Is Economic Volatility Detrimental to Global Sustainability?*

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Abstract

This paper examines the effects of output volatility on global sustainability in a dynamic panel data model allowing for error cross section dependence. It finds that output volatility impedes the process of sustainable development. It further suggests that output volatility exerts a significant effect on natural resources depletion, a key element of sustainability measure, via a financial development channel with respect to liquidity liability ratio. It also shows that lower income countries, lower energy intensity countries and lower trade share countries are in general more vulnerable to macroeconomic volatility or shocks. The findings highlight the interaction between global financial markets and the wider economy as a key factor influencing the sustainable development path, and have significant implications for the conduct of macroeconomic and environmental policies in an integrated global green economy.

Keywords: Output Volatility; Global Sustainability; Genuine Savings; Depletion of Natural Resources; Cross Section Dependence

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1 Introduction

In the 1990s the world economy grew at an averaged rate of 2.7 percent per annum, while in the 21st century it has exhibited an exceptional performance, reaching 3.2 percent per annum by the end of 2008 (World Development Indicators 2010). Following the long period of economic booms, the world economy, especially global financial markets, experienced considerable unstable growth, severe crises, and typically a period of uncertainty and volatility. On the other hand, climate change has become the most severe global challenge of our age, which is in large part due to human activities (IPCC 2001). From 1981 to 2005, some 60 per cent of world's ecosystem have been considered degraded or unsustainably exploited (Barbier 2009). This poses an important question: could economic volatility lead countries down an unsustainable path?

Breaking out against the background of other looming crises, for example, climate crisis, fuel crisis, and food crisis, financial crisis of 2007-2009 has caused enormous damage to the world economy and resulted in the most severe global recession in generations. The global financial crisis of 2007-2009 has been characterized by incredible speed at which volatility spread around the global financial markets. In particular almost every stock market across the globe went through the episodes of volatility outbursts since the end of 2007. Lin (2009) points out that the current economic downturn is "possibly turning a short-run macroeconomic adjustment into a long-term development problem". However, empirical evidence on the impact of economic volatility on long-run sustainable development has been as yet sparse.

This paper takes up the issue of whether economic volatility has a damaging effect on sustainable development. To measure sustainability, it makes use of genuine savings or adjusted net savings, which is the net national savings less natural resources depletion. Existing research on the link between volatility and growth in general indicates a significant impact, positive or negative, of volatility on savings via growth. To ascertain whether the link between volatility and sustainability is not merely due to the link between volatility and savings, this paper goes a step further to examine whether output volatility plays a role in the process of natural resources depletion.

This paper carries out a dynamic panel data study based on data for 128 countries between 1979-2008. To address the issue of cross country dependence driven by the increases in international trade and private capital flows in recent decades, this research considers a common factor structure in the error term, to fully take into account the effects of global shocks which potentially cause error dependence across countries. More specifically, it applies the system Generalized Method of Moments (GMM) method adjusted to allow for error cross section dependence due to Sarafidis *et al.* (2009).

It finds that output volatility exerts a strong negative impact on genuine savings, with the impact exacerbated in low income countries, lower energy intensity countries and lower trade share countries. It further suggests that, in addition to the significant impact of volatility on savings suggested in the literature, the negative effect of output volatility on genuine savings is due to the positive impact of output volatility on natural resources depletion via a financial development channel with respect to liquidity liability ratio. The findings highlight the role of the interaction between global financial markets and the wider economy in promoting global sustainability.

This paper contributes to the literature in several dimensions. First, it explores the effects of output volatility on both genuine savings and the depletion of natural resources. Second, it allows for the possibility of error cross section dependence and tries to correct for the issues of reverse causality and unobserved country-specific effects. Third, it is significant for the conduct of macroeconomic and environmental policies in an integrated global green economy in the sense that development strategies and programs should take adequate account of the state of natural resources, including energy, forests, minerals, soils, freshwater and fisheries, on which future growth is dependent.

The remainder of the paper proceeds in Section 2 to review the literature. Section 3 describes the data and outlines the methodology of GMM estimation without and with cross section dependence. Section 4 presents empirical results. Section 5 concludes.

2 Volatility, Growth and Sustainability

This section sketches the theoretical and empirical research in this field.

Volatility measures the possible variation or movement in a particular economic variable, such as growth rate, usually by a standard deviation of that economic variable over some historical period. Over the past decades, volatility has declined in general; but as an independent research area, it has moved on from a second-order research area to currently "occupy a central position in development economics" (Aizenman and Pinto 2005). There is large research on the link between economic volatility and long-run growth, with substantial controversies.[1] Since high growth performances do not necessarily lead to high levels of development, in comparison to output growth, policy makers have increasingly laid emphasis upon sustainable development as the primary national objective, especially for developing countries. It is therefore very important to understand the impact of economic volatility on sustainable development.

What is sustainable development? The concept of sustainable development or sustainability has evolved over the decades.[2] Sustainable development is actually a different kind of growth, which preserves the environment. It is about economic growth together with environmental protection, with economic growth and environmental protection reinforcing each other.

This research makes use of the widely-used sustainability indicator, genuine savings. Based on standard national accounting conventions, genuine

[1] Theoretically, one line of research finds that volatility is positively related to growth (Sandmo 1970; Ghosh and Ostry 1997; Canton 2002). On the contrary, the other line of research supports a negative impact of volatility on growth (Kharroubi 2007; Aysan 2007). Empirically, while Kormendi and Meguire (1985) and Grier and Tullock (1989) find evidence that output volatility promotes growth, among others, the majority of cross country studies suggest that economic volatility negatively affects long-run growth. Starting with Ramey and Ramey (1995), the study of the negative effect of volatility on growth has flourished, for example, Hnatkovska and Loayza (2005), Loayza *et al.* (2007) and Koren and Tenreyro (2007).

[2] According to World Commission on Environment and Development (1987), sustainable development was defined as "a development path that meets the needs of the present without compromising the ability of future generations to meet their own needs". It has been typically regarded as having three dimensions or "three pillars", namely environmental, social and economic sustainability, which are not mutually exclusive and can be mutually reinforcing (United Nations 2005).

savings takes into account the depletion of natural resources, pollution damages and the investments in human capital. It is the true savings rate in an economy in terms of creating and maintaining total net wealth, which is inclusive of manufactured capital, human capital and natural capital. In recent years, considerable research has been conducted to study what explains the differences of genuine savings rates across countries, identifying a number of variables, such as per capita gross national income, per capita GDP growth rate, age dependency and urbanization (Dietz *et al.* 2007).

Existing research in general indicates a significant impact, positive or negative, of volatility on savings via growth; however, insufficient understandings remain for the impact of volatility on natural resources depletion, which is a key element of sustainability measure. It is still not clear whether, in addition to the significant impact of volatility on savings, the impact of volatility on genuine savings is due to the impact of volatility on natural resources depletion.

If output volatility does play a role in the process of natural resources depletion, what could be the channels for this effect to work through? Potentially, volatility could speed up natural resources depletion and environmental degradation through financial markets, trade, or investment; however, these channels have not been carefully examined.[3] In terms of the channel of financial markets, generally speaking, global economic volatility is likely to increase credit risk and the levels of uncertainty. Due to the loss of confidence, investors are likely to refuse providing funds to the banks while the banks tend to ration the borrowers by providing less credit than requested or restrict the maturity of the loan.[4] The credit crunch or restricted access to finance reduces investment in energy sectors or low carbon projects and discourages people from getting access to low carbon technologies or renewable energy sources, which are typically more costly than the conventional

[3] A number of transmission channels for the effect of volatility on growth have been studied in the literature. Wolf (2005) discusses the roles of factor accumulation, domestic finance, trade, capital mobility and political institutions. In addition, Ramey and Ramey (1995) emphasize the role of the level of investment while Aysan (2007) supports for the productivity of investment rather than the level of investment.

[4] Huang (2011, p.45) provides evidence that output volatility (as well as black market permium volatility) exerts a negative impact on the total size of financial system inclusive of banking sector and stock market in the developing world.

ones while conducive to natural resources conservation and environmental protection (OECD/IEA 2009). The credit crunch negatively affects the development of global carbon markets, which are designed to achieve the dual objectives of sustainable development and emission reductions, as companies are unable to fund capital-intensive offset projects in both regulated and voluntary carbon markets.[5] The credit crunch leads to severe funding cuts for environmental agencies or initiatives to tackle environmental problems like deforestation (Kittiprapas 2002; Kasa and Næss, 2005). The curtailed availability of credit and insurance also reduces trade and investment flows in the natural resources sectors (African Development Bank 2009).

Moreover, the economic crisis and volatility could have significant impacts on natural resources depletion via umemployment and environmental law enforcement. Dauvergn (1999) shows that the lost jobs and falling income associated with financial crisis could trigger very significant pressures on natural resources extraction as people in poor and highly populated countries tend to revert to ecological commons such as fisheries and forests to secure basic subsistence. With detailed survey data, Gaveau *et al.* (2009) find that the 1997-98 crisis caused a significant reversal in law enforcement efforts in the Indonesian area studied which rendered significant losses of "protected" forests and biodiversity.

Against this background, this research aims to contribute to this emerging line of research.

3 Data and Methodology

3.1 The Data

This research studies whether economic volatility has any significant impacts on sustainable development, controlling for per capita GDP growth rate, per capita gross national income, and age dependence ratio.[6] Appendix Table

[5]Hamilton *et al.* (2010) indicate that, due to financial crisis, the global voluntary carbon markets transations declined by 26% while its total values dropped about 47% in 2009 compared to 2008.

[6]We also consider life expectancy ratio and urbanization rate as controlling variables, and energy use per capita and final energy intensity as potential channels, but we find no evidence for them. Data for the life expectancy at birth (total years), urban population

1 contains the description and sources of these variables.

The first dependent variable is the "Genuine Savings" or adjusted net saving, denoted by $GENSAV$. The data for adjusted net savings, excluding particulate emission damage (% of Gross National Income), are taken from the World Bank World Development Indicators Database (2010).[7] In the regression below we use 3-year averages from 1979 to 2008 of the natural logarithm of one plus adjusted net savings divided by 100, $\log(1 + GENSAV/100)$.

The second dependent variable is the "Resource Depletion", denoted by $DEPLETION$. The series of natural resources depletion is the value of net national savings plus education expenditure, minus adjusted net saving and minus carbon dioxide damage. Data for net national savings, education expenditure and carbon dioxide damage are taken from the World Bank World Development Indicators Database (2010). In the regression below we use 3-year averages from 1979 to 2008 of the natural logarithm of one plus natural resources depletion divided by 100, $\log(1 + DEPLETION/100)$.

This analysis mainly focuses on "Output Volatility", denoted by VGR. It is defined as the standard deviation over 3-year interval from 1979 to 2008 of the natural logarithm of one plus per capita GDP growth rate divided by 100, $\log(1 + GR/100)$. The data for the per capita GDP growth rate are from the World Bank World Development Indicators Database (2010).

We control for "per capita GDP Growth" (GR), "per capita GNI" ($GNIPC$), and "Age Dependency Ratio" (AGE). GR is the 3-year averages from 1979 to 2008 of the logarithm of one plus per capita GDP growth rate divided by 100. For $GNIPC$ and AGE, this analysis makes use of 3-year averages from 1979 to 2008 of the logarithms of per capita gross national income and

(% of total) and energy use per capita (kg of oil equivalent per capita) are taken from the World Bank World Development Indicators Database (2010). Data for final energy intensity are from the Enerdata's Global Energy Market Data (2010).

[7] The series of adjusted net savings are equal to net national savings (gross savings less the value of depreciation of produced assets) plus the value of investment in human capital (education expenditure) and minus the value of resource depletion (energy depletion, mineral depletion, net forest depletion) and environmental degradation (carbon dioxide). Since more missing values appear in adjusted net savings including particulate emission damage, this analysis uses adjusted net savings excluding particulate emission damage.

age dependency ratio, respectively. Data for per capita GDP growth rate, per capita gross national income and age dependency ratio (dependents to working-age population) are taken from the World Bank World Development Indicators Database (2010).

Two potential channels will be investigated, namely "Liquidity Liability" (LLY) and "Investment" (KI). LLY, the financial channel, measures the liquid liabilities of banks and non-bank financial intermediaries (currency plus demand and interest-bearing liabilities) over GDP. It reflects the size of financial intermediaries, relative to the economy, including the central bank, deposit money banks and other financial institutions. We use the logarithm of 100 times liquidity liability ratio in the analysis, $\log(100 \times LLY)$. The data for liquidity liability ratio are from the World Bank Financial Development and Structure Database (2010). KI, the investment channel, is the investment share of real GDP per capita measured in percentage (RGDPL), taken from the Penn World Table 6.3 due to Heston *et al.* (2009). In the regression we use the logarithm of investment share of real GDP per capita (RGDPL), $\log(KI)$.

The whole sample contains 128 non-transition economies over the period from 1979 to 2008 where the three-year periods are non-overlapping and each country as listed in the Appendix Table 2 has a maximum of 10 observations. We exclude countries with less than 10 annual observations during the period studied. We consider four dummy variables in this analysis: low income dummy for 31 low income countries, lower income dummy for 63 middle income countries, lower energy intensity dummy and lower trade share dummy. Information on the classifications of income levels is obtained from the World Bank List of Economies (2011). The lower energy intensity dummy is for 65 countries whose averaged final energy intensities over 1979-2008 are below the median value of the averaged final energy intensities. Data on final energy intensity of GDP at purchasing power parities are taken from the Enerdata's Global Energy Market Data (2010). The lower trade share dummy is for 70 countries whose averaged trade shares are below the median value of the averaged trade shares over 1979-2008. Data on trade share (% of GDP) are taken from the World Bank World Development Indicators Database (2010).

Insert Figure 1 here

Figure 1 simply shows the scatter plots between genuine savings and output volatility for whole sample and three subsamples. There is some evidence of a negative association between genuine savings and output volatility.

3.2 Methodology

This section reviews the methods used to study the impact of economic volatility on sustainable development in the context of globalisation. It employs the GMM methods adjusted to allow for error cross section dependence, recently proposed by Sarafidis *et al.* (2009) for a linear dynamic panel model.

In recent decades, the cross country dependence has become an important phenomenon in a globalised world where the existence of common factors, either macroeconomic shocks, common technological shocks or environmental shocks, has the potential to cause stronger interactions in the world economy. To allow for error cross section dependence, the following model has been found appropriate for this application:

$$\begin{aligned} DEPVAR_{it} &= \gamma_i + \alpha DEPVAR_{i,t-1} + \beta_1 VGR_{i,t-1} + \beta_2 GR_{i,t-1} + \\ &\quad \beta_3 GNIPC_{i,t-1} + \beta_4 AGE_{it} + \lambda_i^{'} f_t + v_{it} \qquad (1) \\ i &= 1, 2, ..., 128 \text{ and } t = 2, ..., 10 \end{aligned}$$

where $DEPVAR_{it}$ denotes the dependent variable, $GENSAV_{it}$ or $DEPLETION_{it}$. γ_i is the individual effects. The autoregressive coefficient α is assumed to lie inside the unit circle, $|\alpha| < 1$, to ensure the model stability. The coefficients β_1 to β_4 reflect the existence and direction of any specific effect on $GENSAV_{it}$ or $DEPLETION_{it}$. f_t is a $(r \times 1)$ vector of unobserved time-varying common factors assumed to be nonstochastic and bounded, and λ_i is a vector of factor loadings assumed to be i.i.d., such that $\lambda_i^{'} f_t = \lambda_{i1} f_{t1} + \lambda_{i2} f_{t2} + ... + \lambda_{ir} f_{tr}$ (here r is the number of common factors).[8]

[8] Bai (2009) suggests an interactive effects model including the interaction between factors, f_t, and factor loadings, λ_i, which is more general than an additive effects model, the traditional one-way or two-way fixed effects model. When we take r=2, we have $f_t = (1$

The error term v_{it} is the transitory disturbance term, which is assumed to be independently distributed with zero mean and finite variance. It is also assumed to be uncorrelated with individual effects and common factors, but the correlations between, either individual effects or common factors (f_t and subsequent shocks), and the regressors are possible.

We assume that $VGR_{i,t-1}$, $GR_{i,t-1}$, and $GNIPC_{i,t-1}$ are predetermined with respect to v_{it} in the sense that these variables may be correlated with $v_{i,\ t-1}$ and earlier shocks, but is uncorrelated with $v_{i\ t}$ and subsequent shocks. The assumption on these explanatory variables, except for AGE_{it}, being predetermined rules out the possibility of reverse causality or joint determination.

Below is Equation (1) in first differences:

$$\begin{aligned} \Delta DEPVAR_{it} &= \alpha \Delta DEPVAR_{i,t-1} + \beta_1 \Delta VGR_{i,t-1} + \beta_2 \Delta GR_{i,t-1} + \\ &\quad \beta_3 \Delta GNIPC_{i,t-1} + \beta_4 \Delta AGE_{it} + \lambda_i^{'} \Delta f_t + \Delta v_{it} \qquad (2) \\ i &= 1, 2, ..., 128 \text{ and } t = 3, ..., 10 \end{aligned}$$

where $\Delta DEPVAR_{it} = DEPVAR_{it} - DEPVAR_{i,t-1}$, which applies to ΔAGE_{it}. $\Delta VGR_{i,t-1} = VGR_{i,t-1} - VGR_{i,t-2}$, which also applies to $\Delta GR_{i,t-1}$ and $\Delta GNIPC_{i,t-1}$. $\Delta f_t = f_t - f_{t-1}$ and $\Delta v_{it} = v_{it} - v_{i,t-1}$.

When common factors are assumed to have an identical effect on each cross section unit, a number of methods have been proposed to estimate the dynamic panel data models with a short time dimension, in which first-differencing is used to eliminate the individual effects. Arellano and Bond (1991) propose the first-differenced GMM estimator, denoted by DIF-GMM.[9] For simplicity, we let y_{it} denote $DEPVAR_{it}$ and let x_{it} be a vector of independent variables, e.g. (VGR_{it}, GR_{it}, $GNIPC_{it}$, AGE_{it}). The moment conditions for errors in differences on which the DIF-GMM estimator is based in this application can be written as,

$\eta_t)^{'}$, $\lambda_i^{'} = (\alpha_i\ 1)$, and $\lambda_i^{'} f_t = \alpha_i + \eta_t$, where α_i and η_t are the individual effect and time effect, respectively.

[9] DIF-GMM uses all lagged values of dependent variable and independent variables dated from $t-2$ and earlier as suitable instruments for the differenced values of the original regressors, for example, $\Delta DEPVAR_{i,t-1}$, $\Delta VGR_{i,t-1}$, $\Delta GR_{i,t-1}$, $\Delta GNIPC_{i,t-1}$, and ΔAGE_{it} in this context.

$$E\left[\begin{pmatrix} y_i^{t-2} \\ x_i^{t-2} \end{pmatrix}(\Delta v_{it})\right] = 0 \quad (3)$$
$$t = 3,..,10$$

where $y_i^{t-2} = (y_{i1},\, y_{i2}, ...,\, y_{i,t-2})'$ and $x_i^{t-2} = (x_{i1},\, x_{i2}, ...,\, x_{i,t-2})'$.

The weak instruments problem associated with the DIF-GMM estimator has been widely aware when data are highly persistent. To address this issue, Arellano and Bover (1995) and Blundell and Bond (1998) develop a "system GMM" estimator, denoted by SYS-GMM, by considering a mean stationarity assumption on initial conditions. In addition to the moments for errors in differences described above, the SYS-GMM estimator is also based on the additional moments for errors in levels as follows,[10]

$$E\left[\begin{pmatrix} \Delta y_{i,t-1} \\ \Delta x_{i,t-1} \end{pmatrix}(\gamma_i + v_{it}\ )\right] = 0 \quad (4)$$
$$t = 3,..,10$$

However, in reality common factors are typically having a differential effect across cross-sectional units, causing heterogeneous error cross section dependence. Sarafidis and Robertson (2009) show that the standard DIF-GMM and SYS-GMM estimators are not consistent in the presence of heterogeneous error cross section dependence, for the standard instruments these estimators rely on with respect to lagged values of the dependent variable, in either levels or first-differences, are invalid.

Under the assumption of heterogeneous error cross section dependence, Sarafidis *et al.* (2009) suggest a consistent first-differenced GMM estimator, denoted by DIF-GMM-C, and a consistent system GMM estimator, denoted by SYS-GMM-C. These two GMM estimators only rely on partial instruments consisting of the regressors. More specifically, based on the partial moment condition (5) as shown below the DIF-GMM-C estimator is consistent under the assumption of heterogeneous error cross section dependence.

[10] The additional mean stationarity condition of (y_{it}, x_{it}) enables the lagged first-differences of the series (y_{it}, x_{it}) dated $t-1$ as instruments for the untransformed equations in levels.

This applies to the SYS-GMM-C estimator, which is based on partial moment conditions (5) and (6) in the following:

$$E\left[x_i^{t-2}\Delta v_{it}\right] = 0 \qquad (5)$$
$$t = 3,..,10$$

$$E\left[\Delta x_{i,t-1}(\gamma_i + v_{it}\ )\right] = 0 \qquad (6)$$
$$t = 3,..,10$$

A new testing procedure for detecting error cross section dependence in a linear dynamic panel model has been proposed by Sarafidis *et al.* (2009). Under the null hypothesis of homogeneous error cross section dependence (CSD), the CSD test enables the examination on whether any error cross section dependence remains after including time dummies.[11] The finite sample simulation-based results in Sarafidis *et al.* (2009) show the good performance of the CSD test, especially for the version based on system GMM estimator.

4 Empirical Results

This section firstly presents the econometric evidence on whether output volatility has significant impacts on both genuine savings and its key element, natural resources depletion. Secondly, it moves on to examine the channels through which volatility affects natural resources depletion.

The DIF-GMM and SYS-GMM reported assume cross-sectionally independence; in the contrary, DIF-GMM-C and SYS-GMM-C are under the

[11] The CSD test is the Sargan's difference tests based on either the two-step first-differenced GMM estimator or two-step system GMM estimator. The Sargan's difference test statistics based on two-step first-differenced GMM estimator is the difference between the Sargan statistics for DIF-GMM with standard set of moment conditions (3) and the Sargan statistics for DIF-GMM-C using restricted set of moment conditions (5). The Sargan's difference test statistics based on two-step system GMM estimator is the difference between the Sargan statistics for SYS-GMM with standard set of moment conditions (3) and (4) and the Sargan statistics for SYS-GMM-C using restricted set of moment conditions (5) and (6).

assumption of errors being cross-sectionally dependent. A finite sample correction is made to the two-step covariance matrix using the method due to Windmeijer (2005) for both the first-differenced GMM estimator and system GMM estimator under either assumption. In this analysis we only use lagged values of y_{it} and x_{it} from $t-2$ to $t-4$ as instruments.[12]

For any GMM estimators, three specification tests are conducted to address the consistency. The first two are the Serial Correlation tests, M1 and M2, which test the null hypothesis of no first-order serial correlation and no second-order serial correlation in the residuals in the first-differenced equation, respectively. Given that the errors in levels are serially uncorrelated, we would expect to find significant first-order serial correlation, but insignificant second-order correlation in the first-differenced residuals. The third is a Sargan test of overidentifying restrictions, which examines the overall validity of the instruments by comparing the moment conditions with their sample analogue. For SYS-GMM and SYS-GMM-C, an additional test, namely the Difference Sargan test denoted by Diff-Sargan, is carried out. The Difference Sargan test examines the null hypothesis that the lagged differences of the explanatory variables are uncorrelated with the errors in the levels equations due to Blundell and Bond (1998).[13]

Once the model is well-specified, we further examine the properties of the model using various tests. To examine whether genuine savings or natural resources depletion is indeed Granger-caused by economic volatility, a Granger causality test is conducted.[14] The point estimates for the long-run effect are also reported with the standard errors approximated by using the delta method. However, since the long-run effect is calculated as a non-linear function of the model parameters, it is worth noting that this effect may be imprecisely estimated. To test for the presence of the unobserved

[12] To avoid the possible overfitting bias associated with using the full Arellano and Bond (1991) instrument set, Bowsher (2002) proposes to selectively reduce the number of moment conditions for each first-differenced equation.

[13] The statistic, called an incremental Sargan test statistic, is the difference between the Sargan statistics for DIF-GMM (or DIF-GMM-C) and Sargan statistics for SYS-GMM (or SYS-GMM-C).

[14] The Sargan statistics for the unrestricted model and restricted model, with the same moment conditions, are compared using an incremental Sargan test statistics, which is asymptotically distributed as χ^2_r, where γ is the number of restrictions.

individual effects, a heterogeneity test for the null of no heterogeneity is conducted.[15] Finally, the new cross-sectional dependence (CSD) tests based on first-differenced GMM estimator and system GMM estimator as explained above are carried out, respectively.

4.1 The Impacts of Volatility on Sustainability

4.1.1 Genuine Savings

This subsection studies whether output volatility has led to unsustainability in the economy over the period from 1979 to 2008. Table 1 reports the evidence for the whole sample of 128 countries. Table 2 presents evidence when the interaction term between output volatility and the low income dummy, lower energy intensity dummy or the lower trade share dummy is included to distinguish the volatility effects on genuine savings across different groups of countries.

Insert Table 1 here

Columns 1 and 2 in Table 1 are concerned about the case of cross-sectional independence, whilst columns 3 and 4 are for the case of cross-sectional dependence. The CSD tests based on first-differenced GMM estimator and system GMM estimator fail to reject the null of homogeneous error cross section dependence in this table (as well as Table 2), suggesting that the assumption of cross-sectional independence is appropriate for this context. We naturally focus on the DIF-GMM and SYS-GMM estimates. The specification tests indicate that two models are well specified. More specifically, we can reject no first-order serial correlation but cannot reject the hypothesis that there is no second-order serial correlation in the models. The Sargan tests do not signal that the instruments in the models are invalid. The Diff-Sargan tests for SYS-GMM cannot reject the null of the additional moment conditions being valid, implying that SYS-GMM is a more reliable estimator than the DIF-GMM in this context.

The SYS-GMM suggests that the impact of output volatility on genuine savings is significantly negative. It also provides evidence that the age

[15] It also uses an incremental Sargan test statistic, the difference between the Sargan statistics for DIF-GMM (or DIF-GMM-C) and Sargan statistics for SYS-GMM (or SYS-GMM-C) where the lagged levels are used as instruments in the levels equations.

dependency ratio is negatively present in the model within 5% significance level. The finding on the negative effect of volatility is confirmed by the Granger Causality test, which rejects the null at 3% significant level. The long-run effect is also calculated with the effect being more sizeable than the short-run effect.

Under certain circumstances the CSD might lack power because it is based on the overidentifying restrictions test statistic, and accordingly this result is better to be interpreted with caution. Subsection 4.2 provides evidence for such a cross section dependence to exist when the transmission channels are investigated.

In principle, the first-differenced GMM and system GMM estimates impose homogeneity on all slope coefficients, under assumption of either the cross-sectional independence or cross-sectional dependence. One concern over GMM estimates is that these parameters may be heterogeneous across countries, which is actually confirmed by the Heterogeneity test clearly rejecting the null. To address this concern we simply include the interaction term between output volatility and the low income dummy, lower energy intensity dummy or the lower trade share dummy, seperately. In what follows we turn to Table 2.

Insert Table 2 here

In Table 2, the low income dummy, the lower energy intensity dummy and the lower trade share dummy are used. The specification tests including M1, M2 and Sargan tests indicate that all six models are well-specified. Diff-Sargan tests further show that SYS-GMM is a more reliable estimator than DIF-GMM for this case. The SYS-GMM estimates in columns 2, 4 and 6 confirm the strong negative impact going from output volatility to genuine savings. The volatility effect on genuine savings is relatively small in lower energy intensity countries, in comparison to the whole sample and other country groups.

In general, this subsection provides evidence that output volatility is indeed an impediment to global sustainability in terms of genuine savings, especially for low income countries, lower energy intensity countries and lower trade share countries. This finding points to the possible damaging consequences of output volatility for the economy as a whole, consistent with what has happened during global financial crisis of 2007-2009. In the aftermath of the subprime crisis and housing bubbles burst in mid-2007, worldwide credit crunch has triggered a sustained period of stress and instability in global financial markets and the worst global recession for generations.

However, since genuine savings is the net national savings minus natural resources depletion, the negative impact of volatility on genuine savings identified above is likely driven by the negative impact of volatility on growth and savings, as widely examined in the literature. Is output volatility depleting natural resources or causing environmental degradation while impeding growth and savings?

4.1.2 Depletion of Natural Resources

This subsection aims to study if output volatility leads to environmental decline or higher depletion of natural resources. Table 3 and Table 4 report evidence without and with interaction terms, respectively.

Insert Table 3 here

Table 3 reports evidence for the whole sample of 128 countries where dependent variable is Resource Depletion. Based on first-differenced GMM estimator, the CSD test clearly rejects the null of homogeneous cross-sectional dependence. According to Sarafidis and Robertson (2009), the standard DIF-GMM estimator is not consistent in the presence of heterogeneous error cross section dependence. As expected, Sargan's test for DIF-GMM rejects the null while Sargan's test for DIF-GMM-C fails to reject the null and CSD test rejecting the null. However, for DIF-GMM-C, the serial correlation test, M1, cannot reject the null, suggesting that DIF-GMM-C is not reliable.

Based on system GMM estimator, the CSD test cannot reject the null, suggesting that SYS-GMM rather than SYS-GMM-C is appropriate for this context. For SYS-GMM, the serial correlation tests, M1 and M2, indicate that we can reject the hypothesis of no first-order serial correlation but cannot reject no second-order serial correlation. The Sargan tests cannot reject the null that the instruments in the model are valid. The Diff-Sargan test cannot reject the null that the additional moment conditions are valid, supporting SYS-GMM estimator for the more reliable estimator for this context. The SYS-GMM estimates provide strong evidence on a positive effect of output volatility on natural resources depletion in the global economy. It also provides evidence that per capita GNI and age dependency ratio are important variables to be included in the model within 1% significance level.

Insert Table 4 here

Table 4 looks at if the finding above is robust to the inclusion of interaction term between output volatility and the lower income dummy or lower energy intensity dummy. The specification tests including M1, M2 and Sargan tests indicate that the models for SYS-GMM and SYS-GMM-C are well-specified. Diff-Sargan test further shows that SYS-GMM is a more reliable estimator than the DIF-GMM for this case. The SYS-GMM estimates in columns 2 and 4 provide evidence for a strong positive impact going from output volatility to natural resources depletion. The significant negative impacts of per capita GNI and age dependency ratio on natural resources depletion have also been observed. The volatility effect on natural resources depletion is smaller in the lower income countries than that in the whole sample and lower energy intensity countries.

In summary, this subsection finds output volatility causes damaging effects on genuine savings. Also it finds that the damaging impacts on genuine savings of output volatility is likely due to its positive impact on natural resources depletion, in addition to possible negative impact of output volatility on net national savings suggested in the literature. The significant effects have been shown aggravated in low income countries, lower energy intensity countries and lower trade share countries, suggesting that these countries are especially vulnerable to macroeconomic shocks. The results are in general robust to the use of alternative estimation methods, and not due to unobserved heterogeneity, or reverse causality.

4.2 The Channels

This subsection goes a step further to investigate the underlying mechanisms or channels through which volatility affects sustainable development. It specifically focuses on natural resources depletion, $DEPLETION$, being the dependent variable.

Insert Table 5 here

Table 5 presents evidence on whether output volatility works through either financial development measure or investment share on natural resources depletion. The possible financial development channel considered is the Liquidity Liability Ratio. Based on first-differenced GMM and system GMM estimators, the CSD tests clearly reject the null of homogeneous cross-sectional dependence, suggesting that the DIF–GMM-C and SYS-GMM-C are consistent estimators, in contrast to DIF–GMM and SYS-GMM estimators, respectively. For DIF-GMM-C, the serial correlation tests, M1 and M2, indicate that we can reject the hypothesis of no first-order serial correlation but cannot reject no second-order serial correlation. The Sargan tests cannot reject the null that the instruments in the model are valid. For SYS-GMM-C, M1 cannot rejects the null, we focus on the DIF-GMM-C estimates.

The DIF-GMM-C estimates clearly indicate that output volatility is no longer significant in the model while liquidity liability ratio enters the model significantly. This result is supported by the Granger causality test for the effect of output volatility which can not reject the null. Apparently, liquidity liability ratio picks up the effect of output volatility on natural resources depletion and is indeed the channel through which output volatility induces natural resources depletion therefore hampering sustainability.

Next, we examine the potential channel of investment ratio. With the inclusion of investment ratio, models for DIF-GMM, DIF-GMM-C and SYS-GMM are not well-specified. For the model associated with SYS-GMM, the specifications tests are in general satisfactory. Based on first-differenced GMM and system GMM estimators, the CSD test clearly rejects the null, further suggesting that the SYS-GMM is consistent estimator. As it shows, investment share is insignificant in the model while output volatility continues to significantly enter the model. Basically, this research suggests no evidence that investment ratio picks up the effect of output volatility on natural resources depletion; but this doesn't necessarily rule out the possibility that investment ratio is a channel for output volatility to affect sustainability because several models are not well specified when investment ratio is added. Further research is needed in this regard.

Moreover, a number of other potential transmission channels have been examined, including final energy intensity and energy consumption per capita. There is no evidence for either final energy intensity or energy consumption per capita to enter the models significantly. This remains an interesting area for further research.

In sum, a financial development channel has been identified via which the effect of volatility works through the natural resources depletion to genuine savings. It sheds some light on the interaction between economic downturn and financial crisis during the 2007-2009 global financial crisis. After the collapse of the U.S. subprime mortgage market in 2007, especially the failure of Lehman Brothers in 2008, the global economic downturn caused by credit crunch further impacted the financial system by increasing the credit risk and the levels of uncertainty. The rising credit risks further amplified the sharp drop in global demand for commodities and global manufacturing, with adverse implications for sustainable exploitation of natural resources and sustainability of growth. This finding has significant implications in the sense that financial markets can play a crucial role in the process of unsustainability caused by economic volatility and highlights the interaction between global financial markets and the wider economy as a key factor influencing the sustainable development path.

It also finds evidence for cross country dependence in this context when the financial development channel is investigated. This is perhaps due to the fact that financial markets are typically associated with cross-border financial linkage or financial integration; accordingly macroeconomic volatility or financial crisis in one country tends to spread around global financial markets rapidly.

5 Summary and Conclusions

This paper investigates the issue of whether economic volatility has a damaging effect on sustainability. It carries out a dynamic panel data study based on data for 128 countries over 1979-2008 and makes use of the genuine savings or adjusted net savings to measure the level of sustainable development.

Special attention has been paid to the effect of output volatility on natural resources depletion and the channel for this effect to work through. To address the issue of cross country dependence caused by global shocks, this research applies the system GMM method adjusted to allow for error cross section dependence due to Sarafidis *et al.* (2009).

This analysis finds that output volatility causes damaging effects on genuine savings for the whole sample. It further suggests that output volatility exerts significant effects on the key component of genuine savings, natural resources depletion, via a financial development channel with respect to liquidity liability ratio. This research also shows that lower income countries, lower energy intensity countries and lower trade share countries are in general more vulnerable to macroeconomic volatility or shocks. The resilience of those countries to financial crisis and economic volatility will no doubt play an important role in building a sustainable global economy. Therefore, understanding the nature of volatility and how to manage its consequences should be of considerable interest to the governments of those countries, especially developing countries.

However, the ability to tackle volatility impacts in those countries might be constrained by an underdeveloped financial sector, weak institutions and other political economy considerations. Empirical research continues to show that underdeveloped financial sector and weak institutions in developing countries could even amplify the adverse effects of volatility on long-run growth and sustainable development, and result in permanent setbacks and a long-run development problem relative to developed countries. Governments in those countries should aim to liberalize financial sectors with adequate regulation and supervision and strengthen capacities to mobilize and manage financial resources and deliver public services effectively. Any efforts by governments to strengthen energy-saving development mode and macroeconomic fundamentals could help lay the foundation for a long-run sustainable development.

Internationally, it is recommended that supportive frameworks should be created for facilitating financial development, energy savings, climate change adaptation and mitigation, and low carbon economy. Dedicated resources for development should be made available for vulnerable nations and people around the world. The increased and better financial assistance will enable those countries to cope more effectively with economic volatility or crisis, and improve safety nets and basic services like health and education.

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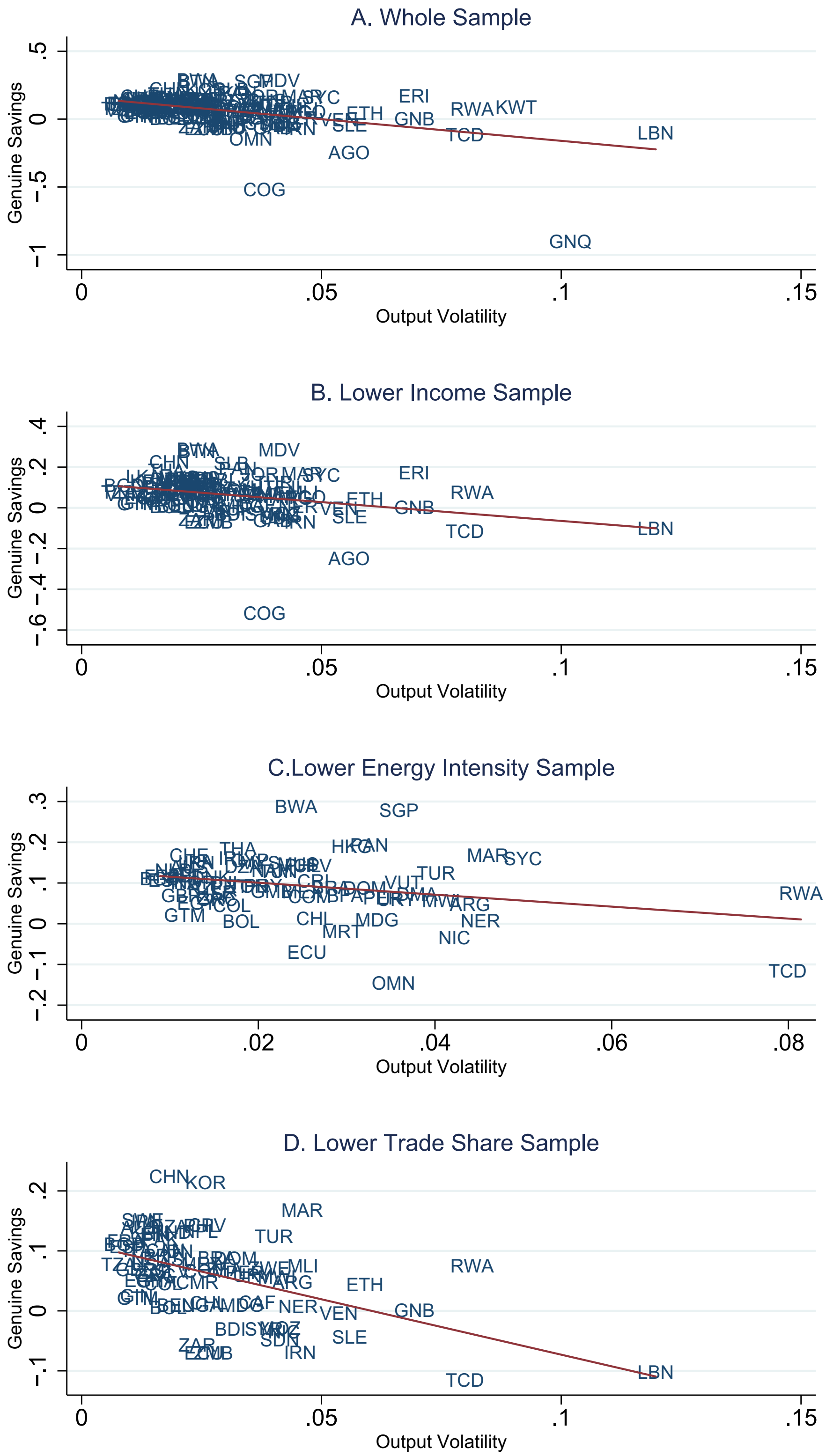
Figure 1: Scatter Plots of Genuine Savings and Output Volatility



Note: Variables and data sources are described in the text.

Table 1 . Output Volatility and Genuine Savings (I): 1979-2008

Dependent Variable:	Cross-sectional independence		Cross-sectional dependence	
Genuine Savings	DIF-GMM	SYS-GMM	DIF-GMM-C	SYS-GMM-C
Lag 1 Genuine Savings	0.207	0.584	-0.525	0.013
	[0.406]	[0.000]***	[0.358]	[0.983]
Lag 1 Output Volatility	-0.175	-0.252	0.286	-0.191
	[0.360]	[0.010]**	[0.557]	[0.650]
Lag 1 per capita GDP Growth	0.061	-0.038	0.511	0.043
	[0.715]	[0.753]	[0.462]	[0.890]
Lag 1 per capita GNI	-0.012	-0.021	0.030	-0.043
	[0.765]	[0.311]	[0.779]	[0.291]
Age Dependency	-0.024	-0.208	-0.172	-0.415
	[0.837]	[0.022]**	[0.318]	[0.033]**
M1	0.10	0.01	0.96	0.52
M2	0.56	0.88	0.22	0.65
Sargan test	0.33	0.84	0.26	0.32
Diff-Sargan test		1.00		0.46
Granger causality test	0.23	0.03	0.34	0.10
LR effect	-0.22	-0.61	0.19	-0.19
[Standard error]	[0.29]	[0.28]	[0.25]	[0.54]
Heterogeneity test		0.00		0.01
CSD test	0.48	1.00		
Observations	896	1022	896	1022

Notes: 128 countries over the period of 1979-2008. Genuine Savings is measured by 3-year averages of genuine savings (% of GNI). Output volatility is measured by the standard deviation over 3-year interval of the per capita GDP growth. Controlled variables are the 3-year averages of per capita GDP growth rate, per capita GNI, and age dependence ratio. These variables are taken in logs. See text for their definitions. Under the assumption of cross-sectional independence first-differenced GMM estimates, denoted by DIF-GMM, and system GMM estimates, denoted by SYS-GMM, are reported. When cross-sectional dependence is allowed, their counterpartes are reported, DIF-GMM-C and SYS-GMM-C. Both first-differenced GMM and system GMM results are two-step estimates with heteroskedasticity-consistent standard errors and test statistics; the standard errors are based on finite sample adjustment of Windmeijer (2005). M1 and M2 test the null of no first-order and no second-order serial correlation in first-differenced residuals, respectively. The Sargan tests the overidentifying restrictions for GMM estimators, asymptotically χ^2. Diff-Sargan tests the null of mean stationarity for system GMM estimators in which SYS-GMM or SYS-GMM-C use standard moment conditions. The Granger causality test examines the null hypothesis that genuine savings are not Granger-caused by volatility measure (p-values are reported). LR effect is the point estimate of long-run effect of volatility measure on genuine savings with its standadrd error approximated by using the delta method. The Heterogeneity test examines the null hypothesis that there is no heterogeneity across countries. CSD test is to examine the null hypothesis of homogeneous error cross section dependence due to Sarafidis et al. (2009). Robust p values in brackets below point estimates. *, **, *** significant at 10%, 5%, 1%, respectively.

Table 2 . Output Volatility and Genuine Savings (II): 1979-2008

Dependent Variable:	**Low Income Dummy**		**Lower Energy Intensity Dummy**		**Lower Trade Share Dummy**	
Genuine Savings	**DIF-GMM**	**SYS-GMM**	**DIF-GMM**	**SYS-GMM**	**DIF-GMM**	**SYS-GMM**
Lag 1 Genuine Savings	0.240	0.646	0.217	0.606	0.164	0.580
	[0.287]	[0.000]***	[0.351]	[0.000]***	[0.421]	[0.000]***
Lag 1 Output Volatility × DUMMY	-0.214	-0.270	-0.009	-0.147	-0.183	-0.245
	[0.423]	[0.108]	[0.932]	[0.049]**	[0.399]	[0.060]*
Lag 1 per capita GDP Growth	0.134	0.030	0.132	0.018	0.080	-0.021
	[0.310]	[0.802]	[0.400]	[0.885]	[0.632]	[0.863]
Lag 1 per capita GNI	0.006	-0.007	-0.006	-0.024	-0.001	-0.024
	[0.874]	[0.684]	[0.898]	[0.246]	[0.977]	[0.250]
Age Dependency	-0.055	-0.136	-0.024	-0.212	-0.072	-0.216
	[0.582]	[0.093]*	[0.841]	[0.022]**	[0.537]	[0.014]**
M1	0.08	0.01	0.09	0.01	0.09	0.01
M2	0.53	0.95	0.51	0.93	0.42	0.91
Sargan test	0.44	0.83	0.38	0.80	0.16	0.70
Diff-Sargan test		1.00		1.00		1.00
Granger test	0.31	0.13	1.00	0.34	0.36	0.09
LR effect	-0.28	-0.76	-0.01	-0.37	-0.22	-0.58
[Standard error]	[0.36]	[0.51]	[0.14]	[0.24]	[0.28]	[0.33]
Heterogeneity		0.01		0.03		0.04
CSD test	0.60	1.00	0.65	1.00	0.49	1.00
Observations	896	1022	896	1022	896	1022

Notes: The low income dummy variable is for 31 low income countries. The lower energy intensity dummy variable is for 65 lower energy intensity countries whose averaged final energy intensities over 1979-2008 are below the median value of the averaged final energy intensities. The lower trade share dummy variable is for 70 lower trade share countries whose averaged trade shares (% of GDP) over 1979-2008 are below the median value of the averaged trade shares. See Table 1 for more notes.

Table 3. Output Volatility and Resource Depletion (I): 1979-2008

Dependent Variable:	Cross-sectional independence		Cross-sectional dependence	
Resource Depletion	DIF-GMM	SYS-GMM	DIF-GMM-C	SYS-GMM-C
Lag 1 Resource Depletion	-0.023	-0.418	0.058	-0.077
	[0.915]	[0.006]***	[0.496]	[0.623]
Lag 1 Output Volatility	0.051	0.195	0.044	0.082
	[0.470]	[0.055]*	[0.541]	[0.253]
Lag 1 per capita GDP Growth	0.038	0.102	0.018	0.024
	[0.804]	[0.343]	[0.882]	[0.761]
Lag 1 per capita GNI	0.002	-0.046	0.002	-0.029
	[0.940]	[0.008]***	[0.926]	[0.095]*
Age Dependency	-0.026	-0.272	-0.054	-0.104
	[0.654]	[0.001]***	[0.342]	[0.196]
M1	0.70	0.09	0.62	0.91
M2	0.50	0.88	0.18	0.88
Sargan test	0.01	0.59	0.12	0.57
Diff-Sargan test		1.00		1.00
Granger causality test	0.31	0.17	0.17	0.11
LR effect	0.05	0.14	0.05	0.08
[Standard error]	[0.06]	[0.07]	[0.07]	[0.06]
Heterogeneity test		0.00		0.00
CSD test	0.01	0.46		
Observations	895	1021	895	1021

Notes: 128 countries. The resource depletion is measured by 3-year averages of the sum of energy depletion, mineral depletion and net forest depletion, defined in the text. See Table 1 for more notes.

Table 4. Output Volatility and Resource Depletion (II): 1979-2008

Dependent Variable:	Lower Income Dummy		Lower Energy Intensity Dummy	
Resource Depletion	DIF-GMM	SYS-GMM	DIF-GMM	SYS-GMM
Lag 1 Resource Depletion	-0.031	-0.412	-0.058	-0.433
	[0.823]	[0.012]**	[0.791]	[0.010]***
Lag 1 Output Volatility	0.030	0.124	0.034	0.179
× DUMMY	[0.408]	[0.062]*	[0.618]	[0.052]*
Lag 1 per capita GDP Growth	0.043	0.066	0.047	0.053
	[0.581]	[0.522]	[0.724]	[0.582]
Lag 1 per capita GNI	0.007	-0.048	0.005	-0.050
	[0.761]	[0.009]***	[0.791]	[0.008]***
Age Dependency	-0.031	-0.288	-0.036	-0.280
	[0.601]	[0.001]***	[0.531]	[0.001]***
M1	0.67	0.13	0.83	0.11
M2	0.46	0.78	0.54	0.63
Sargan test	0.02	0.53	0.01	0.42
Diff-Sargan test		1.00		1.00
Granger causality test	0.14	0.60	0.55	0.40
LR effect	0.03	0.09	0.03	0.13
[Standard error]	[0.03]	[0.04]	[0.06]	[0.06]
Heterogeneity test		0.00		0.00
CSD test	0.01	0.30	0.03	0.25
Observations	895	1021	895	1021

Notes: The lower income dummy is for 31 low income countries and 63 middle income countries. See previous tables for more notes.

Table 5. Channels Through Which Output Volatility Affects Resource Depletion: 1979-2008

Dependent Variable:	**Financial Development Channel**				**Investment Channel**			
Resource Depletion	**DIF-GMM**	**SYS-GMM**	**DIF-GMM-C**	**SYS-GMM-C**	**DIF-GMM**	**SYS-GMM**	**DIF-GMM-C**	**SYS-GMM-C**
Lag 1 Resource Depletion	0.106	-0.386	0.191	-0.401	-0.050	-0.397	-0.051	-0.091
	[0.159]	[0.021]**	[0.104]	[0.171]	[0.585]	[0.032]**	[0.581]	[0.448]
Lag 1 Output Volatility	-0.012	0.212	-0.017	0.194	0.068	0.208	0.120	0.101
	[0.862]	[0.024]**	[0.819]	[0.037]**	[0.098]*	[0.031]**	[0.003]***	[0.054]*
Lag 1 Liquidity Liability	0.024	0.006	0.031	0.004				
	[0.099]*	[0.827]	[0.055]*	[0.927]				
Lag 1 Investment					-0.004	-0.005	0.023	-0.009
					[0.816]	[0.816]	[0.217]	[0.471]
Lag 1 per capita GDP Growth	-0.030	0.105	-0.040	0.097	0.053	0.124	0.121	0.046
	[0.718]	[0.324]	[0.764]	[0.291]	[0.372]	[0.288]	[0.096]*	[0.346]
Lag 1 per capita GNI	-0.011	-0.072	-0.018	-0.059	-0.002	-0.045	0.006	-0.031
	[0.620]	[0.002]***	[0.610]	[0.064]*	[0.933]	[0.014]**	[0.806]	[0.073]*
Age Dependency	-0.077	-0.289	-0.085	-0.234	0.005	-0.229	-0.046	-0.120
	[0.195]	[0.001]***	[0.167]	[0.067]*	[0.912]	[0.001]***	[0.332]	[0.096]*
M1	0.11	0.18	0.05	0.26	0.78	0.15	0.91	0.85
M2	0.25	0.75	0.15	0.72	0.74	0.95	0.29	0.85
Sargan test	0.08	0.46	0.78	0.80	0.02	0.48	0.14	0.62
Diff-Sargan test		1.00		0.57		1.00		1.00
Granger causality test	0.18	0.02	0.22	0.10	0.08	0.18	0.01	0.01
LR effect	-0.01	0.15	-0.02	0.14	0.06	0.15	0.11	0.09
[Standard error]	[0.08]	[0.07]	[0.09]	[0.07]	[0.04]	[0.06]	[0.04]	[0.05]
Heterogeneity test		0.00		0.00		0.01		0.00
CSD test	0.00	0.07			0.02	0.21		
Observations	773	890	773	890	895	1021	895	1021

Notes: 128 countries. The financial development channel via liquidity liability and the investment channel via investment share of GDP are examined, separately. See previous tables for more notes.

Appendix Table 1. The Variables

Variable	Description	Source
Genuine Savings	Adjusted net savings, excluding particulate emission damage (% of Gross National Income). The regression uses the 3-year averages of the natural logarithm of one plus the adjusted net savings divided by 100, log(1+GENSAV/100), because some countries have negative values of GENSAV.	World Bank World Development Indicators (WDI) (December, 2010)
Resource Depletion	Depletion of natural resources (% of Gross National Income), including energy depletion, mineral depletion and net forest depletion. The regression uses the 3-year averages of the natural logarithm of one plus the depletion of natural resources divided by 100, log(1+DEPLETION/100).	Calculated based on data from WDI (2010)
Output Volatility	Standard deviation over 3-year interval from 1979 to 2008 of the natural logarithm of one plus the annual growth rate of GDP per capita divided by 100.	Calculated based on data from WDI (2010)
Per capira GDP Growth	The annual growth rate of GDP per capita. The regression uses log(1+GR/100).	WDI (2010)
Per capita GNI	The gross national income per capita. The regression uses GNIPC in log.	WDI (2010)
Age Dependency	The age dependency ratio (dependents to working-age population). The regression uses log(AGE).	WDI (2010)
Investment	The investment share of real GDP per capita (RGDPL). The regression uses log(KI).	Penn World Table 6.3 (PWT) (2009)
Liquidity Liability	The ratio of liquid liabilities of banks and non-bank financial intermediaries (currency plus demand and interest-bearing liabilities) to GDP. The regression uses log(100*LLY).	Calculated based on data from World Bank Financial Development and Structure Database (FDS) (2010)
Low Income Dummy	Dummy for low income countries	World Bank List of Economies (Jan 2011)
Lower Income Dummy	Dummy for low and middle income countries	World Bank List of Economies (Jan 2011)
Lower Energy Intensity Dummy	Dummy for lower energy intensity countries whose averaged final energy intensities over 1979-2008 are below the median value of the averaged final energy intensities.	Calculated based on data from Global Energy Market Data of Enerdata (2010)
Lower Trade Share Dummy	Dummy for lower trade share countries whose averaged trade shares over 1979-2008 are below the median value of the averaged trade shares.	Calculated based on data from WDI (2010)

Appendix Table 2: The List of Countries in the Full Sample

Code	Country Name	Code	Country Name	Code	Country Name
AGO**	Angola	GBR	United Kingdom	NOR	Norway
ARG**	Argentina	GHA*	Ghana	NPL*	Nepal
AUS	Australia	GIN*	Guinea	NZL	New Zealand
AUT	Austria	GMB*	Gambia	OMN	Oman
BDI*	Burundi	GNB*	Guinea-Bissau	PAK**	Pakistan
BEL	Belgium	GNQ	Equatorial Guinea	PAN**	Panama
BEN*	Benin	GRC	Greece	PER**	Peru
BFA*	Burkina Faso	GTM**	Guatemala	PHL**	Philippines
BGD*	Bangladesh	GUY**	Guyana	PNG**	Papua New Guinea
BHR	Bahrain	HKG	Hong Kong, China	PRT	Portugal
BHS	Bahamas	HND**	Honduras	PRY**	Paraguay
BLZ**	Belize	IDN**	Indonesia	RWA*	Rwanda
BOL**	Bolivia	IND**	India	SAU	Saudi Arabia
BRA**	Brazil	IRL	Ireland	SDN**	Sudan
BTN**	Bhutan	IRN**	Iran, Islamic Rep.	SGP	Singapore
BWA**	Botswana	ISL	Iceland	SLB*	Solomon Islands
CAF*	Central African Republic	ISR	Israel	SLE*	Sierra Leone
CAN	Canada	ITA	Italy	SLV**	El Salvador
CHE	Switzerland	JAM**	Jamaica	SUR**	Suriname
CHL**	Chile	JOR**	Jordan	SWE	Sweden
CHN**	China	JPN	Japan	SWZ**	Swaziland
CIV**	Cote d'Ivoire	KEN*	Kenya	SYC**	Seychelles
CMR**	Cameroon	KHM*	Cambodia	SYR**	Syrian Arab Republic
COG**	Congo, Rep.	KOR	Korea, Rep. (South)	TCD*	Chad
COL**	Colombia	KWT	Kuwait	TGO*	Togo
COM*	Comoros	LBN**	Lebanon	THA**	Thailand
CPV**	Cape Verde	LKA**	Sri Lanka	TON**	Tonga
CRI**	Costa Rica	LUX	Luxembourg	TTO	Trinidad and Tobago
CYP	Cyprus	MAR**	Morocco	TUN**	Tunisia
DJI**	Djibouti	MDG*	Madagascar	TUR**	Turkey
DMA**	Dominica	MDV**	Maldives	TZA*	Tanzania
DNK	Denmark	MEX**	Mexico	UGA*	Uganda
DOM**	Dominican Republic	MLI*	Mali	URY**	Uruguay
DZA**	Algeria	MNG**	Mongolia	USA	United States
ECU**	Ecuador	MOZ*	Mozambique	VCT**	St. Vincent and the Grenadines
EGY**	Egypt, Arab Rep.	MRT*	Mauritania	VEN**	Venezuela, RB
ERI*	Eritrea	MUS**	Mauritius	VNM**	Vietnam
ESP	Spain	MWI*	Malawi	VUT**	Vanuatu
ETH*	Ethiopia	MYS**	Malaysia	ZAF**	South Africa
FIN	Finland	NAM**	Namibia	ZAR*	Congo, Dem. Rep.
FJI**	Fiji	NER*	Niger	ZMB*	Zambia
FRA	France	NIC**	Nicaragua	ZWE*	Zimbabwe
GAB**	Gabon	NLD	Netherlands		

Note: This table lists the country codes and names for 128 countries considered in the whole sample. Countries with * are the low income countries while countries with ** are the middle income countries according to World Bank List of Economies (Jan 2011).