JOURNAL OF APPLIED ECONOMICS AND BUSINESS

VOL. 7, ISSUE 3 – SEPTEMBER, 2019

Education and Novel Technology Research Association

Journal of Applied Economics and Business

VOL. 7, ISSUE 3 – SEPTEMBER, 2019

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Content

Journal of Applied Economics and Business

OPEN ACCESS ARTICLE

THE EFFECTS OF NON-PERFORMING LOANS REDUCTION MEASURES ON SYSTEMIC RISK IN EUROPEAN BANKING SYSTEM

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Disclaimer: The views expressed in this paper are solely of the author and do not necessarily reflect any stance of the SRB. Responsibility for the content lies entirely with the author.

Abstract

The current paper presents a quantitative analysis of the future relationship of loans regarded as dormant with established reduction measures on systemic risk of banks in the European banking system. The reduction measures are a legal framework sought to be put in place to ensure Non-Performing Loans (NPLs) in the region are managed in a better way and, where possible, minimise their crippling effects on the banking industry. The paper is the starting point of further evaluation as the regulations have not been fully implemented and require more input from all banking industry stakeholders.

Keywords: *Risk Reduction Measures; NPLs; Systemic Risk; European Union; Banking.*

INTRODUCTION

The main challenges facing banks include effective management of non-performing loans (NPLs), which directly affect their overall financial sustainability. Putting regulatory policies in place to control NPLs is a sound move by governments and stakeholders and will work towards making the banking sector more stable and prudent in lending. The NPLs reduction measures in the European Union are macroprudential milestones that, if well executed, can safeguard the industry from arbitrary collapse and uncertainties.

The present study provides a critical analysis and evaluation of the effects of NPLs reduction measures on systemic risk. In the EU banking system, credit purchasers and credit servicers are prevented from benefiting by barriers generated by divergent national legislation; thus, a focused and coherent regulatory and supervisory regime is lacking. In addition, non-bank purchasers of credit are faced with regulations in some Member States, creating obstacles to purchasing credits. The same issue limits competition in the internal market due to the decreasing number of interested purchasers. On the other hand, such low competition leads to an inefficient and competitive NPLs market. As held, markets for NPLs feature small trade volumes (European Commission, 2018). In general, differences embedded in regulatory standards in the Member States lead to heightened fragmentation in the market, which limits the free flow of capital and services in the EU. Other effects include insufficient competition in and weak performance of the secondary market for bank credits. The limited involvement of investors and servicers signifies weak competitive pressures in the dual markets, i.e. the market for purchasing and the market for credit servicing. This results in higher fees for credit servicing to purchasers; thus banks bidding for low prices may discover that selling NPLs to non-bank investors weakens their incentives for offloading high-stock NPLs (European Commission, 2018).

The paper has five sections: the first section introduces the study, the problem statement, the research questions and the main contribution. The second section presents the conceptual framework and especially a critical review of the NPLs reduction measures in Europe and empirical studies that have evaluated the effects of NPLs on systemic risk of banks. Section three presents the methodological approach used to implement the econometric model proposed in the research and key variables, i.e. dependent and independent variables. Section four presents results generated using the STATA program. Section five presents the findings of the research, recommendations, limitations and direction for future research.

The following research questions have guided the study's investigation:

> Q_1: What are the future effects of NPLs Reduction Measures on Systemic Risk in the European Union banking system?; and
>
> Q_2: How efficient will NPLs Reduction Measures be in controlling Non-Performing Loans of Banks in the European Union?

The NPLs legal framework has gaps due to its failure to achieve the intended goals. For instance, such failures could be orchestrated by poor implementation of the regulations or mismatch of the regulations with NPLs (KPMG, 2018). Therefore, NPLs reduction measures must be adequate to address the adverse effects of non-performing loans at the policy level. According to Cerulli et al., (2017), legal uncertainties, including a lengthy foreclosure process, suppresses the options for reordering in a direct way the influence of the time required to recover NPLs in a given country. For instance, inefficient judicial forum increases the amount of time for recovery, which in turn increases the NPLs. On the other hand, it is reasonable to believe that the efficiency in the judicial system will have a positive impact on the NPLs ratio.

The present study illustrates the future effects of NPLs Reduction Measures on Systemic Risk on a sample of EU banks. A number of studies have evaluated the relationship between NPLs and systemic risk but not on the grounds of the regulatory framework such as the ones currently proposed in the EU (See KPMG, 2018). Therefore, the findings are expected to add value in narrowing the gaps in knowledge in section two; and much more in establishing the significant effects of reduction measures adopted in the EU towards systemic risk.

LITERATURE REVIEW

A number of studies in the past have been developed to examine the effects of reduction measures in the banking system. The notable issue has been that non-performing loans across the world are negatively impacting on banking systems. Therefore, this has led to the establishment of numerous creative solutions, including well-formulated risk techniques, with the hope that they would reduce non-performing loans to a commendable degree. For instance, the study by Chih-Ching (2016, pg.34) indicated that regulations should be supported by incentives to facilitate target banks to undertake the "non-performing loan reduction task".

Other studies have debated regulatory plans adopted to reduce NPLs. Further, related studies have examined the impact of creative regulatory solutions on NPLs control. For instance, the study by Erdinc and Gurov (2016) analysed the enactment of risk management protocols that are advanced guided by Basel Capital Accord towards the reduction of NPLs. In addition, Saga and others (2016, pg.45) proposed a "knowledge-based automated compliance auditing system" to be used to process loans and determine whether the applications of the loan are riskier. Stijepović (2014) recommended a model referred to as the Podgorica Approach that relied on the quantitative assessment of NPLs which could be reversed back to performing mode via a process of restructuring. Further reviews that may be mentioned refer to those evaluating NPLs remedies by establishing their key antecedents (for example Louzis et al., (2012), Ghosh (2015) and Vithes-sonthi (2016).

NPLs Reduction Measures and Systemic Risk

SRISK estimates the amount of capital which a bank will require to overcome insolvency in a financial crisis scenario; furthermore, it relies on accounting data to estimate liabilities and market data related to equities and equity volatility (Shin and Zigrand, 2013). According to Adrian and Brunnemeier (2011), systemic risk takes place during high credit demand since the market is optimistic about the risk level and the manner in which it amplifies industry damage during a crisis, referred to as the spillover effect (Andrian & Brunnermeier, 2011). On the other hand, Danielsson et al., (2013) perceived systemic risk as the "aggregation of the risk of market volatility from major market participants" (pg.33).

Patro, Qi and Sun (2013) viewed systemic risk to be the capacity of a large-scale breakdown within a financial system triggered by a number of systemic events such as the bankruptcy of major financial institutions. According to Gorvett (2015), systemic risk is not equal to the aggregate total of individual risks, since the latter does not incorporate account risks linked to portfolio activities across financial institutions; which include those that lead to destructive procyclicality as well as high linearity in terms of asset returns that amplifies economic shocks and causing disruptions to macroeconomic policies (Ouhibi et al., 2017).

In the present study, such outcomes are attributable to increased non-performing loans during the Eurozone crisis. In fact, systemic risk and systematic risk are completely distinct concepts since the latter focuses more on market risk, and may not be reducible through diversification (Danielsson et al., 2013). In the study, systemic risk was computed based on the "capital shortfall" approach; according to Acharya et al., (2012), the method emphasises the contribution of the bank towards the overall financial failure as opposed to individual failures. In the same vein, systemic risk (SRISK) has been defined as the capital fund an enterprise is required to have in the event of another financial crisis. Systemic risk can be modelled as follows (Ouhibi et al., 2017):

$$SRISKi,t = E\ t\text{-}1\ (\text{Capital Shortfalli} \setminus \text{Crisis})$$

Vukovic and Domazet (2013) examined the effects of dormant loans on systemic risk: for instance, NPLs had a causal impact on systemic risk with rapid effect in Serbia's banking industry. Further results of the study indicated that absolute and selected magnification of dormant loans led to increased occurrence of systemic risk in the Serbian banking industry.

In recent years, the emphasis has been on literature evaluating NPLs), since most researchers seek to understand the factors leading to systemic risk (Mejra et al., 2010). On the other hand, the relationship or causal effects of dormant Loans with systemic risk have also been of concern (Hassad & Ghak, 2010). In the study by Faward and Taqodus (2013), the authors used an OLS regression and established that there is significant relationship between NPLs and macroeconomic variables such as FDI, unemployment, GDP annual growth, inflation, the CPI, real interest rates, effective exchange rates, industrial production, and exports.

In the study by Mejra et al., (2011), the authors used Panel regression models to analyze the macroeconomic sources in relation to systemic risk. The key independent variables included exports of goods and services, fixed capital formation, disposable income, FDI, real GDP, net foreign assets, principles of Bale, ratio of asset loans, and deposit loans. In the studies, the authors examined the effects of macroeconomic sources on systemic risk in the banking industry taking the case review of newer members of the EU. The results depicted that macroeconomic sources significantly worsened the loans considered to be non-performing in the region. The study by Vukovic and Domazet (2013) established that NPLs were the main generator of systemic risk in Serbia's domestic banking sector and similar results were affirmed in other countries in transition.

In a study by Cerulli et al., (2017) the authors examined the relationship between NPLs and systemic factors in banks. The focus was on three major NPLs determinants namely: the adequacy of the judicial system, degree of interest rates, and economic growth. For instance, inefficient judicial systems increase the recovery time and hence worsen NPLs. On the other hand, economic growth has an impact on household cash flows when there is a recession, which in the end causes difficulties in the repayment of bank loans. According to Salas and Saurina (2012), GDP growth negatively impacts on NPLs while interest rates raise the actual value of the borrower's debt; rendering debt servicing much expensive. In fact, high interest rates lead to loan defaults and in the long run aggravate NPLs.

TABLE 1. SUMMARY OF KEY LITERATURE

Author	Key Findings
Erdinic & Gurov, 2016	Advanced risk management techniques using Basel Capital Accord to reduce NPLs
Saga et al., 2016	Knowledge-based automated compliance auditing system- detect risk in loan applications
Stijepović, 2014	Podgorica Approach to examine quantitative assessment of NPLs
Louzis et al., 2012; Vithes-sonthi, 2016	Reduce NPLs by establishing their determinants
Vukovic & Domazet, 2013	NPLs increase systemic risk
Merja et al., 2011	Macroeconomic factors significantly increase NPLs
Cerulli et al., 2017	Adequacy of the judicial system, decreased interest rates and economic growth are the major determinants of NPL

The key summary of the literature is as shown in Table 1 with indications that several authors have supported the significant effects of NPLs towards systemic risk. The notion from each of the authors is that NPLs are not a spontaneous outcome but that they are influenced by external factors such as the judicial system, decreased interest rates, and economic growth. Therefore, there is concurrence among the authors that some measures ought to be taken to eradicate the risks of NPLs The authors that provided methodologies to control or reduce NPLs indicate a higher link to risk and detection. Thus, the concern has been much more on how to capture the likelihood of risk occurrence and take mitigation measures. The authors seem to propose a remedy that alleviates the risk of NPLs from their source. In fact, Cerulli et al., have reflected on three factors that serve as the determinants of NPLs. The judicial system factor is important for the present research because reduction measures adopted in the EU for the banking sector should be based on efficient protocols in order to be successful. In a similar context, the study by Merja et al., linksmacroeconomic factors to increased NPLs, which means they also believe causes come from external factors.

The major gap in the literature is that inasmuch as most scholars examined the effects of NPLs towards systemic risk in the banking sector, none contemplated the moderating effects of NPLs reduction measures. There is still minimal literature that has examined the legal framework of NPLs in the banking sector beyond the European Union and its effects on systemic risk. It is still a new debate in the EU and an area requiring more exploration now and in the future.

A number of assumptions can be made when building the conceptual framework to guide the study: the relationship between NPLs and systemic risk is positive and causal. As a hypothesis, it can be inferred that increased NPLs lead to increased systemic risk. However, the conformity with NPLs reduction measures proposed in the EU should be expected to moderate the increasing effects of NPLs on systemic risk. Thus, the moderating effects of NPLs reduction measures are key to this research. The conceptual model is as shown in Appendix A.

The proposed model depicts the relationship between NPLs reduction measures proposed in the EU and their effects on SRISK. The model states that the reduction measures may not directly affect systemic risk but they would have moderating effects on the actual relationship between NPLs performance and SRISK. On the other hand, the effect of NPLs towards SRISK would also be affected by macroeconomic forces, including economic growth and the level of economic uncertainty index in the EU. Against this backdrop the following provisional hypotheses hold:

H_1: NPLs significantly increases SRISK in EU banks;

H_2: NPLs moderated by NPLs Reduction Measures will decrease SRISK in EU Banks;

H_3: NPLs mediated by macroeconomic factors i.e. GDP and economic uncertainty increase SRISK in EU Banks; and

H_4: Mediation effects of macroeconomic factors i.e. GDP and economic uncertainty when moderated by NPL reduction measures will decrease NPLs effects to SRISK in EU Banks.

METHODS, MODEL AND VARIABLES DEVELOPMENT

The preferred method was quantitative research because of the ability to work with numerical data and, based on such an approach, test or reject formulated hypotheses

(Willis, 2007). In order to test the hypotheses, the first review was the establishment of the relationship between NPLs reduction measures as a statutory framework and systemic risk; thus, a quantitative approach was most suitable due to its ability to provide an objective standpoint over the analysed data (Watzlawik & Born, 2007).

SRISK in the study was computed as:

$$SRISK_{i,t} = E\ (k\ (Debt + Equity) - Equity)\ /\ Crisis) = k\ Debt_{i,t} - (1\text{-}k)(1\text{-}LRMES_{i,t}) * Equity_{i,t}$$

The model parameter can be interpreted in the following manner: *k* signifies the capital ratio of the company, *debt* points to the book value of debt for the firm, *equity* signifies the firm's equity market value on a daily basis, and *LRMES* will be used to signify the Long Run Marginal Expected Shortfall.

The hypothesis formulated is based on the fact that NPLs serve as the driving force towards heightened systemic risk at EU commercial banks.

> *Ha:* NPLs performance with mediation of NPLs reduction measures will lower systemic risk of commercial banks in the European Union region.

Further, the 1st econometric model proposed in the study was as follows:

$$(SRISK\ /\ MKT\_CAP)_{i,t} = \alpha i + \beta_1 * NPL\%_{i,t} + \beta_2 * NIM\%_{i,t} + \beta_3 * NII\%_{i,t} + \beta_4 * LDR\%_{i,t} + \beta 5 * ln\ (PU)_t + \beta 6 * ln(GDP)_t + \lambda_{i,t}$$

As indicated, the dependent variable was the systemic risk and in the proposed model, it can be deduced that SRISK value highly links to the bank size: due to this the author normalised SRISK using Market Capitalisation to eliminate the size effect in the panel regression results. MKT CAP was collected from the annual reports of the selected banks for the respective periods. As per the second model, the NPLs ratio was considered as the independent variable ahead of inclusion of another control variable derived from the NPLs regulatory framework. The same shall be re-evaluated in the third econometric model proposed in due course. In order to render the results of NPLs more robust, consideration was given towards adding two kinds of control variables.

The first type included bank characteristics that may also determine SRISK performance. For instance:

> *NIM (%)*: Net Interest Margin was computed by virtue of dividing interest returns by earnings assets on average. In this paper, the author held the assumption that NIM has positive correlation to bank performance in EU and so may be deemed as a SRISK buffer.

> *NII (%)*: Non-interest income is used to denote the banks' participation in various market activities such as investment, intermediary operations and

consultancy. The author holds that non-interest income in EU banks has contributed greatly towards higher profitability and in stabilising the earnings base of the entire banking system.

LDR (%): Loan-to-deposit ratio shall evaluate the liquidity condition of EU banks; thus, where the ratio shall be too high then the banks may face the risk of inadequate money to pay back loans whenever customers demand withdrawal requests. On the other hand, where the ratio is too low, the banks in EU would have difficulty in generating optimal earnings. As a result, a lower LDR may be a pointer to safe liquidity hence lower SRISK level.

The second type shall be macro indicators which will be used to clarify whether the variations in SRISK derive from banks controlling NPLs at individual level or whether this is triggered by the region's economic condition.

Log (PU): uncertainty deriving from economic policy triggers stock market volatility and weakens investment activities in regions that are policy-sensitive like the EU banking sector. According to Patro and Sun (2013), economic uncertainty may be measured based on newspaper coverage frequency. Therefore, larger policy uncertainty may increase market panic and suppress the capital required to be achieved within a crisis scenario. The data was derived from the Economic Policy Uncertainty Index covering the EU for the specified period.

Log (GDP): The variable was adopted to test or rather examine whether economy size in the European region makes a noticeable contribution towards SRISK. Based on this, real GDP for EU as a region was recorded in US $ million.

The third model is NPLs reduction measures proposed in the EU region towards NPLs performance in the European Union region, and the identifiable effects on systemic risk. In other words, from the evaluation of the NPLs reduction measures in the EU, the central independent variable should be based on key applications of the provisions: hence, several proxies needed to be defined and represented using a dummy variable. In this regard, given the provisions evident in NPLs reduction measures, it was possible to build a "reform variable" denoted as "Rit" which was used to capture the applicability and effectiveness of the Reduction Measures: value 1 being the case where bank i is in full conformity with the Reduction Measures at any time t like a year, while zero if otherwise. Therefore, for bank groups there would be: Rit = 0 for 2008-2018 and Rit = 1 for 2008-2018. In addressing the hypothesis in that effective enforcement of NPLs Reduction Measures lead to decrease in NPLs hence lowering the SRISK, the following empirical specification was proposed:

$$SRISK_{i,t} = \alpha i + \beta_1{*}NPL\ Reduction\ Measures + \beta 2{*}NPL\%_{i,t} + \beta 3{*}NIM\%_{i,t} + \beta 4{*}NII\%_{i,t} + \beta 5{*}LDR\%_{i,t} + \beta 6{*}ln\ (PU)_t + \beta 7{*}ln(GDP)_t + \lambda_{i,t}$$

The annual reports of selected banks i.e. EU-listed commercial banks, in the period 2008-2018 were used to gather key financial data required to implement the models; other data was derived from the World Bank and Compustat Financial Database. The data was based on 46 commercial banks in the EU with a focus on having at most 500 observations.

The analysis of data was implemented using the STATA program to run fixed effects and random effects estimations. Therefore, the two models were used to estimate the panel data regressions. A sensitivity analysis was carried out to justify the stability of the parameters selected. For instance, Hausman test, model specification Ramsey RESET, Multicollineairity (VIFs) and Durbin-Watson Test.

FINDINGS

In this section the main findings have been reported with output from Stata program explained guided by panel data regressions. Upon declaring the time-series it was established that the model data was a strongly balanced panel.

Descriptive statistics are reported in Appendix B. The general observation indicates that apart from the mean scores for NII (5.6892) and the dummy variable for NPLs reduction measures (.8192), GDP (.1328) and SRISK (-.4334) other variables such as NIM (.1198), LDR (.5174), and NPLs (2.5121) had their standard deviations lower than the average scores. The same results indicated that there was a negative mean value for systemic risk which represents the case for the European Banks. On this metric it can be affirmed that on average the banking sector has kept the trend for systemic risk in the negative and that is a good thing. The reason is that it signifies a low rate of collapse among the 46 banks in the region. Also, standard deviation scores below the mean values represented a consistent trend that did not deviate much from the mean performance.

Systemic risk indicates having a weak but positive linearity to NPLs reduction measures (.127) and a negative but weak linearity when correlated to non-performing loans (-.072). Another negative and weak linearity can be cited between systemic risk and loan-to-deposit ratio (-.108) and non-interest income (-.115).

Regression Analysis

In appendix C, the OLS regression indicates an F-Statistics with a probability value of .000 which affirms a statistical significant difference between systemic risk and the rest of the independent variables. However, the R Squared at 8.62% is reason to believe there exists a weak fitness between the dependent and independent variables. The Anova results affirm that LDR (β = -.1007, P-Value = 0.018), NIM (β = .4737, P-Value = .000), NII (β = -.0408, P-Value = .013) are significant predictors of SRISK.

The Hausman test results rejected the alternate hypotheses, fixed effects panel regression were not used this paper. However, they have been provided in Appendix D for any future use.

In appendix E, the random effects panel regression results indicate a chi2 significance of .0025. Thus, the model is acceptable and the independent variables can be used to explain the trend in SRISK for the European Banks. However, an overall R squared at 8.53% means a low score goodness-of-fit across the dependent and independent variables. In the model, only NIM (β = .3858, P-Value = .002) and NII (β = -.0327, P-Value = .042) indicated havingpredictive significance to SRISK of the European commercial banks.

The hypotheses test results were based on the random effects panel regression just for purposes of comparison. The results are as summarised in Table 2.

TABLE 2. HYPOTHESES OUTCOMES

Hypotheses (Null)	Random Effects
NPLs will significantly increase SRISK in EU banks	Not Confirmed
NPLs moderated by NPLs Reduction Measures will decrease SRISK in EU Banks	Not Confirmed
NPLs mediated by macroeconomic factors i.e. GDP and economic uncertainty will increase SRISK in EU Banks	Not Confirmed
Mediation effects of macroeconomic factors i.e. GDP and economic uncertainty when moderate by NPL reduction measures will decrease NPLs effects to SRISK in EU Banks	Not Confirmed
NPLs performance, with mediation of NPL reduction measures, will lower the systemic risk of commercial banks in the European Union region	Not Confirmed

Robust Checks

The key hypothesis is:

Null: Random effects model is most suitable.

Alternate: Fixed effects model is most suitable.

The results in appendix G give a probability value of 0.0729 which means the null hypotheses is to be accepted. In that case, the random effects model is the most appropriate to use to interpret the future effects of NPLs reduction measures on systemic risk of EU commercial banks.

The results in Appendix H give a F statistic at 0.60 and the p-value at 0.6143; it means the null hypothesis has to be accepted by asserting that the powers of the independent variables do not jointly add that much explanatory power to the model. Hence, it may not be appropriate to include the designated independent variables into the model.

The test results are presented in Appendix I, where on average the coefficients are not more than 10 in the column for VIF. In that case, the model used does not have multicollinearity problems.

Discussion on Findings

As can be seen from the results, systemic risk indicates to have positive linearity to NPLs reduction measures. However, the nature of linearity is that it provides grounds to determine what is the direction of a relationship, hence it outlines the importance to policymakers in the banking sector in EU. For instance, positive linearity between the legal framework currently proposed in the EU should be in a position to reduce systemic risk and not increase it even in the slightest metrics. Weak linearity supports such a trend which should invite more scrutiny to the legal framework and be certain it would not be proportionate to systemic risk in the banking industry. In fact, the results should indicate that NPLs reduction should negatively influence systemic risk. In the random effects model, the beta results indicated that NPLs had a non-significant beta and it is actually a worrying establishment. The reason is that it does not state the relationship between NPLs reduction (β=.106,.149) hence it would not be possible to predict the exact effects to systemic risk.

The indications from the findings are that the effects of NPLs reduction measures to systemic risk of commercial banks in Europe cannot be taken for granted. However, the significant effects were not sufficiently or strongly emergent from the data findings.

CONCLUSION

In conclusion, the assertions that can be drawn from this study are that systemic risk is significantly affected by NPLs reduction measures or the statutory framework. In that regard, the ongoing review on its implementation in the European Union should be accorded maximum attention as, if well directed, it can support the banking industry ing addressing the proliferation of NPLs in the region. However, the analysis needs to be re-looked into and the conceptual model proposed in the study further explored to document the excluded factors in the current paper pertaining to NPLs reduction measures that have an effect on systemic risk to banks in the EU.

The decision to institute a legal framework to govern and oversee non-performing loans is a significant consideration with a high likelihood of addressing the challenges leading to systemic risks to commercial banks in the EU. Banking policymakers in the European Union may consider increasing the value of the secondary markets for credit and liberalising the security recovery requirements. In order to re-formulate the findings of the study and justify its findings, it is better for future scholars to undertake a mixed methods research guided by surveys and interviews with industry experts. The importance of such a study would be to establish the exact effects of the proposed NPLs reduction measures on systemic risk by seeking the opinion of experienced professionals in the banking sector. The reason is that given NPLs reduction measures are still not fully executed, an econometric analysis may not provide the actual scenario in terms of the effects on systemic risk.

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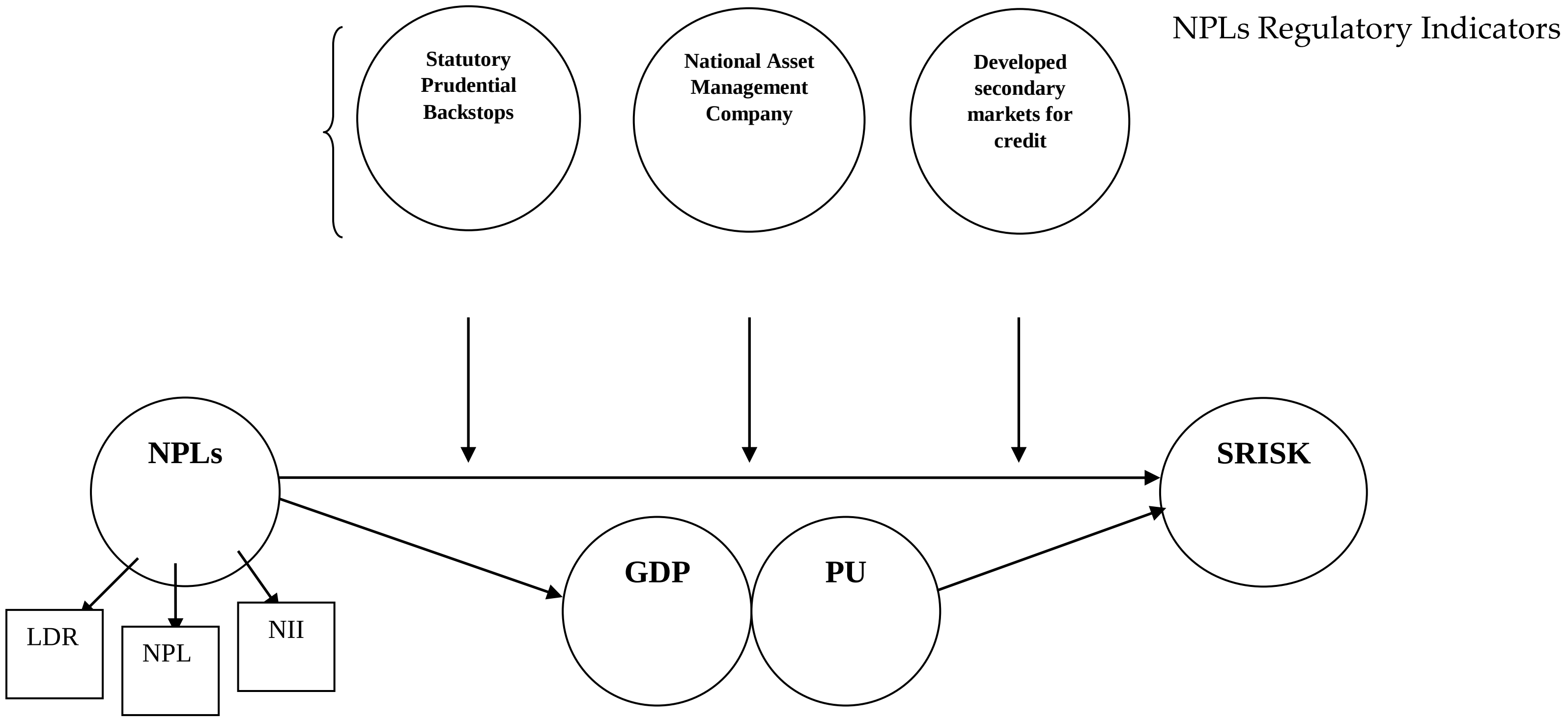
APPENDICES

APPENDIX A: CONCEPTUAL FRAMEWORK



APPENDIX B: DESCRIPTIVE STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
NIM	470	.1198428	.2043183	-1.0211	.6559
LDR	470	.5174083	.5279777	-1.8267	2.0518
NPL	470	2.512069	3.02751	-.5229	7.8001
NII	470	5.689162	1.352021	0	7.2798
MC	470	5.689162	1.352021	0	7.2798
Dummy	470	.8191489	.3853049	0	1
GDP	470	.1327849	1.152262	-2.6762	4.5813
SRISK	470	-.4334226	.4523768	-3.3161	.2404

Source: (Stata Program)

APPENDIX C: LINEARITY MATRIX

	NIM	LDR	NPL	NII	MC	Dummy	GDP	P.U.	SRISK
NIM	1.0000								
LDR	0.2008	1.0000							
NPL	-0.1979	0.1137	1.0000						
NII	0.2270	0.3780	0.0254	1.0000					
MC	0.2270	0.3780	0.0254	1.0000	1.0000				
Dummy	0.1996	0.0069	-0.0787	0.0050	0.0050	1.0000			
GDP	0.0620	0.1393	-0.0242	0.0392	0.0392	-0.1468	1.0000		
P.U.	0.003	0.005	-0.001	-0.046	-0.046	-0.1724	0.0751	1.0000	
SRISK	0.1890	-0.108	-0.072	-0.115	-0.115	0.127	0.066	0.012	1.0000

Source: (Stata Program)

APPENDIX D: OLS REGRESSION MODEL

Source	SS	df MS	Number of Obs	470
		F (7, 462)	=6.23	
Model	8.27469779	7 1.18209968	Prob > F	=0.0000
Residual	87.703695	462.189834838	R^2	=0.0862
		Adj R^2	=0.0724	
Total	95.9783928	469.204644761	Root MSE	=0.4357

SRISK	Coef.	Std. Err. t	P>t	95% Conf.	Interval
Dummy	.1192466	.0548867 (2.17)	0.030	.011388	.2271051
LDR	-.1007209	.0423088 (-2.38)	0.018	-.1838624	-.0175794
NIM	.4737072	.106954 (4.43)	0.000	.2635307	.6838837
NPL	-.0004102	.0068786 (-0.06)	0.952	-.0139273	.013107
NPL	0	(omitted)			
NII	-.0407674	.016345 (-2.49)	0.013	-.0728871	-.0086476
GDP	.0343896	.017912 (1.92)	0.055	-.0008095	.0695886
P.U.	.0071973	.0192052 (0.37)	0.708	-.030543	.0449376
cons	-.3079425	.10158 (-3.03)	0.003	-.5075585	-.1083265

Source: (Stata Program)

APPENDIX E: FIXED EFFECTS MODEL

R^2: within	**0.0185**	**Obs per group: min**	**10**
Between	0.0248	**Avg**	10.0
Overall	0.0185	**Max**	10
		F (7,416)	1.12
Corr (u_i, Xb)	-0.1017	**Prob > F**	0.3497

Srisk	Coef.	Std. Err.	P > ǀtǀ	[Interval]
Dummy	-.0532378	.150442	0.724	.2424833
NIM	.2442843	.1677883	0.146	.574103
LDR	-.0489371	.0751357	0.515	.0987558
NPL	.0185116	.0248312	0.456	.0673219
NII	-.024107	.0166925	0.149	.0087052
GDP	.0263745	.0205043	0.199	.0666795
P.U.	.0231084	.0199537	0.247	.062331
cons	-.3084825	.1646149	0.062	.0150981
Sigma_u	.23732735			
Sigma_e	.40596388			
rho	.25471005	(fraction	of variance due to u_i)	

Source: (Stata Program)

APPENDIX F: RANDOM EFFECTS MODEL

Random-effects GLS regression	**Number of Obs**	**470**
Group variable: bank1	Number of groups	47
R^2: within = 0.0141	Obs per group: Min	10
Between = 0.3237	Avg	10.0
Overall = 0.0853	Max	10
	Wald chi2(7)	22.04
Corr (u_i, X) = 0 (assumed)	Prob > chi2	0.0025

Srisk	Coef.	ǀP>zǀ	Interval]
Dummy	.1056791	0.149	.2491127
NIM	.3858165	0.002	.6321575
LDR	-.076447	0.127	.0216246
NPL	.0001659	0.986	.0188466
NII	-.0326519	0.042	-.0011296
GDP	.0296456	0.112	.0662333
Pu	.0153471	0.418	.0525249
_cons	-.346498	0.002	-.1260757
Sigma_u	.15403097	-	-
Sigma_e	.40596388	-	-
rho.	12584343 (fraction of variance due to u_i)		

Source: (Stata Program)

APPENDIX G: HAUSMAN TEST RESULTS

Test:	Ho:	difference in coefficients not systematic
	chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)	
	= 12.97	
	Prob>chi2 = 0.0729	

Source: (Stata Program)

APPENDIX H: MODEL SPECIFICATION RAMSEY RESET

Ramsey RESET test using powers of the fitted values of srisk
Ho: model has no omitted variables
F(3, 459) = 0.60
Prob > F = 0.6143

Source: (Stata Program)

APPENDIX I: MULTICOLLINEAIRITY (VIFS)

Variable VIF	1/VIF	
LDR	1.23	0.811169
NII	1.21	0.828832
NIM	1.18	0.847607
Dummy	1.10	0.905023
NPL	1.07	0.933332
GDP	1.05	0.950196
Pu	1.04	0.963289
Mean VIF	1.13	

Source: (Stata Program)

Journal of Applied Economics and Business

OPEN ACCESS ARTICLE

FROM GLOBAL EARTH MAGNETIC FIELD TO THERAPEUTIC EXPERIENCE: TOWARDS A THEORETICAL FRAMEWORK FOR DEVELOPING TOURISM PRODUCT

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Abstract

Beside the gravity, the magnetism is one of the fundamental properties of the Earth and it is native and fundamental to our planet's existence. Recently, an interest is paid to the biomagnetism as a special scientific field dealing with the influence of the global Earth's magnetic field on humans. So it became a diagnostic tool and a therapeutically procedure for many diseases, like: neuronal or cardiac diseases, trauma injuries, brain and heart miss functions and problems. Hence, large number of academicians argue that this global Earth influence could and should not be neglected. Some other, more specific studies focus on the so-called Schumann resonance magnetic field frequencies that exhibit some peculiar properties not only to human's environment, but also to human's behavior and wellbeing. The objective of the paper is to introduce some new insights and raise a discussion if the existence of such magnetic fields may be a reason why people feel more relaxed and healthier when visiting some recreational locations (like: tourist resorts, wellness, spa and recreation centers) and tourist attractions (like: churches, monasteries, geo-parks, etc.). So, the paper discusses that the recreational areas that are affected by the low-frequency electromagnetic fields and stream with high positive signals on human behavior and health conditions of tourists, visitors, and excursionists, may offer ultimate satisfaction in an ambient with positive and harmonious energy vibrations. Finally, the findings may assist in identifying new strategic dimensions for promoting new aspects of tourism product. Tourism along with the wellness industry, often relies on to the health-promoting atmospheres which may be related to many other medical practices, therapy interventions, holistic approaches, leisure pursuance leading to tourism destinations development.

Key words:

Low frequency; Schumann resonance; Therapeutic effect; Tourism.

INTRODUCTION

The Earth is a very complex and multi-structured rocky type planet. Due to a geodynamo mechanism in the outher liquid and metallic Earth's core, the main part of the Earth's magnetic field is known as the main field, or core field. Such flow is driven by buoyancy forces and influenced by the Earth's rotation and generates large electric currents that induce a magnetic field, compensating for the natural decay of the field over the space and time. Yet, the Earth's magnetic field is certainly not static, but varies dramatically over long periods of time. While the major source for Earth's magnetic field is the electric currents deep in the molten outer core of the Earth, the source of electromagnetic fields in the human body could be traced in the rhythmic heart activities. The heart is by far the largest electric generator in the body. It continuously pumps and creates a magnetic field around itself which goes way beyond the skin. It creates various signals, like electric, sound, pressure, heat, light, magnetic and electromagnetic. So, the human body is heavily influenced not only by the external but also by the internal magnetic field generated within the body, called biofield. The frequencies of biofields, particularly the so-called extreme low frequencies (ELF) of the pulsations range from 0.3-30 [Hz] are found to have positive therapeutical effects on humans.

When addressing tourism and leisure services, the health issue seems to be of great importance to everyone, regardless of the individuality in specific needs. So, rejuvenation, relaxation, detoxification and overall therapeutic mind-set, emerged as new exploratory aspects for initiating added-value tourism products of spa and wellness tourism. Some potential is found in the possibility to create a state of synchronization between positive emotions, cardiovascular, respiratory, immune and nervous systems, which are influenced by the Schumann resonance (SR) (Schumann, 1952).

Though SR literature is continuously growing, the issue of how the global Earth magnetic field may lead to therapeutic experience for tourists that visit tourist attractions with positive vibrations, is barely discussed. This paper attempts to fill this gap by proposing to initiate an identification of new frontiers, thus demonstrating the manner in which some areas have the potential to reflect the therapeutic benefit of the Earth's magnetic field on tourists. Besides offering a theoretical framework for perceiving new approaches in developing tourism product, the study adds to the current research on electromagnetic field radiation. With just few exceptions, (Cingoski, 2019; Petrevska & Popovski, 2019), to our best knowledge, no academicians have dealt with this topic in this manner.

LITERATURE REVIEW

The electromagnetic frequency has effects on global coherence of living things, so the literature review commences with a discussion of the concept of positive paradigm and potential dynamics over tourism and leisure activities. The SR is vastly explored and the literature is continuously growing. It was detected by Balser and Wagner (1960) as a spectrum of resonant electromagnetic waves in the extremely low-frequency range in the Earth-ionosphere cavity. Generally, the studies were focused on evaluating the characteristics of global lightning and thunderstorm activity (Nickolaenko et al., 2003; Nickolaenko, 1997; Nickolaenko & Hayakawa, 2002), monitoring the global upper-tropospheric water vapor changes (Price, 2000), and monitoring planetary temperature (Williams, 1992). Furthermore, Nickolaenko and Rabinowicz (1982) used the SR in the exploration of the electrical activity and lower ionosphere parameters on celestial bodies.

SR AND THERAPEUTIC BENEFITS

The literature contains a large body of work exploring the effects of the Earth magnetic field on all living beings, including humans in their natural environment. Figure 1 clearly shows the presence of the SR by forming distinct peaks starting around the fundamental frequency of 7.8[Hz] with higher harmonic components at 14, 20, 26, 33, 39 and 45[Hz].

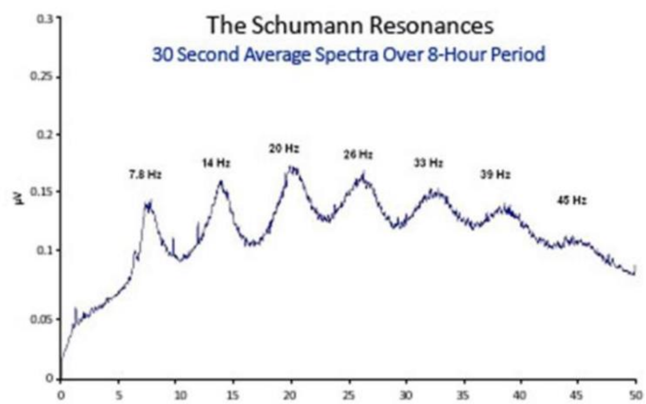

FIGURE 1. SCHUMANN RESONANCE
Source: Edwards. (2015).

As noted by McCraty et al., (2012), and McCraty and Deyhle (2015) this directly overlaps with the central nervous system alpha wave bandwidth which is associated with the psychophysiological coherence of 0.1[Hz], the approximate 10-second cycle of ocean waves and the hypothetical resonant frequency of the Earth. Furthermore, Brizhik et al., (2009) discuss the postulation of feedback loops between all living systems and the Earth's magnetic field, enabling encoded information to be communicated non-locally between people at a subconscious level. In the same line, Lynch (2014), McCraty (2003) and Rosch (2014) argue that the presence of electromagnetic interactions within and between people have vast implications for interpersonal communication, psychotherapy, healing, and future related research and praxis, which have hardly been tapped.

It was noted that during the long evolution phase, the human brain adjusted its normal activity to the most intrinsic Earth-based frequencies (the Schumann resonance and the Earth's core frequencies), and actively interacts with them. In case of their obstruction or limitations, problems might occur with the normal human's brain activity leading to neurological disorders and decesses, such as disruption of melatonin synthesis, decrease in self-confidence and working ability, especially during the autumn and spring periods, depression and especially, manic-depressive illness, enhanced anxiety and sleep disturbances (Ward & Henshaw, 2016), Alzheimer's, Parkinson's, or Huntington's deceases (Gubbins & Herrero-Bervera, 2007), and even increased number of suicides (Ward & Henshaw, 2016; Brahic, 2008).

Petrevska and Popovski (2019) found a significant presence of the basic pulsation of the SR along with other positive harmonics when assessed a spa center. They confirm the presence of positive therapeutic effects, whereas the frequencies around 7-8[Hz] support the bone growth, frequencies around 10[Hz] support the ligament healing, while the frequencies around 15[Hz] are in favor for capillary formation, fibroblast proliferation and decrease skin necrosis (Human frequency blog b, 2019). Such variety of positive effects derived from the ELF highlights the possibility to identify and promote locations where people visit to seek leisure, wellness or health (Morita et al., 2006) and feel more relaxed, with a rejuvenated body and empowered brain and heart activity, leading to general improvement of their wellbeing.

The presence of SR at specific locations provoke positive physiological actions to the health and wellbeing through nature experiences, in the line of additional involving of the five human senses exposures (sight, smell, hearing, taste, and touch) (Lazzerini et al., 2018). Hence, as of early 1900s, many recreational environments detected their biological benefits and therapeutic potential (Kinne, 1997) and applied health resort programs and concepts (Linning, 2007; Roubal et al., 2017). So, along the 'basic tourism product', many recreational areas that stream SR signals may form an initial point for additional development of tourism attractions and destinations, based on the positive impulses of the nature. By such, a specific tourism product with zero seasonality and no negative effects to the environment may be promoted. In addition to the traditional recreational packages, the new approach may include prompt hope to the natural, historic and cultural heritage preservation, along with the health-inducing: life quality, welfare (mood, performance, relaxes, detox), medicine indications (metabolism, respiratory and circulatory systems), elderly care and chronic diseases treatments. Slowly, the awareness of the natural healing option rises, so it is a case when recreational facilities offer to sleep in magnetic beds, or the case when the souvenir shops sell small magnetic objects for energy, preventive purposes, and healing.

CONCLUSION

The Schumann resonance is a global level important discovery that Earth produces natural electromagnetic waves in the ELF of 7.83[Hz]. It spreads a signal that positively or negatively affects all living beings, including humans in their natural environment. The research discussed some impacts that this resonance may have over tourists and visitors that visit or prospectively intend to visit different tourist locations. It was pointed over that some attractions with tourism motives (like churches, monasteries, spas, mines, geo-tourist locations, etc.) may benefit from such perception if being promoted as locations that offer therapeutic experience. From a scientific point of view, the paper offers the possibility to perceive some effects of the SR on tourists, visitors and excursionists from different approaches (psychological, neurological, physiological, etc.), with a focus on the therapeutic benefits. From a practical point of view, the findings may assist in identifying new frontiers and strategic dimensions for promoting new aspects for developing tourism product based on positive and harmonious energy vibrations in tourism locations.

LIMITATION AND FUTURE WORK

The research has many open issues that may serve as productive starting points for future work. The most profound is the lack of substantial accurate measurements on sampled locations in order to assess signal impulses, along with numerous repetitions to purify the data from magnetic storms and sub-storms, electric discharges and thunderstorms that may occasionally appear.

The limitations, however, do not diminish the significance of the findings, but they rather suggest some broad directions for further research. Notwithstanding the difficulties, this article assists in a better understanding of the distribution of the magnetic field signals, dispersion and potential positive effects on tourists and visitors. Overall, the research generates useful findings and points to valuable directions for further work.

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Journal of Applied Economics and Business

OPEN ACCESS ARTICLE

ASSESSING THE REGIONAL VARIATIONS OF DISASTER IMPACT IN THE UNITED STATES

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Abstract

This paper utilizes state level data to address the relationship between disasters and economic growth in the United States. Focus is placed on the regional nature of this relationship. The analysis is conducted at two levels: first, utilizing all fifty states to provide a broad model for the entire United States, and second, utilizing only the nine states that define the Northeast United States to generate a more tightly focused single-region model for comparison with the results from the broader national analysis. The results of each model suggest that disasters do affected variations in economic growth and produces differing results for the regional and national models.

Key words:

Disaster, Economic growth, United States, Regional model.

INTRODUCTION

The relationship between disasters and macroeconomic performance is still ambiguous however, several distinct themes are emerging. First, there is existing research on the impacts of disasters that are focused on individual disasters in cities and connected regions, for example, Hurricane Katrina's impact on New Orleans or on the greater Gulf region. These studies have found significant downturns in economic output at the tightly-focused geographic region in the aftermath of the disaster. Ewing et al., (2010) and Gordon (et al., 2010) found that Hurricane Katrina's devastation of the New Orleans area resulted in a downturn in economic output for the city and for the state of Louisiana. Also, studies conducted on the impacts of disasters on small Caribbean nations have found that disasters affect those economies in a negative manner (Barrientos, 2010; Easter, 1999; Rasmussen, 2004). Tsunamis in Japan and Indonesia also resulted in significant reductions in short term economic output (Schipper, 2008).

Second, disasters have also been found to have some potential for positive impacts on affected communities (Ewing & Kruse, 2002; Greenberg et al., 2007; Guimaraes et al., 1993; Skidmore & Toya, 2002). They posit that recovery often demands rebuilding, and these rebuild projects may lead to modernization that generates improvements in efficiency and productivity. The projects may be spurred by businesses as they address recovery after disasters or by governments as they infuse funds in severely affected communities. Economic growth after disaster has sometimes outpaced growth rates before the disasters (Surowiecki, 2011).

Third, there are global studies using countries as the unit of analysis when looking at the impact of disasters on GDP. These have had very inconclusive findings. Altay and Ramirez (2010) found that disasters affect global supply chains, and these impacts differ for upstream versus downstream partners. Kellenberg and Morabak (2008) found measurable patterns between losses from natural disaster and economic development. Numerous other studies have found very little or no substantive results. Noy (2007) review of works on the impacts of macroeconomic disasters found evidence that disasters do involve economic downturns in the short term but noted that this work is in its infancy.

No significant emphasis has been placed on the potential for disasters in one region to affect economic performance in other regions. For example, could a disaster in New York affect other states across the nation, or does a bad hurricane season, largely affecting the Southern states, affect state-level macroeconomics across other states in the nation?

Given the findings from single-state, single-disaster studies and from other studies of global disaster impacts, it appears that disasters are capable of producing both positive and negative outcomes. Global studies appear to be challenged by the fact that these varying impacts of disasters may be offsetting each other, i.e. there may be both negative and positive impacts each occurring in different regions and having offsetting effects. This raises the question of whether the negative impacts found in some studies are simply a matter of cases where the destructive effects of the disasters are greater than the gains from rebuilding and modernization, and are the positive findings the converse of this scenario?

Further, are the resulting impacts moderated by non-disaster related factors? For example, does the economic base of a region, state, or nation matter? Would a manufacturing-intense economy be affected differently than a service-based or agricultural-based economy? Finally, do disasters in one region trigger chains of events that eventually affect GDP in the other regions, and if so, can the relationship between those distant disasters be effectively mapped to local changes in GDP? Were the impacts of Hurricane Katrina limited to the Gulf region or that of Super Storm Sandy to the Northeast region?

Drawing inspiration from the above-mentioned issues, four research questions are posed. First, do disasters account for large movements in GDP, e.g. a 0.5, 0.75 or 1 percentage point movement away from the 5-year moving average? Second, are non-disaster related factors capable of moderating the impacts of disasters on state-level GDP? Third, is economic output affected only by present-year disasters, or do disasters in the previous year contribute significantly to economic impacts? Fourth, do a high number of disasters in one region, say, the Midwest, affect GDP movements in other regions, for example, the Northeast, or are the impacts of disasters confined to the local geographic region?

RESEARCH MODEL

Figure 1 presents the theoretical model for the study. Disasters have macroeconomic impacts. These impacts are moderated by the economic base of the states. The moderating factors are chosen here as the percentages of agriculture, services, and manufacturing/industrial activities in each state for the year in question. This allows for analysis of whether agricultural intense states are affected differently from manufacturing or service oriented states.

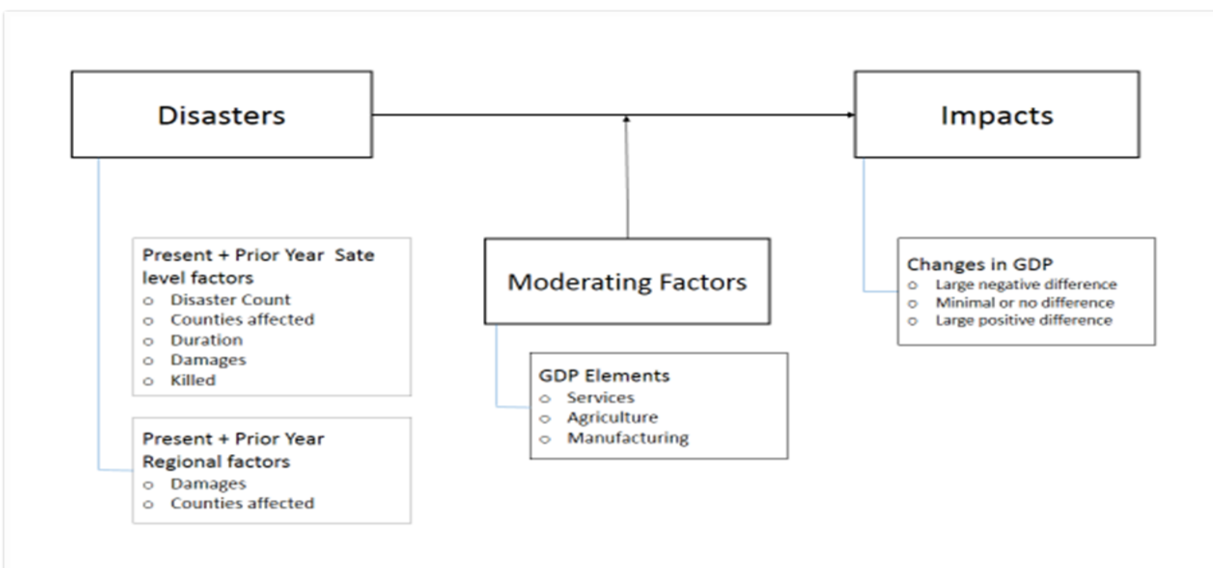

FIG 1. MODEL

Disasters are addressed in two ways:

First, traditional measures utilized in earlier studies are adopted to classify the localized impacts of disasters. The size/scope of the disaster is measured using variables such as count, duration, damages, and number of persons killed. Each of these variables is normalized based on standard conventions (as a percentage of the state's population).

Second, aggregate, regional-level disasters are calculated to facilitate the relationship between disasters in one region and GDP variations in other regions. Two variables, 'damages per region per year' as a percentage of the region's GDP and 'counties affected' per region per year as a percentage of the total number of counties in the region, are chosen for the analysis. Both variables are utilized at present- and prior-year levels (Preliminary analysis of the data pointed to greater significance of these two aggregate variables).

DATA AND METHODOLOGY

Data is taken from two sources:

First, the SHELDUS database managed by the University of South Carolina provides details on the disasters. County-level data is provided on each disaster. This includes start and end dates, injuries, deaths, and monetary value of damages for each disaster for each county in every state. A summary table showing the disaster counts and damages caused is presented in Appendix C. Common disaster types include severe thunder storms, winter weather, flooding, wind damage, and tornadoes. Damages (in 2,000 dollars) totaled $333.8 billion over the period 1991-2008. The data are adapted to reflect the state as the unit of analysis for each year of the study. Disaster data are also available from other sources (For example, FEMA data through www.data.gov). The SHELDUS database provides data on damages that were deemed important to this study, and as such, was chosen as the better source for disaster-related data.

Second, the Bureau of Economic Affairs' (BEA) website provides information for the gross domestic product (GDP) for each state, GDP growth, and the proportion of each state's economy comprised of agricultural-, industrial-, and services-based activities. State-level Real GDP grew at an average of 2.51% over the study period. Agriculture accounted for as little as 0.67% to as high as 2.24% of any state's GDP during the period. Industrial activities accounted for as little as 9.01% to as much as 34.07% of a state's GDP. Finally, services accounted for as little as 67.1% to as much as 80.13% of a state's GDP.

Independent Variables

The list of independent variables is shown in Table 1. Variables are addressed at the present- and prior-year level. The thesis here is that impacts of investments in recovery and rebuilding are an important part of disaster analysis and its impact on GDP. Prior-year events influence the process of recovery, and as such, the positive impacts such as productivity improvements that are often associated with disasters. There is no precedence for the utilization of one versus multiple years of prior disasters to examine productivity improvements or the likely macroeconomic effects. The decision to include the prior year's disaster is, however, deemed essential here.

TABLE 1. DESCRIPTION OF THE STUDY VARIABLES

Abbreviation	Full description	Level
StateYear	Unique identifier: each state for each year of the study (e.g. California 2001)	State
Agriculture	Percentage of State GDP Output generateg from agricultural related activities	State
Munafacturing	Percentage of State GDP Output generateg from Industrial/munafacturing related activities	
Services	Percentage of State GDP Output generateg from services	
Count-sqMi	Number of disasters per square mile	State
Count-pop	Number of disasters per 100,000 persons residents	
Affected	Percentage of counties affected that year	
Duration	Sum of ((counties affected) * (number of days)) /(no of counties in the state)	
Damages	Damages / State-GDP	
Injuries	Injuries / State Population	
Deaths	Deaths / State Population	
MWCouAffected	(Number of Midwest counties affected) / (number of counties in the midwest)	Regional Aggrergrate
MWDamages	(Damages in the midwest) / (GDP for midwest region)	
NECouAffected	(Number of northeast counties affected) / (number of counties in the northeast)	
NEDamages	(Damages in the northeast) / (GDP for northeast region)	
SouCouAffected	(Number of South counties affected) / (number of counties in the south)	
SouDamages	(Damages in the south) / (GDP for midwest south)	
WestCouAffected	(Number of West counties affected) / (number of counties in the west)	
WestDamages	(Damages in the west) / (GDP for west region)	
RealGDP	Real GDP (year = 2000)	State
5YRavge	5 year moving average of GDP (does not include present year)	State
gdp-Diff	Difference between real GDP and the 5 year average.	State
Class	0 = large negative deviation, 1 = very little ir no deviation; 2 = large positive deviation	State

Disasters are analyzed at the state level in terms of disaster counts, duration, damages caused, and number of persons killed. The database does not report persons affected (often assessed in disaster impact analysis). Disasters are reported at the county level allowing us to generate a measure of the affected base for each disaster. The percentage of counties affected by the disaster is utilized as a measure of its impact on the state. For example, one disaster may affect all counties in the state while another affect only a modest fraction of the counties.

The variables are normalized as conventionally done in disaster-related literature. Of note is the normalization of 'Disaster counts'. This is processed in two ways - the number of disasters per 100,000 residents and the number of disasters per square kilometer. Both means of normalizing disaster counts are commonly used in the existing literature. The 'Feature Selection' option in Statistica 10.0 identifies which variables are more significant to the analysis in question. In no cases were both of these normalized variables found to influence the analysis. The full listing of variables and normalizations is presented in Appendix A.

Dependent Variables

GDP change is addressed as a three-tiered, dependent variable, namely, negative GDP change, very minimal change, and positive change relative to the 5- year moving average. There is no precedence in the existing for the level of change utilized as the thresholds. Three unique levels were studied to see the extent to which the predictability of the model changes with the differing thresholds values. The first case utilized a 0.5% threshold. Here, the dependent variable was categorized as:

i. Negative GDP change greater than -0.5 percentage points as "0";

ii. GDP change between -0.5 and 0.5 as a "1"; and

iii. GDP change greater than 0.5 as "2".

The second and third case used thresholds of 0.75% change and 1% change, respectively. The final results are discussed for the level with highest predictive accuracy.

		Predicted		
		0	1	2
Actual	0	Y	x	x
	1	x	Y	x
	2	x	x	Y

FIG 2. CLASSIFICATION MATRIX

As shown in Figure 2, the accuracy of the resulting neural network will be a measure of the extent to which it predicts the 0's, 1's and 2's accurately as 0, 1, and 2 in the test data.

The Neural Network

As presented by Panda and Narasimhan (2007) neural networks do present advantages over other linear and non-linear modeling techniques. Their flexible nonlinear mapping capability allow them to continuously approximate measurable functions with good degrees of accuracy. Also, being nonparametric and data driven they impose very few constraints on the underlying process from which the data is generated. These positives have led to broad usage in fields ranging from medical applications (Kaur & Wasan 2006), to bankruptcy modeling (Wilson & Sharda 1994), exchange rate modeling (Jamal & Sundar 1998) and sales forecasting (Lau et al., 2012).

Neural networks do however have their weaknesses. Minor changes in configurations, number of neuron and/or hidden layers sometimes lead to great changes in the output results. Changes in weightings associated with input variables can also affect results. To overcome these problems we utilized the defaults settings in Statistica's neural network.

The analysis is conducted using the neural network functionality in Statistica (v. 12.0). Unlike many stand-alone neural network software packages, Statistica provides default options for the data analysis with information such as the number of layers and hidden neurons. The algorithms used in the optimal models are provided as a part of the package. Changes may be made to these default settings; however, numerous preliminary runs found very little changes in the output when the defaults settings were adjusted. As such, the decision was made to adopt the default settings as the study's runs were executed. It should be noted that these defaults are not static. A larger dataset will default to a larger number of internal neurons, for example. The net result here is that it moves the discussion away from the extent to which the network is tailored and squarely to the actual output of the networks.

Statistica divides the presented data into three blocks: seventy percent for training the network, fifteen percent for testing the network, and the final fifteen percent for validation of the trained network. The network is trained and tested interactively. This minimizes the risk of the training process getting tied to a suboptimal path with great training output but poor testing results. This interactive training and testing delivers a model that is then validated against the final 15% of the data. This becomes the unseen data against which the predictability of the network is tested. As such, the quality of the final results is attained from the validation performance.

FINDINGS

The model generates an output for each of the three levels of the dependent variables, namely percentage changes to GDP at the "0.5", "0.75", and "1" levels. The predictability results for the entire U.S. and for the Northeast region are shown in Table 2. As stated earlier, Statistica trains and tests the network during development, and the final test of the network performance is the validation performance. This is done against a sample of the data that is held out for assessing the network quality (and is not seen by the training and testing procedures). As such, the validation performance is the critical output for us.

The USA analysis, i.e. fifty state dataset, generated validation performance of 61.4 when using GDP change of 0.5% as the threshold. This validation performance falls to 58.77 and 57.89 when GDP change is held at the 0.75 and 1%, respectively. The validation performance is much higher for the Northeast states. At the 0.5 and 0.75 GDP change thresholds, the model delivers validation performance of 81.82%. This falls to 77.27 for the 1% change in GDP. Given that both national and regional-levels of analysis have optimal results at GDP change of 0.5%, the rest of the study findings will focus only on this set of network outputs.

TABLE 2. VALIDATION PERFORMANCE FOR THE NEURAL NETWORKS

Region	GDP Movement	Network Name	Training Performance	Test Performance	Validation Performance
USA	0.50	MLP-15-9-3	65.18	59.65	***64.10***
	0.75	MLP-15-16-3	66.85	65.79	58.77
	1.00	MLP-11-4-3	54.19	63.19	57.89
NE	0.50	MLP-12-12-3	82.08	81.82	***81.82***
	0.75	MLP-12-10-3	88.68	77.27	81.82
	1.00	MLP-12-8-3	72.64	59.09	77.27

Table 3 shows the classification output for both USA and NE states. As seen on the left the model predicts the USA (50 states) fairly well, but not exceptionally. The '0s' and '2s', i.e. the large negative and positive deviations from 5-year average GDP, are handled much more accurately than the cases that did not fluctuate significantly from the 5-year moving averages. The NE state generates much higher quality results. Predictions are excellent for the '0s' and '2s' and marginal for the '1s'. The '2s', for example, are predicted accurately 100% of the time (nine of nine cases).

TABLE 3. CLASSIFICATION OUTPUT FOR USA AND NE STATES AT 0.5% CHANGE IN GDP

USA		Classified as 0	Classified as 1	Classified as 2	Total
Actual	0	**28**	0	7	35
Actual	1	12	**3**	6	21
Actual	2	17	2	**39**	58
	Total	57	5	52	

NE		Classified as 0	Classified as 1	Classified as 2	Total
Actual	0	**7**	3	0	10
Actual	1	1	**2**	0	3
Actual	2	0	0	**9**	9
	Total	8	5	9	

The ROC Curves

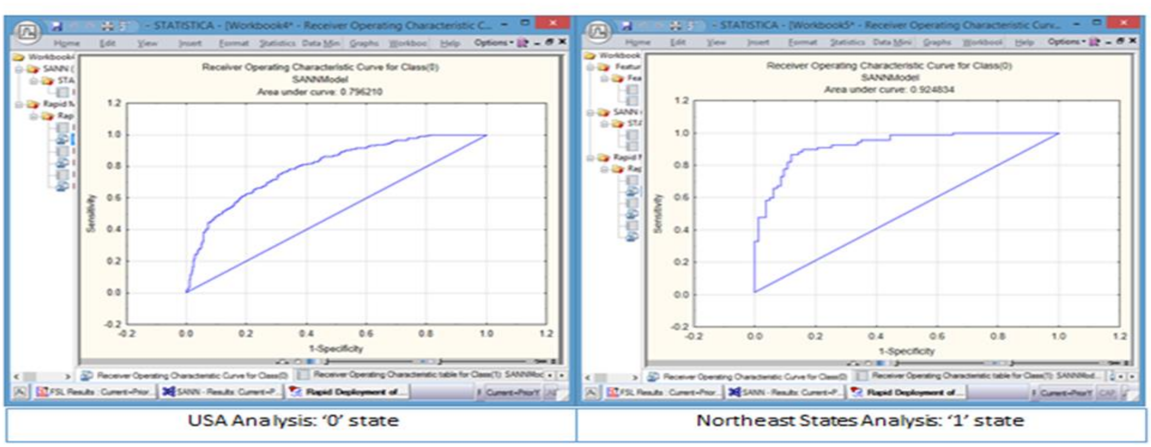

FIG 3. THE ROC CURVES FOR THE (0) STATES FOR USA AND NORTHEAST STATES

A sample of the receiver operating characteristics (ROC) curve is presented in Figure 3. The ROC curves show the accuracy of classification (i.e. percent of true positive to false positive for the model). The choice of a 3X3 matrix, rather than the more conventional 2X2 matrix used in most neural network analyses, resulted in three unique ROC curves generated by the software. Figure 2 presents the ROC curves for the '0s' for both the full USA analysis and the Northeast states analysis. The full set of figures is available in Appendix C.

The area under the ROC curves varies from 0.5 to 1, with 0.5 representing no discrimination and 1 representing perfect discrimination (Flaherty & Patterson, 2003). As seen in Figure 2, the area under the ROC curves for the USA and Northeast states were 0.8 and 0.92, respectively, for the '0' classification. The values for the '1' classification for the USA and NE states analyses were 0.71 and 0.81, respectively. The values for the '2' classification for the USA and NE states analyses were 0.82 and 0.95, respectively. A summary of the ROC values is presented in Table 4.

TABLE 4. FULL LIST OF ROC CURVE VALUES

	USA	Northeast
(0)	0.80	0.92
(1)	0.71	0.81
(2)	0.82	0.95

The Independent Variable Rankings

Statistica produces a measure of the importance of the independent variables to the neural network analysis and ranks the variables by chi-square value. Each chi-square and p-values are provided for each variable entered into the analysis. These results are presented in Tables 5 and 6. As seen in the tables, the aggregate variables dominate the model. They account for the top eight variables in the national study and the top 6 in the more focused Northeast study. Of note is the fact that the same variables do not dominate the two separate analyses. The 'percentage of Northeast counties affected in the prior year' leads the national analysis. This is followed by the 'percentage of Midwest counties affected in the prior year' and the 'percentage of Southern counties affected in the present year". The top three variables for the Northeast regional study are: the 'percentage of West counties affected in the present year', the 'percentage of West counties affected in the prior year' and the 'percentage of Southern counties affected in the prior year'.

Several patterns emerge in the results in addition to the dominance of regional aggregates over state-level variables:

First, both present- and prior-year variables are significant in the models.

Second, the 'percentage of counties affected' variable ranks higher than the 'damages as a percent of GDP' variable. In other words, while both variables are important, the macroeconomic effect of disasters is more closely tied to the number of counties affected by the disasters than by the level of damage caused by the disaster.

TABLE 5. SIGNIFICANCE OF THE INDEPENDENT VARIABLES FOR USA ANALYSIS

Rank	Variable Name	Chi-square	p-value
1	Percentage of Northeast counties affected in prior year	148.89	0.000000
2	Percentage of Midwest counties affected in prior year	137.40	0.000000
3	Percentage of Southern counties affected in present year	118.89	0.000000
4	Damages in Midwest counties in present year	118.06	0.000000
5	Percentage of Midwest counties affected in present year	112.83	0.000000
6	Percentage of Southern counties affected in prior year	109.90	0.000000
7	Percentage of West counties affected in present year	97.67	0.000000
8	Percentage of Northeast counties affected in present year	92.03	0.000000
9	Level of Services in the state's economy	89.75	0.000000
10	Damages in Midwest counties in prior year	80.92	0.000000
11	Damages in Northeast counties in prior year	76.50	0.000000
12	Percentage of West counties affected in prior year	71.99	0.000000
13	Damages in West counties in present year	66.67	0.000000
14	Damages in Northeast counties in present year	47.63	0.000021
15	Number of disasters per 100,000 residents	49.34	0.002750

TABLE 6. SIGNIFICANCE OF THE INDEPENDENT VARIABLES FOR NORTHEAST ANALYSIS

Rank	Variable Name	Chi-square	p-value
1	Percentage of West counties affected in present year	64.98	0.000000
2	Percentage of West counties affected in prior year	61.86	0.000000
3	Percentage of Southern counties affected in prior year	55.25	0.000000
4	Damages in Midwest counties in present year	56.59	0.000000
5	Percentage of Northeast counties affected in present year	55.63	0.000001
6	Percentage of Midwest counties affected in prior year	59.09	0.000001
7	Level of Services in the state's economy	66.01	0.000003
8	Damages in Midwest counties in present year	40.66	0.000013
9	Percentage of Northeast counties affected in prior year	53.52	0.000022
10	Percentage of Southern counties affected in present year	37.88	0.000161
11	Damages in Midwest counties in prior year	29.61	0.000990
12	Damages in Northeast counties in prior year	35.24	0.001354
13	Level of Agriculture in the state's economy	37.09	0.005105

> Third, while 'percentage of counties affected' dominates the study, the variables do change as the unit of the analysis changes. The 'percentage of Northeast counties affected in the prior year' leads the national analysis, while 'the percentage of West counties affected in the present year' leads the Northeast analysis. Also only thirteen variables are significant in the Northeast analysis, with twelve producing the optimal model, while there are fifteen variables in the optimal model for the national study, and all fifteen are significant at the 0.01 level.

The state-level variables were led by the 'percentage of service in the state's GDP'. This was the only state-level variable in the optimal model for the Northeast study and was ranked seventh. The contribution of agriculture to the state's GDP was also significant but not a part of the optimal model. There were two state-level variables in the fifteen that defined the optimal model for the national analysis. The 'percentage of service in the state's GDP' was ninth, and the 'disaster counts per 100,000 residents' was fourteenth.

DISCUSSION

Steady, modest growth in GDP is the assumed state for geopolitical regions. This growth can be managed in many ways. The goal of this study was not to predict exact GDP growth, e.g. will state-level GDP vary from the moving average by 0.25 vs. 0.30 percentage points. Instead we addressed the larger movements in GDP. Can disasters account for large movements, e.g. 0.5, 0.75 or 1 percentage point movement from the 5-year moving average? Further the model addressed both large negative and large positive movements from the 5-year moving average.

While most neural network models are constructed as a 2x2 matrix, the nature of this analysis demanded a 3x3 matrix. The 3x3 matrix naturally delivers a greater number of cells, potentially containing false positive and false negative results, and, as such, usually has somewhat lower prediction rates than most 2x2 models. Nevertheless, the ROC (Figure 2 and Table 4) shows that the predictability of the model is good. Furthermore, they support the thesis that a more focused study delivers significantly higher quality results than broadly defines studies namely, the regional level versus the national level. ROC measures are 10 percentage points or higher for the Northeast analysis compared to the national analysis. The study findings support the ability of the model to strongly predict GDP movements for the Northeast states and to moderately predict GDP movements for the greater United States.

The ROC data shows the effectiveness of the model of predicting both large positive and negative movements in GDP relative to the 5-year moving average. For the Northeast analysis, large positive and negative fluctuations in GDP have ROC values of 0.95 and 0.92, respectively. Cases with little or no fluctuations in GDP have ROC values of 0.82

(Figures in Appendix B). While the predictability is lower for the USA model, the pattern is the same.

The ability to predict the GDP fluctuations is also presented in Table 3. All nine of nine large positive variations (classified as 2's) are correctly classified. Seven of ten large negative variations are properly classified (as 0's), with three classified as 'no significant fluctuation (i.e. 1's). It should be noted that no large negative fluctuations were misclassified as large positive fluctuations, and similarly, no large positive fluctuations were misclassified as large negative fluctuations. In addition, cases classified as large negative fluctuations were correct seven of eight times, and cases classified as large positive fluctuations were all correctly classified. In other words, the disaster-related variables effectively predicted both large negative and large positive fluctuations in state-level GPD from the moving average.

There are obvious differences in the variables affecting the Northeast analysis and those affecting the national analysis. This suggests that there is not a definitive set of variables that affect the relationship between disasters and macroeconomics at a universal level. As such, comparative regional analyses should be expected to uncover a different collection and/or ranking of variables for each region. Larger scale analysis, especially global studies, face the risk of these differing local models offsetting each other and failing to deliver conclusive results.

Most previous studies on the subject matter have largely focused on the individual country data in a global analysis. The findings here suggest a need for three adjustments:

First, regional aggregate variables do influence the relationship.

Second, narrowing the focus of the studies, for example, to continental regions rather than global-focused studies should help the classification models.

Finally, focus needs to be placed on the impacts of disasters in one region on the GDP movements of nations in other regions.

A research question addressed whether non-disaster related factors are capable of moderating the impacts of disasters on state-level GDP movements. Of the three moderating factors only percentage of services in the state's economic mix was found to be significant. This held for both the regional and national models as shown in Tables 5 and 6. Percentage of agriculture and percentage of manufacturing in the state's economic mix were not found to be significant.

Another research question asked whether economic output is affected by previous year disasters or simply by disasters in the present-year. In both the national model and the Northeast region model, present-year and prior-year variables were found to impact movements in GDP. In both models, six prior-year variables accompanied the present-year variables in the optimal model. While the influence of the present-year variables on GDP movements is expected, the large number of prior-year variables suggests that economic impacts of disasters often lags the disasters themselves. The present-year and prior-year variables in the Northeast model are predominantly variables related to regions outside of the Northeast, as discussed below.

The actual state-level disaster-related variables are largely missing in both the national model and the Northeast model. Only one variable, 'disaster counts per 100,000 residents', was significant in the national analysis. There were no state-level, disaster-related variables in the optimal model for the Northeast region. Only 'percentage of counties affected in previous year' showed up in the top fifteen variables. This had a p-value of 0.038 and was not a part of the twelve-variable optimal model. The finding that actual disaster-related state-level variables minimally contribute to the optimal model's prediction capability may be the result of the much larger impact of other regions' disasters.

Finally, we asked whether a high number of disasters in one region, say, the Midwest, affect GDP in other regions, for example, the Northeast, or are the impacts of disasters confined to the local geographic region. Our findings support the thesis that disasters in one region do affect GDP in other regions and states in those regions. As shown in Table 4, the 'percentage of West counties affected by disasters in the current year' was the leading variable for the Northeast analysis, but not, interestingly, one of the Northeast states' own aggregate variables. In addition, the highest-ranked Northeastern aggregate variable is fifth in rank, namely, the 'percentage of Northeast counties affected in present year', while the top four ranked variables relate to regions outside of the Northeast. The dominance of other regional aggregate variables over state-level aggregate variables is surprising. It seems to suggest that single regions within a well-developed, interdependent economy could feel the negative or positive impact of disasters in other regions more than their own regional disaster impact. Whether this is the result of supply chain development, regional specialization, or some other structural effect cannot be determined in this study, but it is an unexpected phenomenon that should be explored in future studies.

CONCLUSION

The study findings support the thesis that disasters are capable of causing movements in GDP. This is in line with earlier findings that disasters affect the GDP of small nations and that disasters do have supply chain implications. Little impact has been shown on the economies of larger nations. In fact, the conclusions from these studies suggest that the economic impacts of disasters on smaller nation are not mirrored in larger economies such as the United States. The findings suggest that disasters affect the economies of larger nations, but that these impacts are observable at smaller, regional levels for example at the state level in the United States.

The findings also suggest the need to look at the impacts of disasters scenario in other regions on the macroeconomics of the region under analysis. This has implications for global studies. Will disasters in the one continent, e.g. Asia, affect macroeconomics in other regions, e.g. Europe or North America? There is also a need for further work in calibrating the relationships in other regions. The findings here address the differences in quality of results between a focused Northeast analysis and a full 50-state US analysis. The nature of the relationships in other regions may also need to be calibrated. Further, does a parsimonious four region model provide a better base for analysis than other regional alignment of states? All of these questions point to the need for further, future study given what was revealed in this study's findings.

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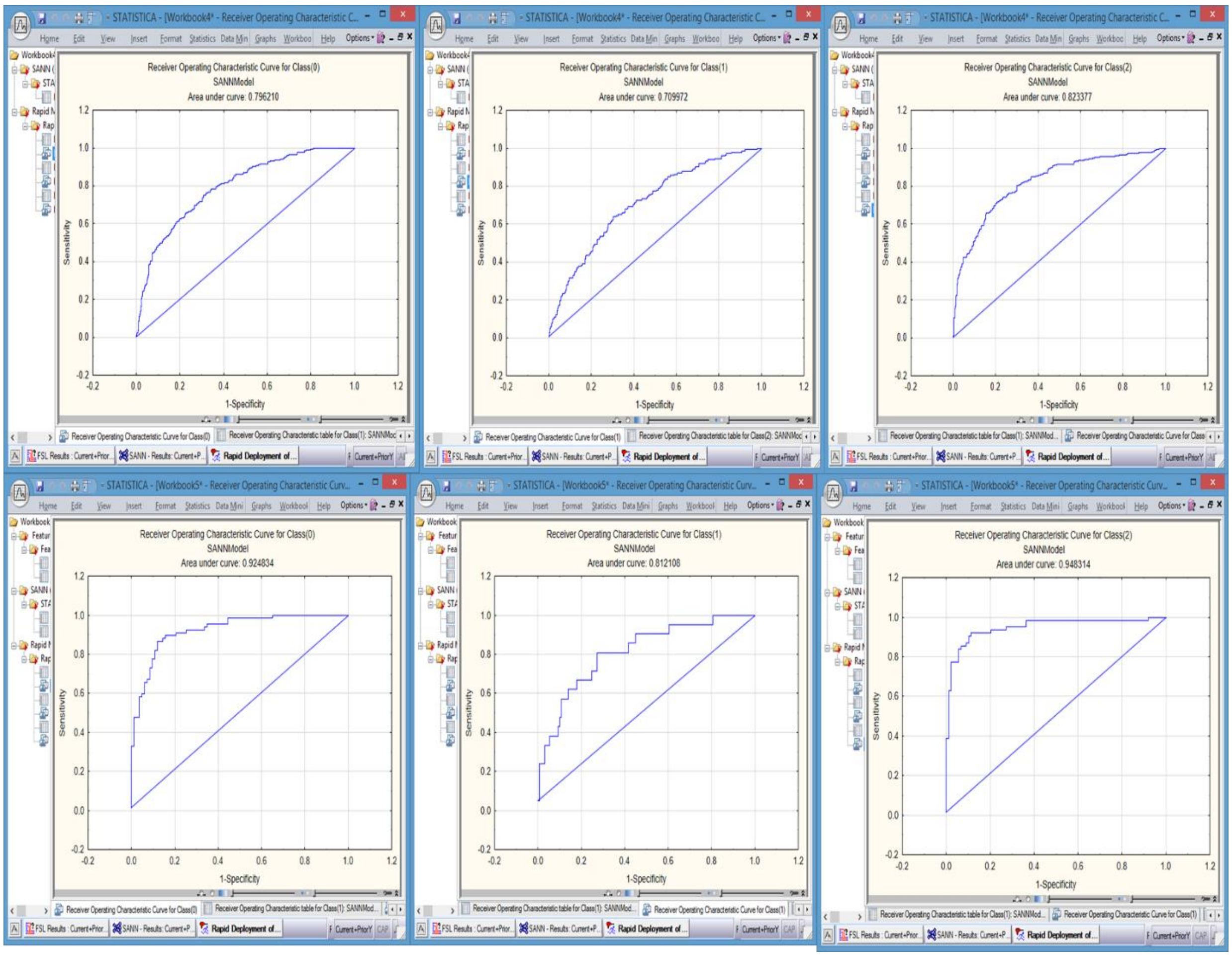
APPENDIX A: FULL LIST OF VARIABLES

Abbreviation	Full description	Level
StateYear	Unique identifier: each state for each year of the study (e.g. California 2001)	State
Agriculture	Percentage of State GDP Output generateg from agricultural related activities	State
Munafacturing	Percentage of State GDP Output generateg from Industrial/munafacturing related activities	
Services	Percentage of State GDP Output generateg from services	
Count-sqMi	Number of disasters per square mile	State
Count-pop	Number of disasters per 100,000 persons residents	
Affected	Percentage of counties affected that year	
Duration	Sum of ((counties affected) * (number of days)) /(no of counties in the state)	
Damages	Damages / State-GDP	
Injuries	Injuries / State Population	
Deaths	Deaths / State Population	
MWCouAffected	(Number of Midwest counties affected) / (number of counties in the midwest)	Regional Aggrergrate
MWDamages	(Damages in the midwest) / (GDP for midwest region)	
NECouAffected	(Number of northeast counties affected) / (number of counties in the northeast)	
NEDamages	(Damages in the northeast) / (GDP for northeast region)	
SouCouAffected	(Number of South counties affected) / (number of counties in the south)	
SouDamages	(Damages in the south) / (GDP for midwest south)	
WestCouAffected	(Number of West counties affected) / (number of counties in the west)	
WestDamages	(Damages in the west) / (GDP for west region)	
PriCount-sqMi	Prior Year's Count-sqMi	State
PriCount-pop	Prior Year's Count-pop	
PriAffected	Prior Year's Affected Normailzed	
PriDuration	Prior Year's Duration Normailzed	
PriDamages	Prior Year's Damages Normailzed	
PriInjur	Prior Year's Injur Normailzed	
PriDeaths	Prior Year's Deaths Normailzed	
PriMWCouAffecte	Prior Year's MWCouAffected	Regional Aggrergrate
PriMWDamages	Prior Year's MWDamages	
PriNECouAffected	Prior Year's NECouAffected	
PriNEDamages	Prior Year's NEDamages	
PriSouCouAffected	Prior Year's SouCouAffected	
PriSouDamages	Prior Year's SouDamages	
PriWestCouAffect	Prior Year's WestCouAffected	
PriWestDamages	Prior Year's WestDamages	
RealGDP	Real GDP (year = 2000)	State
5YRavge	5 year moving average of GDP (does not include present year)	State
gdp-Diff	Difference between real GDP and the 5 year average.	State
Class	0 = large negative deviation, 1 = very little ir no deviation; 2 = large positive deviation	State

APPENDIX B: THE ROC CURVES



Top row presents output for the 50-state national model (across the page: 0, 1, and 2 states).

Bottom row presents the output for the northeast model (across the page: 0, 1, and 2 states).

APPENDIX C: SUMMARY OF DISASTER COUNTS AND DAMAGES IN 2000 DOLLARS

Disaster Types	Count of HAZARD_TYPE	Damages '2000 Dollars'
Avalanche	484	$ 2,914,371
Coastal - Flooding	6,265	57,834,590,643
Drought - Heat	124	314,896,623
Earthquake	24	25,652,144,847
Flooding	34,401	46,887,677,145
Fog	440	20,432,210
Hail	20,506	12,226,215,825
Heat	4,318	996,832,344
Hurricane/Tropical Storm	2,770	126,960,092,349
Landslide	403	1,474,429,371
Lightning - Severe Storm/Thunder Storm	90,504	18,399,552,081
Tornado	11,631	13,720,636,780
Tsunami/Seiche	15	25,125,060
Volcano	1	-
Wildfire	1,292	11,479,314,935
Wind	30,071	6,001,242,341
Winter Weather	39,382	11,852,006,094
Grand Total	242,631	$ 333,848,103,019

Counts are reported at the county level. This translates to 57,733 when analysis at state level incidents per year.

APPENDIX D: 4 REGIONAL ALIGNMENT OF US STATES

Northeast	South	Midwest	West
Connecticut	Alabama	Kansas	Alaska
Maine	Arkansas	Illinois	Arizona
Massachusetts	Delaware	Indiana	Colorado
New Hampshire	Florida	Iowa	California
New Jersey	Georgia	Michigan	Hawaii
New York	Kentucky	Minnesota	Idaho
Pennsylvania	Louisiana	Missouri	Montana
Rhode Island	Maryland	Nebraska	Nevada
Vermont	Mississippi	North Dakota	New Mexico
	North Carolina	Ohio	Oregon
	Oklahoma	South Dakota	Utah
	South Carolina	Wisconsin	Washington
	Tennessee		Wyoming
	Texas		
	Virginia		
	West Virginia		
n=9	n=16	n=12	n=13