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MONETARY POLICY UNDER NATURAL DISASTER SHOCKS

by Alessandro Cantelmo[*], Nikos Fatouros[†], Giovanni Melina[‡] and Chris Papageorgiou[‡]

Abstract

With climate change increasing the frequency and intensity of natural disasters, how should central banks respond to these catastrophic events? Looking at IMF reports for 34 disaster-years, which occurred in 16 disaster-prone countries from 1999 to 2017, what emerges is a non-negligible heterogeneity in central banks' responses to climate-related disasters. Using a standard small-open-economy New-Keynesian model with disaster shocks, we show that, consistently with textbook theory, inflation targeting remains the welfare-optimal regime. The best strategy for monetary authorities is to resist the impulse to accommodate in the face of catastrophic natural disasters, and rather to continue to focus on price stability.

JEL Classification: E5, E52, E58, F41, Q54.
Keywords: natural disasters, climate change, DSGE, monetary policy, exchange rate regimes.
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1 Introduction[1]

Climate change is projected to make natural disasters even more frequent and severe (IPCC, 2018), with the frequency of hurricanes of category 4 or greater expected to increase by 39-87% over the 21st century (Knutson et al. 2013). The macroeconomic literature has investigated important policy aspects associated with climate shocks from a fiscal viewpoint, including investment in resilient infrastructure, pre-disaster and post-disaster donor support and insurance. However, except for a few notable contributions (see e.g. Fratzscher et al., 2020; Klomp, 2020; McKibbin et al., 2021; and Cantelmo, 2022), the monetary policy angle has almost been neglected. This paper tackles precisely this issue: what should central banks do in response to climate-related shocks?[2]

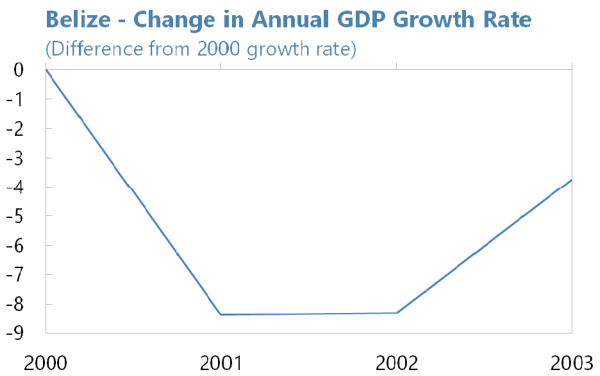
While advanced economies can still absorb these shocks relatively well, as the damages created by these catastrophes are a small fraction of their GDP, in disaster-prone Emerging and Developing Economies (EMDEs) natural disaster shocks are already major determinants of macroeconomic outcomes (see Table A.1 in Appendix A and Cantelmo et al., 2023). As we show in the paper, in these countries central banks already respond to natural disaster shocks, making them the most appropriate laboratory to study this matter.

In some countries, natural disaster shocks are already of the same, if not greater, importance as those that are typically regarded as major macroeconomic shocks. Take Belize, which was hit by hurricane Keith in October 2000 and by hurricane Iris in October 2001. Both hurricanes caused damages of the tune of 30 percent of GDP each, and GDP growth in 2001 and 2002 was about 8 percentage points lower than in the pre-shock year (Figure 1-a). To put things in perspective, at the time of the oil crisis of the early 1970s—often regarded as a typical large exogenous shock in macroeconomics—U.S. GDP growth in 1974 and 1975 was about 6 percent lower than in 1973 (Figure 1-b). This is to say that, in some countries, natural disaster shocks are already of the same, if not greater, importance as those that are typically regarded as major macroeconomic shocks, and in this paper we show that the monetary policy regime in place makes a sizable difference in terms of welfare.

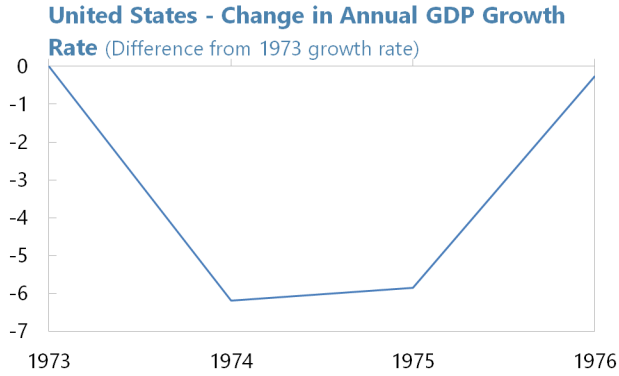
[1]Earlier versions of this paper were previously circulated with the title "Monetary Policy in Disaster-Prone Developing Countries." We thank Chris Adam, Michele Caivano, Martin Cerisola, Stephane Hallegatte, Olamide Harrison, Erik Klok, Gunes Kamber, Anton Korinek, Tonny Lybek, Jesus Fernandez-Villaverde, Oren Levintal, Stefano Neri, Alessandro Notarpietro, Cathy Pattillo, Massimiliano Pisani, Alessandro Secchi, Tim Willems, Jiaxiong Yao, Yunhui Zhao, Robert Zymek, participants at the IMF Conference on *Climate-Related Natural Disasters: Macroeconomic Effects and Policy Responses* and many more IMF colleagues for helpful comments and suggestions. Financial support by UK's FCDO and the Government of the Republic of Korea is gratefully acknowledged. All errors are ours. The views expressed in this paper are those of the authors and do not necessarily represent those of the International Monetary Fund, IMF policy, Banca d'Italia, FCDO or the Government of the Republic of Korea.

[2]Throughout the paper we interchangeably label these shocks as "climate-related" or "natural disaster" shocks.

Figure 1: Change in Annual GDP Growth Rate in the Aftermath of Large Macroeconomic Shocks



(a) Change in Annual GDP Growth Rate in Belize After Hurricane Keith (2000)



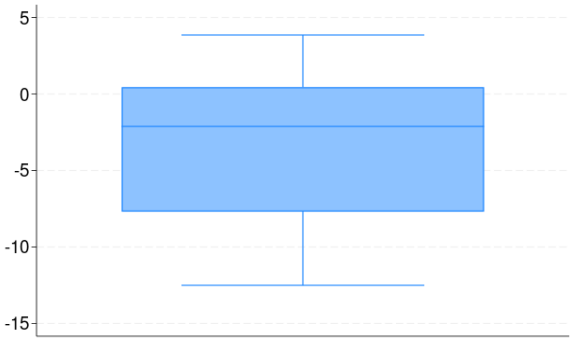
(b) Change in Annual GDP Growth Rate in the United States After the 1973 Oil Crisis

Source: IMF International Financial Statistics.

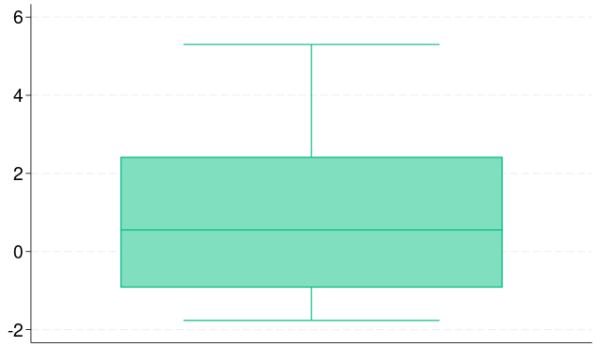
While monetary policy is not a substitute for structural and financial climate adaptation policies, welfare losses from ill-devised monetary policy rules may compound with those deriving from the devastating impacts of disasters. Establishing the adequate monetary policy regime is not a trivial task because, in the aftermath of these events, at least two policy challenges typically arise. The first is that many countries adopt pegs or exchange rate anchors and thus lack full monetary policy independence. The second is that the occurrence of a natural disaster often behaves like a supply shock, generating an increase in inflation and a decrease in GDP (Figure 2). Hence, a trade-off arises between stabilizing inflation and sustaining output. The monetary policy response to these events has been rather heterogeneous and there is no consensus on what best practices should be.

Therefore, this paper focuses on two research questions. The first is: how is monetary policy set in disaster-prone countries? To answer this question, we build stylized facts using a narrative analysis of IMF staff reports over the past 20 years, published around the occurrence of natural disasters. The second question is: what should be the optimal policy rule? To provide an answer, we use the rather standard model in Fernández-Villaverde and Levintal (2018), in which disaster shocks affect the capital stock and productivity and we use the same solution method—Taylor projection—which proves to be accurate and tractable in a stochastic environment with large shocks. We extend this framework along three dimensions: (1) we allow the effect of disasters on productivity to have both a permanent and a temporary component (as in Gourio, 2012) in line with empirical findings, and to affect export demand, so as to capture the experience of many countries, including those dependent on tourism; (2) we introduce a small-economy set-up along the lines of Gali and Monacelli

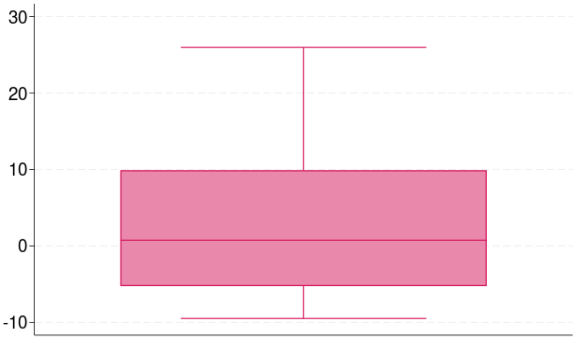
Figure 2: Distribution of Changes in Key Macroeconomic Variables in the Aftermath of Natural Disasters in Disaster-Prone Countries



(a) Change in Real GDP Growth



(b) Change in CPI Inflation



(c) Change in Real Money Growth

Sources: IMF World Economic Outlook Database and authors' calculations.
The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles, respectively; and the top and bottom markers denote the maximum and the minimum, respectively. The sample is restricted to cases that suffered cumulative damages of at least 5 percent of GDP in a given year. A similar picture emerges when considering damages above 1 percent of GDP.

(2005) to account for exchange rate fluctuations as, again, this is an important aspect of disaster-prone countries; and (3) we consider an array of alternative Taylor-type interest rate rules capturing several possible monetary policy regimes and evaluate the associated welfare outcomes. While we calibrate the model to an average disaster-prone country, to capture disaster sizes and intensities that make these shocks relevant for monetary policy, its structure is rather general and lends itself to be applied to a wide variety of countries. It follows that the policy implications we draw from the model results can be extended more broadly.

The main results are as follows. The narrative analysis suggests that natural disasters are typically followed by a decline in output and often by an increase in inflation. If there is at least some degree of monetary policy independence, central banks generally change their

monetary policy stance in the aftermath of disasters. While monetary policy is commonly tightened, there is a sizable minority of cases in which it is accommodated. Policy appraisals and advice by IMF staff have also been mixed, possibly underscoring that while tightening is a direct consequence of concerns toward inflation, stimulating economic activity might have been prioritized in certain cases.

The model analysis demonstrates that, from a welfare standpoint, an inflation targeting regime—whereby inflation can depart temporarily from target—is superior both to extreme regimes, such as strict inflation targeting or hard pegs, and to hybrid regimes in which monetary policy reacts also to output and the exchange rate, besides inflation. These results echo much of the literature on optimal monetary policy rules where the superiority of inflation targeting in the presence of supply shocks is a well established result.

In these contributions, the inflation-output tradeoff resulting from supply-side disturbances is generally solved in favor of inflation stabilization (see Kollmann, 2002, Gali and Monacelli, 2005, Schmitt-Grohé and Uribe, 2007 and Giannoni, 2014, among many others). In particular, Kollmann (2002) finds that, in a small open economy model with physical capital, the optimal monetary policy rule entails a large response to inflation, while responding to the exchange rate is welfare-detrimental, a result emphasized also by Gali and Monacelli (2005). Schmitt-Grohé and Uribe (2007) provide analogous prescriptions about the inflation response in a closed economy without capital, where responding to the output gap is suboptimal. We consider a model that embeds features of both Kollmann (2002) and Schmitt-Grohé and Uribe (2007), but in which physical capital, TFP and exports are hit by large and frequent natural disaster shocks. In this setting, the optimal interest-rate responsiveness to inflation is sufficiently small to allow for temporary deviations of inflation, while keeping it anchored to the central bank's target in the medium run. Also under these circumstances, directly responding to output or exchange rate fluctuations is welfare-detrimental.

The remainder of the paper is structured as follows. Section 2 reviews the related literature. Section 3 summarizes the main stylized facts stemming from the narrative analysis. Sections 4 and 5 present the model and its calibration, respectively. Section 6 discusses the model results, including welfare outcomes associated with alternative monetary policy rules. Finally, Section 7 concludes. The appendix complements the paper with a detailed list of disaster-prone countries (Appendix A), a thorough documentation of the narrative analysis (Appendix B) and a sensitivity analysis of the findings (Appendix C).

2 Related Literature

Besides the vast monetary policy literature, the paper is related also to four strands of the macroeconomic literature on natural disasters. The first strand is the growing body of studies on the economic impacts of climate change and natural disasters, which either report estimates of empirical models (e.g., IPCC, 2018; Hsiang and Jina, 2014; Burke et al., 2015; IMF, 2017; Kamber et al., 2013; De Winne and Peersman, 2021; Kabundi et al., 2022, among many others) or resort to theoretical macroeconomic models with climate change (e.g. Cashin et al., 2017, and Nordhaus, 2019). We contribute to this research area with our novel narrative analysis on the monetary policy responses to natural disaster shocks.

The second strand includes macroeconomic models with rare disaster shocks (Barro, 2006; Gabaix, 2012; Gourio, 2012; Isore and Szczerbowicz, 2017; Fernández-Villaverde and Levintal, 2018), introduced to provide a framework with realistic macroeconomic and asset pricing properties. However, none of these contributions offers a normative analysis of monetary policy as we do. Fernández-Villaverde and Levintal (2018) provide a fast and accurate solution method for DSGE models with rare disasters. As discussed, we employ their solution method and extend their model with features that are key for the analysis of optimal monetary policy rules in the context of natural disasters.

The third strand comprises macroeconomic models for disaster-prone economies. Marto et al. (2018), Adam and Bevan (2020) and Cantelmo et al. (2023) employ models similar to ours, but without nominal rigidities or monetary policy. While they assess fiscal policy options, ours is the first study that compares monetary policy regimes in this context.

Finally, the fourth strand comprises both empirical and theoretical contributions on monetary policy in the presence of natural disaster shocks. On the empirical side, Heinen et al. (2018), Parker (2018) and Klomp (2020) provide evidence of inflationary effects triggered by natural disasters. Accordingly, Fratzscher et al. (2020) and Klomp (2020) estimate an increase in the monetary policy rate in countries that adopt an inflation targeting regime. Morover, Jordà et al. (2022) estimate that the natural rate of interest increases after a war, which is a large disaster shock with physical capital destruction akin to natural disasters.[3] Based on the view that the monetary policy rate should track the natural rate (see e.g. Barsky et al., 2014), the response to a shock that causes a large physical capital destruction should entail a monetary policy tightening. By suggesting a focus on the inflation stabilization, our results are consistent with these findings.

On the theoretical side, Keen and Pakko (2011) use a standard DSGE model to show

[3]Conversely, it decreases in response to pandemics, which are shocks that trigger a large fall in labor supply without impacting physical capital.

that, to stabilize the output gap in response to a (small) natural disaster, it is optimal to raise the policy rate.[4] Kim and Ruge-Murcia (2019) simulate a New-Keynesian model in which standard business cycle shocks take a skewed distribution with a long tail, to infer the optimal (Ramsey) monetary policy in presence of extreme realization of these shocks. In other words, they do not contemplate large shocks to physical capital to mimic natural disasters. They conclude that the Ramsey policy stabilizes inflation. McKibbin et al. (2021) exploit a large-scale multi-country model to evaluate the central bank's inflation-output trade-off in response to a carbon-pricing shock. By comparing the impulse responses of output and inflation under three alternative monetary policy regimes—strict inflation targeting, price-level targeting and nominal GDP targeting—they conclude that output losses are lower under the nominal GDP targeting, at the expense of higher inflation. Furthermore, using a similar model to ours, calibrated to an advanced economy, Cantelmo (2022) studies the different implications of disaster risk and disaster strikes for the conduct of monetary policy without, however, deriving normative conclusions. Our main novel angle in this strand of the literature is the welfare-based ranking of a wide array of alternative monetary policy rules in response to natural disaster shocks.

Drawing on this extensive body of the literature, our framework situates itself within the context of cashless representative-agent models. We recognize that when considering the heterogeneous impacts of economic shocks, including natural disasters, there can be asymmetric effects on individuals or groups of agents. To capture these nuances, Marto et al. (2018) employ a model without monetary policy featuring two distinct types of agents: Ricardians, who optimize and have the ability to smooth consumption across periods through saving and borrowing, and Rule-of-Thumb agents, who consume their income as it is received. Heterogeneous Agents New-Keynesian (HANK) models offer an even richer setting. For example, in a closed-economy model without natural disasters, Dávila and Schaab (2023) explore how monetary policy dynamics become intricate and might harbor biases when one moves away from the representative agent assumption. While these considerations are important, they are outside the scope of this paper. We seek to chart new territory by evaluating the optimality of monetary policy frameworks in a small-open-economy experiencing natural disaster shocks, using a setting that departs minimally from the related literature.

As regards the role of money, in these models, it serves primarily as a unit of account, and monetary policy impacts via interest-rate rules affecting agents' optimizing behavior (Woodford, 1998; 2003; Clarida et al., 1999; 2000). Gali and Monacelli's (2005) influential

[4]They simulate a disaster of the size of Hurricane Katrina which caused damages of about 0.4% of U.S. GDP. Moreover, they solve the model with a second-order perturbation, which would miss much of the effects of the larger shocks we consider.

work offers the small-open-economy version of the conventional, cashless DSGE framework. We leverage many of its features to build our model and assess several monetary policy regimes within a small-open-economy environment. Thus, it seems appropriate to maintain the cashless economy assumption for comparability purposes. To incorporate money demand, we would need to introduce additional elements. For example Schmitt-Grohé and Uribe (2007) impose cash-in-advance constraints, but find that their conclusions regarding optimal monetary policy remain consistent whether the model is cashless or not. Moreover, the introduction of cash-in-advance constraints in our model would further convolute several behavioral equations due to the enhanced complexity of Epstein-Zin's recursive preferences. In sum, to preserve comparability and simplicity, we choose to adhere to the cashless paradigm.

3 Stylized Facts

In this section, we build stylized facts based on the findings of a narrative analysis on the response of monetary authorities following the occurrence of a climate-related natural disaster. We obtain the relevant information from IMF staff reports prepared after the so-called "Article IV" consultations in the year of, and one year following, the occurrence of a disaster, covering the macroeconomic and inflation performance in the aftermath of climate-related disasters, and IMF's evaluations and advice on the monetary policy stance.[5]

We focus on disaster-years where annual damages were at least 1 percent of GDP, subject to staff report availability. For countries in currency unions (such as the Eastern Caribbean Currency Union), we cross-reference Article IV staff reports of the IMF mission to the union's central bank. Our final sample consists of 34 disaster-years, that occurred in 16 disaster-prone countries from 1999 to 2017. Table B.1 of the appendix shows the complete list of countries and disasters used in our dataset, as well as the annual damages (as a percentage of GDP). Section B of the Appendix documents the whole process by reporting quotes extracted from the relevant IMF Article IV staff reports, for all disaster-country observations. This

[5]After downloading all the relevant archived IMF staff reports (pairs of disaster occurrences-countries), we read the documents to answer the survey questions covered in Subsection 2.1. Article IV consultations are part of the IMF's country surveillance, an ongoing process that culminates in regular (usually annual) comprehensive consultations with individual member countries. These consultations are known as Article IV consultations because they are required by Article IV of the IMF's Articles of Agreement. During an Article IV consultation, an IMF team of economists visits a country to assess economic and financial developments and discusses the country's economic and financial policies with government and central bank officials. Due to staff report availability, in a few cases we base our answers on consultations occurred two (El Salvador, 2011; Micronesia, 2015 and Solomon Islands, 2014) and three years (Samoa, 2012) after the disaster.

Figure 3: Narrative Analysis: Impact of Natural Disasters, Monetary Policy Stance of Affected Countries, and IMF Appraisal

Sources: IMF staff reports and authors' calculations.
Notes: Estimates are based on a narrative analysis of IMF staff reports on disaster-prone developing countries over the period 1999 to 2017. The analysis is restricted to weather-related natural disasters with associated damages of at least 1% of GDP (according to the EMDAT database), subject to IMF staff report availability. These criteria lead to a sample of 34 incidents that occurred in 16 countries. The time horizon considered in IMF staff's assessment of the monetary policy stance is within one year after the occurrence of each disaster. Constraints to changes in the monetary policy stance are typically hard pegs or dollarized economies. The aftermath of a disaster is defined as the period, generally shorter than one year, between the occurrence of the disaster and the IMF mission to the country. IMF Staff provide an appraisal of the MP stance adopted, and advice on the stance to adopt in the near future, with a time horizon usually not longer than one year after the completion of the IMF mission. Inflation increased in the aftermath of a disaster in 13 disaster cases, declined in only 6 cases, and it was generally stable in 15 disaster cases. Constraints to changes in the monetary policy stance are typically hard pegs or dollarized economies.

procedure enables us to construct a complete dataset of qualitative data.

The main findings of the narrative analysis, regarding the economic performance, the monetary policy stance adopted, as well as the IMF staff appraisal and advise on monetary policy, shortly after a natural disaster occurrence, are summarized in Figure 3. In most cases, GDP growth declined and, often, inflation increased. Figure B.1 of the Appendix, illustrates some features of the affected countries.

Panel B of Figure 3 summarizes the monetary policy stance adopted in the aftermath of disasters, in countries where monetary policy could be mobilized. The monetary policy stance was changed in virtually all cases where there was room for maneuver. This finding highlights the perceived importance of monetary policy as a tool for mitigating the adverse effects of natural disasters. When changed, the monetary policy stance was tightened in slightly more than half of the cases (almost 56 percent of disasters), and accommodated in the remaining cases, signaling heterogeneous importance attributed to inflation on one hand, and to output losses on the other. The main monetary policy tool utilized in the aftermath of disasters was the interest rate, but there were several cases where other policy tools, such as the money supply, where mobilized. Panels E and F of Figure 3, present the IMF appraisal and advice on monetary policy.

IMF staff and/or directors always agreed with authorities when they adopted a tight monetary policy stance, but also with loosening in a number of cases (about half of instances in which authorities adopted a loose monetary policy stance). Even though IMF staff did not oppose to accommodative monetary responses in their appraisal of policies adopted in the aftermath of certain disasters, there are no cases where the advice was to switch from a tight to a loose monetary policy stance in the near future, while the reverse is true. This outcome is likely due to concerns about inflation derailment and anchoring of expectations.

The heterogeneity in the monetary policy conduct and advice, raises questions on what policymakers' priorities should be. We investigate these issues using the model outlined in the following section.

4 The model

The framework is a small-open-economy New-Keynesian (NK) model with stochastic trend growth and disaster shocks. Households supply labor and decide on the optimal level of consumption and investment. The economy's consumption and investment basket include domestic and imported goods, with a set up along the lines of Gali and Monacelli (2005). Firms combine capital and labor to produce a domestic good. Differently from a standard NK model, households feature Epstein-Zin preferences (Epstein and Zin, 1989), which help

capture appropriately the effects of disaster risk, and disaster shocks hit the capital stock and total factor productivity as in Gourio (2012) and Fernández-Villaverde and Levintal (2018), besides impacting the demand for exports. Therefore, natural disasters affect both aggregate supply and aggregate demand. Finally, an array of alternative Taylor-type interest rate rules captures a number of possible monetary policy regimes.

4.1 Disasters

The modeling of disasters closely follows Fernández-Villaverde and Levintal (2018). Investment, x_t, is subject to quadratic adjustment costs $S\left[\frac{x_t}{x_{t-1}}\right] = \frac{\kappa}{2}\left(\frac{x_t}{x_{t-1}}\hat{z}_t - \hat{z}\right)^2$ as in Christiano et al. (2005), where $\hat{z}_t = \left(\frac{A_t}{A_{t-1}}\right)^{\frac{1}{1-\alpha}}$ is the technological stochastic trend growth and A_t is the permanent component of productivity. It follows that the law of motion of capital is:

$$k_t^* = (1-\delta)\, k_t + \left(1 - S\left[\frac{x_t}{x_{t-1}}\right]\right) x_t, \tag{1}$$

with:

$$k_t = k_{t-1}^* e^{-d_t \theta_t}, \tag{2}$$

where k_t is the actual capital stock in period t, equal to the capital stock k_{t-1}^* chosen by households in period $t-1$ net of a possible disaster shock, as governed by the term k_{t-1}^* $e^{-d_t\theta_t}$. In particular, the dummy variable d_t takes value 1 with probability p_d, in case of a disaster realization, and 0 with probability $(1-p_d)$ otherwise. When a disaster occurs, the capital stock falls by a quantity θ_t, which follows an autoregressive process:

$$\log \theta_t = (1-\rho_\theta)\log\bar{\theta} + \rho_\theta \log\theta_{t-1} + \sigma_\theta \epsilon_{\theta,t}, \tag{3}$$

where the random variable θ_t takes a log-normal distribution with average disaster size $\bar{\theta}$, persistence parameter ρ_θ, and stochastic volatility $\sigma_\theta\epsilon_{\theta,t}$.[6]

It is important to note that a disaster realization is a one-off event, i.e. it occurs only in one quarter (when $d_t = 1$). Conversely, disaster risk shocks are persistent. Equation (3) implies that agents may temporarily expect the average disaster size $\bar{\theta}$ to be higher or lower, with ρ_θ governing the persistence of the risk shock.

In addition to destroying part of the capital stock, disaster shocks affect also total factor productivity (TFP), A_t^{agg}. Along similar lines as Gourio (2012) and Cantelmo (2022), TFP has both a permanent, A_t, and a temporary component, A_t^T, meaning that disasters might

[6]Epidemics and pandemics are expected to work differently because they are not associated with a destruction of capital.

be followed by a partial recovery.[7] The permanent component is specified as a random walk with a drift while the temporary component follows a AR(1) process:

$$\log A_t^{\text{agg}} = \log A_t + \log A_t^T, \tag{4}$$

$$\log A_t = \log A_{t-1} + \Lambda_A + \sigma_A \epsilon_{A,t} - \omega\,(1-\alpha)\, d_t \theta_t, \tag{5}$$

$$\log A_t^T = \rho_A \log A_{t-1}^T - (1-\omega)\,(1-\alpha)\, d_t \theta_t, \tag{6}$$

where Λ_A is the steady-state TFP growth, $\sigma_A \epsilon_{A,t}$ is the Gaussian component of permanent TFP and ρ_A is the persistence of temporary TFP. Parameter $\omega \in [0,1]$ governs the relative impact of disasters on the two components of TFP. Moreover, disaster variables in the two processes of TFP are rescaled by the labor share of income, $(1-\alpha)$, to ensure that capital and output fall by the same proportion.

It is important to clarify that our analysis is predicated on the presumption of a homogeneous firm type, thus, potential differences in the impact of natural disasters across diverse sectors are not incorporated in this study. This simplifying assumption is a commonly employed methodological practice within macroeconomic models with natural disaster shocks, aiming to reduce their complexity. Nevertheless, we acknowledge that the impacts of disasters may be asymmetric across sectors, a fact underscored by studies that have shown that the disaster's fallout is contingent on sectoral vulnerabilities (see, e.g., Hallegatte et al., 2010). Furthermore, again for the sake of simplicity, our study does not account for credit rationing or financial frictions at the firm level, which may be heterogeneous and become more acute in the aftermath of natural disasters.[8]

4.2 Households

The representative household's utility reads as:

$$V_t^{1-\psi} = U_t^{1-\psi} + \beta E_t \left(V_{t+1}^{1-\gamma}\right)^{\frac{1-\psi}{1-\gamma}}, \tag{7}$$

where the period-t utility U_t is defined over consumption c_t and labor l_t, $U_t = e^{\xi_t} c_t \,(1-l_t)^{\nu}$, while V_{t+1} is its continuation value. Parameter γ governs risk aversion while $1/\hat{\psi}$ is the intertemporal elasticity of substitution, where $\hat{\psi} = 1-(1+\nu)\,(1-\psi)$ is its inverse. As noted by Caldara et al. (2012), the importance of recursive preferences is twofold. First, they allow

[7] See discussion in Section 5. This specification nests that of Isore and Szczerbowicz (2017) and Fernández-Villaverde and Levintal (2018). The latter assumes that only the permanent component of TFP is subject to disasters hence, by construction, disasters have permanent effects.

[8] For models with financial frictions, see, e.g., Curdia and Woodford (2010) and Carlstrom et al. (2010), who find that also in this context, stabilizing inflation is the desirable policy.

for a distinction between γ and $\hat{\psi}$.[9] Second, they imply a trade-off between current and a certainty equivalent of future utility. Households therefore have preference for early ($\gamma > \hat{\psi}$) or later ($\gamma < \hat{\psi}$) resolution of uncertainty. These features are particularly appealing in our context where agents face the risk of natural disasters, which induces precautionary savings captured by the recursive structure of preferences.

Households consume a constant-elasticity-of-substitution (CES) basket (c_t) of home $\left(c_t^H\right)$ and foreign goods $\left(c_t^F\right)$. Thus,

$$c_t = \left[\varphi^{\frac{1}{\chi_c}} \left(c_t^H\right)^{\frac{\chi_c - 1}{\chi_c}} + (1-\varphi)^{\frac{1}{\chi_c}} \left(c_t^F\right)^{\frac{\chi_c - 1}{\chi_c}}\right]^{\frac{\chi_c}{\chi_c - 1}}, \tag{8}$$

where φ indicates the home good bias and $\chi_c > 0$ is the intratemporal elasticity of substitution.

The consumption basket is the numeraire of the economy, with the unit price of this basket corresponding to:

$$1 = \left[\varphi \left(\frac{p_t^H}{p_t}\right)^{1-\chi_c} + (1-\varphi) \left(\frac{p_t^F}{p_t}\right)^{1-\chi_c}\right]^{\frac{1}{1-\chi_c}}, \tag{9}$$

where p_t^H represents the price of home goods, p_t^F represents the price of foreign goods, and p_t is the price of the composite consumption good. The relative price of home goods will then be $\tilde{p}_t^H \equiv \frac{p_t^H}{p_t}$. The relative price of foreign goods is $s_t \equiv \frac{p_t^F}{p_t} = \frac{e_t p_t^*}{p_t}$, where e_t is the nominal exchange rate and p_t^* is the price level of foreign goods expressed in foreign currency. Assuming that the law of one price holds, s_t corresponds also to the real exchange rate, defined as the price of one unit of foreign consumption basket in units of the domestic basket.

The definition of the real exchange rate pins down the following purchasing power parity relationship linking domestic to foreign inflation:

$$\frac{s_t}{s_{t-1}} = \frac{e_t}{e_{t-1}} \frac{\Pi_t^*}{\Pi_t}, \tag{10}$$

where $\Pi_t \equiv \frac{p_t}{p_{t-1}}$ is the gross domestic inflation rate and $\Pi_t^* \equiv \frac{p_t^*}{p_{t-1}^*}$ is the gross foreign inflation rate, which is exogenous and follows an autoregressive process,

$$\log\left(\frac{\Pi_t^*}{\Pi^*}\right) = \rho_{\Pi^*} \log\left(\frac{\Pi_{t-1}^*}{\Pi^*}\right) + \epsilon_t^{\Pi^*}, \tag{11}$$

[9] The more standard case of expected utility can be achieved by setting $\gamma = \hat{\psi}$.

where ρ_{Π^*} is the autoregressive parameters, and $\epsilon_t^{\Pi^*}$ is a mean zero, normally distributed random shock with standard deviation $\sigma_t^{y^*}$.

Minimizing total consumption expenditures subject to the consumption basket (8) yields the following demand functions for each good:

$$c_t^H = \varphi \left(\tilde{p}_t^H\right)^{-\chi_c} c_t \quad \text{and} \quad c_t^F = (1-\varphi)\,(s_t)^{-\chi_c}\, c_t. \tag{12}$$

Each period, the household's budget constraint (in real terms) reads as:

$$c_t + x_t + \frac{b_{t+1}}{p_t} + e_t \frac{b_{t+1}^*}{p_t} = w_t l_t + r_t k_t + R_{t-1}\frac{b_t}{p_t} + e_t R_{t-1}^* \Psi_{t-1} \frac{b_t^*}{p_t} + F_t + T_t, \tag{13}$$

where x_t denotes investment in capital, w_t is the real wage, r_t is the rental rate on capital k_t, F_t are profits earned from firms, T_t is a lump-sum transfer from the government, b_t represents private domestic bonds which pay a gross return, R_t, and b_t^* are net foreign assets denominated in foreign currency paying a gross return R_t^*, which is exogenous and follows an autoregressive process:

$$\log\left(\frac{R_t^*}{R^*}\right) = \rho_{R^*} \log\left(\frac{R_{t-1}^*}{R^*}\right) + \epsilon_t^{R^*}, \tag{14}$$

where ρ_{R^*} is the autoregressive parameters, and $\epsilon_t^{R^*}$ is a mean zero, normally distributed random shock with standard deviation $\sigma_t^{R^*}$. To prevent b_t^* from being a unit-root process, there exists a premium for holding net foreign assets (as in Schmitt-Grohé and Uribe, 2003), $\Psi_t \equiv \psi_0 \exp\left\{-\psi_1 \left(b_t^* - b^*\right)\right\}$, inversely related to the deviations of national foreign asset holdings, y_t, from their steady state. While ψ_0 captures the average wedge between R_t and R_t^*, $\psi_1 > 0$ makes the interest rate paid on foreign debt instruments elastic to net foreign asset holdings.

The household determines the optimal capital stock, k_t^*, which depreciates at a rate δ, and the investment x_t needed to achieve it.

Optimal choices of consumption, domestic and net foreign assets, labor supply, capital stock, and investment are taken to maximize utility (7), subject to (13), and (1), thus leading to the following first-order conditions:

$$1 = E_t\left[M_{t+1}\frac{R_t}{\Pi_{t+1}}\right], \tag{15}$$

$$1 = E_t\left[M_{t+1}\frac{e_{t+1}}{e_t}\Psi_t\frac{R_t^*}{\Pi_{t+1}}\right], \tag{16}$$

$$w_t = \nu\frac{c_t}{1-l_t}, \tag{17}$$

$$q_t = E_t\left(M_{t+1}e^{-d_{t+1}\theta_{t+1}}\left[r_{t+1}+q_{t+1}\left(1-\delta\right)\right]\right), \tag{18}$$

$$1 = q_t\left[1-S\left[\frac{x_t}{x_{t-1}}\right]-S'\left[\frac{x_t}{x_{t-1}}\right]\frac{x_t}{x_{t-1}}\right]+$$
$$+\,E_tM_{t+1}q_{t+1}S'\left[\frac{x_{t+1}}{x_t}\right]\left(\frac{x_{t+1}}{x_t}\right)^2. \tag{19}$$

Equations (15) and (16) are the Euler equations, where $M_{t+1} \equiv \beta\frac{\lambda_{t+1}}{\lambda_t}\frac{V_{t+1}^{\psi-\gamma}}{E_t\left(V_{t+1}^{1-\gamma}\right)^{\frac{\psi-\gamma}{1-\gamma}}}$ is the stochastic discount factor with Epstein-Zin preferences and λ_t is the Lagrange multiplier on the budget constraint (13). Equation (17) represents the marginal rate of substitution between consumption and leisure, while equations (18) and (19) define the asset price and investment decisions, respectively.

Combining equations (15) and (16) yields the uncovered interest rate parity condition, whereby the domestic and foreign nominal interest rates are equal up to the nominal exchange rate depreciation and the risk premium:

$$\frac{R_t}{R_t^*} = \Psi_t E_t\left[\frac{e_{t+1}}{e_t}\right] = \Psi_t E_t\left[\frac{s_{t+1}}{s_t}\frac{\Pi_{t+1}}{\Pi_{t+1}^*}\right]. \tag{20}$$

Similarly to private consumption, investment x_t is also a CES basket of home, x_t^H, and foreign goods, x_t^F. For simplicity, the elasticity of substitution and the distributional parameter between the home and foreign components of investment are the same as in the consumption aggregator:

$$x_t = \left[\varphi^{\frac{1}{\chi_c}}\left(x_t^H\right)^{\frac{\chi_c-1}{\chi_c}}+(1-\varphi)^{\frac{1}{\chi_c}}\left(x_t^F\right)^{\frac{\chi_c-1}{\chi_c}}\right]^{\frac{\chi_c}{\chi_c-1}}. \tag{21}$$

Minimizing total investment expenditures subject to the consumption basket (21) yields the following demand functions for each type of investment goods:

$$x_t^H = \varphi\left(\tilde{p}_t^H\right)^{-\chi_c}x_t \quad \text{and} \quad x_t^F = (1-\varphi)\left(s_t\right)^{-\chi_c}x_t. \tag{22}$$

4.3 Firms

The firms' side of the model is completely standard and borrowed from Fernández-Villaverde and Levintal (2018), except for the fact that the small-open-economy aspect needs to be taken into consideration. Our model draws upon the Gali and Monacelli (2005) modeling structure by postulating a single sector producing differentiated goods under monopolistic competition and then assembled into one final good, which is partly consumed within the country and partly exported. This simplification streamlines the model, reducing its size for

practical computational purposes. This singular good paradigm may not precisely reflect the reality of small-island economies, which typically export commodities and services such as tourism while domestically consuming a different set of goods. However, the final good can be interpreted as a composite good that represents the complete spectrum of goods and services produced within the economy.[10] Perfectly competitive final good producers combine i domestic intermediate goods according to

$$y_t = \left(\int_0^1 y_{i,t}^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{23}$$

where ϵ is the elasticity of substitution.[11] Intermediate goods producers combine labor and capital according to a Cobb-Douglas production function:

$$y_{i,t} = A_t^{\text{agg}} k_{i,t}^{\alpha} l_{i,t}^{1-\alpha}, \tag{24}$$

where $\alpha \in [0, 1]$ is the capital share of income. Intermediate firms choose inputs and prices to maximize profits $F_{i,t} = \frac{p_{i,t}^H}{p_t} y_{i,t} - w_{i,t} l_{i,t} - r_{i,t} k_{i,t}$, subject to the production function (24) and a Dixit-Stiglitz demand function $y_{i,t} = \left(\frac{p_{i,t}^H}{p_t^H} \right)^{-\epsilon} y_t$, and are subject to Calvo price stickiness. At the symmetric equilibrium all i firms are equal, hence the first-order conditions of the profit-maximization problem imply the following relationships:

$$\frac{k_t}{l_t} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t}, \tag{25}$$

$$g_t^1 = mc_t y_t + \theta_p E_t M_{t+1} \left[\frac{\left(\Pi_t^H\right)^{\chi}}{\Pi_{t+1}^H} \right]^{-\epsilon} g_{t+1}^1, \tag{26}$$

[10] Existing literature such as Marto et al. (2018) has presented models considering natural disasters, wherein they distinguish between tradable and non-tradable sectors, the former of which produce goods that are partly consumed domestically and partly exported. These models, however, employ more conventional solution techniques that cater well to larger models. In contrast, our solution strategy employs a Taylor projection to solve the model, an approach which exhibits efficient handling of medium-sized models such as ours, but it is not suited to effectively process significantly larger models. Thus, while we extend the closed-economy model by Fernández-Villaverde and Levintal (2018) into a small-open-economy setting, we consciously avoid the introduction of a multi-sector structure.

[11] For simplicity the model abstracts from imported intermediate goods, although the capital stock, owned by households, is built with investment goods that are partly imported. For a setting featuring imported intermediate goods explicitly, see Justiniano and Preston (2010), among others. Moreover, the setting is standard in that monopolistic competition is at the level of intermediate firms, which are distinct from final goods producers to allow for Calvo price stickiness.

$$g_t^2 = \left(\Pi_t^H\right)^O y_t + \theta_p E_t M_{t+1} \left[\frac{\left(\Pi_t^H\right)^\chi}{\Pi_{t+1}^H}\right]^{1-\epsilon} \left[\frac{\left(\Pi_t^H\right)^O}{\left(\Pi_{t+1}^H\right)^O}\right] g_{t+1}^2, \tag{27}$$

$$\epsilon g_t^1 = (\epsilon - 1)\, g_t^2, \tag{28}$$

$$1 = \theta_p \left[\frac{\left(\Pi_{t-1}^H\right)^\chi}{\Pi_t^H}\right]^{1-\epsilon} + (1-\theta_p)\left[\left(\Pi_t^H\right)^O\right]^{1-\epsilon}, \tag{29}$$

$$v_t^p = \theta_p \left[\frac{\left(\Pi_{t-1}^H\right)^\chi}{\Pi_t^H}\right]^{1-\epsilon} v_{t-1}^p + (1-\theta_p)\left[\left(\Pi_t^H\right)^O\right]^{1-\epsilon}, \tag{30}$$

$$\tilde{p}_t^H mc_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^{\alpha} \frac{w_t^{1-\alpha} r_t^\alpha}{A_t^{\text{agg}}}, \tag{31}$$

where $\theta_p \in [0,1]$ denotes the per-period probability of not resetting the price; $\chi \in [0,1]$ governs the degree of indexation to past inflation of home good prices, $\Pi_t^H = \frac{p_t^H}{p_{t-1}^H}$; $\left(\Pi_t^H\right)^O = \frac{\left(p_t^H\right)^O}{p_t^H}$ is the ratio between the optimal reset price and the price of the final domestic good; mc_t is the marginal cost expressed in units of domestic goods; g^1 and g^2 are auxiliary variables; and finally v_t^p denotes price dispersion.

4.4 Monetary Policy

The central bank sets the interest rate according to a feedback rule, generalized as follows:

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\gamma_\Pi} \left(\frac{\frac{y_t}{y_{t-1}}}{\exp\left(\Lambda_y\right)}\right)^{\gamma_y} \left(\frac{e_t}{e_{t-1}}\right)^{\gamma_e}. \tag{32}$$

We explore a number of alternative monetary policy regimes in line with the experience of disaster-prone countries, analyzed in Section 3, and the literature. Each case, obtained by means of appropriate parametrization, is labeled and discussed below.[12]

1. **Inflation targeting (IT).** In this case the central bank is concerned exclusively with inflation stabilization, although temporary deviations from the inflation objective are allowed, hence inflation is stabilized at a longer horizon. The larger the responsiveness (γ_Π) of the nominal interest rate to inflation deviations from target ($\bar{\Pi}$), the sooner inflation is brought back to target in the aftermath of shocks. Conversely, in the case where γ_Π is just above 1, the Taylor principle is satisfied, hence inflation expectations

[12]These monetary policy rules imply that the central bank has acquired sufficient credibility and a functioning transmission mechanism between the monetary policy rate to interest rates that affect borrowing and lending, which may be weak, especially in low-income countries.

are anchored, while the monetary policy stance is very mild:

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\gamma_\Pi}. \tag{33}$$

2. **Strict inflation targeting (SIT).** We label strict inflation targeting the limiting case in which the responsiveness of inflation is very large ($\gamma_\Pi \to \infty$) and the central bank keeps the inflation rate constant, i.e. inflation is stabilized in the very short run (Svensson, 2000):

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\gamma_\Pi}, \gamma_\Pi \to \infty. \tag{34}$$

3. **Hard Peg (HP).** In this regime, the central bank's objective is to keep the nominal exchange rate constant (i.e., a fixed exchange rate regime as in Benigno, 2004). In practice, this outcome can be achieved by setting a very large responsiveness of the nominal interest rate to changes in the nominal exchange rate ($\gamma_e \to \infty$):

$$\frac{R_t}{R} = \left(\frac{e_t}{e_{t-1}}\right)^{\gamma_e}. \tag{35}$$

4. **Taylor rule (TR).** This rule follows the standard practice of many central banks that respond to both inflation developments and economic activity. The specific formulation is borrowed from Fernández-Villaverde and Levintal (2018) who, relative to equation (33), include also a responsiveness (γ_y) of the nominal interest rate to output growth:

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\gamma_\Pi} \left(\frac{\frac{y_t}{y_{t-1}}}{\exp(\Lambda_y)}\right)^{\gamma_y}. \tag{36}$$

5. **Exchange-rate-augmented Taylor rule (ERTR).** Relative to the previous regime, this rule allows the central bank to respond also to changes in the nominal exchange rate ($\gamma_e > 0$), (see McCallum and Nelson, 1999, Batini et al., 2003 and Justiniano and Preston, 2010, among many others). This case captures concerns regarding the fact that depreciations may harm welfare via increases in the prices of imports:

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\gamma_\Pi} \left(\frac{\frac{y_t}{y_{t-1}}}{\exp(\Lambda_y)}\right)^{\gamma_y} \left(\frac{e_t}{e_{t-1}}\right)^{\gamma_e}. \tag{37}$$

Section C of the Appendix provides robustness checks to alternative specifications of the rules listed above by allowing also for interest rate inertia, by replacing the interest rate responsiveness to CPI inflation (Π_t) with a responsiveness to inflation of domestic consumption goods prices (Π_t^H), and by targeting nominal GDP.

4.5 Equilibrium

Imports consist of the sum of purchases of foreign goods for consumption and investment,

$$imp_t = c_t^F + x_t^F = (1-\varphi)\,(s_t)^{-\chi_c}\,(c_t + x_t)\,. \tag{38}$$

Exports consist of the foreign demand for home goods, assumed to have an analogous algebraic expression as domestic demand, and to be subject to downward shifts when the economy is hit by natural disasters, $\psi^d d_t \theta_t$, where parameter ψ^d governs the impact of disasters on external demand:

$$exp_t = \varphi^* \left(\frac{p_t^H}{e_t p_t^*}\right)^{-\chi_c^*} y_t^* - \psi^d d_t \theta_t, \tag{39}$$

where φ^* and χ_c^* are the foreign distributional parameter and elasticity of substitution, respectively. The export demand channel captures, e.g., the fall in external demand for exports in the tourism sector when small island countries are impacted by hurricanes or similar natural disasters and the rise in trade barriers as crucial mobility infrastructure (such as harbors and airports) is disrupted. Empirical evidence (e.g., Rossello et al., 2020, among others) finds that events such as tsunamis, floods and volcanic eruptions generally reduce tourist arrivals and may divert tourist flows from one destination to another. This effect may be persistent, especially in low-income countries (Okafor et al., 2021).

Aggregate foreign demand, y_t^* , follows an autoregressive process:

$$\log\left(\frac{y_t^*}{y^*}\right) = \rho_{y^*} \log\left(\frac{y_{t-1}^*}{y^*}\right) + \epsilon_t^{y^*}, \tag{40}$$

where ρ_{y^*} is the autoregressive parameter, and $\epsilon_t^{y^*}$ is a mean zero, normally distributed random shock with standard deviation $\sigma_t^{y^*}$.

Therefore, the resource constraint reads as follows:

$$\tilde{p}^H y_t = c_t + x_t + \tilde{p}^H exp_t - s_t imp_t. \tag{41}$$

The balance of payments equilibrium requires the current account balance to be equal to the change in net foreign assets:

$$p_t^H exp_t - p_t^F imp_t + \left(R_{t-1}^* \Psi_{t-1} - 1\right) e_t b_{t-1}^* = e_t \left(b_t^* - b_{t-1}^*\right). \tag{42}$$

By using the definitions of relative prices, $\tilde{p}_t^H \equiv \frac{p_t^H}{p_t}$ and $s_t \equiv \frac{p_t^F}{p_t} = \frac{e_t p_t^*}{p_t}$, foreign inflation, $\Pi_t^* \equiv \frac{p_t^*}{p_{t-1}^*}$, and the purchasing power parity condition (10), equation (42) can be rewritten in real terms as follows:

$$\tilde{p}_t^H exp_t - s_t imp_t + s_t \left(R_{t-1}^* \Psi_{t-1} - 1\right) \frac{\tilde{b}_{t-1}^*}{\Pi_t^*} = s_t \left(\tilde{b}_t^* - \frac{\tilde{b}_{t-1}^*}{\Pi_t^*}\right), \tag{43}$$

where $\tilde{b}_t^* \equiv \dfrac{b_t^*}{p_t^*}$ denotes the real net foreign assets.

5 Calibration and Solution Method

We calibrate the model to an average *disaster-prone* EMDE at a quarterly frequency to capture disaster sizes and intensities that make these shocks relevant for monetary policy. The model structure, however, is rather general and lends itself to be applied, with appropriate parametrizations, to a wide variety of countries. Table 1 reports the choice of all parameter values for the baseline calibration.

Households. The discount factor (β) is set at 0.9838, such that it yields a steady-state annual interest rate of 8.52%, as reported by Garcia-Cicco et al. (2010) for a set of emerging market economies. Moreover, this value falls also in the range considered by Shen et al. (2018) for low-income countries. As conventional in the business cycle literature, the inverse of the intertemporal elasticity of substitution, $\hat{\Psi}$, is calibrated to the value of 0.5, and the leisure preference parameter, ν, is set at 1.1, such that agents work 1/3 of their time. Given the scant evidence on risk aversion within Epstein-Zin preferences for developing economies, we set $\gamma = 3.8$, as Gourio (2012) and Fernández-Villaverde and Levintal (2018) do for the U.S. economy.[13] Some experimental evidence in countries hit by natural disasters (Cassar et al., 2017 and Cameron and Shah, 2015) suggests that their economic agents tend to exhibit a more risk averse behavior, although these findings are difficult to translate into a

[13] Values of risk aversion between 3 and 4 are needed to replicate the average equity premium, see Barro (2009; 2015) and Gourio (2012).

Table 1: Baseline Calibration

Parameter		Value
Households		
Discount factor	β	0.9838
Inverse of IES of consumption	$\hat{\Psi}$	0.5000
Leisure preference parameter	ν	1.1000
Risk aversion	γ	3.8000
Intratemporal elasticity of substitution between home and foreign good	χ_c	0.6700
Domestic home good bias	φ	0.5502
Average wedge between R_t and R_t^*	ψ_o	1.0084
Interest rate elasticity to net foreign assets	ψ_1	0.0010
Foreign Demand		
Scaling parameter in foreign demand	φ^*	1.0000
Elasticity of foreign demand	χ_c^*	0.5800
Steady state of export-to-GDP ratio	exp_y	0.3231
Impact of disaster shocks on export demand	φ^d	0.2500
Firms		
Capital share of income	α	0.3200
Total factor productivity trend growth rate	Λ_A	0.0035
Weight of disasters on permanent TFP	ω	0.5000
Investment adjustment costs	κ	12.0000
Private capital depreciation rate	δ	0.0250
Automatic price adjustment	χ	0.1100
Calvo price stickiness parameter	θ_p	0.6800
Elasticity of substitution in final good aggregator	ϵ	6.0000
Monetary Policy		
Inflation target	$\bar{\Pi}$	1.0122
Steady state of foreign inflation	$\bar{\Pi}^*$	1.0053
Inflation parameter in Taylor rule	γ_Π	1.5000
Output growth parameter in Taylor rule	γ_y	0.0000
Interest rate smoothing in Taylor rule	γ_R	0.0000
Exchange rate parameter in Taylor rule	γ_e	0.0000
Disaster Shocks		
Persistence of disaster risk shocks	ρ_θ	0.9000
Standard deviation of disaster risk shocks	σ_θ	0.1270
Annual disaster probability	p_d	0.1620
Mean disaster size	$\bar{\theta}$	0.0344
Other Shocks		
Persistence of temporary total factor productivity	ρ_A	0.7100
Persistence of foreign inflation rate	ρ_{Π^*}	0.2144
Persistence of foreign interest rate	ρ_{R^*}	0.8085
Persistence of foreign demand	ρ_{y^*}	0.8751
Standard deviation of total factor productivity shocks	σ_A	0.0280
Standard deviation of foreign inflation shocks	σ_{Π^*}	0.0052
Standard deviation of foreign interest rate shocks	σ_{R^*}	0.0095
Standard deviation of foreign demand shocks	σ_{y^*}	0.0023

value of γ.[14] We therefore see the calibration of risk aversion based on the U.S. economy

[14]See also van den Berg et al. (2009), Dang (2012) and Brown et al. (2018). Fiala (2017) reviews this evidence in more detail and reports also some contrasting results. Cantelmo (2022) shows that sufficiently temporary higher risk aversion in the aftermath of disasters might generate large demand-side in addition

as a lower bound for *disaster-prone* countries. Following Justiniano and Preston (2010), the intratemporal elasticity of substitution between the home and foreign good, χ_c, is set to 0.67, while the home good bias, φ, is set to 0.5502, in order to match the imports-to-GDP ratio of 55 percent in *disaster-prone* countries over the 1997-2017 sample. The average wedge between R_t and R_t^*, ψ_o, is calibrated at 1.0084 in line with a spread between the average deposit rate for *disaster-prone* countries and the average effective Federal Funds rate of 336 annual basis points over the same period. The interest rate elasticity to net foreign assets, ψ_1, is set to 0.001, given that its presence is only necessary to eliminate the unit root that there would otherwise be in net foreign assets (see, e.g., Schmitt-Grohé and Uribe, 2003).

Foreign demand. The scaling parameter in foreign demand, φ^*, is normalized to one, the steady-state export-to-GDP ratio, exp_y, is set to 0.3231, in order to match the data for *disaster-prone* countries over the 1997-2017 sample. The elasticity of demand, χ_c^*, is set to 0.58, following Justiniano and Preston (2010), and the parameter governing the impact of disaster shocks on export demand, φ^d, is set equal to 0.25, to deliver an one-percent increase in the annualized CPI inflation rate in response to an average disaster shock, in line with the experience of the median disaster-prone country reported in Section 1.

Firms. We follow Garcia-Cicco et al. (2010) also in setting the total capital share of income, α, to 0.32, while we set trend TFP growth, Λ_A, to 0.0035, as suggested by Araujo et al. (2016). For the baseline calibration, we assume that the shock is distributed equally between the permanent and stationary components of TFP ($\omega = 0.5$), given the uncertainty surrounding this parameter. However, we check the extent to which the results are robust to alternative choices.[15] The parameter governing investment adjustment costs, κ, is set to 12, in line with the calibration of Schubert and Turnovsky (2011) for a set of developing economies. The private capital depreciation rate, δ, is borrowed from Shen et al. (2018) who set it equal to a value of 0.025. Following the calibration of Justiniano and Preston (2010) for small-open economies, the automatic price adjustment, χ, is set to 0.11, and the Calvo price stickiness parameter is set to 0.68. Lastly, the elasticity of substitution of demand faced by final good producers, ϵ, is set to the conventional value of 6, adopted also by Isore

to supply-side effects.

[15]The extreme cases of $\omega = 0$ and $\omega = 1$ imply that disasters only have a temporary or a permanent effect, respectively. Hsiang and Jina (2014) estimate that tropical cyclones have a highly persistent effect on the growth rate and reject hypothesis of "creative destruction" or "build-back better." Moreover, a peculiarity of disaster-prone countries is that they are subject to recurrent natural disasters, hence even if a single disaster alone would not be very persistent, when more events compound the effects might become virtually permanent. With a focus on other types of disasters, Nakamura et al. (2013) show that disasters are followed by partial recoveries, hence with a temporary higher growth rate of output after the disaster relative to the pre-disaster growth rate. By appealing to their evidence, our baseline calibration assumes that natural disasters have both a short-run and a long-run impact on productivity, hence the aftermath of disasters is characterized by faster growth and a partial recovery.

and Szczerbowicz (2017) in the context of a DSGE model with natural disasters.

Monetary Policy. The inflation target parameter, $\bar{\Pi}$, is calibrated to 1.0122 to match the average annual inflation rate for *disaster-prone* countries of 4.87 percent, while the steady state of foreign inflation, $\bar{\Pi}^*$, is set at 1.0053 to match the average annual U.S. inflation rate of 2.12 percent. For baseline illustrative results, the parameter governing the responsiveness of the interest rate to inflation in the Taylor rule, γ_Π, is set to 1.5, a conventional value that satisfies the Taylor principal (Taylor, 1993), whereas the remaining parameters in the Taylor Rule (γ_y, γ_R, γ_e) are set equal zero, essentially shutting down any additional monetary policy objective besides inflation targeting. However, we activate these objectives in various policy experiments and discuss the calibration of the relevant parameters in the appropriate sections.

Disaster Shocks. Absent evidence specific for EMDEs, we calibrate the persistence of the disaster risk shock, ρ_θ, to 0.90, following Gourio (2012), Isore and Szczerbowicz (2017) and Fernández-Villaverde and Levintal (2018). The standard deviation, $\sigma_\theta = 0.1270$, matches the quarterly dispersion of damages to GDP in *disaster-prone* countries of 28 percent. In accordance with the evidence found for *disaster-prone* countries (Cantelmo et al., 2023), we set the annual disaster probability, p_d, to 16.2 percent and the average loss, $\bar{\theta} = 0.0344$, so that the average disaster destroys about 7 percent of GDP. Note that $\bar{\theta} = -\log(1 - \Delta)$, where Δ is the loss in terms of GDP in a model without the export-demand channel of disaster shocks. Given that the export-demand channel amplifies the disaster-induced GDP loss (see Section 6.4), we set the average loss parameter, $\bar{\theta}$, to a lower number than Cantelmo et al. (2023) to target their same average GDP loss.

Other Shocks. We set the persistence of the temporary component of TFP affected by disaster shocks, ρ_A, equal to 0.71 as in Gourio (2012), while the standard deviation of the shock hitting the permanent component of TFP, σ_A, equal to 0.0280 to match the average for *disaster-prone* countries of the standard deviation of the cyclical component of the logarithm of real GDP, which amounts to 2.87 percent at an annual frequency. In order to calibrate the persistence and standard deviations of shocks to the foreign interest rate, inflation and demand, we estimate AR(1) processes for the U.S. quarterly CPI inflation rate, Federal Funds rate and cyclical components of GDP (computed with a standard HP filter). This leads to the following persistence parameters for the foreign inflation rate, ρ_{Π^*}, the foreign interest rate, ρ_{R^*}, and foreign demand, ρ_{y^*}, of 0.2144, 0.8085 and 0.8751, respectively; and the following standard deviations of shocks to the the same variables, σ_{Π^*}, σ_{R^*} and σ_{y^*} of 0.0052, 0.0095 and 0.0023, respectively.

Solution Method. To simulate our model, we resort to Taylor projection, a solution method proposed by Levintal (2018) and Fernández-Villaverde and Levintal (2018) to solve

DSGE models with rare disasters. Fernández-Villaverde and Levintal (2018) demonstrate that a Taylor projection up to third order is more accurate and generally faster to compute than perturbation methods up to a fifth order of approximation and projection methods (Smolyak collocation) up to a third order to solve a wide range of DSGE models with rare disasters. Taylor projection essentially combines the setup of standard projection methods (e.g. Judd, 1992) with approximation methods via Taylor expansions. The method yields a solution that, although not global, is possible to approximate at many points of the state-space, and this makes it accurate in dealing with large nonlinearities. These features of Taylor projection are particularly appealing for studying natural disasters within a DSGE model and motivate our choice of using a third-order Taylor projection over alternative methods.

6 Results

6.1 Effects of a Natural Disaster Shock in a Small Open Economy

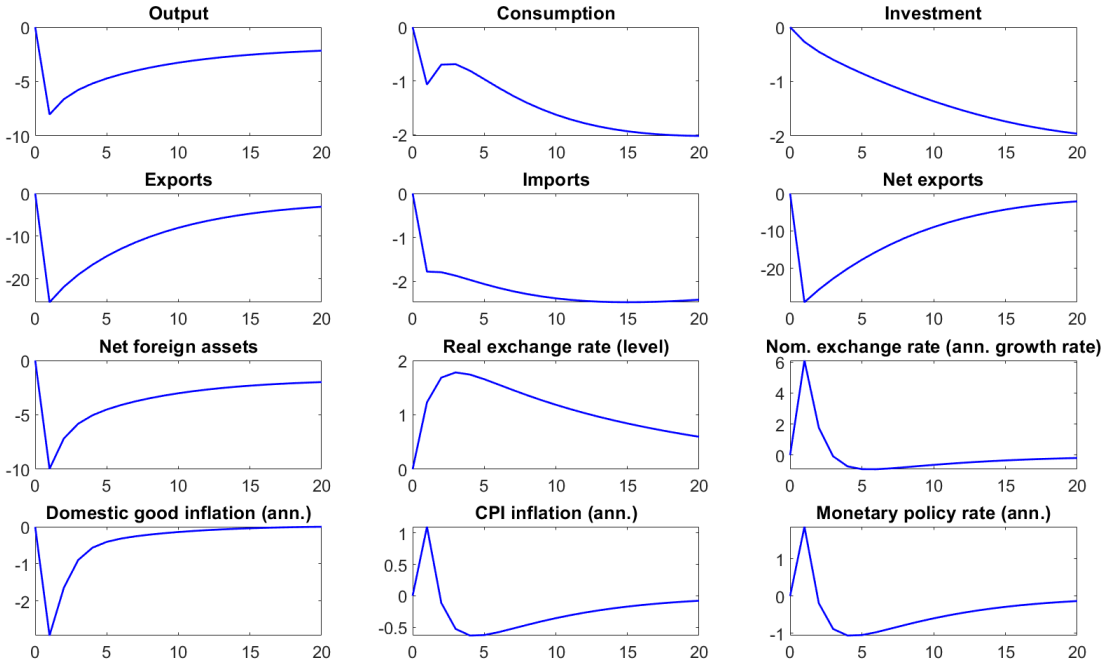
We start from analyzing the effects that the realization of an average natural disaster shock has on disaster-prone small-open economies. In this subsection we present results assuming a CPI inflation targeting, that is, the central bank targets CPI inflation allowing for temporary deviations from the target (alternative monetary policy regimes are presented in Subsection 6.2). As explained in Section 4, the disaster affects the stock of capital and productivity as in other contributions with closed-economy models (Gourio, 2012; Fernández-Villaverde and Levintal, 2018; Cantelmo et al., 2023), with the addition of the export demand channel (motivated in Subsection 4.5 and analyzed in more detail in Subsection 6.4).

As common in the related literature, we obtain the stochastic steady state by simulating the model in the absence of shocks for 100 quarters.[16] Soon afterwards, the model is perturbed by a one-off disaster shock of average size and impulse response functions (IRFs) are traced for 20 quarters.

Output, consumption, investment, exports, imports, net exports and net foreign assets are non-stationary and are plotted in percent deviations from the the pre-disaster balanced growth path as in Gourio (2012). These variables grow each period at the same growth rate as TFP. Given that disasters hit both components of TFP, the growth rate of TFP initially falls and then experiences an overshooting before gradually reverting toward its steady state level (Subsection 4.1). However, there is a permanent effect meaning that the level of non-stationary variables and aggregate productivity is permanently lower than the level they would have reached without the disaster.

[16] We check that this is sufficient for variables to stabilize around a new long-run level.

Figure 4: Impulse Responses of Selected Macroeconomic Variables to an Average Natural Disaster Shock in a *Disaster-Prone* Country



Notes: X-axes are in quarters. Output, consumption, investment, exports, imports, net exports and net foreign assets are expressed in percent deviations from the pre-disaster balanced growth path. Inflation rates, the monetary policy rate and nominal exchange rate growth are as annualized percentage points differences from the stochastic steady state. The real exchange rate is in percentage points deviations from the stochastic steady state. The stochastic steady state is obtained by simulating the model in the absence of shocks for 100 quarters.

Given that the disaster shock affects domestic output and export demand, it acts both as a demand and as a supply shock. The disaster impacts domestic production and incomes while the export channel reduces import capacity via the balance of payment condition (equation 43). Given that the elasticity of substitution between domestic and imported goods (χ^c) is less than unity, the contraction in import demand is less than proportional than the fall in exports, which requires the real exchange rate to depreciate (shown as an increase in the figure) in order to further curb import demand, stimulate exports and induce a net inflow of capital (i.e. a fall in net foreign assets).

The real exchange rate depreciation, which makes imported goods more expensive, compounds with a strong negative income effect exacerbated by the direct disaster impact on exports. The effects of these channels are evident in the persistent decline of consumption and investment. In studies where the export demand channel of disasters is not at play (e.g. Gourio, 2012; Cantelmo, 2022), investment increases, driven by the higher marginal product of capital, in turn caused by the capital destruction (see also Section 6.4). When the export

demand channel is active, the negative income effect and the real exchange rate depreciation prevail on the increase of the marginal product of capital.

The initial sharp depreciation (increase) in the nominal exchange rate, which makes CPI inflation increase, facilitates the real exchange rate depreciation. The fall in the demand for home goods causes a contraction in (sticky) home good prices. Since domestic goods inflation remains below its steady state level for a prolonged period, CPI inflation experiences an undershooting following the initial increase. Given that the central bank targets CPI inflation, the response of the monetary policy rate tracks its dynamics.

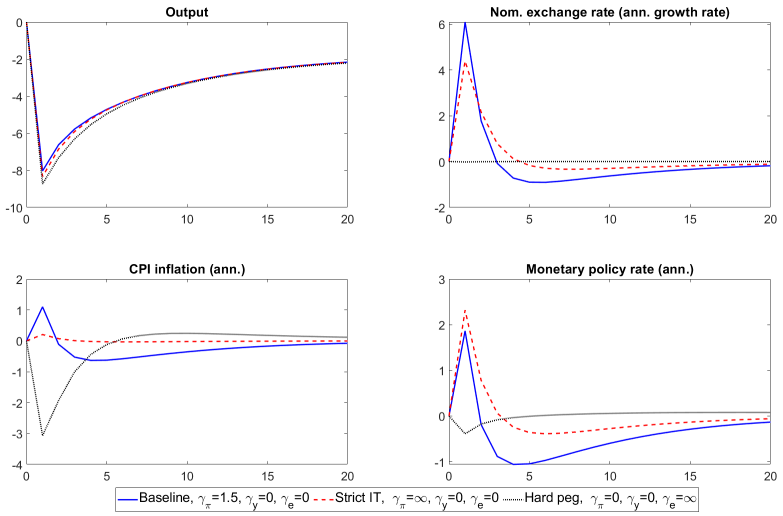
6.2 Differences Associated with Alternative Monetary Policy Regimes

In this subsection we analyze the impact of alternative monetary policy regimes, mimicked by the alternative interest rate rules outlined in Subsection 4.4, in the context of a natural disaster realization. Figure 5 depicts the impulse responses of key macroeconomic variables to the same average natural disaster shock analyzed in the previous subsection, under alternative assumptions on the monetary policy regime.

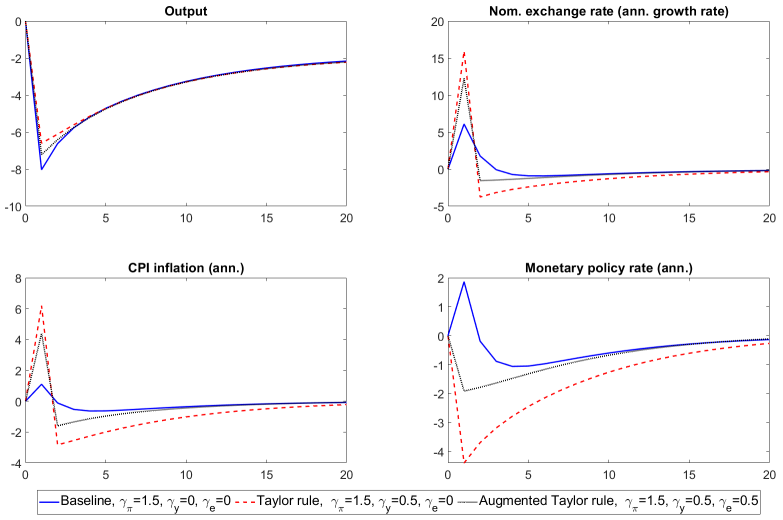
In Subfigure 5-(a) we compare the baseline inflation targeting regime ($\gamma_\Pi = 1.5$, $\gamma_y = 0$, $\gamma_e = 0$), in which the central bank targets only CPI inflation, but allows for temporary departures of inflation from target, with strict inflation targeting, and a hard peg. Strict inflation targeting is achieved by setting a very large interest rate responsiveness to inflation to keep it virtually constant ($\gamma_\Pi \to \infty$, $\gamma_y = 0$, $\gamma_e = 0$). A hard peg is a fixed exchange regime achieved by setting a very large interest rate responsiveness to the exchange rate ($\gamma_\Pi = 0$, $\gamma_y = 0$, $\gamma_e \to \infty$). Relative to the baseline policy, both a hard peg and strict inflation targeting magnify the GDP loss to an extent, by almost one percentage point under a hard peg. Expectedly, the specific monetary policy regime has significant implications for nominal variables. The peg, by definition, eliminates the shock-absorbing effect of the exchange rate, thus exacerbating the recession and causing a fall in aggregate demand and inflation. The central bank accommodates the shock by lowering the policy rate but still the initial output loss is larger than under inflation targeting. Strict inflation targeting requires a more prolonged increase in the interest rate to keep inflation constant. The exchange rate still depreciates, but to a smaller extent than under inflation targeting.

In Subfigure 5-(b) we compare the baseline inflation targeting regime ($\gamma_\Pi = 1.5$, $\gamma_y = 0$, $\gamma_e = 0$) with a conventional Taylor rule, whereby the central bank reacts to inflation and output ($\gamma_\Pi = 1.5$, $\gamma_y = 0.5$, $\gamma_e = 0$), and an exchange-rate-augmented Taylor rule whereby the central bank also reacts to the exchange rate ($\gamma_\Pi = 1.5$, $\gamma_y = 0.5$, $\gamma_e = 0.5$).

Figure 5: Impulse Responses of Selected Macroeconomic Variables to an Average Natural Disaster Shock in a *Disaster-Prone* Country, under Alternative Specification of the Monetary Policy Regime



(a) Baseline (Inflation Targeting), Strict Inflation Targeting and Hard Peg



(b) Baseline (Inflation Targeting), Conventional Taylor Rule and Exchange-Rate-Augmented Taylor Rule

Notes: X-axes are in quarters. Output is expressed in percent deviations from the pre-disaster balanced growth path. Inflation, the monetary policy rate and nominal exchange rate growth are as annualized percentage points differences from the stochastic steady state. The stochastic steady state is obtained by simulating the model in the absence of shocks for 100 quarters.

While, with inflation targeting, monetary policy is tightened following the disaster shock, the responsiveness to output in the conventional Taylor rule leads to a monetary policy

Table 2: Output and Inflation Volatilities, and Welfare Levels Associated with Alternative Monetary Policy Regimes

Monetary policy regime	γ_Π	γ_y	γ_e	Output volatility (%)	Inflation volatility (%)	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	2.8500	0.0086	0.4611	-
Strict inflation targeting	∞	0	0	2.8766	0.0008	0.4597	-0.3253
Hard peg	0	0	∞	3.0500	0.0079	0.4580	-0.6723
Taylor rule	1.5	0.5	0	2.9837	0.0103	0.4575	-0.7807
Exchange-rate aug. TR	1.5	0.5	0.5	2.9863	0.0091	0.4573	-0.8241

Notes: Parameters γ_Π, γ_y and γ_e represent the responsiveness to inflation, output and the exchange rate, respectively, in the interest-rate rule. Output and inflation volatilities are the standard deviations of the percent fluctuations around their respective trends, simulated for 900 quarters, after running the model in the absence of shocks for 100 quarters. The welfare level is the average of the simulated recursive definition of households' welfare. The consumption-equivalent (C.E.) welfare gain represent the permanent increase in consumption (in percent) necessary to make agents as well off as in the inflation targeting regime (with a minus sign representing a welfare loss).

accommodation, which reduces the output contraction by about 1.5 percentage points and leads to a stronger exchange rate depreciation and higher inflation. If the central bank is also concerned with the stability of the exchange rate, this leads to intermediate responses, between those delivered by inflation targeting and a conventional Taylor rule.

6.3 Welfare Outcomes

In the previous subsections, results are based on the analysis of impulse responses to a disaster shock, conditional on monetary policy regimes. This is especially useful to highlight tradeoffs among alternative monetary policy reactions to disasters. The model, and the economies under investigation, however, are subjected by several other shocks, in addition to natural disasters. Therefore, it is informative to simulate the model with all shocks activated and to evaluate welfare outcomes. In Section C.1 of the Appendix we nevertheless show that the results are robust to including only natural disasters and that are not driven by a specific business cycle shock.

Table 2 reports output and inflation volatilities, welfare levels and welfare gain/losses associated with the various monetary policy regimes vis-à-vis the inflation targeting regime.[17]

[17]The alternative monetary policy rules we consider are not optimized, therefore we focus on their relative effects. Choosing another benchmark among those rules would lead to the same welfare ranking. Moreover, below we study how welfare is affected by different values of the parameters in the monetary policy rules. Finally, considering a flexible-price version of the model as the benchmark in the welfare calculations (as e.g. done by Gali and Monacelli, 2005) would compound the losses from sticky prices with those from natural

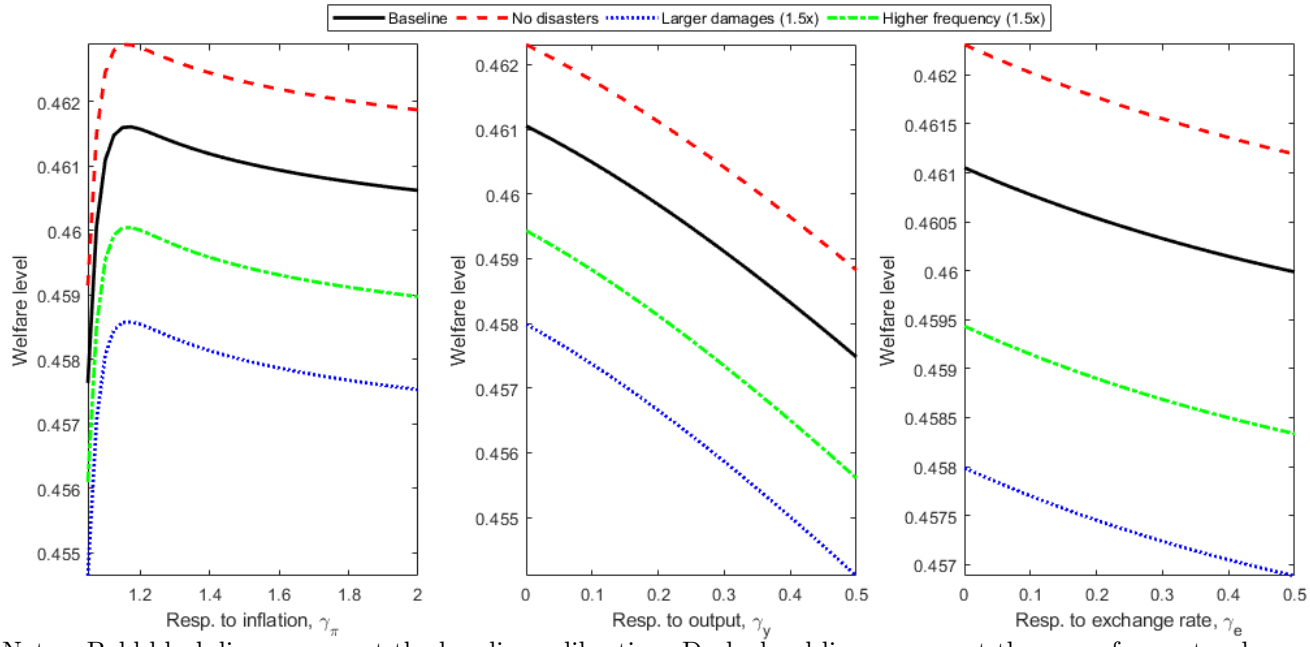
Output and inflation volatilities are captured by the standard deviations of the percent fluctuations of output around its trend and the CPI inflation rate, simulated for 900 quarters, after running the model in the absence of shocks for 100 quarters. The welfare level is the average of the simulated recursive definition of households' utility (equation 7). Finally, the consumption equivalent (C.E.) welfare gain represents the permanent increase in consumption (in percent) necessary to make agents as well off as in the inflation targeting regime (with a minus sign representing a welfare loss). This welfare metric is in the same spirit of Schmitt-Grohé and Uribe (2007) with the difference that we take the model under inflation targeting as the benchmark for calculating the welfare losses rather than the Ramsey policy, as they do. Welfare losses happen to be similar to those reported by Schmitt-Grohé and Uribe (2007). As already mentioned, changing the benchmark would not alter the ranking of the monetary policy rules.

Under the baseline calibration, inflation targeting dominates all other regimes. Relative to this regime, strict inflation targeting leads to a near-zero inflation volatility, a slightly higher output volatility and a welfare loss equivalent to a permanent loss in consumption of about 0.3 percent. A hard peg, by removing the shock-absorbing properties of a flexible exchange rate, is associated with higher output volatility, and to a C.E. welfare loss of about 0.7 percent. In this sense, we extend the results of the small-open economy of Kollmann (2002) to one subject to natural disasters and our findings agree with those of Elekdag and Tuuli (2022) who find that exchange-rate flexibility mitigates the negative impact of weather shocks relative to a fixed-exchange rate regime. Both the conventional and the exchange-rate-augmented Taylor rule deliver an increase in the output and inflation volatilities and a C.E. welfare loss of almost one percent relative to inflation targeting.

Given that the various monetary policy regimes are based on illustrative, and possibly suboptimal, parameterizations, in Figure 6, we report the welfare level as a function of the responsiveness parameters to inflation, output and the exchange rate in the interest-rate rule. In the simulations, these parameters are changed one at a time, leaving the other two set at their baseline values (i.e. $\gamma_\pi = 1.5$, $\gamma_y = \gamma_e = 0$). The same exercise is replicated also under alternative assumptions on the frequency and severity of natural disasters shocks (by keeping all the other shocks activated): (i) no disaster shocks; (ii) larger damages (1.5 larger than baseline); and (iii) higher disaster frequency (1.5 higher than baseline). The no-disaster scenario allows us to evaluate the welfare properties of the different rules in a standard model, i.e. not subject to large negative shocks to capital, TFP and export demand. As expected, the no-disaster scenario delivers a higher welfare level, while higher disaster frequency or severity lead to lower welfare levels than the baseline scenario. How-

disasters but would not alter the welfare ranking among the rules.

Figure 6: Welfare Level as a Function of Responsiveness Parameters to Inflation, Output and the Exchange Rate in the Interest-Rate Rule, under Alternative Assumptions on the Frequency and Severity of Natural Disasters Shocks



Notes: Bold black lines represent the baseline calibration. Dashed red lines represent the case of no natural disasters, while dotted blue and green lines represent the case of more severe and more frequent natural disasters, respectively.

ever, regardless of the assumptions on the disaster-shock calibration, an inflation targeting regime remains the welfare-optimal regime, with a small interest-rate responsiveness to inflation ($\gamma_\Pi \approx 1.17$) being the welfare-maximizing value. This means that the central bank can set the monetary stance at a low level sufficient to stabilize inflation in the medium term, ultimately accommodating a disaster shock to a large extent. Positive values for the monetary policy responsiveness parameters to output or the exchange rate deliver a decrease in the level of welfare.[18] In other words, it is optimal for the central bank to focus only on inflation stabilization, although departures of the inflation rate from target are allowed for in the aftermath of shocks. This way the central bank is able to effectively absorb both demand and supply shocks by stimulating aggregate demand and firms production, respectively, while keeping inflation under control. These results are consistent with the empirical findings of Fratzscher et al. (2020) who show that countries adopting an inflation targeting regime suffer lower output losses and milder surges in inflation than in countries adopting alternative regimes. Moreover, the superiority of inflation targeting in the presence of supply shocks is a well established result in the literature on optimal monetary policy. Indeed, the

[18]Responding to output is welfare reducing also when setting the monetary policy responsiveness to inflation equal to its welfare-maximizing value.

inflation-output tradeoff resulting from supply-side disturbances is generally solved in favor of inflation stabilization (see Kollmann, 2002; Schmitt-Grohé and Uribe, 2007; Keen and Pakko, 2011; Giannoni, 2014; Kim and Ruge-Murcia, 2019, among many others), primarily because it limits inefficient price dispersion. In this model with natural disaster shocks, inflation targeting entails the lowest output volatility and a mild inflation volatility. Inflation targeting achieved this outcome also by boosting the recovery in net exports, via an intermediate nominal exchange rate depreciation in the aftermath of disaster strikes, which would either be too mild under SIT and the hard peg or too large under Taylor rules that respond to output and the exchange rate..

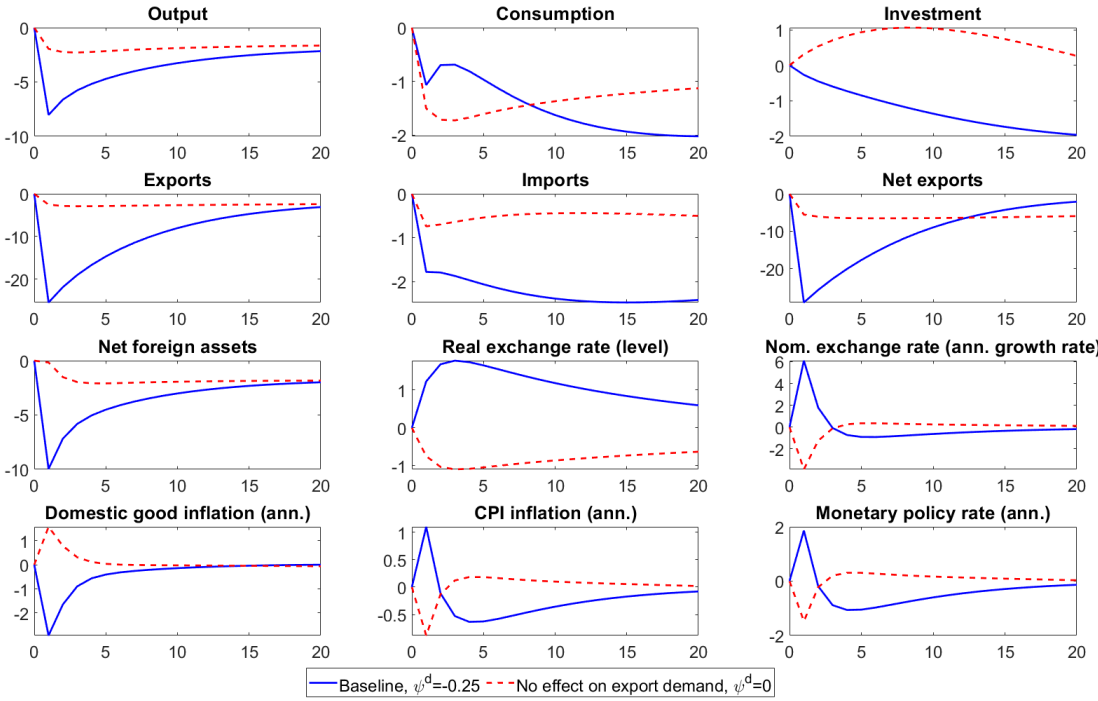
6.4 The Role of the Export Demand Channel

The baseline results include the effects of the export demand channel illustrated in Subsection 4.5, capturing the typical case of tourism-dependent small islands hit by cyclones, which experience an avalanche of cancellations when these episodes ensue. Given that this model feature departs from the closest contributions to this paper in the literature, it seems appropriate to disentangle its role and assess the sensitivity of the results to its removal.

Besides the baseline case with the export channel activated ($\varphi^d = 0.25$), in Figure 7 we also present a counterfactual with no direct impact of the disaster shock on export demand ($\varphi^d = 0$). Removing the export demand channel reduces the aggregate impact of the shock and brings about two consequences. The first is that the stochastic steady state toward which variables converge in the long-run is different. The second concerns the mechanisms at play in the propagation of disaster shocks through aggregate demand.

When the export demand channel is deactivated, the disaster shock behaves as a pure supply-side shock with the decline in home good production leading to an increase in domestic inflation. With export demand effectively insulated from the disaster shock, domestic import capacity is also partially insulated. In the initial periods after the shock, consumption falls more, relative to the case in which the export demand channel is active, and investment increases. The stronger fall in aggregate demand contributes to the inflation decline, which in turn prompts monetary policy easing. The increase in investment is driven by the lower policy rate and the higher marginal product of capital. Later on, consumption increases toward its long-run level, helped by the monetary policy easing. Moreover, the response of imports witnesses a significant quantitative difference relative to the case in which the export demand channel is active, due to the dynamics of investment, consumption and the nominal exchange rate. When exports are directly impacted by disasters, the fall in investment, the more pronounced fall in consumption at later horizons, and the nominal exchange rate

Figure 7: Impulse Responses of Selected Macroeconomic Variables to an Average Natural Disaster Shock in a *Disaster-Prone* Country, under Alternative Assumptions on the Effect of a Natural Disaster on Export Demand



Notes: X-axes are in quarters. Output, consumption, investment, exports, imports, net exports and net foreign assets are expressed in percent deviations from the pre-disaster balanced growth path. Inflation rates, the monetary policy rate and nominal exchange rate growth are as annualized percentage points differences from the stochastic steady state. The real exchange rate is in percentage points deviations from the stochastic steady state. The stochastic steady state is obtained by simulating the model in the absence of shocks for 100 quarters. Bold blue lines represents an average natural disaster shock in a *disaster-prone* country, assuming that natural disasters affect the demand for exports ($\varphi^d = 0.25$). Dashed red lines represents a natural disaster shock of the same intensity, assuming that the disaster has no effect on export demand ($\varphi^d = 0$).

depreciation depress imports to a larger extent. Conversely, absent the direct impact on exports, the different dynamics of consumption and investment, jointly with the nominal exchange rate appreciation, sustain imports.

The supply side shock has an income effect and, given the relatively low elasticity of substitution between the home and imported goods, the adjustment requires an appreciation (decrease) of the real exchange rate to shift the fall in aggregate demand on the domestic good. The real appreciation is achieved by an impact appreciation (decrease) in the nominal exchange rate, which leads to a decline in CPI inflation. Since, in this case, domestic goods inflation remains above its steady state level for a prolonged period, CPI inflation experiences an overshooting following the initial decrease. The response of the monetary

Table 3: Welfare Levels and Losses Associated with Alternative Monetary Policy Regimes–No Export Demand Channel ($\varphi^d = 0$)

Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4566	-
Strict inflation targeting	∞	0	0	0.4548	-0.3942
Hard peg	0	0	∞	0.4529	-0.8103
Taylor rule	1.5	0.5	0	0.4527	-0.8541
Exchange-rate aug. TR	1.5	0.5	0.5	0.4523	-0.9417

Notes: Parameters γ_Π, γ_y and γ_e represent the responsiveness to inflation, output and the exchange rate, respectively, in the interest-rate rule. Output and inflation volatilities are the standard deviations of the percent fluctuations around their respective trends, simulated for 900 quarters, after running the model in the absence of shocks for 100 quarters. The welfare level is the average of the simulated recursive definition of households' welfare. The consumption-equivalent (C.E.) welfare gain represent the permanent increase in consumption (in percent) necessary to make agents as well off as in the inflation targeting regime (with a minus sign representing a welfare loss).

policy rate closely tracks that of CPI inflation.

Since, following disasters, we observe an increase in CPI inflation on average (Figure 2), it seems appropriate to leave this channel activated for the baseline calibration. However, given the empirical heterogeneity in the responses of CPI inflation and monetary policy in the aftermath of disasters (documented in Section 3), the intensity of the export demand channel of disaster shocks (captured by parameter φ^d) represents an effective lever to align responses of these key variables to the experience of specific countries and/or disasters.[19]

Table 3 reports welfare levels and welfare gain/losses associated with the various monetary policy regimes vis-à-vis the inflation targeting regime, when the export demand channel is deactivated ($\varphi^d = 0$). Relative to the baseline case, reported in Table2, the welfare-based ranking of the various regimes remains unaltered, with inflation targeting dominating all other cases.

[19]Under the baseline calibration ($\psi^d = 0.25$) investment falls persistently; it starts recovering after about 7.5 years, and it takes about 12 years for it to stabilize around its new (lower) long-run level. The persistent fall of investment is broadly in line with the empirical evidence reported by Hsiang and Jina (2014). Conversely, when the export demand channel is deactivated ($\psi^d = 0$), investment increases on impact and starts decreasing 2 years after the shock, turning negative after about 6 years and stabilizing at its new (lower) long-run level in about 10 years. Another key difference between the two scenarios is the response of CPI inflation, which is negative when $\psi^d = 0$ and positive under the baseline calibration ($\psi^d = 0.25$), reflecting the median post-disaster increase reported in Figure 2. Parameter ψ^d is clearly country-specific. Calibrating ψ^d to, say, an intermediate value (e.g. $\psi^d = 0.125$) would still deliver an inflation increase, but it would generate a smaller and less persistent fall in investment.

6.5 Accounting for the Long-Term Impact of Natural Disasters on Labor Supply

Weather-related disasters have already caused and are likely to trigger further large cross-country migration, especially in vulnerable areas of the world (see e.g. McLeman and Hunter, 2010; Intergovernmental Panel on Climate Change, 2018; Bhattacharyya and Werz, 2012; McLeman, 2019; Rigaud et al., 2018).[20] Delving into the effects of coastal flooding, Desmet et al. (2021) estimate that rising sea levels and consequent permanent coastal inundation will trigger significant demographic and economic shifts over the next two centuries.[21] In fact, they forecast the displacement of approximately 1.46 percent of the global population by 2200, with dramatic displacement in some countries, e.g. up to about 14 percent in Vietnam. Moreover, similar studies on pandemics have indicated substantial long-term effects on labor supply (Jordà et al., 2022).

Our model abstracts from the impacts of climate disasters on migration and labor supply. Therefore, to ensure the robustness of our findings, we introduce a modification whereby the occurrence of disasters instigates a permanent reduction in labor supply. Following Chang et al. (2007), we assume that labor supply is subject to a permanent shock linked to the realization of a natural disaster. In particular, we define the following random walk process subject to a disaster shock:

$$\log \varepsilon_t^l = \log \varepsilon_{t-1}^l - \zeta_l \left(d_t \theta_t \right), \tag{44}$$

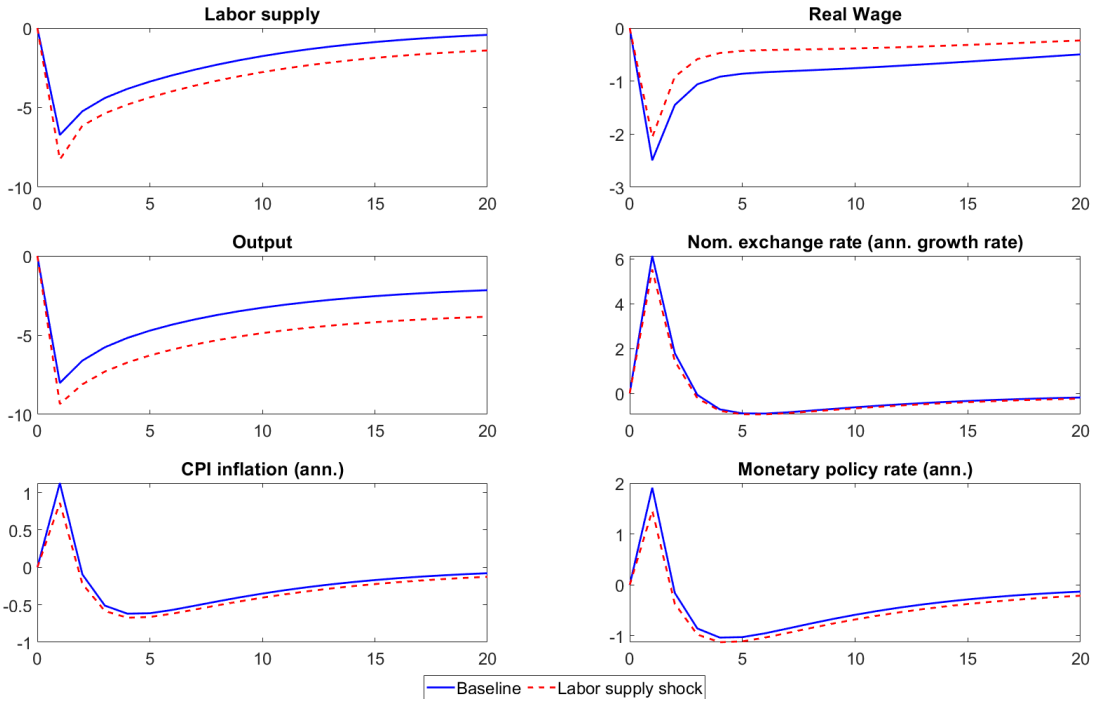
where ζ_l represents a parameter that dictates the permanent impact of disasters on labor supply.[22] This modification has been designed purposefully to represent an extreme scenario, aligning with our objective to ascertain the robustness of our conclusions concerning monetary policy regimes in the face of a substantial long-term decrease in labor supply. Specifically, we calibrate $\zeta_l = 0.25$ to target a long-run population decline of about 10 percent, which is comparable to the prediction of Desmet et al. (2021) for the most affected

[20] McLeman and Hunter (2010) documented multiple instances of significant cross-border movements due to weather-related disasters. The Intergovernmental Panel on Climate Change (2018) has indicated that climate change, by exacerbating climatic variability and extremes, has heightened the vulnerability of South Asian populations, including those in Bangladesh, potentially stimulating migration to India (Bhattacharyya and Werz, 2012). Scientific literature has also shed light on the impacts of climate change on Small Island Developing States, precipitating migration in regions like Tuvalu and Kiribati (McLeman, 2019). Furthermore, a World Bank study (Rigaud et al., 2018) suggests the possibility of climate change inciting the internal migration of over 140 million people by 2050, in sub-Saharan Africa, South Asia and Latin America, which could eventually lead to international displacement.

[21] They exploit a highly spatially disaggregated, dynamic economic model, incorporating factors such as migration, trade, and innovation.

[22] Given that we introduce non-stationarity in labor, this needs to be stationarized by ε_t^l. Other non-stationary variables (e.g. output, consumption, investment, etc) need to be detrended by $z_t \varepsilon_t^l$ rather than only by z_t.

Figure 8: Impulse Responses of Selected Macroeconomic Variables to an Average Natural Disaster Shock in a *Disaster-Prone* Country, baseline vs model with labor supply channel



Notes: X-axes are in quarters. Output is expressed in percent deviations from the pre-disaster balanced growth path. Inflation, the monetary policy rate and nominal exchange rate growth are as annualized percentage points differences from the stochastic steady state. The stochastic steady state is obtained by simulating the model in the absence of shocks for 100 quarters. Bold blue lines represents the effect of an average natural disaster shock in a disaster-prone country under the baseline assumption of no direct effect of natural disasters on labor supply. Dashed red lines the effect of an average natural disaster shock in a disaster-prone country with direct effect of natural disasters on labor supply.

countries by 2200.[23] It is worth noting that our model assumes full employment of the population, so we assume that Desmet et al.'s predictions on the population have a proportional effect on the labor supply.

Figure 8 reports the impulse responses of selected variables to a one-off average natural disaster shock under the baseline specification (blue-solid lines) and under the non-stationary labor supply alternative (red-dashed lines). While under the baseline specification labor supply eventually fully recovers from the initial drop, under the alternative specification labor supply experiences a larger initial drop that is only partly recovered. The lower labor supply amplifies the macroeconomic effects of the shock on output while keeping wages higher

[23]For example, they estimate that compared to a scenario without flooding, the population in 2200 will be lower by 14.6% in Vietnam, 12.4% in Bangladesh and 8.3% in Bahrain.

Table 4: Welfare Levels and Losses Associated with Alternative Monetary Policy Regimes–Labor Supply Channel

Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4630	-
Strict inflation targeting	∞	0	0	0.4609	-0.4536
Hard peg	0	0	∞	0.4586	-0.9503
Taylor rule	1.5	0.5	0	0.4581	-1.0583
Exchange-rate aug. TR	1.5	0.5	0.5	0.4579	-1.1015

Notes: Parameters γ_Π, γ_y and γ_e represent the responsiveness to inflation, output and the exchange rate, respectively, in the interest-rate rule. Output and inflation volatilities are the standard deviations of the percent fluctuations around their respective trends, simulated for 900 quarters, after running the model in the absence of shocks for 100 quarters. The welfare level is the average of the simulated recursive definition of households' welfare. The consumption-equivalent (C.E.) welfare gain represent the permanent increase in consumption (in percent) necessary to make agents as well off as in the inflation targeting regime (with a minus sign representing a welfare loss).

than in the baseline.[24]

Next, we perform the welfare analysis of the alternative monetary policy regimes in the model, assuming permanent effects of disaster shocks on labor supply. The outcome of this exercise is presented in Table 4. Interestingly, the introduction of the labor supply channel in the transmission mechanism of natural disaster shocks does not alter our primary conclusion: inflation targeting continues to stand as the optimal monetary policy regime.

6.6 Summary of Further Robustness Checks

In addition to the various modifications to the model already presented in this Section, we conduct a battery of further robustness checks detailed in Appendix C.

The first check concerns the shocks we introduce in the model. Under the baseline calibration, we feed the simulations with various business cycle shocks, in addition to natural disasters, for the model to deliver reasonable business cycle properties. We therefore switch off one shock at a time, while keeping all other shocks activated (including natural disaster shocks) in order to rule out that the results hinge on the presence of one specific shock.

Second, we substitute the CPI measure of inflation targeted by the central bank with the domestic inflation measure. This seems a necessary experiment given that the latter is a measure of inflation of goods produced domestically, which are not affected by movements

[24]The amplification effect depends on the calibration of parameter ζ_l. While the impulse responses show the impact of a single natural disaster shock of average magnitude, the parameter is calibrated such that labor supply is 10 percent lower over 225 years, during which multiple shocks of different magnitude hit the economy, broadly in line with the prediction of Desmet et al. (2021) for the most affected countries, as already discussed.

in the terms of trade.[25]

Third, we consider the case of nominal GDP targeting, a policy that received attention in the literature but has never been implemented by central banks. A general result in the literature, drawn in closed-economy models (see e.g. McCallum and Nelson, 1999, Garin et al., 2016, Bullard and Singh, 2020 and McKibbin et al., 2021), is that this strategy is desirable under supply shocks that generate the typical inflation-output tradeoff for central banks. We therefore check whether inflation targeting is superior in terms of welfare over nominal GDP targeting in our framework: a small-open-economy model subject to natural disasters that have both supply- and demand-side effects.

Finally, we verify that our results are not driven by some modeling assumptions departing from standard business cycle models used for policy evaluation, spanning from households' utility, to the relative effect of disasters on permanent and temporary TFP, intertia in the policy rule, the elasticity of substitution between home and foreign goods, and the effect of disasters on TFP.

This battery of robustness checks reveals that, while welfare levels change, the main result of the paper still holds: inflation targeting remains the optimal policy under natural disasters.

7 Conclusions

In this paper we assessed the role of monetary policy in contexts where climate-related natural disasters are a major source of macroeconomic fluctuations.

First, we conducted a narrative analysis documenting the effects of natural disasters and central banks' responses. This analysis shows that natural disasters are typically followed by a decline in output and often by an increase in inflation. If there is at least some degree of monetary policy independence, central banks generally change their monetary policy stance in the aftermath of disasters. While monetary policy is commonly tightened, there is a sizable number of cases in which it is accommodated. Policy appraisals and advice by IMF staff have also been mixed, possibly underscoring that while tightening is a direct consequence of concerns toward inflation, stimulating economic activity has been prioritized in certain cases.

[25]Gali and Monacelli (2005) compare the welfare outcomes of targeting these two measures and conclude that using domestic inflation is the optimal policy. However, our aim is not to compare welfare across alternative inflation measures, but verifying whether the welfare ranking of the alternative Taylor rules under consideration is not affected by them.

We then obtained simulations from a macroeconomic model augmented with disaster shocks, used to study alternative monetary policy regimes and evaluated their welfare outcomes. The model analysis demonstrates that, from a welfare standpoint, an inflation targeting regime—whereby inflation can depart temporarily from target—is superior both to extreme regimes, such as strict inflation targeting or hard pegs, and to hybrid regimes in which monetary policy reacts also to output and the exchange rate, besides inflation. In other words, despite the heterogeneous responses in the policy arena, the general superiority of inflation targeting often advocated in the literature extends also to a context with large natural disaster shocks. An important qualification is that the optimal interest-rate responsiveness to inflation is sufficiently small to allow for temporary deviations of inflation from its target. The bottom line is therefore that, even under these difficult circumstances, central banks should continue to focus on price stability, while trying as much as possible to minimize any further impact on the output contraction.

While monetary policy is not a substitute for structural and financial climate adaptation policies, welfare losses from ill-devised monetary policy rules are sizable and may compound with those deriving from the devastating impacts of disasters. This paper abstracts from fiscal responses, which we investigated in previous research (Cantelmo et al., 2023), and does not consider monetary-fiscal policy interactions, which are likely to affect welfare. We conjecture that our results hold also in a context where the fiscal authority responds to natural disasters. The fiscal response would act as a positive aggregate demand shock and would lead to an increase in inflation, making it even more important for a central bank to focus on price stability. We leave this aspect for future research. Furthermore, while for the purposes of our analysis the representative agent framework is adequate, future work should seek to explore heterogeneous impacts of natural disasters in the macroeconomy – and the roles of fiscal and monetary policy in response to these shocks.

References

Adam, C. and Bevan, D. (2020). Tropical cyclones and post-disaster reconstruction of public infrastructure in developing countries. *Economic Modelling*, 93:82–99.

Araujo, J. D., Li, B. G., Poplawski-Ribeiro, M., and Zanna, L.-F. (2016). Current account norms in natural resource rich and capital scarce economies. *Journal of Development Economics*, 120:144 – 156.

Barro, R. J. (2006). Rare Disasters and Asset Markets in the Twentieth Century. *The Quarterly Journal of Economics*, 121(3):823–866.

Barro, R. J. (2009). Rare disasters, asset prices, and welfare costs. *American Economic*

Review, 99(1):243–64.

Barro, R. J. (2015). Environmental protection, rare disasters and discount rates. *Economica*, 82(325):1–23.

Barsky, R., Justiniano, A., and Melosi, L. (2014). The natural rate of interest and its usefulness for monetary policy. *American Economic Review*, 104(5):37–43.

Batini, N., Harrison, R., and Millard, S. P. (2003). Monetary policy rules for an open economy. *Journal of Economic Dynamics and Control*, 27(11):2059–2094.

Benigno, G. (2004). Real exchange rate persistence and monetary policy rules. *Journal of Monetary Economics*, 51(3):473–502.

Bhattacharyya, A. and Werz, M. (2012). Climate change, migration, and conflict in south asia. Technical report, Center for American Progress.

Billi, R. M. (2017). A note on nominal GDP targeting and the zero lower bound. *Macroeconomic Dynamics*, 21(8):2138â2157.

Brown, P., Daigneault, A. J., Tjernström, E., and Zou, W. (2018). Natural disasters, social protection, and risk perceptions. *World Development*, 104:310 – 325.

Bullard, J. and Singh, A. (2020). Nominal GDP targeting with heterogeneous labor supply. *Journal of Money, Credit and Banking*, 52(1):37–77.

Burke, M., Solomon M., H., and Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature*, 527(15725).

Caldara, D., Fernandez, J., Rubio-Ramirez, J., and Yao, W. (2012). Computing DSGE models with recursive preferences and stochastic volatility. *Review of Economic Dynamics*, 15(2):188–206.

Cameron, L. and Shah, M. (2015). Risk-taking behavior in the wake of natural disasters. *Journal of Human Resources*, 50(2):484–515.

Cantelmo, A. (2022). Rare disasters, the natural interest rate and monetary policy. *Oxford Bulletin of Economics and Statistics*, 84(3):473–496.

Cantelmo, A., Melina, G., and Papageorgiou, C. (2023). Macroeconomic outcomes in disaster-prone countries. *Journal of Development Economics*, 161(C).

Carlstrom, C. T., Fuerst, T. S., and Paustian, M. (2010). Optimal monetary policy in a model with agency costs. *Journal of Money, Credit and Banking*, 42(s1):37–70.

Cashin, P., Mohaddes, K., and Raissi, M. (2017). Fair weather or foul? The macroeconomic effects of el niño. *Journal of International Economics*, 106:37–54.

Cassar, A., Healy, A., and von Kessler, C. (2017). Trust, risk, and time preferences after a natural disaster: experimental evidence from Thailand. *World Development*, 94(C):90–105.

Chang, Y., Doh, T., and Schorfheide, F. (2007). Non-stationary hours in a dsge model.

Journal of Money, Credit and Banking, 39(6):1357–1373.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1):1–45.

Clarida, R., Galí, J., and Gertler, M. (1999). The science of monetary policy: A new keynesian perspective. *Journal of Economic Literature*, 37(4):1661–1707.

Clarida, R., Galí, J., and Gertler, M. (2000). Monetary policy rules and macroeconomic stability: Evidence and some theory. *Quarterly journal of Economics*, 115(1):147–180.

Curdia, V. and Woodford, M. (2010). Credit spreads and monetary policy. *Journal of Money, Credit and Banking*, 42(s1):3–35.

Dang, D. A. (2012). On the sources of risk preferences in rural Vietnam. MPRA Paper 38738, University Library of Munich, Germany.

Dávila, E. and Schaab, A. (2023). Optimal Monetary Policy with Heterogeneous Agents: Discretion, Commitment, and Timeless Policy. NBER Working Papers 30961, National Bureau of Economic Research, Inc.

De Winne, J. and Peersman, G. (2021). The adverse consequences of global harvest and weather disruptions on economic activity. *Nature Climate Change*, 11(8):665–672.

Desmet, K., Kopp, R. E., Kulp, S. A., Nagy, D. K., Oppenheimer, M., Rossi-Hansberg, E., and Strauss, B. H. (2021). Evaluating the economic cost of coastal flooding. *American Economic Journal: Macroeconomics*, 13(2):444–86.

Douenne, T. (2020). Disaster risks, disaster strikes, and economic growth: the role of preferences. *Review of Economic Dynamics*, 38:251–272.

Elekdag, S. and Tuuli, M. (2022). Weather shocks and exchange rate flexibility. IMF Working Papers 22/XX, International Monetary Fund.

Epstein, L. G. and Zin, S. E. (1989). Substitution, risk aversion, and the temporal behavior of consumption and asset returns: A theoretical framework. *Econometrica*, 57(4):937–969.

Fernández-Villaverde, J. and Levintal, O. (2018). Solution methods for models with rare disasters. *Quantitative Economics*, 9(2):903–944.

Fiala, O. (2017). *Experiencing Natural Disasters: How This Influences Risk Aversion and Trust*, pages 43–83. Springer International Publishing, Cham.

Fratzscher, M., Grosse-Steffen, C., and Rieth, M. (2020). Inflation targeting as a shock absorber. *Journal of International Economics*, page 103308.

Gabaix, X. (2012). Variable rare disasters: An exactly solved framework for ten puzzles in macro-finance. *The Quarterly Journal of Economics*, 127(2):645–700.

Gali, J. . and Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *Review of Economic Studies*, 72(3):707–734.

Garcia-Cicco, J., Pancrazi, R., and Uribe, M. (2010). Real business cycles in emerging

countries? *American Economic Review*, 100(5):2510–31.

Garin, J., Lester, R., and Sims, E. (2016). On the desirability of nominal GDP targeting. *Journal of Economic Dynamics and Control*, 69(C):21–44.

Giannoni, M. P. (2014). Optimal interest-rate rules and inflation stabilization versus price-level stabilization. *Journal of Economic Dynamics and Control*, 41(C):110–129.

Gourio, F. (2012). Disaster risk and business cycles. *American Economic Review*, 102(6):2734–66.

Hallegatte, S., Dumas, P., and Hourcade, J.-C. (2010). A note on the economic cost of climate change and the rationale to limit it below 2Â°c. Policy Research Working Paper Series 5179, The World Bank.

Heinen, A., Khadan, J., and Strobl, E. (2018). The price impact of extreme weather in developing countries. *The Economic Journal*, 0(0).

Hsiang, S. M. and Jina, A. S. (2014). The causal effect of environmental catastrophe on long-run economic growth: Evidence from 6,700 cyclones. NBER Working Papers 20352, National Bureau of Economic Research, Inc.

Intergovernmental Panel on Climate Change (2018). Special Report: Global Warming of 1.5 C. Technical report.

International Monetary Fund (2017). The effects of weather shocks on economic activity: How can low income countries cope? World Economic Outlook, International Monetary Fund.

Isore, M. and Szczerbowicz, U. (2017). Disaster risk and preference shifts in a New Keynesian model. *Journal of Economic Dynamics and Control*, 79(C):97–125.

Jensen, H. (2002). Targeting nominal income growth or inflation? *American Economic Review*, 92(4):928–956.

Jordà, O., Singh, S. R., and Taylor, A. M. (2022). Longer-Run Economic Consequences of Pandemics. *The Review of Economics and Statistics*, 104(1):166–175.

Judd, K. L. (1992). Projection methods for solving aggregate growth models. *Journal of Economic Theory*, 58(2):410–452.

Justiniano, A. and Preston, B. (2010). Can structural small open-economy models account for the influence of foreign disturbances? *Journal of International Economics*, 81(1):61–74.

Kabundi, A., Mlachila, M., and Yao, J. (2022). How persistent are climate-related price shocks? IMF Working Papers 22/XX, International Monetary Fund.

Kamber, G., McDonald, C., Price, G., et al. (2013). Drying out: Investigating the economic effects of drought in New Zealand. Technical report, Reserve Bank of New Zealand Wellington.

Keen, B. D. and Pakko, M. R. (2011). Monetary policy and natural disasters in a DSGE

model. *Southern Economic Journal*, 77(4):973–990.

Kim, J. and Ruge-Murcia, F. (2019). Extreme events and optimal monetary policy. *International Economic Review*, 60(2):939–963.

Klomp, J. (2020). Do natural disasters affect monetary policy? A quasi-experiment of earthquakes. *Journal of Macroeconomics*, 64:103164.

Knutson, T. R., Sirutis, J. J., Vecchi, G. A., Garner, S., Zhao, M., Kim, H.-S., Bender, M., Tuleya, R. E., Held, I. M., and Villarini, G. (2013). Dynamical downscaling projections of twenty-first-century atlantic hurricane activity: CMIP3 and CMIP5 model-based scenarios. *Journal of Climate*, 26(17):6591 – 6617.

Kollmann, R. (2002). Monetary policy rules in the open economy: Effects on welfare and business cycles. *Journal of Monetary Economics*, 49(5):989–1015.

Levintal, O. (2018). Taylor projection: A new solution method for dynamic general equilibrium models. *International Economic Review*, 59(3):1345–1373.

Marto, R., Papageorgiou, C., and Klyuev, V. (2018). Building resilience to natural disasters: An application to small developing states. *Journal of Development Economics*, 135(C):574–586.

McCallum, B. T. and Nelson, E. (1999). Nominal income targeting in an open-economy optimizing model. *Journal of Monetary Economics*, 43(3):553–578.

McKibbin, W. J., Morris, A. C., Wilcoxen, P. J., and Panton, A. J. (2021). Climate change and monetary policy: Issues for policy design and modelling. *Oxford Review of Economic Policy*, 36(3):579–603.

McLeman, R. (2019). International migration and climate adaptation in an era of hardening borders. *Nature Climate Change*, 9:911–918.

McLeman, R. and Hunter, L. (2010). Migration in the context of vulnerability and adaptation to climate change: insights from analogues. *Wiley Interdisciplinary Reviews: Climate Change*, 1(3):450–461.

Nakamura, E., Steinsson, J., Barro, R., and Ursua, J. (2013). Crises and recoveries in an empirical model of consumption disasters. *American Economic Journal: Macroeconomics*, 5(3):35–74.

Nordhaus, W. (2019). Climate change: the ultimate challenge for economics. *American Economic Review*, 109(6):1991–2014.

Okafor, L. E., Adeola, O., and Folarin, O. (2021). Natural disasters, trade openness and international tourism: the role of income levels across countries. *Tourism Recreation Research*, 0(0):1–19.

Parker, M. (2018). The Impact of Disasters on Inflation. *Economics of Disasters and Climate Change*, 2(1):21–48.

Rigaud, K. K., de Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S., McCusker, B., Heuser, S., and Midgley, A. (2018). Groundswell: Preparing for internal climate migration. Technical report, The World Bank.

Rossello, J., Becken, S., and Santana-Gallego, M. (2020). The effects of natural disasters on international tourism: A global analysis. *Tourism Management*, 79:104080.

Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61(1):163–185.

Schmitt-Grohé, S. and Uribe, M. (2007). Optimal simple and implementable monetary and fiscal rules. *Journal of Monetary Economics*, 54(6):1702–1725.

Schubert, S. F. and Turnovsky, S. J. (2011). The impact of oil prices on an oil-importing developing economy. *Journal of Development Economics*, 94(1):18 – 29.

Shen, W., Yang, S.-C. S., and Zanna, L.-F. (2018). Government spending effects in low-income countries. *Journal of Development Economics*, 133:201 – 219.

Svensson, L. E. O. (2000). Open-economy inflation targeting. *Journal of International Economics*, 50(1):155–183.

Taylor, J. B. (1993). Discretion versus policy rules in practice. In *Carnegie-Rochester conference series on public policy*, volume 39, pages 195–214. Elsevier.

van den Berg, M., Fort, R., and Burger, K. (2009). Natural hazards and risk aversion: experimental evidence from Latin America. Technical report.

Woodford, M. (1998). Doing without money: Controlling inflation in a post-monetary world. *Review of Economic Dynamics*, 1(1):173–219.

Woodford, M. (2003). *Interest and prices: Foundations of a theory of monetary policy*. Princeton University Press.

Appendix

A List of Disaster-Prone Countries

Table A.1: *Disaster-Prone Countries*: Fourth Quartile (75%-100%) of the Annual Probability Distribution of Natural Disasters.

Country	Annual Probability per 1000 sq. km (%)	Damages (% of GDP) Average	Max	Small economy
Marshall Islands	100.00	2.72	2.72	Yes*
St. Vincent and the Grenadines	100.00	4.57	15.0	Yes*
Tuvalu	100.00	N.A.	N.A.	Yes*
Micronesia, Fed. Sts.	50.00	1.85	3.49	Yes*
St. Lucia	48.39	1.07	3.13	Yes*
Tonga	46.67	12.2	29.0	Yes*
Grenada	44.12	74.8	148	Yes*
Dominica	33.33	118	260	Yes*
Kiribati	24.69	N.A.	N.A.	Yes*
Maldives	16.67	N.A.	N.A.	Yes*
Comoros	10.75	0.84	0.84	Yes*
Mauritius	9.80	1.69	4.03	Yes*
Samoa	8.80	8.58	16.6	Yes*
Jamaica	5.91	1.41	8.82	No
Gambia	5.31	N.A.	N.A.	Yes**
Cabo Verde	4.96	0.07	0.07	Yes*
Fiji	4.11	1.70	12.9	Yes*
Vanuatu	4.10	30.2	60.1	Yes*
Haiti	3.60	3.69	25.1	Yes**
El Salvador	3.33	1.87	5.33	No
Macedonia, FYR	2.72	0.44	0.86	No
Burundi	2.69	0.24	0.42	Yes**
Rwanda	2.47	0.00	0.00	Yes**
Eswatini	2.30	0.00	0.00	Yes*
Belize	1.96	12.8	33.4	Yes*
Lebanon	1.91	N.A.	N.A.	No
Montenegro	1.81	N.A.	N.A.	Yes*
Dominican Republic	1.75	1.03	9.14	No
Albania	1.74	0.16	0.39	No
Solomon Islands	1.73	0.80	2.04	Yes*
Timor-Leste	1.68	N.A.	N.A.	Yes*
Costa Rica	1.57	0.21	0.67	No
Sri Lanka	1.52	0.24	1.47	No
Moldova	1.33	2.47	9.22	No

Source: Cantelmo et al. (2023).

Notes: Countries are ordered by the annual probability of a natural disaster per 1000 squared kilometers over the sample 1998-2017. EM-DAT provides damages in US dollars. Damages in percent of GDP are obtained dividing damages by GDP of the year of the event. Damages (% of GDP) are computed for each country by using data for each single event over the sample 1998-2017. Small economies comprise small states and low-income countries.*Denotes Small states which are countries with a population below 1.5 million that are not advanced economies or high-income oil exporting countries (IMF). ** Denotes Low-income-countries which are countries with a GNI per capita below $995 in 2017 (World Bank).

B Narrative Analysis

Table B.1: List of Disasters Used in the Narrative Analysis and Corresponding Year of IMF Article IV Staff Report

Country	Year of Disaster	Year of IMF Article IV Staff Report	Cumulative Damages (% of GDP)	Disaster Type
Belize	2000	2001	33.25	Storm
Belize	2001	2002	28.67	Storm
Belize	2007	2008	1.15	Storm
Dominica****	2015	2016*	90.24	Storm
Dominica	2017	2018*	260	Storm
Dominican Republic	1998	1999	9.14	Flood
El Salvador	1998	1999	5.10	Drought, Storm
El Salvador	2005	2006	2.42	Storm
El Salvador	2009	2010	5.49	Drought†, Storm
El Salvador	2011	2013	4.93	Flood
Fiji	2003	2004	1.30	Storm
Fiji	2009	2009	1.97	Flood, Storm†
Fiji	2010	2010	1.26	Storm
Fiji	2012	2013	2.45	Flood, Storm†
Fiji	2016	2017	12.86	Storm
Grenada	1999	2000	1.14	Storm
Grenada	2004	2005*	148.41	Storm
Haiti	1998	1999	4.83	Storm
Haiti	2004	2005	1.44	Storm
Haiti	2012	2012	3.22	Flood‡, Storm
Jamaica	2004	2005	8.82	Storm
Jamaica	2007	2008	2.34	Storm
Jamaica	2010	2011	1.14	Storm
Marshall Islands	2015	2016	2.72	Drought
Mauritius	2002	2003	1.03	Storm
Micronesia, Fed. States of	2015	2017**	3.49	Storm
Moldova	2000	2001	2.45	Drought‡, Storm
Moldova	2007	2007	9.22	Drought
Samoa	2012	2015	16.60	Storm
Solomon Islands	2014	2016	2.04	Flood
Sri Lanka	2016	2017	1.49	Drought†, Flood
St. Vincent and the Grenadines	2002	2002***	2.38	Storm
St. Vincent and the Grenadines	2010	2011*	3.67	Storm
St. Vincent and the Grenadines	2013	2014	14.98	Flood

Source: EM-DAT (EM-DAT: The Emergency Events Database - Universite Catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium.) and Cantelmo et al. (2023).
Notes:*Authors combined Article IV staff reports for the country in question, as well as the ECCU (Eastern Caribbean Currency Union). Both Article IVs are dated at the same year.
**Authors combined Article IV staff reports for the country in question, as well as the ECCU (Eastern Caribbean Currency Union). The ECCU Article IV is dated a year before the country one.
***Authors combined Article IV staff reports for the country in question, as well as the ECCU (Eastern Caribbean Currency Union). The ECCU Article IV is dated a year after the country one.
****Dominica received IMF support (Catastrophe Containment and Relief Trust) under the financial instruments designed for these circumstances, in 2015. The Catastrophe Containment and Relief Trust (CCRT) allows the IMF to provide grants for debt relief for the poorest and most vulnerable countries hit by catastrophic natural disasters or public health disasters. The relief on debt service payments frees up additional resources to meet exceptional balance of payments needs created by the disaster and for containment and recovery. Established in February 2015 during the Ebola outbreak and modified in March 2020 in response to the COVID-19 pandemic.
† This disaster led to damages <1% of GDP, while the other disaster let to damages >1% of GDP. Cumulative damages encompass both disasters.
‡The magnitude of the damages for this particular disaster is unreported, therefore they are excluded from the cumulative damages.

B.1 Methodology

The narrative analysis covers the macroeconomic and monetary policy performance of countries after the disaster, as well as the monetary policy tools that might have been mobilized to mitigate the negative impact that disasters had on the economy. The assessment is conducted by recording the nature of the mobilized monetary policy tools, whether policy was accommodative or tight, the appraisal of the monetary policy stance by IMF staff and/or Board of Directors, and the IMF's advice on the monetary policy stance for the near future.

Table B.2 shows the complete set of questions answered to construct our dataset. Some questions relate to structural features that might change over time, such as the exchange rate regime and monetary policy independence. For example, El Salvador had its own legal tender when Hurricane Mitch struck in October 1998, but did not possess this feature when Hurricane Adrian struck in May 2005, because effective January 1, 2001, the U.S. dollar became its legal tender. Other questions are on the changes in key macroeconomic variables such as the GDP growth rate and the inflation rate, in the aftermath of the disaster. Others relate to the monetary policy response in countries where the monetary policy regime allows to mobilize it. In this respect, we classify as "independent" a monetary policy regime in which a country has full control on their monetary policy; "not independent" a regime of an economy that does not have its own legal tender or it has a hard peg; and "mixed" a regime where, although there is peg or exchange rate anchor, limited capital mobility still allows room for monetary policy. The final set of questions is on the IMF evaluation of these policy actions, and on its advice on future adjustments. The answers to these questions are especially important, because both in the literature and in policy circles, there is no consensus about how monetary policy should be conducted in the aftermath of a disaster. Table B.3 illustrates how the questions are answered using the example of Hurricane Iris that hit Belize on October 4, 2001. Table B.4 provides a detailed documentation of how these questions have been answered, in order to create our dataset. The fourth collumn is using either quotes directly taken from the "Article IV" consultations, or authors' comments (provided in brackets).

Table B.2: Questions Posed to Conduct the Narrative Analysis

#	Question	Possible answers
1	Does the country have its own legal tender?	Y-N
2	Is its currency pegged to some other currency or basket of currencies?	Y-N
3	Can we characterize monetary policy as independent?	Y-N-Mixed
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y-N-NA
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y-N-NA
6	Were there any challenges for maintaining the peg? (peg countries)	Y-N-NA
7	Were reserves impacted negatively?	Y-N-NA
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated-Tightened-Unchanged
9	What was the monetary policy tool authorities used?	Open question
10	Did IMF agree with the authorities' policy action?	Y-N-Neutral
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Accommodate-Tighten-Neutral

Table B.3: Example of Narrative Analysis Documentation: Belize, 2001

#	Question	Answer	Quotes from the 2002 Article IV Staff Report
...			
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Real GDP growth declined from 11 percent in 2000 to 5 percent in 2001, as a result of several hurricanes...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...However, on the positive side, inflation remained very low at an annual rate of $1\frac{1}{4}$ percent...
...			
6	Were there any challenges for maintaining the peg? (peg countries)	Y	...The authorities agreed that current policies were unsustainable and that policy corrections were necessary to prevent severe balance of payments difficulties and maintain the exchange rate peg...
...			
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Given their resolute commitment to the official peg to the US$, the authorities recently acted on staff advice to mop up this liquidity...

Sources: Authors and 2002 Article IV IMF Staff Report for Belize.

Table B.4: Narrative Analysis Documentation

Belize, 2000

#	Question	Answer	Quotes from the 2001 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Belize dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Belize dollar, pegged to the U.S. dollar since 1976...
3	Can we characterize monetary policy as independent?	Mixed	[Belize has a soft peg with some room for independent monetary policy]
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...Real GDP growth is estimated to have increased sharply to 10.4 percent in 2000...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...Consumer prices increased by 1 percent during the year after three years of moderate deflation.
6	Were there any challenges for maintaining the peg? (peg countries)	Y	...the liquidity injection through the DFC operations, increased the liquidity overhang in the economy, and created pressures in foreign exchange markets...
7	Were reserves impacted negatively?	Y	...and a similar loss of net international reserves as the central bank absorbs liquidity...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	...reduce excess liquidity to help secure the sustainability of the exchange rate peg...
9	What was the monetary policy tool authorities used?	Reduce excess liquidity	...reduce excess liquidity to help secure the sustainability of the exchange rate peg...
10	Did IMF agree with the authorities' policy action?	Y	...The staff welcomes the authorities' decision...and believes that a continuation of such a policy...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	....The staff supported the central bank's intention to reduce bank liquidity...

Belize, 2001

#	Question	Answer	Quotes from the 2002 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Belize dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Belize dollar, pegged to the U.S. dollar since 1976...
3	Can we characterize monetary policy as independent?	Mixed	[Belize has a soft peg with some room for independent monetary policy]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Real GDP growth declined from 11 percent in 2000 to 5 percent in 2001, as a result of several hurricanes...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...However, on the positive side, inflation remained very low at an annual rate of $1\frac{1}{4}$ percent...
6	Were there any challenges for maintaining the peg? (peg countries)	Y	...The authorities agreed that current policies were unsustainable and that policy corrections were necessary to prevent severe balance of payments difficulties and maintain the exchange rate peg...
7	Were reserves impacted negatively?	Y	...Overall, net international reserves of the CBB declined...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	...Monetary policy has accommodated the expansionary thrust of fiscal policy with the result that a sizeable liquidity overhang accumulated...
9	What was the monetary policy tool authorities used?	Liquidity injection	...The fiscal deficit was financed from deposits at the Central Bank of Belize (CBB)...
10	Did IMF agree with the authorities' policy action?	N	...the fiscal and monetary policies were unsustainable...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...The staff also recommended a tightening of monetary policy...

Belize, 2007

#	Question	Answer	Quotes from the 2008 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Belize dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Belize dollar, pegged to the U.S. dollar since 1976...
3	Can we characterize monetary policy as independent?	Mixed	[Belize has a soft peg with some room for independent monetary policy]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Following an upturn in 2006, economic growth weakened in 2007, reflecting the impact of Hurricane Dean on agricultural output and tourism, closures in garment and aquaculture industries, and a leveling off in oil production...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...However, inflation remained low at 3 percent...
6	Were there any challenges for maintaining the peg? (peg countries)	N	[No reference to any challenges]
7	Were reserves impacted negatively?	N	...international reserves increased further, to US$108 million by end-2007...
8	Was monetary policy tightened, accommodated or unchanged?	Unchanged	[Monetary policy was unchanged]

Table B.4: Narrative Analysis Documentation

9	What was the monetary policy tool authorities used?	NA	[Monetary policy was unchanged]
10	Did IMF agree with the authorities' policy action?	Y	[Staff did not challenge the authorities' choices]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Neutral	[No mention on future monetary policy changes]

Dominica, 2015

#	Question	Answer	Quotes from the 2016 Article IV Staff Report
1	Does the country have its own legal tender?	N	[Eastern Caribbean dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...given the peg of the EC dollar...
3	Can we characterize monetary policy as independent?	N	...the monetary policy stance is decided by the Monetary Council of the ECCU...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Economic growth contracted by nearly 4 percent last year...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...Inflation is expected to remain low...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	...unchanged peg to the U.S. dollar since 1976...
7	Were reserves impacted negatively?	N	...The ratio of international reserves to money base was 96 percent at end-2015, compared with the statutory mandate of 60 percent...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

Dominica, 2017

#	Question	Answer	Quotes from the 2018 Article IV Staff Report
1	Does the country have its own legal tender?	N	[Eastern Caribbean dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...given the peg of the EC dollar...
3	Can we characterize monetary policy as independent?	N	...this issue goes beyond our authorities'direct purview given that the monetary policy stance is decided by the Monetary Council of the ECCU...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...While Erika had caused severe damage, estimated at 96 percent of GDP...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...Sharp increases in the prices of food and medication were experienced by hurricane-struck countries...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	...unchanged peg to the U.S. dollar since 1976...
7	Were reserves impacted negatively?	Y	...reserves decreased modestly in 2017...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

Dominican Republic, 1998

#	Question	Answer	Quotes from the 1999 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Dominican Peso]
2	Is its currency pegged to some other currency or basket of currencies?	N	...flexible exchange rate policy...
3	Can we characterize monetary policy as independent?	Y	...Monetary policy is conducted through a mix of direct and indirect instruments...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...As expected, real GDP growth slowed modestly...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...inflation rose...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	N	...International reserves rose by about US 100 million...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	...Base money growth (12-month basis) accelerated to nearly 20 percent, mainly reflecting an accommodation...

Table B.4: Narrative Analysis Documentation

9	What was the monetary policy tool authorities used?	Increased broad money growth rate	...Base money growth (12-month basis) accelerate by nearly 20 percent...
10	Did IMF agree with the authorities' policy action?	Neutral	...The mission suggested that the central bank rely more on indirect monetary instruments...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Policy discussions focused on the need to ... through a tighter stance and a prudent monetary policy...

El Salvador, 1998

#	Question	Answer	Quotes from the 1999 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[El Salvador Colón]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...the present peg to the U.S. dollar will be maintained...
3	Can we characterize monetary policy as independent?	Mixed	[El Salvador has a soft peg with some room for independent monetary policy]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Developments in 1999 point to a slowdown in real GDP growth to 2.2% percent...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...consumer prices rose by 4.2 percent (3% percent in the program) due to the impact of Hurricane Mitch...
6	Were there any challenges for maintaining the peg? (peg countries)	Y	...the sustainability of the peg over the medium term will require efforts...
7	Were reserves impacted negatively?	Y	...To reverse the reserve loss, in early November...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	...The rate of growth of broad money declined to 9% percent in 1998...
9	What was the monetary policy tool authorities used?	Decreased broad money	...The rate of growth of broad money declined...
10	Did IMF agree with the authorities' policy action?	Y	...The staff generally agreed with the authorities' strategy...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Neutral	[No mention on future monetary policy changes]

El Salvador, 2005

#	Question	Answer	Quotes from the 2006 Article IV Staff Report
1	Does the country have its own legal tender?	N	[U.S. Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	NA	...As a result, El Salvador has an exchange rate arrangement with no separate legal tender category...
3	Can we characterize monetary policy as independent?	N	...Under dollarization... lack of independent monetary policy...
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...GDP growth has started to accelerate...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...year-on-year inflation fell to $3\frac{1}{2}$ percent...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[The country does not have its own legal tender]
7	Were reserves impacted negatively?	N	...The authorities agreed to keep the central bank's disposable foreign reserves at current levels...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

El Salvador, 2009

#	Question	Answer	Quotes from the 2010 Article IV Staff Report
1	Does the country have its own legal tender?	N	[U.S. Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	NA	...As a result, El Salvador has an exchange rate arrangement with no separate legal tender category...
3	Can we characterize monetary policy as independent?	N	...As a result, El Salvador has an exchange rate arrangement with no separate legal tender category...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...In the first quarter of 2010 GDP fell only 0.5 percent (y/y) after declining 4.9 percent in the last quarter of 2009...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...Prices have remained stable...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[The country does not have its own legal tender]
7	Were reserves impacted negatively?	Y	...decrease in net international reserves ...

Table B.4: Narrative Analysis Documentation

8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

El Salvador, 2011

#	Question	Answer	Quotes from the 2012 Article IV Staff Report
1	Does the country have its own legal tender?	N	[U.S. Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	NA	...As a result, El Salvador has an exchange rate arrangement with no separate legal tender category...
3	Can we characterize monetary policy as independent?	N	...As a result, El Salvador has an exchange rate arrangement with no separate legal tender category...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...El Salvador has been trapped into a risky combination of low growth...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...Inflation remained low...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[The country does not have its own legal tender]
7	Were reserves impacted negatively?	N	...adequate level of gross international reserves...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

Fiji, 2003

#	Question	Answer	Quotes from the 2004 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Fijian Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Since April 1975, the exchange rate of the Fiji dollar has been linked to a basket of currencies of Fiji's five major trading partners...
3	Can we characterize monetary policy as independent?	Mixed	...The mission emphasized that fiscal and monetary policy must be consistent with the peg...
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...Fiji's economic growth in recent years has been high by historical standards...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...inflation remained modest...
6	Were there any challenges for maintaining the peg? (peg countries)	Y	...an adjustment in the peg may need to be considered at some stage, in response to the large external shocks Fiji faces...
7	Were reserves impacted negatively?	Y	...International reserves have declined relative to imports...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	...The tightening of monetary policy in May 2004 was appropriate...
9	What was the monetary policy tool authorities used?	Increased interest rates	...The RBF raised interest rates by 50 basis points...
10	Did IMF agree with the authorities' policy action?	Y	...and the mission endorsed this first tightening of the monetary stance...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...A tightening of monetary policy should play a complementary role...

Fiji, 2009

#	Question	Answer	Quotes from the 2010 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Fijian Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Since April 1975, the exchange rate of the Fiji dollar has been linked to a basket of currencies of Fiji's five major trading partners...
3	Can we characterize monetary policy as independent?	Mixed	...The mission emphasized that fiscal and monetary policy must be consistent with the peg...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...The economy is expected to contract by $2\frac{1}{2}$ percent in 2009...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...inflation did not rise substantially as a result of the devaluation...
6	Were there any challenges for maintaining the peg? (peg countries)	Y	[No reference to any challenges]
7	Were reserves impacted negatively?	Y	...As a result, foreign reserves fell to low levels...

Table B.4: Narrative Analysis Documentation

8	Was monetary policy tightened, accommodated or unchanged?	Unchanged	[No reference to any monetary policy instruments mobilized]
9	What was the monetary policy tool authorities used?	NA	[No reference to any monetary policy instruments mobilized]
10	Did IMF agree with the authorities' policy action?	Y	[Staff did not challenge the authorities' choices]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Staff and the authorities agreed that monetary policy should be tightened...

Fiji, 2010

#	Question	Answer	Quotes from the 2011 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Fijian Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Since April 1975, the exchange rate of the Fiji dollar has been linked to a basket of currencies of Fiji's five major trading partners...
3	Can we characterize monetary policy as independent?	Mixed	...The mission emphasized that fiscal and monetary policy must be consistent with the peg...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Fiji's economy contracted by 3 percent...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...contributed to low inflation...
6	Were there any challenges for maintaining the peg? (peg countries)	N	[No reference to any challenges]
7	Were reserves impacted negatively?	N	...Foreign exchange reserves have improved steadily...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	...Staff did not object to the RBF's accommodative monetary policy...
9	What was the monetary policy tool authorities used?	Decreased policy rates	...accommodative monetary stance as broadly appropriate. Given the structural lack of credit demand and the weak transmission mechanism, the effectiveness of low policy rates may nevertheless...
10	Did IMF agree with the authorities' policy action?	Y	...Staff did not object to the RBF's accommodative monetary policy...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Monetary policy should be gradually tightened...

Fiji, 2012

#	Question	Answer	Quotes from the 2013 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Fijian Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Since April 1975, the exchange rate of the Fiji dollar has been linked to a basket of currencies of Fiji's five major trading partners...
3	Can we characterize monetary policy as independent?	Mixed	...The mission emphasized that fiscal and monetary policy must be consistent with the peg...
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...helping the economy expand by 2.2 percent, despite the negative impact from Cyclone Evan and the massive floods...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...inflation was on a declining trend in 2012 reaching 2.5 percent (new 2008 base) by year end. In September 2013, inflation was 3.1 percent...
6	Were there any challenges for maintaining the peg? (peg countries)	N	[No reference to any challenges]
7	Were reserves impacted negatively?	N	...and international reserves have stabilized to a comfortable level...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	...The authorities have maintained an accommodative monetary policy...
9	What was the monetary policy tool authorities used?	Decreased interest rates	...Low interest rates and the one-time payouts under The FNPF reform were the main drivers for growth...
10	Did IMF agree with the authorities' policy action?	Y	...Directors saw the accommodative monetary policy as appropriate...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...the RBF should use open market operations more aggressively to reduce excess liquidity and, if necessary, tighten policy rates...

Fiji, 2016

#	Question	Answer	Quotes from the 2017 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Fijian Dollar]
2	IIs its currency pegged to some other currency or basket of currencies?	Y	...Since April 1975, the exchange rate of the Fiji dollar has been linked to a basket of currencies of Fiji's five major trading partners...
3	Can we characterize monetary policy as independent?	Mixed	...The mission emphasized that fiscal and monetary policy must be consistent with the peg...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...GDP growth is estimated to have rebounded to 3.8 percent in 2017 from 0.4 percent in 2016...

Table B.4: Narrative Analysis Documentation

5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...Directors noted that the pickup in headline inflation...
6	Were there any challenges for maintaining the peg? (peg countries)	N	[No reference to any challenges]
7	Were reserves impacted negatively?	Y	...but foreign reserves remained adequate...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	...Monetary policy remains accommodative...
9	What was the monetary policy tool authorities used?	Decreased interest rates	...The combination of lower lending interest rates and...
10	Did IMF agree with the authorities' policy action?	Y	...Maintaining an accommodative monetary policy stance was appropriate in the aftermath of Cyclone Winston...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Monetary policy should be tightened as the recovery becomes firmer...

Grenada, 1999

#	Question	Answer	Quotes from the 2000 Article IV Staff Report
1	Does the country have its own legal tender?	N	[Eastern Caribbean dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...the Eastern Caribbean dollar, that has been pegged to the U.S. dollar...
3	Can we characterize monetary policy as independent?	N	...The ECCU has a common central bank, the Eastern Caribbean Central Bank (ECCB)...
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...reflecting the rapid growth in activity, the average per capita income rose...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...by a reduction in unemployment and low inflation...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	...unchanged peg to the U.S. dollar since 1976...
7	Were reserves impacted negatively?	N	...international reserves of Grenada in the ECCB would be maintained...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

Grenada, 2004

#	Question	Answer	Quotes from the 2005 Article IV Staff Report
1	Does the country have its own legal tender?	N	[Eastern Caribbean dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...the Eastern Caribbean dollar, that has been pegged to the U.S. dollar...
3	Can we characterize monetary policy as independent?	N	...The ECCU has a common central bank, the Eastern Caribbean Central Bank (ECCB)...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...The economy contracted by 3 percent in 2004...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...Inflation has remained low...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	...unchanged peg to the U.S. dollar since 1976...
7	Were reserves impacted negatively?	N	...Gross international reserves of the Eastern Caribbean Central Bank (ECCB) have continued to rise...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

Haiti, 1998

#	Question	Answer	Quotes from the 1999 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Haitian Gourde]
2	Is its currency pegged to some other currency or basket of currencies?	N	...It is generally agreed that a flexible exchange rate is appropriate...
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...Haitian authorities have managed to maintain macroeconomic stability...

Table B.4: Narrative Analysis Documentation

5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...Inflation declined...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	N	...official reserves have risen...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	...The authorities have persevered with prudent monetary and fiscal policy...
9	What was the monetary policy tool authorities used?	Decreased broad money growth rate	...use open market operations to control the money supply...
10	Did IMF agree with the authorities' policy action?	Y	...On monetary policy, Directors welcomed the authorities' intention...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Monetary policy will continue to focus on controlling inflation...

Haiti, 2004

#	Question	Answer	Quotes from the 2005 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Haitian Gourde]
2	Is its currency pegged to some other currency or basket of currencies?	N	...It is generally agreed that a flexible exchange rate is appropriate...
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...The property damage and the interruption to economic activity are estimated to have totaled 5½ percent of GDP...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...prices have been highly volatile on a month-to-month basis, as a result of supply disruptions caused by the September 2004 floods...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	N	...and net international reserves have increased...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	...During August–October 2004, interest rates were reduced to 7.6 percent from 13.6 percent...
9	What was the monetary policy tool authorities used?	Decreased interest rates	...During August–October 2004, interest rates were reduced to 7.6 percent from 13.6 percent...
10	Did IMF agree with the authorities' policy action?	N	...Directors expressed concern...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Monetary policy needs to be tightened...

Haiti, 2012

#	Question	Answer	Quotes from the 2012 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Haitian Gourde]
2	Is its currency pegged to some other currency or basket of currencies?	N	...It is generally agreed that a flexible exchange rate is appropriate...
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...GDP continued to grow, albeit modestly, in per capita terms...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...Inflation spiked but remained at single digits...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	N	...Gross liquid international reserves were considerably strengthened...
8	Was monetary policy tightened, accommodated or unchanged?	Unchanged	..Directors endorsed the current neutral stance of monetary policy...
9	What was the monetary policy tool authorities used?	NA	..Directors endorsed the current neutral stance of monetary policy...
10	Did IMF agree with the authorities' policy action?	Y	...Directors endorsed the current neutral stance of monetary policy...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...endorsed the current neutral stance of monetary policy but encouraged the authorities to keep price inflation in check...

Jamaica, 2004

#	Question	Answer	Quotes from the 2005 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Jamaican Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	N	[No peg]
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Real GDP contracted sharply in late 2004 following the devastating effects of Hurricane Ivan....

Table B.4: Narrative Analysis Documentation

5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...Consumer prices registered a marked increase in the aftermath of Hurricane Ivan...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	N	...net international reserves (NIR) increased rapidly...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	...Monetary policy has been geared at containing inflation...
9	What was the monetary policy tool authorities used?	Increased interest rates	...moderate increases in domestic interest rates...
10	Did IMF agree with the authorities' policy action?	Y	[No reference to disagreement]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Directors emphasized the need for careful conduct of monetary and exchange rate policies in the period ahead...

Jamaica, 2007

#	Question	Answer	Quotes from the 2008 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Jamaican Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	N	[No peg]
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Economic growth weakened...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...inflation accelerated...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	Y	...to stem reserve losses...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	....Tighten monetary policy moderately...
9	What was the monetary policy tool authorities used?	Increased interest rates	...increases in interest rates...
10	Did IMF agree with the authorities' policy action?	Y	...Directors commended the authorities' commitment...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Directors were of the view that a further moderate rise in interest rates might be needed to alleviate inflationary . pressures and stem capital outflows...

Jamaica, 2010

#	Question	Answer	Quotes from the 2011 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Jamaican Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	N	[No peg]
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...rebounded from the destruction of tropical storm Nicole in 2010...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...contributed to a fall in 12- month inflation...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	Y	...Net international reserves fell...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	...the central bank lowered the policy rate to 6.25 percent...
9	What was the monetary policy tool authorities used?	Decreased interest rates	...the central bank lowered the policy rate to 6.25 percent...
10	Did IMF agree with the authorities' policy action?	Neutral	[Staff did not challenge the authorities' choices]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Neutral	[No mention on future monetary policy changes]

Marshall Islands, 2015

#	Question	Answer	Quotes from the 2016 Article IV Staff Report
1	Does the country have its own legal tender?	N	[U.S. Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...The U.S. dollar is used as the legal tender...
3	Can we characterize monetary policy as independent?	N	[Does not have its own legal tender]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...overcoming the contraction of the previous year...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...a moderate inflation of 1.1 percent...

Table B.4: Narrative Analysis Documentation

6	Were there any challenges for maintaining the peg? (peg countries)	NA	[Does not have its own legal tender]
7	Were reserves impacted negatively?	N	[No reference to negative impact]
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

Mauritius, 2002

#	Question	Answer	Quotes from the 2003 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Mauritian Rupee]
2	Is its currency pegged to some other currency or basket of currencies?	N	[No peg]
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...real GDP growth is expected to slow in 2002/03...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...Consumer price inflation has recently shown a declining trend...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	N	...the net international reserves of the central bank increased...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	...Monetary policy was tightened in 2002/03...
9	What was the monetary policy tool authorities used?	Increased interest rates	...monitor liquidity conditions carefully before reducing interest rates...
10	Did IMF agree with the authorities' policy action?	Y	...Directors agreed that monetary policy in Mauritius is appropriately tight..
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...the staff discussed the importance of maintaining prudent monetary and exchange rate policies...

Micronesia, Fed. States of, 2015

#	Question	Answer	Quotes from the 2017 Article IV Staff Report
1	Does the country have its own legal tender?	N	[U.S. Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	NA	...U.S. dollars, the legal tender and official currency in the FSM...
3	Can we characterize monetary policy as independent?	N	[Does not have its own legal tender]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Real GDP is estimated to have grown by 3.0 percent in 2016 (after 3.7 percent in 2015)....
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...Inflation is expected to remain low...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	...U.S. dollars, the legal tender and official currency in the FSM...
7	Were reserves impacted negatively?	N	...The ratio of international reserves to money base was 96 percent at end-2015, compared with the statutory mandate of 60 percent...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

Moldova, 2000

#	Question	Answer	Quotes from the 2001 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Moldovan Leu]
2	Is its currency pegged to some other currency or basket of currencies?	N	...fully floating exchange rate...
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...real GDP is expected to remain flat in 2000...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...In 2000 inflation was much lower...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]

Table B.4: Narrative Analysis Documentation

7	Were reserves impacted negatively?	N	...Reserves increased to US$181 million...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	...Monetary policy was successfully tightened in the first half of 2000...
9	What was the monetary policy tool authorities used?	Increased interest rates	...reverse the downward trend in interest rates...
10	Did IMF agree with the authorities' policy action?	Y	...Monetary policy was successfully tightened in the first half of 2000...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	....disciplined monetary policy...

Moldova, 2007

#	Question	Answer	Quotes from the 2007 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Moldovan Leu]
2	Is its currency pegged to some other currency or basket of currencies?	N	...fully floating exchange rate...
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...The economy grew strongly in the first half of 2007, but slowed somewhat in the second half due to...the summer drought....
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...inflation continues to be stubbornly in double digits...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	N	...The build-up of reserves at the end of the year exceeded US$ 1.3 billion which was well above what was projected under the program...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	....Despite the tightening up early in the year, reserve money continued o grow which prompted the central bank to raise reserve requirements...
9	What was the monetary policy tool authorities used?	Increased interest rates	...and raised policy interest rates by 2.5 percentage points...
10	Did IMF agree with the authorities' policy action?	Y	...The authorities and staff agreed that monetary policy should remain tight until disinflation is firmly reestablished....
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...The authorities and staff agreed that monetary policy should remain tight until disinflation is firmly reestablished....

Samoa, 2012

#	Question	Answer	Quotes from the 2015 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Samoan Tala]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...The exchange rate of the tala is pegged to a basket of currencies...
3	Can we characterize monetary policy as independent?	Mixed	[Samoa has a soft peg with some room for independent monetary policy]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...Growth is recovering gradually from natural disasters...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...and inflation remains subdued...
6	Were there any challenges for maintaining the peg? (peg countries)	N	...pegged against a basket of major trading partner currencies, has remained broadly stable...
7	Were reserves impacted negatively?	N	...reserves are adequate...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	... A loose monetary policy has supported the recovery...
9	What was the monetary policy tool authorities used?	Decrease interest rates	...lower interest rates...
10	Did IMF agree with the authorities' policy action?	Y	...monetary policy is appropriate...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...stressed that the central bank should stand ready to adopt a tightening stance...

Solomon Islands, 2014

#	Question	Answer	Quotes from the 2016 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Solomon Island Dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...The basket exchange rate regime is operating well...
3	Can we characterize monetary policy as independent?	Mixed	[Solomon Islands have a soft peg with some room for independent monetary policy]
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	.... The impact of Cyclone Raquel and El Niño has caused a reduction in agricultural production...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...There was a return to low inflation...
6	Were there any challenges for maintaining the peg? (peg countries)	N	[No reference to any challenges]

Table B.4: Narrative Analysis Documentation

7	Were reserves impacted negatively?	Y	...FX reserves could diminish in the future and should not divert attention...
8	Was monetary policy tightened, accommodated or unchanged?	Accommodated	...Monetary policy remains accommodative...
9	What was the monetary policy tool authorities used?	NA	[no reference to a specific instrument, just the reference above]
10	Did IMF agree with the authorities' policy action?	Y	...Directors considered the current monetary policy stance to be appropriate...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Accommodate	...Directors considered the current monetary policy stance to be appropriate...

Sri Lanka, 2016

#	Question	Answer	Quotes from the 2017 Article IV Staff Report
1	Does the country have its own legal tender?	Y	[Sri Lankan Rupee]
2	Is its currency pegged to some other currency or basket of currencies?	N	[No peg]
3	Can we characterize monetary policy as independent?	Y	[The country has its own legal tender that features no peg]
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...Growth has held up despite severe weather...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...inflation has picked up...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	[No peg]
7	Were reserves impacted negatively?	Y	...international reserves hit their bottom...
8	Was monetary policy tightened, accommodated or unchanged?	Tightened	...the Central Bank of Sri Lanka (CBSL) raised the policy rate by 25 basis points...
9	What was the monetary policy tool authorities used?	Increased interest rates	...the Central Bank of Sri Lanka (CBSL) raised the policy rate by 25 basis points...
10	Did IMF agree with the authorities' policy action?	Y	...Monetary policy should be tightened further...
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	Tighten	...Monetary policy should be tightened further...

St. Vincent and the Grenadines, 2002

#	Question	Answer	Quotes from the 2002 Article IV Staff Report
1	Does the country have its own legal tender?	N	[Eastern Caribbean dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...EC dollar pegged to the U.S. dollar...
3	Can we characterize monetary policy as independent?	N	...St. Vincent and the Grenadines (VCT) is a member of the Eastern Caribbean Currency Union (ECCU) with a common currency, the EC dollar...
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...slight pick up in real GDP growth to about 1 percent...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...low inflation and exchange rate stability...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	...unchanged peg to the U.S. dollar since 1976...
7	Were reserves impacted negatively?	N	...in the increase in excess reserves...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

St. Vincent and the Grenadines, 2010

#	Question	Answer	Quotes from the 2011 Article IV Staff Report
1	Does the country have its own legal tender?	N	[Eastern Caribbean dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Caribbean Currency Union (ECCU) with a common currency, the EC dollar...EC dollar (pegged to the U.S. dollar...
3	Can we characterize monetary policy as independent?	N	...St. Vincent and the Grenadines (VCT) is a member of the Eastern Caribbean Currency Union (ECCU) with a common currency, the EC dollar...
4	Did GDP contract or slowdown in the aftermath of the disaster?	Y	...As a result, real GDP contracted by a cumulative 4.7 percent since 2007 and is expected to remain slightly negative this year...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	Y	...Inflation has picked up ...
6	Were there any challenges for maintaining the peg? (peg countries)	NA	...unchanged peg to the U.S. dollar since 1976...

Table B.4: Narrative Analysis Documentation

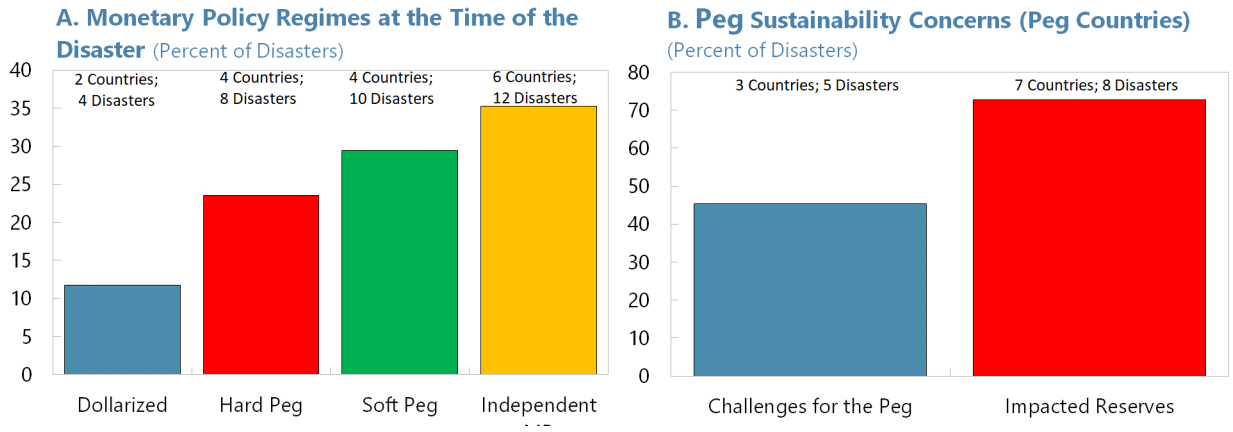
7	Were reserves impacted negatively?	N	...in the increase in excess reserves...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

St. Vincent and the Grenadines, 2013

#	Question	Answer	Quotes from the 2014 Article IV Staff Report
1	Does the country have its own legal tender?	N	[Eastern Caribbean dollar]
2	Is its currency pegged to some other currency or basket of currencies?	Y	...Caribbean Currency Union (ECCU) with a common currency, the EC dollar...EC dollar (pegged to the U.S. dollar...
3	Can we characterize monetary policy as independent?	N	...St. Vincent and the Grenadines (VCT) is a member of the Eastern Caribbean Currency Union (ECCU) with a common currency, the EC dollar...
4	Did GDP contract or slowdown in the aftermath of the disaster?	N	...modest recovery that had brought growth to 2.4 percent in 2013...
5	Did inflation increase (or was it expected to increase) in the aftermath of the disaster?	N	...Average inflation is estimated to have fallen...
6	'Were there any challenges for maintaining the peg? (peg countries)	NA	...unchanged peg to the U.S. dollar since 1976...
7	Were reserves impacted negatively?	N	...This indicates that the level of reserves is in general adequate...
8	Was monetary policy tightened, accommodated or unchanged?	NA	[Monetary policy is not independent]
9	What was the monetary policy tool authorities used?	NA	[Monetary policy is not independent]
10	Did IMF agree with the authorities' policy action?	NA	[Monetary policy is not independent]
11	What was the IMF advice on the monetary policy stance to adopt after IMF mission?	NA	[Monetary policy is not independent]

Note: Authors' comments are provided in square brackets.

Figure B.1: Narrative Analysis: Features of Affected Countries



Sources: IMF staff reports and authors' calculations.
Notes: Estimates are based on a narrative analysis of IMF staff reports on disaster-prone developing countries over the period 1999 to 2017. The analysis is restricted to weather-related natural disasters with associated damages of at least 1% of GDP (according to the EMDAT database), subject to IMF staff report availability. These criteria lead to a sample of 34 incidents that occurred in 16 countries. Please note that if we were to consider also non pegged countries, the percentage of countries that experienced an impact on their reserves would go down to 35 percent. The characterization of monetary policy as being independent does not take possible fiscal dominance into account.
* El Salvador switched regimes in 2001 as U.S. Dollar replaced the local Colón as the legal tender.

C Model Sensitivity Analysis

C.1 Excluding one Shock at a Time

A sensitivity experiment worth conducting is switching off one shock at a time, while keeping all other shocks activated (including natural disaster shocks) and computing welfare outcomes across alternative monetary policy regimes. This exercise is meant to rule out that the results presented earlier in the paper, hinge on the presence of one specific shock. As shown in Table C.1, irrespective of the shock being deactivated, the inflation targeting regime continues to dominate all other regimes. The welfare ranking among the other regimes changes to an extent when the foreign interest rate shock or the TFP shock are excluded, leaving the bottom line of the analysis unaltered, i.e. that inflation targeting is the welfare maximizing regime.

Table C.1: Welfare Levels and Losses Associated with Alternative Monetary Policy Regimes–Excluding One Shock at a Time

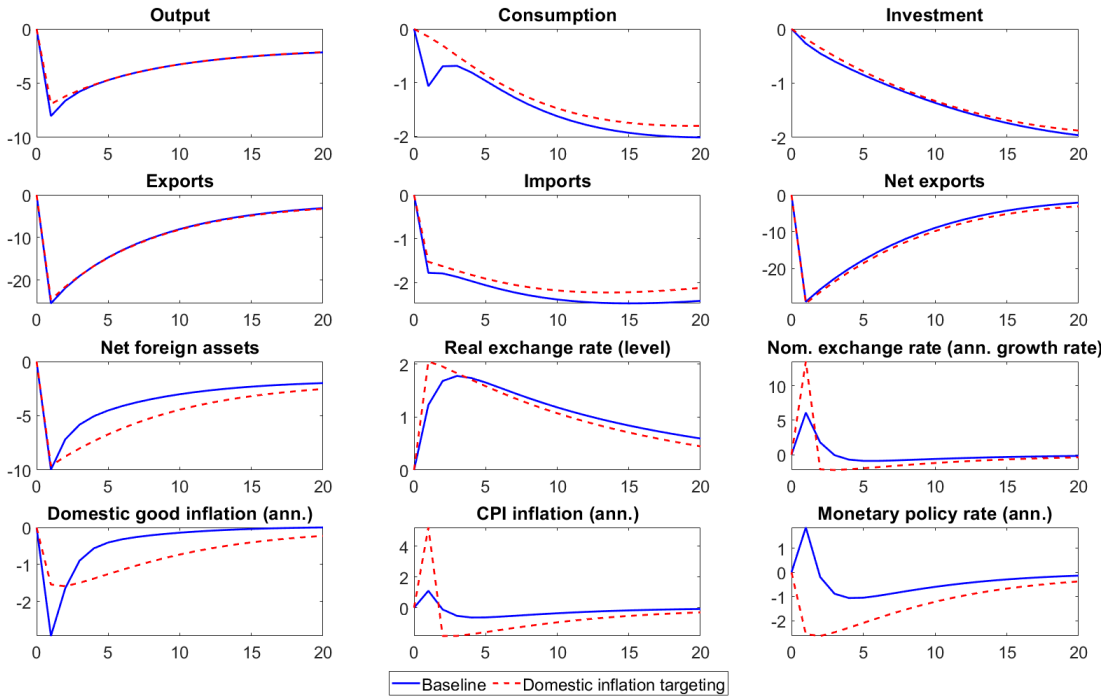
Excluding the foreign inflation shock					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4614	-
Strict inflation targeting	∞	0	0	0.4599	-0.3251
Hard peg	0	0	∞	0.4584	-0.6502
Taylor rule	1.5	0.5	0	0.4579	-0.7586
Exchange-rate aug. TR	1.5	0.5	0.5	0.4577	-0.8019
Excluding the foreign interest rate shock					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4747	-
Strict inflation targeting	∞	0	0	0.4737	-0.2107
Hard peg	0	0	∞	0.4723	-0.5056
Taylor rule	1.5	0.5	0	0.4714	-0.6952
Exchange-rate aug. TR	1.5	0.5	0.5	0.4715	-0.6741
Excluding the foreign demand shock					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4611	-
Strict inflation targeting	∞	0	0	0.4597	-0.3036
Hard peg	0	0	∞	0.4581	-0.6506
Taylor rule	1.5	0.5	0	0.4576	-0.7591
Exchange-rate aug. TR	1.5	0.5	0.5	0.4573	-0.8241
Excluding the TFP shock					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4918	-
Strict inflation targeting	∞	0	0	0.4909	-0.1830
Hard peg	0	0	∞	0.4911	-0.1423
Taylor rule	1.5	0.5	0	0.4914	-0.0813
Exchange-rate aug. TR	1.5	0.5	0.5	0.4912	-0.1220

Notes: see notes to Table 2.

C.2 CPI Inflation Targeting versus Domestic Inflation Targeting

We now analyze how sensitive our results are to the measure of inflation targeted by the central bank. Specifically, we replace CPI inflation (Π_t) with domestic inflation (Π_t^H) in each monetary policy rule. We start by assessing the impulse responses to an average natural disaster shock in Figure C.1. Relative to the baseline, where CPI inflation is targeted (blue-solid lines), targeting domestic inflation (red-dashed lines) has the obvious effect that the latter is stabilized in the medium-run while the former is allowed to increase. This is reflected in the opposite response of the central bank rate, which is lowered to mitigate the fall in domestic inflation. The nominal exchange rate increases more than under CPI inflation targeting. However, in real terms the exchange rate appreciates only slightly more than in the baseline. As a result, net exports only marginally deteriorate but, given the monetary

Figure C.1: Impulse Responses of Selected Macroeconomic Variables to an Average Natural Disaster Shock in a *Disaster-Prone* Country, under Alternative Measures of Inflation in the Monetary Policy Rule



Notes: X-axes are in quarters. Output, consumption, investment, exports, imports, net exports and net foreign assets are expressed in percent deviations from the pre-disaster balanced growth path. Inflation rates, the monetary policy rate and nominal exchange rate growth are as annualized percentage points differences from the stochastic steady state. The real exchange rate is in percentage points deviations from the stochastic steady state. The stochastic steady state is obtained by simulating the model in the absence of shocks for 100 quarters. Bold blue lines represents an average natural disaster shock in a *disaster-prone* country, assuming that the central bank targets CPI inflation. Dashed red lines represents a natural disaster shock of the same intensity, assuming that the central bank targets domestic inflation.

policy accommodation, the initial fall in output is reduced.

Next, we analyze the welfare properties of the monetary policy regimes when the central bank targets domestic inflation. Results are reported in Table C.2. In general, the welfare level is higher relative to targeting CPI inflation.[26] Welfare losses relative to FIT are likewise smaller, except for the case of a hard peg. Therefore, targeting domestic inflation improves welfare relative to targeting CPI inflation, which is a result consistent with Gali and Monacelli (2005). Crucially, the welfare ranking is preserved under the different measures of inflation to target, implying that FIT is still superior to the alternative monetary policy regimes.

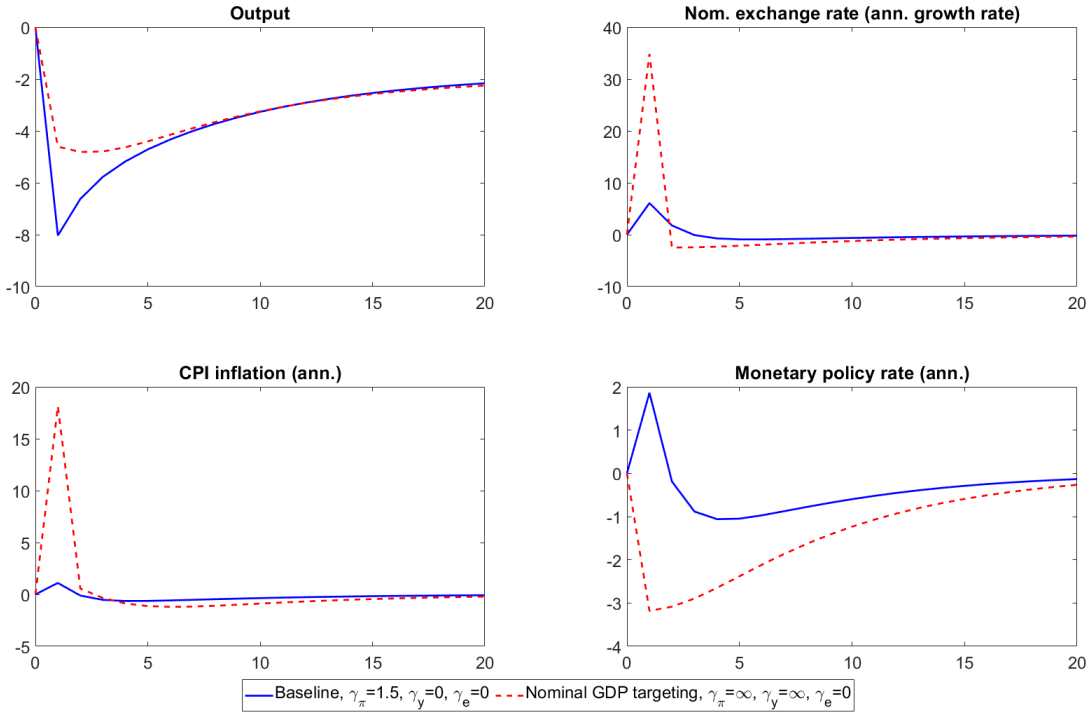
[26]Obviously, welfare is unaffected in case of hard peg. However, the consumption equivalent gain changes because welfare changes in the FIT case.

Table C.2: Welfare Levels and Losses Associated with Alternative Monetary Policy Regimes–Domestic Inflation Targeting

Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4623	-
Strict inflation targeting	∞	0	0	0.4619	-0.0865
Hard peg	0	0	∞	0.4580	-0.9301
Taylor rule	1.5	0.5	0	0.4595	-0.6057
Exchange-rate aug. TR	1.5	0.5	0.5	0.4587	-0.7787

Notes: see notes to Table 2.

Figure C.2: Impulse Responses of Selected Macroeconomic Variables to an Average Natural Disaster Shock in a *Disaster-Prone* Country, under Inflation vs Nominal GDP Targeting



Notes: X-axes are in quarters. Output is expressed in percent deviations from the pre-disaster balanced growth path. Inflation, the monetary policy rate and nominal exchange rate growth are as annualized percentage points differences from the stochastic steady state. The stochastic steady state is obtained by simulating the model in the absence of shocks for 100 quarters. Bold blue lines represents the effect of an average natural disaster shock in a disaster-prone country under the baseline assumption of inflation targeting. Dashed red lines the effect of an average natural disaster shock in a disaster-prone country under nominal GDP targeting.

C.3 Nominal GDP Targeting

In this subsection, we assess the properties of nominal GDP targeting (NGT). This regime has received attention in the literature on optimal monetary policy, although no central banks

Table C.3: Welfare Levels and Losses Associated with Alternative Monetary Policy Regimes–Nominal GDP Targeting

Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4611	-
Nominal GDP targeting	∞	∞	0	0.4486	-2.7109

Notes: see notes to Table 2.

has yet attempted to follow such a strategy. Some studies (McCallum and Nelson, 1999, Garin et al., 2016, Bullard and Singh, 2020 and McKibbin et al., 2021, among others) argue that NGT offers several advantages relative to inflation targeting. First, by targeting the growth rate of nominal GDP, it requires knowledge of easily observable variables, instead of, e.g. the output gap. Second, it does not suffer from indeterminacy issues because, in the long run, NGT is equivalent to price level targeting, which supports a determinate equilibrium for any level of trend inflation. Third, McKibbin et al. (2021) argue that, since climate change will increase the variability of inflation and output because more supply shocks will occur due to disaster strikes, NGT can be more effective than other alternatives at stabilizing the economy. However, these contributions generally neglect the effects of NGT on exchange rate dynamics hence their results do not necessarily extend to a small-open-economy setting. Moreover, Jensen (2002) and Billi (2017) show that the desirability of NGT arises only in the presence of supply shocks, i.e. when the central bank faces a trade-off between stabilizing inflation and output. Since in our setting, there are both demand and supply shocks, it is worth exploring whether NGT is welfare improving relative to other regimes or not.

We follow Garin et al. (2016) in choosing an appropriate parametrization of the Taylor rule to obtain NGT:

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\gamma_\Pi} \left(\frac{\frac{y_t}{y_{t-1}}}{\exp\left(\Lambda_y\right)}\right)^{\gamma_y}, \qquad \gamma_\Pi = \infty, \, , \gamma_y = \infty. \tag{45}$$

In Figure C.2, we compare the baseline inflation targeting regime ($\gamma_\Pi = 1.5$, $\gamma_y = 0$, $\gamma_e = 0$) with nominal GDP targeting ($\gamma_\Pi \to \infty$, $\gamma_y \to \infty$, $\gamma_e = 0$). By targeting the growth of nominal GDP, this regime is very effective at mitigating the output collapse in the aftermath of the disaster realization. This outcome is achieved through an accommodating monetary policy, a large exchange rate depreciation and a spike in inflation, which then returns to its steady state, essentially implying a shift in the price level.

Table C.3 compares welfare under the two regimes. We find that NGT is suboptimal relative to FIT. One reason behind this results is that, as shown by Figure C.2, NGT entails too large shifts in the exchange rate and hence of inflation.

C.4 Alternative Modeling Assumptions

Our final sensitivity checks concern specific modeling assumptions. In particular, we assess welfare under the alternative monetary policy regimes and: (i) CRRA utility function, whereby risk aversion (γ) equals the inverse of the elasticity of intertemporal substituion ($\hat{\Psi}$) and the role of risk is dampened; (ii) more permanent or transitory effects of disasters on TFP by setting ω to 0.75 and 0.25, respectively (relative to the baseline calibration, $\omega = 0.50$); (iii) inertial interest rate rule, with a smoothing parameter $\gamma_R = 0.80$.

Table C.4 reports the results under each alternative modeling assumption. The welfare ranking of monetary policy strategies carries through the various modifications hence FIT remains superior to the alternatives. However, a few remarks are in order. First, employing a CRRA utility function dincreases welfare under all rules and reduces the welfare losses relative to FIT. Underestimating welfare costs of natural disasters with CRRA utility is also highlighted by Douenne (2020).[27] Consistently, since our baseline calibration of risk aversion (i.e. $\gamma = 3.8$) already likely entails underestimating the welfare effects of natural disasters on disaster-prone countries, further reducing it would probably miss much of these effects. Second, even when assuming more permanent or transitory effects of disaster shocks on TFP, the inflation targeting regime is the welfare maximizing policy. Next, adding the interest rate inertia in the monetary policy rule slightly increases welfare relative to the baseline case of no-interest rate smoothing, a result in line with the literature (see, e.g., Schmitt-Grohé and Uribe, 2007). However, the welfare ranking of the various regimes remains unaltered.

We further check whether our results hinge on the calibration of the elasticity of substitution between home and foreign goods. Throughout the paper, we set a baseline value of 0.67, which suggests low substitutability, in line with other papers on emerging markets economies. Here, we increase the value of this parameter to 1.2, an illustrative value above 1, which implies a substantially larger degree of substitutability. Results reported in Table C.4 suggest that the ranking of the monetary policy regimes is not affected by the degree of substitutability between home and foreign goods.

Finally, we assess the role of the TFP channel of disasters. We exclude the impact of natural disasters on TFP by setting $d_t = 0$ in equations (5) and (6). This modification has nontrivial consequences for the propagation of disasters as we are effectively assuming that the impact of a given shock is smaller and purely transitory. The corresponding panel of Table (C.4) shows that the ranking of the monetary policy rules is only slightly affected, although

[27] In particular, Douenne (2020) shows that lowering risk aversion to equal the inverse of the elasticity of intertemporal substituion leads to underestimate the welfare costs of natural disasters. Conversely, increasing the inverse of the elasticity of intertemporal substituion to equal risk aversion leads to conclude that natural disasters foster growth. All in all, these two parameters have empirically very different values hence Epstein-Zin preferences are more appropriate for the quantitative assessment of disasters.

Table C.4: Welfare Levels and Losses Associated with Alternative Monetary Policy Regimes–Alternative Modeling Assumptions

CRRA utility function ($\gamma = \hat{\Psi} = 0.5$)					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4831	-
Strict inflation targeting	∞	0	0	0.4823	-0.1656
Hard peg	0	0	∞	0.4814	-0.3519
Taylor rule	1.5	0.5	0	0.4807	-0.4968
Exchange-rate aug. TR	1.5	0.5	0.5	0.4806	-0.5175
More permanent effects of disasters on TFP ($\omega = 0.75$)					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4622	-
Strict inflation targeting	∞	0	0	0.4607	-0.3245
Hard peg	0	0	∞	0.4591	-0.6707
Taylor rule	1.5	0.5	0	0.4584	-0.8222
Exchange-rate aug. TR	1.5	0.5	0.5	0.4583	-0.8438
More transitory effects of disasters on TFP ($\omega = 0.25$)					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4598	-
Strict inflation targeting	∞	0	0	0.4584	-0.3045
Hard peg	0	0	∞	0.4568	-0.6525
Taylor rule	1.5	0.5	0	0.4564	-0.7395
Exchange-rate aug. TR	1.5	0.5	0.5	0.4562	-0.7829
Interest rate inertia in Taylor rule ($\gamma_R = 0.80$)					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4622	-
Strict inflation targeting	∞	0	0	0.4596	-0.5625
Hard peg	0	0	∞	0.4580	-0.9087
Taylor rule	1.5	0.5	0	0.4595	-0.5842
Exchange-rate aug. TR	1.5	0.5	0.5	0.4592	-0.6491
Higher elasticity of substitution between home and foreign goods ($\chi_c = 1.20$)					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4639	-
Strict inflation targeting	∞	0	0	0.4626	-0.2802
Hard peg	0	0	∞	0.4606	-0.7114
Taylor rule	1.5	0.5	0	0.4592	-1.0131
Exchange-rate aug. TR	1.5	0.5	0.5	0.4594	-0.9700
No effects of disasters on TFP ($d_t = 0$ **in eq.** (5) and (6))					
Monetary policy regime	γ_Π	γ_y	γ_e	Welfare level	C.E. gain w.r.t. FIT (%)
Inflation targeting	1.5	0	0	0.4897	-
Strict inflation targeting	∞	0	0	0.4890	-0.1403
Hard peg	0	0	∞	0.4887	-0.2102
Taylor rule	1.5	0.5	0	0.4897	-0.0135
Exchange-rate aug. TR	1.5	0.5	0.5	0.4893	-0.0876

Notes: see notes to Table 2.

the C.E. losses with respect to FIT are reduced compared to that under the benchmark calibration. Importantly, the general message concerning the superiority of inflation targeting still holds. However, it is also worth highlighting that the TFP channel of natural disasters is an important driver of the welfare outcomes, in addition to capturing realistic features of natural disasters (see discussion in footnote 13).

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2022

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