World Commodity Prices and Partial Default in Emerging Markets: An Empirical Analysis*

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Abstract

Most sovereign defaults are partial, with heterogeneous post-default outcomes, and commodity prices are an important determinant of sovereign default and the subsequent restructurings. In the case of emerging countries, as a result of direct dependence of government on revenues from commodity exports, declines in commodity prices reduce government's resources to service the external debt thereby increase the chances of default. In this paper, we construct a country-specific commodity price index with time-varying weights based on commodity exports to quantify the impact of commodity prices on the partial default rate measured by debt arrears. We show that declines in commodity prices have a significant, positive effect on the default rate. The overall predicted effects for a one-standard deviation decrease in a composite of the level and change of the price index at its 1st, 2nd, and 3rd quartile, on average, are 14.2, 12.5, and 9.3 percentage points respectively. We also show that for a country-specific one-standard deviation decrease in the composite price index, the predicted effect varies from insignificant to an increase of 33.8 percentage points. The country-specific effect on the default rate generally increases in magnitude with a country's dependence on commodity exports, while it depends heterogeneously on external indebtedness—increasing in magnitude for low levels (below a threshold of about 30 percent) of debt and decreasing thereafter.

Keywords: Sovereign default, commodity prices, partial default, emerging countries
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1 Introduction

Most sovereign defaults are partial, with heterogeneous post-default outcomes, and commodity prices are an important determinant of initial default and subsequent restructurings of sovereign debt. Multiple sovereign defaults follow troughs in global commodity prices and default cycle is usually associated with collapsing commodity prices for primary commodity producers (Reinhart and Rogoff, 2009; Reinhart, Reinhart, and Trebesch, 2016). Declines in commodity prices reduce government's resources to service the external debt, both directly (by reducing its revenues from commodity exports) and indirectly (by reducing its tax revenues through slowdown in economic activity), thereby increasing chances of default and subsequent debt restructuring. Being a direct source of the government revenues, commodity exports is likely to be an important determinant of the default behavior of emerging countries, especially of the countries with a high share of commodities in their exports. In this paper, we investigate and provide a quantitative assessment of the role of prices of exported commodities in precipitating the sovereign default risk.[1] We construct a country-specific commodity price index, with time-varying weights based on commodity exports, to quantify the impact of commodity prices on the partial default rate (defined to include accumulated arrears, hence, capturing both default and debt restructuring thereafter) and apply the fractional response model to a panel of 21 emerging countries with annual observations over 1970—2013.[2,3]

A number of important empirical results emerge. First, we show that decline in commodity prices has a significant, positive effect on the default rate—on an average 14.2, 12.5, and 9.3 percentage points increase at the 1st, 2nd, and 3rd quartiles of a composite of the price index. Second, we show that the predicted effect on the default rate has considerable cross-country variation—for a country-specific one-standard deviation decrease of the composite price index, this effect varies from insignificant to an increase of 33.8 percentage point (Nigeria). Third, the predicted country-specific effect on the default rate is found to generally increase in magnitude with a country's dependence on commodity exports, while this effect depends heterogeneously on a country's external indebtedness—increasing in magnitude below a threshold of about 30 percent of debt-to-GDP and decreasing thereafter.[4]

[1] When it comes to analyzing the role of commodity prices for sovereign default, the common approach in the literature has been an indirect one that focuses on the role of terms-of-trade. In our view, there are two reasons for this choice. First, compared to commodity prices, terms-of-trade are a more broad-based measure of country's ability to pay and thus deserve to be analyzed in their own right as a determinant of the sovereign default risk. Second, it is well known that, in the case of most emerging countries, terms-of-trade are driven, to a great extent, by trends in world prices. Therefore, for these countries, in the absence of the availability of a country-specific commodity price index, terms-of-trade may be considered as a useful proxy for commodity prices.

[2] We use the IMF definition for emerging countries, in line with our approach of constructing the price index which is based on IMF (2009). The countries included in our sample, which are in Africa, the Americas, Asia, Eastern Europe, and the Middle East, are those that have full information available of the external public debt arrears for all years up to 2013. Because of the missing information of the external public debt arrears, Chile, as a well-known commodity exporter with default history, is not included.

[3] In the related literature in commodity prices and sovereign default, Reinhart, Reinhart, and Trebesch (2016) also apply a fractional response model to predict the share of countries entering default.

[4] Our main results continue to hold with no significant differences under a series of robustness tests, including the

In addition to the main results for commodity prices, we also show that other fundamentals have significant and expected effects on the default rate: Default history positively and significantly (in a statistical sense) affects the default rate. The effect of the domestic credit is also positive and statistically significant. Net capital transfers and official flows & grants, which represent other international sources of funds, negatively affect the default rate. The directions of the effects of an exchange rate peg (negative), being a member of OPEC (positive), international reserves (negative), the growth rate of GDP (negative), and inflation (positive) are also as expected, which is consistent with the literature.[5]

Two main features of our approach, combined together, allow us to provide, to our knowledge, the first economically-significant quantitative estimates of the effect of prices of commodity exports on the default rate. These features (or contributions) of our paper *vis-à-vis* the existing literature can be summarized as follows.

The first feature relates to the construction of the *country-specific* commodity price index for exports mentioned above. Our price index simultaneously accounts for annual changes in the relative values of commodity exports (as in Hilscher and Nosbusch, 2010) and employs a broad-based, two-stage aggregation of various commodity prices using the *dynamically-weighted* Jevons formula (IMF, 2009). Incorporating the changing structure of exports in constructing our price index allows us to use a longer period for the analysis, starting from 1970, despite a significant evolution of export structure for many countries in our study. Also, the country-specific nature of the price index, with export weights varying overtime, helps us control for the effects of common, global shocks on the default rate. Our endogeneity tests show that the use of time-varying weight of commodity exports to construct the country-specific commodity price index does not cause endogeneity problem, consistent with the evidence in Chen, Rogoff, and Rossi (2010) and Hilscher and Nosbusch (2010).[6,7]

Secondly, our paper focuses on the effect of the fluctuations in commodity prices on the partial default rate, which proxies for the *realized* risk of both initial default and post-default restructuring, as it is constructed by including accumulated arrears in both the numerator (arrears) and the

analysis of the impacts from default history, international reserves, and dropping no/low default countries.

[5]See Subsection 3.2. The Choice of Explanatory Variables and Section 4. Empirical Results.

[6]Chen, Rogoff, and Rossi (2010) show that "commodity currency" exchange rates have surprisingly robust power in predicting world commodity prices but the reverse relationship that commodity prices forecast exchange rates to be notably less robust. This is due to that, in contrast to the current exchange rate, the world price dynamics are driven mostly by global supply and demand conditions, which are typically quite inelastic. Thus, world commodity prices can serve as an exogenous shock to most commodity exporters. Hilscher and Nosbusch (2010) also state that an export-weighted price index, which uses time-varying weights of major commodities traded in world market, is plausibly exogenous.

[7]Our procedure for constructing the price index, from a methodology perspective, is relevant to the literature that has developed and used price indices to analyze the implications of commodity prices for various macroeconomic outcomes, in general, not just for sovereign default (Arezki and Brückner, 2012; Fernandez, Schmitt-Grohé, and Uribe, 2017; Fernandez, Gonzalez, and Rodriguez, 2018). Hilscher and Nosbusch (2010) investigate the impact of the volatility of economic fundamentals on sovereign yield spreads and construct an export-weighted price index using time-varying weights with the prices of 12 major commodities to eliminate the endogeneity of their terms-of-trade measure, which is a work closely-related to ours. Our price index, by using *country-specific, time-varying* weights and focusing on the implications of price shocks for commodity exports on sovereign default risk, extends and contributes to this strand of literature as discussed in more detail in Section 2.

denominator (total repayments due).[8,9] Earlier studies that have analyzed the effects of macroeconomic fundamentals on sovereign default have used as a dependent variable either the credit ratings or CDS/EMBI (credit default swap/emerging market bond index) spreads (to proxy *anticipated* default risk), a binary outcome for a (*realized*) default, or the sharing of countries entering default (Reinhart, Reinhart, and Trebesch, 2016).[10] The use of CDS/EMBI spreads in the existing literature restricts the beginning of the period of analysis to the early 1990s, whereas the use of the partial default rate allows us to do analysis over a longer time span, from 1970, which corresponds to the time span of our country-specific price index. Moreover, while the theory predicts a tight relationship between anticipated risk (captured by spreads) and realized default (captured by default events, default frequency, default rate etc.), it fails to be consistent with the relationship between anticipated risk and realized default as it exists in the data (Uribe and Schmitt-Grohé, 2017, Table 13.5).[11] In light of this empirical mismatch, it is useful to extend the existing literature focusing on the realized default risk as dependent variable from a binary outcome of default to the *continuous* outcome of default measured by the partial default rate, which is similar to the analysis of anticipated default risk where a continuous outcome in terms of spreads is used.[12]

In addition to the contributions to the literatures on the construction of commodity price indices and on the effects of commodity prices/terms-of-trade on sovereign default, as outlined above, our dependent variable, the partial default rate, also speaks to literature on post-default restructuring, as it captures not only the information on initial default but also the information on any subsequent restructuring and settlement.

A rapidly-developing literature focusing on the heterogeneity of post-default restructurings shows a great degree of variation in terms of the haircuts and duration (which are also positively

[8] Easton and Rockerbie (1999) define the default as the occurrence of accumulated arrears on principal and interest payments at any time, rather than the standard definition in which a default is identified with the occurrence of a rescheduling of principal payments (Benjamin and Wright, 2013; Borensztein and Panizza, 2009; Detragiache and Spilimbergo, 2001). See Equation (1) in Section 2.

[9] Asonuma and Trebesch (2016) define post-default restructurings as the cases, in which payments are missed unilaterally and without the agreement of creditor representatives (unilateral default prior to negotiations). According to their coding, post-default restructurings account for around two thirds (111 out of 179) of all sovereign debt exchanges since 1978, and they are quite frequent like the occurrence of partial default as measured by the definition of Easton and Rockerbie (1999). See Table 1. Statistics of Partial Default Rate (1970–2013).

[10] For example, Baldacci, Gupta, and Mati (2011) investigate the (fiscal and political) determinants of sovereign bond spreads in a panel of 46 emerging economies over 1997–2008, showing a negative relationship between the level of terms-of-trade and spreads. Maltritz (2012) analyzes the determinants of sovereign yield spreads of 10 European Monetary Union members over the period 1999–2009 and reaches a similar conclusion. In a panel of 31 emerging economies over 1994–2007, Hilscher and Nosbusch (2010) show that both the change in terms-of-trade as well as its volatility are important predictors of EMBI spreads. Aizenman, Binici, and Hutchison (2013) find that CDS spreads consistently decrease with increase in the changes in Goldman Sachs Commodity Index (GSCI) and oil price in a panel of European Union countries over 2005–2012. Similarly, Zinna (2013) assesses the relationship between an emerging markets risk measure and both the level and the change of GSCI. There is also a literature studying the impact of terms-of-trade volatility on sovereign risk premia (see Aizenman, Jinjarak, and Park, 2016; Catão and Kapur, 2006; Catão and Sutton, 2002).

[11] Also see Arellano (2008) and Chatterjee and Eyigungor (2012).

[12] By using the partial default rate as the dependent variable, our paper also complements the emerging theoretical/quantitative literature that examines the partial default mechanism (Arellano, Mateos-Planas, and Rios-Rull, 2019; Atolia and Feng, 2019; Aguiar, Amador, Farhi, and Gopinath, 2013, 2014; Alfaro and Kanczuk, 2009; Dubey, Geanakoplos, and Shubik, 2005).

correlated). It has tried to address *this* puzzling heterogeneity by looking at the determinants from both creditors' and debtor's side. We show that our commodity price index, from the debtor's side, is an important determinant of this heterogeneity of the post-default outcomes. This is so because it is a more specific variable, with a within-country time-variation linked to fundamentals, that captures the changes in the fiscal situation of the government, especially for those emerging countries with the export of commodities as an important source of revenue as mentioned earlier. Asonuma and Joo (2020) explore the creditors' negotiation stances both during and at the end of restructurings and find that creditor's GDP growth as well as financial cycles play an important role in explaining the dynamics of debt restructurings and settlements (haircuts). In a recent study, they also show that declines in debtor's public investment and its slow recovery correlate with delays in restructuring. Trebesch and Zabel (2017) investigate the costs of sovereign debt crises and find that the debtor coerciveness indictor (Enderlein et al., 2012), which captures, in particular, the payment and negotiation behavior of governments towards foreign creditors, is positively correlated to the size of haircuts. Benjamin and Wright (2013) document that default is more likely to occur and creditor losses (haircuts) are substantial when debtor's output is below trend. Finger and Mecagni (2007) examine key factors, such as debt level, fiscal performance, economic growth, real interest, and exchange rates, driving the debt dynamics around the time of restructuring.[13]

Besides showing that our commodity price index is an important debtor's side determinant of the heterogeneity of post-default restructuring as mentioned above, we also extend this literature in another aspect. Unlike the current literature, our work does not look at each restructuring as a separate unit of analysis but rather takes a more broad-based, macro approach—looking at the annual time series for each country, which could include *multiple* debt issuances. Thus, our use of the partial default rate could be interpreted as a new perspective to understand the characteristics and dynamics of post-default restructuring.

The remainder of this paper is organized as follows. The next section provides details of the steps for data preparation, especially for the partial default rate and the two-tier, dynamically-weighted price index for exports. Section 3 introduces the fractional response model for panel data and outlines details for the model specification. Section 4 collects the estimation results for the baseline and alternative regressions. In Section 5, two endogeneity tests are conducted for the baseline regressions. Section 6 investigates the country-specific effect of the price index on the default rate and its variation with the degree of a country's dependence on the commodity exports and external indebtedness. Section 7 checks the robustness of the main results. The last section concludes.[14]

[13] There is also a strand literature that looks at the heterogeneity in terms of preemptive or "voluntary" *vs.* post-default restructurings. See Asonuma and Trebesch (2016) and Hatchondo, Martinez, and Padilla (2014). Also see Asonuma, Chamon, Erce, and Sasahara (2020), Asonuma, Chamon, and Sasahara (2016), and Sturzenegger and Zettlelmeyer (2006) for additional empirical analysis.

[14] Online Appendices contain more details of the data and of some of the results of empirical analysis.

2 Data

Our paper concentrates on explaining the effects of fluctuations in commodity prices on the partial default rate across countries and through time. For this purpose, we use data on public and publicly guaranteed (PPG) external debt, world commodity prices, commodity export values, interest rates, exchange rate regimes, international reserves, official flows, capital transfers, output (GDP), domestic credit, and inflation.[15] Data on international reserves, official flows, GDP, domestic credit, and inflation are from World Bank Open Data, ranging from 1970 to 2013 annually. Data on exchange rate regimes is from Shambaugh (2004). The information of capital transfers is from IMF Balance of Payments Statistics. More information about the data, including abbreviations, sources, and measurements, is provided in Table A.1 in the online Appendix A.

In the following two subsections, we outline the details for the creation of the dependent variable, the partial default rate, and the main explanatory variable, the country-specific commodity price index for exports.

2.1 Partial Default Rate

Incorporating default as a matter of degree in models of lending to less-developed countries is important (Easton and Rockerbie, 1999). We follow the literature and measure the sovereign default risk using the information about accumulated PPG external debt arrears on principal and interest payments. The perspective of using debt arrears to define default is in accordance with the fact that most sovereign defaults are partial (Alfaro and Kanczuk, 2009; Das, Papaioannou, and Trebesch, 2012), although, the early sovereign debt literature treated default as a binary event.

The partial default rate is defined as the ratio of the (accumulated end-of-period) debt arrears on external debt to the total debt payments due:

$$Partial\ Default\ Rate = \frac{Debt\ Arrears}{Total\,Debt\,Payments\,Due} = \frac{Debt\ Arrears}{Debt\,Arrears + Actual\,Debt\,Service} \quad (1)$$

The expression on the right hand side of the second equality sign follows from the fact that the total debt payments, which consist of the accumulated debt arrears from the previous period plus the current due, are also equal to the accumulated end-of-period debt arrears and the actual debt service payments in the current period (*e.g.*, also see Arellano, Mateos-Planas, and Rios-Rull, 2019; Atolia and Feng, 2019).

Table 1 summaries the essential statistics, the mean, standard deviation, positive arrears frequency, and the mean of the partial default rate conditional on positive arrears, for 21 emerging countries as defined by IMF. Accordingly, Figure 1 (a)–(c) plot the time series of the partial default rates for countries in different regions, and Figure 2 (a) and (b) display the histograms of the partial default rates and the non-zero partial default rate, respectively. Being a proportion, the partial default rate is always bounded between 0 and 1.

[15] The data on PPG external debt, including debt arrears and service, comes from the World Development Indicator (WDI), part of World Bank Open data, ranging from 1970 to 2013 annually, with shorter periods for some countries.

The following five features of default (rate) in our sample deserve mention: (1) Sovereign defaults are almost, always partial: the only case of nearly full default is Peru with the highest partial default rate of 0.99 (Figure 1 (a)); (2) The majority observations of default rates are *piling up* at zero, implying no default, as shown in Figure 2; (3) (Partial) default, however, is also quite *frequent*: the average frequency of positive arrears is 0.48; (4) Partial default rates vary a lot: the average standard deviation is 0.23, although, even for the non-zero partial default rates, the majority of observations are located between 0.00 and 0.20 (Figure 2 (b)); and (5) The partial default rate is *heterogeneous* across countries and regions, averaging from 0.00 to 0.49 during default years. Compared with emerging countries in Asia, emerging countries in the Americas and EMA (Eastern Europe, the Middle East, and Africa) have higher average annual default rates.

2.2 Country-Specific Commodity Price Index

Collapsing commodity prices, besides rising world interest rates and resulting sharp capital flow reversal, are one of the main causes of the string of sovereign defaults in the 1980s and the recent default waves in emerging markets (Bulow and Rogoff, 1989; Reinhart, Reinhart, and Trebesch, 2016). Typically, decline in commodity prices (and the accompanying declines in terms-of-trade) affects a country through various channels that are associated with economic slowdown and balance of payments problems, which raise default risk. The fluctuations in the prices of exported commodities can impact real activity by directly affecting margins of exporters and is likely to trigger financial instability through a reduction in government revenues and a shortening of sovereign debt maturity (Agarwal, Duttagupta, and Presbitero, 2020; Eberhardt and Presbitero, 2021). In the case of many emerging countries under our study, which are big commodity exporters, yet another, arguably even more important and more direct, channel operates to augment these forces, as revenues from the sale of or the royalties on commodities are a significant part of the government revenues in these countries. Thus, decline in commodity prices also directly reduces government's resources to service the external debt, deteriorating the balance of payments and increasing the chances for default. With this direct channel from commodity prices to government revenues in view, we create a country-specific commodity price index based on a country's exports.

The price index is constructed based on the methods outlined in Export and Import Price Index Manual (IMF, 2009). The construction of the index involves two stages. In the first stage, price indices are estimated for dynamically-weighted elementary aggregates. In accordance with the IMF manual, elementary aggregates are constructed by grouping individual commodities and services into groups of relatively homogeneous commodities and services, expected to have similar price movements.[16,17] These commodities are identified with the information of global commodity prices

[16] We select, and group homogeneous commodities based on the SITC division. For example, soybean oil and peanut oil, and iron ore and copper ore are grouped into the same elementary aggregates, respectively.

[17] Besides satisfying the above criteria, commodities selected for constructing elementary aggregates in our paper satisfy the following requirements as well: they are representative of all commodities within the elementary aggregates with large enough global transaction volumes and remain on the market for some time to reduce disappearing and replacement situations.

in the Global Economic Monitor (GEM) commodity database, part of World Bank Open Data.[18] The second stage averages elementary price indices to obtain higher level indices by using as weights the country-specific dynamic relative traded (export) values for the elementary aggregates.

There are various ways of aggregating individual prices in an index at both stages. The IMF manual discusses the Carli index, the Dutot index, and the Jevons index. There are two approaches for selecting the most suitable formula to combine the elementary price indices: the axiomatic approach and the economic approach. We follow the axiomatic approach, which requires that the method selected should satisfy certain specified axioms or tests, and based on this approach select the Jevons index.[19,20] Then the Jevons index is used to yield a two-stage dynamically-weighted and chained year-to-year index formula. For individual commodity m in the elementary aggregate n with price p_m and relative export value weight w_m, the price index for that elementary aggregate n is given by:

$$P_n^t = \prod_m (\frac{p_m^2}{p_m^1})^{w_m^1} \prod_m (\frac{p_m^3}{p_m^2})^{w_m^2} \cdots \prod_m (\frac{p_m^t}{p_m^{t-1}})^{w_m^{t-1}} \tag{2}$$

where $t \geq 2$ and $\sum_m w_m^s = 1$, $s = 1, 2, ..., t-1$. In the second stage, elementary price indices, P_n^t, are aggregated to obtain higher level indices, P^t, by using the country-specific dynamic relative export values for associated elementary aggregates as weights: $P^t = \sum_n P_n^t w_n^{t-1}$, where $t \geq 2$ and $\sum_n w_n^s = 1$, $s = 1, 2, ..., t-1$. Finally, the price index is deflated by the US CPI as in Fernandez, Schmitt-Grohé, and Uribe (2017).

Table 2 reports the statistics, including the mean, standard deviation, and minimum and maximum, of the original price index. The reference year for the index is 1970. The average value is 90.40 with standard deviation of 89.72, implying *large fluctuations* in the price index. The distribution of the price index (Figure 3) is highly skewed to the right, and the majority of observations are below 200. This gives a rough idea of the spread of the price index and how it is affected by the extreme values. These extreme values are caused by the heterogeneity of the price index across countries: a country-specific price index is not only determined by world prices, but also by the country's own commodity export structure. Countries, such as Ecuador, Mexico, and Venezuela in the Americas, Indonesia in Asia, and Nigeria in EMA, have high mean and extremely high maximum values.

As mentioned earlier, our work is relevant to the literature that constructs price indices to analyze the implications of commodity prices for various macroeconomic outcomes, not just for sovereign default, such as the transmission of changes in commodity prices to bank lending and the

[18] See the online Appendix A, Table A.2: The Category Structure of Global Economic Monitor (GEM) Commodities Database as Presented in the Commodity Price Data (a.k.a. Pink Sheet)

[19] There are five basic tests of the axiomatic approach: proportionality test, changes of units of measurement test, time reversal test, transitivity test, and allowing for substitution test. The Carli index fails the time reversal, transitivity, and allowing for substitution tests. The Dutot index fails changes of units of measurement and allowing for substitution tests. The Jevons index, on the other hand, passes all the tests (IMF, 2009, Table 10.2).

[20] The economic approach requires a specific sample design involving quantities or value shares to translate a sample unweighted elementary index into an estimator of a weighted overall index and needs a check as to whether this estimated weighted index is an appropriate target, that is, one based on the behavioral assumptions of the enterprises or households responsible for exporting or importing the commodities. In other words, by taking account of the interdependence between prices and quantities and by making necessary behavioral assumptions of exporter/importer, the economic approach aims to estimate an "ideal" or "true" economic index for the elementary aggregates.

effect of the commodity price shock on the credit supply (Agarwal, Duttagupta, and Presbitero, 2020), the effect of commodity price shock on the aggregate fluctuations (Fernandez, Gonzalez, and Rodriguez, 2018) and on the movements of domestic output in individual countries (Fernandez, Schmitt-Grohé, and Uribe, 2017), the heterogeneity of the response of the real effective exchange rate to world commodity price shocks (Chen and Lee, 2018), the co-integrating relationship between real exchange rates and a set of fundamentals including commodity terms-of-trade (Ricci, Milesi-Ferretti, and Lee, 2013), and the effects of the revenue's windfalls from international booms on external debt (Arezki and Brückner, 2012).[21]

Our index advances these efforts, for example, in the following ways: *Vis-à-vis* Fernandez, Gonzalez, and Rodriguez (2018), we allow for *time variation* in the weights in the construction of the country-specific price index. This is necessary for our empirical study, as over the period under our study, 1970–2013, there has been a slow but substantial evolution in the export structure of many emerging countries. In relation to Fernandez, Schmitt-Grohé, and Uribe (2017), we use *country-specific export weights* to capture the impact of fluctuations in commodity prices that is specific to a country.

In the following section, we introduce the methodology applied in this paper, the fractional response model for panel data, and outline details for our model specification.

3 Model Specification

This section begins with the discussion of the appropriate econometric model to use in light of the properties of the dependent variable, the partial default rate, which is a proxy for the realized sovereign default risk. Recall, we focus on the impact of the fluctuations in commodity prices on sovereign default risk. Thereafter, the section delves, into the appropriate choice for the main explanatory variable related to commodity prices and other controls.

[21] Agarwal, Duttagupta, and Presbitero (2020)'s country-specific commodity net export price index (Gruss, 2014) is calculated based on 45 commodities and their predetermined 3-year average weights. Fernandez, Gonzalez, and Rodriguez (2018) create country-specific commodity price measures for Brazil, Chile, Colombia, and Peru over 1980–2014 with the information of 44 commodities' prices, using constant weights (averages of 1999–2004 period) in the price index for various commodity groups, which is a reasonable assumption for estimation and analysis over the period 1980–2014. Fernandez, Schmitt-Grohé, and Uribe (2017) use data from World Bank's Pink Sheet to construct three separate world commodity price indices for the cyclical components of Fuel, Agriculture, and Metal and Minerals, deflated using the US CPI. These indices are average prices of representative individual commodities weighted by world shares. Chen and Lee (2018)'s price index is defined as the world nominal prices of a country's major commodity exports, which is deflated by the price index of the manufactured exports of all industrial economies. Ricci, Milesi-Ferretti, and Lee (2013)'s commodity price-based terms-of-trade is constructed from the prices of six commodity categories (Food, Fuels, Agricultural Raw Materials, Metals, Gold, and Beverages) and measured against the manufacturing unit value index of the WEO database. It is weighted by the time-average (1980–2001) of export and import shares of each commodity category, defined in SITC II, in the total trade. Arezki and Brückner (2012) create a country-specific commodity export price index with time-invariant value of exported commodities (aluminum, beef, coffee, cocoa, copper, cotton, gold, iron, maize, oil, rice, rubber, sugar, tea, tobacco, wheat, and wood) in the GDP.

3.1 The Fractional Response Model

Fractional response model (FRM) is an econometric approach that is capable of modeling bounded dependent variables, which especially exhibit piling-up at *one* of the two boundaries (or corners). The FRM for cross-sectional observations was introduced by Papke and Wooldridge (1996).[22] It was extended to panel data in Papke and Wooldridge (2008). Reinhart, Reinhart, and Trebesch (2016) apply FRM to predict the share of countries entering default when they study the association between the ebb and flow of financial capital, the commodity price super-cycle, and sovereign defaults for emerging countries since 1815.[23] In our dataset, not only the observations of the partial default rate are naturally bounded between zero and one, but also the majority of them pile up at one of the boundaries, zero. The FRM for panel data properly takes both these features of the data on the default rate into account.[24]

The panel data method of FRM used in our paper is proposed in Papke and Wooldridge (2008) as a nonlinear panel data model that recognizes the bounded nature of the dependent variable. For an observation for cross-section i and time period t, the dependent variable is $y_{it}(0 \le y_{it} \le 1)$, and a set of explanatory variables $\mathbf{x}_{it}$ is a $1 \times K$ vector.

The *assumption* (**Assumption 1.**) is

$$E(y_{it}|\mathbf{x}_{it},\ c_i) = G(\mathbf{x}_{it}\boldsymbol{\beta} + c_i), \qquad t = 1, \dots, T \tag{3}$$

where c_i is the unobserved effect. The $K \times 1$ vector $\boldsymbol{\beta}$ describes *the directions* of partial effects. By dropping the cross-sectional index i, the partial effect for continuous x_{jt}, $j = 1, \dots, K$ is

$$\frac{\partial E(y_t|\mathbf{x}_t,\ c)}{\partial x_{jt}} = \beta_j g(\mathbf{x}_t\boldsymbol{\beta} + c) \tag{4}$$

where $g(\boldsymbol{.})$ is the probability density function. And the partial effect for discrete changes is

$$G(\mathbf{x}_t^{(1)}\boldsymbol{\beta} + c) - G(\mathbf{x}_t^{(0)}\boldsymbol{\beta} + c) \tag{5}$$

where $\mathbf{x}_t^{(1)}$ and $\mathbf{x}_t^{(0)}$ are two different values of covariates.

According to Papke and Wooldridge (2008), two additional assumptions are needed to identify the average partial effects and $\boldsymbol{\beta}$. The first additional *assumption* (**Assumption 2.**) concerns the *exogeneity* of $\{\mathbf{x}_{it},\ t = 1, \dots, T\}$. Specifically, it is assumed that $\{\mathbf{x}_{it},\ t = 1, \dots, T\}$ is strictly

[22] The FRM for cross-sectional observations is an extension of the general linear model. It provides an alternative approach for dealing with the variables bounded at both extremes where observations "pile-up" at one of the extreme points. In particular, it ensures the predicted values of the dependent variable lie within the empirically plausible range.

[23] Also see Gallani and Krishnan (2017) for the application of FRM in survey research in Accounting.

[24] This method improves upon the two-limit Tobit model which is the frequently used alternative for such data. We carry out the sensitivity analysis for the baseline regressions, by changing the methodology to the two-limit Tobit model. Although the marginal effects of the two-limit Tobit analysis show that the significant, negative effects of commodity prices on the default rate hold without significant differences in magnitude, the two-limit Tobit model does not allow the variation of average marginal effects (AMEs) with respect to the variation of the price index. The results for the two-limit Tobit model are available upon request.

exogenous conditional on c_i:

$$E(y_{it}|\mathbf{x}_i,\, c_i) = E(y_{it}|\mathbf{x}_{it},\, c_i), \qquad t = 1, \ldots, T \tag{6}$$

where $\mathbf{x}_i \equiv (\mathbf{x}_{i1}, \ldots, \mathbf{x}_{iT})$ is the set of covariates in all time periods. It rules out the lagged dependent variables in $\mathbf{x}_{it}$, as well as other predictors that may react to past changes in y_{it}.

The second additional *assumption* (**Assumption 3.**) is the conditional normality assumption imposed on the distribution of c_i. Instead, our analysis uses country effects to control for the unobserved time-invariant effect. Thus, the estimation of β_j is possible up to a common scale factor, along with the consistent estimation of average partial effects. The three assumptions impose no additional distributional assumptions on the distribution of dependent variable and they place no restrictions on the serial dependence in the dependent variable through time.

By assuming $G(.) = \Phi(.)$, Bernoulli Quasi-maximum likelihood estimator (QMLE) solves

$$\max_{\boldsymbol{b}} \sum_{i=1}^{N} \{ y_{it} \ln \Phi\left(\mathbf{x}_{it}\boldsymbol{\beta} + c_i\right) + (1 - y_{it}) \ln\left[1 - \Phi\left(\mathbf{x}_{it}\boldsymbol{\beta} + c_i\right)\right] \} \tag{7}$$

which avoids a two-step estimation of a pooled weighted nonlinear least squares (PWNLS) estimator.[25,26] The “pooled fractional probit” estimator is consistent whenever the conditional mean is correctly specified. The assumption

$$Var(y_{it}|\mathbf{x}_i,\, c_i) \equiv \sigma^2 \Phi\left(\mathbf{x}_{it}\boldsymbol{\beta} + c_i\right)\left[1 - \Phi\left(\mathbf{x}_{it}\boldsymbol{\beta} + c_i\right)\right] \tag{8}$$

where $0 \le \sigma^2 \le 1$, holds for fractional response when y_{it} is a proportion, or the number of Bernoulli draws is not observed.

3.2 The Choice of Explanatory Variables

3.2.1 Three Specifications of Country-Specific Commodity Price Index

The existing empirical work finds both the level and the change of commodity prices (as well as terms-of-trade) to be important determinants of default risk (Aizenman, Binici, and Hutchison, 2013; Zinna, 2013; Maltritz, 2012; Baldacci, Gupta, and Mati, 2011; Hilscher and Nosbusch, 2010), but no studies document how they also directly impact the debtor’s post-default behavior through government budgeting. Our paper, accordingly, fills this gap by examining the effects of both the level and the change of the (log of) country-specific commodity price index for exports on the partial default rate, which captures the information of both default and post-default restructuring.

For the level specification, we allow for the possibility that the default rate may respond to commodity prices with a lag. In particular, we experiment with a fourth-order geometric lag of the

[25] As Papke and Wooldridge (2008) note, the Probit function leads to computationally simple estimators in the presence of unobserved heterogeneity or endogenous explanatory variables.

[26] See Equation (3.1) in Papke and Wooldridge (2008) for the PWNLS estimator.

commodity price index, but the specification with only the first lag is found to have the highest likelihood.[27] Thus, we present results for the level specification for the first lag of the commodity price index (P_1). We follow a similar approach for the change specification. For a fourth-order geometric lag of the change in the commodity price index, we find that the specification with equal weights on all four lags has the highest likelihood.[28] Thus, we present results for the change specification for the average four-year price change in the commodity price index (ΔP_4). We, then, consider the specification of a composite price index that includes both the level and the change of price index as determinants of the default rate to capture the overall effect. In either of these three specifications, we also allow for interaction effects as discussed later in this subsection.

3.2.2 Other Explanatory Variables

We also examine other determinants of default and post-default settlement to isolate the effect of our main explanatory variable(s).

The variables that account for the foreign revenue through commodity export are commodity export-to-GDP ratio, exchange rate regime, and whether a country is a member of the organizations of world commodity exporting countries, i.e., the Organizations of the Petroleum Exporting Countries (OPEC). The estimations include the commodity export-to-GDP ratio, because the foreign revenue through commodity export is determined by the movements of both price and quantity. We include the exchange rate regime as its choice is often guided by international trade considerations. According to Klein and Shambaugh (2010), a small open economy's exchange rate, whose value is pegged to the price of the main export commodity, would then depreciate with a fall in that price, helping to offset the contractionary effects. One of the presumed benefits of an exchange rate peg is that it should expand trade, at least with the base country. The exchange rate peg is expected to have a *negative* effect on the partial default rate. OPEC dummy is included to control for the potentially different behavior of the price of oil due to the exports of OPEC countries, relative to the export prices of other countries.

We also include variables that account for the debt payment situation of individual countries, namely, whether a country has debt arrears in the previous year and the external debt-to-GDP ratio. Being in arrears can affect the incentive to repay in the current period *ceteris paribus*. The external debt-to-GDP ratio directly determines the level of the debt obligation of an economy.

[27] We consider a geometric distributed lag model ($\tilde{\rho} \in [0, 1]$) for the level variable:

$$\frac{\tilde{\beta}}{\sum_{s=0}^{3} \tilde{\rho}^s} \left(\ln P_{t-1} + \tilde{\rho} \ln P_{t-2} + \tilde{\rho}^2 \ln P_{t-3} + \tilde{\rho}^3 \ln P_{t-4} \right),$$

and the maximization of likelihood results in $\tilde{\rho} = 0$. We do not include current commodity price index to avoid the endogeneity problem.

[28] We consider a geometric distributed lag model ($\rho \in [0, 1]$) for the change variable:

$$\frac{\beta}{\sum_{s=0}^{3} \rho^s} \left[\ln \frac{P_t}{P_{t-1}} + \rho \ln \frac{P_{t-1}}{P_{t-2}} + \rho^2 \ln \frac{P_{t-2}}{P_{t-3}} + \rho^3 \ln \frac{P_{t-3}}{P_{t-4}} \right]$$

and the maximization of likelihood results in $\rho = 1$.

These two factors are expected to have *positive* effects on the partial default rate.

In the literature, a number of other variables accounting for macroeconomic fundamentals have been found to be relevant.[29] Accordingly, we also include as controls the official flows & grants-to-debt service ratio and net capital transfers-to-GDP ratio (both of which represent other sources of foreign revenue), the international reserves-to-debt service ratio, the average 3-year change in real GDP, the domestic credit-to-GDP ratio, and inflation, where the latter two reflect domestic liquidity conditions.[30]

We include not only country effects but also year effects in our empirical approach. Country effects are used to control for country-specific unobserved heterogeneity, such as unobserved domestic characteristics that may affect the government budget. Year effects are used to control for all *other* time-varying global shocks that may change a country's government foreign revenues. We are able to do so because we develop and use a *country-specific* measure of commodity prices. Besides using year effects to control for global shock, we also specifically control for the potentially *heterogenous* effect of the global interest rate by interacting it with the external debt-to-GDP ratio to reflect the cost of rolling over debt or the opportunity cost of international lenders.

Finally, we allow for the possibility that the impact of commodity prices on the default rate may depend on other macroeconomic fundamentals. In particular, our specifications allow for interaction of the commodity price index with the commodity export-to-GDP ratio, the external debt-to-GDP ratio, as well as the exchange rate peg. That is, we allow for the fact that the magnitude of the effect of commodity prices on the default rate may depend on the values of the commodity export-to-GDP ratio, the external debt-to-GDP ratio, and the exchange rate regime.[31]

4 Empirical Results

We estimate a fractional response model (FRM) using the pooled Bernoulli QMLE described in the previous section to investigate how the fluctuations in commodity prices are associated with the *realized* sovereign default risk measured by the partial default rate. The estimated model is used to predict the overall as well as country-specific effects of commodity prices on the default rate. Our approach is similar to that in Reinhart, Reinhart, and Trebesch (2016), who also use FRM to predict the share of countries entering default, as FRM is a preferred model for both Reinhart, Reinhart, and Trebesch (2016)'s dependent variable and ours which is naturally bounded (between 0 and 1) with possible bundling at one end.

The main results are organized as follows. Firstly, we report the results of alternative regressions with country and year effects for the level and change price index specifications. Secondly, we

[29] See, for example, Asonuma and Joo (2020), Benjamin and Wright (2013), and Finger and Mecagni (2007).

[30] Lopez-Espinosa, Moreno, Rubia, and Valderrama (2017) show that high expected GDP growth and low domestic credit-to-GDP ratios protect countries against sovereign risk especially in times of global distress.

[31] Reinhart, Reinhart, and Trebesch (2016) show that for countries that are not primary commodity producers, the association between default cycle and collapsing commodity prices are not significant. Eberhardt and Presbitero (2021) show that the effect of commodity price volatility on banking crises is especially concentrated in low-income countries with a fixed exchange rate regime and a high share of primary goods in production.

determine the overall predicted effect of the composite price index which is composed of both the level and change of the price index. As the level and the change of the price index are not independent, as expected, the effects are not additive. However, the overall effect is significantly larger than either one alone.

4.1 Separate Regressions with Level and Change of Commodity Price Index

Table 3 contains the estimates of the OLS model (1) (for the comparison of the direction of the effect) and the alternative regressions of the fractional response Probit model (2) − (7) for the level and the change of the price index respectively. Except the dummy variables of the exchange rate peg, OPEC, and the default history, all other explanatory variables are lagged. The results of $\boldsymbol{\beta}$ coefficients show the *directions* of the effects of the price index and other variables on the default rate. We also calculate the average marginal effects (AMEs) of a one-standard deviation decrease in the level and the change of the price index at various quartiles showing the magnitude of the effect of commodity prices on the default rate.

4.1.1 Regressions with the Level of Price Index

In Table 3 (a), the first panel contains the main explanatory variable, the lagged level of the commodity price index, and its interactions. The second panel collects other explanatory variables that are common across all regressions. Two potential variables each are available for both capital inflows and domestic inflation. These variables are collected in the third panel of Table 3 (a) and various regressions examine different combinations of these variables. In particular, all four different combinations, with one potential proxy each for capital inflows and domestic inflation, are considered. Model (7) that includes both potential variables for capital inflows and domestic inflation is also explored.

Starting with the other explanatory variables, as expected, the default history positively affects the default rate. The coefficient of the exchange rate peg, though insignificant, consistently shows suggestive evidence of a negative effect on the default rate. This result reinforces the facts documented in Klein and Shambaugh (2010). Being an OPEC member indicates a higher rate of default once default occurs, when the net capital transfers-to-GDP ratio is included. The variables related to other sources of foreign revenue, i.e., the net capital transfers-to-GDP ratio and official flows & grants-to-debt service ratio, impact the default rate negatively as expected, as does the international reserves-to-debt service ratio. Our findings are consistent with the evidence of the nexus between the end of capital flow bonanzas and economic crises, especially sovereign defaults, presented by Reinhart, Reinhart, and Trebesch (2016). The effects of domestic credit-to-GDP for Model (2) − (7) are positive and statistically significant, which is consistent with the conclusion in Lopez-Espinosa, Moreno, Rubia, and Valderrama (2017). Other domestic variables, i.e., the average 3-year GDP change and the CPI inflation rate, also show suggestive evidence of expected negative effect, in line with the findings of Banjamin and Wright (2013), and positive effect, respectively.

For the lagged level price index, Model (2) – (7) draw a consistent conclusion: it has a negative effect on the default rate. The estimated *direction* coefficient of the non-interacted variable of lagged level price index ranges from -1.770 to -1.465 and are all statistically significant at 1-percent level. To highlight the predicted effect of the level price index, in the lowest panel of Table 3 (a), we report the average marginal effects (AMEs) for a one-standard deviation (0.850 unit) decrease in the lagged level price index at its 1st, 2nd, and 3rd quartile. A decrease in the lagged level price index increases the partial default rate significantly. The AMEs at all three quartiles are fairly robust and do not change much for Model (2) – (7). The strongest AME at the 1st quartile is -0.131, or -13.1 percentage points. The strongest AMEs at the 2nd and 3rd quartiles are -0.102 (-10.2 percentage points) and -0.075 (-7.5 percentage points), respectively.

4.1.2 Regressions with the Change in Price Index

Table 3 (b) summarizes the results of the estimated effects of the specification of the average 4-year change in the price index. We organize Table 3 (b) in the same way as Table 3 (a). The second and third panel of Table 3 (b) show the directions of the effects of an exchange rate peg, default history, OPEC, the international reserves-to-debt service ratio, the average 3-year GDP change, the domestic credit-to-GDP ratio, the net capital transfers-to-GDP ratio, the official flows & grants-to-debt service, and the CPI inflation rate for Model (2) – (7). These directions of the effects are consistent with the expected directions hypothesized in Section 3 and with the directions of the effects in Table 3 (a).

The estimated coefficients in the first panel indicate that the direction of the effect of the average 4-year change in the price index is positive while this effect is significantly affected by the commodity export-to-GDP ratio and external debt-to-GDP ratio.[32] The predicted effects, as captured by the AMEs of the 4-year change in the price index at quartiles, are still significant though less so compared to the regressions of the level specification. However, the effects do not change much across alternative regressions, except perhaps Model (7), when all variables are included. The strongest AME at the 1st quartile is -0.042, or -4.2 percentage points. The strongest AMEs at the 2nd and 3rd quartiles are -0.038 (-3.8 percentage points) and -0.033 (-3.3 percentage points) respectively.

4.2 Composite Commodity Price Index and the Overall Effect

We begin by noting that the level and the change of the price index variables used separately in the previous subsection are just different transformations of the same underlying data on commodity prices converted to a country-specific index. Thus, it is desirable to assess the overall impact of commodity prices on the default rate by considering both of these price-index-based variables in the same regression.

[32] We investigate the impacts from the commodity export and from the indebtedness on the effect of commodity prices in the cross-country analysis in Section 6, after discussing the overall effects of the commodity price index and its associated endogeneity tests.

The estimation results in Table 4 include results for Model (3) – (7) from Table 3 with the composite of both the level and change variables of the price index.[33] The new regressions conclude that the composite variable of the price index has negative effects on the default rate and that the direction coefficients are statistically significant for Model (5) – (7). The AMEs are once again significant and very similar across alternative regressions. For example, for Model (6), which returns the highest pseudo R-square, the overall effect of a one-standard deviation (0.358 unit) decrease of the composite variable at its 1st, 2nd, and 3rd quartiles, the AMEs are now -0.142, -0.125 and -0.093 respectively, which are seen to be higher than both the level and change specifications considered earlier. More generally, the ranges of our predicted AMEs for alternative regressions at these quartiles are -0.142 to -0.118, -0.126 to -0.078, and -0.094 to -0.040, respectively. For the analysis in the remaining part of this paper, we consider Model (6), with highest Pseudo R-square, as the baseline regression.

Also, consistent with the level and the change specifications, the other fundamentals continue to have statistically significant and expected effects on the default rate as before. Default history positively and significantly (in a statistical sense) affects the default rate. The effect of domestic credit-to-GDP ratio is also positive and statistically significant. Net capital transfers-to-GDP ratio and official flows & grants-to-debt service ratio, which represent other international sources of funds, affect the default rate negatively. The directions of the effects of an exchange rate peg (negative), being an OPEC member (positive), the international reserves-to-debt service ratio (negative), the average 3-year GDP change (negative), and inflation (positive) are also as expected.

5 Testing for the Endogeneity of Country-Specific Commodity Price Index

In our study of the effect of the country-specific commodity price index on the default rate, it is reasonable to think that the dynamic country-specific commodity export structure could be correlated with time-varying unobservables. In particular, endogenous supply changes in response to the fluctuations in world commodity prices are likely to amplify the change in our country-specific price index, which will likely result in a downward bias in the estimated effects of commodity prices on the default rate.

In order to address this potential endogeneity problem, we use a two-step control function approach introduced by Papke and Wooldridge (2008), which allows for continuous endogenous variables. The conditional mean Equation (3) now is expressed as:

$$E\left[y_{it}\right| x_{it1},\, \mathbf{z}_{it},\, c_i,\, \upsilon_{it}] = E\left[y_{it}\right| x_{it1},\, \mathbf{z}_{it1},\, c_i,\, \upsilon_{it}] \tag{9}$$

$$E\left[y_{it}\right| x_{it1},\, \mathbf{z}_{it1},\, c_i,\, \upsilon_{it}] = \Phi\left(\beta_1 x_{it1} + \mathbf{z}_{it1}\boldsymbol{\delta}_1 + c_i + \upsilon_{it}\right) \tag{10}$$

[33] We estimate and choose the relative weights on the level and change variables in the composite-based on the maximum likelihood criteria. For those composite-based specifications, which return the same highest likelihood, we further select the specification that returns the highest AME at the first quartile of the composite price index.

where c_i is the time-invariant unobserved effect and υ_{it} is a time-varying omitted factor that can be correlated with x_{it1}. The exogenous variables are $\mathbf{z}_{it} = (\mathbf{z}_{it1}, \mathbf{z}_{it2})$, where some time-varying, strictly exogenous variables $\mathbf{z}_{it2}$ (which include instrument variables (IVs)) are excluded from (10). To allow the instruments to be systematically correlated with time-invariant omitted factors, we include country effects in our analysis.

Specifically, we estimate a linear reduced form for x_{it1} (In our baseline regressions, they are the level and the change of price index respectively.) for each country i:

$$x_{it1} = \psi_i + \mathbf{z}_{it}\boldsymbol{\delta}_2 + \upsilon_{it2} \tag{11}$$

where the nature of endogeneity is through the correlation between υ_{it} and the reduced form error υ_{it2}. Step 1 is to estimate the reduced form (11) with IVs and obtain the residuals, $\hat{\upsilon}_{it2}$. Additional assumptions are: $\upsilon_{it} = \eta_1 \upsilon_{it2} + e_{it1}$, where $e_{it1} | (\mathbf{z}_i, \upsilon_{it2}) \sim N\left(0, \sigma_{e1}^2\right), \qquad t = 1, \ldots, T$.[34]

In Step 2, we use the pooled Probit QMLE of y_{it} on $x_{it1}, \mathbf{z}_{it1}, c_i, \hat{\upsilon}_{it2}$:

$$E\left[y_{it} | x_{it1}, \mathbf{z}_{it}, c_i, \upsilon_{it2}\right] = \Phi\left(\beta_{e1} x_{it1} + \mathbf{z}_{it1}\boldsymbol{\delta}_{e1} + c_i + \eta_{e1}\upsilon_{it2}\right) \tag{12}$$

to estimate β_{e1}, $\boldsymbol{\delta}_{e1}$, η_{e1}, and the country effect coefficient. The test for endogeneity of x_{it1} is obtained as an asymptotic t-statistics on $\hat{\upsilon}_{it2}$. x_{it1} is exogenous, if $\eta_{e1} = 0$, and the results obtained in Subsection 3.1 are accepted.

5.1 Bartik Instrument

In the first test of endogeneity of our price index, we use the Bartik instrument (Goldsmith-Pinkham, Sorkin, and Swift, 2018). We define the IVs as the country-specific price index formed by using the country-specific commodity export shares for the year 1962, along with the world commodity prices in real 2010 US dollars.[35] We estimate the reduced form in Step 1 for each country (time series). The residuals from Step 1 for all (i, t) pairs are used in Step 2 in the fractional response regressions.[36]

Table 5 (a) lists the estimated coefficients for the residuals, $\hat{\upsilon}_{it2}$ and AMEs predicted for Step 2.[37] We reject the hypothesis that there is an endogeneity issue as the estimated coefficients of the residuals from Step 1 are insignificant in the Step 2 regressions. The predicted AMEs with the country-specific instrument price indices are slightly *higher* but with no significant differences: a one-standard deviation (0.358 unit) decrease of the composite price index, the AMEs at its 1st,

[34] See Papke and Wooldridge (2008), Equation (4.5) and (4.6).

[35] We use the commodity export share of the year 1992 for Russian Federation and Ukraine, as data for these countries starts from 1992. Similar to our price index constructed in Section 2, the IVs are deflated by the US CPI and transformed to level and change specifications, respectively.

[36] We also estimate the reduced form in Step 1 for each year (cross-section) with the Bartik instrument and the World Commodity Price Indices instrument, respectively. In those cases as well, no endogeneity issues are observed based on the coefficients of the estimated residuals in Step 2.

[37] The detailed results are available in the online Appendix B, Table B.1 (a), and show that the direction of the effects of the price index and other macroeconomic fundamentals essentially remain unchanged compared to the baseline regressions.

2nd, and 3rd quartiles are -0.151, -0.131 and -0.098 respectively. This increase in the predicted AMEs is consistent with our expectations. Recall, we anticipated a downward bias in the estimated effects of commodity prices on the default rate due to endogenous supply changes in response to fluctuations in world commodity prices.

5.2 World Commodity Price Indices as Instruments

The IVs used in the second test of endogeneity of the price index are the three world commodity price indices for Energy, Non-energy, and Precious Metals (measured in real 2010 US dollars and constructed with weights based on 2002–2004 developing countries' export values). The IVs are deflated by the US CPI and transformed to level and change specifications, respectively. We estimate the reduced form in Step 1 for each country and obtain residuals for all (i, t) pairs.

As shown in Table 5 (b), the predicted AMEs with world commodity price indices are again slightly *higher* at the 1st quartile, but generally with no significant differences: for a one-standard deviation (0.358 unit) decrease of the composite price index, the AMEs at its 1st, 2nd, and 3rd quartiles are -0.156, -0.133 and -0.098, respectively.[38]

6 Country-Specific Effect on the Partial Default Rate

In this section, we investigate the country-specific effect on the partial default rate in the baseline regression, Table 4, Model (6), of the composite price index. The country-specific effect of commodity prices on the default rate varies as the economic situation facing the individual countries differs. By using countries with a significant high effect of commodity prices on the default rate as examples, we show that the country-specific effect of commodity prices on the default rate generally increases as the commodity export-to-GDP ratio increases, while this effect is found to be *heterogeneous*, depending on a country's external indebtedness.

Table 6 summarizes the AMEs of a country-specific one-standard deviation decrease of the composite price index at the country-specific quartiles of the price index. For a country-specific one-standard deviation decrease, the effect varies from insignificant to 0.338, or 33.8 percentage points increase of the default rate (Nigeria). We interpret our results by comparing them with the facts about the data on the default rate documented in Table 1. Consistent with the findings from the data, the AME is *heterogenous* across counties and regions. The AMEs in the Americas and EMA are generally larger than those of countries in Asia. Countries, like Argentina, Brazil, Peru, Nigeria, Russian Federation and Ukraine, which are in the Americas and EMA and with high mean default rates, have AMEs which are significantly larger than 0.100, or 10.0 percentage points for a country-specific one-standard deviation decrease at the 1st quartile of the composite price index. Indonesia is the only Asian country showed to have the high and significant effect of decrease in

[38] The detailed results for this case are also available in the online Appendix B (Table B.1 (b)) and again show that the direction of the effects of the price index and other macroeconomic fundamentals essentially remain unchanged compared to the baseline regressions.

commodity prices on the default rate. On the other hand, countries like China, India, Malaysia, and Thailand in Asia have the estimated AMEs at the 1st quartile that are low or close to zero, with some insignificant and others not. Similarly, South Africa and Turkey also have low or close to zero effect on the default rate at the 1st quartile of the country-specific price index, consistent with the data, with results being significant for Turkey, but not for South Africa.

The commodity export and external indebtedness are two important dimensions of the economic landscape that can significantly shape the government budget, thereby affect the response of the default rate to the commodity price index. For this reason, we interact the commodity export-to-GDP ratio and the external debt-to-GDP ratio (along with the exchange rate peg) with our main price index to show how the magnitude of the overall predicted effects of commodity prices on the default rate depends on the values of these variables.

Extending the results of Table 6, Table 7 reports the AMEs of a country-specific one-standard deviation decrease at chosen combinations of the quantiles of the commodity export-to-GDP ratio and the external debt-to-GDP ratio for selected representative countries, namely, Argentina, Brazil, Peru, Indonesia, and Nigeria.[39] Figure 4 graphically displays the results in Table 7. For each country, the results are presented in three panels (upper, middle, lower) which represent different quartiles of the country-specific composite price index. In each panel, the individual quantiles of the commodity export-to-GDP ratio and the external debt-to-GDP ratio represent a row and a column respectively.

The results show that the magnitude of the negative predicted effect of the price index on the default rate is generally increasing in the commodity export-to-GDP ratio, also evident in the *downward* sloping layers in the second plot in Figure 4 for each country respectively. Our results are in accordance with the findings in Reinhart, Reinhart, and Trebesch (2016) that for countries that are not primary commodity producers, the association between default cycle and collapsing commodity prices are not significant.[40] Moreover, we find that, for each country, at the same commodity export-to-GDP ratio, this downward slope becomes steeper at a lower value of the composite price index.

The predicted effect of the decrease in the composite price index on the default rate also depends on a country's external debt-to-GDP ratio, but varies across countries. For countries with a relative low external debt level (with a maximum below 30 percent in our sample), such as Brazil and Indonesia, the predicted effect on the default rate to the decrease in the composite price index is generally increasing in magnitude with the external debt-to-GDP ratio. Even for countries with maximum debt levels over 30 percent, such as Argentina and Peru, the effect on the default rate generally increases in magnitude with respect to the external debt level as long as the level is below 30 percent or so. This estimated threshold value of the external debt-to-GDP ratio presented in our

[39]We don't include Russia Federation and Ukraine as the data of these two countries covers a much shorter time span.

[40]In the analysis of the effect of commodity prices on banking crises for low-income countries, Eberhardt and Presbitero (2021) show that the impact from the commodity price volatility is especially concentrated in countries with a high share of primary goods in production. Moreover, as shown in Kaminsky and Reinhart (1999), banking crises typically precede currency or balance-of-payments crises.

cross-country analysis approximates to the one in Finger and Mecagni (2007), where the authors examine key factors driving the debt dynamics around the time of restructuring and estimate a signal threshold debt level of 24.8 percent in an early-warning-system. However, above this threshold of the external debt, the effect reverses the direction, as can been seen in the case of Argentina and Peru (Figure 4 (a) and Figure 4 (c)). Nigeria is a slight exception: the effect in case at the 1st quartile of the price index is decreasing monotonically in magnitude with respect to the the external debt-to-GDP ratio, while the effect on the default rate to the decrease in the price index at the price index's 2nd and 3rd quartiles become weaker as the debt level increases. Nigeria's price index is relatively high, with the mean value of 225.3 and the maximum value of 535.9 (Table 2). Being compared with the cases of Argentina and Peru, we believe the point of reversal of the effect, or the threshold of the external debt level for high values of price index is much lower than the one (30%) observed in other cases.

7 Robustness Analysis

In order to gain more confidence in our results about the effect of commodity prices on the default rate, we carry out a few tests of robustness of our main results of Model (6). In particular, we run additional regressions where we include: the interaction of the price index and the default history and the interaction of the price index and international reserves. We also analyze the baseline regressions by dropping no/low default countries (China, India, and South Africa) based on the statistics in Table 1. The estimated results show consistent conclusions *vis-à-vis* earlier regressions in terms of the direction of the effects of various explanatory variables. The predicted AMEs for the overall effect for these robustness tests are slightly *higher*, but with no significant differences. We present the full results, along with the economic interpretation, in the online Appendix C, Table C.1.

8 Conclusion

External sovereign lending is always exposed to default risk because of the lack of a worldwide enforcement mechanism. This paper investigates the key determinants affecting the ability of emerging countries to repay their external debt. It is commonly admitted that the fluctuations in commodity prices can directly impact export revenues of the governments of individual countries and, thus, affect their ability to repay sovereign debt denominated in foreign currencies and their post-default behavior if there is default. In this paper, we construct a time-varying, country-specific price index of commodity exports to show how fluctuations in commodity prices (and other macroeconomic fundamentals) precipitate the sovereign default rate. It differs from the earlier sovereign debt studies that either treat sovereign default as a binary event or use credit ratings and/or CDS/EMBI spreads as the proxy for anticipated default risk.

Our quantitative estimates from a panel of 21 emerging countries over the period 1970–2013 show that declines in commodity prices have a significant, positive effect on the default rate and this effect on the default rate has considerable cross-country variation. We show the country-specific effect on the default rate generally increases in magnitude with a country's dependence on commodity exports, while it depends *heterogeneously* on external indebtedness—increasing in magnitude for low levels (below a threshold of about 30 percent) of debt and decreasing thereafter. In addition to the main results for the prices of exported commodities, our results for the impact of other fundamentals are also statistically significant.

Overall, our findings are fairly robust in the sense that all results are consistent with economic intuition. The baseline fractional response model can explain about half of the variation in the effect on the partial default rate. Our approach to constructing the time-varying, country-specific commodity price index can be useful in many other contexts, such as sovereign debt issues in low-income and other developing countries. Moreover, our price index can be also used to examine how commodity prices affect the performance of the overall macroeconomy and the conduct of monetary policy (in different frameworks, such as, managed exchange rate regimes or inflation targeting.)

References

[1] Agarwal, I., Duttagupta, R., & Presbitero, A. F. (2020). Commodity prices and bank lending. *Economic Inquiry, 58(2),* 953-979.

[2] Aguiar, M., Amador, M., Farhi, E., & Gopinath, G. (2013). Crisis and commitment: Inflation credibility and the vulnerability to sovereign debt crises. *NBER Working Paper,* No.19516.

[3] Aguiar, M., Amador, M., Farhi, E., & Gopinath, G. (2014). Sovereign debt booms in monetary unions. *American Economic Review: Papers & Proceedings, 104*(5), 101-106.

[4] Aizenman, J., Binici, M., & Hutchison, M. (2013). Credit ratings and the pricing of sovereign debt during the euro crisis. *Oxford Review of Economic Policy, 29*(3), 582-609.

[5] Aizenman, J., Jinjarak, Y., & Park, D. (2016). Fundamentals and sovereign risk in emerging markets. *Pacific Economic Review, 21*(2), 151-157.

[6] Alfaro, L. & Kanczuk, F. (2009). Debt maturity: Is long-term debt optimal? *Review of International Economics, 17*(5), 890-905.

[7] Arellano, C. (2008). Default risk and income fluctuations in emerging economies. *American Economic Review, 98*(3), 690-712.

[8] Arellano, C., Mateos-Planas, X., & Rios-Rull, J. V. (2019). Partial default. *NBER Working Paper,* No. 26076.

[9] Arezki, R. & Brückner, M. (2012). Commodity windfalls, democracy, and external debt. *The Economic Journal, 122(561),* 848-866.

[10] Asonuma, T., Chamon, M., Erce, A., & Sasahara, A. (2020). Costs of sovereign defaults: Restructuring strategies and the credit-investment channel. Unpublished manuscript.

[11] Asonuma, T., Chamon, M., & Sasahara, A. (2016). Trade costs of sovereign debt restructurings: Does a market-friendly approach improve the outcome? *IMF Working Papers*, No.16_222.

[12] Asonuma, T. & Joo, H. (2020). Sovereign debt restructurings: Delays in renegotiations and risk averse creditors. *Journal of the European Economic Association, 18*(5), 2394-2440.

[13] Asonuma, T. & Joo, H. (2020). Sovereign debt overhang, expenditure composition, and debt restructurings. Unpublished manuscript.

[14] Asonuma, T. & Trebesch, C. (2016). Sovereign debt restructurings: Preemptive or post-default. *Journal of the European Economic Association, 14*(1), 175-214.

[15] Atolia, M. & Feng, S. (2019). Sovereign debt: A quantitative comparative investigation of partial default mechanism. Florida State University. Unpublished manuscript.

[16] Baldacci, E., Gupta, S., & Mati, A. (2011). Political and fiscal risk determinants of sovereign spreads in emerging markets. *Review of Development Economics, 15*(2), 251-263.

[17] Benjamin, D. & Wright, M. L. (2013). Recovery before redemption: A theory of delays in sovereign debt renegotiations. Unpublished manuscript.

[18] Borensztein, E. & Panizza, U. (2009). The costs of sovereign default. *IMF Staff Papers, 56*(4), 683-741.

[19] Bulow, J. & Rogoff, K. (1989). Sovereign debt: Is to forgive to forget? *American Economic Review, 79*(1), 43-50.

[20] Catão, L. & Sutton, B. (2002). Sovereign defaults: The role of volatility. *IMF Working Paper,* No. 02_149.

[21] Catão, L. & Kapur, S. (2006). Volatility and the debt-intolerance paradox. *IMF Staff Papers, 53*(2), 195-218.

[22] Chatterjee, S. & Eyigungor, B. (2012). Maturity, indebtedness, and default risk. *American Economic Review, 102*(6), 2674-2699.

[23] Chen, Y. C. & Lee, D. (2018). Market power, inflation targeting, and commodity currencies. *Journal of International Money and Finance, 88,* 122-139.

[24] Chen, Y. C., Rogoff, K., & Rossi, B. (2010). Can exchange rates forecast commodity prices? *Quarterly Journal of Economics, 125(3),* 1145-1194.

[25] Das, U. S., Papaioannou, M. G., & Trebesch, C. (2012). Sovereign debt restructurings 1950—2010: Concepts, literature survey, and stylized facts. *IMF Working Paper*, No.12_203.

[26] Detragiache, E. & Spilimbergo, A. (2001). Crises and liquidity: Evidence and interpretation. *IMF Working Paper,* No. 01_2.

[27] Dubey, P., Geanakoplos, J., & Shubik, M. (2005). Default and punishment in general equilibrium. *Econometrica, 73*(1), 1-37.

[28] Eberhardt, M. & Presbitero, A.F. (2021). Commodity prices and banking crises. *Journal of International Economics*, *131(C).*

[29] Easton, S. T. & Rockerbie, D. W. (1999). What's in a default? Lending to LDCs in the face of default risk. *Journal of Development Economics, 58*(2), 319-332.

[30] Enderlein, H., Trebesch, C., & Daniels, L. (2012). Sovereign debt disputes: a database on government coerciveness. *Journal of International Money and Finance, 31*, 250-266.

[31] Fernandez, A., Gonzalez, A., & Rodriguez, D. (2018). Sharing a ride on the commodities roller coaster: Common factors in business cycles of emerging economies. *Journal of International Economics, 11,* 99-121.

[32] Fernandez, A., Schmitt-Grohé, S., & Uribe, M. (2017). World shocks, world prices, and business cycles: An empirical investigation. *Journal of International Economics, 108,* S2-S14.

[33] Finger, H. & Mecagni, M. (2007). Sovereign debt restructuring and debt sustainability: An analysis of recent cross-country experience. *International Monetary Fund Occasional Paper,* No. 255.

[34] Gallani, S. & Krishnan, R. (2017). Applying the fractional response model to survey research in accounting. *Harvard Business School Working Paper,* No. 16-016.

[35] Goldsmith-Pinkham, P., Sorkin, I., & Swift, H. (2018). Bartik instruments: What, when, why, and how. *NBER Working Paper,* No. 24408.

[36] Gruss, B. (2014). After the boom – Commodity prices and economic growth in Latin America and the Caribbean. *IMF Working Paper,* No. 14_154.

[37] Hatchondo, J. C., Martinez, L., & Padilla, C. S. (2014). Voluntary sovereign debt exchanges. *Journal of Monetary Economics, 61*, 32-50.

[38] Hilscher, J. & Nosbusch, Y. (2010). Determinants of sovereign risk: Macroeconomic fundamentals and the pricing of sovereign debt. *Review of Finance, 14*(2), 235-262.

[39] *International Monetary Fund export and import price index manual: Theory and practice (2009).* Washington, D. C.: International Monetary Fund.

[40] Kaminsky, G.L. & Reinhart, C. M. (1999). The twin crises: The causes of banking and balance-of-payments problems. *American Economic Review, 89(3),* 473-500.

[41] Klein, M. W. & Shambaugh, J. C. (2010). *Exchange rate regimes in the modern era.* Cambridge, Massachusetts: The MIT Press.

[42] Lopez-Espinosa, G., Moreno, A., Rubia, A., & Valderrama, L. (2017). Sovereign tail risk. *Journal of International Money and Finance, 79,* 174-188.

[43] Maltritz, D. (2012). Determinants of sovereign yield spreads in the Euro-zone: A Bayesian approach. *Journal of International Money and Finance, 31*(3), 657-672.

[44] Papke, L. E. & Wooldridge J. M. (1996). Econometric methods for fractional response variables with an application to 401 (K) plan participation rates. *Journal of Applied Econometrics, 11,* 619-632.

[45] Papke, L. E. & Wooldridge J. M. (2008). Panel data methods for fractional variables with an application to test pass rates. *Journal of Econometrics, 145*(1-2), 122-133.

[46] Reinhart, C. M., Reinhart, V. R., & Trebesch, C. (2016). Global cycles: Capital flows, commodities, and sovereign defaults, 1815–2015. *American Economic Review, 106 (5),* 574-580.

[47] Reinhart, C. M. & Rogoff, K. S. (2009). *This time is different: Eight centuries of financial folly.* Princeton, New Jersey : Princeton University Press.

[48] Ricci, L. A., Milesi-Ferretti, G. M., & Lee, J. (2013). Real exchange rates and fundamentals: A cross country perspective. *Journal of Money, Credit, and Banking, 45*(5), 846-865.

[49] Shambaugh, J. C. (2004). The effects of fixed exchange rates on monetary policy. *Quarterly Journal of Economics, 199*(1), 301-352.

[50] Sturzenegger, F. & Zettelmeyer, J. (2006). *Debt defaults and lessons from a decade of crises.* Cambridge, Massachusetts: The MIT Press.

[51] Trebesch, C. & Zabel, M. (2017). The output costs of hard and soft sovereign default. *European Economic Review, 92,* 416-432.

[52] Uribe, M. & Schmitt-Grohé, S. (2017). *Open economy macroeconomics.* Princeton, New Jersey : Princeton University Press.

[53] Zinna, G. (2013). Sovereign default risk premia: Evidence from the default swap market. *Journal of Empirical Finance, 21,* 15-35.

Tables and Figures

Table 1: Statistics of Partial Default Rate (1970–2013)

Country	Mean	Std. Dev.	Frequency of Positive Arrears	Mean Conditional on Positive Arrears
Argentina	0.3435	0.3721	0.7045	0.4876
Brazil	0.1348	0.2049	1.0000	0.1348
Colombia	0.0161	0.0347	0.5455	0.0295
Ecuador	0.1605	0.2868	0.7955	0.2018
Mexico	0.0015	0.0085	0.2045	0.0074
Peru	0.2613	0.3934	0.7045	0.3709
Venezuela, RB	0.0635	0.1258	0.7727	0.0821
China (1981–2013)	0.0000	0.0000	0.0000	0.0000
India	0.0000	0.0001	0.0455	0.0003
Indonesia	0.1067	0.2080	0.5000	0.2134
Malaysia	0.0000	0.0000	0.2045	0.0000
Pakistan	0.0084	0.0508	0.1364	0.0618
Philippines	0.0298	0.0821	0.6136	0.0486
Thailand	0.0004	0.0014	0.1364	0.0028
Bulgaria (1981–2013)	0.1497	0.2828	0.4545	0.3294
Nigeria	0.2668	0.3481	0.8636	0.3089
Romania (1976–1989, 1991–2013)	0.0241	0.0522	0.3243	0.0525
Russian Federation (1992–2013)	0.4115	0.3528	1.0000	0.4115
South Africa (1994–2013)	0.0000	0.0000	0.1000	0.0000
Turkey	0.0048	0.0197	0.2045	0.0233
Ukraine (1992–2013)	0.2913	0.2121	1.0000	0.2913
Total (Number of Observations: 827)	0.1001	0.2319	0.4837	0.2045

Table 2: Price Index deflated by US CPI (1970–2013)

Country	Mean	Std. Dev.	Min.	Max.
Argentina	49.51	27.39	20.70	145.1
Brazil	53.68	34.57	16.60	155.2
Colombia	86.72	51.51	38.40	234.7
Ecuador	150.7	85.68	39.65	318.1
Mexico	190.0	105.3	58.24	451.5
Peru	73.26	54.89	17.11	223.0
Venezuela, RB	226.4	125.3	70.74	536.1
China	106.7	88.21	25.64	336.1
India	51.59	45.14	14.32	196.8
Indonesia	137.5	112.1	34.42	386.3
Malaysia	92.67	46.29	29.93	209.4
Pakistan	41.81	32.34	13.51	139.2
Philippines	47.48	32.76	18.45	180.1
Thailand	48.83	35.28	16.08	179.9
Bulgaria	37.98	28.27	15.00	124.2
Nigeria	225.3	123.9	72.66	535.9
Romania	38.87	32.86	13.67	148.2
Russian Federation (1992–2013)	148.7	60.51	75.36	265.0
South Africa	59.57	25.12	29.05	155.6
Turkey	53.87	30.45	18.66	122.6
Ukraine (1992–2013)	108.0	25.13	78.21	157.7
Total (Number of Observations: 880)	90.40	89.72	13.51	536.1

Table 3: Estimates of Effects of World Commodity Prices on Partial Default Rate

(a) Level – Alternative Specifications

	Model						
	OLS	FRM					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	$\hat{\beta}_j$ – **The Direction of Effect**						
P_1	0.016	-1.474***	-1.465***	-1.628***	-1.514***	-1.641***	-1.770***
P_1*COMEX/GDP	-0.782	-3.069	-0.235	0.604	-2.281	-1.607	2.063
P_1*EXD/GDP	-0.484	2.375	2.489	2.882	2.339	2.653	2.853*
COMEX/GDP*EXD/GDP	-13.045	-21.805	7.597	14.262	-13.867	-7.227	17.938
P_1*COMEX/GDP*EXD/GDP	2.459	-0.036	-4.629	-6.449	-1.239	-2.885	-6.925
P_1*peg	0.048	0.330	0.359	0.362	0.357	0.363	0.323
COMEX/GDP	4.315	17.498	5.571	2.711	13.238	10.697	-3.718
EXD/GDP	2.657**	-6.713	-5.373	-6.982	-7.456	-8.867	-8.186
EXD/GDP*global interest rate	0.048	0.390	0.082	0.102	0.465	0.490	0.265
peg	-0.179	-1.395	-1.521	-1.540	-1.525	-1.551	-1.471
default history	0.048	1.306***	1.182***	1.108***	1.333***	1.268***	1.157***
OPEC	0.122***	0.350	2.205***	2.188***	0.351	0.349	1.985***
int'l reserves/debt service	-0.001	-0.028	-0.032*	-0.028*	-0.043	-0.040	-0.049**
avg. 3-year GDP change	-0.968**	-2.906	-1.405	-1.420	-3.739	-3.798	-2.759
domestic credit/GDP	0.083	0.727*	0.647*	0.686*	0.769**	0.818**	0.801**
net capital transfers/GDP			-12.258**	-12.131**			-14.603***
official flows & grants/debt service					-0.306*	-0.311*	-0.512***
inflation_deflator			8.270E-05		5.460E-06		-1.693E-03**
inflation_CPI				1.040E-04		3.260E-05	1.571E-03**
cons.	-0.039	-0.341	-0.011	0.470	0.027	0.434	1.200
obs.	663	663	524	513	663	652	513
R-Square/pseudo R-Square	0.5457	0.4633	0.4513	0.4537	0.4668	0.4686	0.4638
Std. Dev.: 0.850	**AMEs of 1 Std. Dev. at Quartiles**						
1st (25%)	-0.076**	-0.126***	-0.122***	-0.120***	-0.129***	-0.131***	-0.119***
2nd (50%)	-0.076**	-0.102***	-0.087***	-0.086***	-0.102***	-0.101***	-0.079***
3rd (75%)	-0.076**	-0.075***	-0.049***	-0.048**	-0.069***	-0.068***	-0.041**

Notes: Regressions include country and year effects. Clustered standard errors at country level. Average marginal effects (AMEs) were calculated with *dydx()*.
– * Significant at the 10-percent level.
– ** Significant at the 5-percent level.
– *** Significant at the 1-percent level.

(b) Change – Alternative Specifications

	Model						
	OLS	FRM					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	$\hat{\beta}_j$ – **The Direction of Effect**						
ΔP_4	0.271**	0.169	1.891	1.944	0.439	0.460	1.987
ΔP_4*COMEX/GDP	0.616	-7.427	-28.148*	-28.810**	-7.167	-7.297	-25.557*
ΔP_4*EXD/GDP	-2.332**	-11.501*	-15.892***	-15.988***	-12.001*	-11.976*	-15.037***
COMEX/GDP*EXD/GDP	-0.897	1.093	5.725	5.608	2.660	2.764	5.323
ΔP_4*COMEX/GDP*EXD/GDP	1.279	51.470	104.008***	105.605***	52.005	52.533	98.341***
ΔP_4*peg	-0.359*	-2.145	-1.525	-1.586	-1.994	-2.025	-1.558
COMEX/GDP	-0.105	-3.118	-1.336	-1.154	-3.633	-3.595	-1.052
EXD/GDP	0.944**	0.671	2.567	2.477	0.433	0.327	2.117
EXD/GDP*global interest rate	-0.051	0.220	-0.104	-0.096	0.224	0.232	-0.028
peg	-0.004	-0.142	-0.192	-0.200	-0.156	-0.159	-0.227
default history	0.074**	1.198***	1.077***	1.032***	1.178***	1.144***	1.032***
OPEC	0.055	0.138	1.710***	1.699***	0.198	0.206	1.644***
int'l reserves/debt service	-9.469E-04	-0.016	-0.022	-0.019	-0.017	-0.015	-0.030
avg. 3-year GDP change	-1.031**	-3.456	-3.242	-3.240	-3.449	-3.472	-3.477
domestic credit/GDP	0.108	0.750**	0.640**	0.667**	0.744**	0.767**	0.733**
net capital transfers/GDP			-14.883***	-14.926***			-15.533***
official flows & grants/debt service					-0.206	-0.207	-0.273*
inflation_deflator			1.937E-04**		1.736E-04		-8.984E-04*
inflation_CPI				1.939E-04**		1.737E-04*	9.819E-04**
cons.	0.273***	-3.763***	-4.067***	-4.172***	-3.818***	-3.866***	-4.219***
obs.	661	661	523	512	661	650	512
R-Square/pseudo R-Square	0.5536	0.4549	0.4561	0.4578	0.4579	0.4590	0.4604
Std. Dev.: 0.128	**AMEs of 1 Std. Dev. at Quartiles**						
1st (25%)	-0.023*	-0.042**	-0.039*	-0.040*	-0.038**	-0.038*	-0.032*
2nd (50%)	-0.023*	-0.038**	-0.034**	-0.035**	-0.035**	-0.035**	-0.029*
3rd (75%)	-0.023*	-0.033***	-0.029**	-0.029**	-0.030**	-0.030**	-0.025**

Notes: Regressions include country and year effects. Clustered standard errors at country level. Average marginal effects (AMEs) were calculated with *dydx()*.
– * Significant at the 10-percent level.
– ** Significant at the 5-percent level.
– *** Significant at the 1-percent level.

Table 4: Estimates of *Overall* Effects of World Commodity Prices on Partial Default Rate – Alternative Specifications

	Model				
	FRM				
	(3)	(4)	(5)	(6)	(7)
Variables	$\hat{\beta}_j$ – **The Direction of Effect**				
composite price index	-1.637	-1.878	-2.760**	-2.932**	-1.808***
composite price index*COMEX/GDP	-19.159	-17.930	-10.187	-8.417	2.541
composite price index*EXD/GDP	-6.322	-5.690	1.198	1.964	3.050*
COMEX/GDP*EXD/GDP	-34.912	-33.056	-30.349	-24.600	26.368
composite price index*COMEX/GDP*EXD/GDP	45.673	41.930	10.156	5.796	-8.450
composite price index*peg	1.112	1.121	0.867	0.851	0.321
COMEX/GDP	16.221	15.780	18.861	17.120	-6.734
EXD/GDP	5.975	5.514	-1.522	-2.845	-9.135
EXD/GDP*global interest rate	0.173	0.186	0.593*	0.605*	0.245
peg	-0.814	-0.836	-1.340	-1.386	-1.462
default history	1.157***	1.110***	1.292***	1.235***	1.178***
OPEC	1.893***	1.888***	0.541**	0.536**	1.988***
int'l reserves/debt service	-0.021	-0.019	-0.028	-0.027	-0.054**
avg. 3-year GDP change	-3.998	-4.071	-4.288*	-4.348*	-3.507
domestic credit/GDP	0.745**	0.766**	0.798**	0.827**	0.745**
net capital transfers/GDP	-16.543***	-16.488***			-15.742***
official flows & grants/debt service			-0.244	-0.250	-0.465***
inflation_deflator	6.710E-05		-1.890E-06		-1.473E-03**
inflation_CPI		7.620E-05		1.650E-05	1.375E-03**
cons.	-3.359	-3.289*	-0.749	-0.434	1.584
obs.	523	512	661	650	512
pseudo R-Square	0.4591	0.4608	0.4677	0.4690	0.4660
weight on the change variable	0.8331	0.8299	0.6365	0.6162	0.0000
Std. Dev.	0.196	0.198	0.341	0.358	0.871
	AMEs of 1 Std. Dev. at Quartiles				
1st (25%)	-0.118***	-0.119***	-0.139***	-0.142***	-0.118***
2nd (50%)	-0.099***	-0.101***	-0.126***	-0.125***	-0.078***
3rd (75%)	-0.061***	-0.064***	-0.094***	-0.093***	-0.040***

Notes: Regressions include country and year effects. Clustered standard errors at country level. Average marginal effects (AMEs) were calculated with *dydx()*.
– * Significant at the 10-percent level.
– ** Significant at the 5-percent level.
– *** Significant at the 1-percent level.

Table 5: Endogeneity Tests

(a) Bartik Instrument

	Model (6)		
	Level	Change	Composite
Variables	The Coefficients for $\hat{v}_{it2}$		
residual (level)	0.471		
residual (change)		-0.275	
residual (composite)			0.794
	AMEs of 1 Std. Dev. at Quartiles		
1st (25%)	-0.142***	-0.036	-0.151***
2nd (50%)	-0.108***	-0.033	-0.131***
3rd (75%)	-0.074***	-0.028	-0.098***

Notes: Regressions include country and year effects. Clustered standard errors at country level. Average marginal effects (AMEs) were calculated with *dydx()*.
– * Significant at the 10-percent level.
– ** Significant at the 5-percent level.
– *** Significant at the 1-percent level.

(b) World Commodity Price Indices as IVs

	Model (6)		
	Level	Change	Composite
Variables	The Coefficients for $\hat{v}_{it2}$		
residual (level)	0.778		
residual (change)		2.772	
residual (composite)			1.417
	AMEs of 1 Std. Dev. at Quartiles		
1st (25%)	-0.148***	-0.053*	-0.156***
2nd (50%)	-0.110***	-0.047*	-0.133***
3rd (75%)	-0.074***	-0.039**	-0.098***

Notes: Regressions include country and year effects. Clustered standard errors at country level. Average marginal effects (AMEs) were calculated with *dydx()*.
– * Significant at the 10-percent level.
– ** Significant at the 5-percent level.
– *** Significant at the 1-percent level.

Table 6: AMEs of a Country-Specific One-Standard Deviation at Quartiles by Country

Country	Std. Dev.	AMEs of 1 Std. Dev. at Quartiles 1st (25%)	2nd (50%)	3rd (75%)
Argentina	0.185	-0.132***	-0.129***	-0.118***
Brazil	0.259	-0.227***	-0.169***	-0.068***
Colombia	0.232	-0.029***	-0.011***	-0.003**
Ecuador	0.286	-0.171	-0.118*	-0.064***
Mexico	0.243	-0.016*	-0.007*	-0.003*
Peru	0.325	-0.294***	-0.213***	-0.147***
Venezuela, RB	0.249	-0.220	-0.064***	-0.024**
China	0.329	-1.65E-04**	-0.042**	-1.15E-02***
India	0.342	-1.02E-04	-2.92E-05*	-1.82E-06
Indonesia	0.319	-0.189***	-0.125***	-0.097***
Malaysia	0.235	-4.28E-05	-0.041***	-0.002**
Pakistan	0.253	-0.022***	-0.018***	-0.008***
Philippines	0.226	-0.072***	-0.049***	-0.021**
Thailand	0.255	-0.018	-0.013	-1.86E-03
Bulgaria	0.203	-0.079***	-0.076***	-0.066***
Nigeria	0.245	-0.338***	-0.298***	-0.152***
Romania	0.227	-0.073**	-0.056***	-0.043***
Russian Federation	0.169	-0.232***	-0.209***	-0.131***
South Africa	0.159	-4.08E-05	-1.99E-05	-1.28E-06
Turkey	0.256	-7.31E-05*	-0.031***	-2.97E-07*
Ukraine	0.096	-0.101***	-0.092***	-0.077***

Table 7: AMEs of a Country-Specific One-Standard Deviation at Quantiles of Commodity Export-to-GDP Ratio and External Debt-to-GDP Ratio

(a) Argentina

Argentina						
Price Index 25%				COMEX/GDP		
AME: -0.132***		10%	25%	50%	75%	90%
	10%	-0.148***	-0.150***	-0.160***	-0.170***	-0.176***
	25%	-0.150***	-0.152***	-0.160***	-0.168***	-0.173***
EXD/GDP	50%	-0.148***	-0.149***	-0.156***	-0.164***	-0.168***
	75%	-0.136***	-0.137***	-0.143***	-0.150***	-0.154***
	90%	-0.062	-0.063	-0.070	-0.077*	-0.082*
Price Index 50%				COMEX/GDP		
AME: -0.129***		10%	25%	50%	75%	90%
	10%	-0.127***	-0.129***	-0.139***	-0.150***	-0.157***
	25%	-0.137***	-0.138***	-0.147***	-0.156***	-0.157***
EXD/GDP	50%	-0.141***	-0.142***	-0.150***	-0.158***	-0.163***
	75%	-0.138***	-0.139***	-0.146***	-0.153***	-0.157***
	90%	-0.072	-0.074	-0.081	-0.089*	-0.094*
Price Index 75%:				COMEX/GDP		
AME: -0.118***		10%	25%	50%	75%	90%
	10%	-0.103***	-0.105***	-0.114***	-0.123***	-0.128***
	25%	-0.117***	-0.118***	-0.126***	-0.134***	-0.139***
EXD/GDP	50%	-0.126***	-0.127***	-0.134***	-0.141***	-0.145***
	75%	-0.132***	-0.133***	-0.139***	-0.145***	-0.149***
	90%	-0.080	-0.081	-0.089	-0.096*	-0.101*

(b) Brazil

Brazil						
Price Index 25%				COMEX/GDP		
AME: -0.227***		10%	25%	50%	75%	90%
	10%	-0.168*	-0.170*	-0.178*	-0.206**	-0.226**
	25%	-0.181**	-0.183**	-0.191**	-0.216***	-0.234***
EXD/GDP	50%	-0.194***	-0.196***	-0.203***	-0.225***	-0.241***
	75%	-0.204***	-0.207***	-0.211***	-0.231***	-0.245***
	90%	-0.213***	-0.215***	-0.219***	-0.234***	-0.244***
Price Index 50%:				COMEX/GDP		
AME: -0.169***		10%	25%	50%	75%	90%
	10%	-0.105	-0.107	-0.113*	-0.133*	-0.148*
	25%	-0.121**	-0.122**	-0.128**	-0.147**	-0.161**
EXD/GDP	50%	-0.136***	-0.138***	-0.143***	-0.160***	-0.173***
	75%	-0.150***	-0.152***	-0.157***	-0.172***	-0.184***
	90%	-0.176***	-0.177***	-0.180***	-0.192***	-0.201***
Price Index 75%:				COMEX/GDP		
AME: -0.068***		10%	25%	50%	75%	90%
	10%	-0.030	-0.031	-0.032	-0.038	-0.042
	25%	-0.040*	-0.040*	-0.042*	-0.047*	-0.051*
EXD/GDP	50%	-0.051**	-0.051**	-0.053**	-0.058**	-0.062**
	75%	-0.063***	-0.063***	-0.065***	-0.070***	-0.073**
	90%	-0.094***	-0.094***	-0.095***	-0.098***	-0.100***

(c) Peru

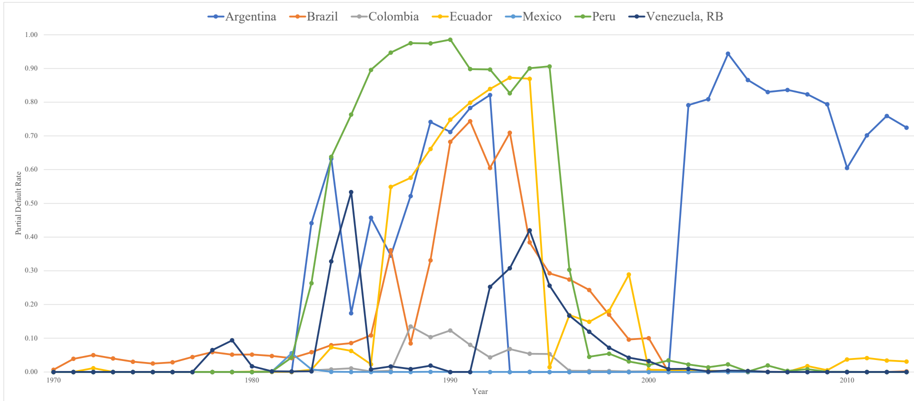
Peru						
Price Index 25%:				COMEX/GDP		
AME: -0.294***		10%	25%	50%	75%	90%
	10%	-0.255**	-0.269**	-0.293**	-0.357**	-0.412**
	25%	-0.277**	-0.286***	-0.301**	-0.339**	-0.374***
EXD/GDP	50%	-0.270***	-0.278***	-0.290***	-0.323***	-0.351***
	75%	-0.247***	-0.253***	-0.264***	-0.291***	-0.314**
	90%	-0.190**	-0.197***	-0.207***	-0.232***	-0.249*
Price Index 50%:				COMEX/GDP		
AME: -0.213***		10%	25%	50%	75%	90%
	10%	-0.118*	-0.125*	-0.136*	-0.169	-0.201
	25%	-0.182***	-0.186***	-0.193***	-0.210**	-0.225*
EXD/GDP	50%	-0.201***	-0.204***	-0.209***	-0.221***	-0.230*
	75%	-0.212***	-0.214***	-0.218***	-0.226***	-0.228*
	90%	-0.191**	-0.194***	-0.199***	-0.205**	-0.204
Price Index 75%:				COMEX/GDP		
AME: -0.147***		10%	25%	50%	75%	90%
	10%	-0.054	-0.056	-0.060	-0.070	-0.080
	25%	-0.113***	-0.113***	-0.114***	-0.115**	-0.115
EXD/GDP	50%	-0.139***	-0.139***	-0.138***	-0.135***	-0.131*
	75%	-0.167***	-0.167***	-0.165***	-0.159***	-0.150**
	90%	-0.175***	-0.175***	-0.175***	-0.169***	-0.158*

(d) Indonesia

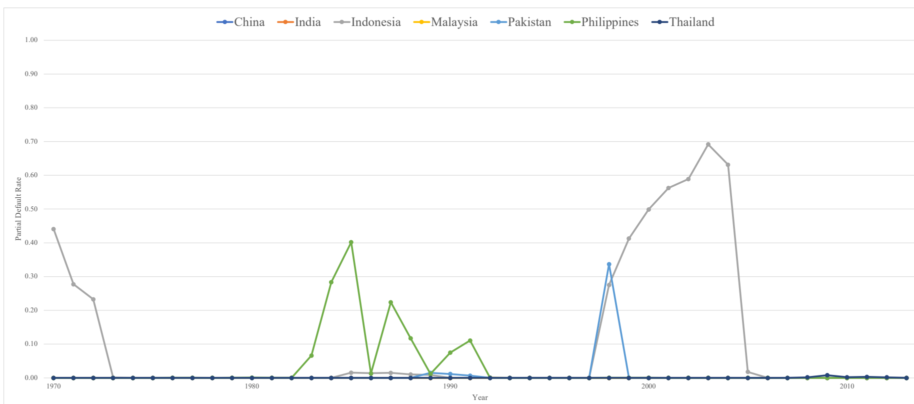
Indonesia						
Price Index 25%:				COMEX/GDP		
AME: -0.189***		10%	25%	50%	75%	90%
	10%	-0.166***	-0.172***	-0.185***	-0.208***	-0.229***
	25%	-0.172***	-0.178***	-0.190***	-0.212***	-0.231***
EXD/GDP	50%	-0.175***	-0.181***	-0.193***	-0.214***	-0.233***
	75%	-0.178***	-0.184***	-0.195***	-0.216***	-0.234***
	90%	-0.179***	-0.185***	-0.196***	-0.217***	-0.234***
Price Index 50%:				COMEX/GDP		
AME: -0.125***		10%	25%	50%	75%	90%
	10%	-0.108***	-0.112***	-0.199***	-0.134***	-0.147***
	25%	-0.114***	-0.118***	-0.125***	-0.139***	-0.151***
EXD/GDP	50%	-0.118***	-0.122***	-0.129***	-0.142***	-0.153***
	75%	-0.122***	-0.125***	-0.132***	-0.144***	-0.155***
	90%	-0.123***	-0.126***	-0.133***	-0.145***	-0.156***
Price Index 75%:				COMEX/GDP		
AME: -0.097***		10%	25%	50%	75%	90%
	10%	-0.082***	-0.085***	-0.090***	-0.100***	-0.108***
	25%	-0.088***	-0.091***	-0.096***	-0.105***	-0.113***
EXD/GDP	50%	-0.092***	-0.094***	-0.099***	-0.108***	-0.115***
	75%	-0.095***	-0.098***	-0.102***	-0.110***	-0.117***
	90%	-0.096***	-0.099***	-0.103***	-0.111***	-0.118***

(e) Nigeria

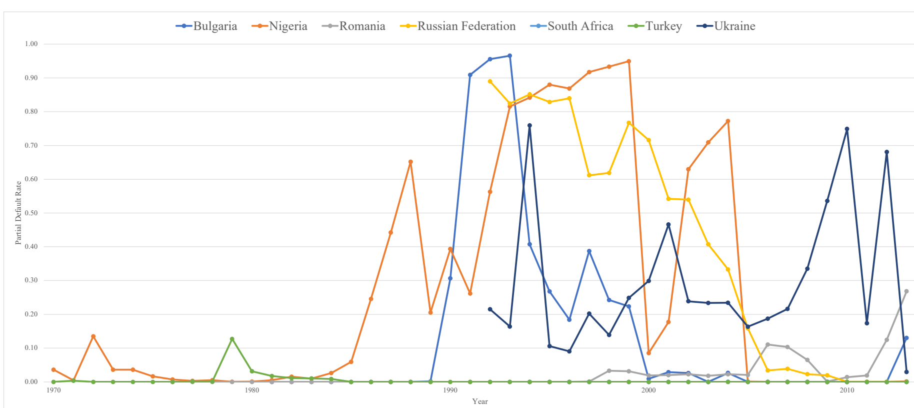
Nigeria						
Price Index 25%:				COMEX/GDP		
AME: -0.338***		10%	25%	50%	75%	90%
	10%	-0.349***	-0.364***	-0.382***	-0.400***	-0.408***
	25%	-0.339***	-0.351***	-0.369***	-0.385***	-0.392***
EXD/GDP	50%	-0.300***	-0.311***	-0.327***	-0.342***	-0.349***
	75%	-0.280***	-0.291***	-0.307***	-0.322***	-0.328**
	90%	-0.257***	-0.268***	-0.284***	-0.299**	-0.306**
Price Index 50%:				COMEX/GDP		
AME: -0.298***		10%	25%	50%	75%	90%
	10%	-0.263***	-0.275***	-0.291***	-0.306***	-0.313***
	25%	-0.273***	-0.283***	-0.297***	-0.310***	-0.316***
EXD/GDP	50%	-0.280***	-0.288***	-0.298***	-0.307***	-0.311***
	75%	-0.275***	-0.282***	-0.292***	-0.301***	-0.304***
	90%	-0.264***	-0.272***	-0.281***	-0.290***	-0.293***
Price Index 75%:				COMEX/GDP		
AME: -0.152***		10%	25%	50%	75%	90%
	10%	-0.105***	-0.105***	-0.105***	-0.105**	-0.105*
	25%	-0.122***	-0.121***	-0.119***	-0.117**	-0.116**
EXD/GDP	50%	-0.165***	-0.161***	-0.156***	-0.150***	-0.148***
	75%	-0.180***	-0.177***	-0.171***	-0.164***	-0.160***
	90%	-0.194***	-0.190***	-0.184***	-0.176***	-0.173***



(a) Americas

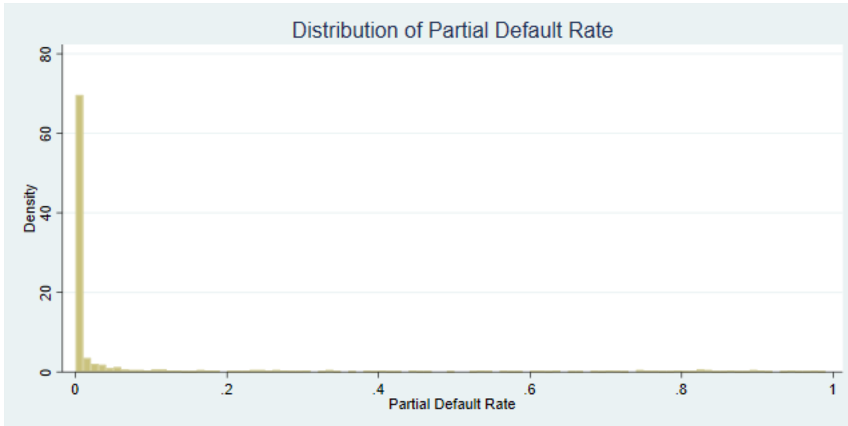


(b) Asia

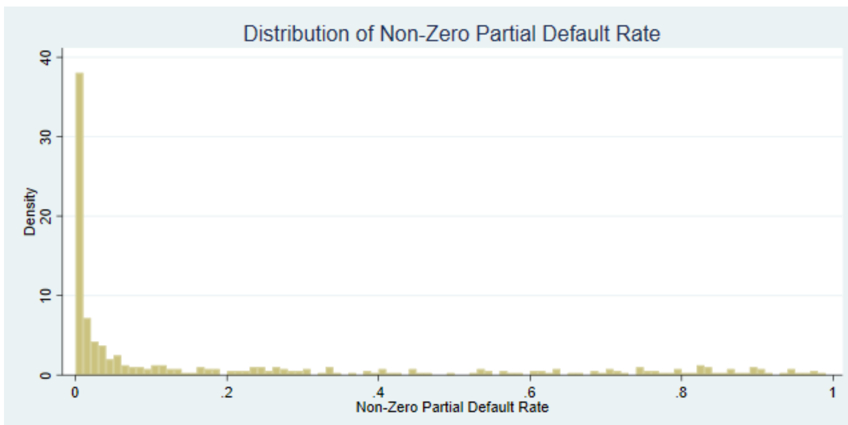


(c) Europe, Middle East, and Africa

Figure 1: Partial Default Rate



(a) Partial Default Rate



(b) Non-Zero Partial Default Rate

Figure 2: The Histogram of Partial Default Rate

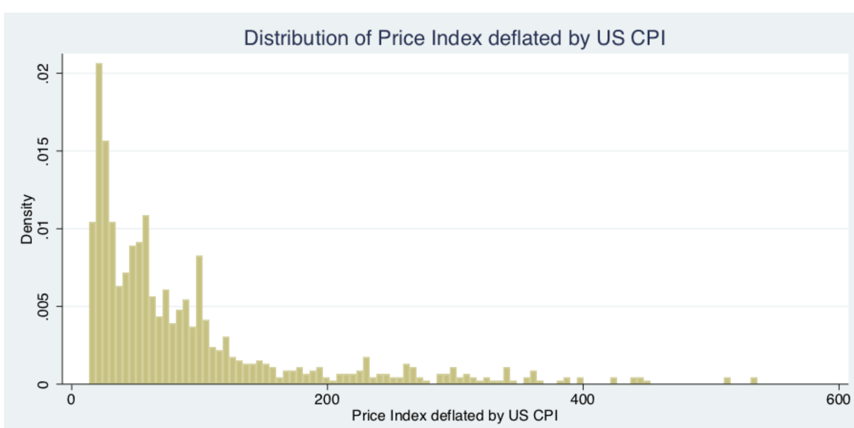
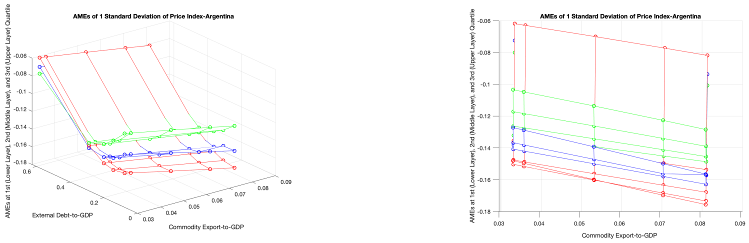
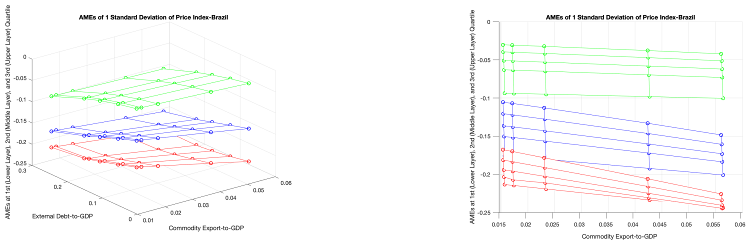


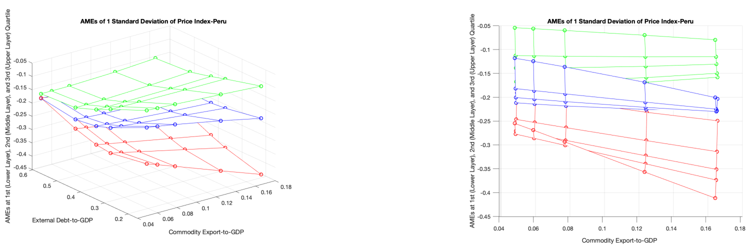
Figure 3: The Histogram of Price Index deflated by US CPI



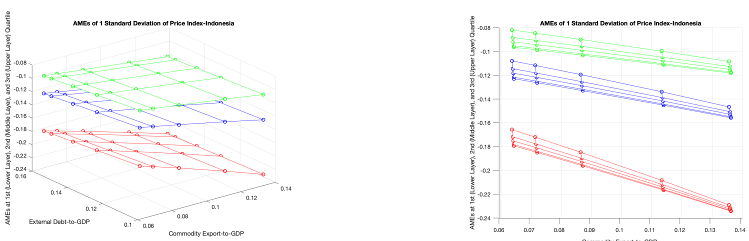
(a) Argentina



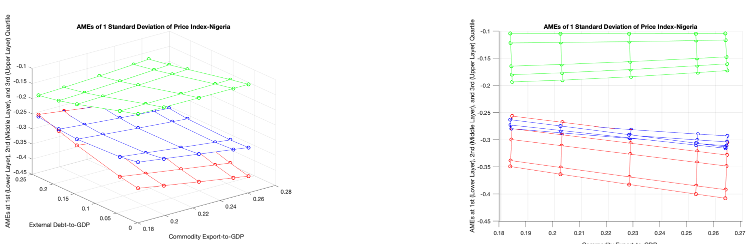
(b) Brazil



(c) Peru



(d) Indonesia



(e) Nigeria

Figure 4: AMEs of a Country-Specific One-Standard Deviation at Quantiles of Commodity Export-to-GDP Ratio and External Debt-to-GDP Ratio