

**METHODOLOGY FOR STRESS TESTING BUSINESS SYSTEMS: A
SYSTEM OF RESILIENCE INDICATORS AND THE PRACTICE OF
CRISIS-DRIVEN PRODUCTION REPURPOSING**

***Summary.** This study proposes a methodology for stress testing business systems based on quantitative resilience indicators. The methodology includes the assessment of capacity reserve, reserve monetization, bottleneck depth, time reserve, employee cross-functionality, and revenue diversification. The procedure covers the diagnostics of the initial enterprise condition, the modeling of stress scenarios, the calculation of residual revenue, and the identification of critical modules. The methodology is validated using simulated data based on crisis-driven production repurposing during the COVID-19 pandemic. The results show that the use of reserve capacity for protective mask production made it possible to preserve a substantial share of pre-crisis revenue and improve the integrated resilience assessment. The study concludes that stress testing can be used for preliminary diagnostics, anti-crisis decision-making, and evaluation of enterprise operational resilience.*

***Key words:** stress testing, business system, enterprise resilience, capacity reserve, crisis-driven production repurposing, COVID-19, residual revenue.*

Recent crisis events have shown that enterprise resilience should be assessed as a measurable property of a business system. The COVID-19 pandemic demonstrated that organizations may retain technically operational capacities while losing their previous demand channels, suppliers, logistics stability, or

workforce availability. In such conditions, effective anti-crisis management requires quantitative indicators that show what share of revenue, production functions, and order fulfillment capacity can be preserved under a specified shock scenario. In this article, stress testing of a business system is understood as a calculation-based procedure for assessing an enterprise’s ability to maintain revenue, production continuity, execution timelines, and process stability under crisis impact [1].

The aim of the article is to develop a methodology for stress testing a business system based on a system of resilience indicators and its practical validation.

The study is based on the analysis of scholarly works on enterprise resilience, supply chain disruption, production repurposing, and crisis management. The methodological component models a production-oriented business system consisting of five modules: procurement, production, fulfillment, call center operations, and distribution. Each module is assessed in terms of its contribution to residual revenue and its vulnerability under crisis impact.

The stress testing methodology consists of four stages:

1. The enterprise’s normal operating condition is established, including the determination of actual module utilization, maximum throughput capacity, share of external revenue, workforce size, and order fulfillment time.
2. Resilience indicators are calculated (Table 1).
3. Stress scenarios are defined.
4. Residual revenue is assessed, and the critical module is identified.

Table 1

System of resilience indicators for the business system

Indicator	Formula	Description
Capacity reserve ratio	$K_{cr} = M_{max} / M_{fact} - 1$	Indicates the reserve capacity of the module relative to its normal workload
Reserve monetization ratio	$K_{mr} = R_{ext} / Q_{res}$	Indicates whether available reserve capacity generates commercial revenue

Bottleneck depth	$Gbd = \Delta R / R0$	Reflects the share of revenue loss resulting from module failure
Time reserve	$Ktr = Tallow / Tfact$	Indicates whether a time reserve exists for order fulfillment
Employee cross-functionality	$Kcf = P2+ / Ptotal$	Reflects the share of employees capable of working across two or more modules
Revenue diversification	$Krd = Rext / Rtotal$	Indicates the share of external revenue in the enterprise's total revenue

For the capacity reserve ratio, the target range is set at 20–40%. A value below 20% indicates module fragility, while a value above 40% requires additional analysis due to the risk of underutilized capacity. The reserve monetization ratio is introduced to distinguish passive reserve capacity from commercially usable reserve capacity, since resilience depends on the enterprise's ability to convert available resources into external revenue.

Four stress scenarios are used: supplier failure, a 50% decline in demand, seasonal downturn, and pandemic shock. The pandemic scenario combines retail demand reduction, growing demand for sanitary and protective products, delivery disruptions, and the need to maintain workforce employment. Under such conditions, the enterprise's resilience depends on reserve capacity, coordination of operations, digital communication, and the ability to redirect production toward new demand [2]. Figure 1 presents the algorithm for stress testing a business system:

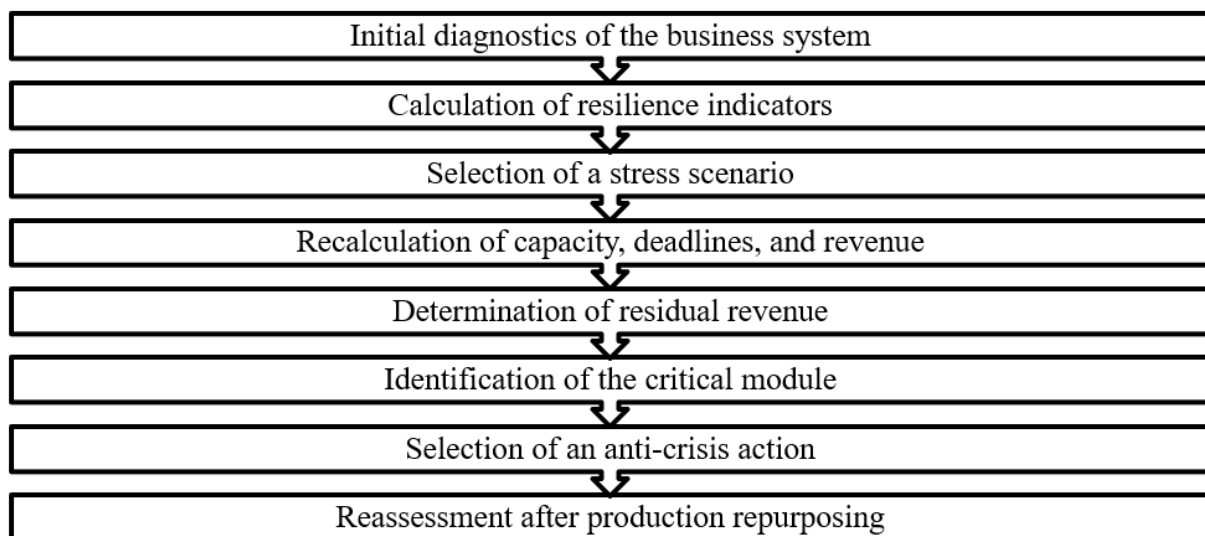


Fig. 1. Algorithm for stress testing a business system

To validate the methodology, a manufacturing enterprise with five operational modules was modeled. Prior to the pandemic, the enterprise produced consumer goods and generated 12 million in monthly revenue through retail channels. Under the pandemic scenario, retail sales were suspended, while personnel, equipment, fabric and packaging suppliers, and part of the distribution network remained available. This allowed the production module to be redirected toward protective mask production. The initial indicators are presented in Table 2:

Table 2

Initial resilience indicators prior to the crisis

Module	Actual utilization, units	Maximum capacity, units	Kcr	Share of external revenue, %	Gbd, %
Procurement	800	1040	0,30	10	28
Production	1000	1350	0,35	12	42
Fulfillment	700	980	0,40	18	24
Call center	600	780	0,30	25	16
Distribution	750	1050	0,40	20	31

Table 2 shows that all modules had an acceptable capacity reserve. The production module was the most critical, since its failure would have led to a 42% revenue loss. At the same time, its 35% capacity reserve created the basis for crisis-driven production repurposing.

Under the 50% demand decline scenario, baseline revenue fell from 12 million to 6 million. In the pandemic scenario, the decline was stronger due to the suspension of retail channels. Redirecting part of production toward protective masks made it possible to use reserve capacity and preserve part of the order flow [3].

Thus, the stress scenarios are modeled as follows (Table 3):

Table 3

Modeled stress test results

Scenario	Residual revenue without intervention, million	Residual revenue after intervention, million	Revenue retention after intervention, %

Supplier failure	8,4	10,1	84
50% decline in demand	6,0	8,7	73
Seasonal downturn	7,5	9,2	77
Pandemic shock	4,8	11,0	92

The most significant effect was observed under the pandemic scenario. Without production repurposing, the enterprise would have preserved only 4.8 million in monthly revenue. Following the launch of protective mask production and the utilization of the existing distribution network, residual revenue increased to 11 million, while revenue retention reached 92% of the pre-crisis level. The obtained result is explained by the fact that the crisis simultaneously reduced existing demand while generating new demand for sanitary and protective products.

An important outcome of the analysis is the change in the role of individual modules. Prior to the crisis, the production module represented the principal bottleneck; however, following production repurposing, criticality shifted toward procurement and distribution. This situation was primarily associated with the increased demand for raw materials, packaging, and rapid delivery. Consequently, stress testing should evaluate not a single module in isolation, but rather the shifting of bottlenecks under each specific scenario. According to reviews of supply chain resilience strategies during the COVID-19 period, the principal shocks of that time were associated with supply disruptions, demand fluctuations, the bullwhip effect, and rising transportation costs [4].

Comparing the enterprise’s condition before and after production repurposing reveals the following pattern (Table 4):

Table 4

Comparison of enterprise conditions before and after production repurposing

Indicator	Before repurposing	After repurposing
Workforce, employees	35	105

Monthly revenue, million.	12,0	11,0
Share of external revenue, %	18	46
Kcf	0,22	0,51
Median order fulfillment time, days	5,2	4,6
Ktr	1,15	1,30
Share of reserve capacity engaged in new product production, %	0	78

Following production repurposing, the enterprise increased its workforce threefold. At the same time, revenue preservation was achieved through the integration of reserve capacity into the new production flow. The share of external revenue increased from 18% to 46%, while employee cross-functionality rose from 0.22 to 0.51. In other words, more than half of the employees became capable of performing tasks across two or more modules. The time reserve also increased, as part of the operational processes was standardized for the mass production of protective masks.

Figure 2 presents the integrated assessment of business system resilience:

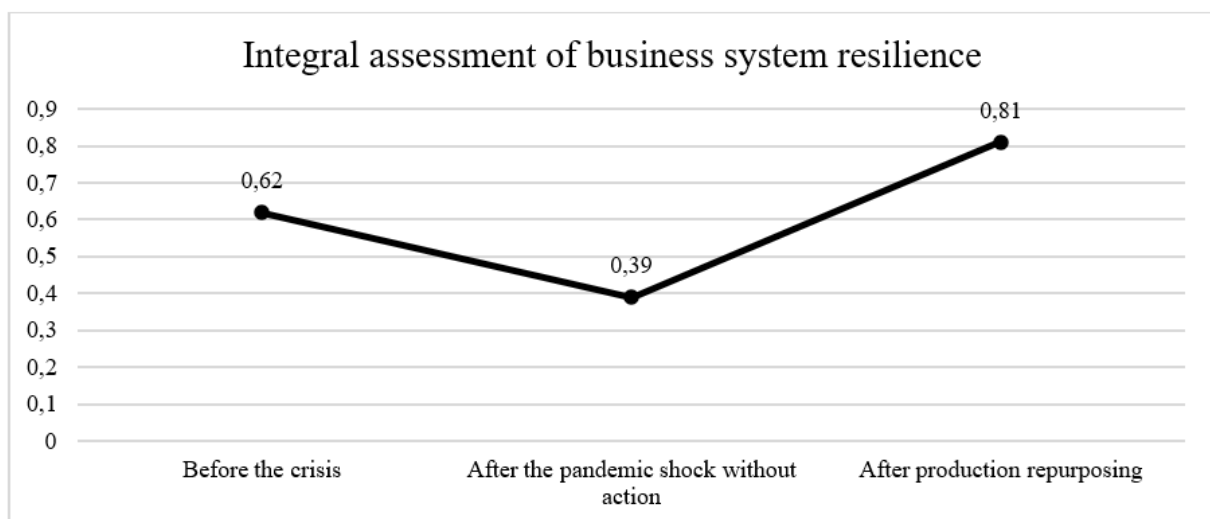


Fig. 2. Integrated assessment of business system resilience

The integrated assessment was calculated as the average of normalized values across six indicators, including capacity reserve, reserve monetization, the presence and severity of bottlenecks, time reserve, employee cross-functionality, and revenue diversification. Under the pandemic shock scenario, the index declined to 0.39. Following production repurposing, however, it increased to 0.81,

indicating that the anti-crisis intervention significantly affected the resilience structure of the enterprise.

The obtained results make it possible to further clarify the essence of stress testing. First, stress testing should be conducted prior to the onset of a crisis. Second, the analysis should incorporate not only financial indicators, but also production capacity, execution timelines, workforce factors, and revenue channels. Third, the principal outcome of a stress test is the calculation of residual revenue and the identification of modules that constrain the recovery process.

For small and medium-sized enterprises, the proposed methodology is of particular significance, since such enterprises typically possess more limited financial reserves and are more strongly dependent on individual suppliers, customers, and employees. At the same time, they are often capable of adapting production more rapidly when reserve capacity has been assessed in advance. Studies examining the dynamics of SME resilience following COVID-19 demonstrate that supply chain risk reduction is influenced by factors such as operational efficiency, financial strength, portfolio diversification, and access to resources [6].

In a broader manufacturing context, stress testing may be employed as a regular procedure integrated into management and decision-making processes. At a minimum, stress testing makes it possible to evaluate an enterprise before a crisis, during a crisis, and after the implementation of anti-crisis measures, thereby enabling the subsequent assessment of the effectiveness of the response strategies adopted. Contemporary models for evaluating the resilience of manufacturing enterprises likewise emphasize the necessity of integrating vulnerability assessment, resilience factors, strategy selection, and the quantitative evaluation of outcomes into a unified analytical framework [7].

Thus, the proposed methodology for stress testing a business system makes it possible to move from a general description of crisis resilience toward a calculation-based assessment of enterprise survivability. The methodology is

founded upon indicators such as capacity reserve, reserve monetization, bottleneck depth, time reserve, employee cross-functionality, and revenue diversification. Their combined application enables the identification of both the enterprise’s resilience margin prior to a crisis and the level of residual revenue it is capable of preserving under a specified shock scenario.

The presented calculations based on the case of production repurposing during the COVID-19 period demonstrated that the existence of production reserves becomes a valuable resource only when such reserves can be monetized. Redirecting the production module toward the manufacture of protective masks made it possible to preserve 92% of pre-crisis revenue, increase the share of external revenue, and improve the integrated resilience assessment from 0.39 after the shock to 0.81 following the implementation of anti-crisis measures.

The scientific significance of the article lies in the fact that stress testing is examined as a method for the quantitative assessment of a business system rather than as a merely formal description of risks. The developed methodology is universal in nature and is recommended for application across various types of organizations. The practical significance of the obtained results lies in the possibility of applying the proposed indicators to enterprises operating in different industries, since the methodology may be used for preliminary diagnostics, the selection of anti-crisis measures, the assessment of production repurposing, and the justification of managerial decisions under crisis-related constraints.

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