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# How do natural disasters impact the exchange rate: an investigation through small island developing states (SIDS)?

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We investigate the response of the real effective exchange rate to tropical cyclones in small islands developing states. Our results show that under flexible exchange rate regimes there is a real exchange appreciation up to two months after the storm. In contrast, a fixed exchange rate almost completely buffer an appreciation.

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## 1. Introduction

Small island developing states (SIDS) are arguably the most severely affected countries by tropical cyclones, as they are unlikely to have sufficiently strong economic structure or infrastructures to provide sufficient resilience, Heger et al. (2008). Moreover, they generally do not have sufficient financial reserves to deal with the subsequent financial consequences. However, while many studies have examined the effects of natural disasters on a number of important macroeconomic variables, such as government spending, tax revenues, public investment, debt, exports and growth, (Strobl, and Ouattara, 2013; Raddatz, 2007 and Noy and Nualsri, 2011), thus far there has been no comprehensive analysis of the impact on the exchange rate. But, for SIDS, which are mostly small open economies reliant on agricultural exports and tourism for their revenue, the exchange rate is likely to provide an important transmission mechanism of such large shocks.

In considering the likely impact of natural disasters in SIDS on the exchange rate there are a number of factors, among which fiscal channels. Indeed, after natural disasters, governments see their costs increase as they have to face emergency and reconstruction expenses. Similarly, the decline in economic activity that follows such natural disasters, often results in lower tax revenues. IMF, 2003 measures natural Disasters in Africa could be associated with a fiscal deficit of 3% that year. Ouattara and Strobl (2013) study in detail the effects of hurricane strikes in the Caribbean over 36 years. They find a short-term impact on government consumption, tax revenue, public investment, debt service and budget balance. Indeed, the transmission mechanism of natural disasters to exchange rate through fiscal policy is as follow. An expansionary fiscal policy leads to an increase of aggregate demand, which affects real money demand. Interest rate raises in the country. This increase in interest rates results in an exchange rate appreciation, since the financial assets denominated in local currency become more attractive. Thus, in the context of a floating exchange rate, we will have an appreciation of the exchange rate, while in the case of a fixed exchange rate, only the real effective exchange rate will appreciate. Similarly, increase in imports and decrease in exports due to natural disasters will result in a deficit in the current account, which in turn will lead to a depreciation of the national currency, in a flexible exchange rate framework. Indeed, a trade balance deficit has to be financed, using reserves to buy the excess of imports. This means that at the end of the day, on the foreign exchange market, the local currency will be less demanded than foreign reserves. This will lead to the depreciation of the currency. Furthermore, effects of fiscal deficit combine with those of balance of payments deficit. Both effects being in the opposite direction, the net effect on exchange rate will depend on the intensity of the two effects.

In the economic literature, economists have studied advantages and drawbacks of both flexible and fixed exchange rate regimes as for shocks absorption. Edwards and Levy-Yeyati (2003) find evidence that terms of trade shocks get amplified in countries that have more rigid exchange rate regimes. Levy-Yeyati and Sturzenegger (2003) bring evidence that countries with more flexible exchange rate grow faster than countries with fixed exchange rate regimes. In both cases of exchange rate regimes, real effective exchange rate movements could be observed, after natural disasters. That’s what our article strives to empirically assess, taking into account the role of exchange rate regime. At this purpose, we use an index for measuring natural disasters. This index catches exogenous shocks, preventing us from endogeneity problems and their treatment, Ouattara and Strobl (2013).

The remaining of the article is organized as follow. In the second section we present the data and some statistics. In the third section we present the econometric model and the results. Then we end with a brief conclusion relating to exchange rate regime and climate shocks absorption.

## 2. Data and Summary Statistics

*2.1 Sample*

Our sample consists of SIDS that are affected by tropical cyclones and for which we have sufficient exchange rate data; see Table1.

*2.2. Exchange Rate Data*

We use the real effective exchange rate provided by the Bruegel database[1] and available at http://bruegel.org/2012/03/real-effective-exchange-rates-for-178-countries-a-new-database/. Data are available for January 1995 to January 2012.

*2.3. Exchange Rate Regime Data*

Instead of using "de jure" classification, we use the Reinhart and Rogoff (2002) exchange rate classification, which takes into account dual or parallel markets to identify differences across exchange rate regimes. In terms of our SIDS sample of 17 islands, we classified those as having relatively fixed exchange rate regimes according to the coarse grid of the Reinhart and Rogoff classification.

**Table I: Summary Statistics**

| SIDS | REER[avg.] | REER[sd.] | ER | STORMS | C[avg. ;≥0] | C[avg.;>0] | C[max.] |
|---|---|---|---|---|---|---|---|
| **Antigua and Barbuda** | 132.4 | 5.7 | 1 | 2 | 0.000258 | 0.009785 | 0.012513 |
| **Bahamas, the** | 112.6 | 7.5 | 1 | 4 | 0.00007 | 0.003097 | 0.006701 |
| **Barbados** | 104.9 | 5.4 | 1 | 0 | 0 | | 0 |
| **Belize** | 107.6 | 4.6 | 1 | 3 | 0.000115 | 0.005088 | 0.012575 |
| **Dominica** | 111.8 | 8.1 | 1 | 0 | 0 | | 0 |
| **Fiji** | 96.4 | 5.6 | 0 | 1 | 1.9E-07 | 1.86E-05 | 1.86E-05 |
| **Grenada** | 104.5 | 3.7 | 1 | 1 | 4.47E-05 | 0.00791 | 0.00791 |
| **Haiti** | 79.9 | 17.2 | 0 | 0 | 0 | | 0 |
| **Jamaica** | 102.4 | 8.7 | 0 | 3 | 8.06E-05 | 0.004755 | 0.013732 |
| **Mauritius** | 101.4 | 4.6 | 0 | 0 | 0 | | 0 |
| **Netherlands Antilles** | 116.9 | 15.8 | 1 | 1 | 5.31E-07 | 5.36E-05 | 5.36E-05 |
| **Samoa** | 100.9 | 8.7 | 0 | 0 | 0 | 0 | 0 |
| **Solomon Island** | 97.4 | 8.6 | 1 | 0 | 0 | 0 | 0 |
| **St. Kitts and Nevis** | 99.0 | 4.6 | 1 | 3 | 0.000129 | 0.007633 | 0.008127 |
| **St. Vincent and Grens** | 111.2 | 8.9 | 1 | 0 | 0 | 0 | 0 |
| **Tonga** | 101.5 | 7.5 | 0 | 0 | 0 | 0 | 0 |
| **Trinidad and Tobago** | 96.1 | 11.5 | 0 | 1 | 3.17E-07 | 5.61E-05 | 5.61E-05 |
| **TOTAL AVG.:** | 104.5 | 8.0 | 0.6 | 1.2 | 4.11E-05 | 0.002954 | 0.003629 |

[1] http://bruegel.org/2012/03/real-effective-exchange-rates-for-178-countries-a-new-database/

This classified 58 per cent of the islands as having a relatively more fixed exchange rate regime – these are listed in Table 1. One may want to note that there were no exchange regime changes over our sample period.

### *2.4. Tropical Cylcone Destruction Index*

To capture the potential destruction due to tropical cyclones we use an index in the spirit of Strobl (2012), which measures wind speed experienced at a very localized level and then uses exposure weights to arrive at an island specific proxy.[2] More specifically, for a set of tropical cyclones, $k=1,\dots, K$, and a set of locations, $i=1, \dots I$, in island $j$ we define tropical cyclone destruction during month $t$ as:

$$C_{j,t} = \sum_{i=1}^{I} w_{i,t-1} \sum_{k=1}^{K} \left(W_{j,i,k,t}^{\max}\right)^3 \qquad W^{max} \geq 178 \text{ km/hr} \qquad (1)$$

where $W^{max}$ is the maximum measured wind speed at point $i$ during a storm $k$, and $w$ are exposure weights in the previous month $t$-1 of locations, $i=1, \dots I$, which aggregate to 1 at the island $j$ level. The maximum measured wind speed is calculated from a wind field model and using storm tracks from HURDAT, see Strobl (2012) for details. As exposure weights, we use annual DMSP nightlight imagery data interpolated to monthly values, similar to Bertinelli and Strobl (2013).

### *2.4. Summary Statistics*

Overall our sample consists of an unbalanced panel of 17 SIDS over the period of 1995 to 2010, with an average of about 149 months of data for each island. We provide summary statistics for all our variables in Table 1.

## 3. Econometric Model and Results

Our main task is to estimate the impact of tropical cyclones on the exchange rates:

$$\Delta \log REER_{j,t} = \alpha + \sum_{s=0}^{S} \beta_{t-s} C_{j,t-s} + \mu_j + \lambda_t + \varepsilon_{j,t} \qquad (2)$$

where *REER* is the real effective exchange rate, defined in terms of logged difference to be stationary, $C$ is our tropical cyclone destruction index, $\mu$ is a vector of country specific indicator variables, $\lambda$ is a vector of year and month indicator variables, and $\varepsilon$ is the error term. In order to take account of the country specific time invariant factors, $\mu$, we simply employ a fixed effects estimator. One should note that we also allow for cross-sectional and serial correlation in $\varepsilon$ by using Driscoll and Kraay (1998) adjusted standard errors.

Our results of estimating (2) for various values of $s$ are shown in Table 2. As can be seen, there is a positive and significant impact of tropical cyclone destruction on the real effective exchange rate (appreciation) of SIDS. If we consider the average (non-zero) value of C, then the coefficient implies that an average destructive cyclone increases the monthly

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[2] Strobl (2012) shows that no weighting for local exposure can substantially underestimate the impact of hurricanes on economic growth.

exchange rate by 0.74%. This result is intuitive given that there is likely to be an increase of public expenses following natural disasters, as, shown by Ouattara and Strobl (2013). Considering potential lagged effects of tropical storms we find that this positive impact persists only up to one more month after the event, with the coefficient decreasing about 27%. If we consider the overall increase over two months, then an average (maximum) strike over our sample caused the real effective exchange rate to fall by 1.3% (1.7%) over two months. Part of this fall of the real effective exchange rate may be due to an increase of imports of reconstruction material and essential goods.

In order to take into account, regime heterogeneity we re-ran our base specification, but included an interaction term between C and the exchange regime dummy in the final columns of Table 2. Importantly we find that, while the destruction term remains positive and significant, the interaction term is negative and significant. Moreover, a simple F-test of equality of coefficients suggest the difference between the coefficients is not statistically different from zero. Thus, a fixed exchange rate regime can completely buffer the impact of a cyclone shock on the real effective exchange rate.

We next experimented with allowing for non-contemporaneous effects and exchange rate regime heterogeneity by including lagged values of $C$ and its interaction with $ER$. For flexible exchange rates the exchange rate appreciation persists up to two months after the strike the cumulative effect for an average (maximum) hurricane is 4.6%. In contrast fixed exchange rate regimes continue to act as buffers after a damaging tropical cyclone, although in the month of the strike the difference in coefficients on the level term of C and its interaction term with the regime dummy remains statistically significant. The difference in coefficient suggests that for fixed exchange regime SIDS an average (maximum) tropical storm will cause the real exchange rate to appreciate by 0.4% (0.5%). For the subsequent months, however, the fixed exchange rate policy was able to countervail all cyclone induced real exchange rate appreciation.

As a final robustness check we also included the average wind destruction of neighboring islands – defined as those within 1000km of an island's centroid – since impacts on their exchange rate could spill over spatially. Including these, denoted as $NC$, however does not change our results in any noticeable manner, as can be seen in the final column of Table 2.

More generally our results on the ability of fixed exchange rate regimes to able to buffer external shocks to the real exchange rate is in line with the theory. On the contrary, flexible exchange rates allow a gain in competitiveness of the economy as a coping mechanism in response to the decrease of exports due to cyclones. Flexible exchange rates therefore play an important role as macroeconomic stabilizer instrument. Our results are in line of those of Bénétrix and Lane (2013), who find a difference in real exchange rate response to fiscal shocks for developed countries according to their exchange rate regime.

**Table II: Econometric Results**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $C_t$ | 0.763** | 0.785** | 0.770** | 0.775** | 1.832** | 1.841** | 1.850** | 1.833** | 1.832** |
| | (0.235) | (0.244) | (0.237) | (0.236) | (0.126) | (0.128) | (0.133) | (0.129) | (0.130) |
| $C_{t-1}$ | | 0.570** | 0.557* | 0.566** | | 1.539** | 1.547** | 1.517** | 1.492** |
| | | (0.219) | (0.216) | (0.217) | | (0.133) | (0.141) | (0.141) | (0.139) |
| $C_{t-2}$ | | | 0.209 | 0.214 | | | 1.280** | 1.243** | 1.243** |
| | | | (0.308) | (0.308) | | | (0.135) | (0.137) | (0.142) |
| $C_{t-3}$ | | | | 0.600 | | | | 0.125 | 0.123 |
| | | | | (0.442) | | | | (0.132) | (0.132) |
| $C_t$*$ER_t$ | | | | | -1.420** | -1.427** | -1.439** | -1.271** | -1.269** |
| | | | | | (0.214) | (0.217) | (0.209) | (0.253) | (0.256) |
| $C_{t-1}$*$ER_{t-1}$ | | | | | | -1.305** | -1.315** | -1.382** | -1.148** |
| | | | | | | (0.235) | (0.209) | (0.274) | (0.241) |
| $C_{t-2}$*$ER_{t-2}$ | | | | | | | -1.427** | -1.545** | -1.540** |
| | | | | | | | (0.193) | (0.253) | (0.242) |
| $C_{t-3}$*$ER_{t-3}$ | | | | | | | | 0.565 | 0.263 |
| | | | | | | | | (0.574) | (0.340) |
| $NC_t$ | | | | | | | | | 0.335 |
| | | | | | | | | | (0.226) |
| $NC_{t-1}$ | | | | | | | | | -0.590 |
| | | | | | | | | | (0.321) |
| $NC_{t-2}$ | | | | | | | | | -0.601 |
| | | | | | | | | | (0.531) |
| $NC_{t-3}$ | | | | | | | | | -0.311 |
| | | | | | | | | | (0.494) |
| **Observations:** | 2496 | 2496 | 2496 | 2496 | 2496 | 2496 | 2496 | 2496 | 2496 |
| **Countries:** | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |

Notes: (a) Driscoll-Kraay (1998) standard errors in parentheses; (b) ** and * indicate 1 and 5 per cent significance levels; (c) all regressions include a complete set of year and month dummies; (d) C is divided by 10e-10 in order to make coefficients more legible.

## 4. Conclusion

Our paper shows that there is an impact of tropical cyclones on the real effective exchange rate, which differs according to the exchange rate regime. More specifically, a flexible exchange rate depreciate in order to help the economy recover from the deterioration of the current account. In contrast fixed exchange rates regimes almost completely buffer the external shock.

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