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How Do Governments Respond after Catastrophes?

Natural-Disaster Shocks and the Fiscal Stance

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Abstract

Natural disasters could constitute a major shock to public finances and debt sustainability because of their impact on output and the need for reconstruction and relief expenses. This paper uses a panel vector autoregressive model to systematically estimate the impact of geological, climatic, and other types of natural disasters on government expenditures and revenues using annual data for high and middle-income countries over 1975–2008. The authors find that, on average budget, deficits increase only after climatic disasters, but for lower-middle-income countries, the increase in deficits is widespread across all events. Disasters do not lead to larger deficit increases or larger output declines in countries with higher initial government debt. Countries with higher financial development suffer smaller real consequences from disasters, but deficits expand further in these countries. Disasters in countries with high insurance penetration also have smaller real consequences but do not result in deficit expansions. From an ex-post perspective, the availability of insurance offers the best mitigation approach against real and fiscal consequences of disasters.

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How Do Governments Respond after Catastrophes? Natural-Disaster Shocks and the Fiscal Stance*

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1. Introduction

Recent observations suggest that natural catastrophes, especially the climatic ones, are increasing both in intensity and frequency. UNEP (2005) stresses that the world is facing an increasing frequency and intensity of disasters that have had devastating impacts based on figures reported by the secretariat of the International Strategy for Disaster Reduction that the ten years prior to 2005 have seen 478,100 people killed, more than 2.5 billion people affected and about US$ 690 billion in economic losses. Hoppe and Grimm (2008), form the Geo Risks Research Department of MunichRe, document that there have been indeed increasing signs that the steady advance of global warming is progressively affecting the frequency and intensity of natural catastrophes.

In addition to their direct costs, usually measured in terms of damages, casualties, and output losses (Raddatz, 2009; Rasmussen, 2004), natural disasters have the potential to constitute a major issue for public finances and debt sustainability in particular (Borensztein et al., 2008; Rasmussen, 2004; International Monetary Fund, 2009; Inter American Development Bank, 2009; World Bank, 2003; World Bank, 2001). The reconstruction of public infrastructure destroyed by a disaster requires increases in government expenditures at the same time that the contraction in economic activity may reduce government's ability to gather resources from standard tax collections. Furthermore, governments facing large disasters may need to mobilize resources to provide emergency relief, aid, and social safety nets to those individuals directly affected by these catastrophes. While international aid may help mitigate some of the immediate consequences of disasters, the amounts involved are usually smaller than the tens of billions that a large disaster may cost and are not promptly available.

The consequences of disasters for public finance and debt sustainability will depend on the nature of the government's reaction to the disasters. Whether governments respond to disasters by increasing expenditures to provide reconstruction and relief after a natural disaster will depend on their capacity to gather resources by increasing fiscal revenues or borrow resources from domestic or international sources, or benefit from previously contracted fiscal policy insurance or other hedges. In absence of these financing options, the governments' only option would be to maintain or even decrease the level of expenditures, limiting its ability to provide reconstruction and relief and potentially increasing the economic consequences of the disaster. The route followed by different governments concerning the combination of expenditures, revenues and borrowing will likely depend on the access to lending, its cost, and on the demand for government services. For instance, countries that can borrow at low cost and face the burden of reconstruction and relief may prefer that route to increasing revenues through taxation or restraining expenditures. And countries where private insurance markets share a large fraction of the reconstruction costs (e.g. by financing the reconstruction of private and public capital) may focus on emergency relief, face smaller funding requirements, and expanding expenditures moderately.

This paper estimates the impact of natural disasters on fiscal sustainability by characterizing how government expenditures and revenues typically respond to different types of disasters, and how these responses relate to a government's ability to borrow and to the availability of private financial sources for private and public reconstruction. Following Raddatz (2009), we do this by estimating the parameters of a Panel Vector Autoregression (PVAR) model that includes real output, government expenditures, government revenues, measures of the occurrence of geological, climatic, and other disasters, as well as other external shocks and standard macroeconomic variables like inflation and interest rates.[1] The three categories of natural disasters we consider follow Skidmore and Toya (2002) and are defined as follows: geological disasters including earthquakes, landslides, volcano eruptions, and tidal waves; climatic disasters including floods, droughts, extreme temperatures, and windstorms; and other disasters including famines, epidemics, insect plagues, wild fires, miscellaneous accidents, industrial accidents, and transport accidents.

Using the parameters of the model we can predict the dynamic response of each of the variables of interest to the occurrence of any type of disaster the same year the disaster occurs and in the years following the disaster. We estimate the model using annual data for high and middle-income countries during the period 1975-2008. While low-income countries are also of interest, data availability and the importance of aid flows for government financing makes them

[1] These types of models use the cross-country dimension of the data to increase the power of the estimation of time series models, and have been routinely used when short time series data is available, as it is the case in this paper.

hard to compare to countries that participate more actively in international financial markets. We identify the response of all variables in the model to the occurrence of each type of natural disasters by assuming that these disasters are acts of God whose occurrence is exogenous to a country's economic conditions. After estimating the average fiscal responses to disasters of all countries in the sample, we contrast the responses of different country groups based on income levels, financial development, and insurance penetration. The contrasts allow us to test whether differences in these country characteristics that proxy for a country's ability to borrow and for the availability of non-governmental sources of funds for reconstruction are associated with different fiscal behaviors and macroeconomic costs of disasters. Crucially, when comparing the responses of countries across groups we also control for differences in income levels across these groups.[2]

We find that while, for middle- and high-income countries, all three types of disasters appear to cause GDP declines, none of the effects is well statistically estimated. However, we observe clear consequences for the fiscal stance after climatic disasters. These consequences are due to expanding expenditure (by 15%) and declining revenue (by 10%) after these episodes. While governments try to proactively attenuate the impact of climatic disasters, they incur significant budget deficits (increase by 25% from initial levels). The GDP impact of climatic shocks is indeed the smallest as a result. Governments do not respond with a fiscal impulse using deficit financing after a geological disaster and this seems to end in higher real consequences for these disasters. This lack of an offsetting fiscal impulse could be driven by government preferences or simply a constrained fiscal space,[3] and we try to shed some light on the merit of these two interpretations by further controlling for initial debt levels and financial

[2] We also characterize the different responses across regions in additional results.

[3] Perotti (2007) puts forth two essential features of fiscal space that we will use in our discussions henceforth. First, fiscal pace is determined by the intertemporal government budget constraint and some notion of fiscal sustainability. This means that in order to increase some type of government expenditures at present one needs to either reduce other expenditures now or in the future, or increase current or future revenues or inflate away existing nominal debt. The ability to increase debt levels in a sustainable manner is thus consistent with having fiscal space available. Second, if one type of expenditure has a higher social marginal return than another and the same cost, resources should be moved from the second to the first type of expenditure.

market development. It appears that initial debt levels do not constrain a government's fiscal space available for disaster response in our sample, for which we conjecture that in this sample high initial debt levels proxy for better access to capital markets. Further, financially developed countries are found to always strongly increase government expenditures after the disasters (by 55%). While deficits increase relatively more in financially developed countries (by 75% as opposed to 10% in less financially developed countries), the resources that an efficient financial system can mobilize may help dealing with the economic consequences of disasters more effectively. The output loss for financially less developed countries appear to be 2 to 10 percent of GDP versus, on average, no significant loss for financially more developed countries. In contrast, countries with high levels of insurance penetration can deal with the economic consequences of disasters without engaging in deficit financing of expenditures.

In addition to quantifying the impact of natural disasters on output and fiscal variables for different groups of countries, our analysis leaves three main messages concerning the use of fiscal-policy financial instruments. First, one needs to be careful when associating high debt levels with a government's limited ability to borrow. A country's stock of debt is the equilibrium outcome of supply and demand factors. Countries with high debt levels may be those that face a larger supply of loans. For those countries, debt levels proxy for a good access to credit rather than a tighter credit constraint. In our sample of high- and middle-income countries, this seems to be the case. Second, countries with more developed financial markets or more developed insurance markets suffer less from disasters (smaller output declines). However, the way they achieve it differs in both cases. In financially developed markets, governments are able to raise funds and increase deficits. Presumably, this response helps alleviate the impact of the disasters. Thus, it seems that governments in financially developed countries have better access to debt markets to attenuate shocks. In contrast, in countries with high insurance penetration, the smaller impact of disasters occurs without an important fiscal expansion. Countries with smaller insurance markets expand deficits more, yet still suffer more from disasters. The availability of insurance seems to reduce the real consequences without requiring an increase in fiscal burdens. It seems, therefore, that while overall financial development helps deal with disasters, the prevalence of insurance does it in a more efficient ex-post manner. Of course, properly weighting these two options requires an explicit consideration of the costs of both strategies: the net present value of interest costs associated with further borrowing from the financial system versus insurance premium costs, which is outside the scope of this paper.

Given the recent emphasis on the use of insurance related strategies to deal with disasters (catastrophe insurance); it is useful to discuss the implications of our results for this strategy. Although our results relate to insurance penetration in the private sector, we believe that fiscal insurance policies could have a similar positive hedging effect and help enhance the disaster relief response and reconstruction and further diminish the real consequences of disasters in a fiscally sustainable manner. The reason is that, in our results the availability of insurance seems to dampen the impact of disasters by taking some of the losses and helping the government to focus fiscal expenses on the remaining un-hedged risks. This mechanism should also apply to fiscal insurance.

If this is the case, governments could avoid jeopardizing fiscal sustainability after natural disasters by purchasing financial products that transfer and disperse some of the financial risks from the natural disasters into financial markets. However, challenges in pricing and cost-benefit analysis concerning these products often leave countries hesitant to use them, assuming they will be able to meet the financial costs of disasters with their current expenditures and the help of official aid. Nevertheless, recent experience suggests that, despite these challenges, countries would like to arrange for some risk transfer mechanism as part of their climate-change risk mitigation strategies (Borensztein et al., 2008). The remainder of the paper is structured as follows. Section 2 describes the data and section 3 explains the estimation methodology. Section 4 presents and discusses the estimation results including for subgroups of countries based on income levels, regional location and financial deepening. Section 5 concludes.

2. Methodological Approach

We estimate the impact of natural disasters on output and fiscal variables across countries using a panel vector autoregression (PVAR) model that relates the variables of interest to its lagged values, and to contemporaneous and lagged indicators of the occurrence of various types of natural disasters. For a given country, the baseline specification of the model corresponds to

$$A_0 x_{i,t} = \sum_{j=1}^{q} A_j x_{i,t-j} + \sum_{j=1}^{q} B_j D_{i,t-j} + \theta_i + \theta_t + \gamma_i t + \varepsilon_{it} \tag{1}$$

where $x_{i,t} = (TT_{i,t}, y_{i,t})', TT_{i,t}$ is the (growth of) a terms-of-trade index, and $y_{i,t} = (EXP_{i,t}, GDP_{i,t}, INF_{i,t}, R_{i,t}, REV_{i,t})'$ is a vector of endogenous variables that includes the (log of) real government expenditures (EXP), GDP per capita (in constant 2000 US dollars) (GDP), the inflation rate (INF), nominal interest rate (R), and government revenues (REV). The main focus of the paper is on EXP, GDP and REV, but we include inflation and interest rates in the y vector as controls for other macroeconomic conditions. This set includes all the conventional macroeconomic variables typically included in macro models (see Monacelli (2005), Linde et al (2008), and Adolfson (2001), among others). The vector $D_{i,t'} = (GEO_{i,,t}, CLIM_{i,t}, OTH_{i,t})'$ includes variables capturing the occurrence of geological, climatic, or other disasters, as described in the next section. The parameters θ_i and θ_t are country and year fixed-effects that capture long run differences in all the variables across countries, and the impact of global factors that are common to all countries in the sample and can be understood as the world business cycle. The coefficient γ_i captures a country-specific trend and is included when the model is estimated in levels only (see below). The residual term $\epsilon_{i,t}$ corresponds to an error term that is assumed i.i.d. The number of lags, q, is assumed to be equal in both summatories. Relaxing this assumption does not importantly change the results. The parameters of the model are matrices, denoted by A_j, and the structural interpretation of the results depends on the identification of the parameters of the contemporaneous matrix A_0. Note at this point that we do not include government deficit explicitly as a variable into the model. The model includes logs of expenditure and logs of revenues, which are by definition always positive. The logged government deficit is then constructed from the evolution of these two variables and the shares of expenditures and revenues in the deficit in the sample of countries.

The main identification assumption of this empirical strategy is that the occurrence of natural disasters is exogenous. They are assumed to be acts of God that are unrelated to any present or past economic variable. Identifying the impact of other shocks in the model requires additional and more controversial assumptions. Throughout the paper, it is assumed that the terms-of-trade do not respond to the y variables at any lags, but probably have a contemporaneous and lagged effect on them, which is equivalent to imposing a diagonal structure in all the A matrices. For the developing and small developed countries included in this study, these assumptions should be uncontroversial. The assumption is more debatable when including developed countries, but the assumption is maintained to ease comparison across groups of countries and specifications.

The fiscal variables are included in the y vector because they are likely to respond to a country's macroeconomic performance, and are identified by assuming a contemporaneous causal order among the variables that is given by their position in the vector. This means that the A_0 matrix of contemporaneous relations among the y variables is assumed block-triangular, which corresponds to assuming that output, inflation, interest rates and revenues respond contemporaneously to changes in expenditures, but government expenditures respond to changes in a country's economic conditions and fiscal revenues only after a year. Similarly, revenues are assumed to respond contemporaneously to changes in expenditures, GDP, inflation, and interest rates, but these variables respond to shocks to revenues only with a one year lag. The assumptions on the ordering of the fiscal variables relative to GDP are similar to those in Blanchard and Perotti (2002) and Ilzetzki et al (2010), but the use of annual data makes them more controversial. While one may reasonably argue that expenditures are planned on an annual basis and do not respond to a contemporaneous quarterly innovations in GDP, assuming that they do not respond to innovations to GDP within the calendar year is more extreme. Nevertheless, this should not be a problem for the identification of the conditional response of fiscal variables and output to the exogenous shocks, which is the main focus of this paper. The ordering of inflation and interest rates relative to output also follow the standard ordering in the monetary policy literature (Christiano et al. (1998)). As in the case of the fiscal variables, the identification of structural shocks to these variables based on causal order with annual data is controversial but should not affect the identification of the impact of the disaster shocks, which is the focus of this paper. The identification assumptions translate in the following matrix of contemporaneous relations (A_0),

$$A_0 = \begin{bmatrix} a_{1,1} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & a_{2,2} & 0 & \cdots & \cdots & \cdots & 0 \\ 0 & a_{3,2} & a_{3,3} & 0 & \cdots & \cdots & 0 \\ 0 & a_{4,2} & \vdots & a_{4,4} & 0 & \cdots & 0 \\ 0 & a_{5,2} & \vdots & \vdots & a_{5,5} & 0 & 0 \\ 0 & a_{6,2} & \vdots & \vdots & \vdots & a_{6,6} & 0 \\ 0 & a_{7,2} & a_{7,3} & a_{7,4} & a_{7,5} & a_{7,6} & a_{7,7} \end{bmatrix}.$$

Similarly, the model restricts the B_j matrices so that disasters do not affect a country's terms of trade at any lags. In particular, the matrix B_0 has the following structure.

$$B_0 = \begin{bmatrix} 0 & 0 & 0 \\ b_{2,1} & b_{2,2} & b_{2,3} \\ b_{3,1} & \vdots & b_{3,3} \\ b_{4,1} & \vdots & b_{4,3} \\ b_{5,1} & \vdots & b_{5,3} \\ b_{6,1} & b_{6,2} & b_{6,3} \end{bmatrix}.$$

The structure of the other B_j matrices is analogous.

The model described in equation (1) correspond to a PVAR, because they assume that the dynamics, represented by the different parameters and matrices, are common across the different cross-sectional units (countries) included in the estimation, which are indexed by i. This is a standard assumption in this literature (see Broda (2004); Ahmed (2003), Uribe and Yue (2006)) because, given the length of the time series dimension of the data (around 20 annual observations), it is not possible to estimate country-specific dynamics unless we reduce importantly the number of exogenous shocks under consideration, the number of lags, or both. However, as noticed by Robertson and Symons (1992), and Pesaran and Smith (1995), this assumption may lead to obtaining coefficients that underestimate (overestimate) the short (long) run impact of exogenous variables if the dynamics differ importantly across countries.

We estimated the parameters of equation (1) for the cases where the series are trend stationary in levels and stationary in differences (with drift). The reason is that standard panel unit root tests offer little guidance on what model is more appropriate. The results of those tests are summarized in Table 2, which presents summary statistics for standard unit root tests performed on a country-by-country basis, as well as results from the Levin et al. (2002) panel unit root test. For most variables, the fraction of countries where the hypothesis of a unit root cannot be rejected is high, but in most cases the panel unit root test cannot reject the null hypothesis of a unit root for the series in levels. For the series in differences, the fraction of individual countries where the unit root hypothesis is rejected and the panel unit root tests strongly reject the hypothesis of a unit root. Thus, there are arguments for estimating the model in both forms. The bulk of the discussion below focuses on the model in levels because the confidence bands for this model were more precisely estimated because more information is preserved for the estimation when employing levels of variables rather than their differences. However, we will also discuss the results in differences for the baseline estimation and, while we will not report the model in differences for all exercises for reasons of space, the results are qualitatively and quantitatively similar to those obtained for the model in levels. Furthermore, even when estimating the model in levels, the interest rate will be included in first differences. The reason is that, although panel unit root tests reject the null of a unit root, when included in levels this series exhibits explosive non-stationary behavior in some specifications.[4]

For the version of the model in differences we also tested for the possibility of cointegration using Pedroni (1999)'s test for cointegration in panels. Although the various statistics proposed by Pedroni (1999) yield somewhat ambiguous results, in most cases the null hypothesis of no cointegration cannot be rejected (see Table 3). Moreover, Pedroni (2004) shows that for the sample characteristics that are closer to those used in this paper (N larger than T) the panel-rho test, which systematically cannot reject the null of no cointegration, has the best size and power properties. Consistently, the model in first differences will be estimated without a cointegration relation.

Standard lag tests suggest estimating the model including two annual lags (Schwartz information criterion). Three annual lags are also considered for robustness.

The parameters of the two versions of the model, estimated in reduced form by SURE are used to recover the impulse-response functions (IRF) of per capita GDP, government

[4] This occurs in a few estimations for groups of countries by region. In these cases, the impulse response functions do not converge back to zero within a 20 year window.

expenditures and revenues, and the resulting budget deficit to each of the structural shocks using the variance-covariance matrices of reduced form errors derived from these coefficients.[5] The confidence bands for the IRF come from parametric bootstrapping on the model assuming normally distributed reduced form errors.

3. Data

To conduct the analysis we collected data on the incidence of disasters and several measures of macroeconomic and fiscal performance for middle and high-income countries. Low-income countries are not included because their fiscal expenditures, revenues, and overall debt are typically related to official and multilateral aid support. Therefore, the fiscal responses to shocks are likely to differ qualitatively from those of other countries and depend on exogenous aid allocation.

Data for natural disasters were obtained from the Emergency Disasters Database (EM-DAT) maintained by the Center for Research on the Epidemiology of Disasters (2008) (CRED). This is a comprehensive database that includes data on the occurrence and effects of over 12,800 mass-disasters in the world since 1900, and is compiled from a diversity of sources. As a general principle, to enter into the database an event has to meet any of the following conditions: there are ten or more people reported killed; there are 100 or more people reported affected; a state of emergency is declared; or there is a call for international assistance.

The data contain information on various types of disasters that following Skidmore and Toya (2002), we classify in three broad categories. Geological disasters include earthquakes, landslides, volcano eruptions, and tidal waves. An important characteristic of this type of events is their unpredictability and relatively fast onset. The second category is climatic disasters. This category includes floods, droughts, extreme temperatures, and windstorms (e.g. hurricanes).

[5] The use of SURE is standard for the estimation of the reduced form equation. It is equivalent to estimating the model equation by equation by OLS, but is more efficient because it takes into account contemporaneous correlations among variables. It also directly estimates the variance-covariance matrix of reduced-form residuals. We use only the two-step version of the estimator for reasons of speed, but when iterated until convergence the SURE estimators are equivalent to the maximum likelihood estimators.

Compared to the previous category, some of these disasters can be forecasted well in advance (so precautions can be undertaken) and have a relatively long onset. The final category is a residual group that includes famines, epidemics, insect plagues, wild fires, miscellaneous accidents, industrial accidents, and transport accidents.

In each category, the incidence of disasters is measured by counting the annual number of events that classify as large disasters according to the following criteria established by the International Monetary Fund (see Fund (2003)): the event either affects at least half a percent of a country's population, or causes damages to the capital stock, housing, human lives, etc. of at least half a percent of national GDP, or results in more than one fatality for every 10,000 people.[6] The relative intensity of disasters is not explicitly captured in our analysis as we use a threshold indicator and then assume that in each disaster category the intensity is similar or averaged within the category.[7]

Starting from this variable, we also construct a different measure that not only counts the number of disasters but also takes into account the month of the year when a disaster occurs, in a manner similar to Noy (2009). This allows disasters occurring early in the year to have a different contemporaneous impact than those that happen near the end of the year. This is basically a re-normalization of the incidence measure described above, since just counting the number of disasters yields an estimation of the output costs of a disaster occurring at the sample mean date during the year. Taking into account the date of occurrence, produces an estimate of the output cost of a disaster occurring January 1st.

[6] Note at this point that this threshold identification of significant disasters does not mechanically imply a decline in GDP, also some relationship with GDP dynamics could exist. This is because the identification threshold looks at the destroyed stock of wealth and production factors rather than the flow of income. GDP is used here as a scaling variable.

[7] While we cannot completely control for the disaster's size, we do separate small and large disasters. Thus, only variation in intensity among large disasters is being ignored. Further, the concern that two episodes may have completely different impact because of their intensity and location is partially controlled by imposing that disasters affect a minimum number of people and cause a minimum damage to capital and wealth. Thus disasters that occur in the middle of the desert are not considered as disasters under our measure. Nonetheless, future work should attempt to consider the disaster's distance to populated centers..

Data on macroeconomic performance, fiscal stance, and other types of external shocks (used as controls in part of the analysis) come from various sources. Real GDP per-capita is measured in constant 2000 U.S. dollars and obtained from the Bank (2008) World Development Indicators (WDI). The terms-of-trade index is the ratio of export prices to import prices computed using the current and constant price values of exports and imports from the national accounts component of the Penn World Tables (version 6.1) and updated using the terms-of-trade data from WDI.

Data on government expenditures and revenues come from WDI, IFS, and EIU. Data on total government debt come mainly from Panizza et al. (2008), complemented with data from WDI, IFS, and EIU. Government expenses are cash payments for goods and services incurred by the government, including wages compensation and interest payments. Revenues include receipts from taxes, social contributions and fees, excluding grants. Data on a country's CPI and inflation rate come from WDI. Official assistance and grants are not included in our analysis so that expenditure and deficit are measured before grants. This is an advantage considering that movements in them may generate movements in deficits that are not related to fiscal sustainability. Official assistance is not included separately as a variable due to its unavailability for developed countries that constitute a major part of our sample.

Finally, data on money market, discount, and deposit interest rates come from the International Monetary Fund (2010) International Financial Statistics. To increase the cross-country coverage of our sample, we select from the three definitions the interest rate series with the longest spell during the sample period, with preference for the money market rates when two or more series had the same coverage. Summary statistics for these variables for the sample of countries during the period of analysis are presented in Table 1. To improve coverage on all macroeconomic and disaster variables, the final sample used in the econometric analysis below is restricted to the post Bretton Woods, 1975-2006 period.

Table 2 takes a first look at the data by comparing, within the sample, the average macroeconomic performance in years with and without disasters. The results show that expenditures grow slightly faster in years with Geological and Climatic disasters, but not significantly so. The year of a geological disaster, expenditures grow 5.6 percent on average, compared to only 2.6 percent for the remaining years. However, both averages have wide dispersion and a two sided test rejects the hypothesis that those two averages are identical only at the 12 percent level. The differences are much smaller and also insignificant for climatic disasters, which result in expenditure growth of 2.7 percent, compared to 2.6 percent for the average year without a climatic disaster. On the revenue side, revenue growth is also higher in the year of a geological disaster than in other years (4.4 versus 3.1 percent, respectively), but is lower in the year of a climatic disaster than in a normal year (2.4 versus 3.3 percent). These unconditional comparisons show only a small increase in the fiscal deficit during a disaster. However, a proper estimation of the impact of a disaster on any macroeconomic variable requires conditioning on the behavior of other variables, as well as global fluctuations in economic activity. The methodological approach outlined in section 2 takes care of that.

4. A Brief Discussion on the Impact of Disasters on Expenditures and Output

The impulse responses that we will present in the next section summarize the response of the key variables included in the VAR (output, government expenses, and revenues) to the occurrence of a large natural disaster. As such, each one of them conveys information on the evolution of the whole system of variables after a shock, and on the full set of relations among variables. These interactions may lead to some apparently unintuitive results that are useful to discuss at this stage.

First, note that from a theoretical point of view, the impact of a disaster on economic activity is ambiguous. A disaster may destroy capital and other factors of production, reducing the amount of output that can be produced with a given amount of labor. However, it also makes people inter-temporally poorer, increasing the incentives to work through a standard wealth effect. The final response of output depends on which of these effects dominate. Further, consider the response to a disaster of a simple system that includes only output, fiscal expenditure, and fiscal revenue. Assume that initially the disaster leads to a decline in output, an increase in expenditure, and that revenue passively follows output. After the initial impact, the evolution of each of these variables will depend on their contemporaneous and lagged relations. In particular, in this example the sign and magnitude of the expenditure multiplier will play a crucial role. If an increase in expenditures leads to an increase in output, this multiplier effect will dampen the initial output decline resulting from the disaster. If the multiplier is large enough, output may actually end up increasing shortly after the disaster instead of declining. Thus, in this example, it is possible to obtain small and even positive responses of output to disasters depending on the impact of the disaster on expenditures and the relation between expenditures and output. It is also possible that a disaster will not lead to an increase in government expenditures if a government does not have the fiscal space for deficit financing. In such a case, expenditures will not react immediately to the shock but follow the declining revenues. Depending on the sign and magnitude of the fiscal multiplier, this may reinforce or dampen the response of output. Of course, if revenues do not follow output passively, the final behavior of all variables will also depend on the impact of a disaster on revenues and the relation between revenues and output and expenditures. Also, if other variables are added to the PVAR their behavior should be considered when tracing down the impact of a shock.

These simple examples highlight that one must be careful when interpreting the results of the impulse-response functions because they do not only convey isolated relations among pairs of variables. One could in principle trace down the transmission looking at the full set of IRF to each of the structural shocks. For instance, in the example above, one could look at the IRF of output to an expenditure shock to gauge the sign and significance of the multiplier and decompose the direct and indirect transmission of a disaster to output. However, as discussed above, while the assumptions for the identification of the impact of disasters and other exogenous variables are relatively uncontroversial, identifying fiscal shocks from causal ordering using annual data has many pitfalls. Thus, the impulse responses to structural shock to endogenous variables must be taken with caution.

In addition, one may argue that disaster effects could be endogenous to the level of income due to better mitigation expenses and mitigation measures. This could then introduce heterogeneity in the response parameters across countries. We address this heterogeneity by comparing results across subsamples based on income levels and other relevant characteristics.[8] Considering the implications that disaster mitigation measures may have on the classification of disasters, we use a measure of disasters that includes only those above some threshold. Thus, an event occurring in a country, which has engaged actively in mitigation, that does not have impact on the stock of wealth, capital or people is not classified as a disaster.

5. Results

This section presents and discusses in detail the estimated impact of natural disasters on output, fiscal expenditures, fiscal revenues, and the deficit. Other macroeconomic variables, like inflation and interest rates, are included in the estimation to control for their behavior around disasters but we do not discuss their response to disasters for reasons of space. For the baseline estimation, the appendix reports the full set of impulse-response functions. We first discuss the baseline results for the full sample of countries included in the analysis. We then document the differential responses across income levels, proxies for the fiscal space, and the development of financial and insurance markets. The appendix presents a detailed discussion of the impact of disasters for different regions.

5.1 Baseline Results

Figure 1 shows the cumulative impulse response functions of real per capita GDP, government deficit, government expenditures, and government revenues. Since the variables are expressed in logs, the non-cumulative IRF show the percentage deviation of the variable with respect to its trend level at each point in time, and the cumulative IRFs displayed in the figure show the cumulative percentage deviation of a variable at each moment. In the long-run, the cumulative IRFs show the total percentage deviation of the variable from its trend resulting from a shock. In this and most figures below, government expenditures and revenues are expressed as a fraction of government deficit using the sample average shares of each deficit component. This means that the evolution of the deficit can be directly obtained by subtracting the evolution of

[8] One can also compare the results across countries with different histories of disasters incidence assuming that those with higher historical incidence would have made more mitigation expenses. This is left for future research.

expenditures and revenues.[9] This evolution is the one shown in the second column of graphs, because the deficit is not directly part of the model specified in equation (1). Obtaining the evolution of deficit as a fraction of GDP only requires subtracting the evolution of real GDP from the evolution of the deficit.

In the average middle- and high-income country, all three types of disasters appear to have a negative impact on GDP (Figure 1, first column) but none of the effects is estimated as statistically significant. There is some indication that the impact of geological disasters on GDP could be more significant than the effects of climatic and other disasters. Note again that the residual disaster category is qualitatively different from the other two, so the impact of these disasters must be taken with care. Consistently, we will henceforth put more emphasis in the discussion of the better-defined geological and climatic disasters.[10]

Fiscal variables respond to disasters. The impulse responses reported in Figure 1 show the evolution of government expenditures and revenues as a share of government deficit, so that the difference between these two series measures the impact of the shock on the deficit. The evolution of the deficit computed in this way is also reported in the second column of the figure. Government expenditure increases significantly in response to climatic and geological disasters, where the former cumulative response lasts relatively longer. On the contrary, expenditures contract strongly after a residual disaster. Revenues experience an insignificant change after all disasters.

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[9] By definition, the deficit is the difference between expenditures and revenues: $D = E - R$. Log-linearizing this expression, the log deviations of deficit correspond to $\hat{d} = s_E \hat{e} - s_R \hat{r}$, where s_E and s_R are the shares of expenditures and revenues on deficit: $s_E = E / D$ and the lowercase letters with hats represent the log deviation of a variable with respect to its trend.

[10] The impact of disasters is significantly negative when we use the money market rate as the relevant interest rate. Although money market rates are better measures of the policy stance than our "merged" interest rate measure, their country coverage is limited and reduce the sample to about one half and biases it toward upper middle and higher income countries. Given the differences documented by income level below, using this interest rate measure may bias the interpretation of our results as applying to the "average" country.

The combination of the significant increase in expenditures and rather unchanged revenues after a climatic shock leads to an important increase in government deficit (25% increase in real terms). After a geological disaster, the increases in expenditures and revenues cancel out, resulting in an insignificant movement in the level of the deficit. Since the output is not changing significantly the deficit increases as a share of GDP. Somewhat surprisingly, deficits decline in real per capita terms after other types of disasters. This decline is larger and significant in contrast to the decline in GDP, so that the deficit declines relative to GDP too. As mentioned above, this may just reflect the heterogeneity and sparsity of the disasters included in this category.

Several of these results are similar to those obtained using a specification in differences (Figure 2), where the estimates suggest strong negative effect of geological disasters on GDP and short-lasting negative impact of the residual disasters on output. In this case, the responses of expenditures to climatic and geological disasters are smaller and less significant. The conclusions regarding the deficit are thus less certain. However, it appears that the deficit increases after a climatic disasters relatively more than after a geological disaster (with the opposite sign, showing rather a contraction of the deficit), and is insignificant but changes sign after other disasters.

Overall, the baseline results imply that GDP could decline after geological disaster but is in general not significantly affected by disasters. In contrast, clear budget consequences follow climatic disasters. These consequences come from an expansion of the expenditure and unchanged revenues after these episodes. It seems that governments actively try to attenuate the impact of these disasters by incurring deficit financing. Coincidently, the output impact of climatic shocks could be the smallest. Following a geological disaster, expenditures and revenues move in similar directions, resulting in a little budget adjustment. After a typical geological disaster, fluctuations in expenses are highly correlated with fiscal revenues. Governments do not massively resort to deficit financing after a geological disaster and this seems to end in higher real consequences for these disasters. This lack of deficit financing may be due to demand factors (government choice) or because of a small fiscal space. Results below controlling for the level of initial debt and financial market development will shed more light on the merit of these two interpretations.

5.2 Robustness

There were several modeling choices made in the estimation of the baseline results. This section briefly explores the robustness of the results to these choices. The discussion above already showed that the use of a model in levels or differences does not importantly affect the results. In what follows we explore the role of the number of lags, the measure of disasters, the measure of output, and the order of the variables in the VAR.

The results of each of these exercises, reported in figures 3 to 7 show that the findings discussed above are not crucially driven by these modeling choices. Adding a third lag turns positive the point estimate for the GDP impact of climatic disasters, but as in the previous case, the impact is not statistically significant (Figure 3). The conclusions regarding deficits, expenditures, and revenues are largely unaffected.

We use two different indicators of the occurrence of disasters. First, a simple index that takes the value 1 if at least one disaster of each category took place in a given year (Figure 4, Panel A). Second, a more complex index that takes into account the month when the disaster occurs, thus reporting the impact of a disaster occurring January 1st (Figure 4, Panel B). In both cases, the output and fiscal impacts of disasters are similar to those reported in the baseline results. Similar results are also obtained when using the Penn World Tables' measure of real per capita GDP that adjusts for purchasing power parity instead of the measure in constant dollars (Figure 5).

As explained in section 3, the baseline estimation in levels included the changes in the (log) interest rate instead of the level of this variable because in some cases its impulse responses suggested non-stationary behavior. While this choice makes a difference for the estimated responses of this variable, it does not importantly affect the estimated responses of output and the fiscal variables to disasters, as shown in Figure 6.

Finally, changing the order of variables in the VAR, so that expenditures are located after output inflation, and interest rates, and just before revenues, does not change the main results either (Figure 7).

Overall, these exercises indicate that the broad patterns documented above are robust features of the data and do not depend crucially on specific modeling choices. In what follows, we will focus only on the baseline model estimated in levels because of its precision relative to the model in differences.

5.3 The Impact of Disasters across Income Levels

The baseline results group all middle and high-income countries together. As discussed in section 3, this increases the number of disasters included in the sample, raising the statistical power of the procedure. The cost is that assuming homogeneity in the parameters may significantly bias the estimates. A possible way of advancing in allowing heterogeneity, while retaining statistical power, is to estimate separately the model for groups of relatively homogeneous countries. One straightforward manner of grouping countries is according to their per-capita income level, which proxies for their overall level of development. The results of this exercise are reported below.

Climatic and Geological disasters have no significant output impact among high-income countries as in the whole sample (Figure 8, first column). Climatic disasters appear to rather induce a small increase in output which is however close to zero and insignificant from a statistical perspective. Geological disasters have a cumulative output effect of about 5 percent (similarly as for the baseline) that is not significant either. The only large significant impact is that of other disasters. However, as shown in Table 1, there is very few and concentrated episodes of Geological and Other disasters among high-income countries. The only country in this group that has experienced large geological disasters is Greece, in three occasions, and the only country affected by other disasters is Barbados. Only for climatic disasters there is enough statistical variation for identification (27 disasters spread across several countries). Thus, the results for Geological and Other disasters in this group of countries are unlikely to be reliable and we will focus on Climatic disasters for the discussion next.

On the fiscal side, both expenditures and revenues increase after a climatic disaster (Columns (3) and (4)). This comovement results in insignificant impacts on the budget deficit. This suggests that high-income countries are likely increasing their expenditures and revenues in response to a Climatic disaster. They can mitigate the impact of these shocks without going into deficit financing, presumably due to a positive multiplier effect of public expenditures.

The situation is different for middle-income countries (Figure 9). The output impact of disasters appears larger for this group, with a cumulative output decline of about 0.9 percent for climatic disasters and about 7 percent for Geological disasters, where only the latter is statistically significant. Contrarily to high-income countries, in this (larger) group of countries, there are many episodes of disasters across several countries, so the results are not driven by a single country or a cluster of episodes. On the fiscal side, disasters are typically associated with significant increases in expenditures after climatic and geological disasters. These increases reach about 17 and 60 percent of the average budget deficit after a climatic and geological disaster, respectively. On the revenue side, there are differences between climatic and geological disasters. While the revenue declines by about 18 percent of the deficit after a climatic disaster, it increases by about 30 percent after a geological disaster. As a result, the cumulative budget deficit increases by about 30 percent following a climatic disaster and by about 30 percent after a geological disaster, but only after a climatic disaster this increase is statistically significant. Of course, given the decline in output, the cumulative-deficit increase as a fraction of GDP would be higher.

Overall, governments in middle-income countries react to disasters by increasing expenditures and relying on deficit financing, thus increasing their overall debt levels. However, despite these attempts, the disasters still result in important output costs that further reduce their ability to service debt, presumably due to a small fiscal multiplier and a larger direct impact of disasters on economic activity relative to high-income countries.

In our sample, the group of middle-income countries encompasses 73 countries. It is thus possible that the group is still too heterogeneous and that the responses discussed above may be contaminated by this heterogeneity. To further check for this possibility we separated this group into two sub-groups of lower- and higher-middle-income countries, again following the World Bank classification. The results are reported in figures 10 and 11.

Lower-middle-income countries are much more heavily affected by disasters than higher-middle-income ones. In the former group, a climatic disaster results in a 4 percent cumulative output decline, while in the latter it leads to an output increase of similar magnitude. Likewise, geological disasters lead to a 15 percent cumulative output decline among lower-middle-income countries and to a negligible decline among higher middle-income countries. The small change in higher-middle-income countries following a geological disaster is not very robust and when looking at the specification in differences there is a similar decline to that for lower-middle-income countries. However, the increase following a climatic disaster in higher-middle-income countries persists across specifications and is unlikely to be driven by specific episodes because there are 77 episodes of climatic disasters among the 28 countries in this group.

Although it may initially look contradictory, it is worth reminding that from a theoretical point of view, the impact of a disaster on economic activity is ambiguous, as discussed in section 4. Thus, one possible interpretation of these findings is that, among higher-middle-income countries the wealth effect associated with a disaster and the positive multiplier of government expenditures dominate the factor destruction effect, leading to a slowly accumulating increase in output.

On the fiscal side, there are completely opposite responses to disasters between these two groups of middle-income countries. Lower-middle-income countries reduce (increase) expenditure and revenue after a climatic (geological) disaster. Higher-middle-income countries follow an opposite pattern for climatic disasters. However, these different patterns yield similar results for the behavior of the budget deficit. In both groups of countries, the deficit increases after a climatic disaster, although the increase is larger and more significant among lower-middle-income ones (30 percent versus 20 percent). The increase in deficit after a geological disaster is not significant in both cases, although the point estimate is also considerably higher among lower-middle-income countries (50 percent increase versus 10 percent decline).

Overall, these results suggest that most of the previous conclusions regarding middle-income countries are driven by the behavior of lower-middle-income ones. In these countries, governments react to disasters by engaging in deficit financing and increasing debt, but are still more affected by the disasters on the real side, further reducing their ability to repay. This coincides with the common observation that relatively poorer countries have lower capacity to efficiently and effectively execute government expenditures. Of course, another possibility is that the direct output-impact of disasters could be higher among these countries. For instance, a smaller stock of capital in lower-middle-income countries could be associated with a higher marginal product of capital, so the output losses associated with a decline in the capital stock would be higher. Another possibility is that the wealth effects that push for an increase in output after a disaster are smaller among these countries.

5.4 Does Indebtedness Affect a Country's Response to Disasters?

The previous results suggest that middle-income countries, especially the poorer ones engage in deficit financing after a disaster without being able to mitigate the impact of these events on the real side of the economy. However, even the ability to engage in deficit financing of expenditure will likely depend on a country's debt level, its access to domestic or international debt markets, and the ability to raise revenues through taxation. In this section we shed light on the role of initial debt on a country's ability to engage in deficit financing by comparing the output and fiscal response to disasters of countries with different initial levels of total government debt.

Despite government debt being an important macroeconomic variable, data on total debt levels is relatively scarce and available for few countries in recent years only. Thus, looking at the role of debt severely reduces the sample of countries under consideration. With this caveat in mind, the results of this exercise are reported in Figure 12.

Contrary to expectations, countries with high levels of initial debt (Panel B) do not suffer more from disasters than those with low levels of debt (Panel A). Climatic shocks induce similar output declines in the two groups, and Geological disasters have larger impact on countries with lower initial debt levels (Panel A). Also, despite similar declines in revenue after a climatic disaster, countries with higher initial levels of debt expand government expenditures relatively more and run higher increases in the deficit. Only for Geological Disasters there is a larger deficit increase among countries with lower debt levels, but this larger increase is associated with a larger decline in revenue relative to countries with higher debt levels. At least in this sample, it seems that initial debt levels do not constrain a government's fiscal space. This apparent paradox is partly explained by the composition of countries in the sample with high and low debt levels. There are many more high-income countries among those with high initial debt levels than among those with low initial debt levels. Also, among upper-middle-income countries, those with higher initial debt levels have higher income per capita than those with lower debt. The average GDP per capita (PPP adjusted) among countries with high debt is about 9900 dollars but only 8600 dollars for countries with lower initial debt. At least in this sample, governments of relatively richer countries have enjoyed better access to debt. This access seems to be serially correlated, so that good access in the past signals for good access in the future rather than a reduced fiscal space.

To check to what extent these differences are driven by income levels we estimated a variation of the model described in equation (1) that instead of splitting the sample in two groups allows the impact of external shocks to vary parametrically with the initial level of debt and a country's level of income. This means that the B_j matrices in equation (1), and the block of the A_j matrices associated with the terms-of-trade fluctuations will vary with the levels of debt and income. After estimating this model, it is possible to construct the IRF for countries with high and low levels of debt controlling for differences in income. Figure 13 reports these IRFs. Each of the panels in the figure reports the impact of a type of disaster on output and fiscal variables for hypothetical countries with low and high debt levels (25^{th} and 75^{th} percentile of the debt to GDP ratios across sample countries), along their one standard deviation confidence bands. These figures show that the patterns documented above survive controlling for differences in average income levels. Countries with higher initial debt levels experience a smaller decline in GDP after a geological disaster, a larger expansion of government expenditures and a smaller (no) contraction of revenues after all types of disasters. In sum, the conjecture raised above that high initial debt levels are probably proxying for better access to funds in this sample is not rejected by controlling for differences in average GDP per capita.

5.5 Financial Development and Insurance Penetration

A disaster typically affects a country's productive capacity by destroying physical and human capital. Replacing that capital is costly and may take time (especially in the case of damages to infrastructure). While there is no way around the time to rebuild capital and infrastructure, and human capital lost may never be replaced, having quick access to financial resources will certainly reduce the time it takes to reconstruct a country's productive capacity. Even though governments may try to provide relief and resources for this reconstruction, a large part of it will likely come from private sources. Therefore, having a well-developed financial system that can finance the reconstruction ex-post or that can gather and price the risks ex-ante through insurance schemes may substantially reduce the need for government financing in the aftermath of a disaster, and make government spending more productive.[11] Next, we study the relation between financial and insurance market development, and the consequences of disasters in relation to government financing and output (GDP) by grouping countries according to the development of these markets and comparing the impact of disasters across these groups. To maintain as many observations and disasters as possible in each group, we first divide our sample between countries with measures of financial development and insurance penetration above and below the sample median respectively.

Climatic and geological shocks have a large negative output impact on countries with low levels of financial development, as measured by the average ratio of private credit to GDP from 1975 to 2008 (Figure 14). Among these countries, a climatic shock results in a cumulative output decline of almost 2 percent, and a geological disaster results in a decline of about 9 percent. In contrast, among more financially developed countries a climatic disaster has a positive impact on output while a geological disaster has no impact on output.[12]

There is no increase in government expenditure after climatic disasters in financially underdeveloped countries, but a large, significant increase of 60 percent of the average budget deficit among more financially developed ones (Figure 14, Panel B, column 3). The latter occurs despite possible contraction in revenues of about 30 percent of the average deficit. As a result, the budget deficit increases importantly in financially developed countries, and only modestly and not significantly among financially underdeveloped ones. There is no qualitative difference in the fiscal response to geological disasters between the two groups.

[11] For instance, this may happen by allowing the government to focus on relief and public good provision instead of providing subsidized credits for the private sector.

[12] This result is not robust to changes in the variable used for interest rates. When using only the money market rates (with the corresponding reduction in the sample), there is a decline in output as a result of a geological disaster, and only a small impact for climatic disasters.

Controlling for income does not change the conclusions. The comparison of the responses to disasters of GDP and fiscal variables in countries with high and low levels of financial development (25th and 75th sample percentiles, respectively) in Figure 15 confirms that more financially developed countries suffer smaller output contractions after disasters, although the differences are not significant. The figure also confirms that expenditures always expand in financially developed countries, and revenues expand after a geological disaster and contract after a climatic disaster. As before, deficits always increase relatively more in financially developed countries.

These results suggest that governments can borrow more easily in more financially developed countries, and that the real consequences of shocks, at least the more frequent climatic ones, are smaller. This is consistent with the financial system facilitating resources both for government financing (e.g. by allowing the issuance of domestic debt) and for private reconstruction. Having access to the resources, which can be mobilized by an efficient financial system, helps dealing with disasters. This is confirmed by unreported results that interest rates also decline in financially developed countries following a climatic shock (while they remain unaltered among financially underdeveloped countries), and suggests that the larger deficit expansion in these countries does not necessarily lead to a larger increase in government debt burdens or concerns about excessive debt burden that would significantly increase the interest rate risk premium for governments. Looking at the differential response of interest payments across these groups of countries would be an interesting exercise that we leave for future research.

The results are different when countries are compared according to the degree of insurance penetration, as measured by the total value of premiums to GDP (Figure 16). It is important to keep in mind that data on insurance penetration is not widely available so the subset of countries with data is biased toward higher-income countries. Thus, the important aspect of this exercise is the comparison between the two groups rather than the estimated responses for each individual group. Comparing the real consequences of shocks, countries with relatively low insurance penetration (Panel A) suffer larger output declines in response to climatic and geological disasters than countries with high insurance penetration (Panel B). At the same time, deficits increase considerably more in countries with low insurance penetration.

In countries with high insurance penetration, expenditures and revenues move closer together resulting in a small change in the fiscal deficit.

Most of these patterns survive controlling for differences in income (Figure 17). Countries with low insurance penetration suffer significantly more after disasters (first column) and increase expenses relatively more (although this difference is not significant). The only difference is that while revenues decline relatively more for countries with low insurance penetration after climatic disasters, they move similarly in both groups after a geological disaster. As a result, deficits increase relatively more after a climatic disaster for countries with low insurance penetration, but increase relatively less after a geological disaster. Nonetheless, when computed as a fraction of GDP, deficits always increase relatively more for countries with low insurance penetration.

Overall, countries with low insurance penetration expand their government deficit after disasters but do not manage to reduce the negative consequences of disasters as much as in those countries with high insurance penetration. One likely interpretation of these findings is that countries with high insurance penetration can quickly allocate resources from existing insurances to recover productive capacity and little fiscal effort is required to dampen the macro consequences of these events. Fiscal resources can then be devoted to relief, and the simultaneous increase in expenditures and revenues suggests that the fiscal effort is mainly redistributive (e.g. providing relief to those affected by increasing revenues from those not affected by the disaster).

Finally, a comparison of these results with those obtained comparing countries with different levels of financial development show that these two dimensions play different roles in the transmission of disasters to the fiscal side. While countries with high financial development or high insurance penetration suffer relatively less from disasters in terms of output decline, a developed financial system allows governments to borrow and finance a deficit at likely low interest rates to reduce the real consequences of disasters. In contrast, countries with high levels of insurance penetration can deal with these real macro consequences without engaging in deficit financing of their expenditures. It seems, therefore, that while overall financial development helps deal with disasters, the prevalence of insurance does it in a more efficient ex-post manner.

Of course, insurance has an ex-ante cost that must be considered for welfare comparisons, but this is beyond the scope of this paper.

6. Conclusion

This paper estimated the implications of natural disasters for public finances by analyzing the cumulative responses of government expenditures, revenues and fiscal deficit to disaster shocks. We found that climatic, geological and other disasters have an important negative impact on the fiscal stance by decreasing output and increasing deficits, especially so in lower-middle-income countries. When controlling for income, there is no clear relation between initial debt and the fiscal impact of disasters. In our sample, countries that were more indebted seem to be those with better access to debt, so that debt levels proxy for better access to capital markets rather than constrained fiscal space. Further, countries with more developed financial or insurance markets suffer less from disasters in terms of output declines. The way this is achieved differs in each case, though. In financially developed markets, governments are able to raise funds and increase deficits. And presumably, this response helps alleviate the impact of the disasters. In contrast, in countries with high insurance penetration, the smaller impact of disasters on GDP occurs without an important fiscal expansion. Countries with smaller insurance markets expand deficits more, yet still suffer more from disasters. It seems that the availability of insurance reduces the real consequences without requiring an increase in fiscal burdens. By extending the implication of this finding, financial markets and development institutions could help in development and penetration of fiscal insurance policies or hedging debt instruments to further diminish disaster consequences. The future research could focus on better identification of the fiscal responses to disasters and the implied consequences for fiscal stance by employing higher frequency (quarterly) data, and increasing the homogeneity of countries in the analyzed sample and exploiting the potential efficiency gains through the use of appropriate estimation methods.

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Table 1. Summary Statistics

Country	Mean				Number of Events			Number of Observations
	GDP per capita	Expenditures / GDP	Revenues / GDP	Deficit / GDP	Geological	Climatic	Other	
East Asia Pacific and South Asia								
China	901	0.156	0.144	-0.011	2	65	0	22
Fiji	1,803	0.285	0.244	-0.042	0	17	0	24
Indonesia	640	0.192	0.185	-0.007	2	1	3	30
Korea, Rep.	5,704	0.162	0.175	0.013	0	1	0	23
Malaysia	2,545	0.291	0.243	-0.048	0	0	0	25
Philippines	942	0.166	0.153	-0.014	2	58	0	29
Sri Lanka	568	0.297	0.197	-0.100	0	29	0	26
Thailand	1,404	0.168	0.161	-0.007	0	20	0	27
Total	***1,734***	***0.214***	***0.187***	***-0.027***	***6***	***191***	***3***	***206***
Europe and Central Asia								
Albania	1,303	0.303	0.232	-0.071	0	3	0	14
Azerbaijan	933	0.261	0.217	-0.044	1	4	0	15
Belarus	1,462	0.293	0.322	0.028	0	1	0	16
Bulgaria	1,754	0.351	0.349	-0.002	0	2	0	17
Croatia	5,171	0.363	0.361	-0.001	0	3	0	13
Czech Republic	5,827	0.341	0.317	-0.024	0	2	0	14
Georgia	842	0.250	0.208	-0.042	1	3	0	12
Hungary	4,399	0.499	0.456	-0.043	0	3	0	26
Kazakhstan	1,402	0.238	0.222	-0.016	0	1	0	13
Latvia	3,741	0.373	0.359	-0.014	0	1	0	14
Lithuania	3,814	0.346	0.317	-0.030	0	1	0	13
Macedonia, FYR	1,775	0.372	0.360	-0.012	0	2	1	15
Moldova	410	0.318	0.307	-0.011	0	3	0	12
Poland	4,034	0.334	0.301	-0.034	0	1	0	17
Romania	1,705	0.324	0.286	-0.038	0	2	0	7
Russian Federation	2,101	0.169	0.183	0.014	0	1	0	13
Slovak Republic	4,222	0.438	0.380	-0.058	0	2	0	12
Slovenia	10,388	0.471	0.462	-0.009	0	2	0	13
Turkey	3,559	0.237	0.175	-0.062	3	2	0	15
Ukraine	795	0.334	0.309	-0.025	0	3	0	15
Total	***3,039***	***0.338***	***0.313***	***-0.025***	***5***	***42***	***1***	***286***
Western Europe and North America								
Austria	17,636	0.372	0.333	-0.039	0	0	0	22
Belgium	17,256	0.493	0.429	-0.064	0	0	0	24
Denmark	23,307	0.381	0.368	-0.013	0	2	0	26
France	20,372	0.521	0.490	-0.032	0	2	0	25
Greece	9,497	0.289	0.201	-0.088	3	2	0	22
Luxembourg	29,981	0.407	0.431	0.024	0	4	0	17
Netherlands	20,934	0.513	0.487	-0.026	0	1	0	25
Portugal	7,939	0.406	0.301	-0.105	0	0	0	19
Sweden	23,397	0.371	0.355	-0.016	0	1	0	32
United States	29,635	0.205	0.180	-0.025	0	3	0	27
Total	***20,331***	***0.394***	***0.357***	***-0.037***	***3***	***15***	***0***	***239***
Midle East, North Affrica, and Sub-Saharan Africa								
Algeria	1,783	0.311	0.308	-0.003	0	1	0	17
Botswana	2,575	0.395	0.462	0.067	0	9	2	29
Cameroon	721	0.174	0.186	0.012	1	2	0	28
Cape Verde	1,280	0.365	0.301	-0.064	0	2	1	13
Egypt, Arab Rep.	1,099	0.376	0.342	-0.034	1	0	0	28
Iran, Islamic Rep.	2,025	0.455	0.410	-0.045	2	0	0	5
Israel	16,212	0.523	0.425	-0.097	0	1	0	19
Jordan	1,748	0.368	0.240	-0.128	0	4	0	27

Table 1. Summary Statistics

Country	Mean: GDP per capita	Mean: Expenditures / GDP	Mean: Revenues / GDP	Mean: Deficit / GDP	Number of Events: Geological	Number of Events: Climatic	Number of Events: Other	Number of Observations
Lebanon	3,707	0.294	0.116	-0.178	0	1	0	5
Lesotho	383	0.437	0.443	0.006	0	6	0	16
Mauritius	2,849	0.237	0.211	-0.025	0	6	1	26
Morocco	1,191	0.320	0.251	-0.069	1	3	0	22
Namibia	2,508	0.299	0.298	-0.002	0	5	0	6
Seychelles	6,106	0.538	0.473	-0.065	1	1	0	19
South Africa	3,218	0.267	0.237	-0.031	0	6	1	29
Swaziland	1,079	0.281	0.276	-0.005	0	12	0	27
Syrian Arab Republic	1,042	0.314	0.253	-0.061	0	1	0	21
Tunisia	1,595	0.340	0.309	-0.031	0	1	0	16
Total	***2,747***	***0.340***	***0.306***	***-0.034***	***6***	***61***	***5***	***354***
Latin America and Caribbean								
Argentina	7,692	0.204	0.200	-0.004	0	3	0	15
Bahamas, The	15,611	0.188	0.174	-0.014	0	5	0	15
Barbados	8,304	0.320	0.285	-0.035	0	3	1	25
Belize	2,844	0.293	0.244	-0.049	0	7	0	25
Bolivia	1,039	0.255	0.165	-0.090	0	10	0	19
Brazil	3,408	0.276	0.264	-0.012	0	4	0	16
Chile	3,271	0.246	0.249	0.003	2	7	0	23
Colombia	2,393	0.277	0.263	-0.014	3	7	0	24
Costa Rica	3,281	0.163	0.134	-0.029	2	8	0	28
Dominican Republic	2,502	0.130	0.130	0.000	0	3	0	14
El Salvador	2,326	0.181	0.160	-0.021	2	4	1	10
Grenada	2,998	0.294	0.263	-0.031	0	0	0	5
Guatemala	1,607	0.120	0.100	-0.020	0	6	0	30
Guyana	882	0.412	0.346	-0.066	0	2	1	3
Honduras	1,121	0.210	0.164	-0.046	0	17	0	24
Jamaica	3,487	0.260	0.254	-0.006	0	1	0	11
Mexico	5,424	0.258	0.229	-0.029	1	8	1	29
Nicaragua	805	0.227	0.164	-0.063	0	1	0	7
Panama	3,395	0.237	0.236	-0.001	1	2	0	14
Paraguay	1,415	0.159	0.157	-0.002	0	4	0	13
Peru	2,077	0.176	0.143	-0.033	1	11	2	32
St. Lucia	2,620	0.270	0.245	-0.025	0	2	0	10
St. Vincent and the Grena	2,264	0.330	0.286	-0.043	0	2	0	21
Uruguay	5,929	0.263	0.244	-0.019	0	3	0	29
Venezuela, RB	5,320	0.221	0.234	0.013	0	1	0	27
Total	***3,840***	***0.231***	***0.207***	***-0.024***	***12***	***121***	***6***	***469***

The table provides descriptive statistics for each country, grouped by regions. Mean values are reported for real GDP per capita, and for government expenditures, government revenue and government deficit as a fraction of the GDP. The number of events by type of disaster, and the number of observations are also listed.

Table 2. Unit Root and Cointegration Tests

Panel A. Unit Root Tests

Variable	Levels			Differences		
	LLC test	IPS test	Frac. Reject (ADF)	LLC test	IPS test	Frac. Reject (ADF)
	(1)	(2)	(3)	(4)	(5)	(6)
GDP per capita	-19.3	-9.2	0.3	-37.0	-27.5	0.8
Government Expenditures	-3.7	-2.3	0.2	-31.7	-29.9	0.8
Government Revenues	-5.6	-3.9	0.2	-26.1	-27.6	0.8
Inflation	-52.2	-28.7	0.6	--	--	--
Interest Rate	-4.6	-2.5	0.2	-50.8	-33.4	0.9
Terms of Trade	-6.9	-5.2	0.3	-39.4	-39.4	1.0

Panel B. Panel cointegration tests

	VAR including TT, GEXP, GDP, GREV, INF, and R	
Alt. hypothesis: common AR coefs.		
	Statistic	Prob.
Panel v-Statistic	-0.72	0.76
Panel rho-Statistic	11.54	1.00
Panel PP-Statistic	-0.19	0.42
Panel ADF-Statistic	-1.50	0.07
Alt. hypothesis: individual AR coefs.		
	Statistic	Prob.
Group rho-Statistic	14.97	1.00
Group PP-Statistic	-3.64	0.00
Group ADF-Statistic	-3.97	0.00

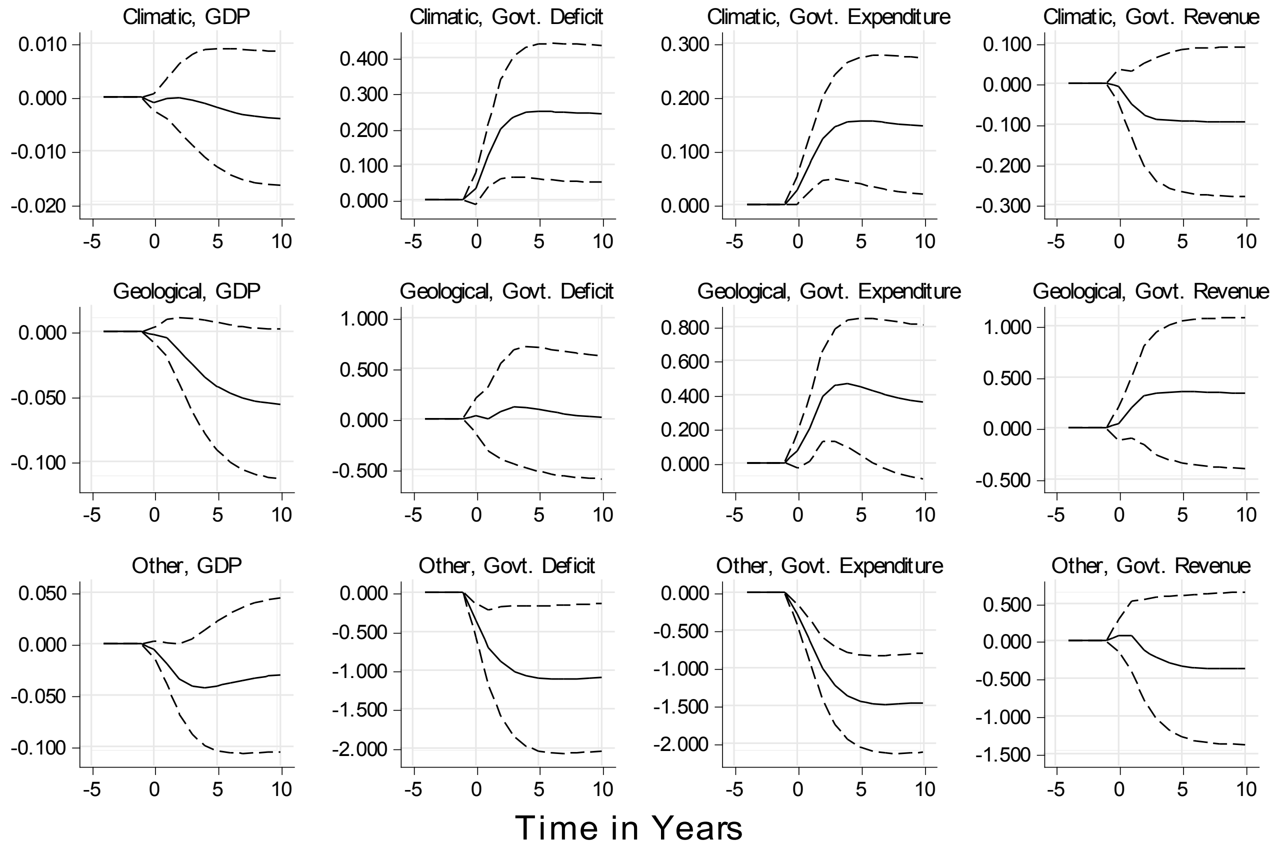
Panel A shows the results of country-by-country and panel unit root tests performed for the main series used in the paper. Columns (1) to (3) show results for the variables in levels, and columns (4) to (6) for the variables in differences. The exception is inflation, which being the changes in the price level, is just included in levels. Columns (1) and (4) show the results of the Levin-Lin Chu panel unit root test, and Columns (2) and (5) the statistics for the Im, Pesaran, and Shin test. Columns (3) and (6) report the fraction of countries inthe sample in which a standard, country-by-country augmented Dickey Fuller test could not reject the null hypothesis of a unit root. All the tests in level allow for a country-specific intercept and trend, and those in differences for the country-specific intercept only. Also, all tests use the Newey-West bandwith selection with the Bartlett kernel for the estimation of the long run variance of the series.
The table in Panel B reports the statistic and associated p-value of the different variants of Pedroni's (1999) panel cointegration test. The null hypothesis in each case is no cointegration.

Table 3. Comparing years with and without disasters. Two Sample Mean Tests

	GDP Growth		Expenditures Growth		Revenues Growth	
	Geological	Climatic	Geological	Climatic	Geological	Climatic
Mean						
No Disaster	0.026	0.026	0.026	0.025	0.033	0.034
Disaster	0.013	0.024	0.036	0.027	0.014	0.028
t-stat						
D = ND	0.141	0.569	0.638	0.779	0.636	0.670
ND > D	0.071	0.285	0.681	0.610	0.318	0.335
ND < D	0.929	0.715	0.319	0.390	0.682	0.665

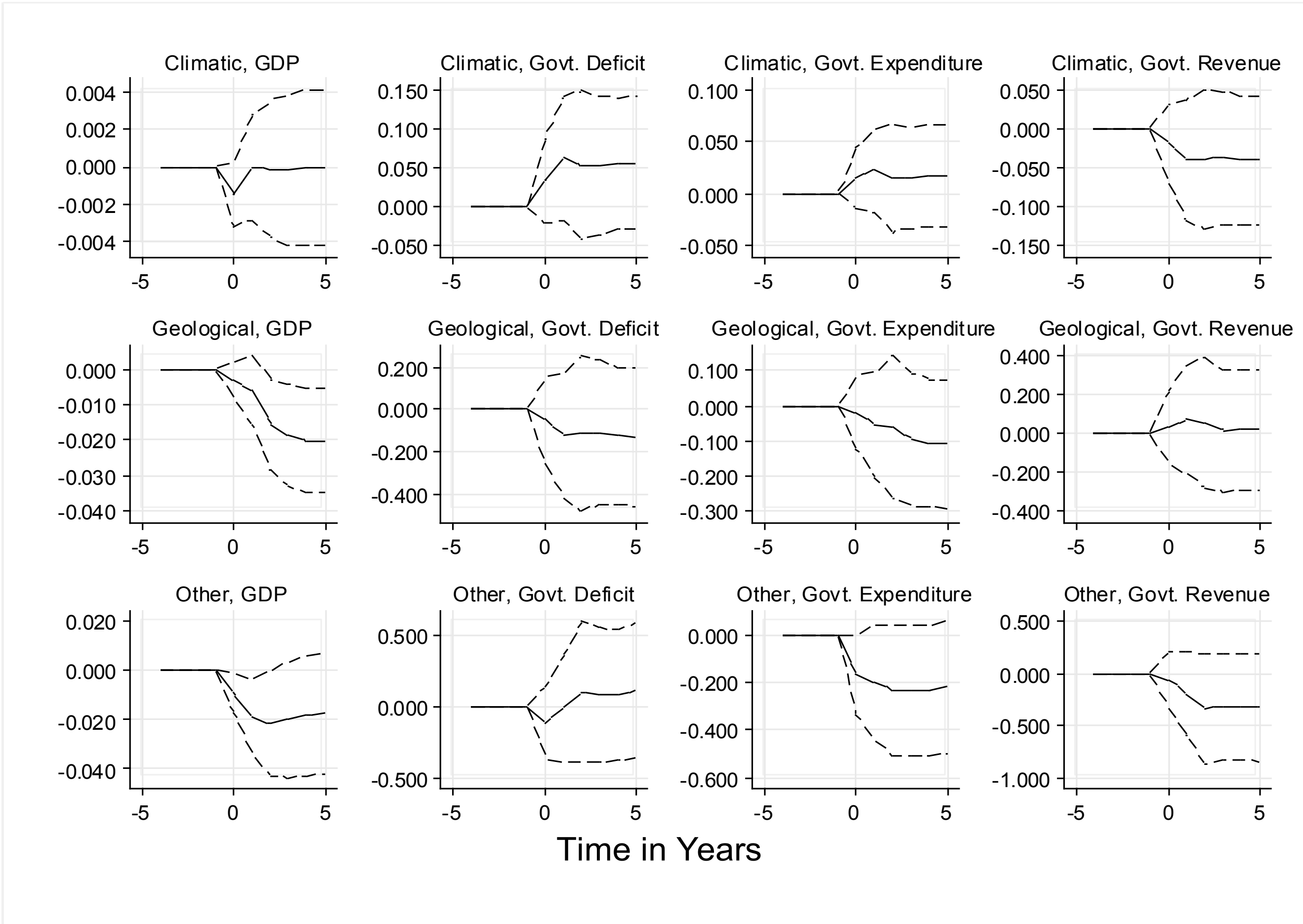
The table shows the t-test for the difference on the average growth of GDP, Expenditures and Revenues, in years when a disaster occurs (Disaster), and in years without disasters (No Disaster). D is the mean of the sample with at least one disaster, and ND is from the sample with zero disasters.

Figure 1. Cumulative Impulse Response Functions of Levels



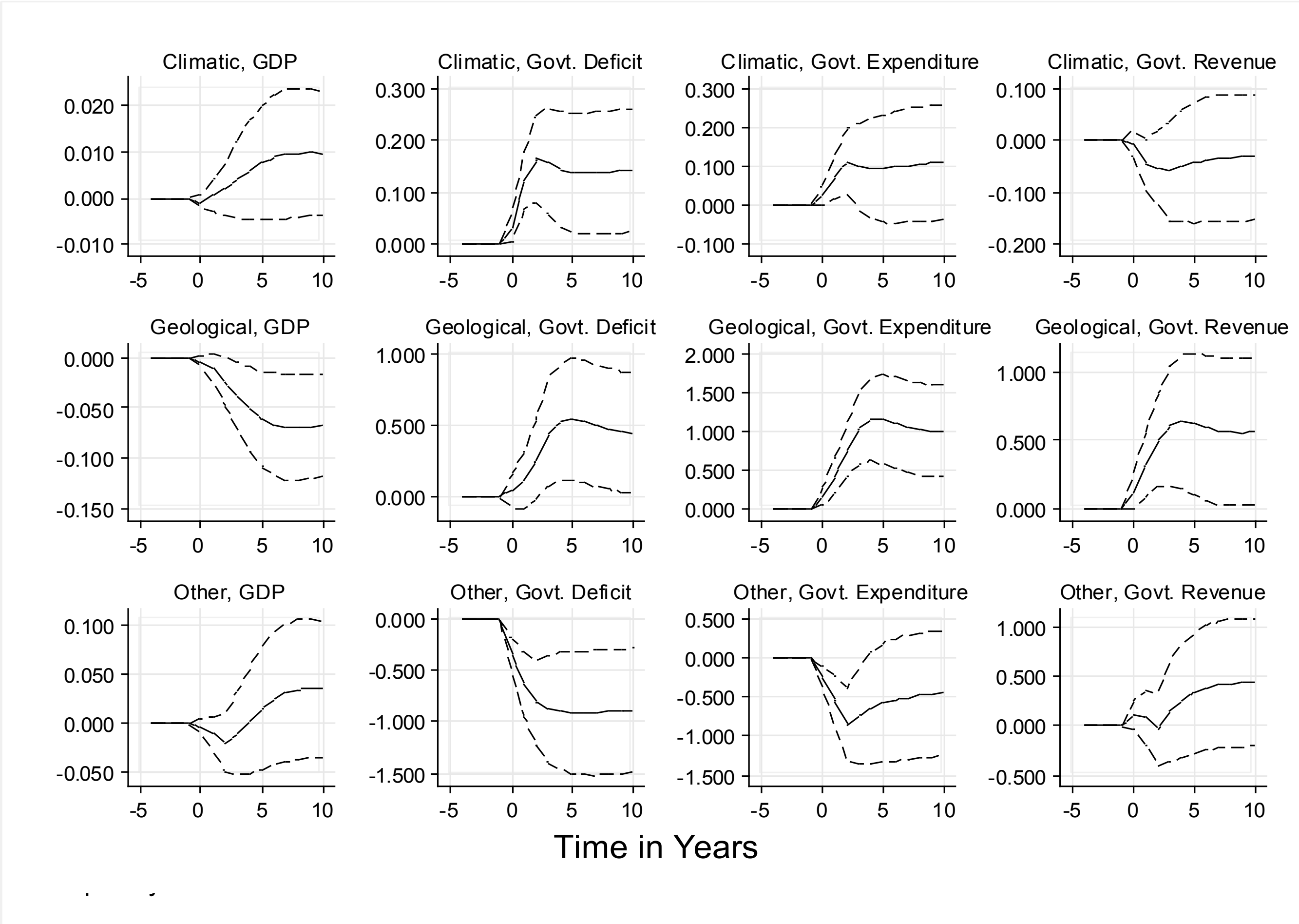
The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 2. Cumulative Impulse Response Functions of Differences



The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from a specification with all variables in differences, and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

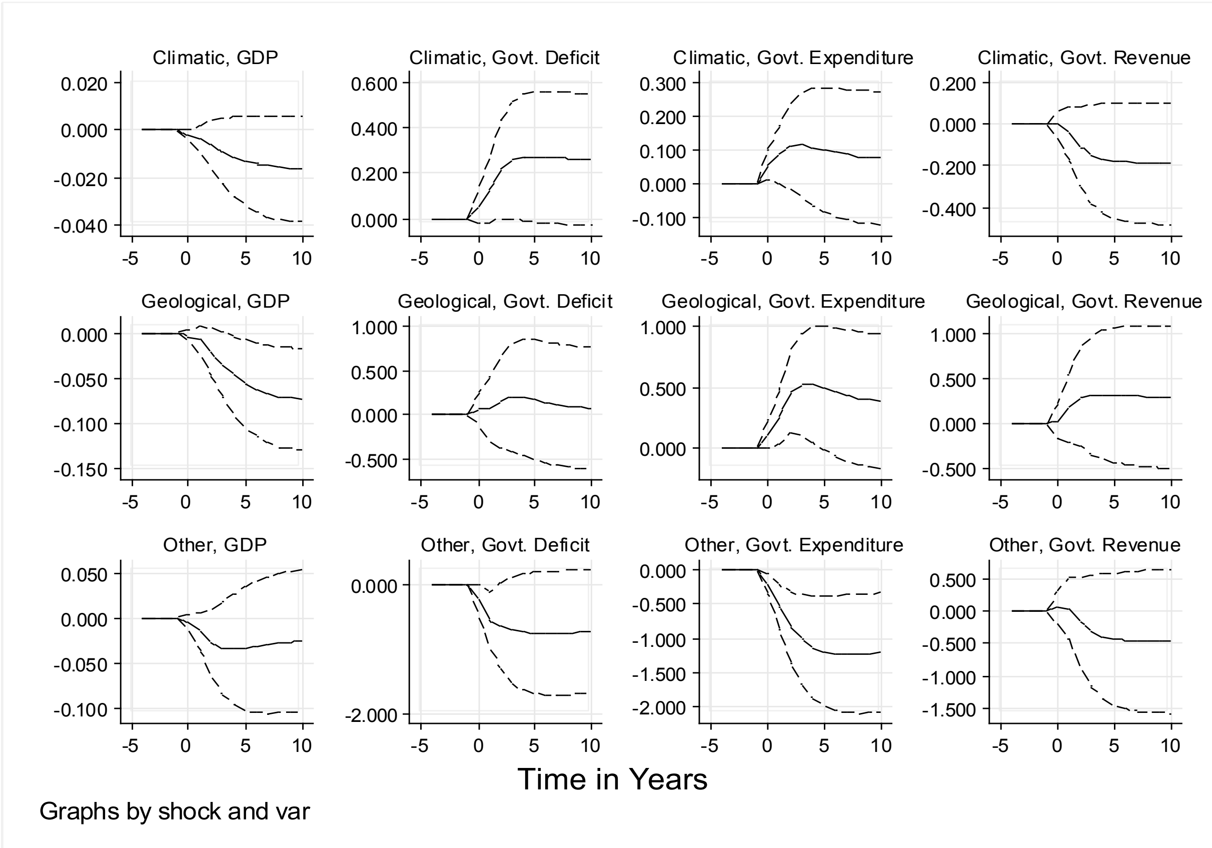
Figure 3. Cumulative IRFs Adding Lags



The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including three lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 4. Cumulative IFRs Using Different Disaster Indicators

Panel A. Index by Category of Disaster



Panel B. Index Considering the Timing of the Disaster

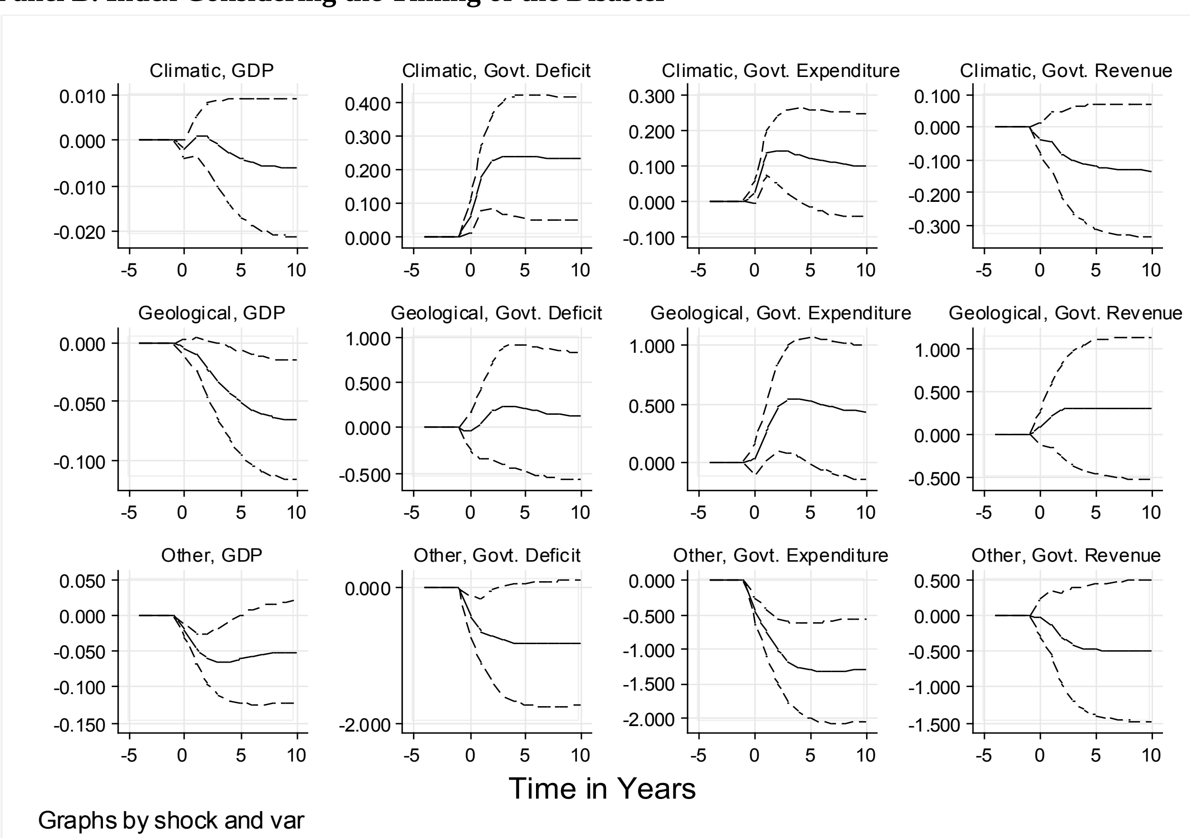
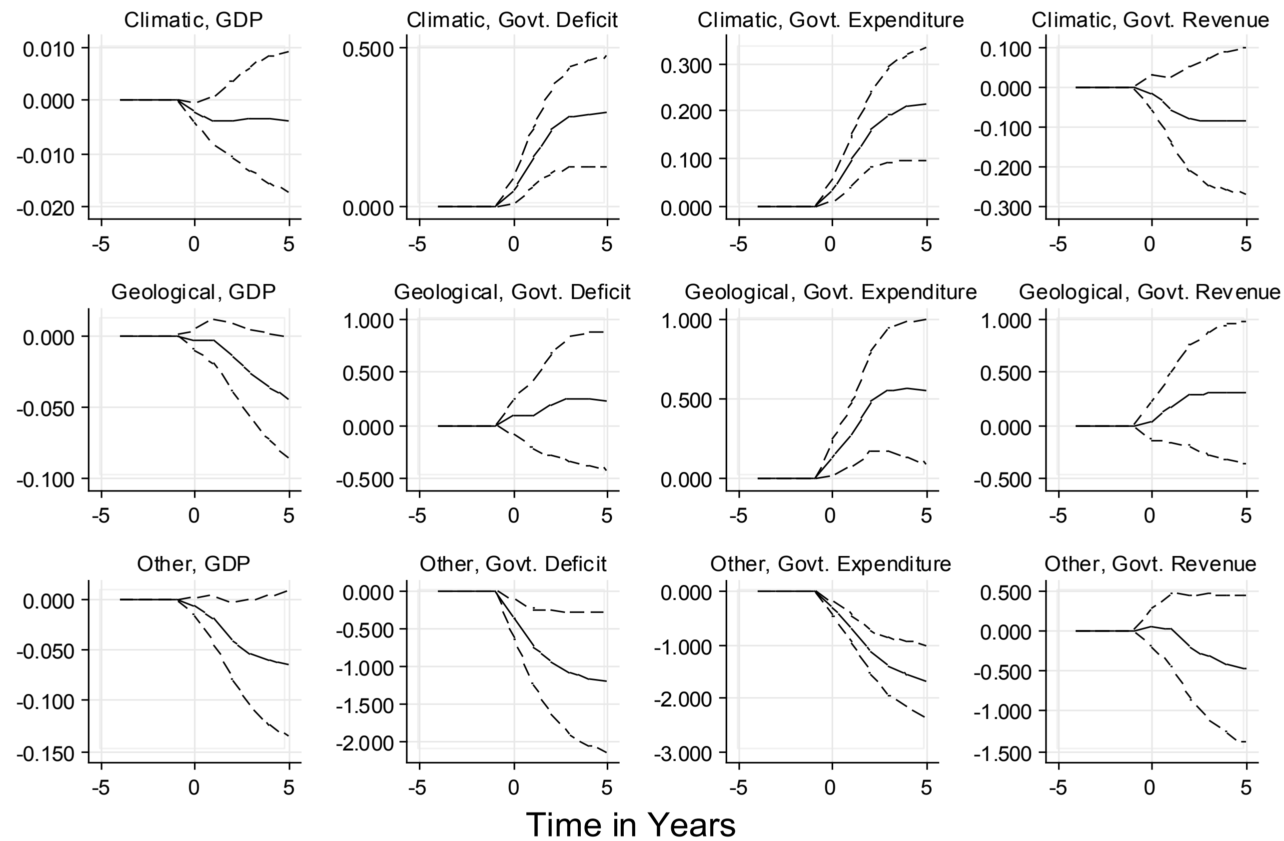


Figure 4. Cumulative IFRs Using Different Disaster Indicators

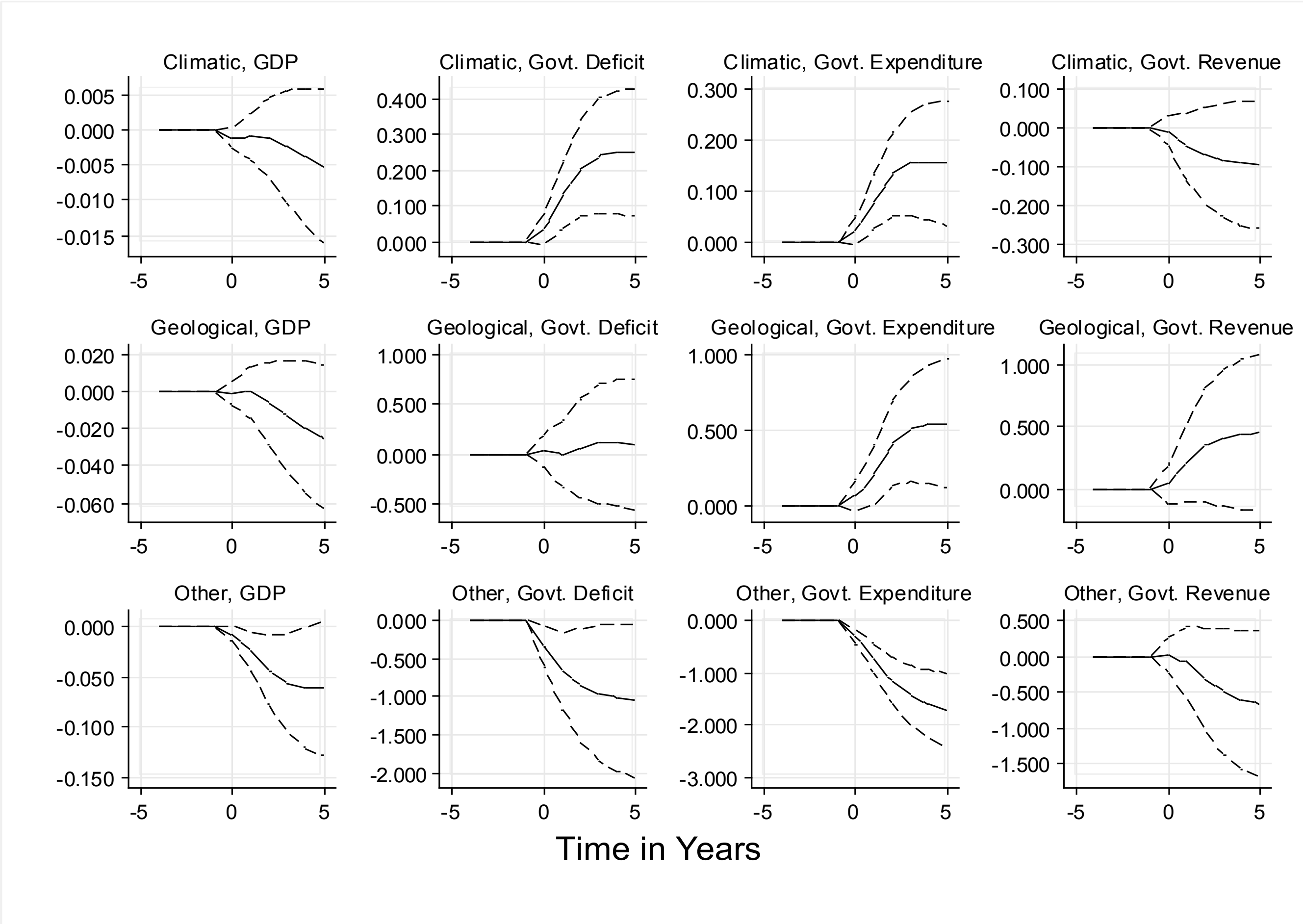
The figures show the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. In Panel A, the index used to show the occurence of disasters takes the value 1 if at least one disaster of each category took place in a given year. In Panel B, this index takes into account the month when the disaster occurs.The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 5. Cumulative IRFs Using a Different Measure of GDP



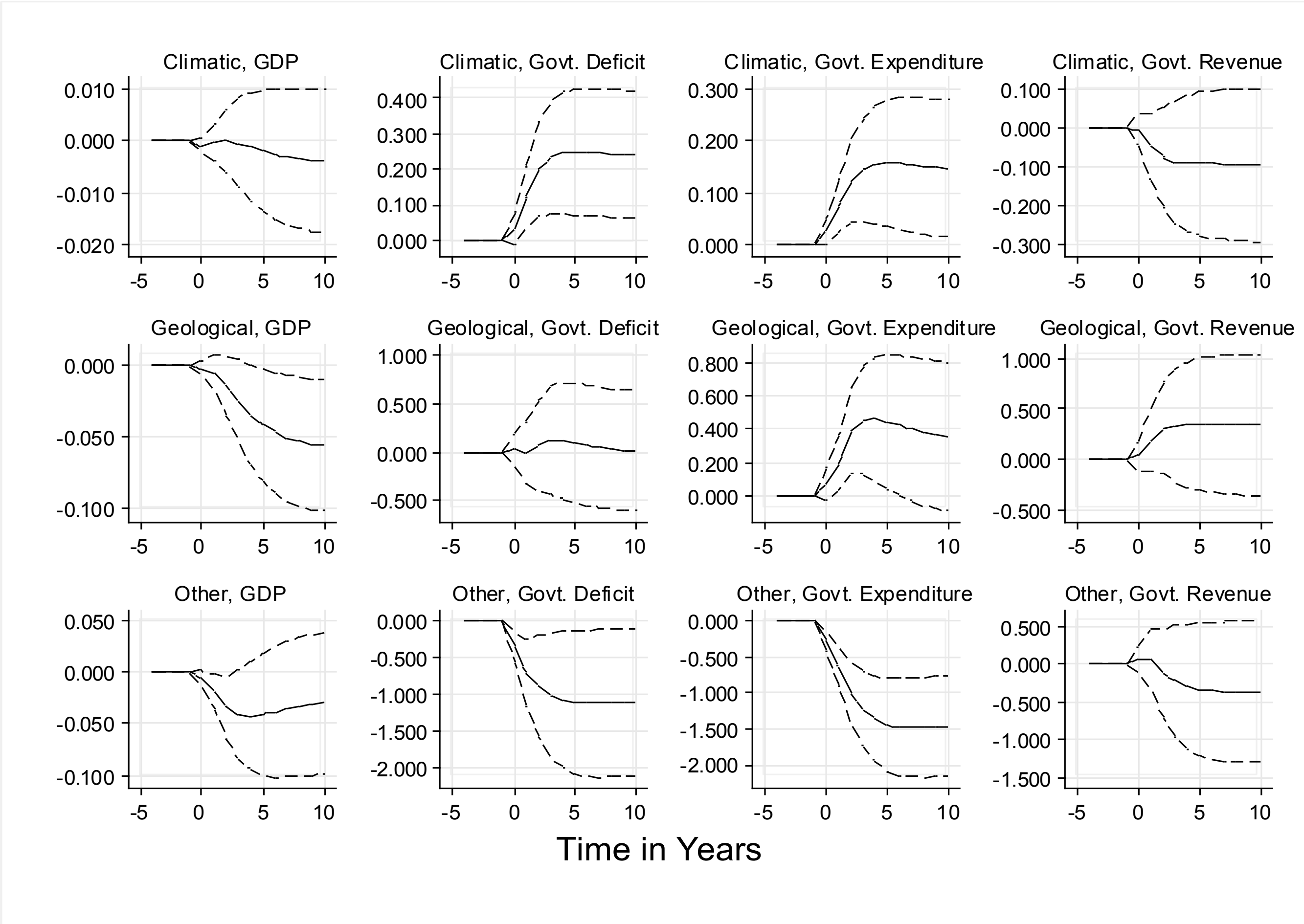
The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. GDP is expressed in real per capita terms and adjusted for purchasing power parity; government deficit is reported in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 6. Cumulative IRFs Using Interest Rate Level



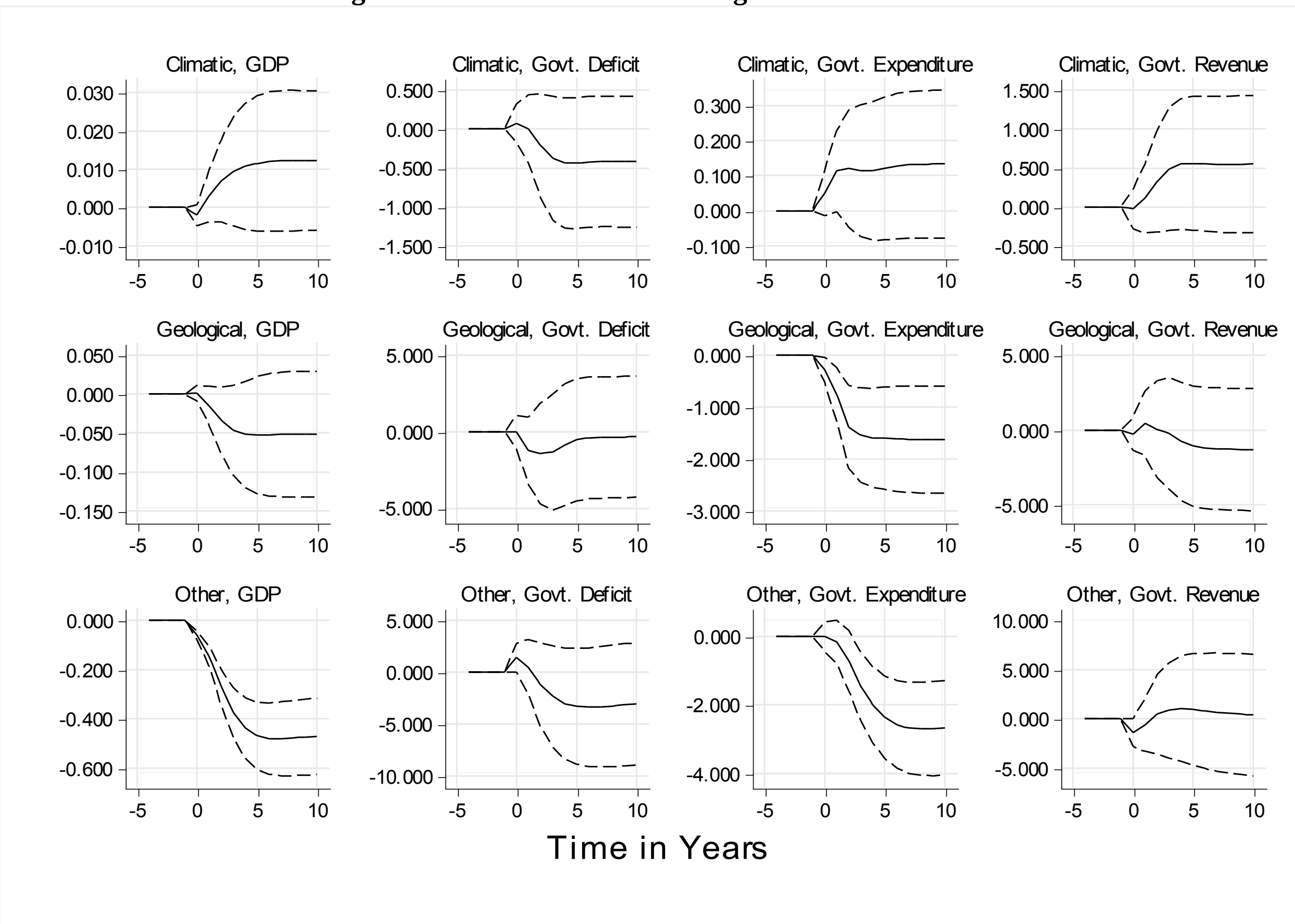
The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels, and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 7. Cumulative IRFs Changing Order in VAR



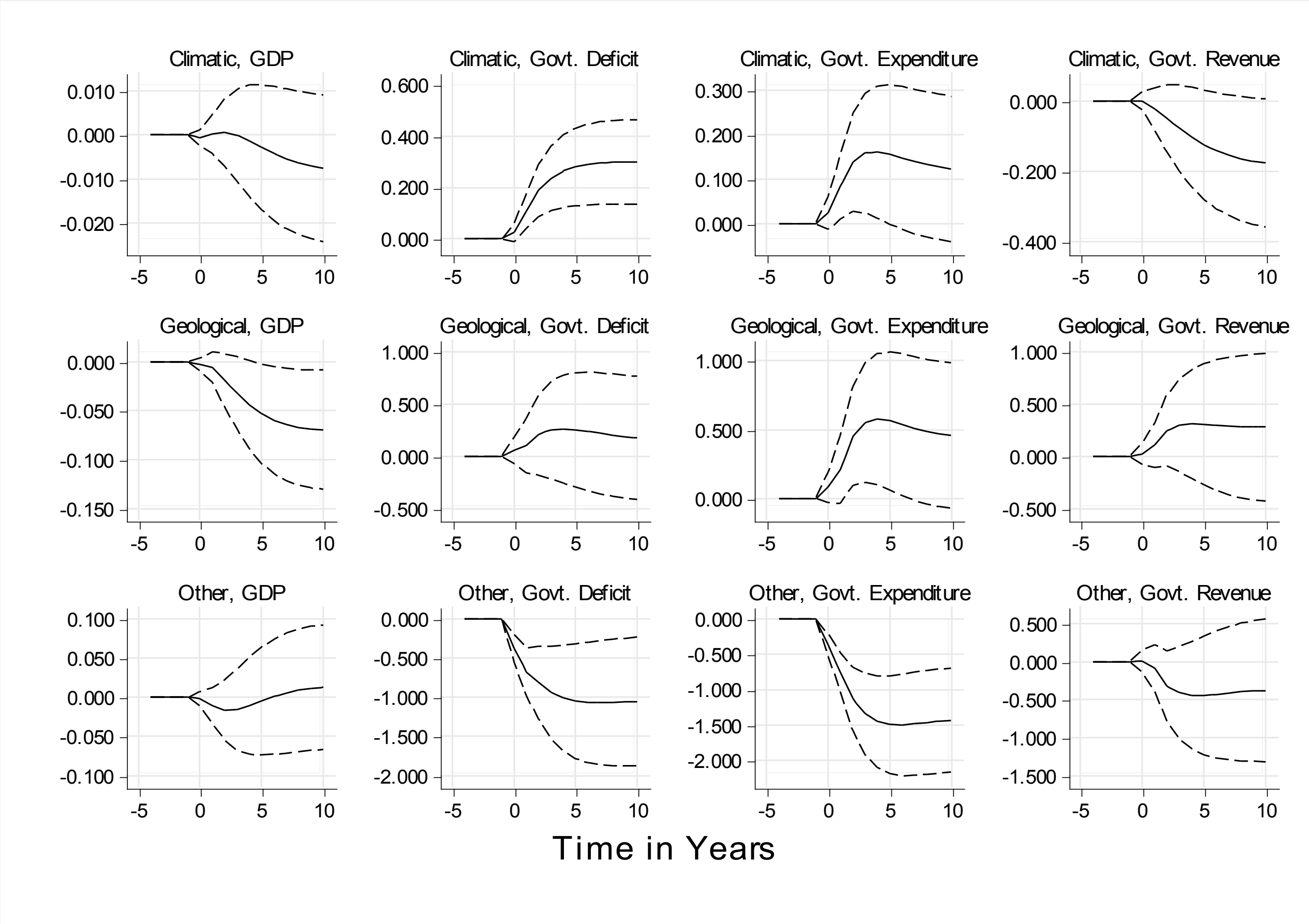
The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: GDP, inflation, interest rate, government expenditures and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 8. Cumulative IRFs for High Income Countries



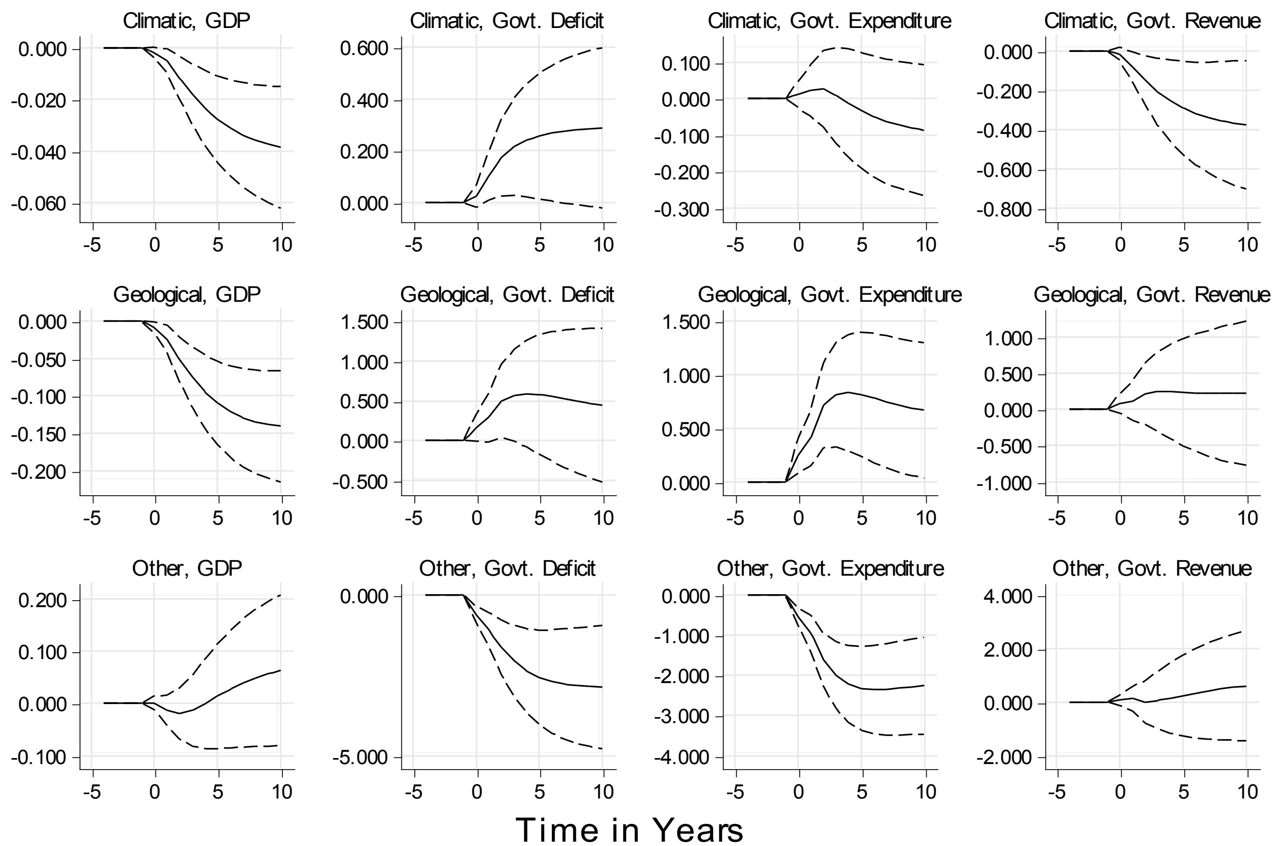
The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues, for a sample of High Income countries according to the World Bank classification. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 9. Cumulative IRFs for Middle Income Countries



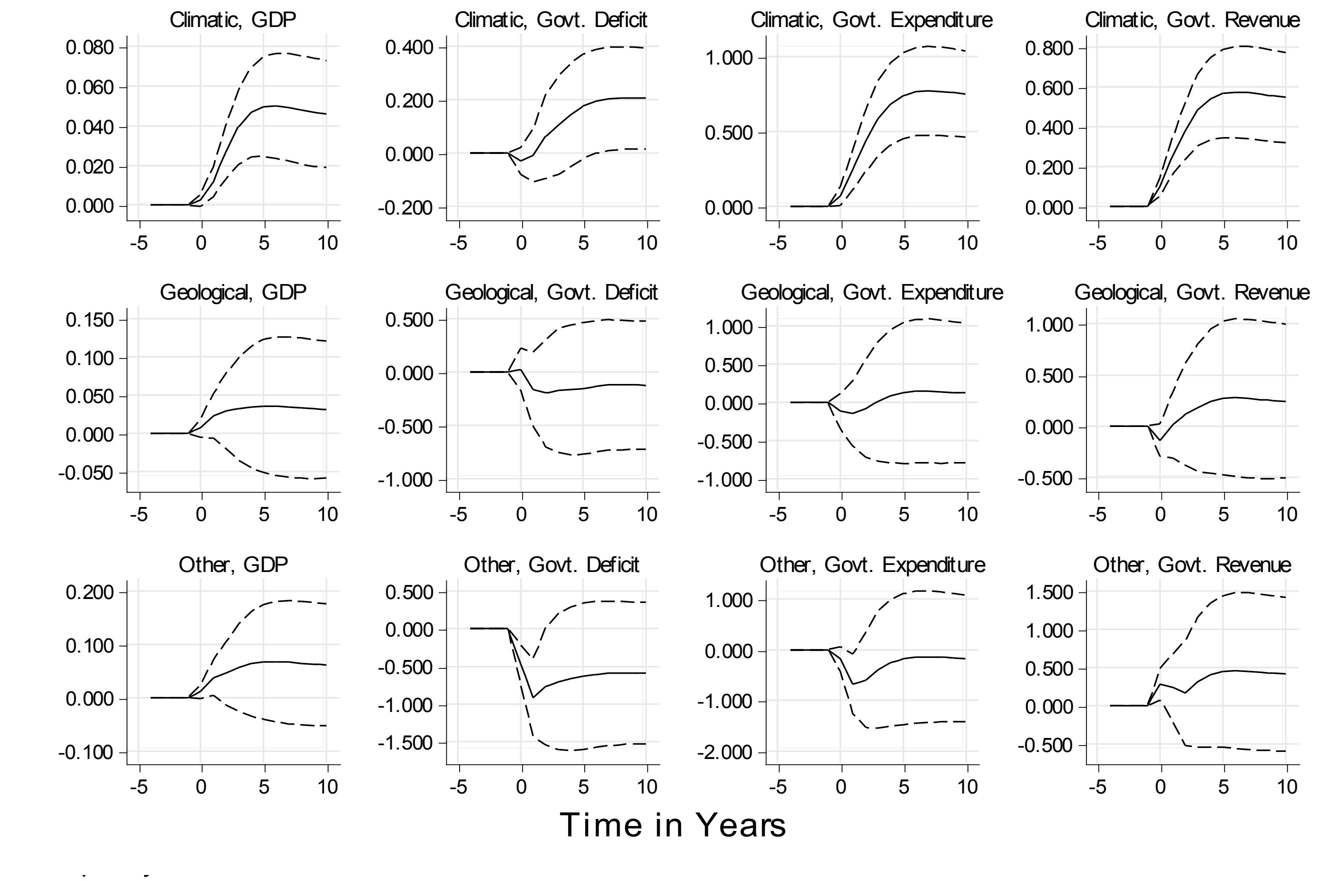
The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues, for a sample of Middle Income countries according to the World Bank classification. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 10. Cumulative IRFs for Low and Middle Income Countries



The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues, for a sample of Low and Middle Income countries according to the World Bank classification. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

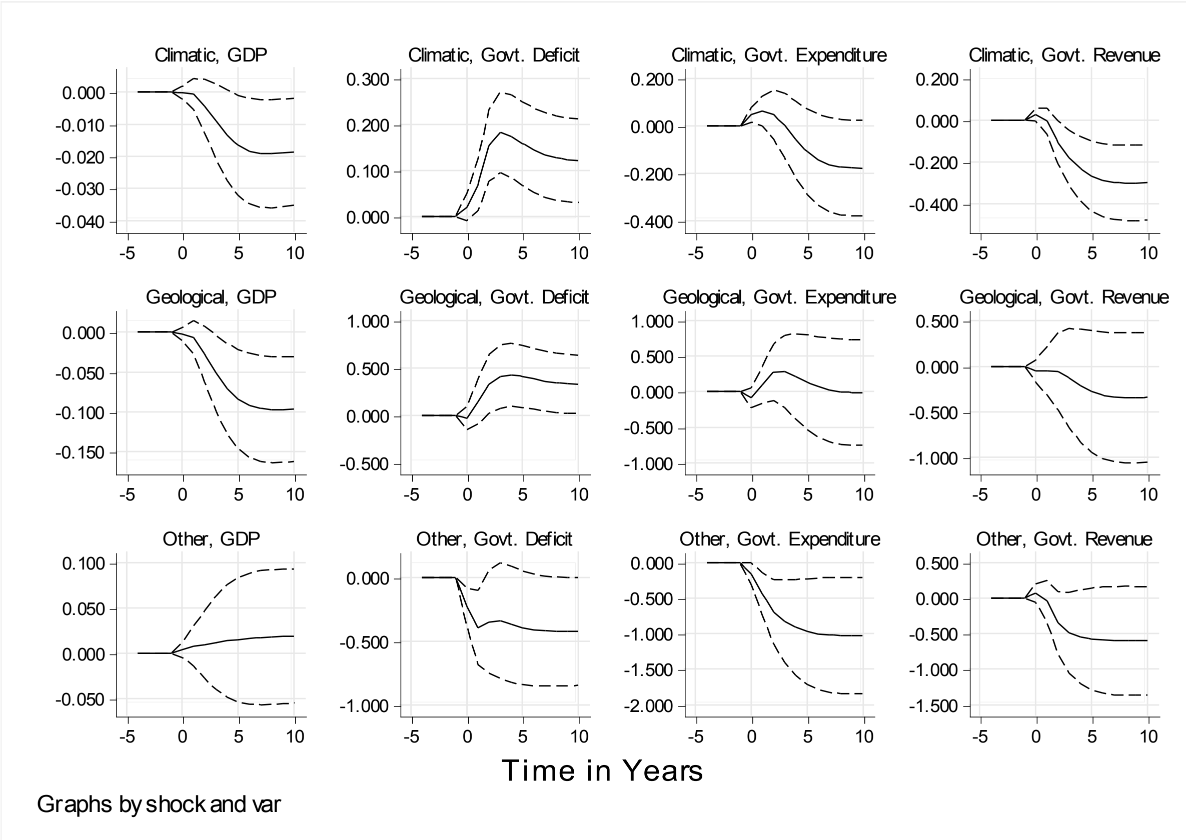
Figure 11. Cumulative IRFs for Higher Middle Income Countries



The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues, for a sample of High and Middle Income countries according to the World Bank classification. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 12 - Cumulative IRFs for Different Debt Levels

Panel A. Low Debt Countries



Panel B. High Debt Countries

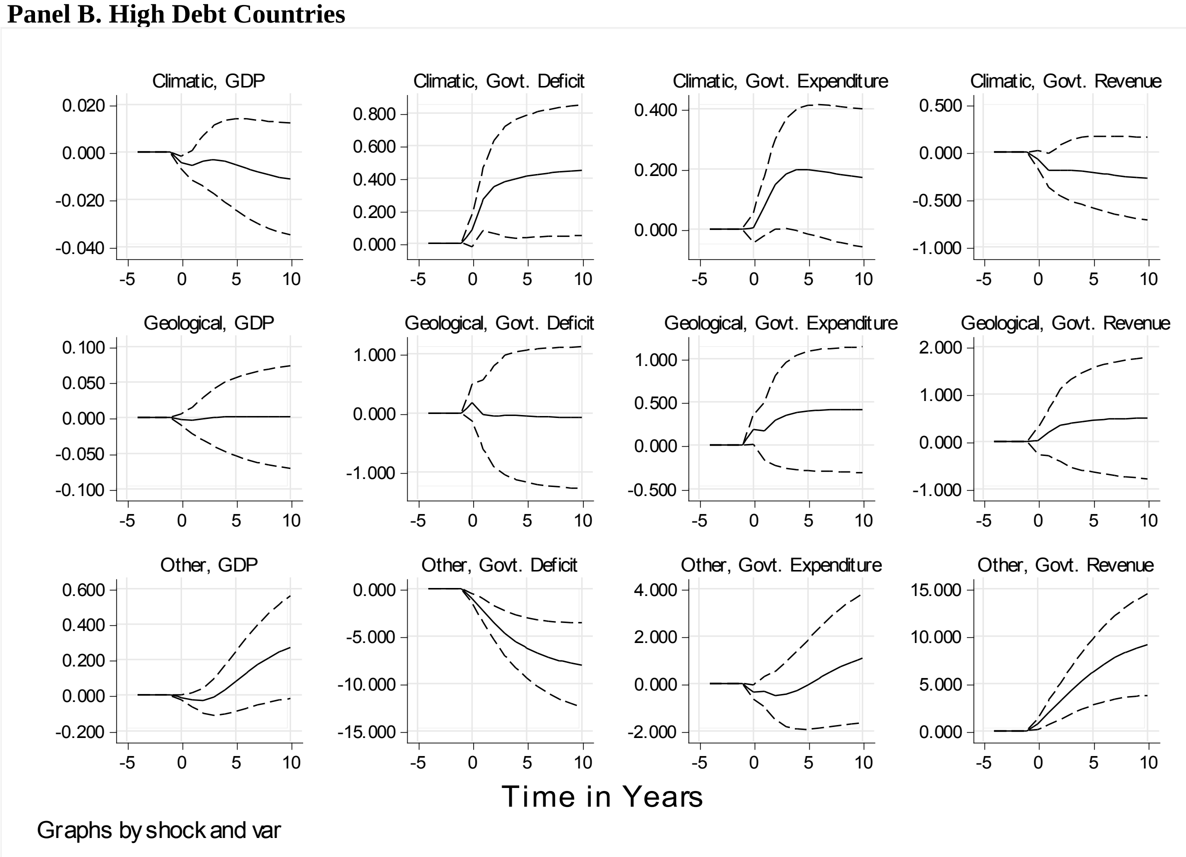
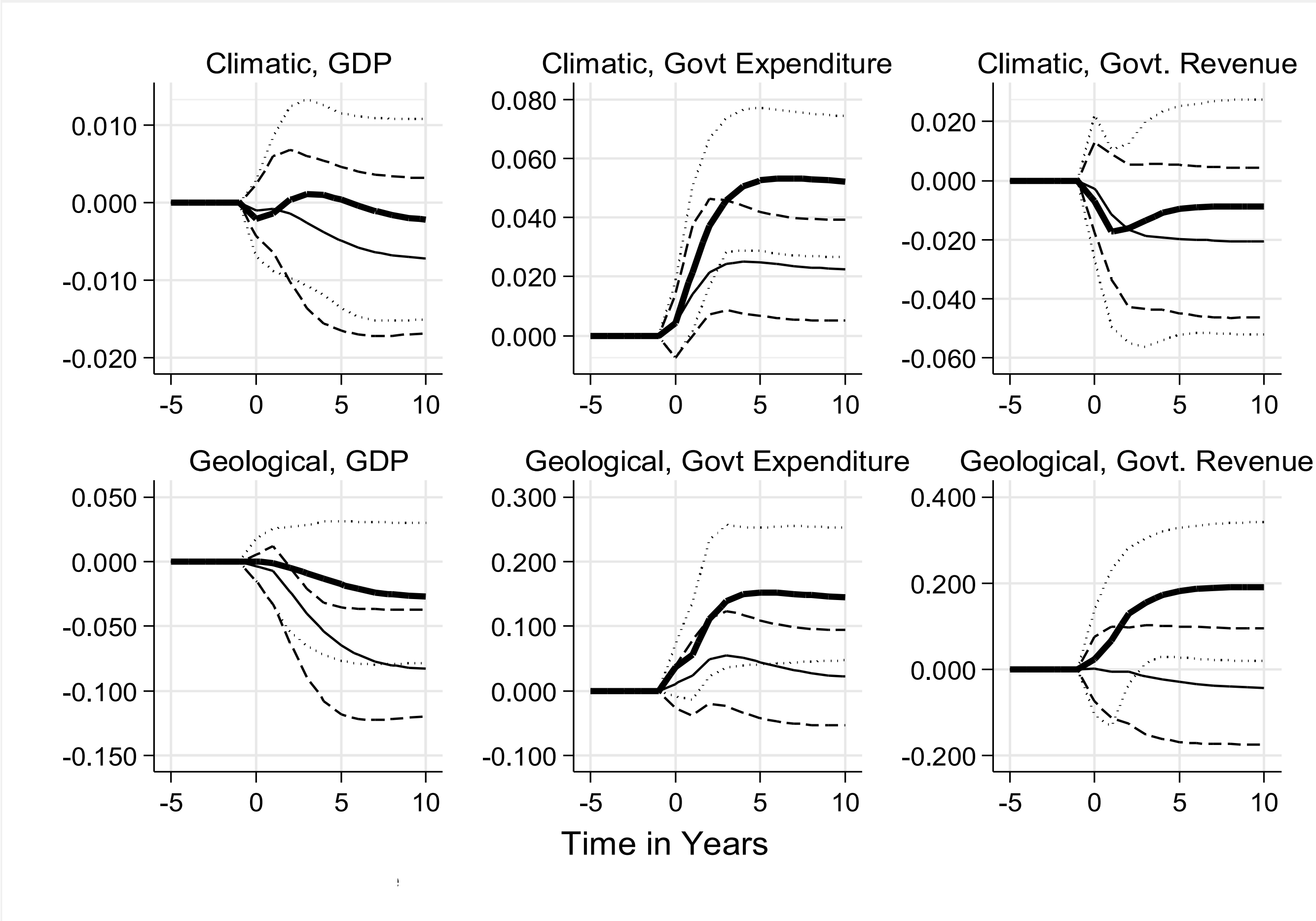


Figure 12 - Cumulative IRFs for Different Debt Levels

The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. Panels A and B reports the results for countries with debt to GDP ratio below and above the sample median respectively. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

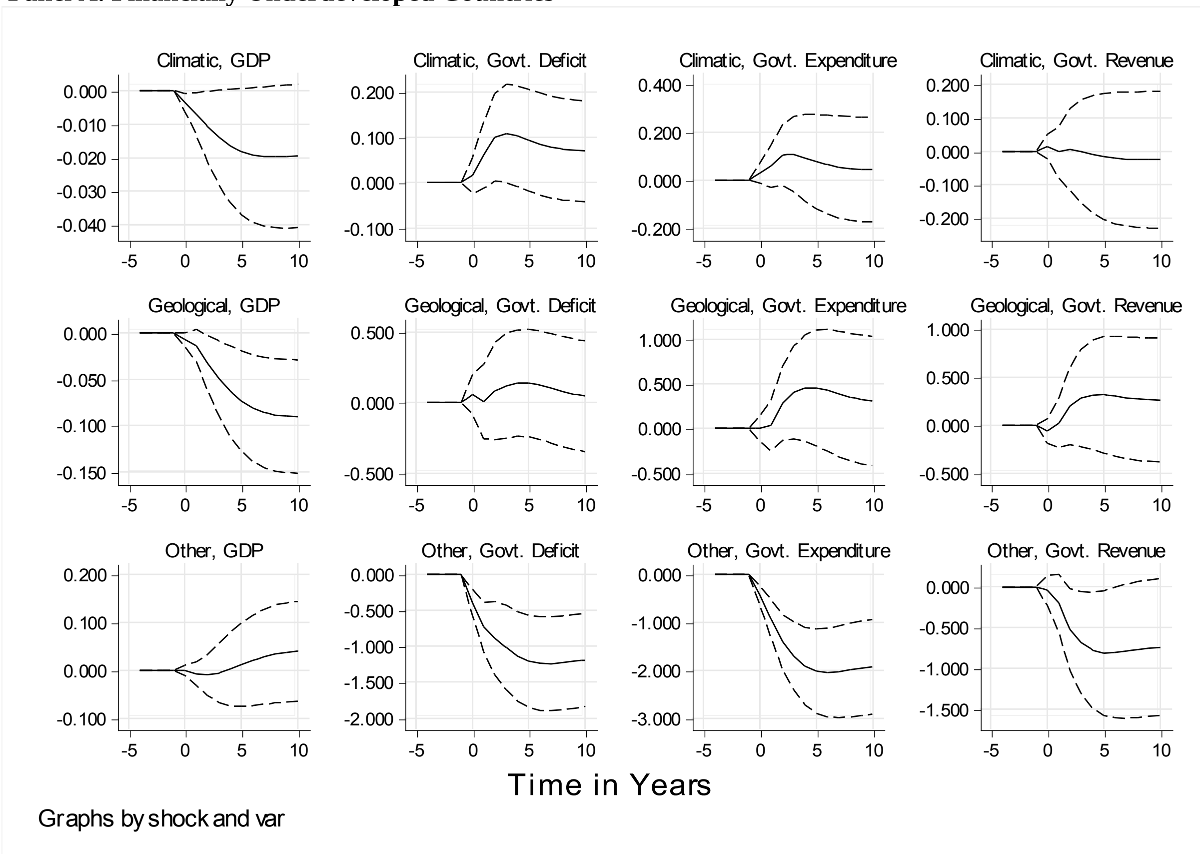
Figure 13 - Cumulative IRFs by Debt Controlling for Income Level



The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues, for countries with high and low levels of debt controlling for differences in income. The solid lines show the impact of a type of disaster, for countries with low (thin line) and high (thick line) debt levels (25th and 75th sample percentiles of debt to GDP ratio respectively). The dotted lines show one standard deviation confidence bands.

Figure 14. Cumulative IRFs for Different Levels of Financial Development

Panel A. Financially Underdeveloped Countries



Panel B. Financially Developed Countries

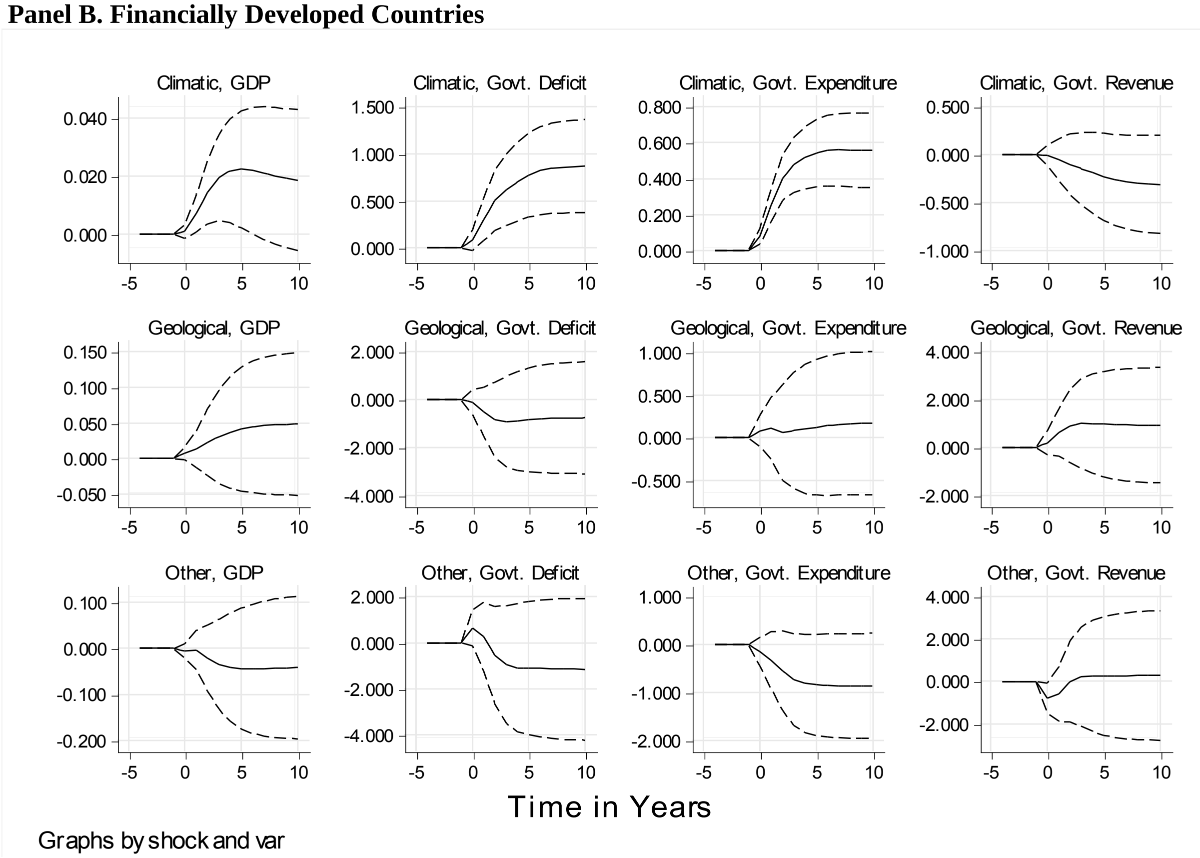
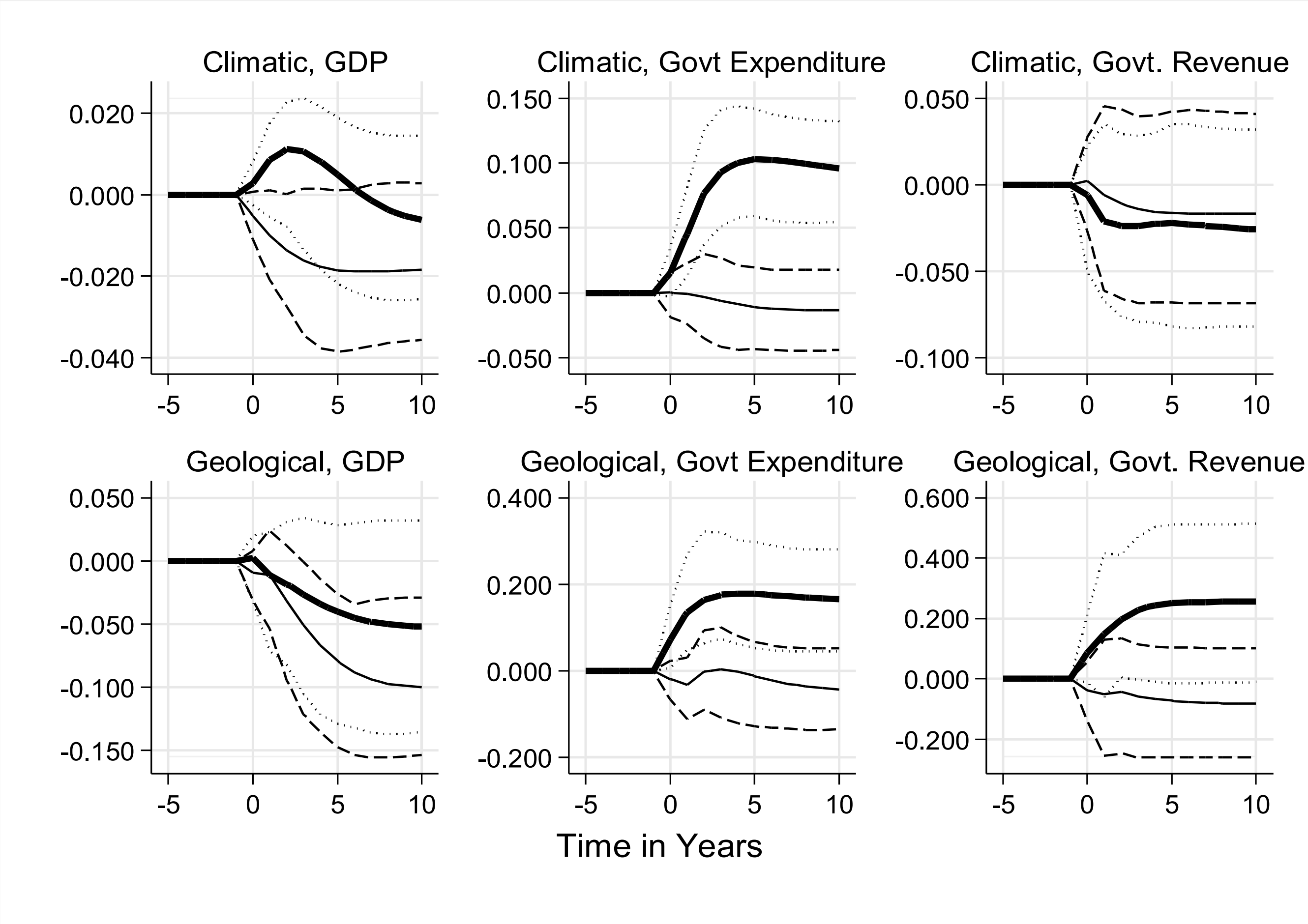


Figure 14. Cumulative IRFs for Different Levels of Financial Development

The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. Panels A and B report the results for countries with the average ratio of private credit to GDP, below and above the sample median respectively. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

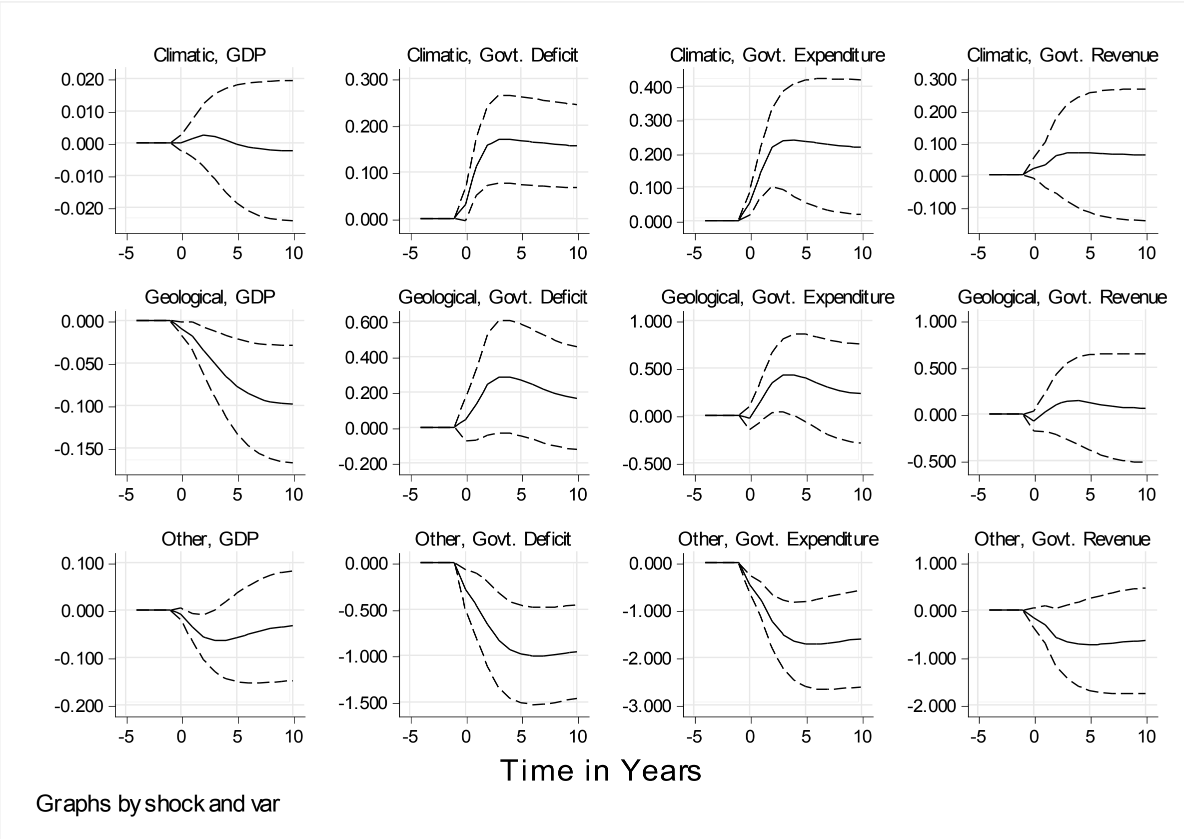
Figure 15 - Cumulative IRFs by Financial Development Controlling for Income Level



The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues, for countries with high and low levels of financial development controlling for differences in income. The solid lines show the impact of a type of disaster, for countries with low (thin line) and high (thick line) levels of financial development (25th and 75th sample percentiles of average ratio of private credit to GDP respectively). The dotted lines show one standard deviation confidence bands.

Figure 16 - Panel A. Cumulative IRFs for Countries with Low Insurance Penetration

Panel A. Countries with Low Insurance Penetration



Panel B. Countries with High Insurance Penetration

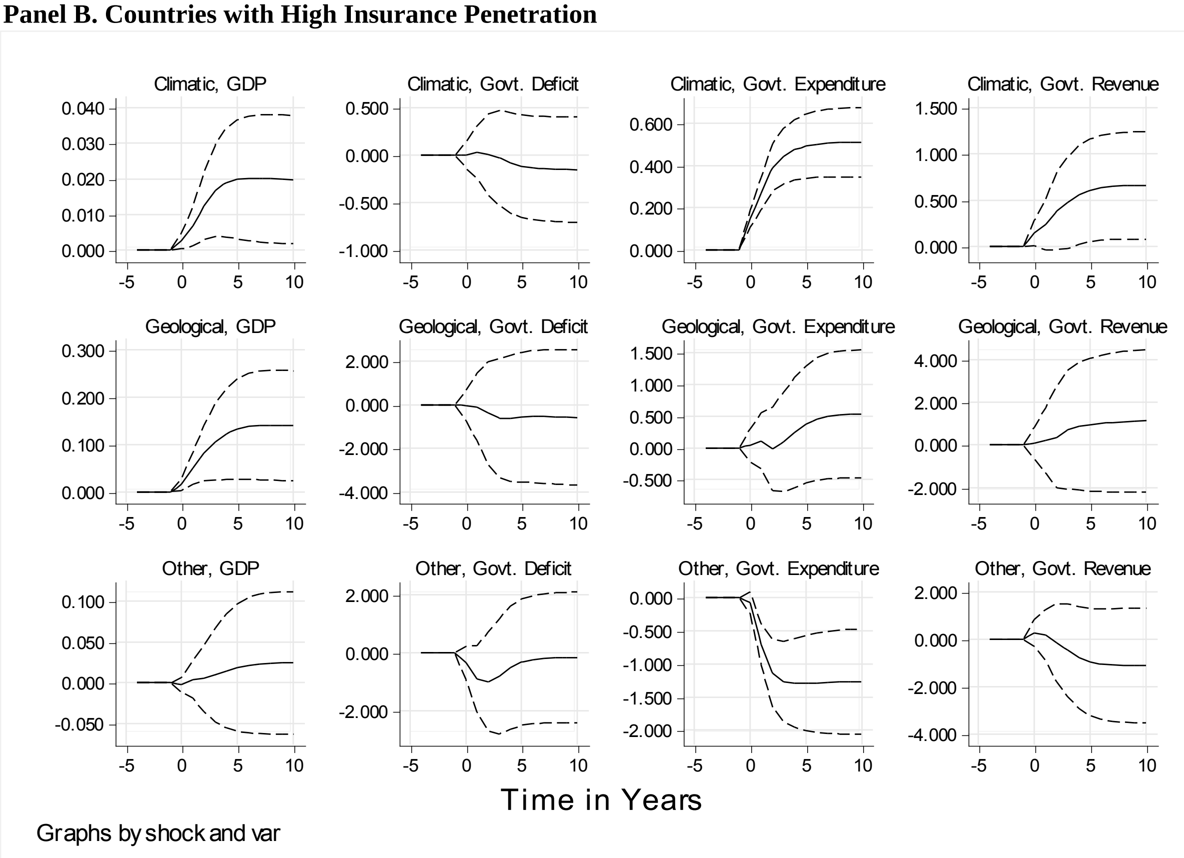
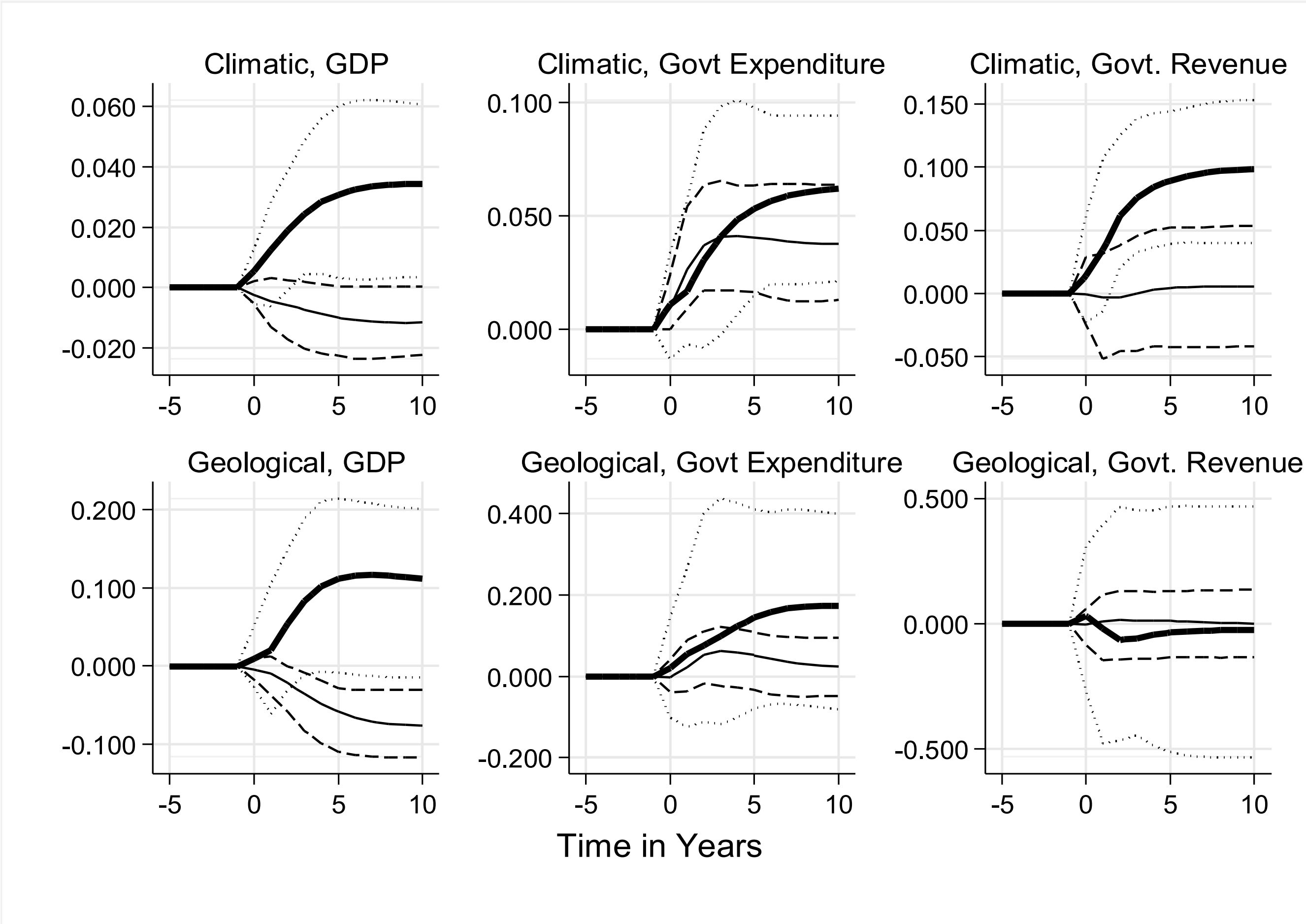


Figure 16 - Panel A. Cumulative IRFs for Countries with Low Insurance Penetration

The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues. Panels A and B report the results for countries with total value of pemium to GDP ratio below and above the sample median respectively. GDP and government deficit are expressed in real per capita terms; government expenditures and revenues are expressed as fractions of the long run government deficit. The parameters used to estimate the IRF come from the baseline specification with all variables expressed in levels (except the interest rate), and including two lags. The order of the endogenous variables entered in the VAR is the following: government expenditures, GDP, inflation, interest rate, and government revenues. The model also includes country specific means and trends, and with time fixed effects that capture global variables. The government deficit is obtained as the weighted difference of revenues and expenditures. The solid lines show the cumulatve percentage deviation of each variable from its trend resulting from a climatic, geological or other natural disasters occured at time 0 (time in years). The dotted lines show one standard deviation confidence bands.

Figure 17 - Cumulative IRFs by Insurance Penetration Controlling for Income Level



The figure shows the cumulative impulse response functions (IRF) for GDP, government deficit, government expenditures, and government revenues, for countries with high and low levels of insurance penetration controlling for differences in income. The solid lines show the impact of a type of disaster, for countries with low (thin line) and high (thick line) levels of insurance pentration (25th and 75th sample percentiles of total value of pemium to GDP ratio respectively). The dotted lines show one standard deviation confidence bands.