0.02. This result suggests that openness to trade should have been treated as an endogenous variable as our theory section shows. In the third column (IV2), we thus treat *EXP*, *OPN* and *OPN TOT* as endogenous and use

[32] In our single equation estimation, three different covariance matrices of error terms are assumed: homoskedastic (equivalent to IV approach), heteroskedastic, and within-country homoskedastic (but heteroskedastic across countries) covariance. However, this consideration does not contribute to significant differences in either the magnitude or the statistical significance of the estimates. For the concise illustration, we report only IV and 3SLS estimates.

the aforementioned IV's and additional IV of productivity difference for openness to trade. The resulting estimate of EXP is –0.12 with a high statistical significance. The validity of IVs are also supported by the high overidentifying restrictions test result of *p*-value=0.93. We see greater estimates of OPN when treating it as endogenous.

To see the importance of government expenditure in stabilizing intersectoral fluctuation, we examine how much of the variations in intersectoral fluctuation can be explained by the variations in government size using the 3SLS estimates. The sample standard deviations of the government size and intersectoral fluctuation are 0.110 and 0.018, respectively. The estimate predicts that the changes in the government size by its sample standard deviation will cause the changes in intersectoral fluctuation by about 72% of its sample standard deviation.[33] This simple computation roughly shows that about 72% of the sample variations in intersectoral fluctuation can be explained by the sample variations in government expenditure.

The estimation of equation (11) provides another interesting result. As we predicted in Section II.2, economic uncertainty measured by intersectoral fluctuation of labor income growth rates becomes larger as an economy is more open to international trade. While the partial effect of openness to trade on intersectoral fluctuation is smaller than that of government expenditure in absolute value, its effect is still nontrivial. The partial effect of openness to trade on intersectoral fluctuation depends on the terms of trade shocks that an economy faces: $\frac{\partial ASY}{\partial OPN} = 0.034 + 1.094 \cdot TOT$. Evaluating this effect at the sample mean of terms of trade shock (0.03), we can see that the changes in the openness to trade by its sample standard deviations (0.288) can cause a change in intersectoral fluctuation by about 107% of its sample standard deviations (0.018). While our empirical specification differs from that of Rodrik (1998), our finding confirms one of his main hypotheses: a more open economy faces higher economic uncertainty.

In Section II.2, we show that external shocks are likely to decrease intersectoral fluctuation in less open economies while they can increase sector-specific income risks in

[33] This result is derived from the following calculation: (.11*.117)/.018=.715.

more open economies. The estimation provides a consistent result with our theoretical prediction. According to our estimation result, the partial effect of terms of trade shock is $\frac{\partial ASY}{\partial TOT} = -0.557 + 1.094 \cdot OPN$.[34] Using this partial effect, we can compute a cutoff value of openness to trade, $open^C$. Since $open^C = \frac{0.557}{1.094} = 0.51$, the estimation result implies that when the openness to trade of an economy is higher (lower) than 50%, an increase in the terms of trade shock raises (reduces) intersectoral fluctuation.[35]

The EXP equation

In the estimation of the government equation (12), we find a similar pattern as in that of the ASY equation (11). The first column under the *EXP* section shows that the OLS estimate of *ASY* is a small negative number, statistically insignificant at a 5% level. We first correct for the endogeneity of *ASY* by using the set of IV's: *TOT*, *OPN*, and *OPN*TOT* treating *OPN* as exogenous. The corrected estimate of *ASY* turns out 5.29, a much greater estimate with statistical significance (see the IV1 column). This result is, however, overshadowed by the low overidentifying restrictions test result of *p*-value=0.08. Put differently, it suggests that *OPN* is again endogenous. To deal with this endogeneity, we thus use *TOT* and *PRDFF* as another set of IV's (see the third column (IV2)). The estimate of *ASY* is now 4.02 with a high statistical significance, and the validity of IVs is supported by the high overidentifying restrictions test result of *p*-value=0.92.

The estimation results support our theoretical prediction: an economy facing higher economic uncertainty has a larger government. The estimate shows that a country with its intersectoral fluctuation one standard deviation (0.018) higher than the sample average has a government 7.4% larger than the average, which amounts to 70% of the sample standard deviation of government expenditure.

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[34] Since we expect the partial effect of terms of trade shock to be zero in a closed economy, the –0.557 intercept in this equation may be puzzling. It is important to remember that this relationship is the 1st order approximation of a nonlinear equation.

[35] The sample mean of openness to trade is 64%.

It is also worth noting all the other estimates reported in *EXP* column. First, the dependency ratio has a positive effect on the size of government although it is found to be statistically insignificant. The regression result confirms Wagner's law, which states that the share of government expenditure increases with income. Specifically, our estimate of .158 means that when we evaluate this at the sample average of government expenditure (.35), the elasticity of the size of government to income is 1.45.[36] In the interpretation of this number, it should be noted that government expenditure includes all kinds of income redistribution as well as government consumption. Lastly, two measures of country size are found to have opposite effects on government expenditure. Given land area, the economy with more population has larger government expenditure while the economy with broader territories has lower government expenditure for a given population. This finding that an economy that is larger in size of territories but smaller in population has a smaller government is also confirmed in the regression that includes population density instead of population and land area separately.[37] In this case, the congestion (population density) may deserve our attention as one of the factors that explain government expenditure.

Accounting for differences among estimates

At this point, we can explain the differences between OLS and IV estimates.[38] Since endogenous variables exert opposite influences on each other, the simultaneous equation bias will push the estimated coefficient toward zero for OLS estimation.[39] In the case of openness to trade, its partial effect on economic uncertainty is much larger in

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[36] From $\frac{\partial EXP}{\partial \log\left(real\ \ GDP\ per\ capita\right)} = 0.158$, we can derive $\frac{\partial \log EXP}{\partial \log INC} = 1.45$.

[37] We can examine the effect of population density on government size, by imposing the restriction that the absolute values of the coefficients on *POP* and *LAND* are identical. All the estimation results of equation (11) and (12) hardly change by imposing this restriction. The coefficient on population density is .043 and it is highly significant.

[38] A formal test for the relevance of IV approach, which is often called "Hausman Test" is also performed. The test results confirm that the difference between OLS and IV estimates is statistically significant in all cases. The test statistics are available upon request.

[39] Government size has a 'negative' influence on intersectoral fluctuation while the latter has a 'positive' effect on the former.

IV_1 estimation compared to OLS or IV_2 estimation, which treat openness to trade as an exogenous variable by ignoring the reverse feedback from intersectoral fluctuation to openness to trade.[40] Given the implied validity of IV's, we perform 3SLS estimation for efficiency improvement. As expected, last columns of Table 3 show somewhat more statistically significant results.

Using other measures of government size

Tables 4 and 5 summarize the estimation results where government size is measured by the share of government spending in GDP or the share of government subsidies and transfers in GDP. It should be noted that by definition, the sum of government spending and government subsidies and transfers is equal to government expenditure in this empirical study. For this reason, the estimates for equation (12) reported in Table 3 are close to the sum of the estimates reported in Tables 4 and 5.

While the estimation results are similar to those in Table 3, we can see a notable distinction in Table 4. While government spending is effective in reducing intersectoral fluctuation, government spending is less sensitive to the changes in intersectoral fluctuation than government expenditure (or transfers and subsidies). The coefficient on intersectoral fluctuation in Table 4 is smaller than that of Tables 3 and 5. This implies that government resorts to redistributive measures when it deals with sector-specific income risks even though government spending is an effective option for this purpose. This finding is consistent with other studies (Gali, 1994; Sachs and Sala-i-Martin, 1992), which point out that government spending is stabilizing even when it is not designed for a stabilization purpose.

In principle, the redistributive measures of government barely affect intersectoral fluctuation in 'gross' income if the demand side is completely passive in the determination of the equilibrium income. However, Table 5 shows that government

[40] As we can see from the high significance and the drastic differences between instrumented and uninstrumented estimates, the estimation results do not seem to suffer from the presence of weak instrument. In the case of equation (12), the F-statistic for first stage regressions is well above the threshold of 10 suggested by Staiger and Stock (1997), which is relevant when only one endogenous variable is included as a regressor.

subsidies and transfers reduce intersectoral fluctuation. There are two general reasons why we have a stabilization effect of the redistributive measures. First, our sectoral value added data from STAN database includes government subsidies and some taxes in it. For this reason, the redistributive measures may reduce intersectoral fluctuation. Second, consumers allocate spending of the transferred income on the final goods in a proportional way. In this case, the transfers to consumers and the government spending have qualitatively equivalent effect on intersectoral fluctuation. As mentioned before, we can see from Tables 4 and 5 that the response of government subsidies and transfers to intersectoral fluctuation (3.230 in IV column) is much greater than that of government spending (0.859). This implies that government does not think its spending is an active policy option for the stabilization of intersectoral fluctuation although government spending is almost as effective as government subsidies and transfers for this purpose. This tendency may be attributable to the fact that redistributive policies put less pressure on government debt adjustment since government tax and transfer system works as social insurance, directing resources from temporarily good sectors to temporarily bad sectors. In addition, if government spending and redistributive measures have qualitatively similar effects on income uncertainty and the connection between government spending and consumer utility is presumably weak, then individuals would prefer redistributive measures.

Another miscellaneous finding is that government subsidies and transfers are less elastic with respect to income changes than government spending. From Table 3, we show that the elasticity of government expenditure is 1.45. The corresponding figures for government spending and government subsidies and transfers are 1.51 and 1.41, respectively (see in Tables 4 and 5). However, it should be noted that government subsidies and transfers are on average larger than government spending and thus their impact on government expenditure is greater even if they are less elastic.[41] In the overall elasticity of 1.45, 59% of the response comes from increases in government subsidies and

[41] The average government expenditure share is 35.1%, which is the sum of government spending share (13.6%) and subsidies and transfers share (21.5%).

transfers and the remaining 41% comes from increases in government spending. In the statistical point of view, the choice of government size makes little differences in the results of overidentification test. As reported in Tables 4 and 5, we cannot reject the overidentifying restrictions at a conventional significance level.

Checking the validity of INC as IV

As argued in Section II.3, the use of income trend may not perfectly handle the potential endogeneity of the income variable. As a robustness test, we re-estimate equations (11) and (12) with *INC* excluded from equation (12). Tables 6 and 7 summarize the estimation results of our key endogenous variables of interest. First, comparing the top panel (using *INC* as IV) with the bottom panel (not using) of Table 6, we find that all the estimates of in equation (11) including *EXP* are hardly affected by the exclusion of *INC* from the identifying restrictions. This lends support to our use of income trend for the *INC* variable. Second, reading Table 7 in the same way as Table 6, we see that while some estimated coefficients of equation (12) change with the exclusion of *INC*, the impact of the primary variable of interest, *ASY*, does not change drastically.

IV. Summary and Conclusion

While there has been an extensive empirical literature on the stabilization effect of government spending on income, no existing paper has examined the interaction between economic uncertainty and government size as the stabilization effort of a government. This paper addresses this issue within a Keynesian framework utilizing the between-sector income volatility as a new measure of economic uncertainty.

Our empirical model allows for the interaction of government size and economic uncertainty in the open economy context. Taking into account the interaction in accordance with our simple models, we obtained the following main results. As Rodrik

(1998) hypothesized, this study finds that an economy with high intersectoral fluctuation will have a large government, but at the same time, the size of government has a substantial effect on the stabilization of intersectoral fluctuation. Examining different measures of government size, we also find that government spending is not an active policy option for stabilization, even though it is almost as effective as the other component of government expenditure in reducing uncertainty.

In the open economy context, we also obtained another interesting result that openness to trade and external shocks are important determinants of economic uncertainty. In open economies, sector-specific shocks cannot be diffused into the whole economy since the domestic price of the final goods of each sector is fixed at the international price. For this reason, more open economies face more sector-specific income risks and the impact of openness to trade on intersectoral fluctuation further rises as an economy is exposed to more intense external shocks. This study also finds that the effect of terms of trade shock on intersectoral fluctuation depends on the openness of an economy. When the sum of export and import relative to GDP is larger (smaller) than 50%, terms of trade shock increases (decreases) intersectoral fluctuation.

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Table 1. Definition of Industries

Industry	Subcategory	Definition
AG00		Agriculture, hunting, forestry and fishing
MQ00		Mining and quarrying
MA00		Total manufacturing (=MA00+⋯+MA10)
	MA01	Food products, beverages and tobacco
	MA02	Textiles, textile products, leather and footwear
	MA03	Wood and products of wood and cork
	MA04	Pulp, paper, paper products, printing and publishing
	MA05	Chemical, rubber, plastics and fuel products
	MA06	Other non-metallic mineral product
	MA07	Basic metals and fabricated metal product
	MA08	Machinery and equipment
	MA09	Transport equipment
	MA10	Manufacturing nec; recycling
EL00		Electricity, gas and water supply
CN00		Construction
WR00		Wholesale and retail trade; restaurants and hotels (=WR01+WR02)
	WR01	Wholesale and retail trade; repairs
	WR02	Hotels and restaurants
TR00		Transport and storage and communication (=TR01+TR02)
	TR01	Transport and storage
	TR02	Post and telecommunications
FI00		Finance, insurance, real estate and business services (=FI01+FI02)
	FI01	Financial intermediation
	FI02	Real estate, renting and business activities
CS00		Community social and personal services

Table 2. Decomposition of Variance

		EXP[1]			SPND[2]			TRSF[3]		
		total[5]	T-var[6]	C-var[7]	total	T-var	C-var	total	T-var	C-var
Obs. = 251[8]	Variation	.0121	.0007	.0114	.0017	.0001	.0016	.0064	.0004	.0059
	% of total[4]		6%	94%		8%	92%		7%	93%

Notes)
1: government expenditure share in GDP,
2: government spending share in GDP,
3: government subsidies and transfers in GDP,
4: T-var/total or C-var/total,
5: variance of government size,
6: time series variation of government size,
7: cross-section variation of government size,
8: 15 OECD countries.

Table 3. Estimation Results: Government Expenditure

Dependent Variable	ASY				EXP			
Estimates	OLS	IV1	IV2	3SLS	OLS	IV1	IV2	3SLS
EXP	-.030 (.018)*	-.127 (.028)***	-.121 (.036)***	-.117 (.034)***				
OPN	.022 (.007)***	.039 (.008)***	.030 (.020)	.034 (.019)				
OPN*TOT	.187 (.112)*	.123 (.113)	1.348 (.799)*	1.095 (.736)				
TOT	-.090 (.064)	-.068 (.064)	-.685 (.405)*	-.556 (.373)*				
ASY					.504 (.208)**	5.287 (2.184)**	4.023 (1.525)***	4.018 (1.524)
POP					.008 (.006)	.037 (.0168)**	.029 (.013)**	.028 (.013)
LAND					-.042 (.003)***	-.052 (.007)***	-.049 (.005)***	-.050 (.005)
DEP					.411 (.245)*	.500 (.426)	.477 (.350)	.462 (.320)
INC					.0764 (.023)***	.188 (.064)***	.159 (.048)***	.162 (.043)
Overid. test	---	.016	.926	.944	---	.016	.926	.944
Obs.	251				251			

Notes)
1. Standard deviations in parenthesis.
2. Overid. test: p-value of overidentifying restriction test
3. For *ASY* equation, IV_1 = using *LAND, DEP, POP, INC* as IV's while treating only *GOV* as endogenous
IV_2 = using *LAND, DEP, POP, INC, PRDFF* as IV's while treating both *GOV* and *OPN* as endogenous;
4. For *EXP* equation, IV_1 = using *TOT, OPN, OPN*TOT* as IV's, while treating *OPN* as exogenous
IV_2 = using *TOT, PRDFF* as IV's, while treating *OPN* as endogenous;
5. *ASY*: intersectoral fluctuation; *OPN*: openness to trade; *TOT*: terms of trade shock
POP: log of population; *LAND*: log of land area in square kilometer; *DEP*: dependency ratio
INC: log of real GDP per capita trend;
6. Year-specific and country-specific intercepts are all controlled in all estimation.

Table 4. Estimation Results: Government Spending

Dependent Variable	ASY				SPND			
Estimates	OLS	IV1	IV2	3SLS	OLS	IV1	IV2	3SLS
SPND	-.118 (.035)***	-.193 (.046)***	-.201 (.067)***	-.190 (.062)				
OPN	.026 (.007)***	.032 (.007)***	.017 (.020)	.020 (.019)				
OPN*TOT	.185 (.109)*	.172 (.105)*	1.848 (.844)**	1.607 (.768)				
TOT	-.088 (.063)	-.084 (.060)	-.931 (.430)*	-.805 (.391)				
ASY					.005 (.091)	1.865 (.882)**	.832 (.517)*	.849 (.516)
POP					-.003 (.003)	.008 (.007)	.002 (.004)**	.001 (.004)
LAND					-.023 (.001)***	-.027 (.003)***	-.025 (.002)***	-.025 (.002)
DEP					.502 (.107)***	.537 (.172)***	.520 (.119)***	.529 (.116)
INC					.050 (.010)***	.093 (.026)***	.069 (.016)***	.071 (.015)
Overid. test	---	.001	.922	.800	---	.270	.589	.800
Obs.	251				251			

Notes) See the notes in Table 3.

Table 5. Estimation Results: Government Subsidies and Transfers

Dependent Variable	ASY				TRSF			
Estimates	OLS	IV1	IV2	3SLS	OLS	IV1	IV2	3SLS
TRSF	.001 (.025)	-.300 (.074)***	-.271 (.087)***	-.277 (.084)				
OPN	.017 (.007)**	.045 (.011)***	.045 (.024)*	.051 (.023)				
OPN*TOT	.207 (.112)*	.065 (.139)*	.759 (.890)	.421 (.861)				
TOT	-.096 (.064)	-.049 (.078)	-.396 (.449)	-.226 (.434)				
ASY					.499 (.174)***	3.422 (1.499)**	3.819 (1.217)***	3.221 (1.212)
POP					.012 (.005)**	.029 (.012)**	.028 (.0100)***	.028 (.010)
LAND					-.019 (.003)***	-.025 (.005)***	-.025 (.004)***	-.025 (.004)
DEP					-.092 (.205)	-.037 (.292)	-.0413 (.279)	-.100 (.272)
INC					.027 (.019)	.095 (.044)***	.090 (.038)**	.087 (.035)
Overid test	---	.196	.546	.920	---	.067	.913	.920
Obs.	251				251			

Notes) See the notes in Table 3.

Table 6. Government Size Effect on Uncertainty: using INC as IV vs. not using

Partial Effect on	Estimation Method	EXP		SPND		TRSF	
		EXP	OPN	SPND	OPN	TRSF	OPN
using INC as IV							
ASY	IV_1	-.117	.066	-.191	.068	-.277	.064
		(.034)	(.012)	(.062)	(.013)	(.084)	(.013)
	IV_2	-.124	.042	-.192	.037	-.283	.046
		(.028)	(.008)	(.045)	(.007)	(.070)	(.010)
	OLS	-.030	.028	-.118	.032	.001	.023
		(.017)	(.006)	(.034)	(.006)	(.024)	(.006)
not using INC as IV							
ASY	IV_1	-.120	.069	-.209	.074	-.277	.062
		(.036)	(.014)	(.074)	(.018)	(.083)	(.014)
	IV_2	-.119	.041	-.181	.036	-.272	.045
		(.029)	(.008)	(.048)	(.007)	(.072)	(.009)
	OLS	-.030	.028	-.118	.032	.001	.023
		(.017)	(.006)	(.034)	(.006)	(.024)	(.006)

Notes)
1. IV_1 = IV estimation assuming that both GOV and OPN are endogenous
2. IV_2 = IV estimation assuming that only GOV is endogenous
3. Partial effect of openness is evaluated at the sample average of TOT (.03).

Table 7. Uncertainty Effect on Government Size:

INC included vs. excluded in equation (12)

Partial Effect on	EXP		SPND		TRSF	
Estimation Method	IV	OLS	IV	OLS	IV	OLS
INC included						
ASY	4.089	.495	.859	-.008	3.230	.503
	(1.528)	(.194)	(.517)	(.085)	(1.214)	(.163)
INC excluded						
Estimation Method	IV	OLS	IV	OLS	IV	OLS
ASY	3.102	.358	.399	-.090	2.703	.448
	(1.226)	(.197)	(.438)	(.088)	(1.007)	(.162)

APPENDIX 1

Proof of Result 1:

Proof: $\lambda_i \equiv \frac{G_i}{N_i \cdot y_i} = \frac{1}{y_i} \cdot \frac{\alpha_i}{N_i} \cdot G = \frac{\lambda}{y_i} \cdot \frac{\alpha_i}{n_i} \cdot y = \lambda$ since $\alpha_i \equiv \frac{G_i}{G}$ and $\alpha_i = \frac{y_i}{y} \cdot n_i \equiv \gamma_i$.

Proof of Result 2:

Proof: Since the proof about expectation is straightforward, we skip it. The variance conditional on t is:

$$\mathrm{var}(\Delta \ln y_{it} \mid t) = E[(\Delta \ln y_{it} - E(\Delta \ln y_{it} \mid t))^2 \mid t]$$

$$= (1-\lambda)^2 \cdot E[(\varepsilon_{it} - E(\varepsilon_{it} \mid t))^2 \mid t] = (1-\lambda)^2 \cdot \mathrm{var}(\varepsilon_{it} \mid t) = (1-\lambda)^2 \cdot \sigma_\varepsilon^2 .$$

Proof of Result 3:

Proof: we prove the unbiasedness of $\overline{y}_t^n$ and $s_{n,t}^2$. The identical steps apply to the proof of the unbiasedness of $\overline{y}_t^\gamma$ and $s_{\gamma,t}^2$. First, we prove the unbiasedness of $\overline{y}_t^n$.

$$E(\overline{y}_t^n \mid t) = E(\sum_{j=1}^M n_j \cdot \Delta \ln y_{jt} \mid t) = \sum_{j=1}^M n_j \cdot E(\Delta \ln y_{jt} \mid t) = \sum_{j=1}^M n_j \cdot [\theta + (1-\lambda)\cdot \mu_t] = \theta + (1-\lambda) \cdot \mu_t$$

$$= E(\Delta \ln y_{it} \mid t) .$$

The unbiasedness of $s_{n,t}^2$ means that $E(s_{n,t}^2 \mid t) = \mathrm{var}(\Delta \ln y_{it} \mid t) = (1-\lambda)^2 \cdot \sigma_\varepsilon^2$.

$$E(s_{n,t}^2 \mid t) = \frac{1}{1-\sum_{j=1}^M n_j^2} \cdot E\left[\sum_{j=1}^M n_j \cdot \left[(\Delta \ln y_{jt} - E(\overline{y}_t^n \mid t)) - (\overline{y}_t^n - E(\overline{y}_t^n \mid t))\right]^2 \mid t\right]$$

$$= \frac{1}{1-\sum_{j=1}^M n_j^2} \cdot E[\sum_{j=1}^M n_j \cdot (\Delta \ln y_{jt} - E(\overline{y}_t^n \mid t))^2$$

$$-2 \cdot \sum_{j=1}^M n_j \cdot (\Delta \ln y_{jt} - E(\overline{y}_t^n \mid t)) \cdot (\overline{y}_t^n - E(\overline{y}_t^n \mid t)) + (\overline{y}_t^n - E(\overline{y}_t^n \mid t))^2 \mid t] .$$

Note that $E(\overline{y}_t^n \mid t) = E(\Delta \ln y_{it} \mid t)$.

$$E(s_{n,t}^2 \mid t) = \frac{1}{1-\sum_{j=1}^M n_j^2} \cdot \{E\left[\sum_{j=1}^M n_j \cdot (\Delta \ln y_{jt} - E(\Delta \ln y_{jt} \mid t))^2 \mid t\right]$$

$$-2 \cdot E\left[(\overline{y}_t^n - E(\overline{y}_t^n \mid t)) \cdot \sum_{j=1}^M n_j \cdot (\Delta \ln y_{jt} - E(\overline{y}_t^n \mid t)) \mid t\right] + E\left[(\overline{y}_t^n - E(\overline{y}_t^n \mid t))^2 \mid t\right]\}$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[\sum_{j=1}^{M} n_j \cdot \text{var}(\Delta \ln y_{jt} \mid t) - E\left[(\overline{y}_t^n - E(\overline{y}_t^n \mid t))^2 \mid t \right] \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[(1-\lambda)^2 \cdot \sigma_\varepsilon^2 - \text{var}(\overline{y}_t^n \mid t) \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[(1-\lambda)^2 \cdot \sigma_\varepsilon^2 - \text{var}(\sum_{j=1}^{M} n_j \cdot [\theta + (1-\lambda) \cdot \varepsilon_{jt}] \mid t) \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[(1-\lambda)^2 \cdot \sigma_\varepsilon^2 \cdot (1-\sum_{j=1}^{M} n_j^2) \right] = (1-\lambda)^2 \cdot \sigma_\varepsilon^2$$

<u>Proof of Result 4:</u>

<u>Proof</u>: Since the proof of variance is almost identical to the proof in Result 2, we skip it. We prove here the unbiasedness of $\hat{\sigma}_n^2$. The same steps apply to the proof of the unbiasedness of $\hat{\sigma}_\gamma^2$. Since $E(\hat{\sigma}_n^2) = \frac{1}{T} \cdot \sum_{t=1}^{T} E(s_{n,t}^2) = E(s_{n,t}^2)$, we show $E(s_{n,t}^2) = (1-\lambda)^2 \cdot \sigma^2$.

$$E(s_{n,t}^2) = \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot E\left[\sum_{j=1}^{M} n_j \cdot (\Delta \ln y_{jt} - \overline{y}_t^n)^2 \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot E\left[\sum_{j=1}^{M} n_j \cdot [(\Delta \ln y_{jt} - \theta) - (\overline{y}_t^n - \theta)]^2 \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[\sum_{j=1}^{M} n_j \cdot E(\Delta \ln y_{jt} - \theta)^2 - E(\overline{y}_t^n - \theta)^2 \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[\sum_{j=1}^{M} n_j \cdot \text{var}(\Delta \ln y_{jt}) - \text{var}(\overline{y}_t^n) \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[\text{var}(\Delta \ln y_{jt}) - \text{var}(\theta + (1-\lambda) \cdot \sum_{j=1}^{M} n_j \cdot \varepsilon_{jt}) \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[\text{var}(\Delta \ln y_{jt}) - (1-\lambda)^2 \cdot \text{var}(\sum_{j=1}^{M} n_j \cdot \varepsilon_{jt}) \right]$$

$$= \frac{1}{1-\sum_{j=1}^{M} n_j^2} \cdot \left[(1-\lambda)^2 \cdot \sigma^2 - (1-\lambda)^2 \cdot \sum_{j=1}^{M} n_j^2 \cdot \sigma^2 \right]$$

$$= (1-\lambda)^2 \cdot \sigma^2$$

APPENDIX 2

The equilibrium of the economy with trade barrier can be summarized as follows.

$$p^R = \frac{[1-\alpha\cdot(1-\gamma)]\cdot\left(\frac{p_2^W}{p_Z}\right)^{\frac{\gamma}{1-\gamma}}\cdot\gamma^{\frac{\gamma}{1-\gamma}}\cdot A_1^{\frac{1}{1-\gamma}}\cdot N_1}{(1-\beta)\cdot\left(\frac{p_2^W}{p_Z}\right)^{\frac{\beta}{1-\beta}}\cdot\beta^{\frac{\beta}{1-\beta}}\cdot A_2^{\frac{1}{1-\beta}}\cdot N_2}$$

$$Z_1^R = (p^R)^{\frac{1}{\gamma-1}}\left(\frac{p_2^W\cdot\gamma\cdot A_1}{p_Z}\right)^{\frac{1}{1-\gamma}}\cdot N_1 \text{ and } Z_2^R = (p^R)^{\frac{1}{\gamma-1}}\left(\frac{p_2^W\cdot\beta\cdot A_2}{p_Z}\right)^{\frac{1}{1-\beta}}\cdot N_2$$

$$w_1^R = (1-\gamma)\cdot A_1\cdot(Z_1^R)^{\gamma}\cdot N_1^{-\gamma} \text{ and } w_2^R = p^R\cdot(1-\beta)\cdot A_2\cdot(Z_2^R)^{\beta}\cdot N_2^{-\beta}$$

$$T^R = \frac{2\cdot\left[\frac{p^R\cdot p_I\cdot(Z_1^R+Z_2^R)}{p_2^W}\right]}{N_1\cdot w_1^R + N_2\cdot w_2^R}$$

The superscript *R* implies the equilibrium values are for the economy **R**. *p* is the domestic price of X_2, p_2^W is the international price of X_2, and p_Z is the international price of the intermediate good. *A*'s are the productivity level of each industry, *N*'s are the number of each type of workers, and *Z*'s are the intermediate goods consumed by each sector. *w*'s are labor income of each type of workers. *T* is trade openness, which is defined as the sum of export and import divided by value added.

The equilibrium of the economy with free trade policy can be summarized as follows.

$$p^F = \frac{p_2^W}{p_1^W}$$

$$Z_1^F = \left(\frac{\gamma\cdot A_1\cdot p_1^W}{p_Z}\right)^{\frac{1}{1-\gamma}}\cdot N_1 \text{ and } Z_2^F = \left(\frac{\beta\cdot A_2\cdot p_2^W}{p_Z}\right)^{\frac{1}{1-\beta}}\cdot N_2$$

$$w_1^F = (1-\gamma) \cdot A_1^{\frac{1}{1-\gamma}} \cdot \left(\frac{\gamma \cdot p_1^W}{p_Z} \right)^{\frac{\gamma}{1-\gamma}} \text{ and } w_2^F = (1-\beta) \cdot A_2^{\frac{1}{1-\beta}} \cdot \left(\frac{\beta \cdot p_2^W}{p_Z} \right)^{\frac{\beta}{1-\beta}} \cdot \left(\frac{p_2^W}{p_1^W} \right)$$

$$S_1^F = A_1 \cdot (Z_1^F)^{\gamma} \cdot N_1^{1-\gamma} \text{ and } S_2^F = A_2 \cdot (Z_2^F)^{\beta} \cdot N_2^{1-\beta}$$

$$D_1^F = \alpha \cdot [N_1 \cdot w_1^F + N_2 \cdot w_2^F] \text{ and } D_2^F = \left(\frac{p_1^W}{p_2^W} \right) \cdot (1-\alpha) \cdot \left[N_1 \cdot w_1^F + N_2 \cdot w_2^F \right]$$

$$T^F = \frac{\left[\left| S_1^F - D_1^F \right| + \left(\frac{p_2^W}{p_1^W} \right) \cdot \left| S_2^F - D_2^F \right| + \left(\frac{p_Z}{p_1^W} \right) \cdot \left(Z_1^F + Z_2^F \right) \right]}{N_1 \cdot w_1^F + N_2 \cdot w_2^F}$$

The superscript *F* implies the equilibrium values are for the economy **F**. *S*'s and *D*'s are domestic productions and demands, respectively. Therefore, the absolute value of the difference between *S* and *D* is the domestic value of final goods trade. The definitions of the rest of the variables are the same as before.