COVID-19 and Indian Apparel Industry: A Logistic Regression Model to assess the Impact on Operation, Development and Sustenance

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Abstract

The persistence of COVID-19 continues through its variants to disrupt several business sectors which causes a ripple-effect to adversely impact the global economy. The short-term impact of this pandemic is well documented but its long-term impact is yet to be understood in its entirety. It therefore, becomes imperative to understand and analyze the impact of the pandemic from the perspective of the Indian apparel industry. While several works focused on the pandemic and its impact on businesses amidst lockdown and restrictions imposed to curb the spreading of COVID-19, this study highlights the status of apparel manufacturing business during the aftermath of the first wave and the looming threat of the ongoing pandemic. This study was undertaken to ascertain the impact of the pandemic on the Indian apparel industry with focus on the dependency on geographical hubs for sourcing, supply chain, organizational functions and operations. Data was collected from 53 strategists and key decision makers from diverse apparel manufacturing organizations in India. Logistics regression models were developed using R programing for analysis with a view to enable the Indian apparel industry and government machinery to assess the impact of identified factors. Based on the analysis, machine learning model using logistic regression was developed in R to enable real-time assessment of market situation for developing appropriate strategies to ensure growth and sustenance of this industry. Insights from the logistic regression models urge the industry and the government machinery to assess the imminent impact of identified factors for taking appropriate measures to develop strategy for industry sustenance. The researchers suggest policy moderation and ratification of schemes to address issues pertaining to administrative procedures for sourcing, buying and logistics, along with booster packages to increase investments augmenting these activities.

Keywords: COVID-19, apparel production, machine learning, R programing, logistic regression

Introduction

The crisis wrought by the COVID-19 pandemic escalated with its second wave, impacting every facet of human life and livelihoods at the national and global levels. It had a crippling impact on the global economy in recent times (Onyema, 2020), comparably worse than that of the Great Depression (Baldwin, 2020). Control and mitigation of its debilitating effects required the imposition of total or partial lockdowns that led to an abrupt halt in the manufacturing, transportation, retail, and hospitality sectors impacting organizational engagement with stakeholders (Xifra, 2020). The impact has been particularly visible in supply chains and operations (Samson, 2018). Spending patterns during the pandemic indicated that reduced income levels led to prioritization of purchasing essential goods like food and hygiene products over clothing (Andersen, et al., 2020). There were increased online searches to find ways for repurposing homewear leading to further drop in demand for apparel and accessories (Choi, 2020). As a result, most apparel manufacturing firms started to diversify into production of face masks and PPE kits to generate income in market segments with scope for higher sales. Globally, the garment production and supply chain has been one of the worst affected sectors (Bain 2020; Anner, 2020; Clean Clothes Campaign, 2020). The dependence of the textile industry supply chain on geographical hubs faced added disadvantage caused by the particularly significant centers of production being designated as critical 'red zones'. The crisis hit the garment industry in Asia and the Pacific particularly hard, affecting millions of workers and enterprises in the supply chains and with observed ripple effects across a number of dimensions (ILO, 2020). The apparel manufacturing sector was hit by four key factors– raw material supply disruption, supply value chain dysfunction, labor unavailability and insufficient demand from buyers. The garment industry in Ethiopia and Kenya took a hit due to worldwide retail closure and the resultant drop in export orders (Kassa, 2020). Orders worth USD 6 billion were cancelled in Bangladesh (Kamruzzaman, 2020) causing havoc on the earnings of apparel workers who are dependent on daily wages as apparel manufacturers were unable to support the operators with steady income (Sen, 2020). In particular, the disproportionate impact on women who make up the majority of the region's garment workers, further exacerbated existing inequalities. Another effect of the pandemic has been the imposition of unprecedented cost-cutting measures. Firms across the world have reduced expenditure on salaries of personnel with high-skill

competencies, though the hiring of personnel for low-skill jobs have not been affected to the same extent. The fact that small-scale firms have been impacted more severely and have ceased hiring, was indicative of the need for additional government support (Campello, 2020).

Prior to onset of the pandemic, the Indian economy was predicted to increase at a rate of 4.8 percent by the end of 2020 (International Monetary Fund, 2020). It was expected that the labor-intensive and knowledge-intensive sectors would maintain the growth momentum (McKinsey Global Institute, 2020). However, during the initial months of the nationwide lockdown, the expected contribution by the manufacturing and construction sectors of one-fifth of the GDP, came to a standstill (Kumar, 2020). The increasing spread of the pandemic has had a negative effect on the stock market (Ashraf, 2020). India's competitive advantage in the apparel sector has been attributed to integrated supply chain management practices incorporating comprehensive dimensions of strategic supplier partnership, customer relationship, information sharing, and process integration. However, the widespread and catalytic implications of the 2020 COVID-19 pandemic on the supply chains of the fashion industry cannot be overstated. Supply Chain practices faced a downslide as disruption of supply from China impacted manufacturing in India, further reducing opportunities for profitability (FICCI, 2020). The announcement by the Government of India to encourage self-reliance through initiatives encapsulated in the *Atmanirbhar Bharat* scheme, was a boost for the value chain. On 12th May 2020, Prime Minister Narendra Modi announced a stimulus package of INR 20 trillion (USD 270 billion) to reduce the debilitating effects of the lockdown that pushed many companies to the brink of bankruptcy. Studies indicate that flexibility in supply chains in the fashion industry (Mcmaster, et al., 2020) can be further strengthened by increasing the pool of small-scale suppliers. Another strategy is to develop local suppliers and near-shore suppliers. Many brands have diversified their product range to include loungewear, comfortable casualwear, and other specialized products to combat the spread of the virus. There is increased demand for more flexibility in manufacturing and operations to identify supply chain concepts that can help in containment of disruptions using suitable tools that can enable connections among multidimensional concepts (Bevilacqua, et al., 2020).

While the lockdown and subsequent imposition of containment and sanitization have reduced footfall and increased operational costs in physical stores, selling through omnichannels including digital selling platforms (Alves, 2020) are helping the fashion retail sector cater to changing demand for style variations (Mcmaster, et al., 2020).

Studies on perceptions of individuals and companies were Modeled using logistic regression (Umaña-Hermosilla, et al., 2020). Logistic regression is used for modeling the probability of the outcome into one of two or more classes, given an input variable. Problem with two classes is called a two-class or binary classification and more than two classes is called a multi-class classification. This method is very dynamic and adaptable for dichotomous classification prediction. R programing is an open-source programing platform which has been used with good success in predictive modeling (Lantz, 2019). It is used for statistical computing for analyzing and graphical representation for visualizing data. It provides various features and resource required for data analysis, visualization, data mining and developing machine learning models. At this uncertain time, the use of predictive modeling as a statistical technique to predict future behavior can prove to be an important tool to formulate a proactive stimulus for the recovery of the apparel manufacturing industry in India.

Research Methodology

While it is evident that global disruption across business sectors due to the widespread COVID-19 pandemic has adversely impacted the economy, there is a need for the analysis of its long-term influence. Existing works focused more on the pandemic and its impact on businesses amidst lockdown and restrictions imposed to curb the spreading of COVID-19. Hence, designing a study for identifying factors impacting the apparel manufacturing business during the pandemic and assess its impact on the Indian apparel industry became essential. Logistics regression models were developed using R programing to enable the Indian apparel industry and the government machinery to assess the impact of identified factors based on which real-time monitoring of market situation to develop appropriate strategies through machine learning growth and sustenance of the Indian apparel manufacturing industry becomes possible.

This research aims to understand the effects of the pandemic from the perspective of the Indian apparel industry through its impact on the supply chain, organizational functions and operations. The industry's dependency on geographical hubs for raw material supply is considered to understand critical production problems. R language provides the best prototype to work with machine learning models, one of the most effective open-source platforms for statistical programing used to identify factors that have high impact and to develop assessment models. The study also proposes measures that can catalyze development and sustenance of the Indian apparel industry against the backdrop of the ongoing COVID-19 and its after-effects. The study was conducted involving 53 key decision makers and strategists representing

the top management at the level of CEOs, Managing Directors and Vice Presidents of selected apparel manufacturing organizations. To gather primary data, a structured questionnaire was designed to record the opinions of the respondents on various aspects including sourcing, order management, resource management, logistics, demand and supply of materials that influence business operations, development and sustenance. The logistic regression model was chosen for analyzing the impact of identified factors through the probability of an event that occurs depending on the value of the independent variables for determining the association between business operation and factors affecting the Indian garment industry during the pandemic (Feng, et al., 2014). The classification was done by estimating the probability of an observation being part of a particular class, to confirm significance of specific factor in that category.

Analysis

Views of the respondents regarding the impact of COVID-19 on the Indian apparel manufacturing industry are tabulated at Table 1 listing various attributes that affect business.

Table 1: Impact of variable factors on Indian apparel manufacturing business during first wave of COVID-19

COVID-19 Impact vs Indian Apparel Industry		**Sourcing difficulties**		**Employees unable to reach office/ factory**		**Problems related to logistics**		**Cancellation of orders**		**Not receiving new orders**		**Brick and mortar store business**		**Online sales commitment completion**		**Warehousing difficulties**		**Sales channel challenges**	
		N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Respondents Opinion	Not affected	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	Slightly affected	2	2	2	2	4	0	3	1	3	1	4	0	4	0	4	0	4	0
	Moderately affected	4	8	8	4	8	4	5	7	5	7	9	3	12	0	11	1	9	3
	Strongly affected	10	26	11	25	13	23	13	23	11	25	18	18	26	10	23	13	20	16
Total		17	36	22	31	26	27	22	31	20	33	32	21	43	10	39	14	34	19

From Table 1 it is evident that the pandemic continues to affect the manufacturing business strongly as strongly agreed by 68 percent of the decision makers/strategists. Less than 10 percent of the respondents mentioned that their business has not been impacted due to the pandemic situation. The respondents felt that the COVID-19 pandemic has had a strong impact on the Indian apparel manufacturing industry (Figure 1).

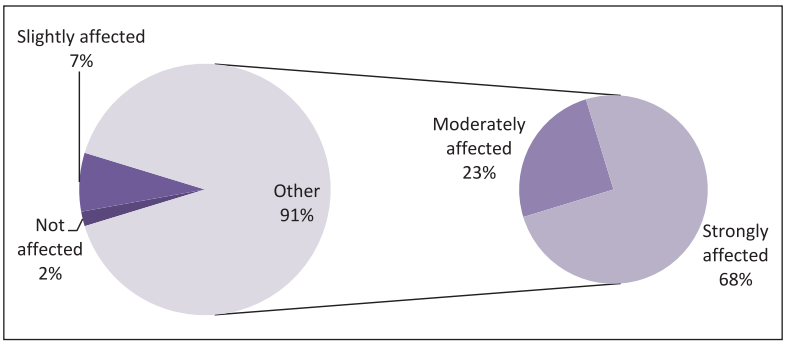

Figure 1: Impact of COVID-19 pandemic on the Indian apparel manufacturing industry

To identify factors that have significant impact, χ^2 test was administered. The results are tabulated in Table 2.

Table 2: Tabulated χ^2 values and order of impact of the factors affecting Indian apparel manufacturing business during the first wave of COVID-19

S.No.	Factors	χ^2 Value	Order of Impact
1	Problems related to logistics	9.905	1
2	Employees unable to reach office/factory	6.435	2
3	Brick and mortar store business	5.974	3
4	Online sales commitment completion	5.820	4
5	Warehousing difficulties	5.555	5
6	Not receiving new orders	4.883	6
7	Sales channel challenges	4.565	7
8	Cancellation of orders	3.689	8
9	Sourcing difficulties	3.021	9

The chi-square analysis reveals that problems related to logistics have the highest impact and are associated with the current red alert scenario in India. During the second wave of the pandemic, restrictions on inter-state movement considered for imposition by the government reflected the sentiments of the respondents. In addition to interstate logistics, the other factors predominantly relate to constraints in sourcing

and buying, handling exports and domestic demand and supply (Table 2). Analysis of responses presented in Table 3 was carried out based on the assumption that certain factors would have an impact on apparel manufacturing due to the impending threat of a persisting COVID-19 pandemic situation.

Table 3: Factors and their impact on Indian apparel manufacturing business during the second wave of COVID-19

COVID-19 Second Wave Impact vs Indian Apparel Industry		Temporary shutdown		Employee absences due to sickness or childcare		Buyers not paying their bills		Reduced logistics services		Reduced certification services		Infrastructure problems		Increased administrative bottlenecks		Reduced investment		Pressure from local/state bodies for reduced operations	
		N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Respondents' opinion	Not affected	1	0	0	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	Slightly affected	2	2	2	2	3	1	0	4	4	0	4	0	3	1	4	0	4	0
	Moderately affected	3	9	8	4	5	7	9	3	12	0	11	1	7	5	8	4	10	2
	Strongly affected	3	33	20	16	24	12	20	16	30	6	30	6	19	17	26	10	20	16
Total		9	44	30	23	33	20	30	23	47	6	46	7	30	23	39	14	35	18

Factors with significant impact are identified using χ^2 and results are tabulated.

Table 4: χ^2 values and order of impact of the factors affecting Indian apparel manufacturing business during the second wave of COVID-19

S.No.	Factors	χ^2 Value	Impact (in decreasing order)
1	Temporary shutdown	10.439	1
2	Reduced logistics services	7.653	2
3	Pressure from local/state bodies for reduced operations	5.936	3
4	Buyers not paying their bills	3.346	4
5	Reduced certification services	3.195	5
6	Reduced investment	2.125	6
7	Employee absences due to sickness or childcare	1.886	7
8	Increased administrative bottlenecks	1.547	8
9	Infrastructure problems	1.385	9

The chi-square analysis in Table 4 reveals that primarily temporary lockdowns and reduced logistics services could impact the apparel manufacturing business in India. Hence, it becomes imperative to develop machine learning models which will not only assess the significance of the impact of factors listed in Table 4 but also describes the relationship between the predictor and the predicted variables, as well as the extent of impact by the predictors on the predicted variables which defines the course of remedial action. Responses from 53 key decision-makers representing garment manufacturing industries across India regarding the impact of the COVID-19 pandemic, were analyzed using logistic regression represented by equation 1 below:

$$\text{Logit}(p) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots\ldots\ldots\ldots\ldots + \beta_k X_k$$

where,

p is the probability of presence of the characteristic or interest,

β_0 is the intercept from the linear regression equation

$\beta_1 X_1$ is the regression coefficient multiplied by value of the predictor

k is the number of predictors

Using equation 1 consider,

p = Impact of the second wave of the COVID-19 pandemic on the Indian apparel manufacturing industry viz.

i. Difficulty accessing resources domestically
ii. Reduced domestic sales
iii. Difficulty in exports
iv. Difficulty in logistics of interstate movement
v. Difficulty in importing resources from abroad
vi. Lower sales for domestic consumers
vii. Increased domestic sales
viii. Improved exports

X_1 = Temporary shutdown

X_2 = Employee absences due to sickness or childcare

X_3 = Non-payment of bills by buyers

X_4 = Reduced logistics services

X_5 = Reduced certification services

X_6 = Infrastructure problems

X_7 = Increased administrative bottlenecks

X_8 = Reduced investment

X_9 = Pressure from local/state bodies for reduced operations

The logit transformation is defined as the logged odds:

p = probability of presence of characteristic

1-p = probability of absence of characteristic

Table 5: Generalized Linear Model (GLM) to predict variables with probability distribution

Response variable	**Predictor variable1**	**Predictor variable2**	**Equation for Impact Assessment**	**Model Fit**
Difficulty accessing resources domestically	Increased administrative bottlenecks	Reduced investment	p = exp(-0.7768 + 2.4386*x1-2.3388*x2)/ [1 + exp(-0.7768 + 2.4386*x1-2.3388*x2)]	Plot 1
Reduced domestic sales	Buyers not paying their bills	-	p = exp(-2.5127 + 2.8143*x1)/ [1 + exp(-2.5127+2.8143*x1)]	Plot 2
Difficulty exporting	Buyers not paying their bills	-	p = exp(-2.1215+2.5644*x1)/ [1 + exp(-2.1215+2.5644*x1)]	Plot 3
Difficulty in interstate logistics	Reduced logistics services	Increased administrative bottlenecks	p = exp(-1489e+00+2.072e+00*x1-2.13e+00*x2)/ [1 + exp(-1489e+00+2.072e+00*x1-2.13e+00*x2)]	Plot 4
Difficulty importing inputs from abroad	No impact			
Lower domestic sales to consumers	No impact			
Increased domestic sales	No impact			
Improved exporting	No impact			

Rather than choosing parameters that minimize the sum of squared errors as in ordinary regression, estimation in logistic regression chooses parameters that maximize the likelihood of observing sample values. Table 5 exhibits the significant response variables

and the predictor variables that continuously impact operations, development and sustenance of the apparel manufacturing industry in India during the pandemic.

The first logistic regression model was created to predict the difficulty in accessing inputs domestically (y) based on the responses received on increased administrative bottlenecks (x1) and reduced investment (x2) as given in equation 2 below:

$$p = \frac{\exp(-0.7768 + 2.4386 * x1 - 2.3388 * x2)}{[1 + \exp(-0.7768 + 2.4386 * x1 - 2.3388 * x2)]}$$

The logistic regression coefficients give the change in the log odds of the outcome for a one-unit increase in the predictor factor(s). Taking the intercept term which corresponds to the β_0, the exponential of β_0 gives the mean odds to accessing resources domestically in the reference category. So, exp (β_0) is 0.46, the chance of difficulty accessing domestic resources with increased administrative bottlenecks and reduced investment. A slight difference in the interpretation of coefficients appears while considering the following coefficients. Increased administrative bottlenecks exp (β_1) has a mean chance of 11.46 times the chance of reference category. Similarly, reduced investment exp (β_2) has a mean chance of 10.36 times the chance of reference category. Whereas, there is a chance that both administrative bottlenecks and reduced investment coexist for which exp (β_1+β_2) is 118.795 times the mean chance of reference category.

Table 6: Table of probability values to assess difficulty of accessing resources domestically

Factor	Mean Chance	Chance of the affecting Factor	Probability of the affecting factor
Reference Group [Difficulty in accessing inputs domestically]			0.32
X1 [Increased administrative bottlenecks]	11.46	4.35	0.92
X2 [Reduced investments]	10.37	3.94	0.91
X1 & X2 [Increased administrative bottlenecks & reduced investments]	45.21	118.80	0.99

Referring to Table 6, the mean probability of difficulty accessing domestic resources is 0.32. Knowing that the mean chance of administrative bottlenecks is 11.46 greater than the mean chance of the reference group, the chance of difficulty to this group can be estimated as 4.35, a probability of increased administrative bottlenecks equals to 0.92. Similarly, the mean chance of reduced investment is 10.37 times the reference

group, which means a chance is equal to 3.94 or probability equals to 0.91. Finally, administrative bottlenecks with reduced investment have a chance equal to 45.21 or probability of difficulty to accessing resources domestically equal to 0.99.

The difficulty in sourcing domestically illustrated in Figure 2, has the probability of 0.99 with increased administrative bottlenecks and reduced investments during the ongoing second wave of the pandemic.

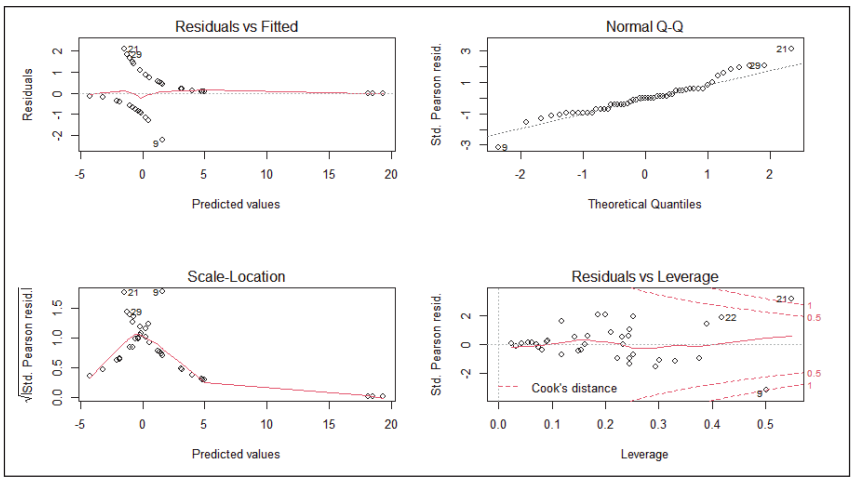

Figure 2: Deviance residual plots for difficulty in accessing resources domestically

Logistic regression model to assess reduced domestic sales due to buyers not paying bills to the manufacturers is given in equation 3 below:

$$\mathrm{p} = (exp(-2.5127 + 2.8143 * \mathrm{x1}))/([1 + exp(-2.5127 + 2.8143 * \mathrm{x1})])$$

The exponential of the intercept term exp (β_0) gives the mean odds to reducing domestic sales in the reference category as 0.08. The chance of reduced domestic sales with buyers not paying bills exp (β_1) has a mean chance of 16.68 times the chance of reference category.

Table 7: Probability values to asses difficulty in reduced domestic sales

Factor	**Mean Chance**	**Chance of the affecting Factor**	**Probability of the affecting factor**
Reference Group [reduced domestic sales]			0.07
X1 [buyers not paying bills]	16.68	1.17	0.53

The mean probability of reduction in domestic sales is 0.07. Knowing the mean chance of buyers not paying bills is 16.68 greater than the mean chance of the reference group, the chance of difficulty to this group was estimated to be 1.17 or a probability of reduced domestic sale due to buyers not paying bills to the manufacturers as 0.53 (Table 7).

Thus, the reduction in domestic sales during the second wave of the pandemic in India has the probability of 0.53 with buyers not paying their bills for goods already procured (Figure 3).

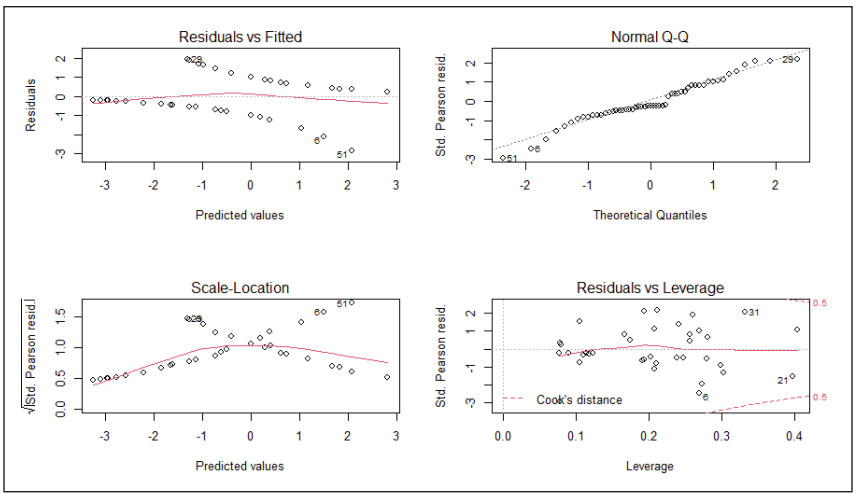

Figure 3: Deviance residual plots for reduced domestic sales

Logistic regression model to assess difficulty in garment exports due to clients not paying bills to the manufacturers is given in equation 4 below:

$$p = \frac{\exp(-2.1215 + 2.5644 * x1)}{[1 + \exp(-2.1215 + 2.5644 * x1)]}$$

The exponential of the intercept term exp (β_0) gives the mean odds to reduction in difficulty in garment exports as 0.12. The chance of reduced domestics exports due to buyers not paying bills exp (β_1) is 12.99 times the chance of reference category.

Table 8: Probability values to assess difficulty in garment exports

Factor	**Mean Chance**	**Chance of the affecting factor**	**Probability of the affecting factor**
Reference Group [difficulty in garment exports]			0.11
X1 [buyers not paying bills]	12.99	1.43	0.59

Table 8 indicates that the mean probability of reduction in domestic sales is 0.11. Knowing that the mean chance of buyers not paying bills is 12.99 greater than the mean chance of the reference group, the chance of difficulty for this group was estimated to be 1.43 or a probability of difficulty in garment exports due to clients not paying bills to the manufacturers equal to 0.59.

The difficulty in garment exports depicted in Figure 4, have the probability of 0.59 during the second wave of COVID-19 in India due to buyers not paying their bills for goods already procured.

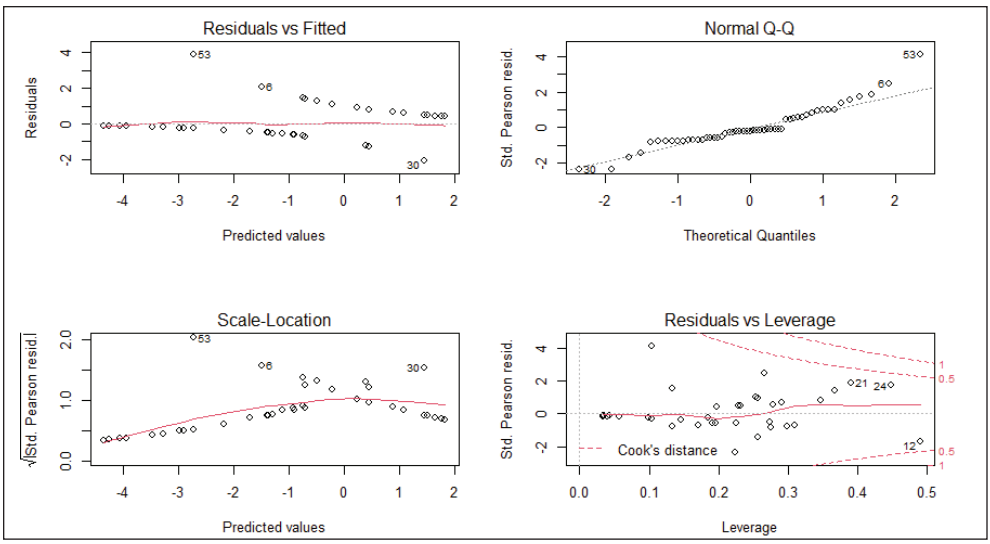

Figure 4: Deviance residual plots for difficulty in garment exports

Logistic regression model to assess difficulty in interstate logistics due to reduced logistics services and increased administrative bottlenecks is given in equation 5 below:

$$p = \frac{\exp(-1.489 + 2.072 * x1 - 2.131 * x2)}{[1 + \exp(-1.489 + 2.072 * x1 - 2.131 * x2)]}$$

The exponential of intercept term exp (β_0) gives the mean odds to accessing resources domestically in the reference category to be 0.26, which is the chance of difficulty accessing domestic resources with reduced logistics services and increased administrative bottlenecks. Reduced logistics services exp (β_1) have a mean chance which is 7.94 times the chance of reference category and increased administrative bottlenecks exp (β_2) have a mean chance which is 8.42 times the chance of reference category to increase the difficulty. Both reduced logistics services and administrative bottlenecks have a mean chance which is 66.87 times the chance of reference category.

Table 9: Probability values to assess difficulty in inter-state logistics

Factor	Mean Chance	Chance of the affecting Factor	Probability of the affecting factor
Reference Group [difficulty in inter-state logistics]			0.21
X1 [Reduced Logistics services]	7.94	1.67	0.63
X2 [Increased administrative bottlenecks]	8.42	1.77	0.64
X1 & X2 [Reduced logistics services & increased administrative bottlenecks]	66.87	14.04	0.94

The mean probability of difficulty in interstate logistics is 0.21. Knowing that the mean chance of reduced logistics services is 7.94 times greater than the mean chance of the reference group, the chance of difficulty to this group was estimated to be 1.67 or a probability of reduced logistics services as 0.63. The mean chance of increased administrative bottlenecks was estimated to be 1.77 or a probability of 0.64. Therefore, reduced logistics services with increased administrative bottlenecks have a chance of 14.04 or a probability of 0.94 for difficulty in interstate logistics (Table 9).

The difficulty in inter-state logistics during the second wave of COVID-19 in India has the probability of 0.94 with reduced logistics services and increased administrative bottlenecks (Figure 5).

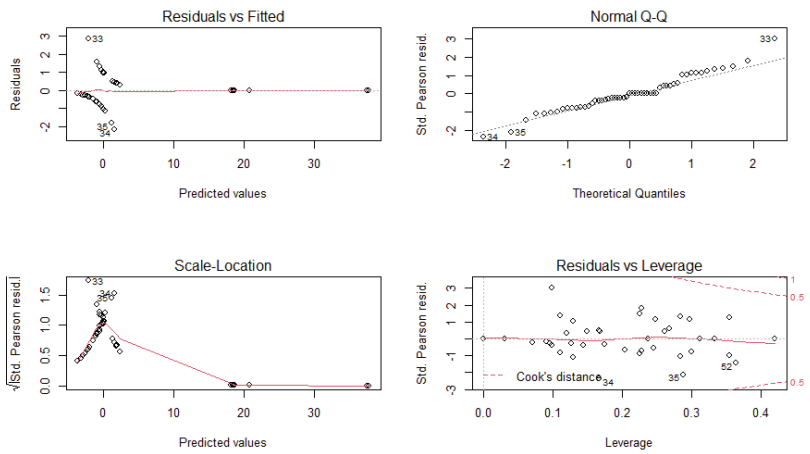

Figure 5: Deviance residual plots for difficulty in inter-state logistics

Findings

This research was designed and steered to specifically understand the long-term impact of the COVID-19 pandemic on the Indian apparel industry based on the factors identified from the perspectives of industry stalwarts. The data collected for these identified factors were analyzed using logistics regression to assess their impact in operation, development and sustenance of the Indian apparel manufacturing industry. A machine learning model was developed in R to catalyze the development and sustenance through dynamic impact assessment of factors with the following key findings:

- During the prevailing uncertainty due to COVID-19, problems related to logistics of both material and workforce continue to be challenging for apparel manufacturers.
- Difficulty in mobilizing these resources lead to delay in completion of orders and timely delivery, precipitated further by warehousing challenges.
- The looming threat of the ongoing pandemic in India will continue to adversely impact the receipt of new orders, and is likely to lead to cancellation of previous orders, depending on the 'red listing' of the country, as seen during the first wave of the pandemic.
- The logistics regression model predicts that the difficulty in sourcing domestically has probability of 0.99 with increased administrative bottlenecks and reduced investments during the pandemic.
- Reduction in domestic sales during the second wave of the pandemic in India has a probability of 0.53 with buyers not paying their bills for goods already procured.
- The difficulty in garment exports has the probability of 0.59 during the third wave of COVID-19 in India due to buyers not paying their bills for already procured goods.
- The difficulty in inter-state logistics during the second wave of COVID-19 in India has a probability of 0.94 with reduced logistics services and increased administrative bottlenecks.
- Other factors viz. difficulty importing inputs from abroad, lowered or increased domestic sales, and improved exports had no impact on the Indian apparel manufacturers during the pandemic.

Conclusion

Self-sustained initiatives during the global uncertainty due to the COVID-19 pandemic motivated industries to identify local resources to Fulfill manufacturing needs. However, industries face difficulties in sourcing necessary resources domestically due to increased administrative bottlenecks including the procedure and permission for inter-state material movement, policy changes and reduced investments. Policy moderations and schemes have to be ratified to address issues pertaining to administrative procedures for sourcing, buying and logistics, along with booster packages to increase investments augmenting these activities to encourage sustenance of the Indian apparel manufacturing industry. Drawing from the insights of the logistic regression models, the industry and government machinery can assess the imminent impact on the factors identified, enabling the development of an appropriate strategy to develop and sustain the Indian apparel manufacturing industry.

The research is an attempt to show the importance of real-time assessment on factors impacting apparel manufacturing business in India. To accomplish dynamic analysis and assessment, a machine learning model was identified for incessant problem solving. The insights from the logistic regression models urges the industry and the government machinery to assess the imminent impact of the identified factors for taking appropriate measures for the strategy development to ensure the Indian apparel manufacturing industry's sustenance. There may be alternatives to the proposed model that can improve the robustness and precision of the outcome, which broadens the scope of further study in the subject matter. Considering the extensive Indian apparel manufacturing ecosystem, similar studies are proposed to be conducted in the textile and retail sector to cover the entire gamut of the fashion supply chain in India.

References

Alves, S.R., Ribeiro, H. and Saravanan, R., 2020. *The digital transformation of traditional Indian retail for sustainable growth*. Economic and Social Development: Book of Proceedings, pp.236-245.

Andersen, A.L., Hansen, E.T., Johannesen, N. and Sheridan, A., 2020. *Consumer responses to the COVID-19 crisis.* [online] Available at: <https://voxeu.org/article/consumer-responses-covid-19-crisis> [Accessed 25 August 2021].

Anner, M., 2020. *Abandoned? The impact of COVID-19 on workers and businesses at the bottom of global garment supply chains*. [online] Available at: <https://www.workersrights.org/wp-content/uploads/2020/03/Abandoned-Penn-State-WRC-Report-March-27-2020.pdf> [Accessed 20 August 2021].

Ashraf, B.N., 2020. Stock markets' reaction to COVID-19: cases or fatalities? *Research in International Business and Finance*, 54, [online] Available at: <https://www.sciencedirect.com/science/article/pii/S0275531920304141> [Accessed 14 August 2021].

Bain, M., 2020. *Coronavirus threatens the livelihoods of garment workers around the world.* [online] Available at: <https://qz.com/1821511/coronavirus-threatens-jobs-of-garmentworkers-in-southeast-asia/> [Accessed 25 August 2021].

Baldwin, R., 2020. *The greater trade collapse of 2020: learnings from the 2008-09 great trade collapse*. [online] 7 April. Available at: <https://voxeu.org/article/greater-trade-collapse-2020> [Accessed 25 August 2021].

Bevilacqua, M., Ciarapica, F.E., Marcucci, G. and Mazzuto, G., 2020. Fuzzy cognitive maps approach for analyzing the domino effect of factors affecting supply chain resilience: a fashion industry case study. *International Journal of Production Research*, *58*(20), pp.6370-6398.

Campello, M., Kankanhalli, G. and Muthukrishnan, P., 2020. Corporate hiring under COVID-19: Labor market concentration, downskilling, and income inequality. *National Bureau of Economic Research*. [online] Available at: <https://ideas.repec.org/p/nbr/nberwo/27208.html> [Accessed 23 August 2021].

Choi, Y.H. and Lee, K.H., 2020. Changes in consumer perception of fashion products in a pandemic - effects of COVID-19 spread. *The Research Journal of the Costume Culture*, *28*(3), pp.285-298.

Clean Clothes Campaign, 2020. *Live-blog: How the Coronavirus influences garment workers in supply chains*. [online] Available at: <https://cleanclothes.org/news/2022/live-blog-on-how-the-coronavirus-influences-workers-in-supply-chains> [Accessed 23 August 2021].

Feng, J., Xu, H., Mannor, S., and Yan, S., 2014. *Robust logistic regression and classification.* [online] Available at: <https://papers.nips.cc/paper/2014/hash/6cdd60ea0045eb7a6ec44c54d29ed402-Abstract.html> [Accessed 7 May 2020].

FICCI, 2020. *Impact of COVID-19 on Indian economy*. [online] Available at: <https://ficci.in/spdocument/23195/Impact-of-COVID-19-on-Indian-Economy-FICCI-2003.pdf> [Accessed 3 September 2021].

IMF, 2020. Policies to support people during the COVID-19 pandemic. In: *Fiscal Monitor.* [online] Available at: https://www.elibrary.imf.org/view/books/089/28929-9781513537511-en/ch01.xml [Accessed 7 May 2020].

Kamruzzaman, M. and Sakib, S.M.N., 2020. *Bangladesh imposes total lockdown over COVID-19.* [online] Available at: <https://www.aa.com.tr/en/asia-pacific/bangladesh-imposes-total-lockdown-over- covid-19/1778272> [Accessed 26 July 2020].

Kassa, W. COVID-19 and trade in SSA: impacts and policy response. Washington: World Bank. [online] Available at: <https://openknowledge.worldbank.org/handle/10986/33841> [Accessed 20 July 2020].

Kumar, S.U., Kumar, D.T., Christopher, B.P. and Doss, C., 2020. The rise and impact of COVID-19 in India. *Frontiers in Medicine*, p.250. https://doi.org/10.3389/fmed.2020.00250.

Lantz, B., 2019. *Machine learning with R: expert techniques for predictive modeling*. Birmingham: Packt Publishing Ltd.

Mckinsey Global Institute, 2020. *India's turning point: an economic agenda to spur growth and jobs*. [online] Available at: <https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/India/Indias%20turning%20point%20An%20economic%20agenda%20to%20spur%20growth%20and%20jobs/MGI-Indias-turning-point-Report-August-2020-vFinal.pdf> [Accessed 14 September 2020].

McMaster, M., Nettleton, C., Tom, C., Xu, B., Cao, C., and Qiao, P., 2020. Risk management: rethinking fashion supply chain management for multinational corporations in light of the COVID-19 outbreak. *Journal of Risk and Financial Management*, 13(8), p.173. https://doi.org/10.3390/jrfm13080173.

Onyema, E.M., Eucheria, D.N.C., Obafemi, D.F.A., Sen, S., Atonye, F.G., Sharma, D.A. and Alsayed, A.O., 2020. Impact of coronavirus pandemic on education. *Journal of Education and Practice*, 11(13), pp.108-121.

Samson, D. and Gloet, M., 2018. Integrating performance and risk aspects of supply chain design processes. *Production Planning & Control*, 29(15), pp.1238-1257. Oxfordshire: Taylor & Francis Online.

Sen, S., Antara, N., Sen, S. and Chowdhury, S., 2020. The apparel workers are in the highest vulnerability due to COVID-19: a study on the Bangladesh Apparel Industry**.** Asia Pacific Journal of Multidisciplinary Research, 8(3). [online] Available at: <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3669298> [Accessed 14 September 2020].

Umaña-Hermosilla, B., De La Fuente-Mella, H., Elórtegui-Gómez, C. and Fonseca-Fuentes, M., 2020. Multinomial logistic regression to estimate and predict the perceptions of individuals and companies in the face of the COVID-19 pandemic in the *ñuble* region, Chile. *Sustainability*, *12*(22), p.9553.

Xifra, J., 2020. Corporate communication, public relations and reputational risk management in the days of COVID-19. *Profesional de la Informacion*, 29(2). [online] Available at: <http://eprints.rclis.org/39942/> [Accessed 14 September 2020].

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