Commodity Dynamics, Producer Diversification, and Output Volatility

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Abstract

The literature has documented a significant increase in commodity return correlations after 2004. What has been the impact of this development on the risk faced by commodity producing countries? We answer this question through an empirical analysis of the market value of commodity producers' output. We select 50 countries by the contribution of commodity production to their GDP and construct value processes for national output based on historical production statistics for 21 commodities and their historical prices. We find that the volatility of output value for well diversified producing countries (effectively producing three or more commodities) has increased from 13.6% in 1995-2003 to 19.5% in 2004-2012. Countries effectively limited to the production of one or two commodities had output volatility of 23.7% in 1995-2003 and 25.5% in 2004-2012. Hence, diversified countries have experienced an increase in risk that is roughly three times larger than that suffered by concentrated producers. We explain these results through an approximate decomposition of national output volatility in terms of the Herfindahl index associated to the specialization in production, average commodity volatility and average pairwise correlations.

Keywords: Commodities; Output volatility; Market concentration; Herfindahl index

JEL codes: Q02; E30.

1. Introduction

This paper explores the determinants of commodity output volatility at the national level. We are motivated by two observations. First, monthly commodity returns, which exhibited pairwise correlations close to 10% on average between 1986 and 2003, have since then become much more correlated. Pairwise correlations for returns in agricultural, mineral, energy and soft commodities were on average close to 30% between 2004 and 2012. The second observation is that commodity producers differ strongly in their degree of diversification. For example, 90% of Russia's commodity output value is due to oil. By contrast, commodity output value from Brazil is 50% from oil, 14% from soybeans, and it also includes significant components in corn, sugar, orange juice, and others. Motivated by these facts we take a portfolio perspective to the risk faced by commodity producers and perform and empirical exploration of the volatility of commodity output value, for the cross section of commodity producers, and across time. A portfolio perspective suggests that diversified commodity producers should experience lower volatility than concentrated producers. How significant is this effect? A portfolio perspective also suggests that the observed increase in commodity correlations should lead to higher output volatility for diversified producers while having a lesser effect on concentrated producers. What are the magnitudes of these effects? Is it possible to identify a simple relationship between the output volatility of a commodity producer, its degree of diversification, and overall commodity market conditions?

We explore these issues empirically on a sample of 50 countries for which the ratio of commodity output value to GDP exceeds 5%. Our sample includes many developing countries but also rich countries such as Norway and Canada. For each country we construct measures of national concentration (or specialization) based on the relative contribution of 22 agricultural, mineral, soft and energy commodities to the dollar value of national commodity output.

Our main findings are as follows. First, between 1986 and 2012, the volatility of commodity output value due to changes in market prices was almost three times larger than the volatility of output value due to yearly changes in physical output. Second, between 1986 and 2003, concentrated commodity producers defined as those countries significantly engaged in the production of two or less commodities, experienced a 25% annual volatility of output value. By contrast, diversified commodity producers, defined as those deriving significant revenues from three or more commodities, faced an average annual volatility close to 15%. Average pairwise commodity correlation during this period was close to 10%. Third, the gap in risk between concentrated and diversified producers narrowed in 2004-2012 to 6%, primarily driven by an increase of the risk faced by diversified producers to 19.5%. This increase, in turn, follows directly from higher pairwise commodity correlations, averaging 30% in this time period. The sizeable increase in commodity output volatility for diversified producers is economically important because commodity output contributes a significant portion of GDP for the countries in our sample. We also find that a simple linear relationship between specialization and output variance holds across time, with parameters solely determined by the overall level of commodity volatility and average cross-sectional pairwise correlation.

This paper is related to several strands of the literature. Output volatility is highly correlated with GDP volatility and it has long been understood as detrimental for economic performance in dimensions such as development, growth, investment, inequality, institutional stability, etc. Some works in the extensive literature dealing with these issues are Ramey and Ramey (1995) on a cross-country negative relationship between volatility and growth and Aizenman and Marion (1999) on a negative correlation between volatility and private investment. More recently, the causes of output volatility have been explored extensively. Koren and Tenreyro (2007) found that GDP growth volatility is higher in poor countries due to, among other reasons, their degree of specialization in manufacturing. Di Giovanni and Levchenko (2009) explored the effect of trade openness on volatility using industry-level data and, among other findings, identified a positive relationship between trade, specialization and output volatility. These papers focus on the fundamental causes of volatility of manufacturing output. Our paper, by contrast, focuses on the volatility of commodity output value and its relationship with the underlying structure of production and overall dynamics in the global commodity markets. The volatility of commodity output value is a first order risk for commodity producers. The gains associated with hedging against commodity price volatility at the national level were quantified by Borensztein et al. (2013). The relationship between the structure of production and commodity markets was explored at the individual commodity level by Merener (2015) who found that individual commodities produced in relatively few countries exhibit stronger global price fluctuations, as reflected by the kurtosis of their returns, than those produced at many locations. In related work, Watugala (2015) found that higher concentration in the importers of a commodity leads to higher commodity price volatility.

The paper is structured as follows: In Section 2 we describe our commodity data and discuss certain aspects of commodity price dynamics between 1986 and 2012. In Section 3 we consider the risk faced by a commodity producing nation and propose a simple decomposition of commodity output volatility in terms of the degree of diversification of production and overall commodity market dynamics. In Section 4 we present our sample of commodity producing countries and our empirical results for the relationship between specialization and commodity output volatility. We conclude in Section 5.

2. Commodity dynamics

We consider in this paper a sample of 21 commodities that were international in the scope of their physical trading and for which there were global price benchmarks during 1986-2012. We rely on near term futures prices generally understood to represent global prices for the commodities in the sample. In some cases and for some countries domestic prices might differ from the most liquid futures prices overseas due, for example, to shipping considerations. But even in those cases local prices are generally strongly correlated with the most liquid futures prices abroad and hence it is appropriate to use the latter for the computation of local commodity price risk.

Our sample includes the most important industrial metals: aluminium, lead, nickel, copper, zinc and tin, traded at the London Metals Exchange (LME). We also include platinum and palladium, traded at NYMEX. We work with the price of Brent oil, rather than WTI, as Brent is widely considered to be more effective in incorporating changes in global aggregate supply and demand. Grains in our sample are corn, wheat and soybeans traded at CBOT. Soft commodities are coffee, cotton, cocoa, sugar and orange juice, currently traded at ICE and at the NYBOT prior to 2007. Rubber is traded at the Tokyo Commodity Exchange and palm oil is traded at the Bursa Malaysia exchange. Rough rice is traded at the CBOT. For each physical commodity we have selected the exchange where it is most liquidly traded and the associated price most likely to be seen as a global benchmark. We do not include electricity of natural gas because they are largely produced and traded domestically hence not priced in a consistent manner across the globe.

From Datastream we obtained monthly prices from January 1st, 1986 to December 31st, 2012. Table 1 displays the list of commodities, their venue of trading, the data data source employed in this paper for production data, and annualized volatility for monthly returns in the periods 1986-1994, 1995-2003, and 2004-2012. Inspection of Table 1 reveals certain regularities. First, volatilities in the cross-section are of the same order of magnitude. The smallest recording is 13.0% (aluminium, in the second period) and the largest one is 36.9% (oil, in the first period). Hence volatilities are relatively close to their cross-sectional means. Second, cross-sectional volatility averages (with commodities weighted equally or, alternatively, according to the dollar value of their global yearly production) exhibited mild variation across periods.

Table 2 displays correlations for monthly returns and selected but representative pairs of commodities in our sample. Correlation structures in 1986-1994 and 1995-2003 were similar, and average correlations for each of these periods (for the full sample of commodities) were close to 10%. Pairwise correlations for 2004-2012 were remarkably different. Almost all entries in this correlation matrix were significantly higher than in earlier periods. The average correlation for the full sample of commodities is 30.8%. Hence, this is in agreement with Tang and Xiong (2012) in documenting a very strong increase in commodity correlations since 2004.

3. A decomposition for output volatility

We present now a simple decomposition for the variance of the market value of a basket of commodities which is to be interpreted as the national output of a commodity producer. Our goal is to formulate a simple framework to guide us later in the empirical testing of the relationship between specialization in commodity production, commodity market conditions, and commodity output volatility.

A country produces N commodities. Commodity k contributes to the value of the national basket according to the prevailing price of the commodity $p_k(t)$ and the size of national output $Q_k(t)$. The value of the basket is

$$V(t) = \sum_{i=1}^{N} Q_i(t) p_i(t),$$

and its total return is

$$r(t) = \frac{\sum_{i=1}^{N} Q_i(t+1)p_i(t+1) - \sum_{i=1}^{N} Q_i(t)p_i(t)}{\sum_{i=1}^{N} Q_i(t)p_i(t)}.$$

This can be decomposed (leaving aside second order terms) as

$$r(t) = r_{price}(t) + r_{quant}(t) \tag{1}$$

with

$$r_{price}(t) = \frac{\sum_{i=1}^{N} Q_i(t)(p_i(t+1) - p_i(t))}{\sum_{i=1}^{N} Q_i(t)p_i(t)} \tag{2}$$

being the contribution to the total return due to variation in commodity prices and

$$r_{quant}(t) = \frac{\sum_{i=1}^{N} p_i(t)(Q_i(t+1) - Q_i(t)}{\sum_{i=1}^{N} Q_i(t)p_i t(t)} \tag{3}$$

the component of the return in output value that is due to the change in produced quantities. In this paper we will use annual and monthly returns, and their corresponding statistics. In the case of annual returns, we simply use quantity and price data with yearly frequency and therefore both terms in (1) are possibly and typically non-zero. In the case of monthly returns we use price data updated monthly combined with quantity data that measures annual production and that is updated yearly (in agreement with publicly available statistics). Hence, in the case of monthly returns, $r(t) = r_{price}(t)$ for every month except January.

We will first explore the empirical contribution of $r_{quant}(t)$ and $r_{price}(t)$ to $r(t)$ using yearly returns. Then, we will focus our attention on the effect of market concentration and commodity price dynamics on the volatility of $r_{price}(t)$ exclusively. Notice that by focusing on $r_{price}(t)$ we will be keeping quantities fixed within all returns but not across time when computing returns in different years. Define

$$w_i = \frac{Q_i p_i(t)}{\sum_{j=1}^{N} Q_j p_j(t)}$$

with $\sum_{i=1}^{N} w_i = 1$ and write the price component as the basket return as

$$r_{price}(t) = \sum_{i=1}^{N} w_i r_i(t)$$

where $r_i(t)$ is the return of the $i - th$ commodity. Let σ_B^2 be the variance of $r_{price}(t)$, which can be written in terms of the variances and correlations of individual commodity returns

$$\sigma_B^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i=1, j \neq i}^{N} w_i w_j \sigma_i \sigma_j \rho_{ij}$$

Our goal is to characterize the variance of the basket in terms of the underlying commodities and the degree of specialization implicit in the structure of production given by $\{w_1, ..., w_N\}$. The degree of concentration is often measured by the Herfindahl index

$$H \equiv \sum_{i=1}^{N} w_i^2 \tag{4}$$

The Herfindahl index takes values between 0 and 1. In our application, a large Herfindahl index indicates a poorly diversified commodity producer. This is the case, for instance, of Saudi Arabia. A related measure of specialization is the inverse of the Herfindahl index

$$N^{Eff} \equiv \frac{1}{H} = \frac{1}{\sum_{i=1}^{N} w_i^2}, \tag{5}$$

which is interpreted as the effective number of commodities produced by the country. In particular, in the equally weighted case with $w^i = 1/N$ it naturally holds that $N^{Eff} = N$, and $N^{Eff} = 1$ for the fully concentrated case of $w_1 = 1$. Let

$$\sigma = \frac{1}{N}\sum_{i=1}^{N} w_i^{World}\sigma_i \tag{6}$$

be the cross-sectional average of commodity volatility where each commodity is weighted according to its contribution to the value of global annual commodity output and

$$\rho = \frac{1}{N*(N-1)}\sum_{i,j=1,j\neq i}^{N} \rho_{ij} \tag{7}$$

the average pairwise correlation. We are interested in an approximate yet simple decomposition of σ_B^2 in terms of the structure of production summarized by H and by the overall commodity market dynamics summarized by $\{\sigma^2, \rho\}$. It holds that

$$\begin{aligned}
\sigma_B^2 &= \sum_{i=1}^{N} w_i^2\sigma_i^2 + \sum_{i,j=1,j\neq i}^{N} w_i w_j \sigma_i \sigma_j \rho_{ij}, \\
&\approx \sigma^2 \sum_{i=1}^{N} w_i^2 + \sigma^2\rho \sum_{i,j=1,j\neq i}^{N} w_i w_j, \\
&= \sigma^2 \sum_{i=1}^{N} w_i^2 + \sigma^2\rho((\sum_{w=1}^{N} w_i)^2 - \sum_{w=1}^{N} w_i^2), \\
&= \sigma^2 H + \sigma^2\rho(1-H).
\end{aligned}$$

and therefore

$$\sigma_B^2 \approx \sigma^2\rho + H\sigma^2(1-\rho). \tag{8}$$

Several conclusions can be derived from (8).

- The relationship between the variance of commodity output value, the degree of concentration H and overall commodity market dynamics given by $\{\sigma, \rho\}$ is non-linear.

- For fixed $\{\sigma, \rho\}$, σ_B^2 is linear and increasing in H as seen in Figure 1. The lowest possible value of σ_B^2 is $\sigma^2\rho$ which corresponds to the systematic risk faced by a fully diversified commodity producer engaged in the production of correlated commoditites. The highest possible value of σ_B^2 is σ^2 which corresponds to the completely specialized commodity producer.

- Changes in commodity market conditions represented by $\{\sigma, \rho\}$ imply variations in output risk. In particular, the output variance faced by commodity producers is proportional to σ^2 regardless of their degree of specialization. However, an increase in ρ leads to an increase in the constant term and decrease in the slope in (8) so that the output volatility for diversified producers increases by a larger amount than that of concentrated producers.

4. Results

4.1. Production data and preliminary calculations

We began our selection of commodity producers by identifying the top 10 producers for each of the commodities in Table 1 during 1986-2012. For each of these countries we then obtained production data with yearly frequency for all commodities in our sample. For aluminium, copper, nickel, tin, zinc, lead, platinum and palladium data were gathered from reports produced by the United States Geological Survey (USGS)[1]. Data for oil was obtained from the British Geological Survey (BGS)[2]. Soybean, wheat, corn, cotton, coffee, sugar, orange juice, and canola output statistics were collected from the Foreign Agricultural Service at the United States Department of Agriculture (USDA)[3]. Finally, cocoa, palm oil, rubber and rough rice data was obtained from the Food and Agriculture

[1]http://minerals.usgs.gov/minerals/pubs/commodity
[2]http://www.bgs.ac.uk/
[3]http://www.fas.usda.gov

Organization (FAO) of the United Nations [4]. We supplemented our production data with yearly GDP data from the World Bank. Then we computed, for each country, the yearly time series of commodity output value, defined as

$$\sum_{i=1}^{N} Q_i(t) p_i(t).$$

and kept in our sample those countries for which the ratio of commodity output value to GDP ratio was larger than 5% during 1986-2012. The list of selected countries is in Table 3. For these countries we also computed their Herfindahl index with yearly frequency and effective number of commodities in their basket. Inspection of Table 3 reveals a wide variation in the relative contribution of commodities to GDP across the sample. The cross-sectional average contribution to GDP is close to 20% but values range from just above 5% to values as high as 59% for oil producers such as Kuwait and Saudi Arabia. The degree of concentration or specialization in the production of commodities also varies strongly across the sample. Brazil is a well diversified commodity producer, with low Herfindahl index and an effective number of commodities equal to 4.7. By contrast, the Herfindahl index of Kuwait and Chile are very high, as these countries concentrate almost exclusively in oil and copper respectively. For the most part, there is little variation in the Herfindahl index across time. This is a consequence of the fact that most countries produce commodities according to their local availability as a natural resource. Some exceptions to this rule are driven by technological change, as in the case of increasing oil production in Canada which had an associated Herfindahl index of 0.33 in 1986-1994 and 0.67 in 2004-2012. Finally, the cross-sectional correlation between the commodity output value to GDP ratio and Herfindahl index is 61%.

We also compute, for each commodity producer in our sample, the average annual volatility for total output returns (as in (1)), volatility for output returns due to annual

[4] http://www.faostat.fao.org

price changes (as in (2)), and volatility for output returns due to yearly changes in produced quantities (as in (3)). Each mark in Figure 2 represents a volatility estimate (due to price changes or physical output changes) for a country in our sample. Across countries, the average for total output return volatility between 1986 and 2012 was 34.6%. The average output return volatility due to changes in quantities was 12.8% and due to changes in prices was 30.9%. Therefore, the bulk of economic risk faced by commodity producers is due to price risk rather than physical output risk. In the remainder of this paper we focus on output value volatility that is caused by the underlying commodity price fluctuations.

4.2. Empirical results on specialization and output volatility

For each of the 50 countries in our sample we compute the variance of output value returns due to monthly price changes, for three periods of equal length: 1986-1994, 1995-2003 and 2004-2010. Variance estimates for each country and period are displayed in Figure 3 as a function of the Herfindahl index. It is apparent for all periods an increasing relationship between specialization and output volatility. However, in order to evaluate the dependence of output volatility on overall commodity market conditions it is appropriate to recall (8) and test

$$\begin{aligned} BasketVariance_k &= \beta_1 Concentration_k + \beta_2 \frac{CommodityProd}{GDP}_k + \beta_3 \frac{GDP}{WorldGDP}_k \\ &\quad + \beta_4 OilDummy_k + Const + \epsilon_k \end{aligned} \tag{9}$$

on the cross-section of commodity producers, where we run a separate regression for each time period. The specification (9) postulates a linear relationship between concentration and output variance as in (8) but also includes several controls for other plausible determinants of output volatility. These are: the relative importance of the commodity sector relative to GDP, the size of the domestic economy, and whether the commodity producer focuses on oil (the OilDummy variable is 1 if oil contributes to 75% or more of domestic commodity output value). Estimation results are presented in the second, fourth and sixth columns of Table 4. The effect of concentration or specialization in commodity output variance is positive and very strongly significant. The effect of controls are not consistently significant. Therefore, concentrated producers face significantly higher risk than diversified producers. In the third, fifth and last columns we also present the estimates for the slope and constant terms in (8) computed using the estimates of σ and ρ for each period, namely (6) and (7), reported already as averages in Tables 1 and 2. These represent overall conditions prevailing in the commodity markets in each period. Remarkably, these slope and intersect estimates based on average market conditions are very close to the coefficients estimated through OLS for all periods. In particular, the large increase in commodity return correlations during 2004-2012 is evident in the sizeable constant term for the last period. There is strong agreement between its value estimated through OLS, and the value predicted by the simple decomposition in (8) and overall market conditions.

In order to gain a more clear understanding of the magnitude of the risk increase due to higher correlations we display in Figures 4, 5, and 6 the volatility of output value (rather than variance) as a function of the effective number of commodities produced by each country. Figures 4 and 5 show very similar behavior, with diversified producer facing significantly lower volatility risk than concentrated producers. This situation changes in the last period with a strong increase in the output value volatility faced by diversified producers. Numerical estimates of this effect are provided in Table 5. The average output volatility for concentrated producers, defined as those with effective number less or equal than 2, had a mild increase from 0.237 to 0.255 from 1995-2003 to 2004-2012. However, diversified producers saw their output volatility increase from 0.136 to 0.195 in the same time period. Hence the increase in risk for diversified producers was roughly three times larger than that suffered by concentrated producers.

Our findings are economically significant in their cross-sectional and time dimensions. The average ratio of commodity output value to GDP for the countries in our sample is close to 20%. Hence, an increase of several percentage points in annual volatility implies a large increase in the volatility of GDP.

5. Conclusions

We study in this paper the relevance of commodity production diversification and overall commodity market conditions to explain the cross-sectional and time variation in the volatility of commodity output value at the national level. We focus on the 50 countries with highest commodity production to GDP ratios, where the basket of commodities includes 21 agricultural, mineral and energy commodities traded and priced globally. We find that the degree of producer specialization, or concentration in the production of few commodities, was significantly and positively correlated with output volatility. Moreover, the increase in commodity return correlations experienced globally since 2004 has increased the risk of diversified commodity producers by an economically important amount. We also find that national output variance is well characterized empirically by a simple approximation of basket variance in terms of the Herfindahl index, average commodity market volatility and average commodity correlation.

References

Aizenman, J., Marion, N. (1999). Volatility and investment: interpreting evidence from developing countries. Economica, 66(262), 157-1179

Arezki, R., Loungani, P., van der Ploeg, R., Venables, A. J. (2014). Understanding international commodity price fluctuations. Journal of International Money and Finance, 42, 1-8

Borensztein, E., Jeanne, O., Sandri, D. (2013). Macro-hedging for commodity exporters. Journal of Development Economics, 101, 105-116.

Giovanni, J. D., Levchenko, A. A. (2009). Trade openness and volatility. The Review of Economics and Statistics, 91(3), 558-585.

Giovanni, J. D., Levchenko, A. A. (2010). The risk content of exports: a portfolio view of international trade (No. w16005). National Bureau of Economic Research.

Koren, M., Tenreyro, S. (2007). Volatility and development. The Quarterly Journal of Economics, 243-287.

Malik, A., Temple, J. R. (2009). The geography of output volatility. Journal of Development Economics, 90(2), 163-178.

Merener, N. (2015). Concentrated Production and Conditional Heavy Tails in Commodity Returns. The Journal of Futures Markets, xx, xx-xx.

Ramey, G., Ramey, V.A., (1995). Cross-country evidence on the link between volatility and growth. American Economic Review 85, 1138-1151.

Tang, K., Xiong, W. (2012). Index investment and financialization of commodities. Financial Analysts Journal, 68, 54-74

Watugala, S. W. (2014). Economic Uncertainty and Commodity Futures Volatility. Available at SSRN 2533995.

Commodity	Production data	Price data	Volatility		
			86-94	95-03	04-12
Aluminum	USGS	LME	0.296	0.130	0.206
Lead	USGS	LME	0.255	0.161	0.326
Nickel	USGS	LME	0.341	0.231	0.339
Copper	USGS	LME	0.235	0.168	0.288
Zinc	USGS	LME	0.230	0.161	0.280
Tin	USGS	LME	0.188	0.142	0.268
Oil	BGS	NYMEX	0.369	0.301	0.295
Platinum	USGS	NYMEX	0.172	0.165	0.219
Palladium	USDA	NYMEX	0.182	0.318	0.284
Soybeans	USDA	CBOT	0.172	0.178	0.246
Wheat	USDA	CBOT	0.187	0.205	0.300
Corn	USDA	CBOT	0.221	0.196	0.280
Coffee	USDA	NYBOT	0.364	0.309	0.236
Cotton	USDA	NYBOT	0.275	0.229	0.289
Cocoa	FAO	NYBOT	0.236	0.234	0.211
Sugar	USDA	NYBOT	0.323	0.257	0.323
Orange juice	USDA	NYBOT	0.288	0.203	0.270
Palm oil	FAO	BME	0.293	0.357	0.243
Rubber	FAO	TCE	0.137	0.209	0.277
Canola	USDA	ICE	0.184	0.154	0.217
Rough Rice	FAO	CBOT	0.356	0.216	0.231
Average			0.253	0.216	0.268
Average by World Prod.			0.309	0.264	0.282

Table 1: List of commodities, data sources, and return volatilities

	1986-1994	Alum.	Copper	Oil	Plat.	Soy	Corn	Coffee	Cotton
Avg.	Copper	0.14							
0.100	Oil	0.15	0.10						
	Platinum	0.17	0.12	0.09					
	Soy	0.39	0.14	-0.01	0.13				
	Corn	0.20	-0.02	-0.28	0.06	0.73			
	Coffee	0.10	0.18	0.06	0.13	0.11	0.02		
	Cotton	0.10	0.14	-0.12	0.09	0.17	0.19	-0.20	
	Rice	0.01	-0.14	-0.24	-0.11	0.15	0.30	0.00	0.01
	1995-2003	Alum.	Copper	Oil	Plat.	Soy	Corn	Coffee	Cotton
Avg.	Copper	0.62							
0.094	Oil	0.27	0.19						
	Platinum	0.33	0.26	0.19					
	Soy	0.05	0.17	-0.02	-0.06				
	Corn	-0.04	-0.05	-0.08	-0.14	0.56			
	Coffee	0.21	0.13	-0.07	0.15	0.06	0.06		
	Cotton	0.05	0.19	0.10	0.12	0.31	0.12	-0.03	
	Rice	-0.03	0.12	-0.04	0.03	0.22	0.09	-0.01	0.18
	2004-2012	Alum.	Copper	Oil	Plat.	Soy	Corn	Coffee	Cotton
Avg.	Copper	0.71							
0.308	Oil	0.53	0.59						
	Platinum	0.54	0.65	0.49					
	Soy	0.31	0.29	0.35	0.44				
	Corn	0.29	0.22	0.27	0.33	0.71			
	Coffee	0.28	0.21	0.19	0.25	0.42	0.40		
	Cotton	0.27	0.22	0.32	0.26	0.33	0.31	0.38	
	Rice	0.24	0.23	0.14	0.25	0.39	0.41	0.17	0.17

Table 2: Correlations of monthly commodity returns.

	% Commodity / GDP	HH 86-94	HH 95-03	HH 04-12	Avg HH	N eff
Argentina	11.0%	0.28	0.34	0.34	0.32	3.1
Bahrain	15.2%	0.50	0.54	0.51	0.52	1.9
Bangladesh	8.7%	0.88	0.82	0.88	0.86	1.2
Bolivia	11.1%	0.16	0.17	0.16	0.16	6.1
Botswana	6.2%	0.61	0.58	0.40	0.53	1.9
Brazil	7.5%	0.13	0.22	0.30	0.21	4.7
Cameroon	23.9%	0.39	0.28	0.29	0.32	3.1
Canada	7.8%	0.33	0.52	0.67	0.51	2.0
Chile	11.6%	0.82	0.89	0.95	0.89	1.1
China	15.2%	0.20	0.20	0.22	0.21	4.8
Colombia	13.8%	0.34	0.40	0.65	0.47	2.1
Costa Rica	9.2%	0.34	0.56	0.57	0.49	2.0
Ivory Coast	28.5%	0.26	0.39	0.33	0.33	3.0
Cuba	5.3%	0.57	0.41	0.39	0.46	2.2
D.R. Congo	16.1%	0.26	0.62	0.47	0.45	2.2
Ecuador	23.2%	0.55	0.53	0.72	0.60	1.7
Egypt	23.7%	0.57	0.58	0.64	0.60	1.7
El Salvador	8.0%	0.45	0.35	0.33	0.38	2.6
Ethiopia	8.9%	0.32	0.28	0.31	0.30	3.3
Ghana	15.5%	0.27	0.32	0.36	0.32	3.2
Guatemala	8.7%	0.27	0.28	0.31	0.28	3.5
Honduras	17.2%	0.27	0.48	0.52	0.42	2.4
India	9.2%	0.23	0.18	0.18	0.20	5.0
Indonesia	31.2%	0.25	0.48	0.54	0.42	2.4
Iran	32.7%	0.85	0.87	0.90	0.87	1.1
Iraq	49.6%	0.92	0.97	0.99	0.96	1.0
Kazakhstan	10.0%	0.47	0.40	0.30	0.39	2.6
Kuwait	59.4%	1.00	1.00	1.00	1.00	1.0
Liberia	44.1%	0.45	0.55	0.40	0.47	2.1
Malaysia	54.7%	0.52	0.79	0.72	0.68	1.5
Mexico	13.4%	0.69	0.79	0.76	0.75	1.3
Nigeria	44.7%	0.69	0.62	0.79	0.70	1.4
Norway	15.6%	0.88	0.92	0.94	0.92	1.1
Pakistan	9.0%	0.31	0.31	0.25	0.29	3.5
Papua N.G	39.7%	0.40	0.62	0.60	0.54	1.9
Paraguay	13.0%	0.30	0.46	0.33	0.36	2.7
Peru	12.7%	0.22	0.19	0.26	0.22	4.5
Philippines	5.2%	0.26	0.24	0.24	0.24	4.1
Russia	24.0%	0.68	0.72	0.86	0.75	1.3
Saudi Arabia	58.5%	0.98	0.99	1.00	0.99	1.0
Thailand	7.7%	0.27	0.25	0.26	0.26	3.9
Turkmenistan	10.4%	0.77	0.49	0.42	0.56	1.8
Uganda	12.7%	0.41	0.37	0.32	0.37	2.7
Ukraine	6.9%	0.49	0.59	0.31	0.46	2.2
UAE	34.5%	0.97	0.94	0.95	0.95	1.0
Uzbekistan	13.9%	0.65	0.44	0.37	0.48	2.1
Venezuela	37.2%	0.90	0.91	0.97	0.93	1.1
Vietnam	20.3%	0.76	0.45	0.37	0.52	1.9
Zambia	25.5%	0.79	0.63	0.66	0.69	1.4
Zimbabwe	6.4%	0.21	0.15	0.17	0.18	5.7

Table 3: Commodity output / GDP ratio, and measures of concentration (Herfindahl index and effective number of commodities produced by each country).

$$BasketVariance_k = \beta_1 Concentration_k + \beta_2 \frac{CommodityProd}{GDP}_k + \beta_3 \frac{GDP}{WorldGDP}_k + \beta_4 OilDummy_k + Const + \epsilon_k$$

Sample: 50 commodity producers with highest commodity production to GDP ratio. Basket variance computed on monthly returns keeping fixed quantities.

	86-94 Real	86-94 Theo.	95-03 Real	95-03 Theo.	04-12 Real	04-12 Theo.
Concentration	**0.091*****	**0.0861**	**0.059*****	**0.0631**	**0.058*****	**0.0549**
	(0.019)		(0.014)		(0.011)	
$\frac{CommodityProd}{GDP}$	-0.015		0.041***		-0.016	
	(0.021)		(0.012)		(0.012)	
$\frac{GDP}{WorldGDP}$	-0.55		0.11		-0.01	
	(0.64)		(0.15)		(0.04)	
Oil producer	0.016*		0.007		0.007	
	(0.009)		(0.007)		(0.006)	
Constant	**0.007**	**0.0096**	**0.001**	**0.0065**	**0.024*****	**0.0244**
	(0.007)		(0.005)		(0.004)	
Sample size	49		49		50	
R-squared	0.65		0.74		0.69	

Table 4: OLS estimation of the effect of concentration of production and controls on the variance of commodity output value.

	1986-1994	1995-2003	2004-2012
Effective number of commodities $\leq$ 2			
Mean basket volatility	0.267	0.237	0.255
Standard error	(0.014)	(0.010)	(0.007)
Number of countries	22	24	23
Effective number of commodities $\geq$ 3			
Mean basket volatility	0.163	0.136	0.195
Standard error	(0.008)	(0.008)	(0.005)
Number of countries	19	13	18

Table 5: Effective number of commodities in a basket and basket volatility.

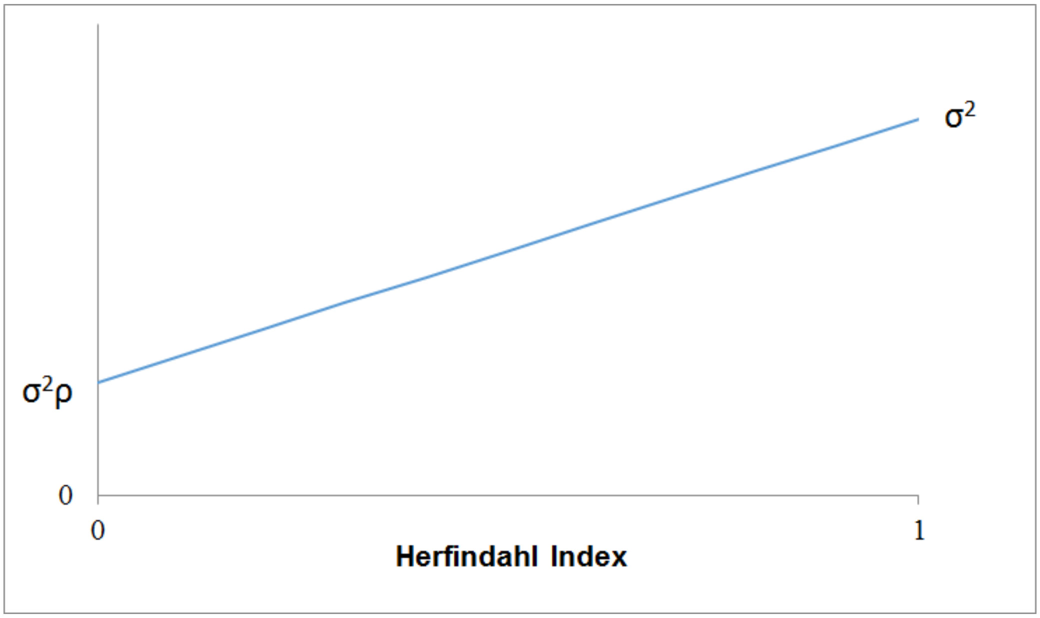

Figure 1: Approximate basket variance and concentration.

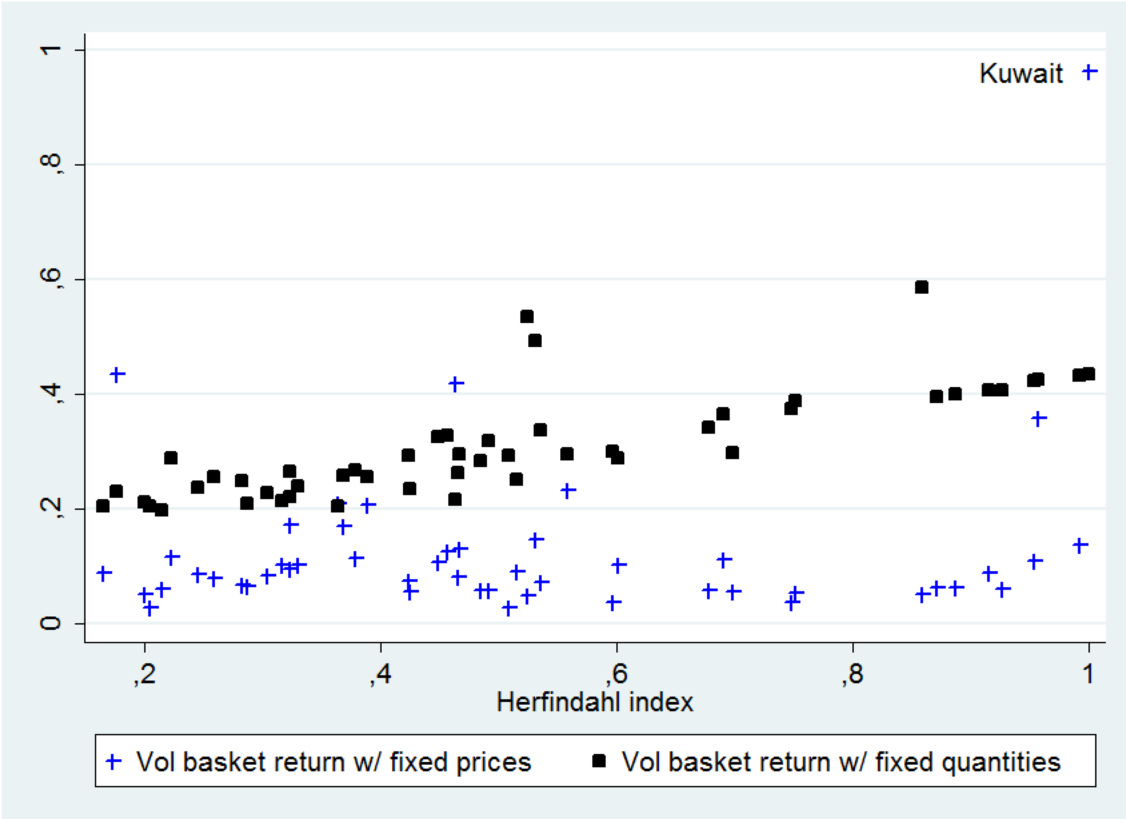

Figure 2: Sources of commodity output value volatility and concentration.

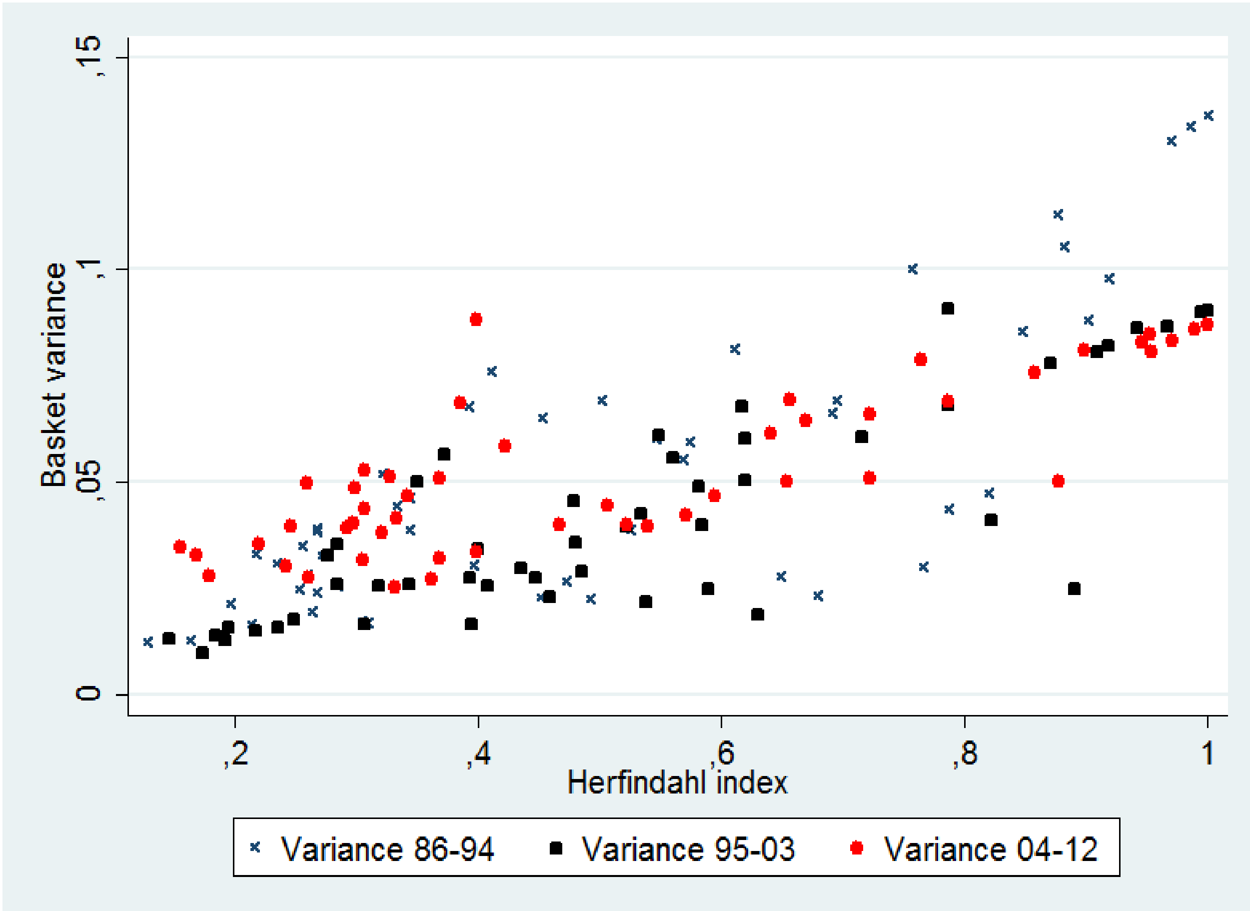

Figure 3: Commodtiy output variance (for fixed quantitites) and concentration.

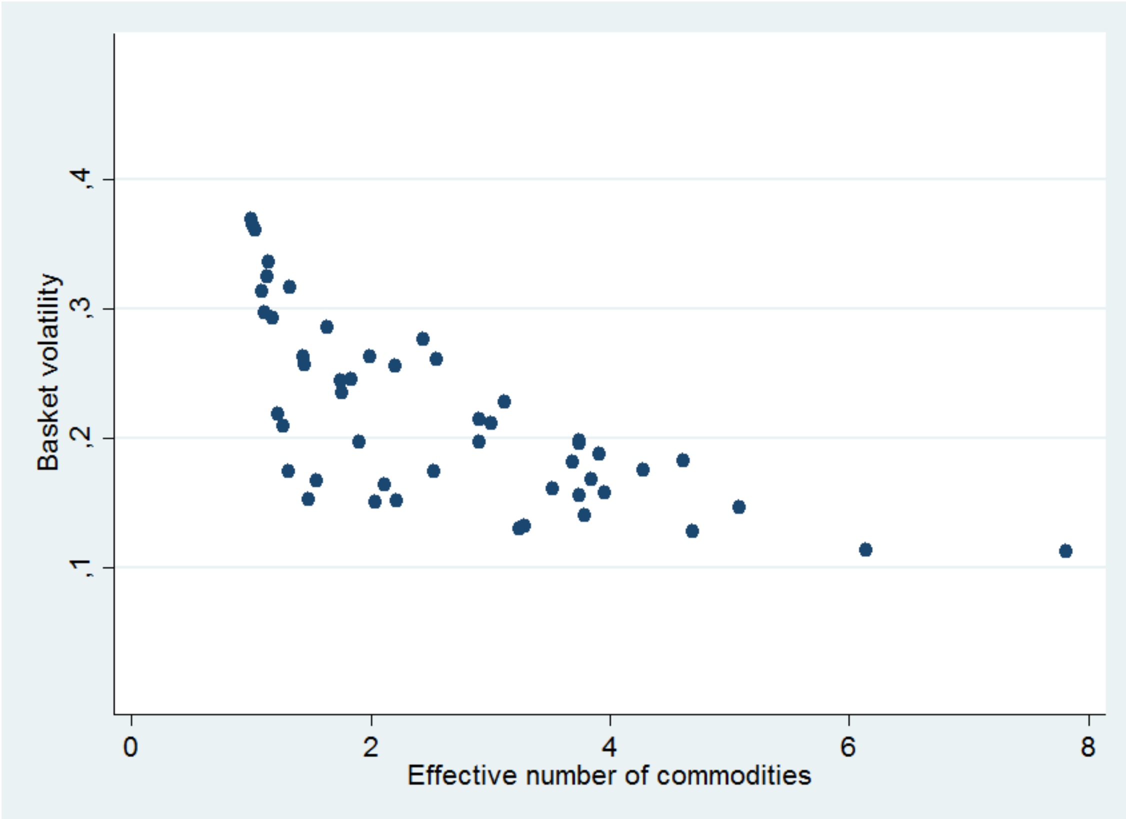

Figure 4: Effective number of commodities produced by each country and volatility of output value, 1986-1994.

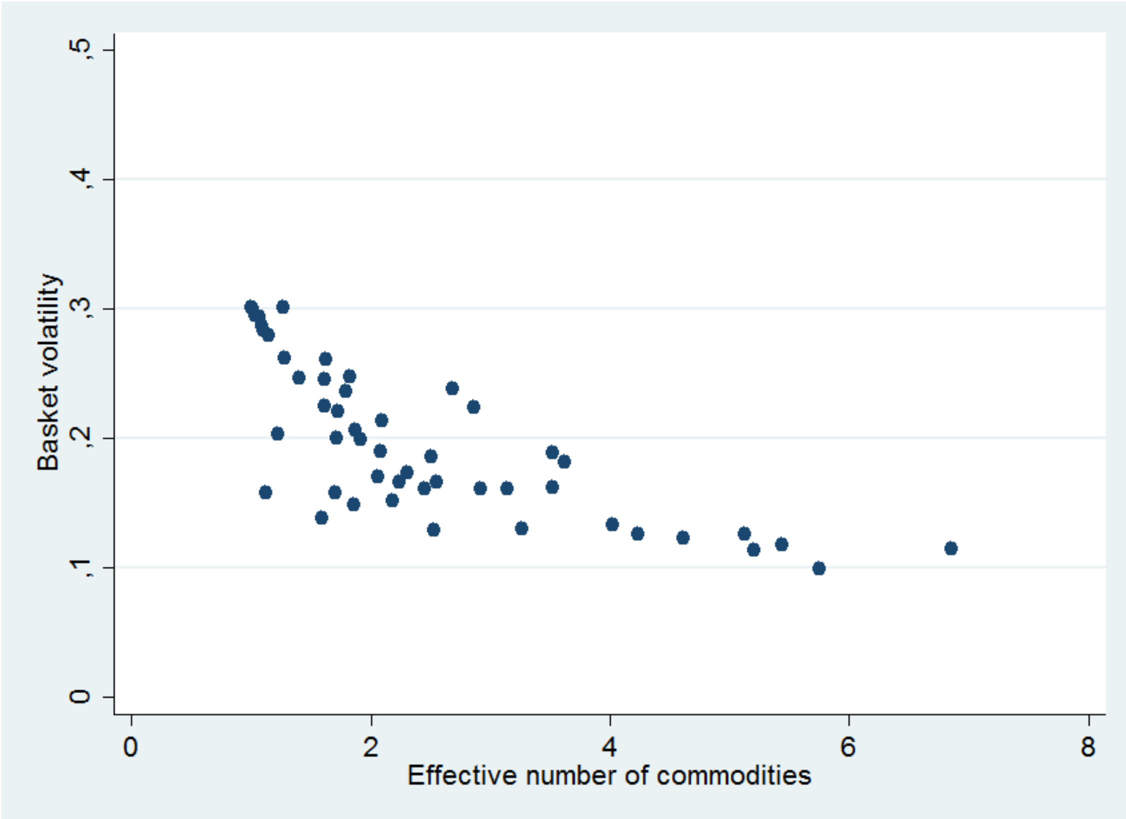

Figure 5: Effective number of commodities produced by each country and volatility of output value, 1995-2003.

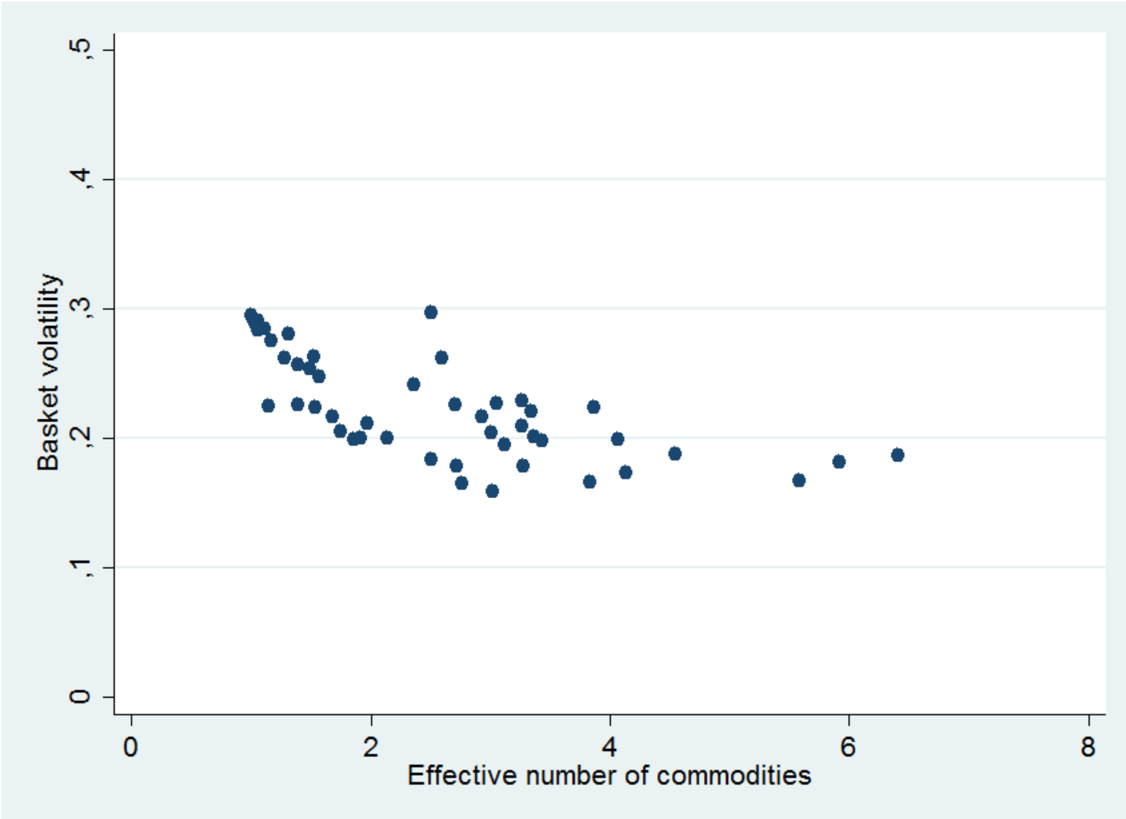

Figure 6: Effective number of commodities produced by each country and volatility of output value, 2004-2012