REPORT

Business Continuity Practices and Resiliency of Manufacturing SMEs in Puerto Rico: Assessing Impact and Moving Forward after Hurricane María.

Prepared by:

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Submitted to:

Puerto Rico Manufacturing Extension Inc. (PRIMEX)

Manufacturing Disaster Assessment Program (MDAP)

May 2020

AMS CONSULTING

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May 30, 2020

Eng. Ramón Vega Alejandro, DBA
PRIMEX
World Plaza Building Suite 1002
Muñoz Rivera # 268 Ave. Hato Rey
San Juan, Puerto Rico 00918

Dear Vega-Alejandro.:

Enclose are the following documents:

(1) Abstract Business Continuity Practices and Resiliency of Manufacturing SMEs in Puerto Rico: Assessing Impact and Moving Forward after Hurricane Maria.
(2) Report Continuity Practices and Resiliency of Manufacturing SMEs in Puerto Rico: Assessing Impact and Moving Forward after Hurricane Maria.
(3) Survey of the study

During the month of June, we will be sending to participants the 1-page Benchmark Report offered as an incentive for participation. You will send you all the reports for your records.

I appreciate the opportunity that was given to collaborate with PRiMEX and help at improving competitiveness of manufacturing SMEs in Puerto Rico through this research. Do not hesitate to contact me if you need additional information regarding this project.

Cordially,

Dr. Alizabeth Sánchez-López, Ph.D.
Principal Investigator
AMS Consulting

ABSTRACT

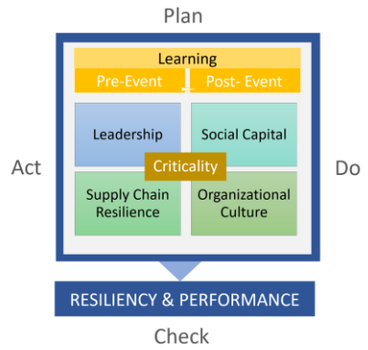
Business Continuity Practices and Resiliency of Manufacturing SMEs in Puerto Rico: Assessing Impact and Moving Forward after Hurricane Maria

Problem Statement

The number of crisis caused by natural disasters increased in the past decades. The unexpected nature of disasters as well as the limited resources of manufacturing SMEs make preparedness and recovery a challenge. Although there are multiple Business Continuity guidelines available, these do not address the heterogeneity of organizational contexts and environments, like manufacturing SMEs in Puerto Rico. Moreover, there is only anecdotal evidence that existing standards have in fact an impact on business continuity and performance after a disaster. ***The purpose of the study is to examine the factors that influence business continuity and performance after disaster; more specifically how business continuity management (BCM) practices including leadership & people; communications & technology; operations & infrastructure and supply chain relations influence continuity of operations and performance after disaster, and to empirically evaluate key assumptions of business continuity and resiliency literature.***

Framework & Methodology

The study adopted triangulated methodology which uses multiple sources. An instrument (*Business Continuity and Resiliency Survey)* was developed to collect the primary data of the study included in the framework (Figure). A total of 158 valid responses were obtained from online surveys. The PRIMEX-MDAP Assessment data was used as secondary source of evidence. This data is a result of the visits the Puerto Rico Manufacturing Extension (PRIMEX) has been conducting for over two years to evaluate the conditions of manufacturing firms after Hurricane Maria as part of the Manufacturing Disaster Assessment Program (MDAP). Descriptive and inferential statistics to develop resiliency, industry and regional profiles was conducted using IBM-SPSS 20 (IBM-Statistics Package for Social Sciences). SmartPLS 3 was used to empirically test the model.



Findings

- Among other indicators, the impact of hurricane Maria in the manufacturing sector was 17,764.0 in millions (55% of the private sector).
- Based on the less conservative definition of resiliency (capacity to return to pre-event conditions), the study suggests the majority (66%) of the firms in our sample are resilient. If we adopt the most conservative view of resiliency most of our sample will classify as survivors (66%) and only 34 percent resilient. However, the firms in the sample seem to struggle in terms of sales and profits. Meanwhile, almost 70 percent are satisfied with their recovery, which suggest that for entrepreneurs' resiliency has not much to do with meeting economic standards, and much more with avoiding demise.
- The empirically tested resiliency model showed Leadership, Entrepreneurial Orientation & Supply Chain Resilience (SCR) explain resiliency in manufacturing SMEs. SCR include formalization, human resources, facilities, production, infrastructure, IT& communications, and supply, distribution-transport, and client indicators.
- There are significant differences between resilient and surviving manufacturing SMEs in all nine SCR factors, disruption capacity; social capital; performance and leadership type (people-oriented versus task oriented). The MDAP assessments also show that resilient firms scored better in recovery level & promptness of re-opening, preparedness, and communications infrastructure. Also manufacturing SMEs that have business continuity plans scored better in recovery level, perceived preparedness, and re-opened faster.
- The average disruption capacity for manufacturing SMEs in Puerto Rico is 0.615 and this indicator is positively related to organizational performance. Evidence suggests age and size influence disruption capacity, where older and larger firms scored higher in the disruption capacity indicator.
- There are more resilient firms in the **metropolitan area**. They score higher in performance, social capital, disruptive capacity, and in SCR, specifically IT& communications, human resources, and suppliers. Their lower learning score may suggest they were more prepared when hurricane Maria hit. The MDAP assessments showed that firms in this region opened before other areas and are more formalized in terms of IT Security and continuity planning.
- The **east central** region is also highly resilient. It scored high in formalization factors and their clients are less concentrated. Like firms in the metropolitan area, they rely heavily on the social capital derived from their entrepreneurial networks. The significantly high learning score suggests firms in this region were less prepared when hurricane Maria hit but adapted. According to the MDAP assessments electricity in this region took longer to recover, but the fact that they do not report changes in terms of generators or alternative energy may suggest the firms in the region were already prepared for this. They introduced changes in communications and scored lower in IT security indicators. Finally, this region reported more permanent losses than other regions.
- Most of the firms in the **west** are in surviving status. They reported lower scores in SRC (Formalization, HRM, Supply, Communications & IT, and infrastructure), social capital, disruption capability and performance. The above is confirmed with MDAP assessments which show they are less prepared in terms of communications, information technologies, business continuity planning, and infrastructure. Nonetheless, the MDAP assessments suggest most of the firms in the west restored operations 100% when visited and had electricity restored before other regions. This may suggest that factors external to the organization exerted more influence. The fact that there are no significant differences in terms of learning when compared to other regions puts manufacturing SMEs in the west in a more vulnerable position.
- **North** region is the most prepared in terms of infrastructure and score above average in terms of resiliency. The MDAP Assessments show the region took longer to restore communications, which relates to their intentions in acquiring satellite technologies. Manufacturing SMEs in the **south** are less formalized, and more vulnerable in terms of supplier concentration and communications & IT. The regional infrastructure (communications & energy) recovered faster than in other regions. Despite the above, manufacturing SMEs in the south used the experience from Hurricane Maria to instill changes (highest learning score).
- The **food manufacturing** subsector is more vulnerable in terms of client and supplier concentration when compared to other sectors. Also, they rely more on family and friends. The MDAP assessments showed this sector underperformed others in terms of resiliency, recovery, and re-opening. The **metals** subsector is currently underperforming (50% are surviving). They are more vulnerable in formalization indicators and infrastructure. Finally, the MDAP show that although **printing & related services** are knowledgeable of cyber-attacks, but no significant differences were found in terms of IT security. Since this subsector manages significant amounts of records, this finding merits attention.

Implications

Strategies and initiatives to foster resiliency in manufacturing SMEs in Puerto Rico should address the supply chain using a holistic approach that includes all nine factors: formalization, human resources management, infrastructure, production, facilities, communications and IT, and supplier, client, distributor considerations. Effective leadership behaviors are dependent on the situation. In post-disaster environments, the most effective leadership behaviors are those concerned with people rather than the task. Cultural aspects of the organization (i.e. entrepreneurial orientation) exert a role in recovery, specially they need to institutionalize proactiveness, innovativeness and embrace risks. To maximize limited resources, supporting institutions should specifically design initiatives that address the needs of each region and subsectors. The profiles in this report are a first attempt to accomplish this.

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May 2020

INTRODUCTION

Antecedents

The number of crisis caused by natural disasters increased in the past decades. The unexpected nature of disasters as well as the limited resources of manufacturing SMEs make preparedness and recovery a challenge. In Puerto Rico, Hurricane Maria hit on September 20 and caused unprecedented damage, where no one in Puerto Rico was spared at least some impact, including loss of communication and electricity, scarcity of water, isolation of some residents, among others. The net impact of Hurricane Maria was estimated by the Puerto Rico Planning Boards in 43,135 (in millions) and over 70 percent is from the private sector (PRPB, 2018).

The above, makes more apparent the need to operate and maintain processes, capabilities and response structures that ensure business continuity after disasters for SMEs. Business continuity is defined as the capability of an organization to continue delivery of products and services within acceptable time frames at predefined capacity relating to a disruption (ISO 23000, 2018), such as a natural disaster. Several organizations follow business continuity management (BCM) guidelines and standards (i.e. ISO, SBA guidelines, among others).

Although international standards provide certain guidelines to establish Business Continuity Management (BCM) practices, these do not address the heterogeneity of organizational contexts and environments, like manufacturing SMEs in Puerto Rico. Moreover, there is only anecdotal evidence that existing standards have in fact an impact on business continuity and performance after a disaster. Based on the above, it is crucial to examine the state-of-the-art of these practices for manufacturing SMEs in Puerto Rico, and how these influence business continuity and performance after disasters, and, therefore minimize the impact of natural disasters on local businesses.

INTRODUCTION

Purpose

The purpose of the study is to examine the effects of hurricane Irma and Maria on manufacturing SMEs in Puerto Rico, and the factors that influence business continuity and performance after disaster. The study evaluates how business continuity management (BCM) practices including leadership & people; communications & technology; operations & infrastructure and supply chain relations influence continuity of operations and performance after disaster. Also, empirically evaluates key assumptions of business continuity and resiliency literature. The specific objectives are:

- *To determine the key resources and processes for business continuity and performance in manufacturing SMEs in Puerto Rico prior and after a disaster.*
- *To examine how these resources and processes influence business continuity and performance of manufacturing SMEs in Puerto Rico after disaster.*
- *To evaluate the level of development (maturity) of business continuity management (BCM) practices, and, therefore, provide measures of preparedness, resiliency and disruptive capacity in manufacturing SMEs in Puerto Rico.*
- *To examine differences in resiliency efforts (resources & processes) of manufacturing SMEs in Puerto Rico and develop profiles based on organizational characteristics and region.*
- *To examine the impact of hurricane Irma and Maria on manufacturing SMEs in Puerto Rico.*

INTRODUCTION

Contribution

The most important contribution of the study is to develop a model of resiliency that empirically tests key assumptions of business continuity literature. This contribution adds value for academia and practitioners. Without confirmation of hypothesized relations, continuity initiatives and practices could be challenge and resisted by entrepreneurs (of no value). Meanwhile, confirmation of the impact of continuity practices on resiliency will increase interest in BCM practices. Another important contribution is identifying the critical processes that affect resiliency. This, in addition to the profiles developed by examining differences among groups will help entrepreneurs and supporting organizations allocate their limited resources in initiatives that produce the best results. Finally the study will provide measures of preparedness, disruptive capacity, and resiliency for manufacturing SMEs in Puerto Rico, which serves as a benchmark to examine where we were, where we are and where we need to be. Overall, the study provides knowledge to assist management of manufacturing firms in Puerto Rico become more resilient.

Limitations

Recovery from natural disasters is a complex long-lasting partnership between individuals, businesses, and public institutions. To understand small business recovery, it is important to look at the internal recovery systems of the business, but also the overlapping systems of family and community recovery. This study was delimited to internal aspects of recovery and resiliency. Another limitation in research with human subjects relates to the willingness of participants and reliance on perceptions of respondents. The sample size in the study was set to comply with the purpose and the analysis required to achieve it (develop model and profiles). In terms of respondent perceptions, researchers in small business recovery (i.e. Marshall et al., 2014) have emphasized how perceptions of business owners are better indicators to assess business recovery. Moreover, organizational research have found high correlations between perceptual and objective measures of performance (i.e. Venkatraman & Ramanujam, V. (1986).

CONCEPTUAL FRAMEWORK

Theoretical Background

According to Cutter et al. (2008) resilience is a system's capacity to absorb disturbance and re-organize into a fully functioning system which includes the capacity to return to the state that existed before the disturbance and, to advance the state through learning and adaptation. According to Rose and Liao (2005) state that economic resilience refers to the ability or capacity of a system to absorb or cushion against damage or loss, hence reducing vulnerabilities. The above definitions suggests the interaction of multiple perspectives. This study adopts from the following perspectives to examine resiliency and business continuity of manufacturing SMEs in Puerto Rico:

(1) Leadership Theories
- Transformational Leadership & Path Goal Leadership Theory

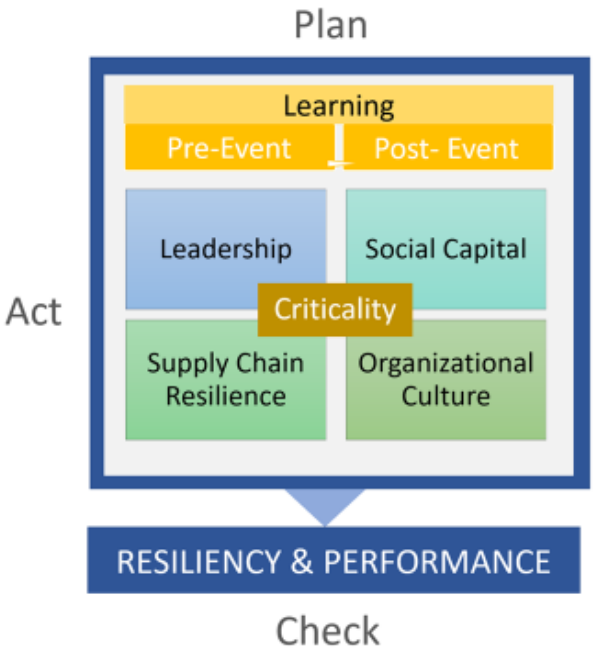
(2) Social Capital Theory

(3) Organizational Theories
- Dynamic Capabilities, Entrepreneurial Orientation & Entrepreneurial Bricolage

(4) Supply Chain Management
- Supply chain resiliency

These theories and their relation to the phenomenon of study will be discuss in the following sections. The propositions are illustrated in the next figure.

CONCEPTUAL FRAMEWORK
Modified Version



Key Propositions

P1: Leadership positively influence resiliency.

P2: Social capital influences resiliency.

P3: Supply chain resilience (SCR) positively influences resiliency.

P4: Organizational Culture influences resiliency.

P5: Disruptive events induce learning.

RESEARCH DESIGN

Method

- The study adopted triangulated methodology which uses multiple sources of evidence including primary and secondary sources.
- A significant amount of literature review was conducted as part of the qualitative stage. The purpose of this review was to build a theoretical robust model for testing. The literature helped identify variables associated to business continuity and develop measurement scales. Also, in-depth interviews were conducted to identify key themes in business continuity within the context of manufacturing firms in Puerto Rico to provide information for survey development. This qualitative stage resulted in a revised/improved research framework and instrument development (survey).
- Primary data from the *Business Continuity and Resiliency Survey* (developed by the PI). PRIMEX-MDAP Assessment data was used as secondary source of evidence. Governmental databases (Bureau of Labor Statistics EQUI File) and reports were reviewed to evaluate impact.
- The sample for the *Business Continuity and Resiliency Survey* were owners and managers of manufacturing SMEs in Puerto Rico. Although the initial plan was to administer the instrument to manufacturing SMEs in Puerto Rico via multiple mechanisms to increase response rates (online, face to face and telephone survey), social distancing due to COVID-19 limited our data collection strategy to online surveys.

RESEARCH DESIGN

Method

- The online platform used to study was gathered primarily from PRiMEX MDAP database. Also, we obtained support from industry associations. The sample frame came primarily from PRIMEX contact lists which have almost 1000 emails collect data was QuestionPro™.
- A screening question was developed to assure participants who completed the survey complied with inclusion requirements: key decision maker (owner or manager) in manufacturing firm (SME) in Puerto Rico. The data collection period was from March - April 2020.
- A total of 710 individuals viewed the email, 246 started the survey and 88 dropped out. The average time to complete the survey was 18 minutes and the completion rate was 64.23% for a total sample of n= 158, which represents around 10 percent of manufacturing SMEs in Puerto Rico based on County Business Patterns (CBP, 2017) estimates (1,598) and 16 percent of he sample frame.
- Based on our experience conducting studies with top management of SMEs in Puerto Rico with suggests a response rate of 8 to 10 percent depending of several factors, this sample size is adequate. Moreover, the sample complies with the parameters to conduct the required analysis (PLS & inferential statistics) to accomplish the purpose of study (model development & profiles).

RESEARCH DESIGN

Method

- To increase responses, participants were offered a reward. Respondents who completed the survey will receive a 1-page Benchmark Report that will include their firm's indicators in comparison to the industry (total sample) during Summer 2020. This in turn will help entrepreneurs identify their strengths and weaknesses in terms of factors associated to resiliency after natural disasters and assist in developing strategies to improve their preparedness level for future events.
- The secondary source of evidence derived from PRIMEX-MDAP Assessments had a sample of (n=230 max.) It included the respondents that completed all assessments.
- The quantitative stage, including the secondary data from MDAP-PRIMEX Assessments and the primary data derived from *Business Continuity and Resiliency of* survey resulted in:
  - an empirically tested resilience model of manufacturing SMEs in Puerto Rico and
  - profiles based on resiliency, regions and industry sectors.
- Descriptive and inferential statistics to develop resiliency, industry and regional profiles was conducted using IBM-SPSS 20 (IBM-Statistics Package for Social Sciences). SmartPLS 3 was used to empirically test the model and hypothesis.

RESULTS

Impact

Secondary Sources

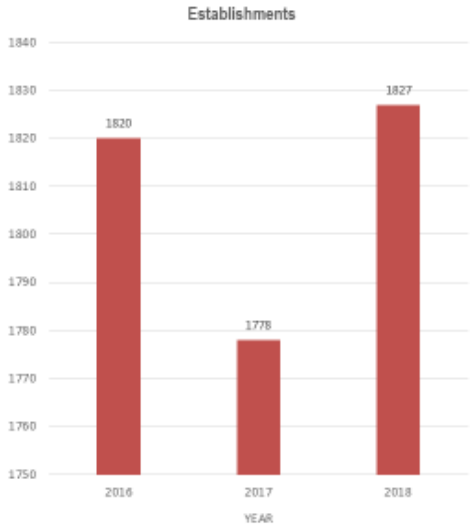
IMPACT ON MANUFACTURING INDUSTRY
Economic Overview Puerto Rico Planning Board

- The net impact for the manufacturing sector was 17,764.0 in millions. This impact considers the expenses (624.4) and losses in income (17,139.6). The impact of the manufacturing sector represents more than 55 percent of the total impact for the private sector. Also it represents 40 percent of the net impact for both the private and public sector. Refer to the table retrieved from the Puerto Rico Economic Summary (2018) of the Puerto Rico Planning Board Report to the Governor available at https://estadisticas.pr/files/inventario/resumen_economico/2018-11-30/JP_ResumenEcon_201811_2_11.pdf

Sector	Daños en Infraestructura y Equipo (Antes, Durante y Después)	Gastos Gastos	Pérdida de Ingresos	Total	Ingresos Recibidos	Impacto Neto
Sector Privado	**7,075.3**	**4,160.5**	**27,411.2**	**38,647.0**	**8,292.5**	**(30,354.5)**
Agricultura	1,824.8	-	182.5	2,007.3	1,400.0	(607.3)
Minería/Construcción	-	117.7	689.1	806.8	-	(806.8)
Manufactura	-	624.4	17,139.6	17,764.0	-	(17,764.0)
Servicios	-	2,232.7	8,943.7	11,176.4	-	(11,176.4)
Comercio	3,601.7	414.0	448.5	4,464.2	4,464.2	-
Personas	1,648.8	771.7	7.8	2,428.3	2,428.3	-
Sector Público	**4,901.9**	**2,010.2**	**2,122.4**	**9,034.5**	**2,644.5**	**(6,390.0)**
Gobierno	4,608.1	1,776.2	2,088.1	8,472.4	2,381.5	(6,090.9)
Municipios	293.8	234.0	34.3	562.1	263.0	(299.1)
Total Neto	**16,879.1**	**8,180.9**	**31,656.0**	56,716.0	**13,581.5**	**(43,134.5)**

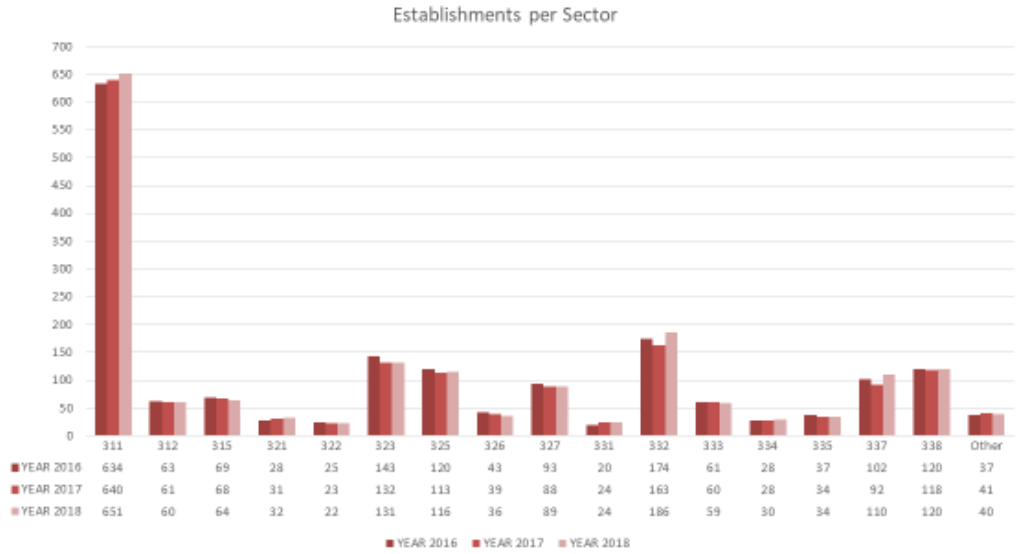
IMPACT ON MANUFACTURING INDUSTRY
Establishments – BLS EQUI File

- The following graphics show a decrease of manufacturing establishments (42) for the period of 2017. From this total over 70 percent were from the East Central Region (18) and the West (12).



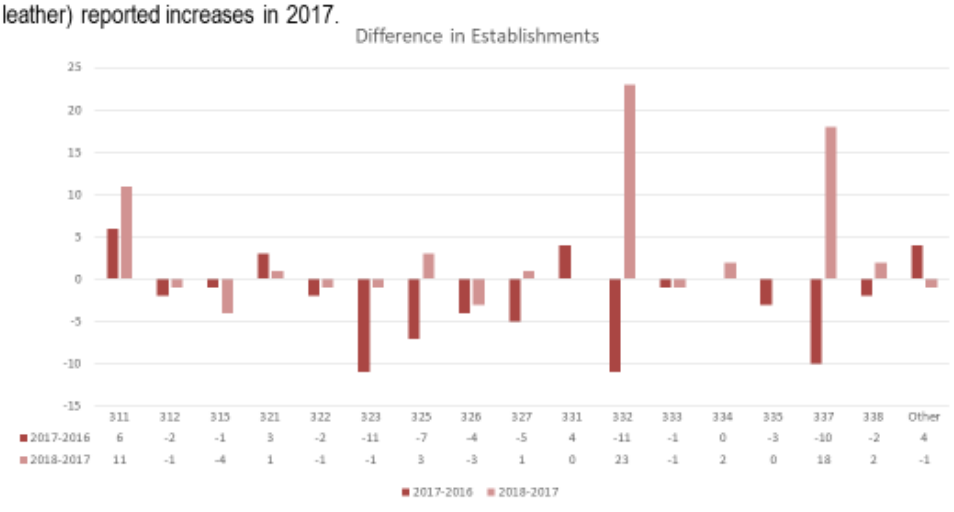
IMPACT ON MANUFACTURING INDUSTRY
Establishments – BLS EQUI File

- The graphic shows the number of establishments per sector. The food manufacturing sector dominates in terms of numbers of establishments, followed by metals, and printing & related services. The manufacturing sector have been increasing in number of establishments even in 2017.

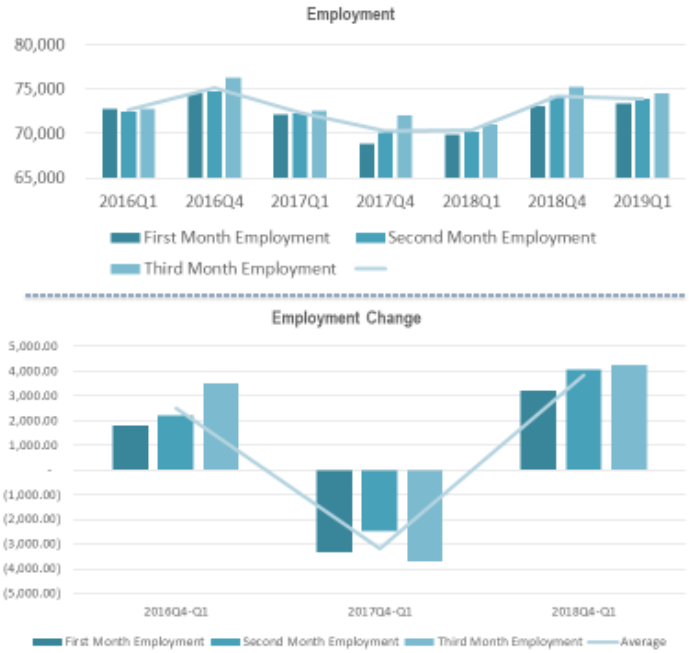


IMPACT ON MANUFACTURING INDUSTRY
Establishments – BLS EQUI File

- The sectors that seemed more affected in terms of decreased number of establishments for 2017 were printing and related services, metals and furniture & related products. The last two (metals & furniture) increased in establishments significantly in 2018, most probably because these are related to major losses post disaster. Primary materials, wood and other (transportation equipment, petroleum products & leather) reported increases in 2017.

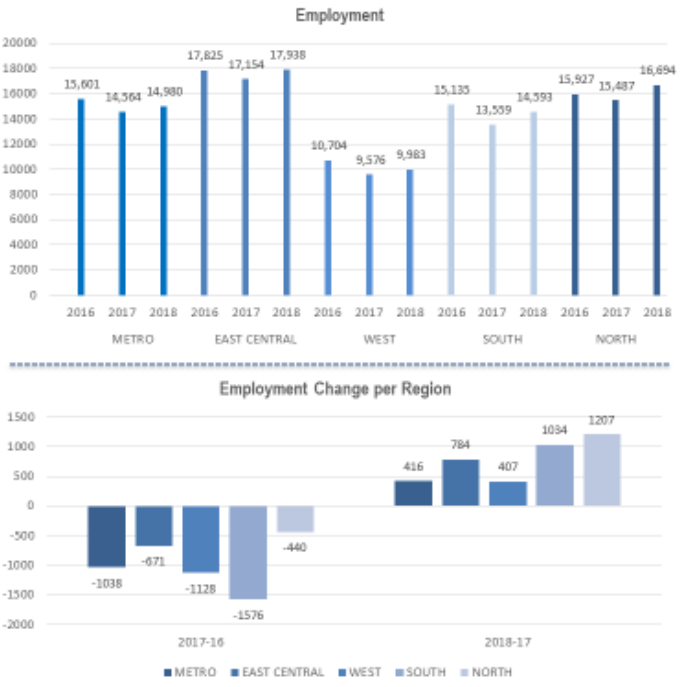


IMPACT ON MANUFACTURING INDUSTRY
Employment – BLS EQUI File



- The graphics show the employment and employment change for the manufacturing sector for period 2016 to 2019. The year Hurricane Maria hit Puerto Rico there was a reduction in employment of over 3,000 within year 2017. However the last quarter of 2018 and 2019 is showing an improved outlook for the sector in terms of employment.

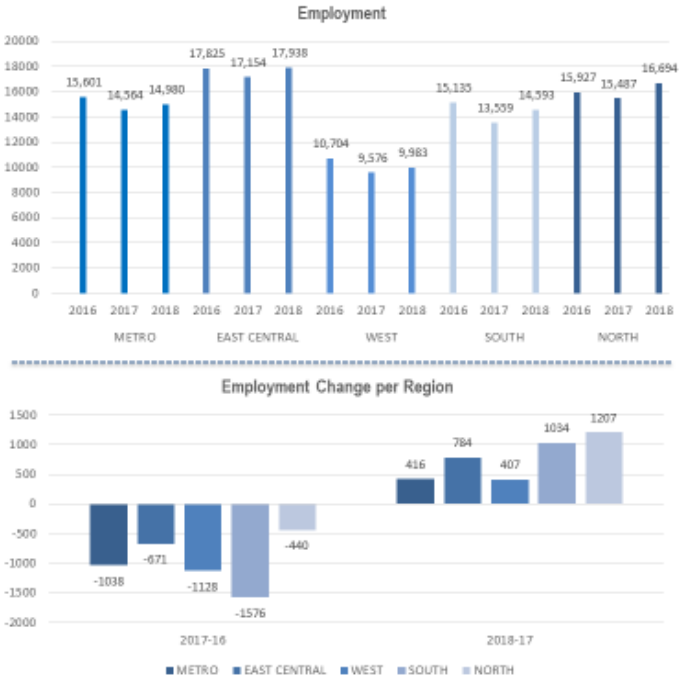
IMPACT ON MANUFACTURING INDUSTRY
Employment– BLS EQUI File



- The graphs show the total amount of employment in the manufacturing sector per region. The east-central region and the north have the most employment in manufacturing.
- The regions that were impacted the most in terms of employment change were the west (11.8%), the south (11.6%) and the metropolitan area (7.1%)

IMPACT ON MANUFACTURING INDUSTRY

Employment– BLS EQUI File



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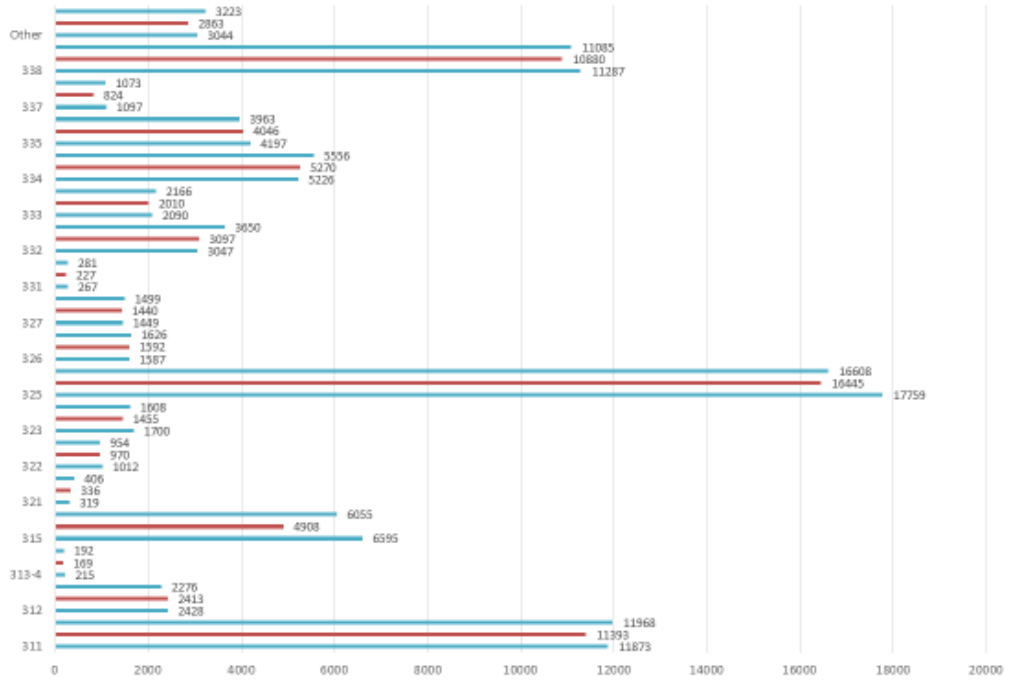
IMPACT ON MANUFACTURING INDUSTRY

Employment per Sector – BLS EQUI File



IMPACT ON MANUFACTURING INDUSTRY
Employment Change per Sector – BLS EQUI File

- The graphic show the change in employment per industry sector for the period 2016-2018. Al sectors, except beverages had lower employment in 2017. The most impacted sector was apparel. However, it appears to recover the most. The second most affected sector in terms of employment change was chemical & pharmaceuticals.

IMPACT ON MANUFACTURING INDUSTRY
Wages per Quarter – BLS EQUI File

- The graph shows a significant reduction of total wages for the manufacturing sector for the last quarter of 2017 (39 millions).

IMPACT ON MANUFACTURING INDUSTRY

Quarterly Wages Changes Per Region

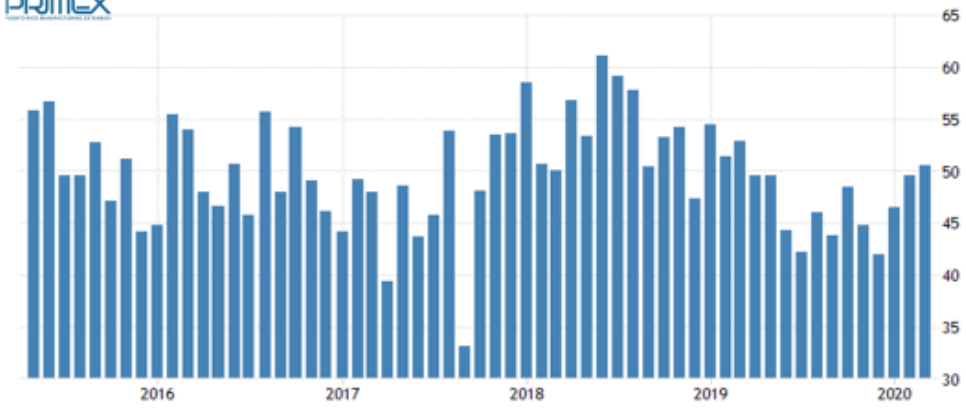
- The graphs show that all regions were negatively impacted in terms of total wages per quarter, except for the northern region. However the west was the most impacted with a difference in 13 millions a quarter.

IMPACT ON MANUFACTURING INDUSTRY

Difference in Quarterly Wages per Sector – BLS EQUI File

- The graphic shows the quarterly change in wages per industry sector for the period 2016-2018. The most impacted sectors were chemical and pharmaceuticals, followed by apparel and food. Electrical equipment as well as beverages went down in 2018.

IMPACT ON MANUFACTURING INDUSTRY
PMI



Actual	Previous	Highest	Lowest	Dates	Unit	Frequency	
50.50	49.50	61.70	33.10	2010 - 2020	points	Monthly	NSA

- The Puerto Rico Manufacturing PMI (Purchasing Manager's Index) is calculated as the simple average of 5 sub-indexes, representing different business conditions in manufacturing establishments: New Orders PMI, Production PMI, Employment PMI, Supplier Deliveries PMI, Own Inventories PMI. The sub-indexes are computed using a diffusion index methodology. In specific, for any given month with respect to the previous month, participants are asked to answer whether the business condition of the establishment: (1) improved, (2) remained the same, or (3) deteriorated. Diffusion indexes are calculated as the percentage of responses that indicate the business condition improved plus half of the percentage of responses that indicate the business condition remained the same. A value above 50 suggests that the business condition has improved from the previous month. The series starts in May 2015 and the lowest reported PMI (33.10) was on September 2017 Retrieved from: https://tradingeconomics.com/puerto-rico/manufacturing-pmi

IMPACT ON MANUFACTURING INDUSTRY
Summary of Findings

- Based on secondary sources, the data presented in this section reflects the impact of Hurricane Maria in the manufacturing industry in Puerto Rico. More specifically, the findings show that:
  - The net impact for the manufacturing sector was 17,764.0 in millions, which represents more than 55 percent of the total impact for the private sector, and 40 percent of the net impact for both the private and public sector.
  - The total establishments, employment and wages in the manufacturing sector decreased for the period.
  - The regions that were impacted the most in terms of establishment change were from the East Central Region and the West, representing 70 percent of all establishments.
  - The regions that were impacted the most in terms of employment change were the west (11.8%), the south (11.6%) and the metropolitan area (7.1%)
  - All regions were negatively impacted in terms of total wages, except for the northern region. However the west was the most impacted with a lost in quarterly wages of 13 millions.
  - All sectors, except beverages had lower employment in 2017. The most impacted sector was apparel. The second most affected sector in terms of employment change was chemical & pharmaceuticals, followed by food manufacturing.
  - There was a difference of 39 millions in quarterly wages between the first and last quarter of 2017.
  - All regions were negatively impacted in terms of total wages per quarter, except for the northern region. The west region was the most impacted.
  - The most impacted sectors were chemical and pharmaceuticals, followed by apparel and food
  - The Purchasing Manager's Index in Puerto Rico hits its lowest in 2017..

RESULTS

Descriptive

Business Continuity Practices and Resiliency Survey

ORGANIZATIONAL CHARACTERISTIES

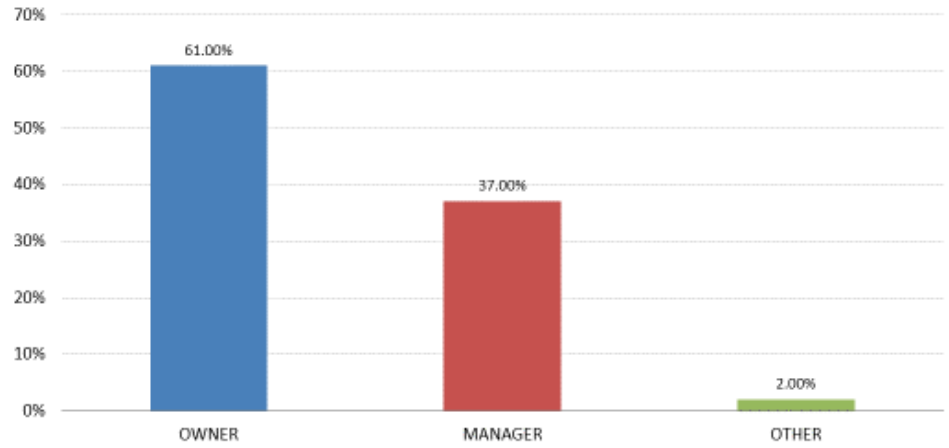
Business Continuity and Resiliency Survey

- The demographic data in the study shows the sample of the study (n=158) consisted of small manufacturing firms, where the majority (62%) have sales of less than 1 million dollars. Of these, 49 percent have annual sales of less than 0.5 millions. This is also confirmed by the number of employees, where 67 percent consisted of manufacturing firms with less than 20 employees. Most of the firms in the sample are relatively mature, where 45 percent have been operating more than 20 years, and 64 percent more than 10 years. However, a fifth (21%) of the firms in the sample where very young by the time of Hurricane Maria since they have been operating for less than 5 years.

- The sectors mostly represented in the sample are: Food (30%), Metal manufacturing (14%), printing and related services (6%) and chemical and pharma (6%). A total of 14% of the respondents classify their businesses as other. This is relatively consistent with County Business Patterns (CBP). In terms of region, most of the manufacturing firms (30.5%) are in the metropolitan area. It is important to note that the metropolitan area includes San Juan, Barranquitas, Bayamón, Cataño, Comerio, Guaynabo, Naranjito, Canóvanas, Carolina, Loíza, Trujillo Alto, Ceiba, Culebra, Fajardo, Luquillo, Rio Grande, Vieques. This is followed by 20.5% of firms in the south, 17.9% located in the east central, 17.9% in the west and 13.2 in the north. The sample sample is relatively distributed across reigions with the exception of the North region, which is underrepresented when compared to number of establishments. Nonetheless, our goal was to obtain the minimum required valid surveys per region to perform regional profiles. Refer to the next charts and tables for descriptive statistics.

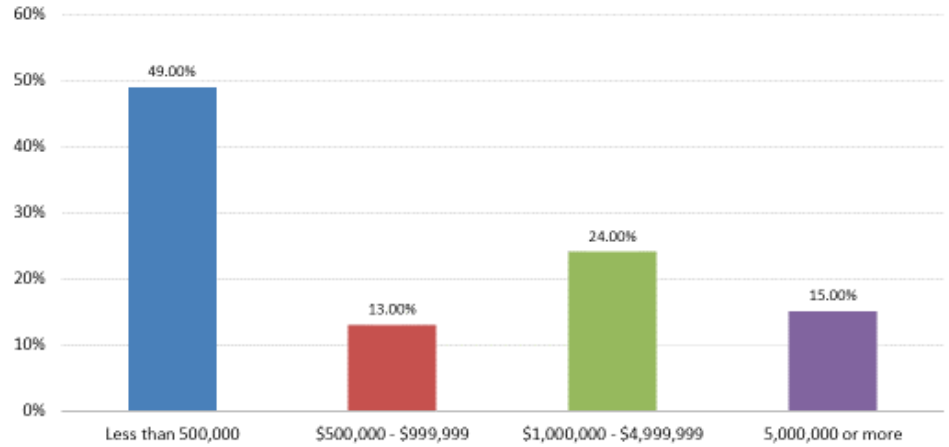
RESPONDENTS

Business Continuity Practices and Resiliency of Manufacturing SMEs Survey (n=158)



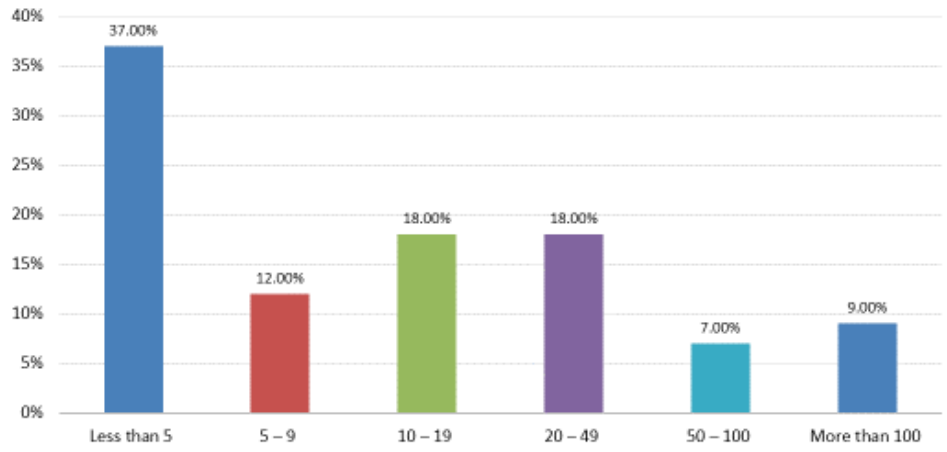
ORGANIZATIONAL CHARACTERISTICS

Size – Sales Volume

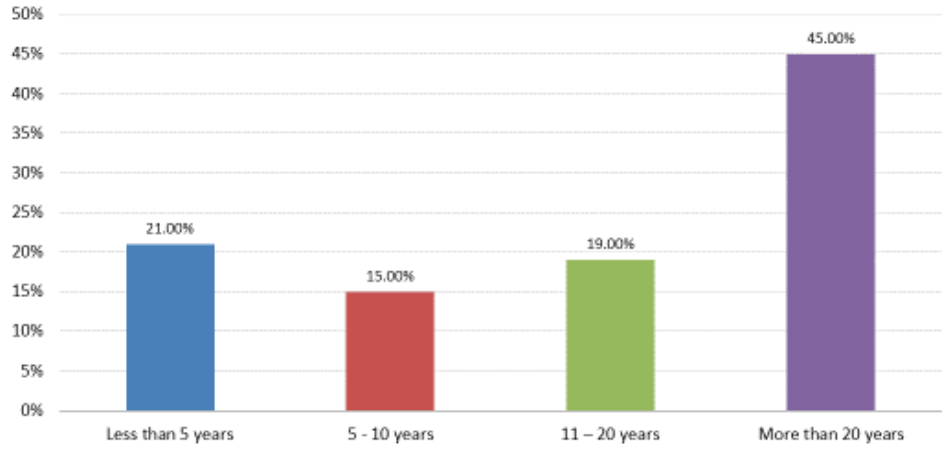


Mean : 2.045 | Confidence Interval @ 95% : [1.865 - 2.225] | Standard Deviation : 1.149 | Standard Error : 0.092

ORGANIZATIONAL CHARACTERISTICS
Size – Employees

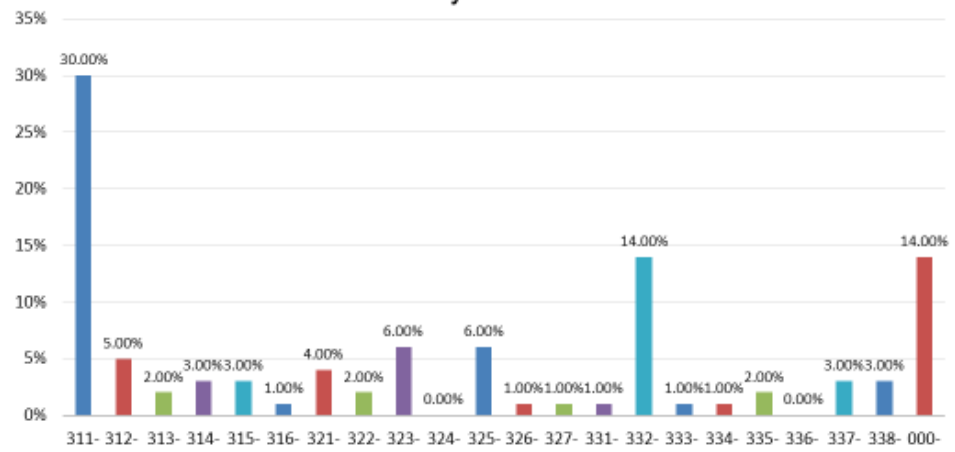


ORGANIZATIONAL CHARACTERISTICS
Age



ORGANIZATIONAL CHARACTERISTICS

Industry Subsectors



Description of Variable

Food Manufacturing: NAICS 311
Beverage and Tobacco Product Manufacturing: NAICS 312
Textile Mills: NAICS 313
Textile Product Mills: NAICS 314
Apparel Manufacturing: NAICS 315
Leather and Allied Product Manufacturing: NAICS 316
Wood Product Manufacturing: NAICS 321
Paper Manufacturing: NAICS 322
Printing and Related Support Activities: NAICS 323
Petroleum and Coal Products Manufacturing: NAICS 324
Chemical Manufacturing: NAICS 325
Plastics and Rubber Products Manufacturing: NAICS 326
Nonmetallic Mineral Product Manufacturing: NAICS 327
Primary Metal Manufacturing: NAICS 331
Fabricated Metal Product Manufacturing: NAICS 332
Machinery Manufacturing: NAICS 333
Computer and Electronic Product Manufacturing: NAICS 334
Electrical Equipment, Appliance, and Component Manufacturing: NAICS 335
Transportation Equipment Manufacturing: NAICS 336
Furniture and Related Product Manufacturing: NAICS 337
Miscellaneous Manufacturing: NAICS 339

ORGANIZATIONAL CHARACTERISTICS

Region Categories

Region	Towns
Metropolitan	San Juan, Barranquitas, Bayamón, Cataño, Comerio, Guaynabo, Naranjito, Canóvanas, Carolina, Loíza, Trujillo Alto, Ceiba, Culebra, Fajardo, Luquillo, Rio Grande, Vieques
Eastern Central	Aguas Buenas, Aibonito, Caguas, Cayey, Cidra, Gurabo, Juncos, San Lorenzo, Humacao, Las Piedras, Maunabo, Naguabo, Yabucoa
West	Aguada, Aguadilla, Añasco, Cabo Rojo, Hormigueros, Isabela, Lajas, Las Marías, Maricao, Mayagüez, Moca, Quebradillas, Rincón, Sabana Grande, San Germán, San Sebastián
South	Adjuntas, Arroyo, Coamo, Guánica, Guayama, Guayanilla, Jayuya, Juana Díaz, Orocovis, Patillas, Peñuelas, Ponce, Salinas, Santa Isabel, Villalba, Yauco
North	Arecibo, Barceloneta, Camuy, Ciales, Corozal, Florida, Hatillo, Lares, Manatí, Morovis, Utuado, Vega Alta, Vega Baja, Dorado, Toa Alta, Toa Baja

ORGANIZATIONAL CHARACTERISTICS
Region

Region	Frequency	Percent	Valid Percent
Metropolitan Area	46	29.1	30.5
East Central	27	17.1	17.9
West	27	17.1	17.9
South	31	19.6	20.5
North	20	12.7	13.2
Total	151	95.6	100.0
Missing	7	4.4	

Note: Sectors were categorized using the regions defined by the Puerto Rico Manufacturing Association (PRMA). However, we included only one metropolitan area, which includes San Juan, west and east metropolitan municipalities.

RECOVERY PREVENTION AND RESPONSE
Business Continuity and Resiliency Survey

- The literature of disaster recovery defines recovery time objective (RTO) as the duration of time within which a business process or operation must be restored after a disaster or disruption in order to avoid unacceptable consequences. Participants were asked to estimate how long the key processes could be inoperable before causing significant losses to their firms. With a 95% confidence level, the RTO estimate ranges between 9 to 12 days. **This number is important because it gives entrepreneurs a benchmark within which to delineate recovery strategies and investment decisions.** Notice that RTO will be inversely related to investment. The lower RTO (less time to recover) the higher the investment requirements (i.e. redundancies).

- The measure of disruption capabilities asked participates to evaluate their capacity to prevent and respond to a disruptive event (i.e. disaster) on a scale from 1 to 7. The data suggests participants perceive they are relatively capable to manage disruptions (i.e. disasters). However, they are slightly less prepared in prevention rather than responding. **This in turn has important implications because the capacity to prevent disruptions will reduce the need to respond. In this sense, investments in preventing disruptions reduces and potentially eliminate the need of resources to respond.** Refer to the next table and chart.

RECOVERY

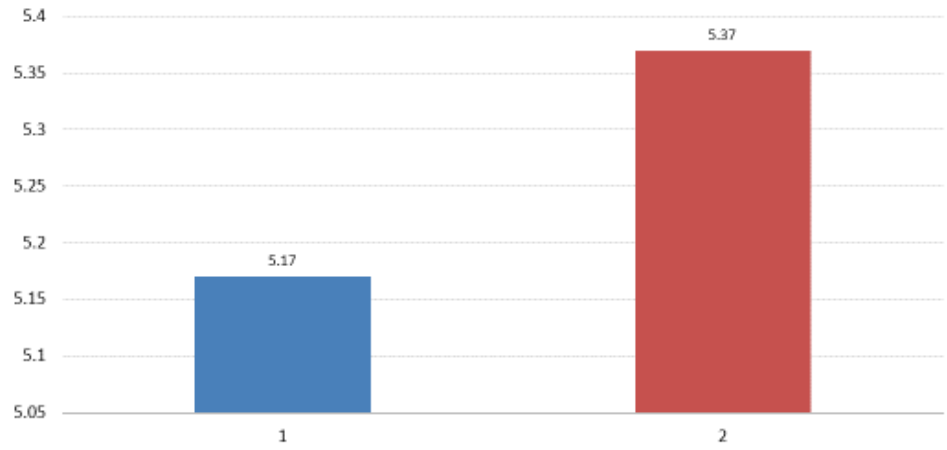
Recovery Time Objective (RTO)

Days	Count	Percent	Cumulative Percent
Don't know	13	6.91%	
Less than 24 hours	9	4.79%	11.70%
1 days	15	7.98%	19.68%
2 days	14	7.45%	27.13%
3 days	22	11.70%	38.83%
4 days	8	4.26%	54.79%
5 days	22	11.70%	43.09%
6 days	3	1.60%	54.79%
7 days	19	10.11%	56.39%
8 days	2	1.06%	66.50%
9 days	1	0.53%	67.56%
10 days	9	4.79%	68.09%
11 days	0	0.00%	72.88%
14 days	11	5.85%	72.88%
15 days	12	6.38%	78.73%
16 days	0	0.00%	85.11%
17 days	3	1.60%	85.11%
21 days	2	1.06%	86.71%
25 days	1	0.53%	87.77%
30 days	11	5.85%	88.30%
More than a month	11	5.85%	94.15%
Total	188	100%	100.00%

Mean : 10.521 | Confidence Interval @ 95% : [9.211 - 11.831] | Standard Deviation : 9.165 | Standard Error : 0.668

PERCIVED DISRUPTIVE CAPABILITY

Prevention & Response



Description of Variables

1. capacity to prevent disruptions with existing resources
2. capacity to respond to disruptions with existing resources

ORGANIZATIONAL CAPABILITIES & CULTURE

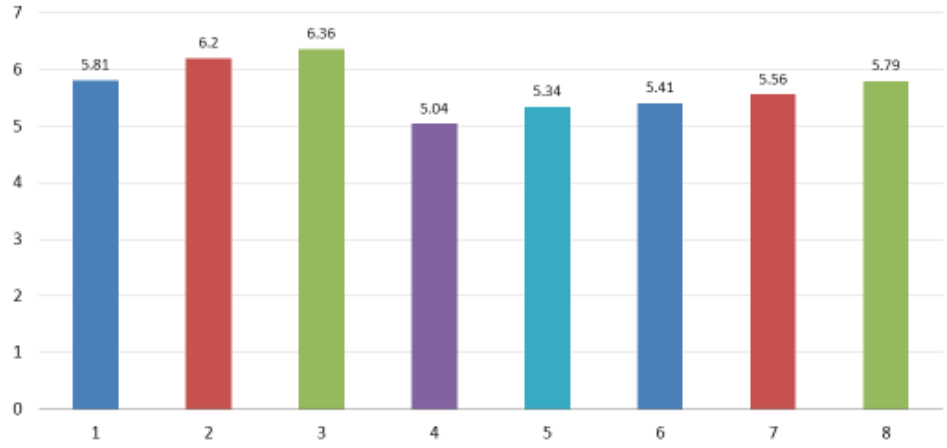
Business Continuity and Resiliency Survey

- Battisti & Deakins (2017) examine the role of dynamic capabilities after the 2010 and 2011 series of major earthquakes Christchurch in New Zealand. Dynamic capabilities (DC) is defined as the firm's capacity to renew and reconfigure its resource base considering changing environments (Teece et al., 1997). This is particularly true in post-disaster environments. Moreover, in post-disaster environments, some firms might not be able to recover their resources or find that resources are no longer relevant in a significantly altered environment. Because of this, they might become reliant on external networks to help them access new resources. Based on this, Batttisti & Deakins (2017) classified dynamic capabilities in: proactive posture & resource integration. Proactive posture relates to the traditional view of DC (capacity to renew and reconfigure resource base). Resource integration relates to the firm's capacity to extract resources from external networks (i.e. reconfigure the resource base with resources of others).

- The data from the survey suggests small manufacturing firms in Puerto Rico are in better position when considering proactive posture (6.12=87%:B) when compared to resource integration (5.43=78%:C). Even more, although they know the minimum required resources needed to maintain operations, the capacity to shift rapidly from business as usual to respond mode is lower. **Finally, the lower level of resource integration (connections with external networks), may hinder the firms' capacity to reconfigure their resources base in post disaster environments.** Refer to the next chart.

DYNAMIC CAPABILITIES

Proactive Posture & Resource Integration



Description of Variables

1. shift rapidly from business-as-usual mode to respond to a disaster
2. clearly defined priorities for what is important during and after a disaster
3. understand the minimum level of resources it needs to operate successfully
4. actively participate in industry and sector groups
5. collaborate with others in our industry to manage unexpected challenges
6. maintain contact with other organizations to provide resources in a disaster
7. contact with organisations that we might have to work within a disaster
8. strong connections to other businesses in the same industry and location

ENTREPRENEURIAL BRICOLAGE & ENTREPRENEURIAL ORIENTATION

Business Continuity and Resiliency Survey

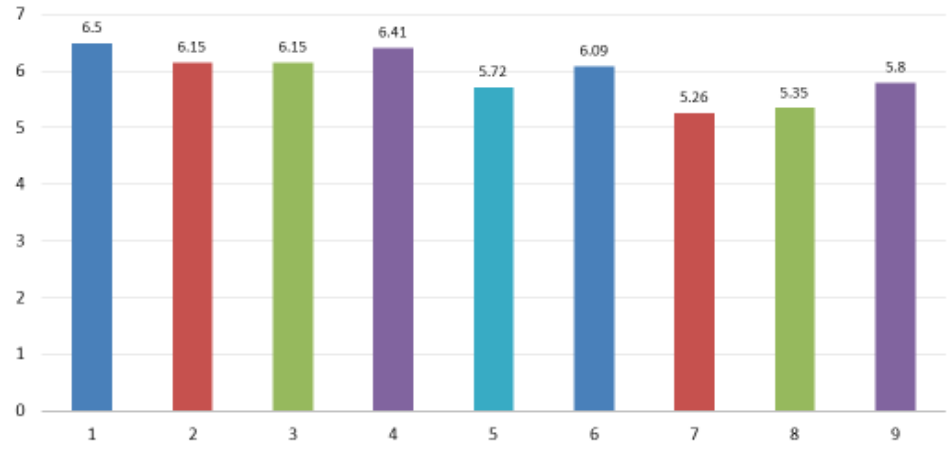
- The concept of bricolage has been adopted across a variety of fields. For example, biologists refer to nature as a bricoleur, using parts of an existing organism as the basis for the evolutionary development of new physical structures and functions, such as a leg being developed into a wing (Jacob, 1977 in Davidsson et al. 2015). Applications of bricolage to entrepreneurship drew from resource-constrained assumptions of new entrepreneurial firms (Baker & Nelson, 2005), which extrapolate to post disaster environments. Because of this, entrepreneurial bricolage (EB) is considered in the study. In its most basic term (based on Lévi-Strauss, 1967), it is defined as making do with what's at hand. On average, respondents demonstrates high levels of entrepreneurial bricolage (6.3=90%:A).

- The resilience and the field of entrepreneurship research has been intertwined for decades. Researchers often use resilience synonymously with preparedness, hardiness, persistence, or self-efficacy to explain why some entrepreneurs and their firms perform better than others. Also, cognitive and behavioral entrepreneurial traits and distinct forms of entrepreneurship are said to foster the ability of firms to adjust to new circumstances (Biggs et al., 2010 in Korber & McNaughton (2018). This, in addition to extant research suggests that when firms are faced with uncertain and unique challenges (i.e. post-disaster environments), they can benefit from an entrepreneurship (Covin & Slevin, 1989; Kraus et al., 2012).

- In established organizations, such an entrepreneurial response is likely to originate from the entrepreneurial orientation (EO). Originally defined by Miller (1983, 2011), entrepreneurial orientation represents the willingness to engage in, and the strategic orientation of, a firm towards innovation, proactiveness, and risk-taking (Covin & Lumpkin, 2011; Lumpkin & Dess, 2015). On average, respondents show lower levels of entrepreneurial orientation when compared to EB (5.8=82%:B). Refer to the next chart.

ORGANIZATIONAL CULTURE

Entrepreneurial Bricolage & Entrepreneurial Orientation



Description of Variable

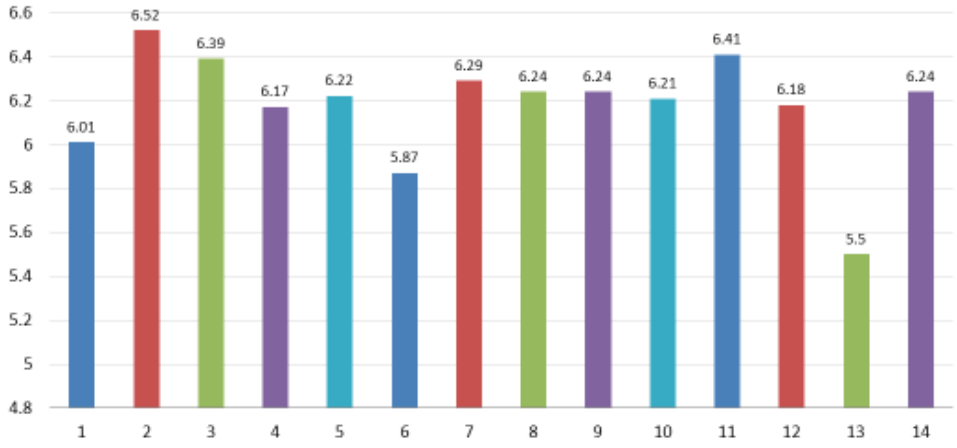
1. Create solutions using only the resources we possess
2. Create new uses for the resources at hand
3. Do more with less
4. Attempt to resolve with what we have rather than acquiring new resources
5. Take risks
6. Introduce improvements
7. Introduce new product & services
8. Act before competitors
9. Test new ways to do things

LEADERSHIP

Business Continuity and Resiliency Survey

- Examination of leaders in this study was based on two leadership theories: Path-Goal Leadership Theory (PGLT) and Transformational Leadership Theory (TLT). The first one (PGLT) is considered a situational theory. It argues that there is not a unique leader, instead, managers should adopt the leader's style or behavior that best fits the employee and work environment in order to achieve a goal (House, 1996). In other words, the leadership style is dependent on the situation. Although there are several styles, the most common are: directive, participative, supportive and achievement oriented.
- The second one (TLT) focuses on how leaders appeal to higher ideals and values of followers. Burns (1978) defined transformational leadership as a process where leaders and followers engage in a mutual process of raising each other to higher levels of morality and motivation. According to Bass & Avolio (1993,1995) transformational leaders move the follower beyond immediate self-interests through idealized influence, inspiration, intellectual stimulation, or individualized consideration.
- The study adopted measures derived from both theories. After conducting factor analysis, we were able to extract two factors that represent people (6.2=89%:B) versus task-oriented leadership styles (6.1=87%:B). Refer to the next chart and tables.

LEADERSHIP BEHAVIORS



Description of Variables

1. **PO-Promote that employees develop creative solutions**
2. **PO-Act as role model to employees**
3. **PO-Inspire employees to emphasize in collective interests**
4. TO-Monitor employees' work
5. **PO-Consult with employees' potential solutions**
6. **PO-Engage employees in decision making**
7. TO-Explain employees how to do the work (tasks)
8. TO-Instruct employees what to do
9. TO-Monitor employees do their jobs according to existing rules
10. **PO-Assist employees resolve what hinder doing their job**
11. **PO-Consider the needs of employees**
12. **PO-Gather resources to satisfy basic needs of employees and their families**
13. TO-Establish challenging goals
14. TO-Promote that employees do their best to accomplish goals

LEADERSHIP STYLES
Factor Analysis

Rotated Component Matrix[a]

	Component	
	TASK	PEOPLE
LEADACHIEV1	.789	
LEADTRANS3	.754	
LEADTRANS4	.751	
LEADACHIEVE2	.727	
LEADTRANS1	.665	
LEADTRANS2	.648	
LEADPAR2		.847
LEADPAR1		.836
LEADTRANF1		.727
LEADSUPP1		.708
LEADTRANF3		.692
LEADTRANF2		.634
LEADSUPP2		.614
LEADSUPP3		.559

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Total Variance Explained

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	8.384	59.886	59.886
2	1.211	8.650	68.536

Extraction Method: Principal Component Analysis.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.908
Bartlett's Test of Sphericity	Approx. Chi-Square	1364.924
	df	91
	Sig.	.000

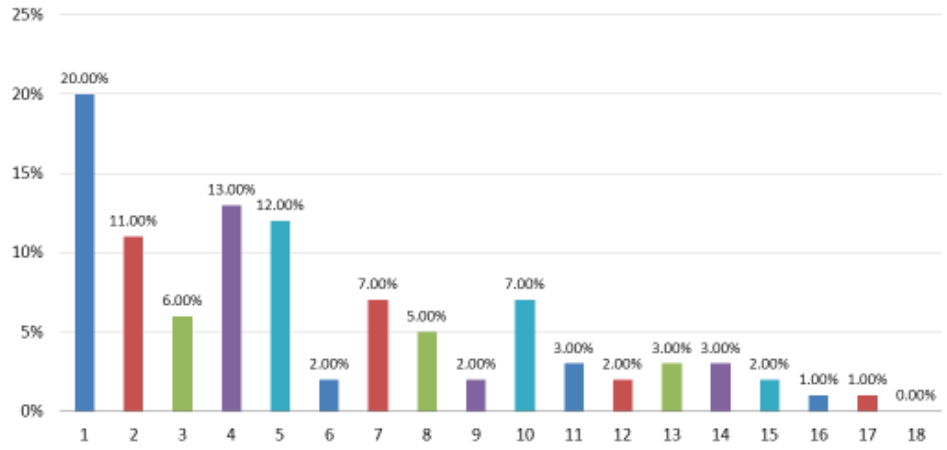
SOCIAL CAPITAL
Business Continuity and Resiliency Survey

- Social capital is essentially concerned with the significance of relationships. Lin (2001) suggested social capital is the resources embedded in social networks accessed and used by actors for actions. Extant literature relates social capital to firm performance. Refer to Stam et al. 2011 for a meta-analysis on social capital of entrepreneurs on small firm performance. Meanwhile, Johannisson & Olaison (2007) and Aldrich (2012) placed social capital at the core of disaster recovery.

- Social capital studies often classify the entrepreneurs' personal networks using size, strong and weak ties, structural holes, and network diversity, among others. For example, Herbane (2018) stressed the importance of personal networks on strategic renewal of SMEs after a crisis. Ruef et al. (2009) distinguishes personal ties from other (i.e. spouse & family versus business acquaintances). In this study we measured size like Batjargal (2003) who counted the total number of relationships. Similar to Davidsson and Honig (2003) and Ruef et al. (2009), the study examines the type of connection (i.e. family and friends versus business contacts or governmental organizations, among others).

- The graphic showed the percentage of respondents who selected each alternative. It is important to notice that participants could select many alternatives. Overall, the graphic demonstrates that entrepreneurs in post-disaster environments rely on their entrepreneurial acquaintances, in the following order: employees, clients, suppliers and other entrepreneurs. Also, they rely on informal (strong ties) such as family and friends. Refer to the next chart.

SOCIAL CAPITAL



Description of Variables

1. Employees
2. Family
3. Friends
4. Clients
5. Suppliers
6. Competitors
7. Other entrepreneurs
8. Distributors
9. Community
10. Insurance Companies
11. Municipal Government
12. FEMA
13. State Government
14. Banks
15. Entrepreneurial Associations
16. NGOs – Community Services
17. NGOs – Entrepreneurial Services
18. None

SUPPLY CHAIN RESILIENCE (SCR)

- Reflecting on the terrorist attacks of September 11, 2001, Rice & Caniato (2003) stated: The supply network is inherently vulnerable to disruption, and the failure of any one element in it could cause the whole network to fail. Interestingly, it is no limited to trading partners but also to governmental agencies, transportation infrastructure, among others involved in the flow of goods. This was evident in the aftermath of Hurricane Maria (i.e. qualified personnel for transports was unavailable and deficient energy infrastructure, among many others).
- Supply chain resilience is defined by Ponomarov and Holcomb (2009) as the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function.
- Jüttner & Maklan (2011) emphasize the role of redundancies and velocity as key routes to flexibility. Redundancies, which presuppose duplicity, has been extensively associated to increases in flexibility. Despite its advantages, maintaining redundancies across the supply chain increases costs. The table reviews the advantages and disadvantages of supply chain resilience actions (Rice & Caniato, 2003).

Supply Chain Resilience Responses by Failure Mode

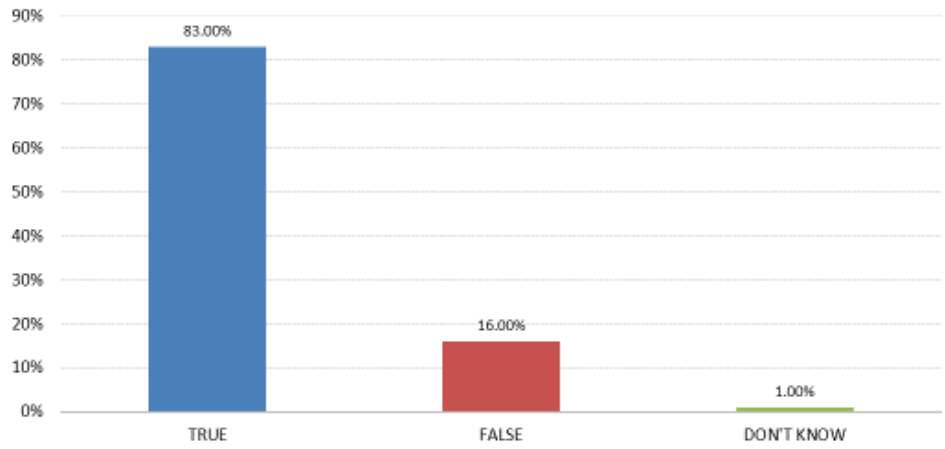
Resilience to Disruption in...	Action	Advantages	Disadvantages
Supply	Use multiple and/or local sources in different locales.	Spreads risk across two firms, two locations; local source protects against international supply shortages.	Higher cost to qualify supplier, lower volume leverage, no assurance additional supplier is more resilient.
	Use single source.	Known supplier, high supplier commitment, leveraged volume.	Vulnerable to disruption unless supplier has multiple flexible sites, backup plans.
	Contract for supplier flexibility.	Contract obligates supplier in advance.	Potentially higher cost per unit, may entail fixed costs for "take or pay" committed volume.[6]
	Modify inventory levels.	Right parts inventory and risk pooling may reduce inventory costs.	Requires periodic analysis by item as conditions change.
	Modify product to use standard parts.	Reduces part and inventory cost, complexity.	Costly to modify existing materials standards.
Transportation	Prepare for and use multiple modes and carriers.	Pre-disruption relationship ensures support in crisis.	May need to commit volume to the alternate modes to get access in a disruption.
	Use spot market for capacity.	Efficient transaction with no upfront or lasting commitment.	Unknown carrier means added risk, potential for exceptional high pricing.
	Use logistics providers to source transportation.	Providers may have greater leverage and access.	Requires commitment (volume, cost) and relationship with logistics provider.
Production Facilities	Use multiple sites, each making multiple products.	Enables shifting production around locations.	Requires standardization in production operations, additional capital for additional facilities.[7]
	Modify inventory levels and policies.	Right finished-goods-inventory levels and risk pooling may reduce inventory costs.	Requires periodic analysis, potential redesign of supply network.
	Modify product to use standard processes.	Leverages common processing capabilities for lower cost, easier backup available.	Costly to modify product and production processes.
	Identify and contract backup production facilities.	Committed backup assured, potential to co-locate at supplier or customer.	Not dependable without contingency contract for the facilities in disruption.[8]
Communications	Use range of communication media.[9] Back up data.	Communication in nearly any event. Protects against data loss.	Must maintain broad range of old and new technology. Still requires physical system in event of system loss.
	Contract for backup IT system. Set up and operate parallel or mirrored IT system.	Provides for near-term system availability. Affords immediate system availability.	Potential delay in immediate response to massive system disruption. Requires cost to build, operate, and maintain separate system in protected environment.
Human Resources	Develop cross-trained workers.	Enables shifting of employees and production as needed.	Must cross-train employees, and modify work system to utilize multi-skilled employees.
	Modify production process for unskilled labor. Back up knowledge.	Allows rapid increase or decrease in capacity. Best practices captured and documented.	Requires simplification of production process (not always feasible). Requires significant investment to capture and maintain knowledge in useful form.

SUPPLY CHAIN RESILIENCE (SCR)

- Using Rice & Caniato (2003) categories, the next graphics show regional concentration of employees, suppliers, distributors and clients. The literature suggests that concentration of the supply chain represents a vulnerability because the risks of regionality are high. This is particularly true in disaster environments where some locations (regions) are affected more than others. For example Branicki et al. (2018) multiple sourcing strategies in generating resilient SMEs
- Of all the components of the supply chain examined, employees (83%) are the most concentrated, followed by clients (55.5%), suppliers (51.25) and distributors (41.5%). The percentages reported here are the average for all the percentages in the previous graphics and represent concentration. Hence, the higher the percentage, the higher the risk in the supply chain.
- In terms of location, most respondents (91.0%) indicated the organization is in an area with easy access and near main roads.
- Based on the significance placed on the community where the firm is located (i.e. Aldrich, 2012, Cheshire, 2015) specially in post-disaster recovery, we examined cohesiveness in the community. The fact that so many participants (45%) answered "Don't Know" suggest certain disconnect between the community and the organization, which may hinder recovery efforts in post-disaster environments. Refer to the next charts (13).

SUPPLY CHAIN RESILIENCE (SCR)

Human Resources - Location

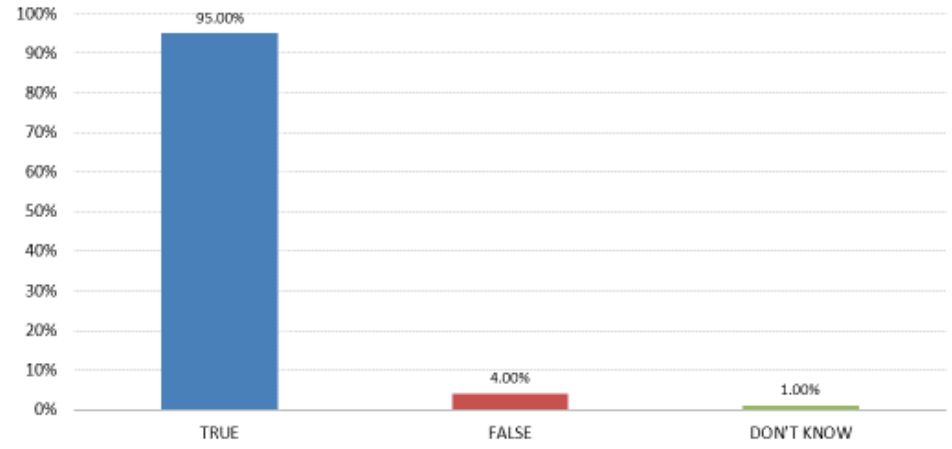


Description of Variable

Most employees live near the organization (same or border-town)

SUPPLY CHAIN RESILIENCE (SCR)

Clients - Location

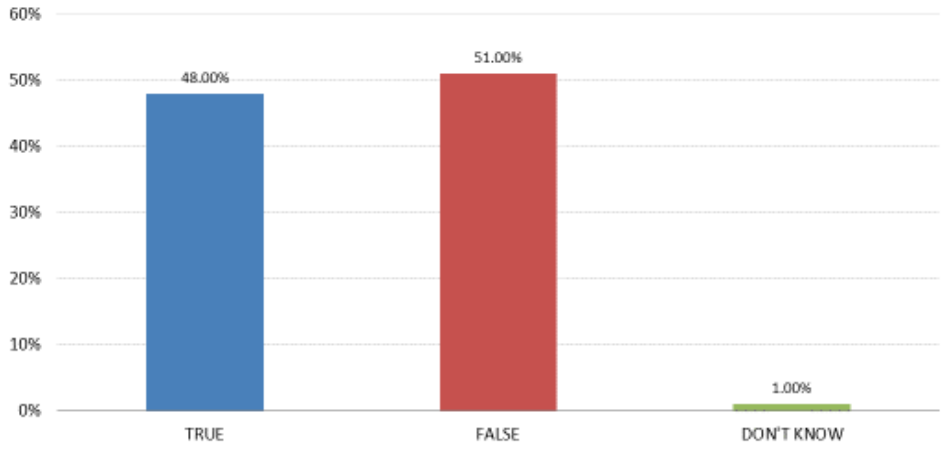


Description of Variable

Most of the organizations' clients are in Puerto Rico.

SUPPLY CHAIN RESILIENCE (SCR)

Clients - Location

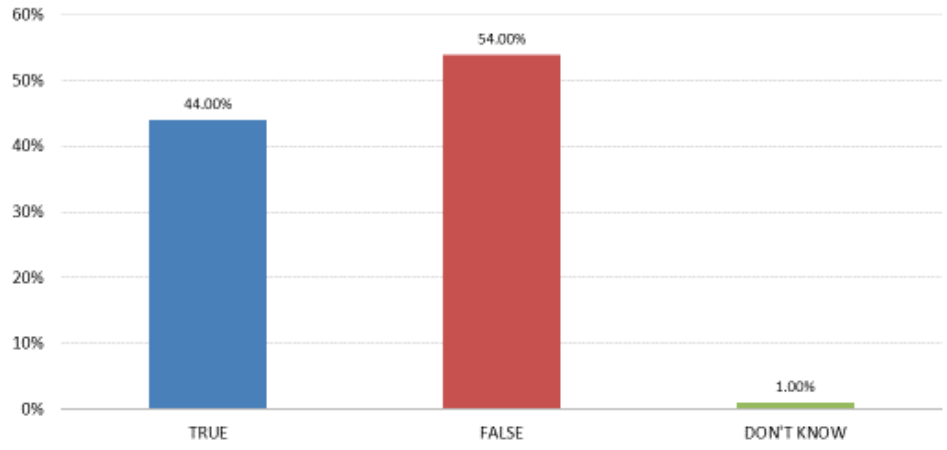


Description of Variable

Most of the organizations' clients are in the same region of the organization (i.e. North, South, Central, East, West).

SUPPLY CHAIN RESILIENCE (SCR)

Clients - Location

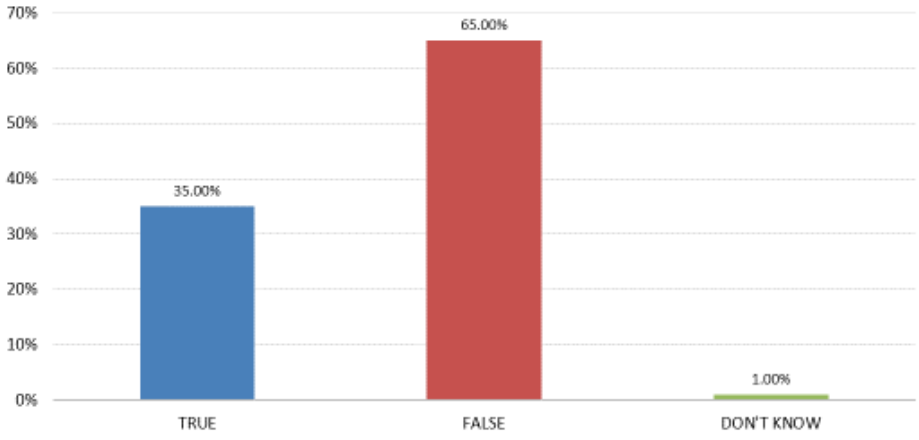


Description of Variable

Most of the organizations' clients are concentrated in a geographic zone (Example: Northeast versus disperse across all the United States)

SUPPLY CHAIN RESILIENCE (SCR)

Clients - Location

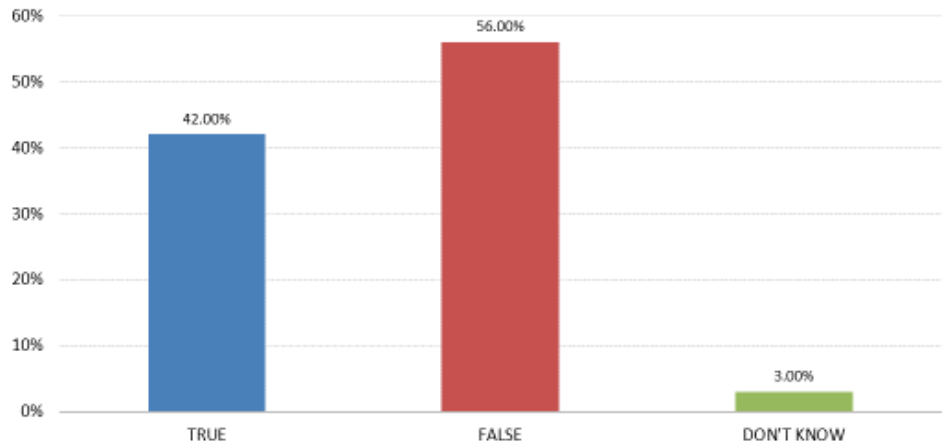


Description of Variable

Most of the organizations' sales are concentrated in one or few clients.

SUPPLY CHAIN RESILIENCE (SCR)

Distributors - Location

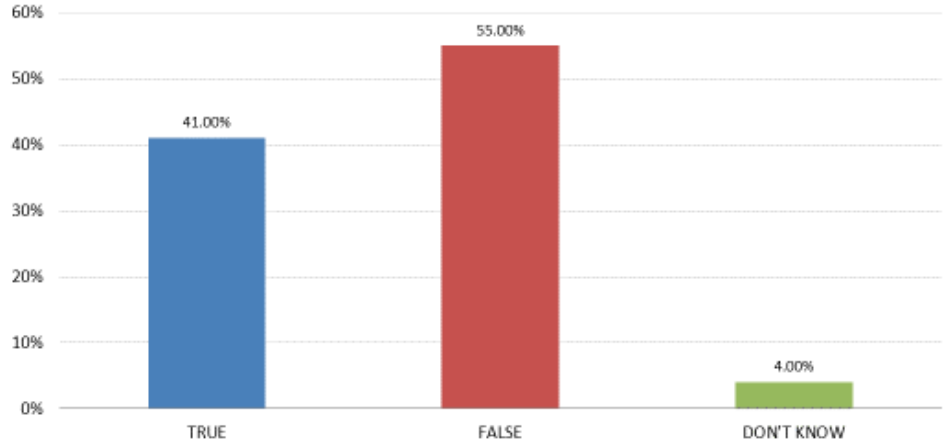


Description of Variable

Most of the organizations' distributors are in the same region of the organization (i.e. North, South, Central, East, West).

SUPPLY CHAIN RESILIENCE (SCR)

Distributors - Location

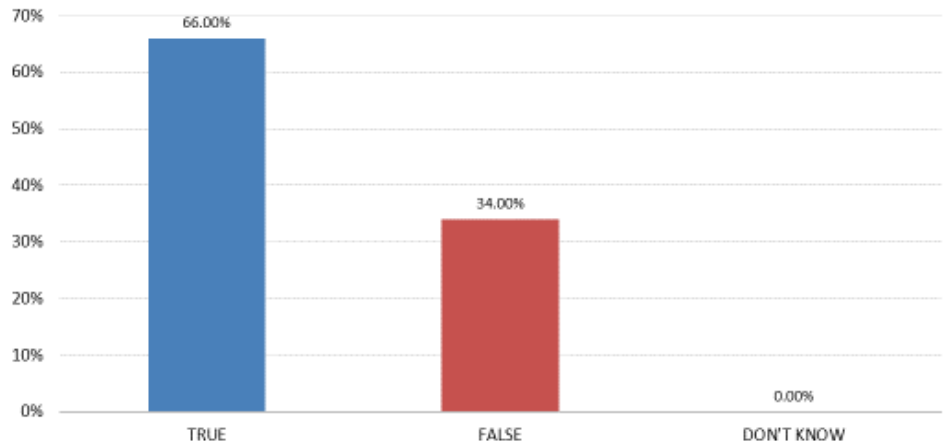


Description of Variable

Most of the organizations' distributors are concentrated in a geographic zone (Example: Northeast versus disperse across all the United States)

SUPPLY CHAIN RESILIENCE (SCR)

Suppliers - Location

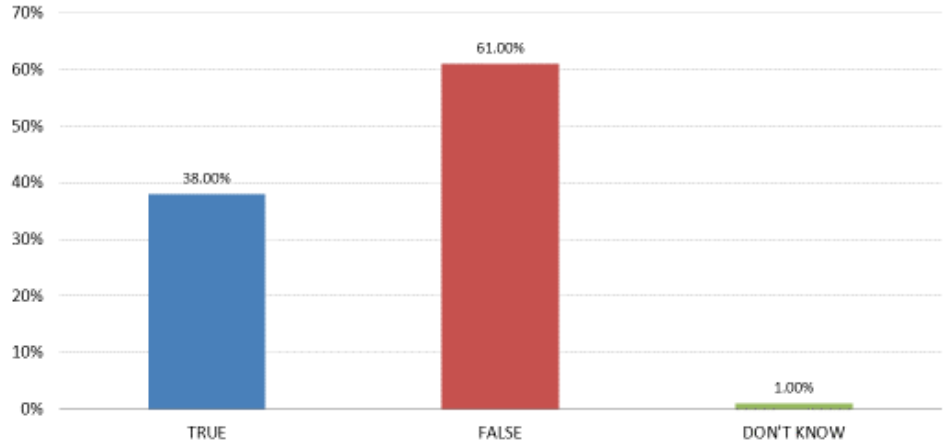


Description of Variable

Most of the organizations' suppliers are in Puerto Rico.

SUPPLY CHAIN RESILIENCE (SCR)

Suppliers - Location

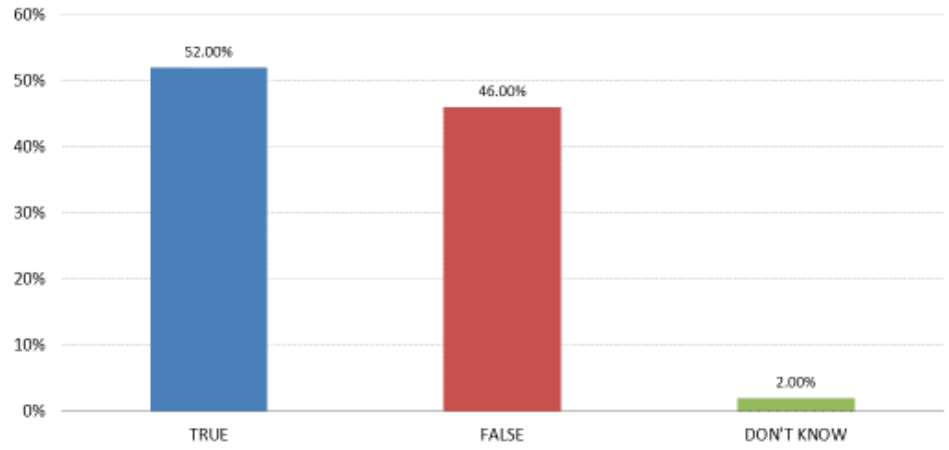


Description of Variable

Most of the organizations' suppliers are in the same region of the organization (i.e. North, South, Central, East, West).

SUPPLY CHAIN RESILIENCE (SCR)

Suppliers - Location

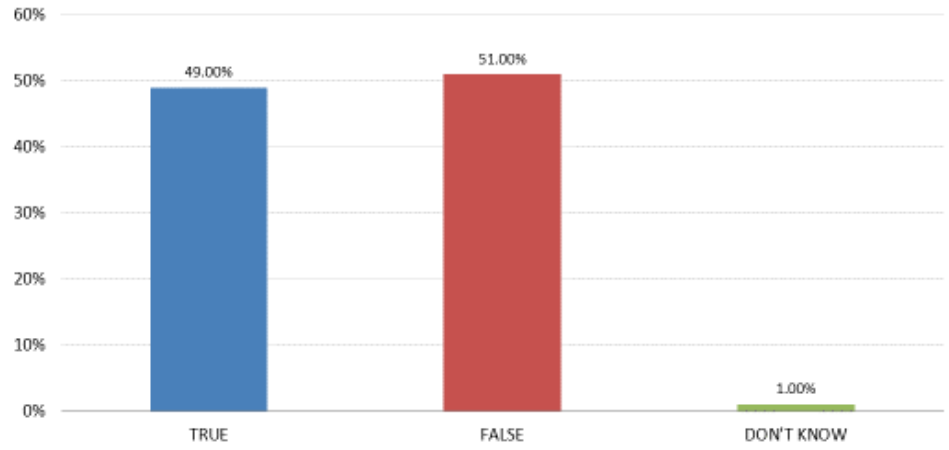


Description of Variable

Most of the organizations' suppliers are concentrated in a geographic zone (Example: Northeast versus disperse across all the United States)

SUPPLY CHAIN RESILIENCE (SCR)

Suppliers - Location

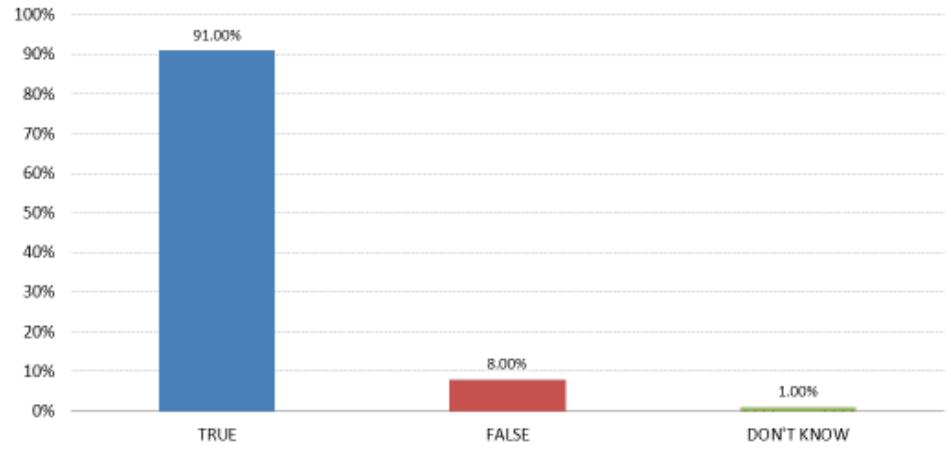


Description of Variable

Most of the organizations' purchases are concentrated in one or few suppliers.

SUPPLY CHAIN RESILIENCE (SCR)

Access - Location

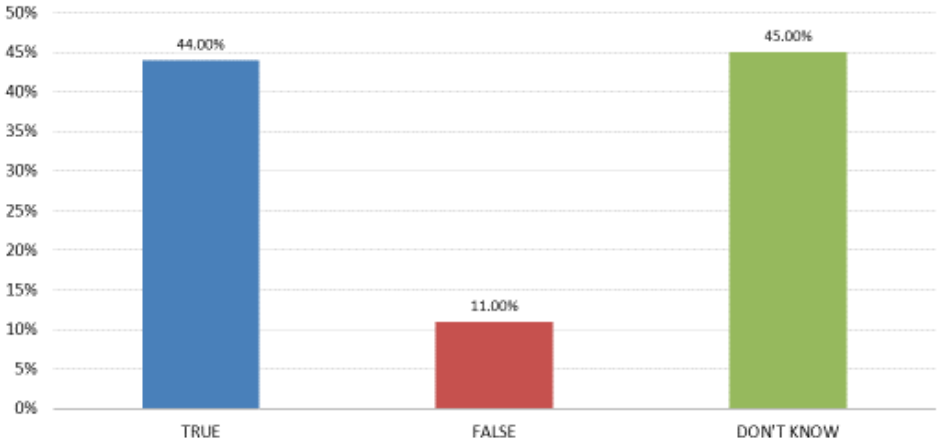


Description of Variable

My organizations is in a location with easy access and near main roads.

SUPPLY CHAIN RESILIENCE (SCR)

Community - Location



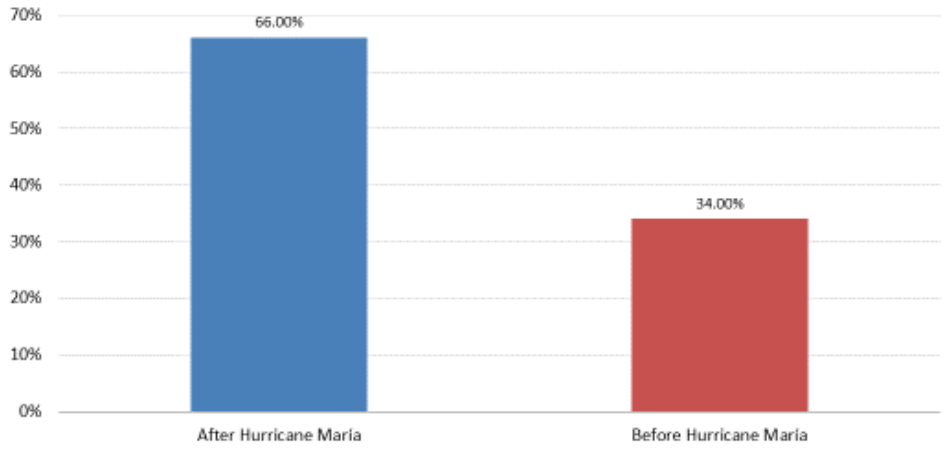
Description of Variable

The community where my organization is located is very united and engaged in the region.

SUPPLY CHAIN RESILIENCE (SCR)

- As previously discussed, many authors have focus on supply chain resilience factors including adaptive capabilities, redundancies across the supply chain, multi-sourcing strategies, cross trained personnel, product modifications to use standard processes among many others (i.e. Rice & Caniato, 2003; Ponomarov and Holcomb, 2009; Jüttner & Maklan, 2011). Nonetheless, others like Branicki et al. (2017) and Korber and McNaugh (2017) focused on individual resiliency, formalization (i.e. planning) and learning. This last one is of particular importance since resiliency, in its broadest sense not only requires the system's capacity to return to the state that existed before the disturbance, but also to advance the state through learning and adaptation (Cutter et al. 2008).
- In the next slides, we discuss the formalization, supply chain resilience (SCR) factors and learning, before and after hurricane Maria. Participants were asked to select which resilience factors were in place before and after the hurricane. The difference in resilience factors before and after the hurricane suggest learning. Moreover, the higher the difference the most critical the factor and the firms' vulnerability based on Hurricane Maria's experience.
- The data in this study suggest manufacturing SMEs were in a relative vulnerable position when Hurricane Maria hit the island. This is shown in the increase of measures introduced after the disaster (learning). For example, prior Maria only 34 percent of the sample had protocols to prevent and respond in case of a disaster (formalization factor). After Hurricane Maria it increased almost by double. After formalization, we see increased changes in the following order: infrastructure, facilities, human resources, communications & IT, production and transports. Refer to the next charts (SCR).

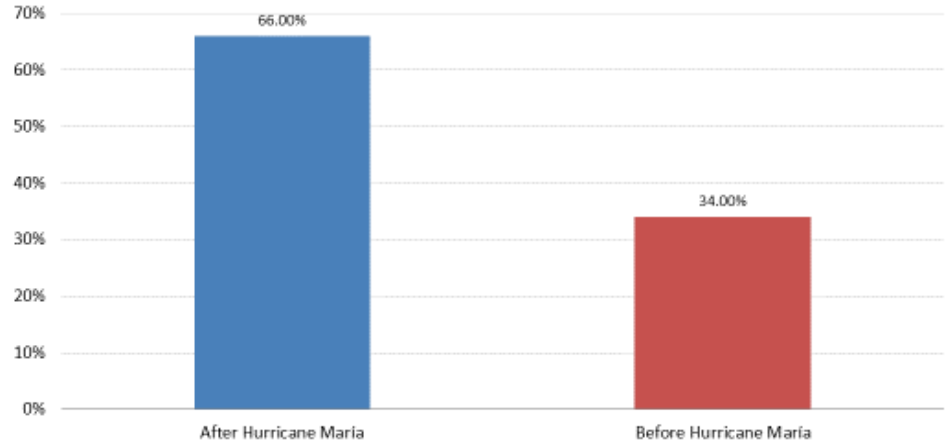
SUPPLY CHAIN RESILIENCE (SCR)
Formalization



Description of Variable

The organization has protocols to prevent interruptions. (32% change)

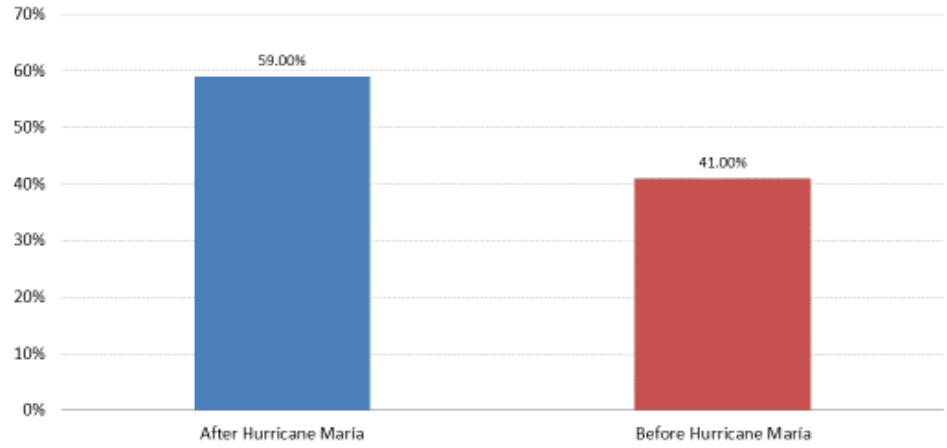
SUPPLY CHAIN RESILIENCE (SCR)
Formalization



Description of Variable

The organization has protocols to respond to interruptions. (32% change)

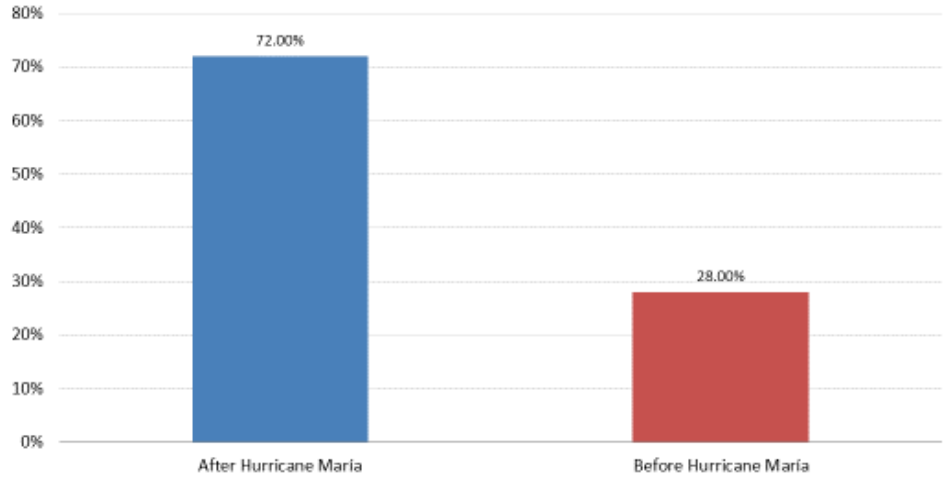
SUPPLY CHAIN RESILIENCE (SCR)
Formalization



Description of Variable

The organization has operational manuals (SOPs). (18% change)

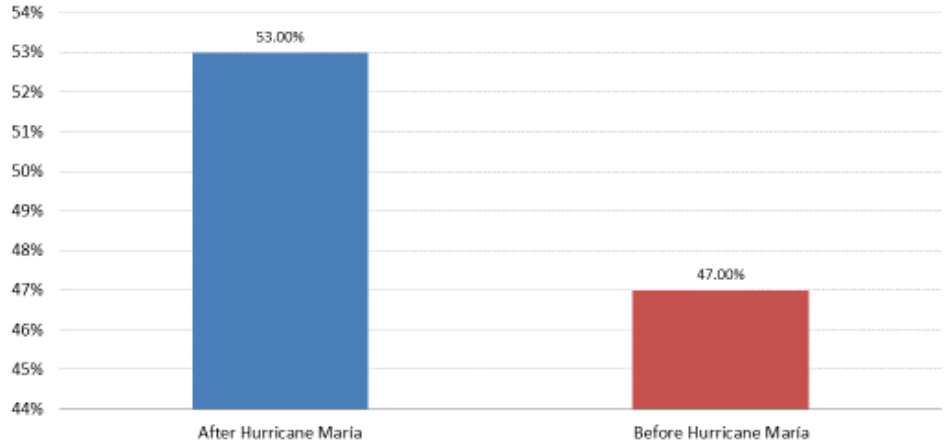
SUPPLY CHAIN RESILIENCE (SCR)
Formalization



Description of Variable

The organization has been certified or trained in risk management and business continuity. (44% change)

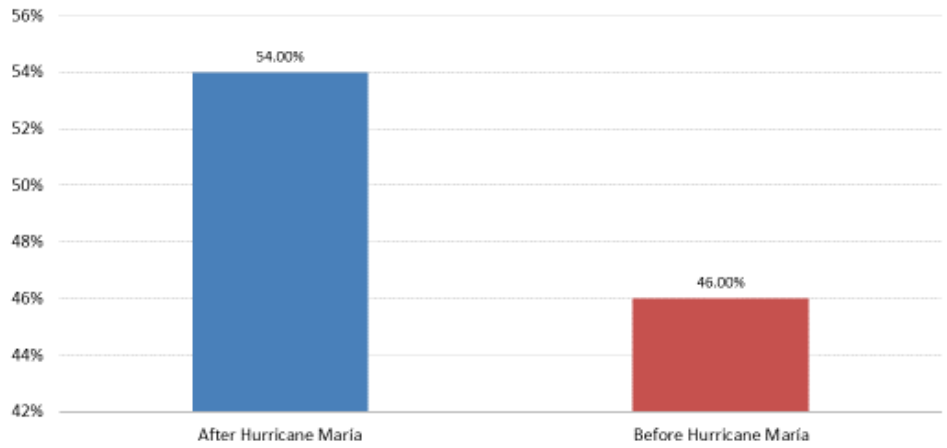
SUPPLY CHAIN RESILIENCE (SCR)
Distributors/Transports



Description of Variable

The organization has a variety of transport modalities (owned or contracted) to distribute products. (6% change)

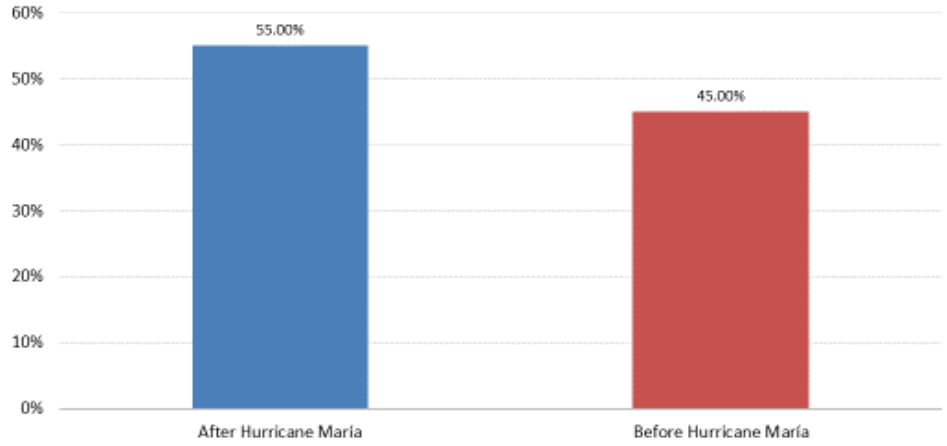
SUPPLY CHAIN RESILIENCE (SCR)
Distributors/Transports



Description of Variable

The organization has its own transports to distribute products. (8% change)

SUPPLY CHAIN RESILIENCE (SCR)
Production

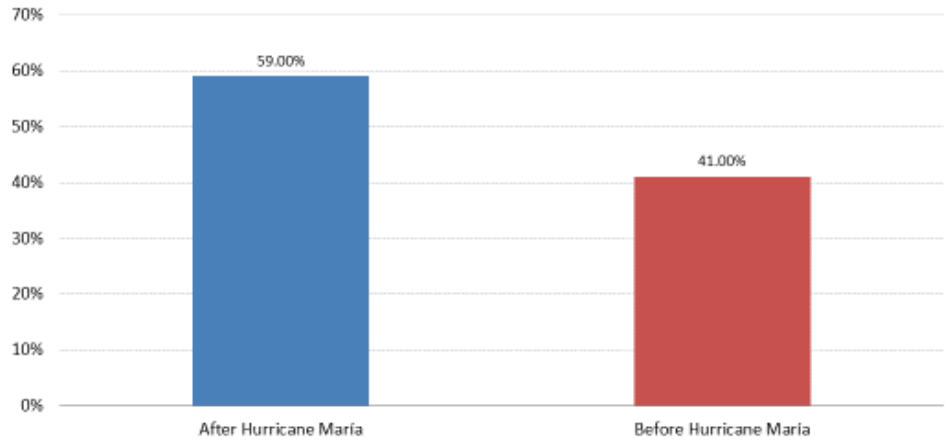


Description of Variable

The organization has the capacity to rapidly modify or mobilize inventory. (10% change)

SUPPLY CHAIN RESILIENCE (SCR)

Production

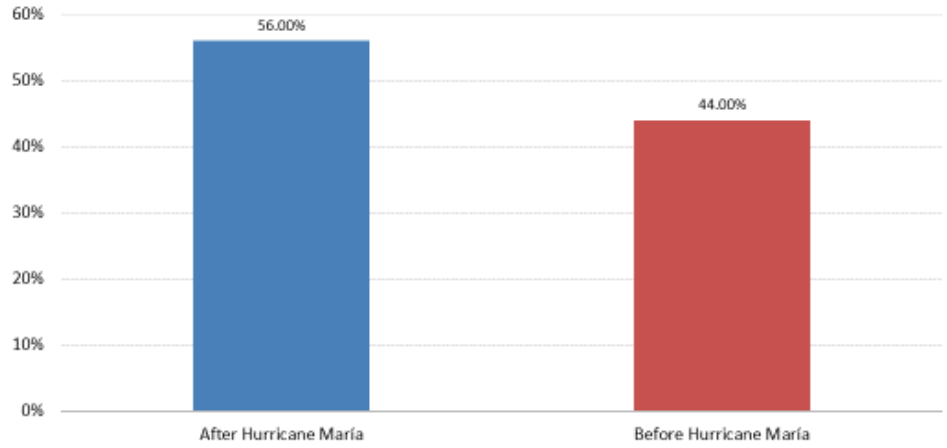


Description of Variable

The organization has the capacity to increase or reduce production capacity cost efficiently. (18% change)

SUPPLY CHAIN RESILIENCE (SCR)

Production

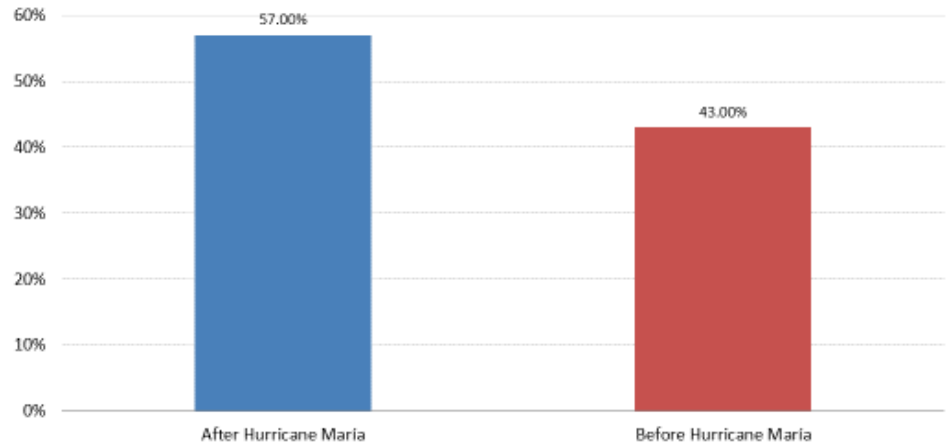


Description of Variable

The organization has standard production processes that are easy to replicate. (12% change)

SUPPLY CHAIN RESILIENCE (SCR)

Production

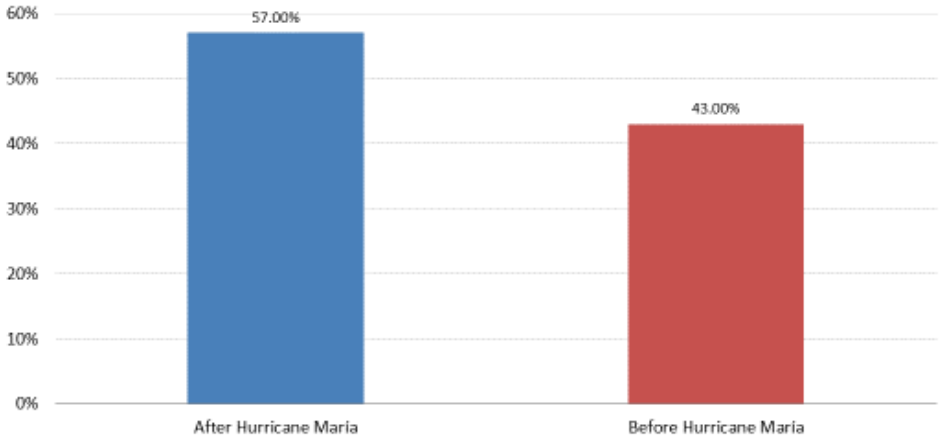


Description of Variable

The organization has sufficient inventory to continue operations after a disruption. (14% change)

SUPPLY CHAIN RESILIENCE (SCR)

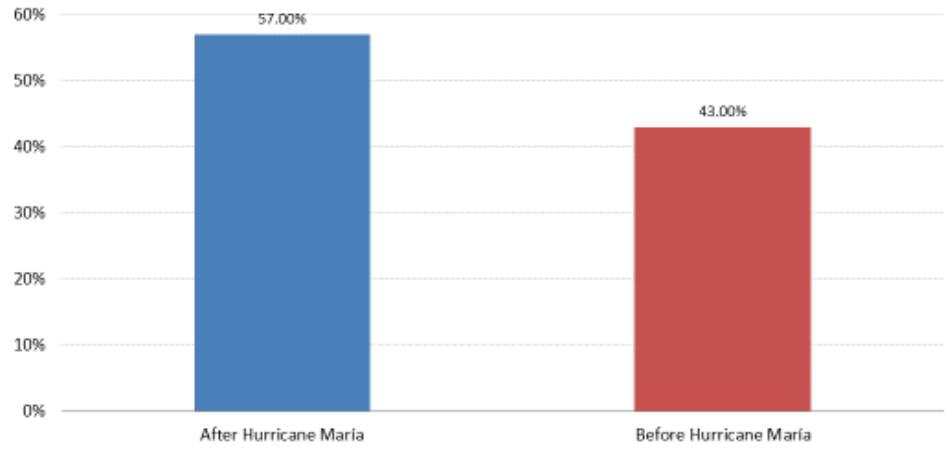
Production



Description of Variable

The organization has the capacity to modify products in standard parts to potentiality outsource production during disruptions. (14% change)

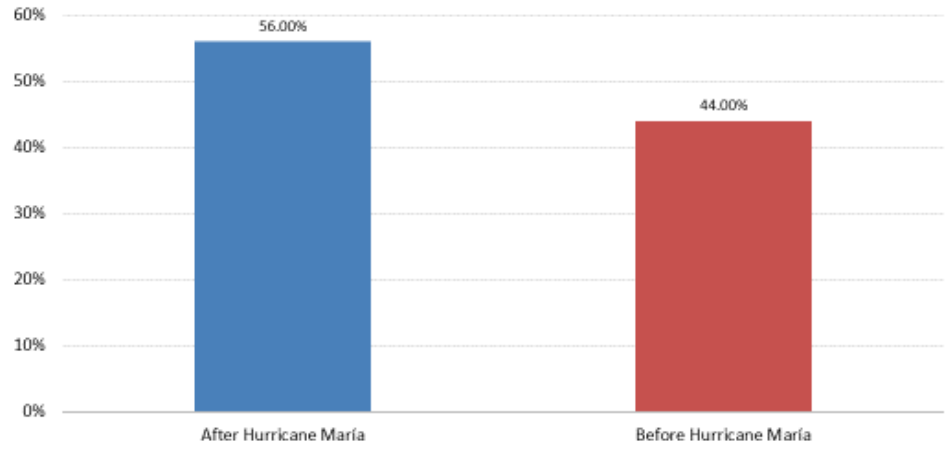
SUPPLY CHAIN RESILIENCE (SCR)
Facilities



Description of Variable

The organization has identified other companies that could manufacture their products in disruptive events. (14% change)

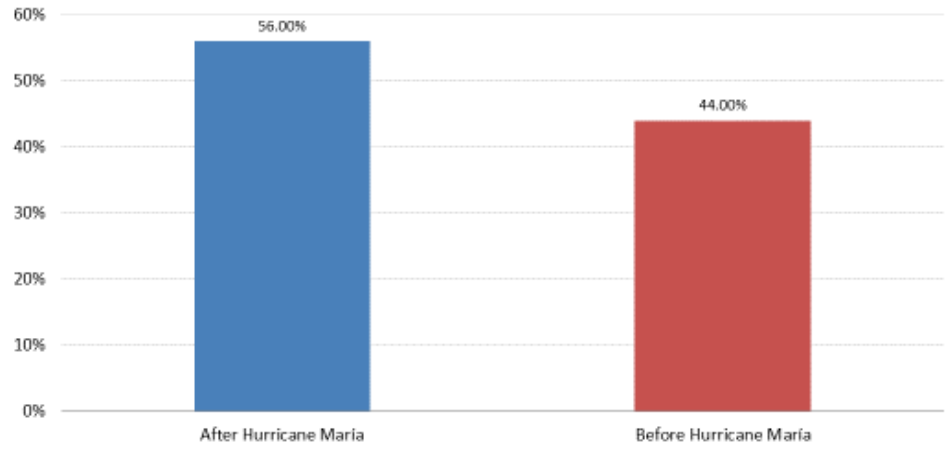
SUPPLY CHAIN RESILIENCE (SCR)
Facilities



Description of Variable

The organization has identified other companies to sell inventory in disruptive events. (12% change)

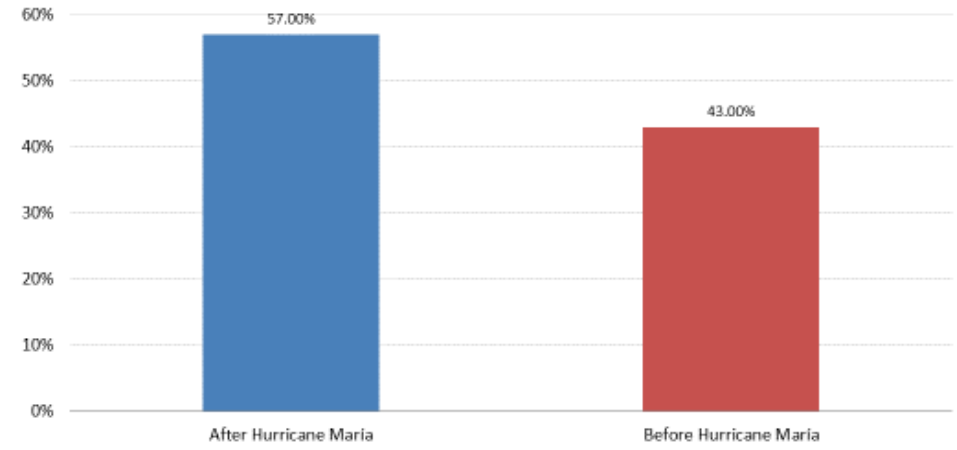
SUPPLY CHAIN RESILIENCE (SCR)
Facilities



Description of Variable

The organization has various sites/facilities to manufacture products. (12% change)

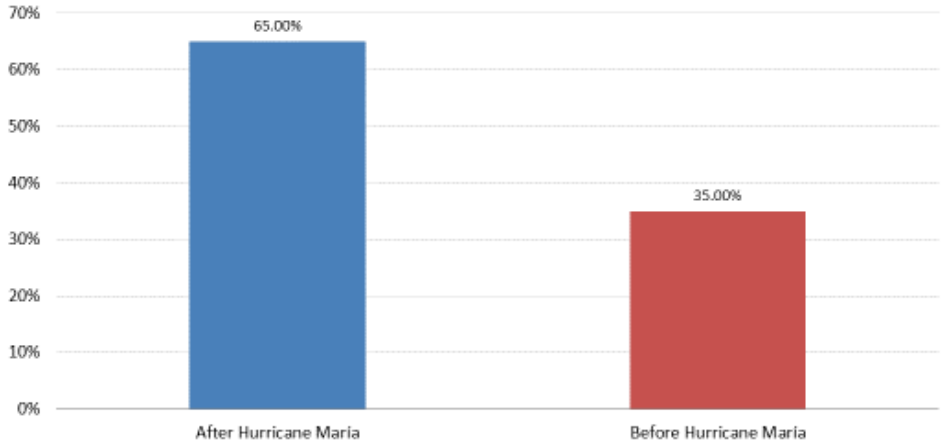
SUPPLY CHAIN RESILIENCE (SCR)
Facilities



Description of Variable

The organization conducts periodic inspections of the facilities. (14% change)

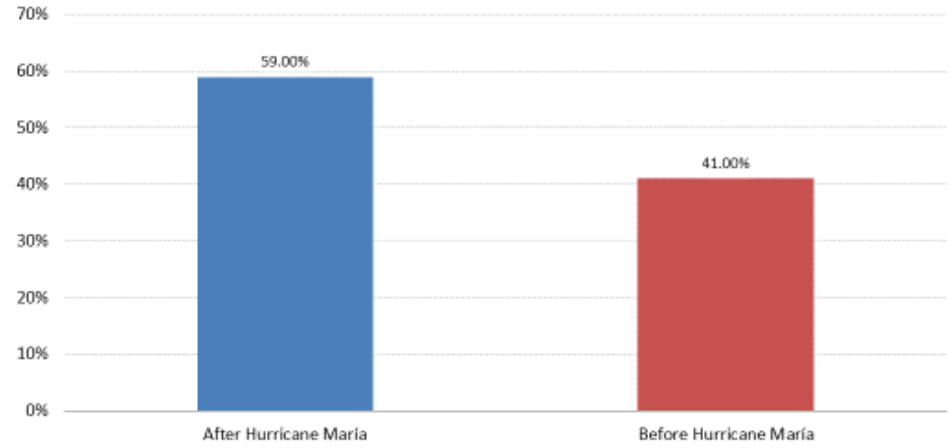
SUPPLY CHAIN RESILIENCE (SCR)
Facilities



Description of Variable

The organization has identified other places to relocate in case of a disruptive event. (30% change)

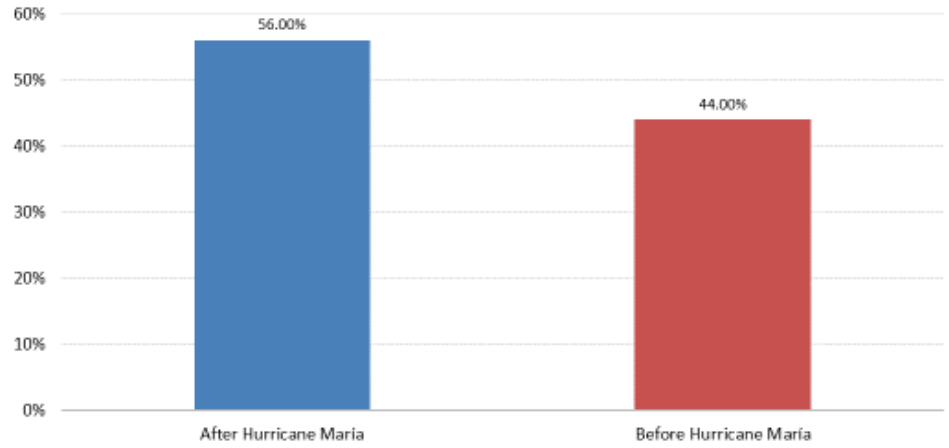
SUPPLY CHAIN RESILIENCE (SCR)
Communications & Information Technologies



Description of Variable

The organization has diverse channels to communicate with employees, suppliers, clients and other in case of disruptive events. (18% change)

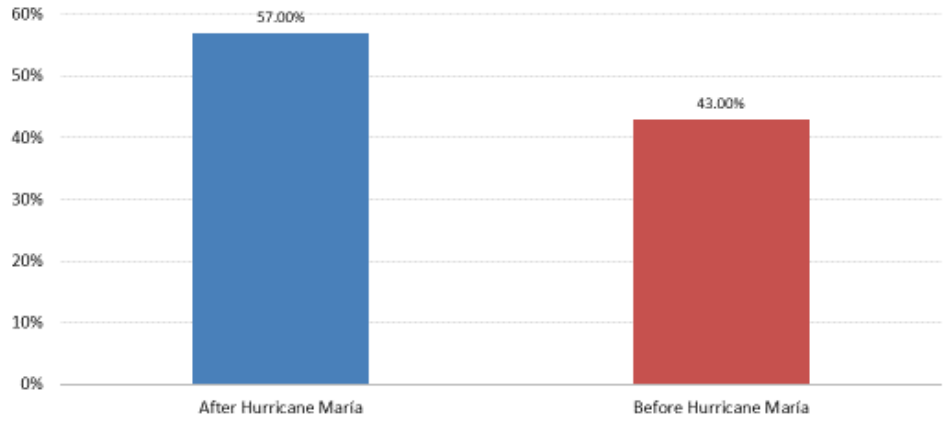
SUPPLY CHAIN RESILIENCE (SCR)
Communications & Information Technologies



Description of Variable

The organization has manual systems (i.e. forms) to continue operating if connectivity is lost. (12% change)

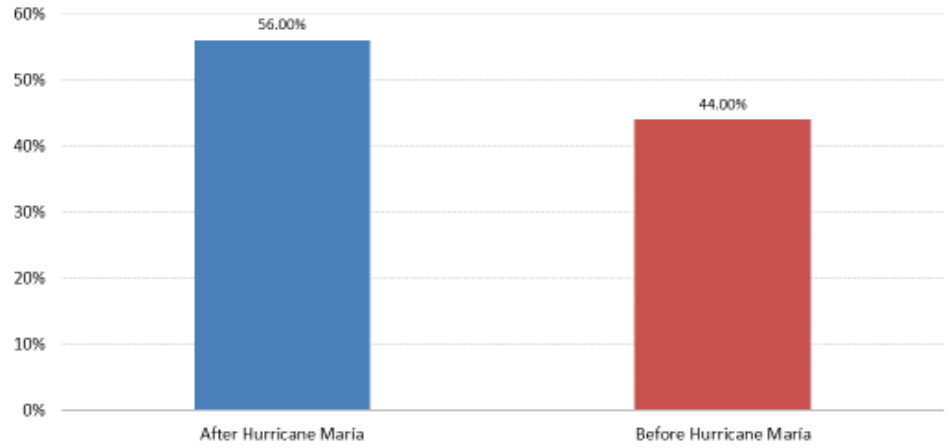
SUPPLY CHAIN RESILIENCE (SCR)
Communications & Information Technologies



Description of Variable

The organization has redundant information systems. (14% change)

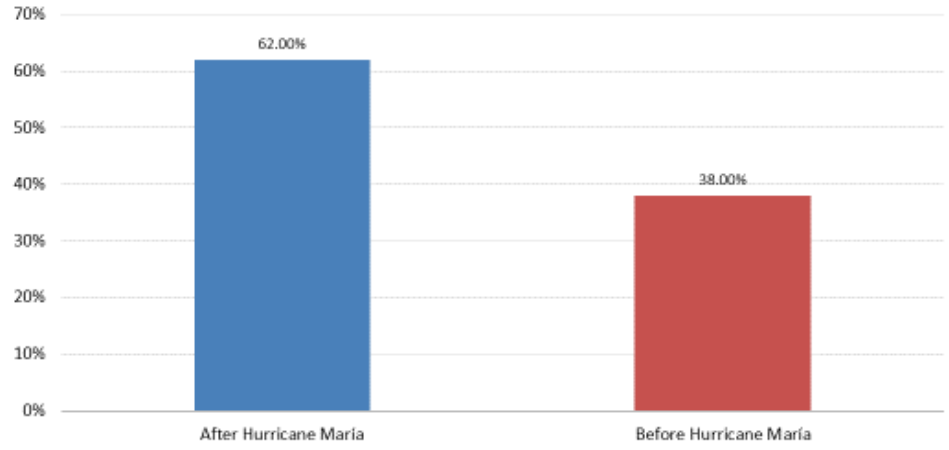
SUPPLY CHAIN RESILIENCE (SCR)
Communications & Information Technologies



Description of Variable

The organization conducts back-up of information. (12% change)

SUPPLY CHAIN RESILIENCE (SCR)
Human Resources

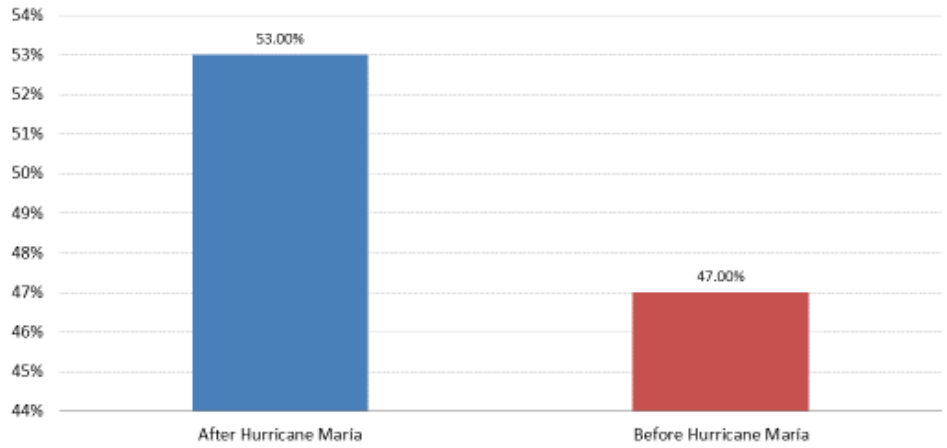


Description of Variable

Employees have roles assigned when business disruptions. (24% change)

SUPPLY CHAIN RESILIENCE (SCR)

Human Resources

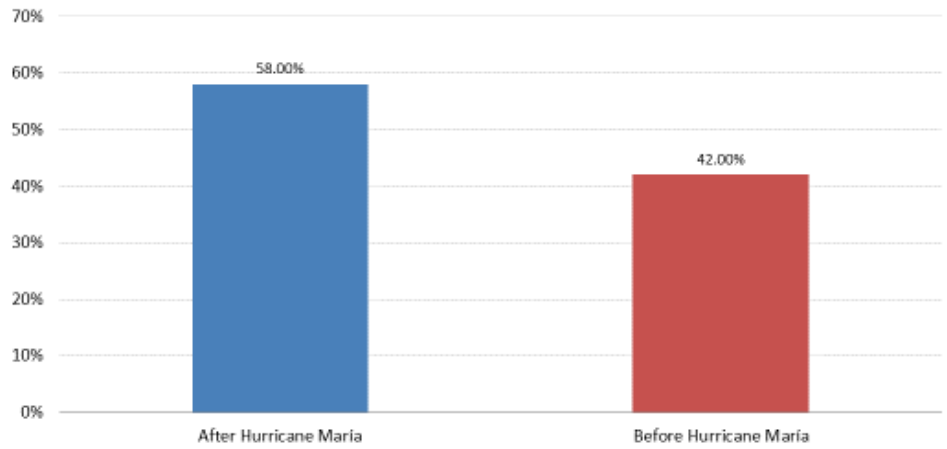


Description of Variable

The organization has employees that can perform multiple roles and functions in different areas of the organization. (6% change)

SUPPLY CHAIN RESILIENCE (SCR)

Human Resources

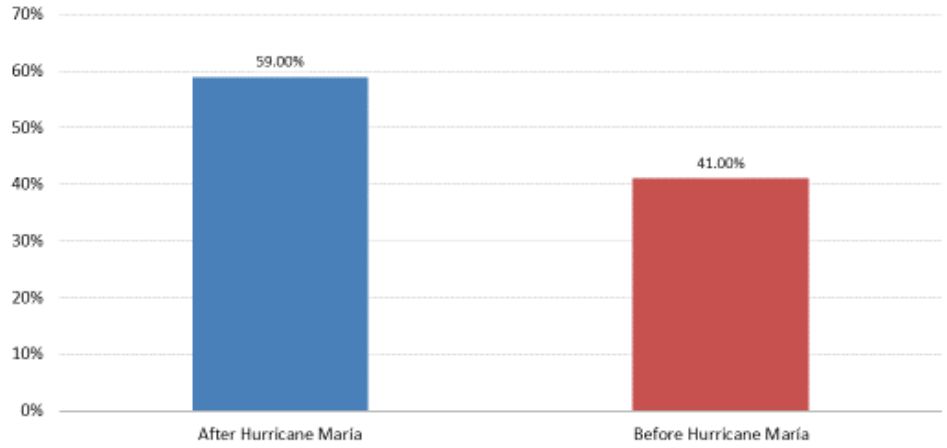


Description of Variable

The organization has employees trained in protocols to manage disruptive events. (16% change)

SUPPLY CHAIN RESILIENCE (SCR)

Infrastructure

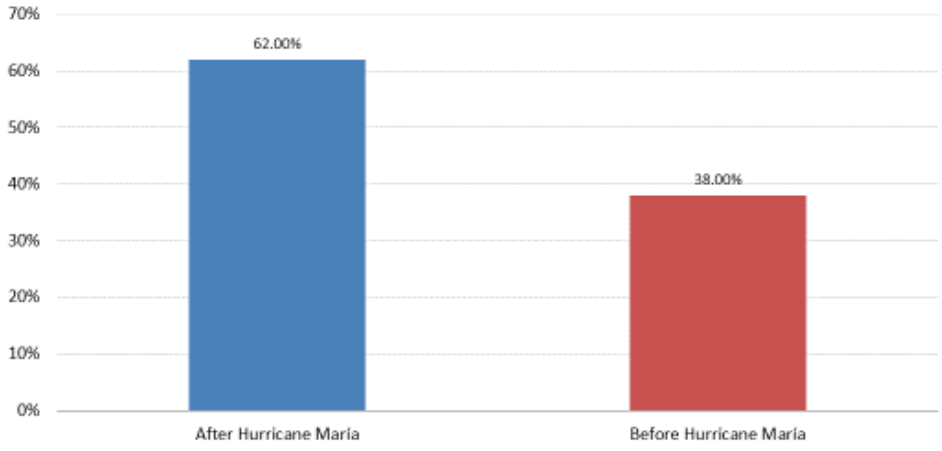


Description of Variable

The organization has electric generators to operate at more than 90 percent capacity. (18% change)

SUPPLY CHAIN RESILIENCE (SCR)

Infrastructure

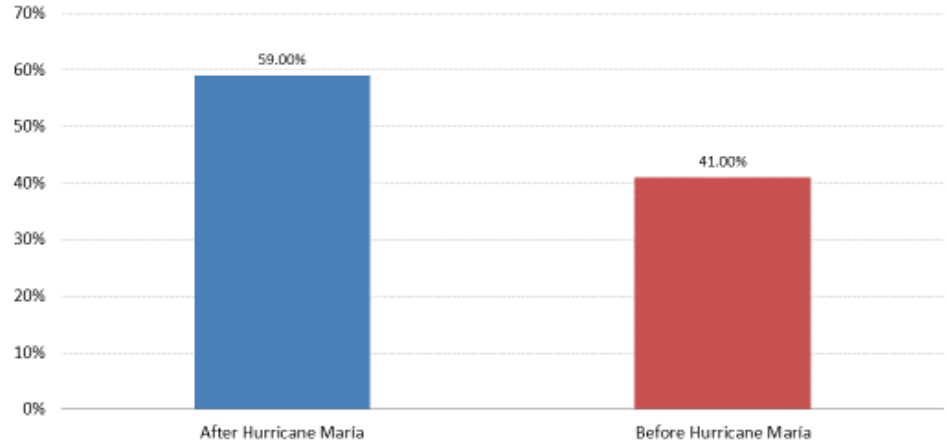


Description of Variable

The organization possesses solar panels or other independent energy sources (independent of Puerto Rico Energy Power Authority - PREPA). (24% change)

SUPPLY CHAIN RESILIENCE (SCR)

Infrastructure

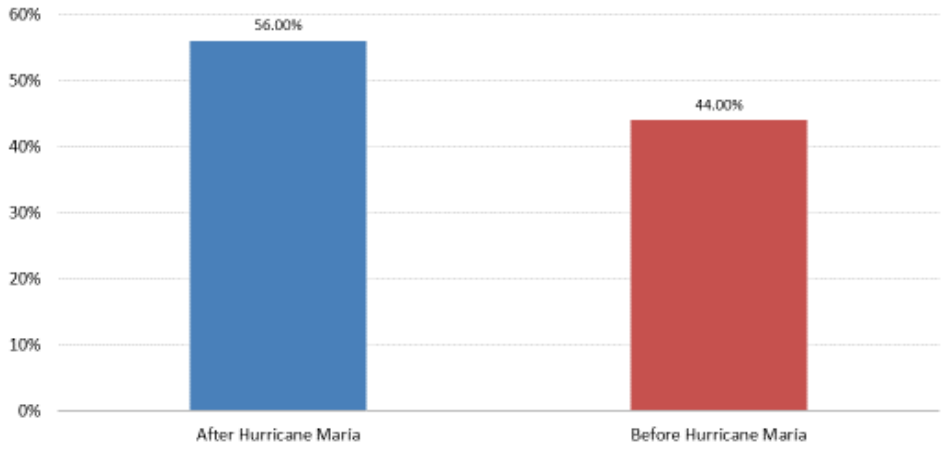


Description of Variable

The organization maintain fuel (gas, diesel, other) reserves to last for a minimum of 3 days. (18% change)

SUPPLY CHAIN RESILIENCE (SCR)

Infrastructure

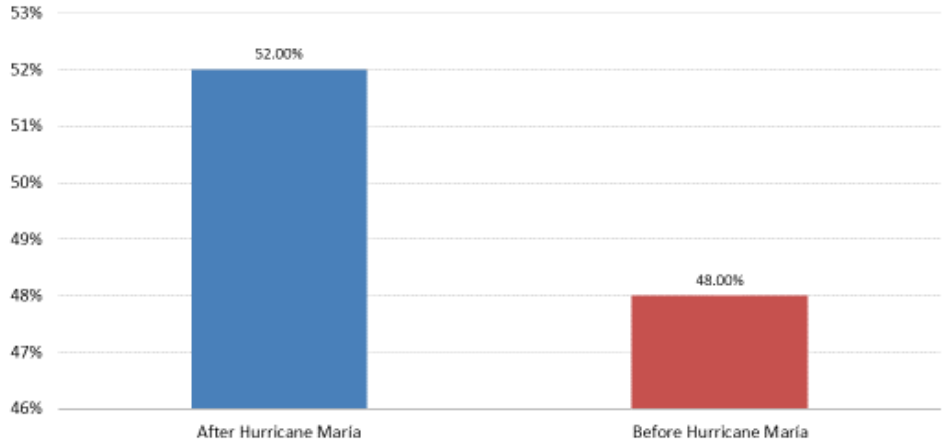


Description of Variable

The organization maintains water reserves or cistern to use for a minimum of three days. (12% change)

SUPPLY CHAIN RESILIENCE (SCR)

Cash Reserves



Description of Variable

The organization maintains cash reserves. (4% change)

SUPPLY CHAIN RESILIENCE (SCR)

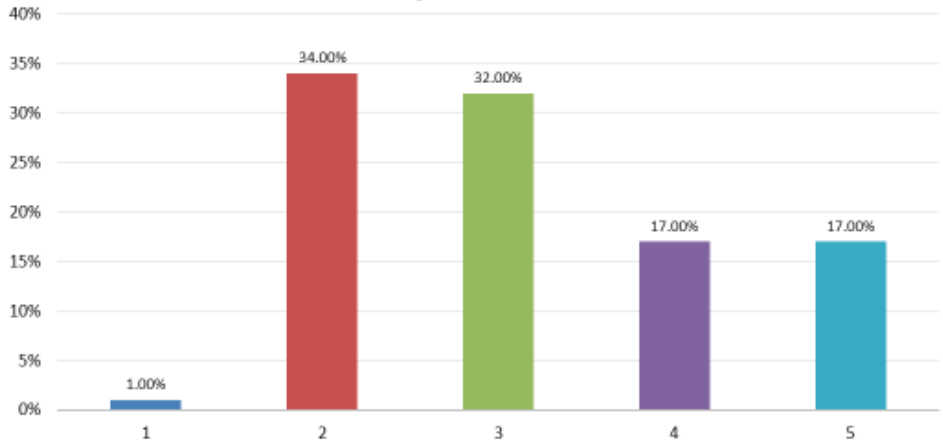
- The literature on resiliency has provided multiple definitions and from various disciplines. Jones (2008) defined resilience as the ability of a system to cope with such forces or hazards and return to its normal operating status once the perturbations have been removed . Powley (2009) defined it as the power of organizational units to resume, rebound, bounce back, or positively adjust to untoward events.
- Marshall & Schrank (2014) proposed a small business disaster recovery research framework using as reference Brown et al. (2008) recovery dimensions. According to the authors, recovery is dependent on the timeframe use to evaluate recovery, the scale of interest or entities (i.e. the community, the family, or the organization, among others), and perception. Regarding the last one (perceptions), the authors emphasize the importance of assessing the perception of business owners because they know what they have done, why they have done (or not done) something, and therefore can better report recovery indicators.
- The timeframe in this study is 2 years after the disaster and the scope is manufacturing SMEs. To control for other recent disasters in the southern region (e.g. earthquakes), we asked respondents to classify their organizations' recovery status and performance by December 2019. These are based on business owners'/managers' perceptions using as benchmark the organizational conditions prior the disaster (Hurricane Maria).

SUPPLY CHAIN RESILIENCE (SCR)

- Although the most pragmatic manner to classify the status of a business after a disaster will be operating versus non-operating businesses (the demise of the business), the reality is that it is not always observable, and as suggested by Marshall & Schrank (2014), the study employed the following status categories: survived, recovered, or resilient.
- The authors defined survived as businesses operating but that have not reached predisaster characteristics typical for their business. Olshansky & Chang (2009), and Swanson et al. (2009) they defined recovered as the capacity to return to pre-event conditions, which is also, one of the views to define resilience (Marshall & Schrank, 2014), while other views focuses on adaptation, regeneration, preempting vulnerabilities and exploiting capacities that result in exceeding baseline performance (i.e. Swanson et al. 2009).
- Finally, Cutter et al. (2008) defined resilience as a system's capacity to absorb disturbance and re-organize into a fully functioning system that includes not only a system's capacity to return to the state that existed before the disturbance, but also to advance the state through learning and adaptation.
- Based on the less conservative definition of resiliency (capacity to return to pre-event conditions), our study suggests the majority (66%) of the firms in our sample are resilient. However, if we adopt the most conservative view of resiliency most of our sample will classify as survivors (66%) and only 34 percent resilient. In terms of performance measures, the firms in our sample seem to struggle in terms of sales and profits with a combined average of (3.75=54%:F). Given that almost 70 percent of the sample seems satisfied with their recovery suggest that for entrepreneurs' resiliency has not much to do with meeting economic standards, and much more with avoiding demise, somewhat reminiscent of Albert Einstein's famous quote: "You never fail until you stop trying". Refer to the next 3 charts.

RESILIENCY LEVEL

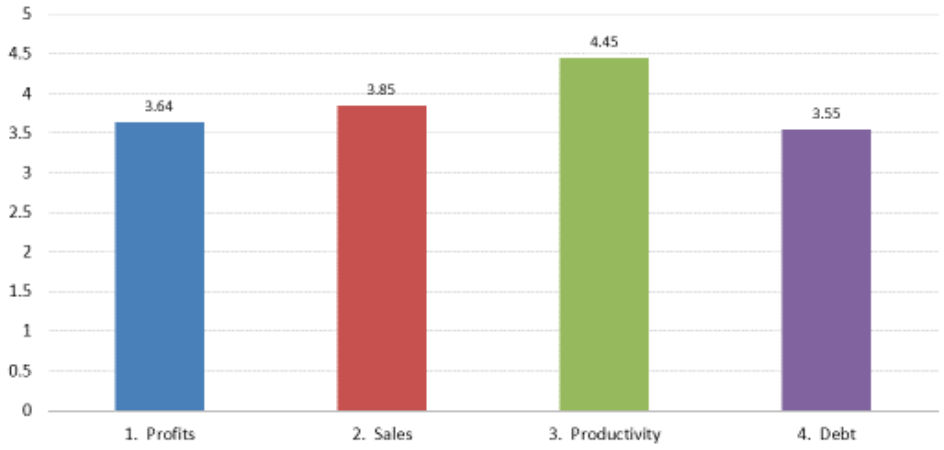
Status by December 2019



Description of Variables

1. Ceased operations or is in process of closure because was not able to recuperate after Hurricane Maria.
2. Continues to operate but is in worst conditions (under performing) than before Hurricane Maria.
3. Is operating at the same level and conditions (performing) than before Hurricane Maria.
4. Is performing at a better level and under better conditions than before Hurricane Maria.
5. Is performing at a better level and under better conditions than before Hurricane Maria and introduced new products, services and/or process improvements.

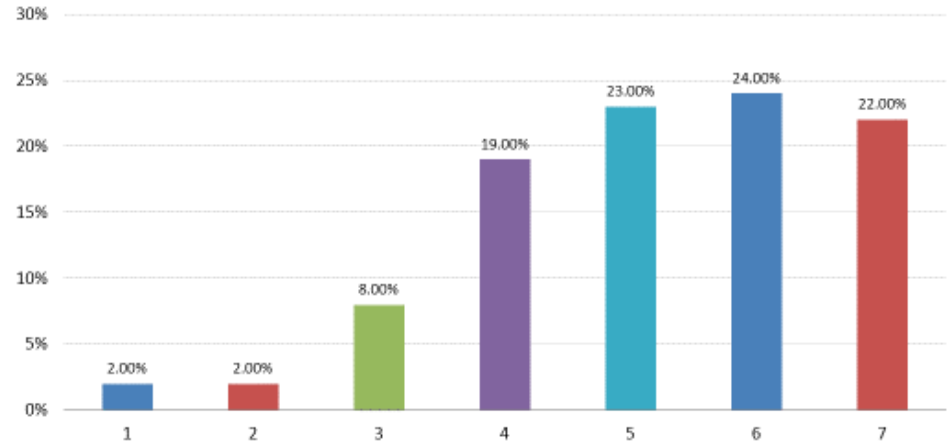
ORGANIZATIONAL PERFORMANCE
Perceptual



Description of Variables

1. Perceptual evaluation of organizational profits by December 2019
2. Perceptual evaluation of organizational sales by December 2019
3. Perceptual evaluation of organizational productivity by December 2019
4. Perceptual evaluation of organizational debt by December 2019

ORGANIZATIONAL PERFORMANCE
Satisfaction



Description of Variable

Satisfaction with overall recovery capacity of the organization, where 7 = very satisfied and 1 = very unsatisfied.

RESULTS

Model Development

Business Continuity Practices and Resiliency Survey

RESILIENCY MODEL
PLS-SEM

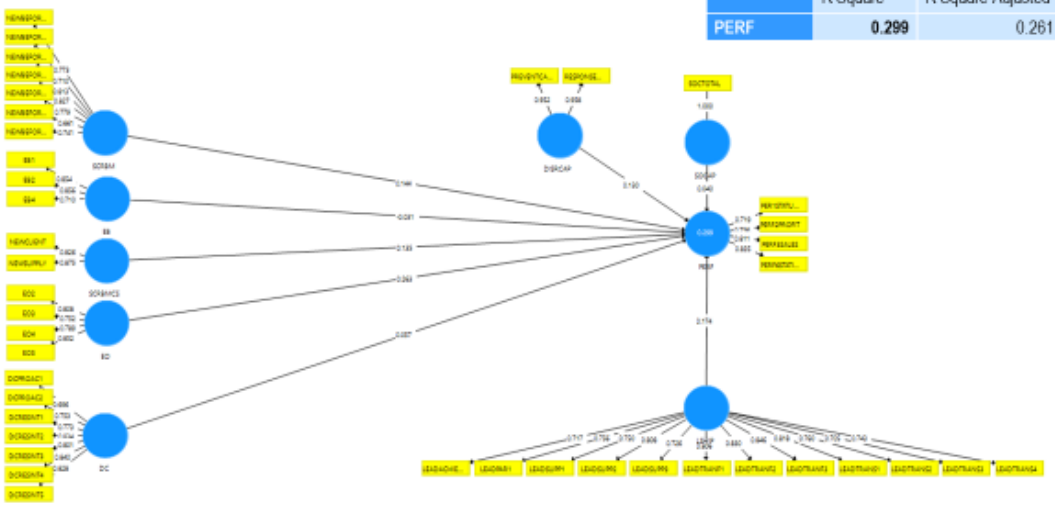
- As previously stated, one of the most important contributions of the study was to develop a model of resiliency to empirically test assumptions of business continuity literature. To accomplish this, the study employed structural equation models (PLS-SEM). The popularity of PLS-SEM can be attributed to the method's ability to evaluate the measurement of latent variables (very predominant in social and business research), while also testing relationships between latent variables (Hair et al. 2014). Also, PLS-SEM can be applied to nonnormal data (does not requires distributional assumptions), is adequate when using small sample sizes; and it permits the use of formative measures.
- Contrary to other techniques, PLS-SEM does not have a standard goodness-of-fit statistic. When evaluating the PLS-SEM model it is important to examine the reliability and validity of the outer models and the hypothesized relationships within the inner model. The indicators to assess the outer model are the factor loadings and VIF. However, to examine validity and reliability of the inner model we look at the Cronbach's Alpha (> 0.70), Composite Reliability (0-1) and Average Variance Extracted (AVE) (> 0.50). The Fornell-Larcker criterion (VIF ≤ 3.3) helps identify collinearity problems particularly important when using formative factors, which is not the case in this study. The quality of the model is assessed based on its ability to predict the endogenous constructs, which can be indicated by the coefficient of determination (R-squared) and the path-coefficients.
- In our model, three factors predicted 30 percent of the variation (R-square) on the dependent construct (resiliency): Entrepreneurial Orientation (26.3), Leadership and Supply Chain (17.4) Resilience (14.4). The next table summarizes the main findings. Afterwards, refer to the model images (Algorithm and Bootstrap) and the tables with assessment indicators.

RESILIENCY MODEL
Hypothesis Tests Summary

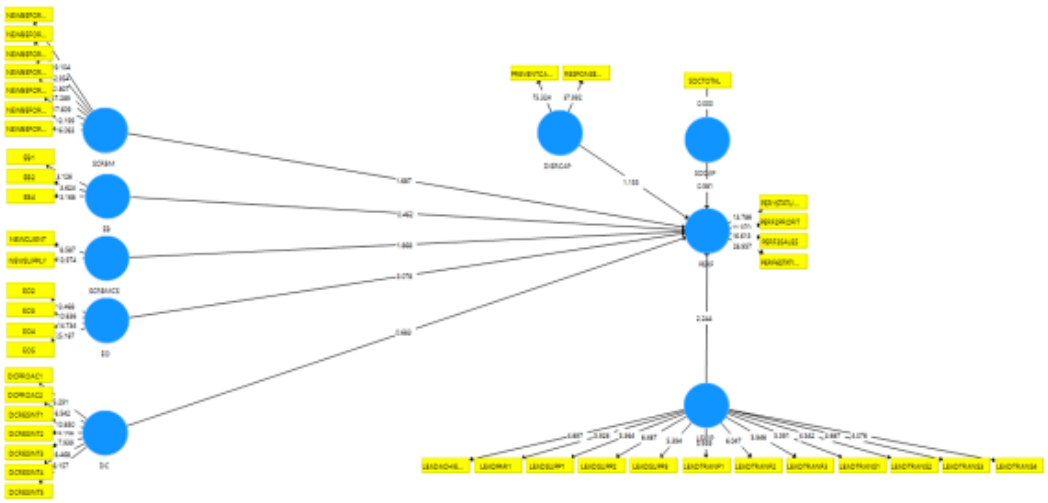
Hypothesis	Results
H1: Dynamic capabilities positively influence resiliency. of SMMs in Puerto Rico	Not supported
H2: Disruptive capability positively influences resiliency of SMMs in Puerto Rico	Not Supported
H3: Entrepreneurial Bricolage positively influences resiliency of SMMs in Puerto Rico	Not supported
H4: Entrepreneurial orientation positively influences resiliency of SMMs in Puerto Rico	Supported
H5: Supply chain resiliency (supplier and client) influences resiliency of SMMs in Puerto Rico	Supported
H6: Leadership positively influences resiliency of SMMs in Puerto Rico	Supported
H7: Supply chain resiliency positively influences resiliency of SMMs in Puerto Rico	Supported
H8: Social capital positively influences resiliency of SMMs in Puerto Rico	Not supported

RESILIENCY MODEL
PLS Algorithm

R Square		
	R Square	R Square Adjusted
PERF	0.299	0.261



RESILIENCY MODEL
Bootstrapping



RESILIENCY MODEL
PLS Algorithm

Path Coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values (90% confidence)
DC -> PERF	0.057	0.055	0.082	0.695	0.488
DISRCAP -> PERF	0.130	0.123	0.110	1.177	0.240
EB -> PERF	-0.031	-0.018	0.070	0.436	0.663
EO -> PERF	**0.263**	0.254	0.087	3.024	**0.003**
SCRBMCS -> PERF	**0.135**	0.143	0.073	1.837	**0.067**
LSHIP -> PERF	**0.174**	0.181	0.086	2.025	**0.043**
SCRBM -> PERF	**0.144**	0.153	0.086	1.681	**0.093**
SOCAP -> PERF	0.040	0.036	0.065	0.621	0.535

OUTER LOADINGS

	Original Sample (O) (> 0.70)	Sample Mean (M) (> 0.70)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
DCPROAC1 <- DC	0.696	0.704	0.078	8.928	**0.000**
DCPROAC2 <- DC	0.753	0.754	0.074	10.201	**0.000**
DCRESINT1 <- DC	0.773	0.759	0.067	11.553	**0.000**
DCRESINT2 <- DC	0.834	0.816	0.076	10.965	**0.000**
DCRESINT3 <- DC	0.801	0.779	0.089	8.968	**0.000**
DCRESINT4 <- DC	0.840	0.826	0.075	11.250	**0.000**
DCRESINT5 <- DC	0.828	0.819	0.062	13.385	**0.000**
EB1 <- EB	0.854	0.807	0.255	3.353	**0.001**
EB2 <- EB	0.856	0.803	0.224	3.826	**0.000**
EB4 <- EB	0.710	0.679	0.196	3.620	**0.000**
EO2 <- EO	0.808	0.803	0.059	13.764	**0.000**
EO3 <- EO	0.752	0.743	0.067	11.303	**0.000**
EO4 <- EO	0.789	0.788	0.049	15.946	**0.000**
EO5 <- EO	0.852	0.845	0.036	23.550	**0.000**

OUTER LOADINGS

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
LEADACHIEVE2 <- LSHIP	0.717	0.690	0.144	4.976	**0.000**
LEADPAR1 <- LSHIP	0.756	0.725	0.137	5.512	**0.000**
LEADSUPP1 <- LSHIP	0.750	0.707	0.142	5.282	**0.000**
LEADSUPP2 <- LSHIP	0.808	0.771	0.166	4.880	**0.000**
LEADSUPP3 <- LSHIP	0.726	0.694	0.167	4.339	**0.000**
LEADTRANF1 <- LSHIP	0.806	0.786	0.158	5.092	**0.000**
LEADTRANF2 <- LSHIP	0.830	0.802	0.158	5.254	**0.000**
LEADTRANF3 <- LSHIP	0.846	0.810	0.151	5.602	**0.000**
LEADTRANS1 <- LSHIP	0.818	0.780	0.136	6.025	**0.000**
LEADTRANS2 <- LSHIP	0.760	0.717	0.155	4.906	**0.000**
LEADTRANS3 <- LSHIP	0.705	0.659	0.170	4.158	**0.000**
LEADTRANS4 <- LSHIP	0.743	0.699	0.167	4.437	**0.000**

OUTER LOADINGS

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
NEWBEFORECOMMIT <- SCRBM	0.773	0.769	0.044	17.675	**0.000**
NEWBEFOREFACILITIES <- SCRBM	0.710	0.707	0.056	12.581	**0.000**
NEWBEFOREFORMALIZATION <- SCRBM	0.813	0.807	0.041	19.747	**0.000**
NEWBEFOREHRM <- SCRBM	0.827	0.823	0.030	27.278	**0.000**
NEWBEFOREPRODUCTION <- SCRBM	0.779	0.778	0.043	17.922	**0.000**
NEWBEFORETRANSPORT <- SCRBM	0.661	0.661	0.059	11.229	**0.000**
NEWBEFORINFRAESTRUCTURE <- SCRBM	0.741	0.739	0.049	15.202	**0.000**

OUTER LOADINGS

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
NEWCLIENT <- SCRBMCS	0.826	0.820	0.082	10.115	**0.000**
NEWSUPPLY <- SCRBMCS	0.875	0.867	0.062	14.021	**0.000**
PER1STATUS2019 <- PERF	0.719	0.720	0.048	15.007	**0.000**
PERF2PROFIT <- PERF	0.756	0.758	0.062	12.110	**0.000**
PERF3SALES <- PERF	0.811	0.815	0.048	16.892	**0.000**
PERF6STATISFACTION <- PERF	0.835	0.829	0.026	32.631	**0.000**
PREVENTCAPACITY <- DISRCAP	0.952	0.951	0.013	72.829	**0.000**
RESPONSECAPACITY <- DISRCAP	0.958	0.956	0.011	85.576	**0.000**
SOCTOTAL <- SOCAP	1.000	1.000	0.000		

Collinearity Statistics (VIF)

Outer VIF Values	
	VIF ≤ 3.3
DCPROAC1	2.134
DCPROAC2	2.403
DCRESINT1	2.538
DCRESINT2	4.446
DCRESINT3	3.757
DCRESINT4	3.905
DCRESINT5	2.547
EB1	1.560
EB2	1.560
EB4	1.366
EO2	1.626
EO3	1.765
EO4	1.704
EO5	2.007
LEADACHIEVE2	1.918
LEADPAR1	2.335
LEADSUPP1	2.895
LEADSUPP2	3.535
LEADSUPP3	3.265
LEADTRANF1	2.771
LEADTRANF2	3.083
LEADTRANF3	3.348
LEADTRANS1	3.462
LEADTRANS2	3.014

Collinearity Statistics (VIF)

Outer VIF Values	
	VIF ≤ 3.3
LEADTRANS3	3.406
LEADTRANS4	3.374
NEWBEFORECOMMIT	2.021
NEWBEFOREFACILITIES	1.764
NEWBEFOREFORMALIZATION	2.214
NEWBEFOREHRM	2.330
NEWBEFOREPRODUCTION	1.974
NEWBEFORETRANSPORT	1.464
NEWBEFORINFRAESTRUCTURE	1.788
NEWCLIENT	1.252
NEWSUPPLY	1.252
PER1STATUS2019	1.442
PERF2PROFIT	2.771
PERF3SALES	3.080
PERF6STATISFACTION	1.406
PREVENTCAPACITY	3.108
RESPONSECAPACITY	3.108
SOCTOTAL	1.000

PRIMEX

RESILIENCY MODEL

PLS Algorithm

Construct Reliability and Validity

	Cronbach's Alpha (> 0.70)	rho_A (> 0.70)	Composite Reliability (0-1)	Average Variance Extracted (AVE) (> 0.50)
DC	0.901	0.906	0.921	**0.626**
DISRCAP	0.903	0.906	0.954	**0.912**
EB	0.741	0.780	0.850	**0.655**
EO	0.817	0.833	0.877	**0.641**
SCRBMCS	**0.620**	**0.629**	0.839	**0.723**
LSHIP	0.940	0.965	0.947	**0.598**
PERF	0.801	0.890	0.863	**0.611**
SCRBM	0.877	0.879	0.905	**0.577**
SOCAP	1.000	1.000	1.000	**1.000**

Discriminant Validity

Fornell-Larcker Criterion

	DC	DISRCAP	EB	EO	LOCATION	LSHIP	PERF	SCRBM	SOCAP
DC	**0.791**								
DISRCAP	0.369	**0.955**							
EB	0.184	0.274	**0.810**						
EO	0.335	0.461	0.418	**0.801**					
SCRBMCS	-0.001	0.225	0.056	0.278	**0.851**				
LSHIP	0.370	0.076	0.161	0.141	-0.131	**0.773**			
PERF	0.279	0.378	0.193	0.426	0.268	0.227	**0.782**		
SCRBM	0.163	0.486	0.219	0.216	0.315	0.073	0.328	**0.760**	
SOCAP	0.107	0.029	0.004	0.099	0.257	-0.081	0.121	0.166	**1.000**

PRIMEX

PUERTO RICO MANUFACTURING EXTENSION

RESULTS

Profiles

Business Continuity Practices and Resiliency Survey

AMS CONSULTING

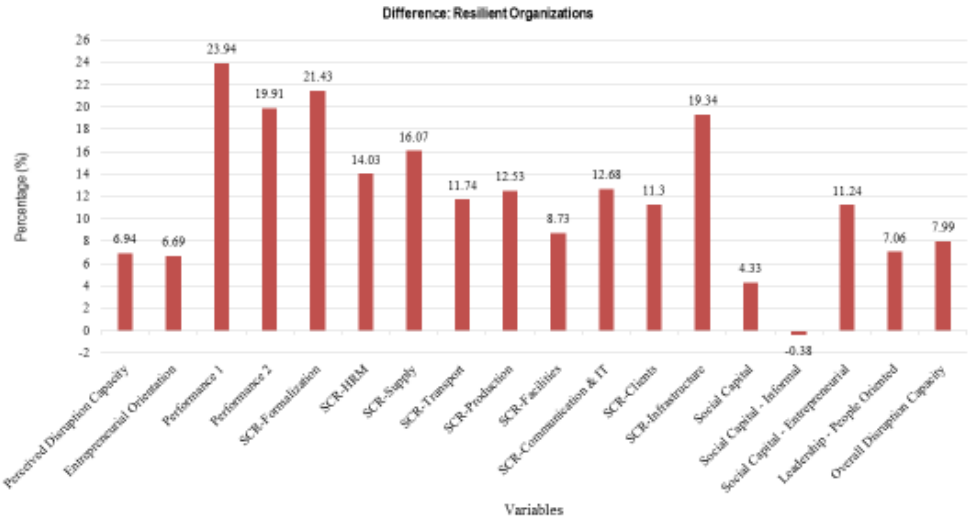
PROFILE
Resilient Organizations

- The data in the table shows that resilient organizations are different from survivors. As mentioned earlier, resilient organizations are those who reported to be in equal or better position than before Hurricane Maria. When compared to surviving manufacturing SMEs, resilient organizations are characterized by:
  1) Resilient Supply Chains.
  2) People-Oriented Leaders
  3) Higher Social Capital
  4) Entrepreneurial Orientation and Disruption Capability
  5) Better Performance
- Interestingly, resilient organizations rely less in family & friends (i.e. informal social capital) and rely more on entrepreneurial social capital (i.e. employees, clients, suppliers, distributors and other entrepreneurs).

***Note these values represent the average for the whole sample and therefore can be used to identify opportunity areas.**

VARIABLES	RESILIENT (N = 102)	SURVIVOR (N = 54)	AVERAGE (N=156)	F-VALUE	SIGN.
Perceived Disruption Capabilities	.7705	.7011	**.7465***	3.997	.047
Entrepreneurial Orientation	.8271	.7602	**.8039***	5.958	.016
Performance 1	.6963	.4569	**.6134***	109.620	.000
Performance 2	.4882	.2891	**.4193***	89.576	.000
SCR-Formalization	.6912	.4769	**.6170***	13.833	.000
SCR-HRM	.6588	.5185	**.6103***	9.415	.003
SCR-Supply	.5172	.3565	**.4615***	7.595	.007
SCR-Transport	.6544	.5370	**.6138***	6.026	.015
SCR-Production	.6549	.5296	**.6115***	5.787	.017
SCR-Facilities	.4725	.3852	**.4423***	2.888	.091
SCR-Infrastructure	.6054	.4120	**.5385***	11.094	.001
SCR-Communications & IT	.6640	.5372	**.6201***	4.411	.037
SCR-Clients	.4510	.3380	**.4119***	7.197	.008
Social Capital	.2511	.2078	**.2361***	4.274	.040
Social Capital-Informal	.3775	.3813	**.3822***	3.794	.053
Social Capital - Entrepreneurial	.4203	.3079	**.3814***	9.346	.003
Leadership – People Oriented	.9112	.8406	**.8870***	7.465	.007
Overall Disruption Capacity	.6427	.5628	**.6151***	9.122	.003

PROFILE
Percentage Differences



PROFILE
Metro versus Other Regions

- The data in the table shows there are regional differences. When compared to other regions, manufacturing SMEs located in the metropolitan area are characterized by:
  1) Resilient Supply Chains (HRM, Supply, Communications & IT, and infrastructure).
  2) Higher Social Capital
  3) Higher Disruption Capability
  4) Better Performance
  5) More Resilient
- Similar to the profile that compared resilient versus survivors, manufacturing SMEs in the metropolitan area rely less in family & friends (i.e. informal social capital) and rely more on entrepreneurial social capital (i.e. employees, clients, suppliers, distributors and other entrepreneurs).
- The learning score for manufacturing SMEs in the metropolitan region is lower than the rest of the regions. The fact that learning is measured as changes incorporated in the supply chain after Hurricane Maria may signal preparedness. The high scores in SCR factors, performance and status provides evidence that firms located in the metropolitan area were more prepared when hurricane Maria hit than those located in other regions.

VARIABLES	METRO (N = 46)	OTHERS (N = 105)	AVERAGE (N=151)	F-VALUE	SIGN.
Perceived Disruption Capability	.8043	.7207	.7462	5.304	.023
Performance 1	.6593	.5917	.6123	4.651	.033
Performance 2	.4611	.3997	.4184	4.955	.028
SCR-HRM	.6739	.5810	.6093	3.680	.057
SCR-Supply	.5543	.4286	.4669	4.171	.043
SCR-Communications & IT	.6893	.5844	.6164	2.733	.100
Social Capital-Informal	.3043	.4381	.3974	3.949	.049
Social Capital - Entrepreneurial	.4293	.3655	.3974	2.621	.108
Learning	.1113	.2627	.2166	16.556	.000
Status Binary	.8043	.5905	.6556	6.681	.011

PROFILE
East Central Area

VARIABLES	EAST CENTRAL (N = 27)	OTHERS (N = 124)	AVERAGE (N=151)	F-VALUE	SIGN.
SCR-Formalization	.7593	.5806	.6126	5.696	.018
SCR-Clients	.4907	.3931	.4106	3.242	.074
Social Capital	.2860	.2285	.2388	4.760	.031
Social Capital - Entrepreneurial	.4491	.3710	.3849	2.719	.101
Learning	.3185	.1944	.2166	7.290	.008

- The data in the table demonstrates regional differences in terms of supply chain resilience factors. The east central region scored higher in formalization factors (i.e. prevention & response protocols, continuity training, and operational manuals). When compared to other regions, manufacturing SMEs located in the east central area are less vulnerable in terms of SCR-Clients (i.e. clients are less concentrated when compared to other regions). Also, they score higher in terms of social capital (total & entrepreneurial).
- The learning score for manufacturing SMEs in the east central region is significantly higher than the rest of the regions. As previously noted, this finding may indicate firms in this region were less prepared when hurricane Maria hit than those located in other regions, and therefore have incorporated more changes in their supply chain than other regions.

PROFILE

West versus Other Regions

- The data in the table shows there are regional differences between the west and other areas. When compared to other regions, manufacturing SMEs located in the west area are characterized by:

  1) Lower scores in SRC (Formalization, HRM, Supply, Communications & IT, and infrastructure).
  2) Lower Social Capital
  3) Lower Disruption Capability
  4) Lower Performance

- It could be argued that manufacturing SMEs in the west are primarily in surviving status. This in addition to the fact that there are no significant differences in terms of learning (changes) when compared to other regions puts manufacturing SMEs in the west in a more vulnerable position.

VARIABLES	WEST (N = 27)	OTHERS (N = 124)	AVERAGE (N=151)	F-VALUE	SIGN.
Perceived Disruption Capacity	.6852	.7594	.7462	2.848	.094
Performance 1	.5381	.6285	.6123	5.792	.017
Performance 2	.3496	.4334	.4184	6.460	.012
SCR-Formalization	.4815	.6411	.6126	4.516	.035
SCR-HRM	.5111	.6306	.6093	4.233	.041
SCR-Supply	.3241	.4980	.4669	5.578	.019
SCR-Infrastructure	.4074	.5685	.5397	4.717	.031
SCR-Communications & IT	.5067	.6402	.6164	3.075	.082
Social Capital	.1934	.2487	.2388	9.413	.038
Social Capital - Entrepreneurial	.2778	.4083	.3849	7.845	.006
Status Binary	.4074	.7097	.6556	9.143	.003

PROFILE

North & South versus Other Regions

- The data in the first table (North) show only one significant difference for manufacturing SMEs in the North Region. The score (%) indicates that the north region is the most prepared in terms of infrastructure including independent energy sources, water reserves, fuel reserves and generators).

North

VARIABLES	NORTH (N = 20)	OTHERS (N = 131)	AVERAGE (N=151)	F-VALUE	SIGN.
SCR-Infrastructure	.6750	.5191	.5397	3.427	.066

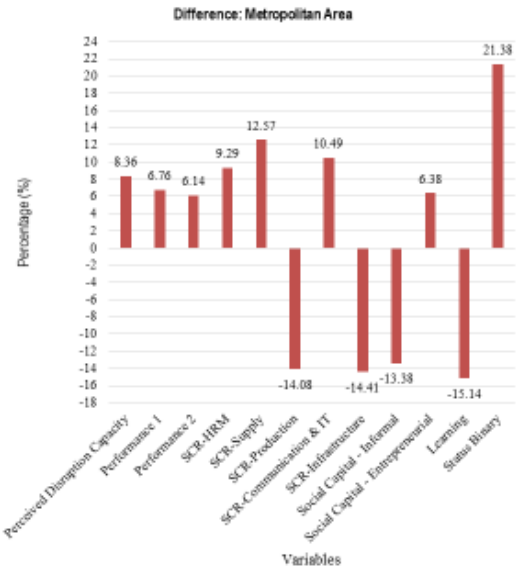
- Meanwhile, manufacturing SMEs in the south are less formalized, are more vulnerable in terms of supplier concentration and communications & IT (i.e. information & communications redundancies) than other regions. However, a main difference in manufacturing SMEs in the south is that they use the experience from Hurricane Maria to instill changes, and hence making these more prepared to other disasters.

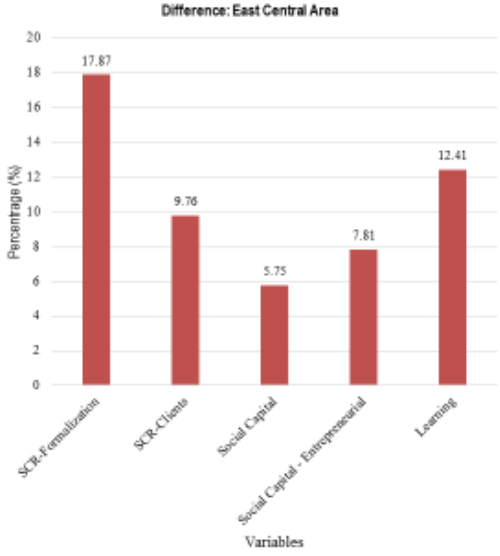
South

VARIABLES	SOUTH (N = 31)	OTHERS (N = 120)	AVERAGE (N=151)	F-VALUE	SIGN.
SCR-Formalization	.5161	.6375	.6126	2.869	.092
SCR-Supply	.3710	.4917	.4669	2.934	.089
SCR-Communications & IT	.4839	.6506	.6164	5.403	.021
Learning	.3119	.1919	.2166	7.582	.007

PROFILE

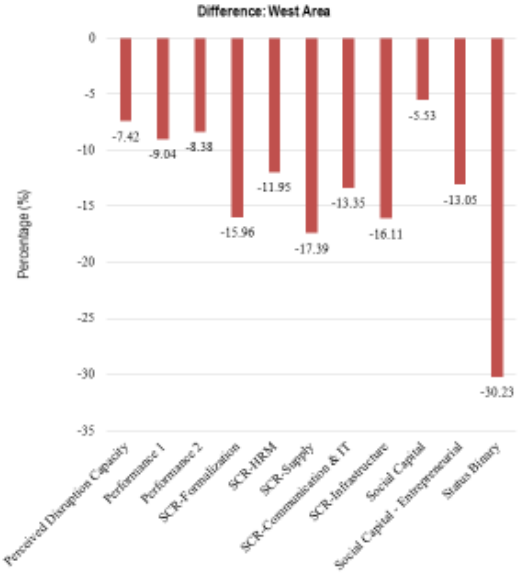
Percentage Differences - Regions

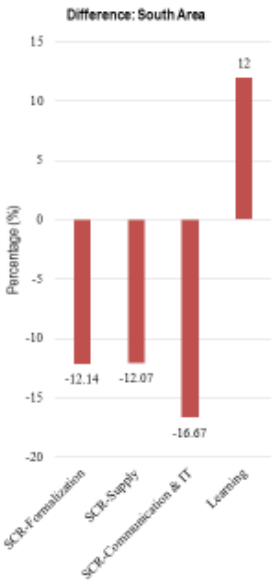


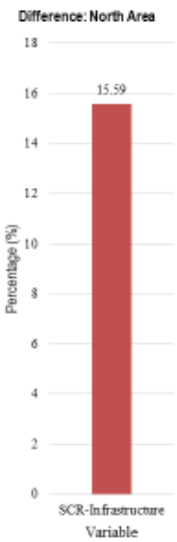


PROFILE

Percentage Differences - Regions







PROFILE
Food & Metals versus Other Sectors

Food

VARIABLES	FOOD & BEVERAGES (N = 54)	ALL OTHER SECTORS (N = 101)	AVERAGE (N = 155)	F-VALUE	SIGN.
SCR-Supply	.3889	.4950	.4581	3.244	.074
SCR-Clients	.3657	.4356	.4113	2.652	.105
Social Capital-Informal	.5278	.3218	.3935	10.878	.001
Learning	.2567	.1961	.2712	2.675	.104

- The data in both tables demonstrate there are significant differences in terms of SCR factors, performance and resiliency among sectors. The first table show that the Food sector is more vulnerable in terms of client and supplier concentration when compared to other sectors. Also, it shows that these firms rely more on family and friends. This may be since almost 50 percent of the firms in this sector have less than 5 employees.

Metals

VARIABLES	METALS & WOOD (N = 28)	ALL SECTORS (N = 127)	AVERAGE (N=155)	F-VALUE	SIGN.
Performance 1	.5400	.6301	.6138	6.090	.015
Performance 2	.3554	.4339	.4197	5.919	.016
SCR-Formalization	.5089	.6398	.6161	3.119	.079
SCR-Clients	.3393	.4272	.4113	2.734	.100
SCR-Infrastructure	.3661	.5787	.5403	8.571	.004
Status Binary	.5000	.6929	.6581	3.839	.052

- The industry of metals is underperforming its counterparts and appears more vulnerable in terms of three SCR factors. Only 50 percent fall within the category of resilient which is significantly less when compared to other sectors (almost 70 percent). After evaluating other secondary data (BLS EQUI-File) we found some evidence of a potential bell-curve relationship for this sector in post-disaster environments.

PROFILE
Other Sectors

VARIABLES	OTHER (N = 52)	FOOD-BEVERAGE-METAL-WOOD (N = 82)	AVERAGE (N=134)	F-VALUE	SIGN.
Perceived Disruption Capacity	.7994	.7208	.7472	5.036	.026
Performance 1	.6579	.5916	.6138	4.937	.028
Performance 2	.4575	.4007	.4197	4.623	.033
SCR-Formalization	.7019	.5728	.6161	4.618	.033
SCR-HRM	.6962	.5631	.6077	8.283	.005
SCR-Supply	.5962	.3883	.4581	12.964	.000
SCR-Transport	.6971	.5680	.6113	7.234	.008
SCR-Communications & IT	.7762	.5377	.6177	16.452	.000
SCR-Clients	.4808	.3762	.4113	5.949	.016
SCR-Infrastructrue	.6202	.5000	.5403	4.007	.047
Social Capital-Informal	.2981	.4417	.3935	5.010	.027
Learning	.1537	.2493	.2172	6.735	.010
Status Binary	.8269	.5728	.6581	10.457	001

- The data in this table demonstrates significant differences in terms of , capabilities, performance, resiliency and in all SCR factors. It is important to notice that the other category in this table is represented by textile and apparel followed by printing and related services, and then other sectors. These are being compared with food and metals (the two previous profiles).
- The data suggests the sectors within the other category are in a better position in all factors when compared to food, metal and wood. Also they rely less in informal network.

RESULTS

Disruption Capacity

Business Continuity Practices and Resiliency Survey

OVERALL DISRUPTION CAPACITY

Manufacturing Firms in Puerto Rico

DISRUPTION CAPACITY			95% Confidence Interval	
			Lower	Upper
Mean		.6151	.5886	.6409
Median		.6350	.6000	.6600
Percentiles	25	.5100	.4700	.5600
	50	.6350	.6000	.6600
	75	.7175	.6900	.7575

- A measured of disruption capacity was develop. It is a composite measure that includes the weighted factors proven to influence resiliency in the PLS-SEM model: entrepreneurial orientation, leadership and supply chain resilience. The weights assigned to each factor are based on their path coefficients. The indicator goes from 0 to 1. A value close to 1 suggests high disruption capacity. These include entrepreneurial orientation, leadership and all supply chain resilience variables. The values for the supply chain resilience factors are those reported for after Hurricane Maria. This is done so that the lessons learned can be captured in the measure. The mean values and percentiles shown in the table suggest there is still area for improvement. To test the relevance of this measure we examined its influence on performance. The results for the regression analysis are in the next table. The findings show that disruption capacity positively influences performance.

DISRUPTION CAPACITY & PERFORMANCE

Evidence

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.296[a]	.088	.082	1.10115

a. Dependent Variable: PERFORMANCE

b. Predictors: DISRUPTION CAPACITY

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.956	1	17.956	14.809	.000[b]
	Residual	186.730	154	1.213		
	Total	204.686	155			

a. Dependent Variable: PERFORMANCE

b. Predictors: DISRUPTION CAPACITY

DISRUPTION CAPACITY & SIZE

Descriptives

OVERALL DISRUPTION CAPACITY

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Less than 5	57	.5379	.16436	.02177	.4943	.5815	.16	.88
5 to 9	18	.6483	.13721	.03234	.5801	.7166	.41	.89
10 to 19	28	.6786	.10773	.02036	.6368	.7203	.42	.87
20 to 49	28	.6036	.13568	.02564	.5510	.6562	.36	.92
40 to 100	11	.7064	.12730	.03838	.6208	.7919	.47	.89
More than 100	14	.7107	.20315	.05429	.5934	.8280	.38	.95
Total	**156**	**.6151**	**.16140**	**.01292**	**.5895**	**.6406**	**.16**	**.95**

- The table above illustrates the relation between the measure of disruption capacity and size. The findings suggest that disruption capacity is somewhat related to size, where smaller firms have lower disruption capacity than larger firms. More specifically, firms with 40 or more employees have higher disruption capacity than firms with less than 5 employees at 95.0 confidence level.

DISRUPTION CAPACITY & AGE

Descriptives

OVERALL DISRUPTION CAPACITY

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Less than 5	32	.6159	.15448	.02731	.5602	.6716	.27	.87
5 to 10	24	.5817	.15780	.03221	.5150	.6483	.34	.88
11 to 20	30	.5810	.14582	.02662	.5265	.6355	.17	.79
Over 20 years*	**70**	**.6407**	**.17028**	**.02035**	**.6001**	**.6813**	**.16**	**.95**
Total	156	.6151	.16140	.01292	.5895	.6406	.16	.95

- The table above illustrates the relation between the measure of disruption capacity and age of the firm. The findings suggest that disruption capacity is somewhat related to age. More specifically, older firms (over 20 years) have higher disruption capacity.

DISRUPTION CAPACITY & REGION

- There were no significant differences found for the measure of Overall Disruption Capacity and the regions. Nonetheless, we include the indicators per region for descriptive purposes. Notice that the average for the sample is .6124
  - Metropolitan Area (.6367)
  - East Central Area (.6289)
  - West Area (.5885)
  - South Area (.5877)
  - North Area (.6045)
- Although there are still opportunities for improvement for all areas, the data suggests the west and the south area have more opportunity for improvement than the others.

RESULTS

Profiles

PRIMEX-MDAP Assessments

ABOUT THE SAMPLE

Resiliency Profiles- PRIMEX-MDAP Assessments

- As part of the Manufacturing Disaster Assessment Program, the Puerto Rico Manufacturing Extension (PRIMEX) has been actively visiting manufacturing firms across the island for over two years to evaluate to evaluate their conditions after Hurricane Maria. The profiles in this section have been developed using the data collected by the organization. The first profile (resiliency profile) is based on a valid sample of 217 firms. The characteristics of the sample for the resiliency profile are shown in the tables below.

REGION	FREQUENCY	PERCENT
Metro	19	8.8%
East Central	64	29.5%
West	60	27.6%
South	49	22.6%
North	25	11.5%
Total	217	100%

SECTOR	FREQUENCY	PERCENT
Food	68	31.3%
Textiles	11	5.1%
Metals	26	12.0%
Printing & Related Services	20	9.2%
Minerals & Non-Metallics	13	6.0%
Other	79	36.4%
Total	217	100.00%

PROFILE PRIMEX-MDAP ASSESMENTS

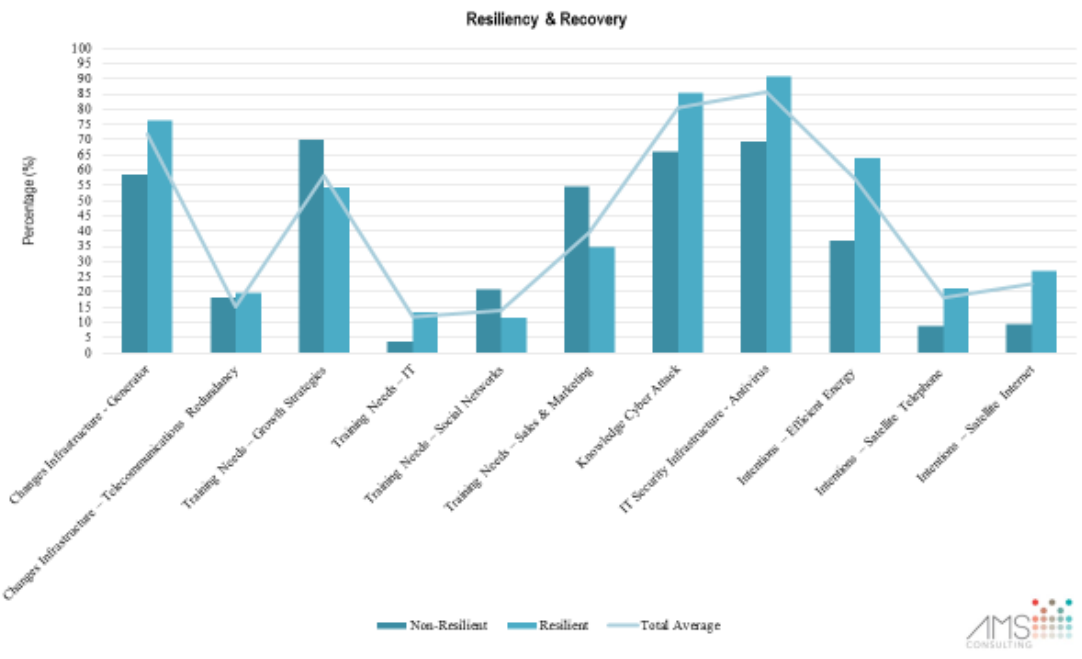
Resiliency

	Survivors (N = 53)	Resilient (N = 164)	Total Average (N = 217)	F-value	Sig.
Recovery Level (scale 1-4)	2.8868	3.7914	3.5694	53.783	.000
Perceived Preparedness Level (scale 1-3)	1.9623	2.1159	2.0783	3.045	.082
Promptness of Reopening (scale 1-4)	2.5660	3.5092	3.2778	44.851	.000
Preparedness – Communications (scale 1-3)	2.2885	2.5090	2.4558	5.574	.019
Infrastructure – Communications (# days)	90.2941	66.5849	72.3429	5.633	.019
Knowledge Cyber Attack	.6604	.8528	.8056	9.791	.002
IT Security Infrastructure –Antivirus	.6923	.9074	.8551	15.640	.000
Personnel – Electric Repairs	.1500	.2857	.2530	2.976	.086
Changes Infrastructure - Generator	.5849	.7622	.7189	6.355	.012
Changes Infrastructure – Telecommunications Redundancy	.1819	.1951	.1521	10.006	.002
Training Needs – Growth Strategies	.6981	.5427	.5806	4.011	.046
Training Needs – IT	.0377	.1341	.1176	3.817	.052
Training Needs – Social Networks	.2075	.1159	.1382	2.838	.094
Training Needs – Sales & Marketing	.5472	.3476	.3963	6.819	.010
Intentions – Efficient Energy	.3696	.6383	.5722	10.709	.001
Intentions – Satellite Telephone	.0889	.2101	.1803	3.401	.067
Intentions – Satellite Internet	.0952	.2692	.2267	5.596	.019

- The table above illustrates resilient firms rated higher in all factors when compared to survivors, which confirms resilient firms were more prepared. Survivors need more training than resilient firms. Interestingly, although surviving firms were on average 90 days without communication technology, these have less intentions in satellite technologies (i.e. telephone & internet). Although supplier, client and distributor indicators are higher for resilient firms than survivors, the differences were not significant at a 95% confidence level. Also, electricity took longer to re-establish for surviving firms, but the differences were not significant.

PROFILE PRIMEX-MDAP ASSESMENTS

Resiliency



PROFILE PRIMEX-MDAP ASSESMENTS

Business Continuity Planning

	No Continuity Plan (N = 155)	Continuity Plan (N = 47)	Total Average (N = 202)	F-value	Sig.
Recovery Level (scale 1-4)	3.5548	3.8511	3.6238	4.578	.034
Perceived Preparedness Level (scale 1-3)	2.0000	2.2979	2.0700	10.216	.002
Promptness of Reopening (# days)	3.1776	3.6809	3.2965	10.634	.001
Resiliency (scale1-3)	2.0867	2.0698	2.0829	.017	.895

- Formalization of resilience (i.e. business continuity planning) differed resilient companies from survivors in the Continuity and Resiliency Survey of manufacturing SMEs. Hence, it was surprising that the MDAP resilience profile did not found significant differences in terms of business continuity planning. Because of this, we conducted an analysis to evaluate the differences in recovery & preparedness between firms that have continuity plans versus those that do not. The findings show that manufacturing SMEs that have business continuity plans scored better in recovery level, perceived preparedness and re-open faster. The literature on business continuity suggests planning influences preparedness and recovery more so for the discussion and analysis that has to be conducted among key members in the organizations to develop delineate contingencies, rather than for the fact of having a written document.

ABOUT THE SAMPLE

Regional Profiles PRIMEX-MDAP Assessments

Sectors

	FREQUENCY	PERCENTAGE
Food	76	33.0
Textiles	11	4.8
Metals	26	11.3
Printing & Related Services	21	9.1
Non-Metallic & Minerals	13	5.7
Other	83	36.1
Total	230	100

Regions

	FREQUENCY	PERCENTAGE
Metropolitan	23	10.0
East Central	68	29.6
West	61	26.5
South	53	23.0
North	25	10.9
Total	230	100

- In the next pages we present profiles by region and sectors. The tables here describe the distribution of sectors and regions represented in the next analysis. As expected, food manufacturing SMEs dominate the samples, followed by metals, and printing & related services. The other categories is represented by chemical & pharma (22%), furniture & related products (18%, and textiles & apparel (16%).
- In terms of regions, the east central region is the most represented, followed by the west. It is important to notice that the sample in this analysis considers the manufacturing SMEs that completed all PRIMEX assessments.

PROFILE PRIMEX-MDAP ASSESMENTS

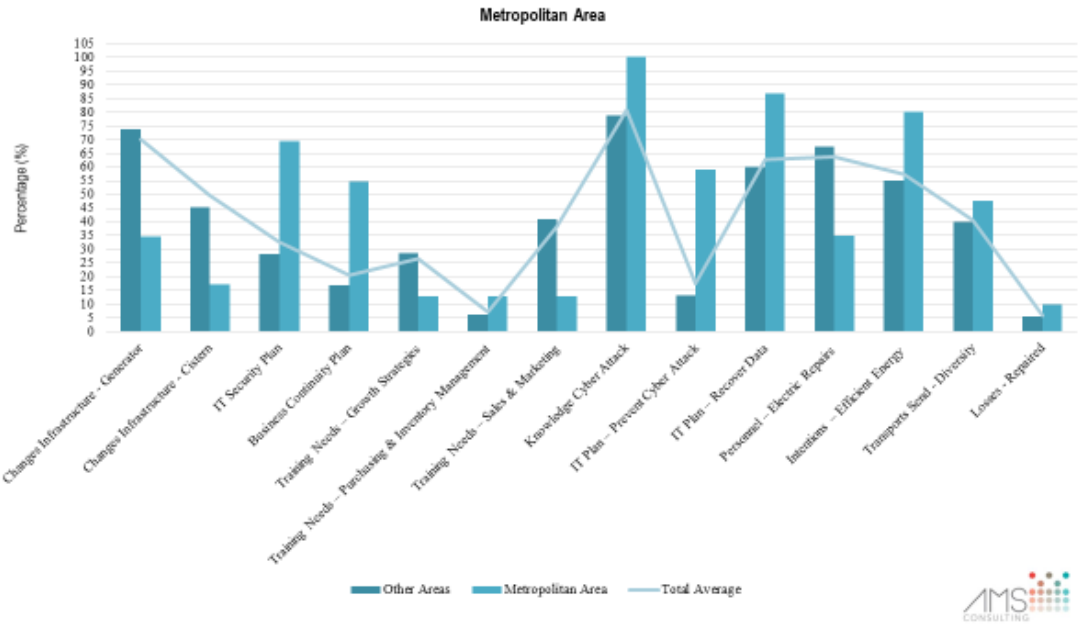
Metropolitan Area

	Other Areas (N = 207)	Metro Area (N = 23)	Total Average (N = 230)	F-value	Sig.
Promptness of Reopening (scale 1-4)	3.2574	3.6087	3.2933	2.757	.098
Preparedness – Communications (scale 1-3)	2.4314	2.6957	2.4581	4.223	.041
Change in Preparedness Level (scale 1-3)	2.7291	2.9130	2.7478	3.411	.066
IT Security Preparedness (scale 1-3)	1.6505	2.6818	1.7500	34.226	.000
Business Continuity Plan	.1707	.5455	.2070	18.205	.000
IT Security Plan	.2843	.6957	.3260	16.966	.000
IT Plan – Prevent Cyber Attack	.1311	.5909	.1754	33.006	.000
IT Plan – Recuperate from Cyber Attack	.6014	.8667	.6275	4.128	.044
Knowledge Cyber Attack	.7864	1.000	.8070	5.923	.016
Changes Infrastructure - Generator	.7391	.3478	.7000	13.101	.000
Changes Infrastructure - Cistern	.4541	.1739	.4955	8.247	.004
Training Needs – Purchasing & Inventory Management	.0631	.1290	.0714	3.562	.060
Training Needs – Growth Strategies	.2850	.1290	.2653	6.829	.009
Training Needs – Sales & Marketing	.4106	.1304	.3826	7.030	.009
Personnel – Generator Maintenance	.6731	.3500	.6364	8.282	.005
Intentions – Energy Efficiency	.5500	.8000	.5750	4.665	.032
Repairs	.0562	.0978	.0603	2.864	.092
Transports-Send	.3991	.4774	.4069	8.282	.005

- The table above illustrates that firms in the metropolitan area opened before other regions and are more formalized in terms of IT Security and continuity planning. Firms in this region seem to have less training needs except for Purchasing and Inventory Management.

PROFILE PRIMEX-MDAP ASSESMENTS

Metropolitan Area



PROFILE PRIMEX-MDAP ASSESMENTS

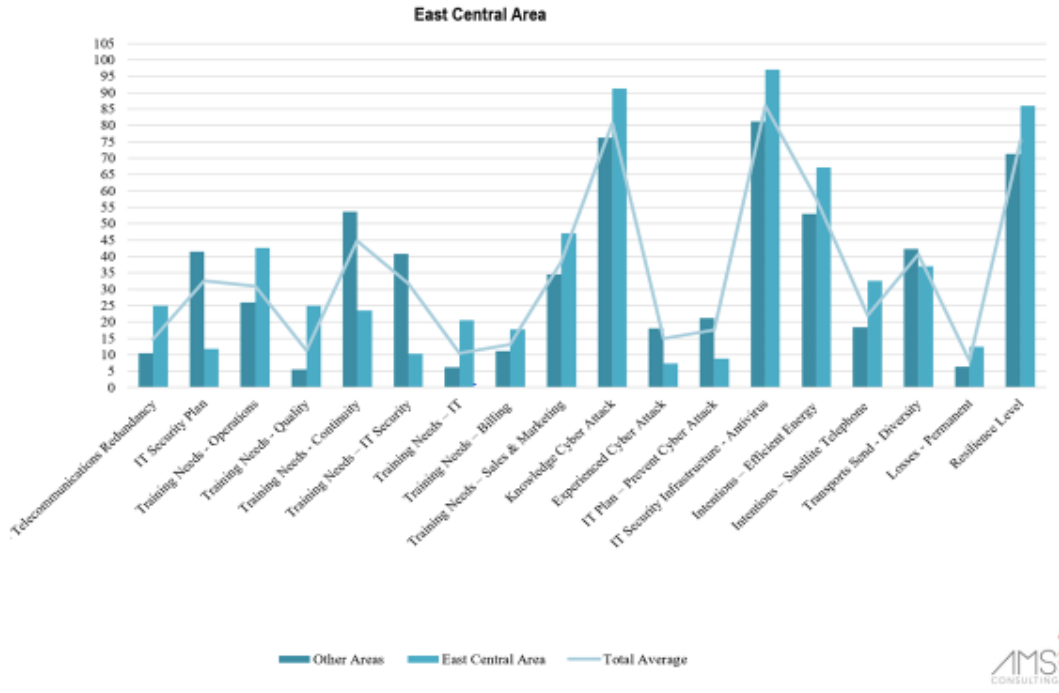
East Central

	Other Areas (N = 162)	East Central (N = 68)	Total Average (N = 230)	F-value	Sig.
Resilience Level	.7124	.8594	.7558	5.361	.022
Infrastructure – Electricity (# days)	69.7452	104.6406	79.8507	16.772	.000
Preparedness – Communications (scale 1-3)	2.3789	2.6515	2.4581	10.456	.001
Change in Preparedness Level (scale 1-3)	2.7911	2.6471	2.7478	4.844	.029
IT Security Preparedness (scale 1-3)	1.8438	1.5294	1.7500	6.829	.010
IT Security Plan	.4151	.1176	.3260	20.765	.000
Knowledge Cyber Attack	.7625	.9118	.8070	6.976	.009
Experienced Cyber Attack	.1813	.0735	.1491	4.410	.037
IT Plan – Prevent Cyber Attack	.2125	.0882	.1754	5.164	.024
IT Security Infrastructure - Antivirus	.8125	.9701	.8590	10.035	.002
Changes Infrastructure – Telecommunications Redundancy	.1049	.2500	.1478	8.217	.005
Training Needs - Operations	.2593	.4265	.3087	6.395	.012
Training Needs -Quality	.0556	.2500	.1130	19.430	.000
Training Needs - Continuity	.5370	.2353	.4478	18.934	.000
Training Needs – IT Security	.4074	.1029	.3174	22.302	.000
Training Needs – IT	.0617	.2059	.1043	11.069	.001
Training Needs – Billing	.1111	.1765	.1304	19.430	.000
Training Needs – Marketing & Sales	.3457	.4706	.3826	3.180	.076
Intentions – Efficient Energy	.5294	.6719	.5750	3.644	.058
Intentions – Satellite Internet	.1838	.3261	.2198	4.104	.044
Transports – Send	.4222	.3704	.4069	3.047	.082
Losses - Permanent	.0638	.1242	.0816	10.876	.001

- The table above illustrates that firms in the East Central region rated higher in terms of communication's preparedness and resiliency, although these reported more permanent losses than other regions. Electricity in the region took longer to recover, but the fact that they do not report changes in terms of generators may suggest the firms in the region were already prepared for this. The next step appears to be alternative energy as reported by intentions.

PROFILE PRIMEX-MDAP ASSESMENTS

East Central

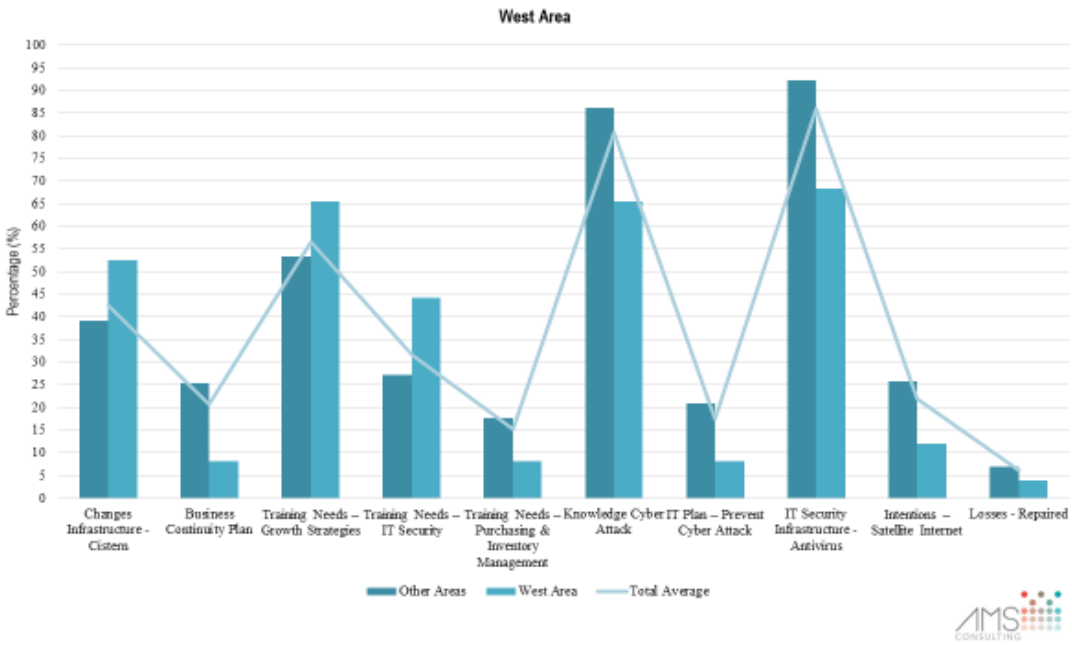


PROFILE PRIMEX-MDAP ASSESMENTS
West Region

	Other Area (N = 169)	West Area (N =61)	Total Average (N = 230)	F-value	Sig.
Infrastructure – Electricity (# days)	85.2563	65.6721	79.8507	4.872	.028
Preparedness – Communications (scale 1-3)	2.5301	2.2623	2.4581	9.580	.002
IT Security Preparedness (scale 1-3)	1.8383	1.5082	1.7500	7.060	.008
Knowledge Cyber Attack	.8623	.6557	.8070	12.819	.000
IT Plan – Prevent Cyber Attack	.2096	.0820	.1754	5.098	.025
IT Security Infrastructure - Antivirus	.9222	.6833	.8590	22.685	.000
Business Continuity Plan	.2530	.0820	.2070	15.337	.000
Changes Infrastructure - Cistern	.3905	.5246	.4261	3.313	.070
Training Needs – Purchasing Inventory	.1775	.0820	.1522	3.188	.076
Training Needs – Growth Strategies	.5325	.6557	.5652	2.777	.097
Training Needs – IT Security	.2722	.4426	.3174	6.117	.014
Intentions – Satellite Internet	.2576	.1200	.2198	4.048	.046
Losses - Repairs	.0688	.0369	.0603	3.647	.057

- The table above suggest firms in the West region are less prepared in terms of communications, information technologies and business continuity planning. This region also reported more changes in infrastructure (generators and cisterns) than other regions. Despite the fact these were less prepared in terms of communications, their intentions towards acquiring telecommunications infrastructure (i.e. satellite internet) are lower than their counterparts.

PROFILE PRIMEX-MDAP ASSESMENTS
West Region



PROFILE PRIMEX-MDAP ASSESMENTS

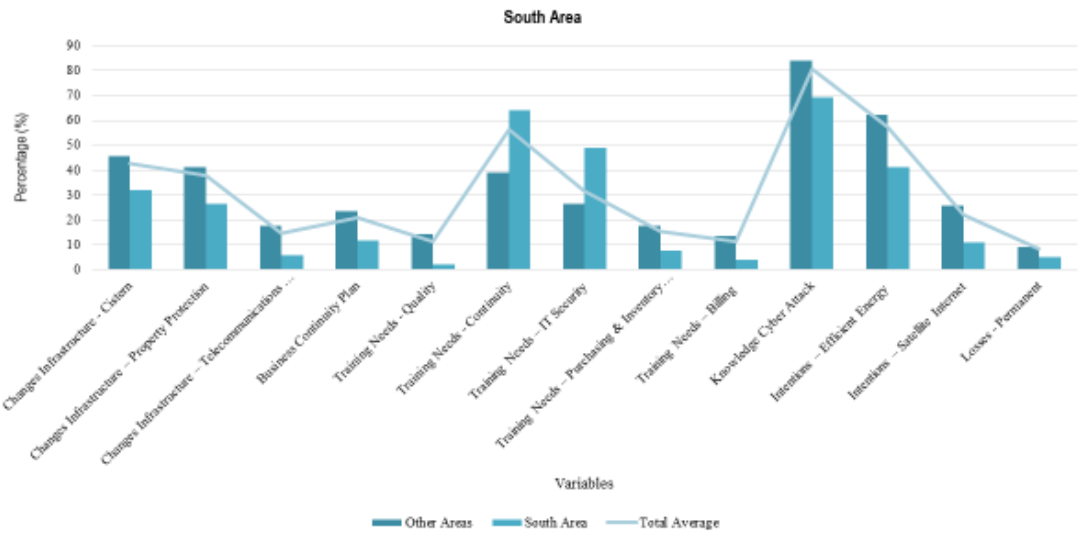
South Region

	Other Areas (N = 177)	South Area (N = 53)	Total Average (N = 230)	F-value	Sig.
Perceived Preparedness (scale 1-3)	2.1130	1.9592	2.0796	3.006	.084
Infrastructure – Electricity (# days)	86.2081	56.9375	79.8507	9.449	.002
Infrastructure – Communications (# days)	77.2573	54.5833	72.2877	5.059	.026
Preparedness – Communications (scale 1-3)	2.5029	2.3077	2.4581	4.472	.036
Changes Infrastructure – Cistern	.4576	.3208	.4261	3.140	.078
Changes Infrastructure - Telecommunications	.1751	.0566	.1478	4.601	.033
Changes Infrastructure - Property	.4124	.2642	.3783	3.844	.051
Business Continuity Plan	.2343	.1154	.2070	3.474	.064
Knowledge Cyber Attack	.8409	.6923	.8070	5.786	.017
Training Needs -Quality	.1412	.0189	.1130	6.203	.013
Training Needs – Purchasing & Inventory	.1751	.0755	.1522	3.156	.077
Training Needs - Continuity	.3898	.6415	.5642	10.850	.001
Training Needs – IT Security	.2655	.4906	.3174	9.859	.002
Training Needs - Billing	.1356	.0377	.1130	3.928	.049
Intention – Satellite Internet	.2574	.1087	.2198	4.491	.035
Intention – Efficient Energy	.6234	.4130	.5750	6.558	.011
Losses - Permanent	.0917	.0482	.0816	4.665	.032

- The table above show firms in the southern region rated lower in terms of perceived preparedness, including in communications. Also, less firms have continuity plans when compared to other regions. However, communication systems and electricity restored before in the south that in other areas (after eliminating extreme cases). When compared to other regions, the south instilled less changes in infrastructure than other regions.

PROFILE PRIMEX-MDAP ASSESMENTS

South Region



PROFILE PRIMEX-MDAP ASSESMENTS

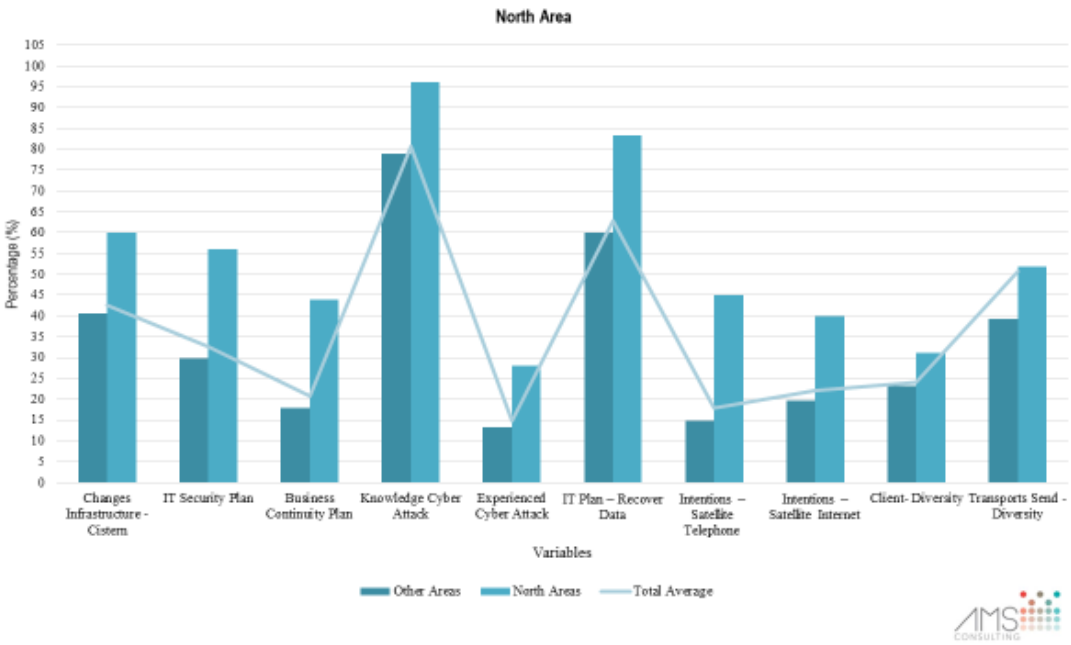
North Region

	Other Areas (N = 205)	North (N =25)	Total Average (N = 230)	F-value	Sig.
Infrastructure – Communications (# days)	69.0410	98.6667	72.2877	4.921	.028
IT Security Preparedness (scale 1-3)	1.6700	2.400	1.7500	18.008	.000
IT Security Plan	.2970	.5600	.3260	7.161	.008
Knowledge Cyber Attack	.7882	.9600	.8070	4.261	.040
Experienced Cyber Attack	.1330	.2800	.1491	3.821	.052
IT Plan – Recover Cyber Attack (Data)	.6000	.8333	.6275	3.741	.055
Business Continuity Plan	.1782	.4400	.2070	9.597	.002
Changes Infrastructure – Cistern	.4049	.6000	.4261	3.492	.063
Intentions – Satellite Internet	.1975	.4000	.2198	4.310	.039
Intentions – Satellite Telephone	.1477	.4500	.1786	11.743	.001
Transports - Send	.3932	.5192	.5081	8.591	.004
Clients	.2322	.3120	.2409	7.232	.008

- The table above illustrates communications in north region took longer to restore than other regions. This may be the reason why manufacturing SMEs in the north are more interested in satellite communication technologies. Also, manufacturing SMEs in the north are more formalized in terms of the IT Security and Business Continuity. More specifically, they reported to be more prepared in IT Security, which may be due to having experienced more cyber attacks.

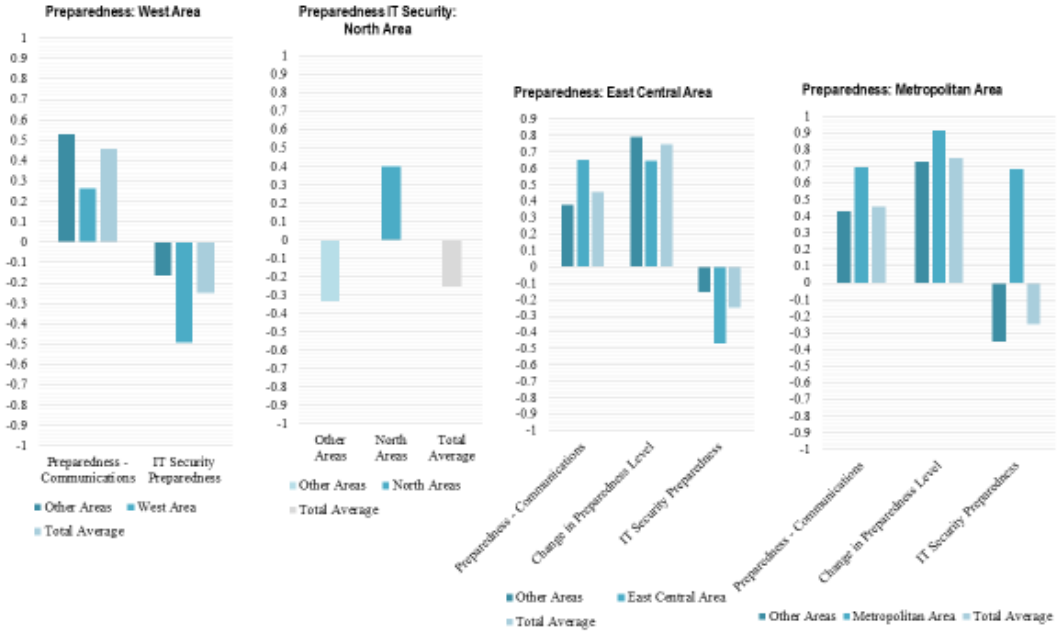
PROFILE PRIMEX-MDAP ASSESMENTS

North Region



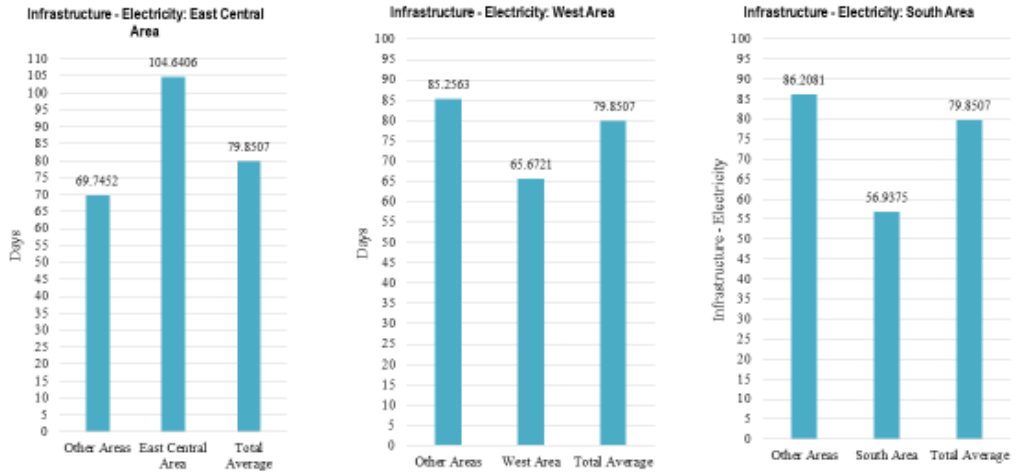
PROFILES PRIMEX-MDAP ASSESMENTS

Preparedness Difference per Region



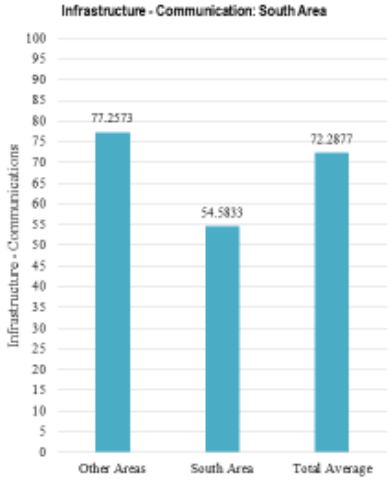
PROFILES PRIMEX-MDAP ASSESMENTS

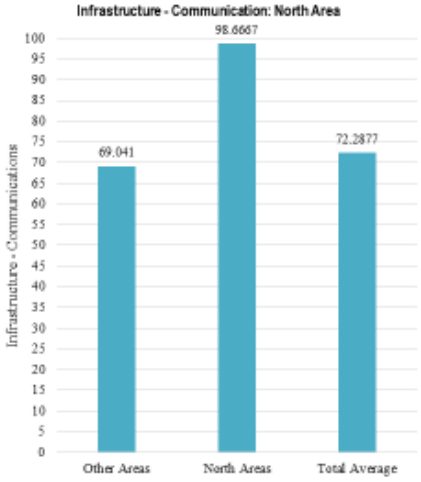
Infrastructure Electricity per Region



PROFILES PRIMEX-MDAP ASSESMENTS

Infrastructure Communications per Region





PROFILE PRIMEX-MDAP ASSESMENTS

Food & Beverages

	All other Sectors (N = 154)	Food & Beverages (N = 76)	Total Average (N = 230)	F-value	Sig.
Resilience Level	.8121	.6324	.7558	8.412	.004
Recovery Level (scale 1-4)	3.6732	3.4133	3.5877	4.746	.030
Promptness of Reopening (# days)	3.4371	3.0000	3.2933	10.624	.001
Change in Preparedness Level (scale 1-3)	2.6974	2.8514	2.7478	5.817	.017
IT Security Preparedness (scale 1-3)	1.8312	1.5811	1.7500	4.482	.035
IT Security Plan	.3636	.2466	.3260	2.327	.079
Knowledge Cyber Attack	.8377	.7432	.8070	2.872	.092
Experienced Cyber Attack	.1883	.0676	.1491	5.840	.016
IT Plan – Recover Cyber Attack (Data)	.6765	.5294	.6275	3.170	.077
IT Security Infrastructure - Antivirus	.8947	.7867	.8590	4.905	.028
Changes Infrastructure – Property Protection	.4156	.3026	.3783	2.770	.097
Changes Infrastructure – Telecommunications Redundancy	.1818	.0789	.1478	4.138	.039
Training Needs – Sales & Marketing	.3312	.4868	.3826	5.295	.022
Training Needs – Billing	.1429	.0526	.1130	4.171	.042
Intentions – Satellite Internet	.2797	.1094	.2198	7.367	.007
Intentions – Satellite Telephone	.2308	.0758	.1786	7.218	.008
Intention – Efficient Energy	.6418	.4394	.5750	7.621	.006

- The table above illustrates differences between the food sector and other industries. When compared to other, the food & beverages sector reported less resiliency, recovery and took longer to re-open. Their financial condition was lower than the rest. Firms in the food industry underperform other sectors in aspects related to IT and communications. However, they report major changes in preparedness than other regions.

PROFILE PRIMEX-MDAP ASSESMENTS

Metals and Printing & Related Services

Metals

	All Other Sectors (N = 204)	Metals (N = 26)	Total Average (N=230)	F-value	Sig.
IT Security Preparedness (scale 1-3)	1.8203	1.5161	1.7823	3.486	.063
Changes Infrastructure – Cistern	.4461	.2692	.4261	2.962	.087
IT Security Plan	.3532	.1154	.3260	6.033	.015
IT Plan – Recover Cyber Attack (Data)	.6496	.4375	.6275	2.772	.098
Training Needs – IT Security	.2990	.4615	.3174	2.821	.094
Training Needs – Purchasing & Inventory Management	.1324	.3077	.1522	5.581	.019
Training Needs – Billing	.0980	.2308	.1130	4.089	.044

Printing & Related Services

	All Other Sectors (N = 209)	Printing & Related Services (N = 21)	Total Average (N = 230)	F-value	Sig.
Perceived Preparedness (scale 1-3)	2.1019	1.8500	2.0796	3.845	.051
Change in Preparedness Level (scale 1-3)	2.7670	2.5500	2.7478	4.201	.042
Changes Infrastructure - Cistern	.4498	.1905	.4261	5.322	.022
Knowledge Cyber Attack	.7874	1.000	.8070	5.619	.019
IT Infrastructure - Antivirus	.8447	1.000	.8590	3.828	.052
Intentions – Satellite Telephone	.1955	.0000	.1788	4.090	.045
Losses – Permanent	.0750	.1481	.0816	6.240	.013

- When compared to other sectors, metals seem to be less formalized and prepared in IT Security issues. The training needs in the sector include purchasing & inventory management and billing. Meanwhile, printing & related services reported to be less prepared in IT indicators. Although they are knowledgeable of cyber attacks, they are not as prepared in preventing a cyber attack when compared to other sectors.

PROFILE PRIMEX-MDAP ASSESMENTS

Other Sectors

	Food-Metals-Printing (N = 83)	Other Sectors* (N = 147)	Total Average (N = 230)	F-value	Sig.
Recovery Level (scale 1-4)	3.4672	3.7264	3.5877	5.335	.022
Perceived Preparedness (scale 1-3)	1.9833	2.1887	2.0796	8.031	.005
Promptness of Reopening (scale 1-4)	3.1833	3.4190	3.2933	3.376	.067
Resilience Level	.6930	.8252	.7558	5.204	.024
IT Security Preparedness (scale 1-3)	1.6148	1.9823	1.7823	11.749	.001
Changes – Telecommunications Redundancy	.0894	.2150	.1478	7.323	.007
IT Security Plan	.2417	.4206	.3260	8.474	.004
Experienced Cyber Attack	.0661	.2430	.1491	14.786	.000
IT Plan – Prevent Cyber Attack	.1066	.2547	.1754	8.866	.003
IT Plan – Recover Cyber Attack (Data)	.5610	.7042	.6275	3.370	.068
Training Needs - Operations	.3821	.2243	.3087	6.818	.010
Training Needs -Quality	.1463	.0748	.1130	2.936	.088
Intentions – Satellite Internet	.1327	.3214	.2198	9.803	.002
Intentions – Satellite Telephone	.0680	.3011	.1786	19.745	.000
Intentions – Efficient Energy	.5048	.6526	.5750	4.519	.035
Personnel Electric	.2021	.3571	.2753	5.447	.021

- Other sectors, when compared to food, metals and printing, seemed to perform better in terms of recovery, preparedness and resiliency. Are more prepared in terms of IT planning, prevention and recovery. Also, they are more interested in satellite telecommunications technologies and more efficient energy alternatives.

CONCLUSIONS

Findings & Implications

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- The impact of Hurricane Irma and Maria in the manufacturing sector was 17,764.0 in millions, which represents more than 55 percent of the total impact for the private sector, and 40 percent of the net impact for both the private and public sector. There were reductions in total establishments, employment and wages. The regions that was most impacted in terms of establishments, employment and wages was the west. The most impacted sectors in terms of employment was apparel, chemical & pharmaceuticals, and food manufacturing. The Purchasing Manager's Index (PMI) in Puerto Rico hits its lowest in 2017.
- Despite the negative effects, the evidence from both the Business Continuity and Resiliency survey and the MDAP-Assessments suggest there was learning based on changes made after the hurricane. According to the survey, most of the learning occurred in terms of formalization.
- The MDAP-Assessments demonstrate manufacturing firms made changes in infrastructure. The most significant change was the acquisition of generators, followed by cisterns, property protection and telecommunications redundancies.
- Based on the less conservative definition of resiliency (capacity to return to pre-event conditions), the study suggests the majority (66%) of the firms in our sample are resilient. If we adopt the most conservative view of resiliency most of our sample will classify as survivors (66%) and only 34 percent resilient. However, the firms in the sample seem to struggle in terms of sales and profits. Meanwhile, almost 70 percent are satisfied with their recovery, which suggest that for entrepreneurs' resiliency has not much to do with meeting certain standards, and much more with avoiding demise.

CONCLUSIONS
Findings & Implications

- The empirically tested resiliency model showed Leadership, Entrepreneurial Orientation & Supply Chain Resilience (SCR) explain resiliency in manufacturing SMEs. SCR include formalization, human resources, facilities, production, infrastructure, IT& communications, and supply, distribution-transport, and client indicators.
- Of all SCR indicators, formalization is the highest (61.7%). This finding is promising particularly since all evidence suggest that formalization initiatives (i.e. having protocols in place) influence resilience and performance. The lowest indicator were SCR indicators related to clients, suppliers and facilities.
- Most of the firms scored high on Entrepreneurial Orientation (80%) and People Oriented Leadership (88%). Because of this, the focus of supporting initiatives should be on improving supply chain resiliency through clients, suppliers and facilities.
- There are significant differences between resilient and surviving manufacturing SMEs in all nine SCR factors, disruption capacity; social capital; performance and leadership type (people-oriented versus task oriented). The MDAP assessments also show that resilient firms scored better in recovery level & promptness of re-opening, preparedness, and communications infrastructure. It also showed that SMEs with continuity plans scored better in recovery level, perceived preparedness, and re-opened faster.
- The average disruption capacity for manufacturing SMEs in Puerto Rico is 0.615 and this indicator is positively related to organizational performance. Evidence suggests age and size influence disruption capacity, where older and larger firms scored higher in the disruption capacity indicator.

CONCLUSIONS
Findings & Implications

- There are more resilient firms in the **metropolitan area** (80.43%). They score higher in performance, social capital, disruptive capacity, and in SCR, specifically IT& communications, human resources, and suppliers. Their lower learning score suggest they were more prepared when hurricane Maria hit. This is somewhat confirmed with the reported infrastructure changes in the MDAP assessments (less than other regions). The MDAP assessments showed that firms in this region were more prepared, opened before other areas and are more formalized in terms of IT Security. The firms in this region show high intentions in alternative energy. Hence, support programs in this regions should focus on access (i.e. funding alternative energy) rather than awareness.
- The **east central** is also highly resilient (74.07%). This is confirmed in the MDAP Assessments, where 85.9% were reported as resilient, which is above the 75.58% average for all regions. The region scored high in formalization factors and their clients are less concentrated. Like firms in the metropolitan area, they rely heavily on the social capital derived from their entrepreneurial networks. The significantly high learning score suggests firms in this region were less prepared when hurricane Maria hit but managed to adapt. According to the MDAP assessments electricity in this region took longer to recover, but the fact that they do not report changes in terms of generators or alternative energy may suggest the firms in the region were already prepared for this. They introduced changes in communications but scored lower in IT security indicators. Finally, this region reported more permanent losses than other regions, which may be related to the reduced number of establishments in the region, according to the BLS – EQUI File data.

CONCLUSIONS
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- According to the Business Continuity and Resiliency Survey most of the firms in the **west** are in surviving status (60%). They reported lower scores in SRC (Formalization, HRM, Supply, Communications & IT, and infrastructure), social capital, disruption capability and performance. The above is confirmed with MDAP assessments which show they are less prepared in terms of communications, information technologies, business continuity planning, and infrastructure (as reported by changes).

- Nonetheless, the MDAP assessments suggest most of the firms in the west restored operations 100% when visited and had electricity restored before other regions. These findings may suggest that factors external to the organization exerted more influence. As an example, in an interview with the owner of a bakery in the west, he said he was prepared and opened quickly but most of his clients and even employees left Puerto Rico after the hurricane hit.

- Finally, the fact that there are no significant differences in terms of learning when compared to other regions puts manufacturing SMEs in the west in a more vulnerable position. Moreover, it is important to notice that the BLS EQUI-File data shows the west was significantly impacted in terms of employment and total establishments.

CONCLUSIONS
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- **North** region is the most prepared in terms of infrastructure according to the Business Continuity and Resiliency Survey and it is above the average in terms of resiliency (70.0%) The MDAP assessments show they took longer to restore communications, which relates to their intentions of acquiring satellite technologies. However, manufacturing SMEs in the northern region were prepared in terms of IT security and business continuity planning, and according to the MDAP assessments they appear to have more diverse transports and clients. The BLS-EQUI File data suggest the north was the least affected.

- The manufacturing SMEs in the **south** are less formalized, are more vulnerable in terms of supplier concentration and communications & IT. This is confirmed by MDAP assessments which showed lower preparedness levels. Nonetheless, the regional infrastructure (communications & energy) recovered faster than in other regions. Despite the above, manufacturing SMEs in the south used the experience from Hurricane Maria to instill changes (highest learning score), making these more prepared for other disasters. The low changes in infrastructure in the MDAP Assessments suggest the learning the in the southern region relates to other supply chain factors. This is confirmed by the fact that the SCR-infrastructure indicator in the Business Continuity and Resiliency Survey for this region was 50.0 percent, which is below the average for all other regions.

CONCLUSIONS
Findings & Implications

- According to the Business Continuity and Resiliency Survey, the **food manufacturing** subsector is more vulnerable in terms of client and supplier concentration when compared to other sectors. Also, they rely more on family and friends. It scored higher in learning than other sectors which shows they are adapting, but the indicator is still relatively low (.257). The MDAP assessments showed this sector underperformed others in terms of resiliency, recovery, and re-opening. The BLS-EQUI File data shows the food manufacturing sector was one of the most impacted but appears to be expanding in terms of establishments, employment and wages. This in turn suggests opportunities to the develop SCR supporting initiatives targeted to this sector.

- The **metals** subsector is currently underperforming (50% are surviving). They are more vulnerable in formalization indicators and infrastructure. The MDAP assessments show this sector is unprepared in IT Security issues. The evidence from the BLS-EQUI file suggest this sector has bell-curved relationship after disaster. It could be hypothesized that as opportunities for the sector in post disaster environments emerge, the amount of establishments and employment increases, until saturation. The significant drops in wages could be indicative of reducing salaries or shifts due to financial hardship. The same pattern was observed with sector 325 – furniture.

- The MDAP show that although **printing & related services** are less prepared. Although they are knowledgeable of cyber-attacks, there are no significant differences between this sector and others in terms of IT security indictors. This merits attentions particularly because this subsector manages significant amounts of records.

CONCLUSIONS
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- Finally, strategies and initiatives to foster resiliency in manufacturing SMEs in Puerto Rico should address the supply chain using a holistic approach that includes all nine factors: formalization, human resources management, infrastructure, production, facilities, communications and IT, and supplier, client, distributor considerations. Effective leadership behaviors are dependent on the situation. In post-disaster environments, the most effective leadership behaviors are those concerned with people rather than the task. Cultural aspects of the organization (i.e. entrepreneurial orientation) exert a role in recovery, specially they need to institutionalize proactiveness, innovativeness and embrace risks. To maximize limited resources, supporting institutions should specifically design initiatives that address the needs of each region and subsectors. The profiles in this report are a first attempt to accomplish this.

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