Output volatility and growth: combining panel data with an instrument

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Abstract

The effect of output volatility on long-run economic growth is still an unsettled question in the literature. This paper contributes to this question by proposing a new instrument for output volatility that allows for the estimation of the volatility-growth relationship in panel data. We instrument output volatility using the volatility of a commodity terms of trade index. The panel nature of this instrument allows us to focus on within-country variation by adding both country and time period fixed effects into our specifications. The key contribution of this paper is the combination of addressing endogeneity with an instrument and focusing on within-country variation using panel data techniques. Our finding is that output volatility and long-run growth are negatively associated: a 1% increase in output volatility leads to a 0.028 percentage point lower average annual growth rate over the long run.

Keywords: volatility, terms of trade shocks, uncertainty.
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1 Introduction

Output volatility has long been hypothesized to have an effect on long-run economic growth. Different economic models such as those employed by Anglo-Saxon or Nordic countries permit different levels of economic fluctuations throughout the business cycle (Sapir (2016)). But what are the long-run growth effects of such differences? A Schumpeterian 'creative destruction' effect could imply a positive relationship between growth and volatility, but the uncertainty generated by economic fluctuations can also be detrimental (Doepke (2006)). In fact, the theoretical literature has found that the effect of volatility on growth is ambiguous and is sensitive to modeling techniques and the calibration of factors such as risk aversion (Jones and Manuelli (2005)).

Results are similarly ambiguous on the empirical side. While some studies find a positive effect of volatility on growth (Kormendi and Meguire (1985), Grier and Tullock (1989)), most of the more recent literature tends to find a negative relationship (Ramey and Ramey (1995), Fatas (2001), Martin and Rogers (2000), Badinger (2010), Ezcurra and Rios (2015)). Nevertheless, skepticism about these findings remains (Doepke (2006)). With a few exceptions, these studies mostly rely on cross-country evidence and are subject to endogeneity issues. Badinger (2010) is the first one to address this question with an instrumental variable, but he does so in a cross-country setting.

This paper looks at the relationship between volatility and long-run growth in panel data with an instrumental variable. This set-up allows us to not only address endogeneity, but to do so in a setting that focuses on within-country variation by including country and time period fixed effects. We do so by instrumenting output volatility with commodity terms of trade volatility using a new panel data set from the IMF (Gruss and Kebhaj (2019)). We focus on 15-year time periods.

Our findings reinforce the view that economic fluctuations on average have a negative effect on long-run growth. The magnitude of the effect is fairly stable across specifications, and implies that on average a 1% increase in output volatility implies a 0.38% lower growth over a 15-year period. This corresponds to an approximately 0.028 percentage point lower average annual growth rate.

2 Empirical strategy

We estimate panel data regressions of the form

$$\Delta \ln y_{it} = \alpha \sigma_{it}^{y} + \beta X_{it} + \gamma_i + \delta_t + \varepsilon_{it},$$

where $\Delta \ln y_{it}$ is real GDP per capita growth in country i in time period t, σ_{it}^{y} is the standard deviation of annual real GDP per capita growth rates during period t, X_{it} represents control variables, γ_i and

δ_t are country and time period fixed effects, and ε_{it} are robust standard errors clustered at the country level. Our coefficient of interest is α, which measures the sensitivity of long-run growth rates to output volatility.

We divide our global sample up into four roughly 15-year periods ranging from 1962 to 2017. Our baseline control variables include initial GDP per capita in the first year of the period, average years of schooling, trade intensity, and the Polity IV index measuring the extent of democracy. As a robustness check, we also replace the composite Polity IV index with the measure of executive constraints from the same data set, and with POLCON V from Henisz (2000). This latter variable measures political constraints and is used as an indicator of institutional quality in related papers such as Fatas and Mihov (2013) and Badinger (2010). A more detailed description of our data can be found in Appendix B.

Importantly, our specification includes country and time period fixed effects, which means we control for all time-invariant country-specific characteristics as well as all common global shocks in any given period. In addition, we instrument for output volatility using the volatility of country-specific commodity export price indices from Gruss and Kebhaj (2019). This data set consists of a price index of commodities such as agricultural raw materials, energy, food and beverages, and metals. The different commodities are weighted by their share in total commodity exports. Thus our instrument captures the effect of arguably exogenous commodity price shocks on a country's export sector.

A potential problem with our instrument is if the commodity weights in the price index respond to commodity price shocks. For instance, if a new gold mine is discovered in a country, it could increase long-run growth and at the same time change the commodity price index by increasing the weight of gold in it. To rule out such endogenous movements in the commodity price index, we use the fixed-weight version of the commodity price index, which uses average 1980-2015 trade flows as weights for every year in the sample (Gruss and Kebhaj (2019)).

The novel aspect of our empirical strategy is that we introduce a dynamic instrument into the literature, which allows us to simulteanously instrument for output volatility and include country and time period fixed effects in our specifications.

3 Results

The results of our analysis are summarized in Table A.1. The first row shows the coefficient on output volatility when instrumented by commodity price shock volatility. The coefficients are significantly negative in all columns. Column (1) shows a univariate specification that still includes fixed effects. From Column (2) onward, we control for initial GDP per capita to capture the fact that poorer countries tend to grow faster. In Columns (3)-(5), we individually introduce our controls proxying for human capital, integration into the world economy, and institutions. Finally, in Column (6) we control for all variables. The first-stage F-statistics are high indicating a strong first stage. Figure 1 shows a conditional scatter plot corresponding to Column (6) of Table A.1.

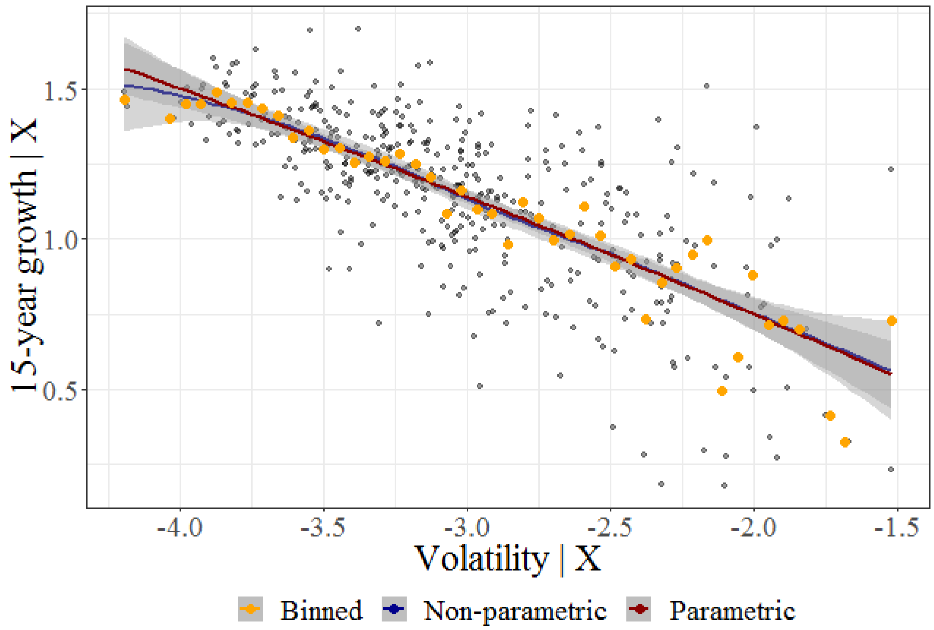

Figure 1: Conditional scatter plot of output volatility and 15-year growth

The magnitude of the coefficient on output volatility is fairly stable throughout the table ranging from -0.270 to -0.379. For comparison, we also show what the coefficient on output volatility would be in each column if we estimated our specifications with OLS instead. The OLS coefficients are also negative though not always significant. They are also fairly stable but about a factor of four smaller than the IV estimates suggesting there is considerable omitted variable bias.

The interpretation of the coefficient in Column (6) is that a 1% increase in output volatility decreases the 15-year growth rate by 0.38%. This corresponds to a 0.028 percentage point reduction in the average annual growth rate.[1] This is very close to the estimates reported by Badinger (2010).

We now turn to several robustness checks in Table A.2. The first three columns of the table look at several subsamples, while the last three consider alternative control variables. In Column (1), we concentrate on a poor country sample by excluding countries classified as high-income by the World Bank. In Column (2), we focus on richer countries by excluding countries classified as low-income by the World Bank. In Column (3), we exclude resource-rich countires by restricting

[1] If we let $g \equiv \frac{y_{t+14}}{y_t} - 1$, then the effect on the average annual growth rate is given by $(1+g)^{1/14} - [(1+g)(1-0.0038)]^{1/14}$. This effect depends on g to a small extent: at the sample minimum g the effect is 0.023 percentage points, at the sample maximum it is 0.030 percentage points.

the sample to those countries whose natural resource rents is in the top 25% globally as a % of GDP.[2] In Column (4), we substitute our measure of institutions, the composite Polity IV index, with a single component of the Polity IV index that measures only executive constraints. This is indeed a better predictor of long-run growth, but the coefficient on output volatility is unaffected by this change. In Column (5), we instead use the political constraints measure by Henisz (2000), a common measure of institutional quality in the literature. In Column (6), we include both executive constraints and political constraints. The results in Column (4)-(6) are broadly unchanged even if we include our measure of Polity IV – most notably the coefficient on output volatility still comes in significant with a similar magnitude.

Altogether, Table A.2 shows that the effect of output volatility on long-run growth is robust to different subsamples and measures of institutions. The results are not constrained to poorer or richer countries only. Neither are they only prevalent in resource-rich countries despite our instrument being based on commodity prices. Finally, even when we control for institutional quality with different variables that are potentially better measures than the Polity IV index, the relationship between output volatility and growth remains unchanged.

4 Conclusion

Our paper examined the relationship between output volatility and long-run economic growth. The key novelty of this contribution is the combination of panel data with an instrumental variable to address endogeneity. The panel data set-up allows us to focus on within-country variation in a global sample. Our conclusion is that output volatility and 15-year GDP per capita growth rates are negatively related. A 1% increase in output volatility decreases 15-year growth rates by 0.38% on average, which corresponds to a 0.028 percentage point lower average annual growth rate. Our results imply that policy measures dampening output volatility can potentially be beneficial for long-run growth rates.

[2] This corresponds to 10.7% of GDP. We look at average natural resource rents as a % of GDP over 1960-2017. This data is from the World Bank, see Appendix B for more details.

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A Tables

Table A.1: Main results

	Dependent variable:					
	15-year GDP per capita growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Output volatility	-0.270^{*}	-0.319^{*}	-0.356^{*}	-0.316^{*}	-0.353^{*}	-0.379^{*}
	(0.155)	(0.167)	(0.188)	(0.169)	(0.185)	(0.197)
Log initial GDPpc		-0.428^{***}	-0.356^{***}	-0.439^{***}	-0.415^{***}	-0.347^{***}
		(0.068)	(0.074)	(0.076)	(0.072)	(0.080)
Avg. schooling			-0.005			0.006
			(0.036)			(0.036)
Trade intensity				0.061		-0.044
				(0.105)		(0.117)
Polity IV					-0.019	-0.008
					(0.053)	(0.052)
First-stage F	22.982	22.288	17.658	22.236	19.733	15.499
Country and period FE	Yes	Yes	Yes	Yes	Yes	Yes
OLS coefficient	-0.063	-0.069	-0.099^{**}	-0.071	-0.071	-0.103^{***}
	(0.055)	(0.045)	(0.039)	(0.045)	(0.048)	(0.039)
Observations	514	514	440	514	486	425
R^2	0.395	0.511	0.510	0.514	0.503	0.494

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

This table shows the negative relationship between output volatility and 15-year GDP per capita growth in country-level panel data covering 1962-2017. All columns include country and period fixed effects. Output volatility is instrumented by trade-weighted commodity export price shocks. Initial GDP per capita is calculated in the first year of the 15-year periods. Schooling, trade intensity and Polity IV are averaged over the 15-year periods. The coefficients on output volatility in the corresponding OLS models are reported in the "OLS coefficient" row. Robust standard errors are clustered at the country level.

Table A.2: Robustness checks

	Dependent variable:					
	15-year GDP per capita growth					
	Poor	Rich	No resource-rich	Ex. con.	Pol. con.	Both
	(1)	(2)	(3)	(4)	(5)	(6)
Output volatility	-0.297	-0.389^{**}	-0.414^{*}	-0.366^{*}	-0.370^{*}	-0.346^{*}
	(0.194)	(0.193)	(0.214)	(0.201)	(0.198)	(0.208)
Log initial GDPpc	-0.229^{***}	-0.388^{***}	-0.250^{**}	-0.360^{***}	-0.343^{***}	-0.357^{***}
	(0.071)	(0.098)	(0.098)	(0.081)	(0.079)	(0.079)
Avg. schooling	-0.022	-0.001	-0.014	0.009	0.005	0.005
	(0.044)	(0.036)	(0.039)	(0.036)	(0.037)	(0.037)
Trade intensity	-0.017	-0.104	-0.019	-0.040	-0.046	-0.048
	(0.205)	(0.127)	(0.136)	(0.114)	(0.118)	(0.114)
Polity IV	0.028	-0.036	0.006			
	(0.051)	(0.056)	(0.058)			
Executive constraints				0.005^{*}		0.006^{**}
				(0.003)		(0.003)
POLCON V					0.016	-0.059
					(0.115)	(0.115)
First-stage F	12.199	13.466	14.657	16.392	13.932	13.449
Country and period FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	295	355	334	423	422	415
R^2	0.563	0.476	0.406	0.515	0.507	0.532

Note: *p<0.1; **p<0.05; ***p<0.01

This table shows the robustness of the negative relationship between output volatility and 15-year GDP per capita growth in country-level panel data covering 1962-2017. All columns include country and period fixed effects. Output volatility is instrumented by trade-weighted commodity export price shocks. The "Poor" column excludes high-income countries, the "Rich" column excludes low-income countries, the "No resource-rich" column excludes resource-rich countries. Columns (4)-(6) replace Polity IV with alternative controls for institutional quality. Robust standard errors are clustered at the country level.

B Data description

B.1 Dependent variables

15-year GDP per capita growth: This is calculated as $\ln \frac{y_{t+14}}{y_t}$, where y_t is real GDP per capita in year t. The source is the Penn World Table 9.1 (Feenstra et al. (2015)). GDP per capita in any given year is calculated as the real GDP ("rgdpna") divided by population ("pop"). The data covers years 1950-2017.

B.2 Independent variables

Output volatility: This is the standard deviation of annual real GDP per capita growth rates within 15-year periods. Annual growth rates are calculated as $\frac{y_t}{y_{t-1}} - 1$. The periods for which we calculate these are 1962-1974, 1975-1989, 1990-2004 and 2005-2017. The source for the underlying real GDP per capita data is the Penn World Table 9.1 (Feenstra et al. (2015)).

Commodity export price shocks: This is the instrumental variable for output volatility. It refers to the standard deviation of a trade-weighted commodity export price index within 15-year periods. The periods for which we calculate these are 1962-1974, 1975-1989, 1990-2004 and 2005-2017. The source for the underlying price index is Gruss and Kebhaj (2019). We use the historical fixed-weight export price index, where weights are the share of a commodity in total commodity trade.

Log initial GDP per capita: This is the natural logarithm of real GDP per capita in the first year of the 15-year period, i.e. in 1962, 1975, 1990, and 2005. The source is the Penn World Table 9.1 (Feenstra et al. (2015)).

Average schooling: This refers to average years of total schooling for the population aged 25-64. This is available for 1950-2010 in five-year intervals. We take the average of all observations within our 15-year periods. E.g. for 1975-1989, we average the 1975, 1980 and 1985 observations. The source is Lee and Lee (2016).

Trade intensity: This is the share of exports plus imports in GDP. It is calculated from the Penn World Table 9.1 (Feenstra et al. (2015)) as the share of exports in GDP ("csh_x") plus the share of imports ("-csh_m"). It is calculated for the initial year of the 15-year periods.

Polity IV: This is the Polity 2 ("polity2") measure from the Polity IV data set. It is a composite measure of *de jure* democracy ranging from -10 (full autocracy) to +10 (full democracy). The source is Marshall et al. (2018). The range for this data is 1800-2017. We take the mean over our 15-year periods.

Executive constraints: This is the executive constraints ("exconst") measure from the Polity IV data set.

It is a constraints on the executive ranging from 1 (unlimited authority) to 7 (executive parity or subordination). The source is Marshall et al. (2018). The range for this data is 1800-2017. We take the mean over our 15-year periods.

Political constraints: This is a meaure of political constraints ("polconv") from Henisz (2000). The range for this data is 1960-2016. We take the mean over our 15-year periods.

B.3 Subsampling variables

World Bank income category: The category of income in which a country is according to the World Bank. There are four categories: low-income, middle-low, middle-high, and high-income. The source is World Bank (2018).

Resource richness: This refers to natural resource rents as a % of GDP. The source is the World Bank database. The variable's identifer is "NY.GDP.TOTL.RT.ZS", and the time span is 1960-2017. We use the mean value over the entire period.