Natural Disasters and Rural Vietnam: Estimations and Forecasts

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ABSTRACT

Using disaster data from the emdat.be website and data for six regions in Vietnam, this paper investigates the impacts of natural disasters on the gross product per capita of the three rural sectors that have been affected the most by disasters—agriculture, fishery, and forestry—over the period 1995 to 2013. The preliminary tests reveal endogeneity and contemporaneous correlations among these three sectors. Hence, a combination of instrumental variable (IV) estimations and system seemingly unrelated regressions (SSUR) are employed. The results reveal that disasters have different impacts on different sectors of the rural Vietnam with agriculture suffering the heaviest losses, fishery second, and forestry suffers the least. We then analyze the effects of reforestation as a disaster prevention measure and provide forecasts on the forest development in Vietnam.

1. Introduction

The economic reform in Vietnam has brought on rapid economic development in rural Vietnam. Together with the positive impacts such as higher GDP per capita, infrastructure and human capital improvements, and access to new technology, are a host of negative effects, including deforestation and pollutions that cause suffering for most residents, especially the ones who live in the remote areas. To some extent, the negative consequences of disorganizing development exacerbate the negative impacts of natural disasters on rural production. This paper looks into the effects of natural disasters in the presence of deforestation and reforestation in rural Vietnam.

In contrast to the earlier papers by Vu and Im (2014), who analyze the impacts of natural disasters on household income using data on 64 sub-regions, and Noy and Vu (2010), who estimate the effects of natural disasters on aggregate outputs in Vietnam, this paper focuses on the impacts of natural disasters on three sectors that are the most vulnerable to disasters - agriculture, forestry, and fishery - using data for six large regions in Vietnam. The research uses a combination of instrumental variable (IV) estimations and seemingly unrelated regressions for a system of equations (SSUR) with different dependent variables and different explanatory variables introduced by the University of California at Los Angeles (2014).

Different from data for households and firms in Vietnam, which are organized into eight regions, aggregate data for economic sectors are divided into six large regions: Red River Delta, Northern Midlands and Mountain Areas, North Central and Central Coastal Areas, Central Highlands, South East, and Mekong River Delta. In general, disasters often occur in a whole region or sometimes multiple regions at the same time. To reflect this fact, the data provided by the Center for Research on the Epidemiology of Disasters (CRED) from its website, emdat.be, are for each occurrence instead of for each of the 64 sub-regions in Vietnam. These characteristics justify our use of the panel dataset for six large regions in this paper.

Researches on the macroeconomic impact of natural disasters, such as Albala-Bertrand (1993), generally show evidence for positive impact on GDP but adverse effects on the trade and current accounts. The intuition is that the destruction reduces the stock of goods available, while it also leads to increase in the flow of spending investment for reconstruction. Skidmore and Toya (2002) call this phenomenon the "creative destruction" evidence, which is related to the concept introduced by

Schumpeter (2008). Paxson (1992) investigates the effect of natural disasters in the mostly rural least developed countries. Employing time-series data in combination with cross-sectional data, the author examines the impact of regional rainfall on household transitional income. The result shows that sudden rainfall affects household income but not consumption. Hence, the household income affected by regional rainfall is only considered a measure of transitory income that has a negligible effect on household permanent income.

There are also papers on a single country. Horwich (2000) analyzes the impacts of the Kobe earthquake of 1995 in Japan and emphasizes that human capital is the most crucial factor of production in any economy. Selcuk and Yeldan (2001) examine the August 1999 earthquake in Turkey. Using general equilibrium computation, they estimate the transition path of the Turkish economy to its new equilibrium after the earthquake and offer the best policy as a negative indirect tax in form of a subsidy financed by foreign aid to individual sectors to recover their capital losses. Halliday (2006) examines the impact of the 2001 earthquakes on net migration from El Salvador to the United States. He shows that unfavorable agricultural conditions in El Salvador raises both migration to the United States and remittances sent back to El Salvador. He finds that the 2001 earthquakes reduced net migration to the United States.

Regarding the nexus between deforestation and natural disasters, Hammill, Brown, and Crawford (2005) point out that the severe damage caused by the powerful cyclone that hit India’s Orissa coast in October1999 was a consequence of deforestation that exaggerated the impact of the disaster. Most damage occurred in the vastly-deforested new settlement areas along Orissa’s coast when the storm surge ripped through a 100-km long barren stretch, the Ersama block, killing thousands of people within minutes. Brown, Crawford and Hammill (2006) also show that the Indian Ocean tsunami of 2004 that took the life of more than 300,000 people were an indirect consequence of the deforestation in the area. In Vietnam, Ngoc Cam (2011) reports that the devastating floods of 2010 that caused severe damage to people and property were a direct consequence of the deforestation along the upper streams.

Pham Thi Thanh Thuy (2010) indicates that the forest covering rate of Vietnam was 43.2% in 1943 but dropped to 27.7% in 1990. On the other hand, Meyfroidt và Lambin (2008) show that this rate went up from 27.7% to 39% during 1990–2005. From the United Nations Food and Agriculture Organization website, we find that the current covering rate is 44%, slightly higher than that of 1943. This is a big improvement thanks to rigorous forest planting rate of 2.2% during 1995–2005. Although this rate dropped to 1.1% during 2005–2013, it was not serious enough to reduce the forest covering rate in Vietnam. However, deforestation is still a problem with the rate of forest destroyed due to both illegal exploitations and fires at 0.8% during 2005–2013.

To incorporate these concerns on the forest development and its effects, this research aims at making an assessment of the three disaster impacts—the number of people killed, the number of people affected, and the monetary damages—in the presence of deforestation and reforestation. Different from the aforementioned authors, we examine all disasters in Vietnam during 1995–2013 instead of a single event and focus on the rural area of Vietnam. Also in contrast to the above papers, we combine IV estimations with SSUR to control for the endogeneity and contemporaneous correlations among the cross-sectional residuals. Moreover, we use data for three typical sectors in rural Vietnam—agriculture, forestry, and fishery—instead of only farming sector as in Paxson (1992) or aggregate macroeconomic data as in Albala-Bertrand (1993).

Section two of this paper provides details on the data used in the research. Section three introduces methods for estimating the effects of the natural disasters. Section four analyzes the estimation results regarding the impacts of natural disasters on the production in the three economic sectors. Section five discusses the reforestation versus deforestation and provides alternative forecasts on the forest development in Vietnam. Section six offers policy suggestions and conclusions.

2. Data

The issue of which dataset we are going to use is important because it affects the way we build the model for this paper. As discussed in Vu and Im (2014), there are two datasets on disasters. The first dataset is available on the Disaster Inventory System/Disaster Information Management System website (desinventar.net) provided by United Nations Office for Disaster Risk Reduction. This dataset is for 64 provinces and municipal cities (64 sub-regions) in Vietnam but does not report the onset month of each incident. The second dataset is available from the Emergency Events Database website (emdat.be) provided by the Center for Research Epidemiology of Disasters (CRED) and Office of U.S. Foreign Disaster Assistance (OFDA). This dataset is for each incident that affects large regions and reports the onset month of each disaster.

Since we examine the macroeconomic effects of the disasters on three sectors in the rural areas using data for six large regions in Vietnam, utilizing this dataset is rather appropriate.

We use three reported measures of the magnitude of the disasters in emdat.be divided by the population of each region to form the impact measures (*IMM*) mostly similar to Noy (2009): (i) the fraction of population killed (*KIL*); (ii) the fraction of population affected (*AFF*); and (iii) the total damages per capita in US thousand dollars (*DAM*). For any incident that affects more than one region, we sum the total population of the affected regions, divide the impact measure by this sum, and then assign this value to each region. Table 1 provides a summary of these three impact measures for the estimation period from 1995 to 2013. This table reveals that the disasters in Vietnam during this period were distributed quite evenly although the North Central Area and Central Coastal Area suffer the most damage in two out of the three impact measures.

Table 1

Impact measures of disasters in Vietnam during 1995–2013

Region	Killed	Affected	Damages
Unit	(Persons)	(Persons)	($US thousands)
Red River Delta	941	51,187,233	458,210
Northern Midlands and Mountain Areas	704	396,495,093	253,162
North Central Area and Central Coastal Area	3,640	917,486,486	4,475,682
Central Highlands	518	9,064,388	139,163
South East	521	11,477,790	596,403
Mekong River Delta	5,043	76,715,007	1,142,425

Source: emdat.be

Using the emdat.be dataset also has the advantage of calculating the weight of each impact measure on the economy depending on the onset time. Different from Noy (2009), who use a monthly weight based on the onset months, we use quarterly weight based on the onset quarters (OQ) because there are numerous incidents occurred in different months that call for grouping them into four quarters per year. Also different from Noy (2009), who assigns a zero value to an incident occurring in December of a current year, we spread the effects out into two years (eight quarters). Thus, the current impact (IM_t) based on the impact measures (IMM) is:

$$IM_t = IMM_t*(8-OQ)/8 \quad (1)$$

The lagged impact in the following year (IM_{t-1}) is:

$$IM_{t-1} = IMM_t*OQ/8 \quad (2)$$

For example, a disaster which occurs in the fourth quarter of 2012 will have one half of the impact on 2012 and the other half on 2013, whereas a disaster which occurs in the first quarter of 2012 will have 7/8 of the impact on 2012 and the remaining 1/8 on 2013.

Table 2 reports the number of disasters occurring in the six regions of Vietnam during 1995–2013. This table, in combination with Table 1, reveals that the North Central and Central Coastal Areas suffered the most from disasters. Although the Northern Midlands and Mountain Areas experienced higher numbers of disaster, they endured less severe impacts than the Mekong River Delta did as shown in Table 1. Nationwide, there were 867 disasters reported by the CRED during 1995–2013.

Table 2

Number of disasters in Vietnam during 1995–2013

Region	Number	Mean	Standard Deviation
Red River Delta	42	2.2	1.4
Northern Midlands and Mountain Areas	229	9.0	6.8
North Central Area and Central Coastal Area	362	11.1	7.0
Central Highlands	55	2.9	2.5
South East	78	4.1	2.8
Mekong River Delta	102	5.4	3.7
Total	867	51.4	35.8

Source: emdat.be

Data for most of the other variables are from GSOV's Statistical Yearbooks. Data for agricultural (*AGRI*), forestry (*FOREST*), fishery (*FISH*), and industrial production (*INDUS*) are divided into two periods: the ones for 1995–2011 use 1994 constant price, the one for *FOREST* in 2012–2013 use 2010 constant price whereas for *INDUS* during 2005–2013 use current prices. We use the comparative period from 2005 to 2013 and the producer price index for industrial production to adjust all values to 1994 constant price. Data for *AGRI* and *FISH* are not available for the period 2012–2013. The retail sale values (*SALE*) are converted into the 1994 constant price using the consumer price index. For a proxy on education (*EDU*), we calculate the sum of primary, secondary, vocational, technical schools and college enrollments in each region. Data on the number of medical staff are used as a proxy for available health care (*HEAL*). Data on freight traffic on road (*ROAD*) and water way (*WATER*) in millions of tons.km are used as proxies for infrastructure. All these variables are divided by population to obtain per capita measures. Data on the areas of forest destroyed/deforestation (*DEFOR*), forest planted/reforestation (*REFOR*), and aquaculture (*AQUAA*), are in hectare (ha). Data on wood production (*WOOD*) are in cubic meter (m^3). Data on aquaculture production (*AQUAP*) are in tons, and data on poverty level (*POVER*) are already in percentage of the population.

Table 3 displays types of disasters in Vietnam. The table shows that all regions have storms and floods as the most frequent disasters whereas epidemics often occur in the large urban areas.

Table 3

Types of disasters in Vietnam during 1995–2013

Region	Storm	Flood	Epidemic	Drought	Land Slide	Other	Total
Red River Delta	13	11	12	2	2	3	42
Northern Midlands & Mountain Areas	89	94	9	8	21	8	229
North Central & Central Coast Areas	161	136	18	11	20	16	362
Central Highlands	16	21	4	3	5	6	55
Southeast	19	24	17	2	6	10	78
Mekong River Delta	21	42	9	8	12	9	102
Total	319	328	74	34	64	52	867

Note: other consists of hailstones, extreme weathers, and miscellaneous events.

Source: emdat.be

Data on household per capita income (*PERCA*) are from Vietnam Household Living Standards Survey provided by General Statistics Office of Vietnam (GSOV). Data are for even years from 2002 to 2012. We project the data for odd years using a combination of averaging and trending methods to obtain yearly data from 2001 to 2013. Data are for monthly per capita income in current Vietnamese Dong, so we multiply the data by twelve months to obtain per capita income per year and use the consumer price index to convert current values to real values. Since our estimation period is from 1995 to 2013, we have an unbalanced panel, for which we use binary dummies to control. Data on the real interest rate (*RINT*) for Vietnam are from the International Monetary Fund's *International Financial Statistics*. We use the regional indicator variables to account for the regional differences in financial markets.

3. Methodology

Based on the variables formed in equation (1) and (2), we estimate a system of equations in logarithmic form:

$$\ln AGRI_{i,t} = \alpha_1 + \alpha_2 \ln IM_{i,t} + \alpha_3 \ln IM_{i,t-1} + \beta \ln X_{i,\mathrm{t}} + \varepsilon_{i,t} \tag{3}$$

$$\ln FOR_{i,t} = \gamma_1 + \gamma_2 \ln IM_{i,\mathrm{t}} + \gamma_3 \ln IM_{i,t-1} + \chi \ln \mathrm{Y}_{i,\mathrm{t}} + f_{i,t} \tag{4}$$

$$\ln FISH_{i,t} = \delta_1 + \delta_2 \ln IM_{i,t} + \delta_3 \ln IM_{i,t-1} + \phi \ln \mathrm{Z}_{i,\mathrm{t}} + g_{i,t} \tag{5}$$

where *AGRI*, *FOR*, and *FISH* are annual gross product per capita in agricultural, forestry, and fishery sectors, respectively. IMs are the weighted impacts of *KIL*, *AFF*, or *DAM*, all in per capita forms, to be estimated in three separate systems. X, Y, and Z are vectors of control variables, *i* is the regional index, and *t* the time index.

To examine the indirect impact of deforestation (ln*DEFOR*) in addition to its direct impact on the three typical sectors in rural areas, we also form the following interaction variables:

Ln*DEKIL* = ln*KIL**ln*DEFOR*,

ln*DEAFF* = ln*AFF* *ln*DEFOR*, and

ln*DEDAM* = ln*DAM* *ln*DEFOR*

We use a downward piecewise process to avoid omitted variables, starting with all available variables and performing the Variance Inflation Factors test to detect the multicollinearity as discussed in Kennedy (2008). Table 4 displays the results for two possible combinations of variables where log of industrial production per capita can be used alternatively with poverty level.

Table 4

Final results of VIF tests with two possible combinations of variables

First Combination			Second Combination		
Variable	VIF	1/VIF	Variable	VIF	1/VIF
Poverty Level	5.72	0.17	Industrial Product	6.64	0.15
Aquaculture Product	4.26	0.23	Aquaculture Product	3.81	0.26
Road Traffic	3.35	0.29	Road Traffic	3.12	0.32
People Affected	2.95	0.34	People Affected	3.02	0.33
Forest Destroyed	2.61	0.38	Forest Destroyed	2.87	0.34
Forest Planted	2.14	0.47	Education	2.18	0.45
People Killed	2.11	0.47	Water-Way Traffic	2.18	0.46
Total Damage	2.01	0.49	People Killed	2.10	0.48
Water-Way Traffic	1.94	0.52	Total Damage	2.04	0.49
Education	1.51	0.66	Forest Planted	1.95	0.51
Real Interest Rate	1.19	0.84	Real Interest Rate	1.11	0.90
Mean VIF	2.71		Mean VIF	2.82	

The p-values for the White tests on the heteroskedasticity are all greater than 0.10, implying no serious heteroskedasticity problem for all three equations (3), (4), and (5). The p-values for the Arellano-Bond tests on the autocorrelation of AR(1) and AR(2) processes are also all greater than 0.10, implying no serious autocorrelation problem. The p-values of the Modified Hausman tests reveal that two disaster impact measures, ln*KIL* and ln*DAM*, have endogeneity problems. Hence, Instrumental Variables (IVs) estimations are needed for these two variables.

To see whether or not the economic development exacerbates disaster damage we conduct Granger-Causality tests. We perform a regression for each of the disaster measure variables on product per capita lags, together with all control variables for each sector, and test the significance of the product per capita lags. The t-tests for single coefficients and the F-tests for joint significances (at any lag structure) all indicate that the product per capita in each sector does not Granger-cause the disaster damages. Hence, the system does not have a simultaneous bias problem.

Finally, we perform the Breusch-Pagan Lagrange Multiplier test on the system and discover that there are contemporaneous correlations among the residuals with the p-values all smaller than 0.05. This is understandable because all three sectors are in rural Vietnam with similar local customs and rules of law as well as under similar central government policies and economic conditions. They also share overwhelmingly similar types of disasters, especially storms and floods. Therefore, it is likely that the impacts of any omitted factors on the production of the agricultural sector will be similar to the ones on the other two sectors.

Since there are endogeneity problems for ln*KIL* and ln*DAM*, a combination of IV and SSUR estimations for the systems involving these two variables is appropriate, whereas the system involving ln*AFF* needs only SSUR estimation. SSUR estimations assume that the residuals of the systems are not serially correlated over time. This condition is satisfied through the aforementioned Arellano-Bond test results. The basic SSUR estimation, which is a system generalized least squares (SGLS) procedure, can be performed in three steps as follows:

(i) Estimate the three equations separately using ordinary least squares.

(ii) Use the residuals from the OLS estimation in step (i) to estimate $\sigma^2_{(3.1)}, \sigma^2_{(3.2)}, \sigma^2_{(3.3)}$, and $\sigma^2_{(3.1),(3.2),(3.3)}$ and

(iii) Use the estimates from step (ii) to regress the three equations jointly within a GLS framework.

In this research, step (i) is modified slightly by using fixed effect (FE) estimations instead of OLS to control for the regional differences. We try ln*AFF* as the instrumental variable for ln*KIL* and ln*DAM*. A reduced form estimated on each separate equation—(3) with ln*KIL* as the dependent variable and (5) with ln*DAM* as the dependent variable—shows that ln*AFF* in (3) is highly correlated with ln*KIL* (with the p-value = 0.000), and ln*AFF* in (5) is highly correlated with ln*DAM* (with the p-value = 0.032). Since the estimated equations have similar control variables and ln*AFF* is exogenous, it is not correlated with the residuals. Hence, ln*AFF* is a valid instrument. We perform two separate (FE) regressions, one with ln*KIL* as the dependent variable, and one with ln*DAM* as the dependent variable, on ln*AFF* and the other control variables. We then use the predicted value of ln*KIL* (ln*KILH*) and that of ln*DAM* (ln*DAMH*) as instrument in the SSUR regressions.

4. Effects of disasters on gross product per capita in three sectors

Table 5 shows regression results for effects of the three impact measures on the gross product of the three sectors that are affected the most by disasters in rural Vietnam. Due to the characteristics of SSUR regressions that might produce coefficient estimates that are highly insignificant in themselves but jointly significant with other variables, we only eliminate any variable with the p-value greater than 0.90. When this occurs, we either drop this variable or replace it with an equivalent variable in the available list that was eliminated due to multicollinearity problem. As discussed in Greene (2003) and Wooldridge (2003), an adjusted R-squared in a IV estimation does not have a meaningful interpretation. Instead of an adjusted R-squared, we provide the root mean square error (RMSE). A small RMSE implies a good fit in addition to a p-value of the model smaller than 0.05.

Panel 5(a) reports the results for agriculture. Since there are the current and lagged values involved, we calculate the sums of these values to form a composite impact measure and perform tests on the significance of the composite impact. For example, summing up current and lagged values of "ln*KIL*" yields – 0.0543, this implies that for one percent increase in the ratio of people killed to population, there is a decrease of agricultural product per capita by 0.0543%, and the p-value of 0.0019 indicates that the composite impact is significant. The same method of calculation should be applied for the other variables. From this panel, one can see that all three disaster measures—ln*KIL*, ln*AFF*, and ln*DAM*—affect agricultural product per capita negatively and the sums of their individual values are also negative and significant. Although ln*INDUS* is only a control variable, it is noteworthy that its estimated coefficients are negative and significant in all three columns, implying the industrialization process does cause a reduction in the agricultural production in rural Vietnam. However, effects of the industrialization process on forestry and fishery are highly insignificant with p-values greater than 0.90 and so are omitted in Table 5.

Table 5

Results from SSUR estimations on three typical sectors in rural Vietnam

Panel (5a) Dependent variable: Log of gross agricultural product per capita

Variable	LnKIL	LnAFF	LnDAM
Current Impact	-.0390**	-.0104***	-.0251***
	(.016)	(.007)	(.010)
Lagged Impact	-.0153***	-.0032***	-.0064**
	(.002)	(.001)	(.041)
Composite Impacts	-.0543***	-.0136***	-.0315***
	(.0019)	(.0004)	(.0011)
LnDEKIL	-.0032*		
	(.078)		
LnDEAFF		-.0092**	
		(.041)	
LnDEDAM			-.0018*
			(.100)
LnINDUS	-.1104**	-.0999**	-.1602***
	(.018)	(.012)	(.001)
LnDEFOR	.0214		-.0099
	(.157)		(.296)
LnROAD	.1180***	.1598***	.2577***
	(.000)	(.000)	(.000)

Table 5 (continued)

Variable	LnKIL	LnAFF	LnDAM
RINT	-.0104***	-.0077***	-.0049*
	(.000)	(.000)	(.080)
LnAQUAP	.0511	-.0016	-.0252
	(.137)	(.954)	(.518)
LnEDU	1.0976***	1.2019***	1.1991***
	(.000)	(.000)	(.000)
Panel (5b) Dependent Variable: Log of Gross Forestry Product per Capita			
Current Impact	-.0011	.0029	-.0145**
	(.932)	(.320)	(.050)
Lagged Impact	-.0020	.0028	.0052
	(.878)	(.253)	(.453)
Composite Impact	-.0031	.0057	-.0093**
	(.8807)	(.1507)	(.0486)
Ln*DEFOR*	-.0062	-.0081	-.0061
	(.570)	(.343)	(.550)
Ln*REFOR*	.0267**	.0197	.0309**
	(.020)	(.149)	(.033)
Ln*ROAD*	.0960***	.0495	.0023
	(.008)	(.236)	(.143)
Ln*PERCA*			.0533
			(.132)
RINT	-.0102**	-.0146***	-.0062
	(.031)	(.002)	(.292)
Ln*AQUAP*		.1476***	.1287
		(.000)	(.123)

Table 5 (continued)

Panel (5c) Dependent Variable: Log of Gross Fishery Product per Capita

Current Impact	-.0356***	-.0001	-.0200**
	(.004)	(.945)	(.019)
Lagged Impact	-.0228*	-.0012	-.0110
	(.067)	(.428)	(.247)
Composite Impact	-.0584**	-.0013	-.0310***
	(.028)	(.662)	(.0046)
Ln*DEFOR*	-.0206**	-.0061	.0533***
	(.046)	(.243)	(.000)
Ln*REFOR*		.0112	.0075
		(.175)	(.676)
Ln*ROAD*	.2243***	.0723**	
	(.000)	(.011)	
Ln*WATER*	.0330***	.0602***	.0448***
	(.009)	(.000)	(.008)
Ln*AQUAP*		.5616***	
		(.000)	
Ln*AQUAA*	.7613***		1.168***
	(.000)		(.000)
Ln*EDU*	.3434***		.4201***
	(.002)		(.007)

Average RMSE for the system: .0659; average p-value for the model: 0.0000

Notes: ***, **, * indicate the significant levels at 1%, 5%, and 10% respectively, with p-values in parentheses.

Panel (5b) reports the results for forestry. The results show that all individual and composite impacts of "ln*KIL*" and "Ln*AFF*" are not statistically significant, whereas the current and composite impacts of "Ln*DAM*" are negative and statistically significant.

Pane (5c) reports the results for fishery and reveals that all individual and composite impacts of "Ln*KIL*" are negative and statistically significant. All individual and composite impacts of the variable "Ln*AFF*" are not statistically significant, whereas the current and composite impacts of "Ln*DAM*," are negative and statistically significant.

5. Deforestation versus reforestation and forecasts of forest development in Vietnam

From Table 5, we also see that the deforestation affects the gross product per capita negatively most of the time, either directly or indirectly. To interpret the indirect effect, we solve for the estimated coefficient of each interaction variable. For example, for Ln*DEKIL* = ln*KIL**ln*DEFOR*, holding other variable constant:

$$\mathrm{Ln}\,AGRI = \beta\,\mathrm{Ln}\,DEFOR * \mathrm{Ln}\,KIL$$

$$\beta = \frac{\mathrm{Ln}\,AGRI\ /\ \mathrm{Ln}\,KIL}{\mathrm{Ln}\,DEFOR}$$

Hence, β measures the fraction of decrease in agricultural product per capita indirectly caused by one percent increase in the area of forest destroyed that raises the mortality rate through disasters. For example, the estimated coefficient of Ln*DEKIL* in Panel (5a) is - 0.0033, implying that there is a 0.0033% decrease in agricultural product per capita indirectly caused by one percent increase in the deforestation that raises the mortality rate from disasters. The interpretations for Ln*DEAFF* (= ln*AFF**ln*DEFOR*) and Ln*DEDAM* (= ln*DAM**ln*DEFOR*) are in the same manner.

Table 5 also shows that there are positive effects, in spite of being still limited, of reforestation on the production per capita levels. For example, one percent increase in reforestation raises forestry production by 0.027%, and the p-value of 0.020 implies that the effect is statistically significant. Since there are negative effects of deforestation and positive effects of reforestation, having some knowledge on forest development in the future is important.

The Food and Agriculture Organization of the United Nations (2014) shows that the growth rate of reforestation in Vietnam was 1.1% while the rate of deforestation due to illegal exploitation and fires combined was 0.8% during 2005–2013. Modifying the theoretical framework for GDP growth suggested by Thirlwall (2003), we provide forecasts for the forest development in Vietnam.

Define the following variables:

C_T = targeted rate of forest covering

R_d = current rate of deforestation (= 0.8% in the year of 2013)

C_c = current rate of forest covering (44% in the year of 2013)

R_R = current rate of reforestation (= 1.1% in the year of 2013)

T = the time it takes Vietnam to reach a targeted rate of forest covering

The model can be presented as follows:

$$C_C (1 + R_R)^T = C_T (1 + R_d)^T \qquad (6)$$

Taking the natural logarithm of equation (6) yields:

$$\ln C_C + T\ln(1+R_R) = \ln C_T + T\ln(1+R_d)$$

$$T[\ln(1+R_R) - \ln(1+R_d)] = \ln C_T - \ln C_C$$

Solving for T to obtain:

$$T = \frac{\ln \frac{C_T}{C_C}}{\ln(1+R_R) - \ln(1+R_d)}$$

Suppose Vietnam wishes to increase its forest covering rate from 44% to 50%, then:

$$T = \frac{\ln(50/44)}{\ln(1.011) - \ln(1.008)} = 43$$

Thus, it takes Vietnam 43 years to increase the forest covering rate from 44% to 50% if the reforestation rate remains at 1.1% and the deforestation rate remains at 0.8%.

Suppose Vietnam wishes to increase its forest covering rate from 44% to 48%, then:

$$T = \frac{\ln(48/44)}{\ln(1.011) - \ln(1.008)} = 29$$

Thus, it takes Vietnam 29 years to increase the forest covering rate from 44% to 48%. if the reforestation rate remains at 1.1% and the deforestation rate remains at 0.8%.

The second question is how fast the reforestation rate should be so that the targeted rate of forest covering will be reached in T years. This is similar to the question raised in Thirlwall (2003) concerning GDP growth rate. However, we present a solution that is more accurate than the relative approximation by Thirlwall. From equation (6):

$$(1+R_R)^T = \frac{C_T(1+R_d)^T}{C_C}$$

$$1+R_R = \left[\frac{C_T(1+R_d)^T}{C_C}\right]^{1/T}$$

$$R_R = \left[\frac{C_T}{C_C}(1+R_d)^T\right]^{1/T} - 1 \qquad (7)$$

Suppose Vietnam plans to reach the target rate of 50% forest covering in 2020, which is seven years from 2013, substituting T = 7 into equation (7):

$$R_R = \left[(50/44)(1+0.008)^7\right]^{1/7} - 1 = 0.027 = 2.7\%$$

Hence, the required rate of reforestation is 2.7% if the rate of deforestation remains at 0.8%.

If Vietnam wishes to reach the target rate of 48% forest covering in 2020, then:

$$R_R = \left[(48/44)(1+0.008)^7\right]^{1/7} - 1 = 0.021 = 2.1\%$$

Thus, the required rate of reforestation is 2.1%, which is achievable, as Vietnam already reached the reforestation rate of 2.2% during 1995–2005, although this rate dropped to 1.1% during 2005–2013.

If Vietnam is able to reduce the deforestation to 0.6% and wishes to achieve the targeted rate of 48% forest covering by 2020, then:

$$R_R = \left[(48/44)(1+0.006)^7\right]^{1/7} - 1 = 0.019 = 1.9\%$$

Thus, the required rate of reforestation is only 1.9% if the rate of deforestation falls from 0.8% to 0.6%. This target is even easier to achieve.

6. Policy suggestions and conclusions

Based on the research results, we recommend the following policies:

First, tighten the government-people linkage, especially between the local government and the farmers who usually have little access to the newest information. This will increase the dissemination of the information to the faraway areas, raising the awareness of and preparedness against the coming disasters. Second, improve local infrastructure, including telephone lines and broadcasting system in addition to road and water way to raise the level of damage prevention in the rural area. Third, encourage and enable rural households to send children to schools, help the rural adults attending evening classes to foster knowledge of disaster impacts and effective prevention measures. Fourth, reduce impacts of disasters in advance by stocking up emergency supplies, including food, water, first aid kits, water purification units, medical supplies, temporary shelters, and generators. Fifth, strengthen activities against deforestation to reduce the area of forests destroyed by fires and illegal exploitations. Finally, mobilize all rural households to plant new forests. Most trees, especially mangroves, reduce the frequency and harmful impacts of flash floods and storms. Many regions have been very successful in planting mangroves and utilize mangrove forests in saving the residents' lives and properties. This activity needs to be encouraged in the whole nation.

In sum, this paper investigates the effects of disasters on the three sectors that endure the most from disasters in rural Vietnam. The results reveal that agricultural sector suffers the most severe impacts of disasters, the fishery second, and the forestry the least. Forecasts for alternative plans are then offered that shows that a target of 48% forest covering rate in 2020 is achievable if the deforestation remains at 0.8% and even easier to reach if the deforestation rate falls to 0.6%.

As in any research, this paper has certain limitations. First, data on several variables are not comprehensive and might render inaccurate magnitudes of the estimated coefficients. Hence, it is better to pay attention to the signs of the estimate coefficients instead of the specific values of the point estimates. Second, since data obtained from emdat.be are for each incident that affects a large region, we believe that using data on six large regions of Vietnam reflects these regional impacts more precisely. However, this causes some losses of detailed information that might be available if sub-regional data are used. Finally, we only focus on the three sectors that suffer the most from the disasters. It is also important to examine the effects of the disasters on the gross product per capita of several other sectors in Vietnam, which is left for future research■

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