

# Measurement and Influencing Factors of Export Resilience: From Material Mechanics to International Trade

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**Abstract:** The concept of resilience comes from the field of physics and refers to the ability of an object to resist damage under external forces. Nowadays, resilience is widely applied in engineering, ecology, psychology, and economics, especially in the field of international trade. Export resilience has become a hot research topic. However, how to measure export resilience and find the influencing factors of export resilience has become an urgent problem for relevant scholars to solve. This article first combines the theoretical knowledge of materials mechanics and economics in the field of international trade, and constructs the inherent connection between the two; In addition, this article proposes measurement methods and principles for three dimensions of export resilience; Finally, this study combines the theories of material mechanics and international trade to analyze the three major factors that affect export resilience, providing a basis and analytical approach for other studies.

**Keywords:** Material Toughness; Export Resilience; Comparative Advantage; Product Relevance.

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## 1. Introduction

The concept of "toughness" originates from classical physics and Old English "toh", which means "strong texture, toughness, and strong viscosity". Griffith (1921), the father of fracture mechanics, defined toughness as the ability of a material to resist failure under instantaneous loading [1]. A similar concept to resilience is Resilience, which means resilience. However, in Chinese related research, it is sometimes translated as resilience. The term originates from the Latin word "resilio" and refers to the ability and speed of a system to recover to a state before impact or interference occurs [2]. This article will first introduce the concepts of toughness in the fields of materials mechanics and economics in international trade, search for their connection, and then propose a measurement method for export toughness based on the theory of materials mechanics, and use economic theory to analyze the influencing factors of export toughness.

## 2. The Concept and Evolution of Resilience

### 2.1. "Toughness" in Materials Mechanics

In material mechanics, toughness is defined as the ability of a material to resist failure. In material mechanics, the material first resists deformation after being subjected to an external force, and the deformation that can be fully restored when the external force disappears is called elastic deformation. This stage is called resilience in material mechanics. But if the external force continues and the material exceeds its elastic limit, the irreversible deformation that occurs is called plastic deformation. Material mechanics believes that the material undergoes plastic deformation after elastic deformation and has toughness until it is destroyed. Therefore, Toughness includes Resilience.

### 2.2. Resilience in International Trade

The concept of resilience began in physics, went through

engineering resilience, ecological resilience, and evolutionary resilience, and ultimately reached economic resilience, refined to the field of international trade, before the concept of export resilience emerged. According to Martin (2012), a representative figure of the evolutionary school, the economic system should resist crises in the short term and recover from them, while in the long term, it should achieve self-renewal and reorientation through innovation and learning[3]. Therefore, export resilience should also be defined as the ability of exports to resist, recover, and improve under shocks.

### 2.3. The Intrinsic Connection between the Two

The "resilience" used for export toughness is actually the stage of elastic deformation in material mechanics. During this stage, the material first resists elastic deformation under external forces, which is called stiffness in material mechanics. Correspondingly, it refers to the ability of exports to maintain stability under external shocks (such as the 2008 financial crisis and Covid-19), which is called export resistance. In the elastic deformation of material mechanics, the material can recover to its original state after being subjected to force, corresponding to the outlet returning to the level before the impact, which is called the outlet restoring force. However, material mechanics can only explain the restoration of materials to their original state, but it cannot explain the phenomenon of exports exhibiting greater performance than before after complete recovery under impact. This is also known as transformational lifting force, which is explained by the evolutionary school as the ability of exports to break through the growth path before impact [4].

## 3. Principles and Methods for Measuring Export Resilience

### 3.1. Principles for Measuring Export Resilience

Based on the toughness theory of material mechanics, this article believes that the measurement principle for export

toughness should be to first measure the export resistance, and then measure the export recovery force after the export decline ends. The two cannot be confused like some studies, and of course, they cannot only emphasize the recovery ability [5] or resistance ability [6], but rather the unity of the two in the short term. In the long run, it is necessary to step out of the field of material mechanics and measure the unique transformation and upgrading power of the economic system.

### **3.2. Measurement of Resistance**

In material mechanics, an object first resists elastic deformation after being subjected to force. The stronger the resistance, the greater the stiffness of the material, and the less likely it is to undergo elastic deformation. Therefore, the measurement of export resilience resistance should be the degree to which the export value of a region, city, or enterprise deviates from the level of export value at the time of the impact event. In other words, the less the decrease, the stronger the export resistance. But the measurement stage of resistance should be when exports begin to decline until they begin to recover, which represents the ability of export value to resist the decline.

### **3.3. Measurement of Recovery**

In material mechanics, resilience represents the amount of energy that a material can absorb during elastic deformation, which means that the greater the product between the magnitude of the force and the degree of elastic deformation, the better. However, the greater the degree of elastic deformation, the slower the recovery time. The optimization problem in economics requires the export system to have the ability to recover quickly. Therefore, to measure the resilience of exports, the export system should start to recover until it reaches the level between shocks. The degree of export deviation during this period is divided by the time taken to obtain the recovery speed, which is used to measure the resilience of exports.

### **3.4. Measurement of Transformation Enhancement Power**

The measurement of transformation and upgrading power requires measuring whether the growth path has changed after exports have fully recovered to their original level. If the growth rate remains the same after complete recovery, then its transformation and upgrading ability is weak. If a breakthrough can be achieved, it indicates that its transformation and upgrading ability is strong. The measurement method is to measure how much the export volume exceeds the original level.

## **4. Factors Affecting Export Resilience**

After obtaining a measurement method for export resilience, this article begins to discuss the factors that affect export resilience in combination with economic theory. From the perspective of the measurement process, the factors that affect export resilience are nothing more than the factors that affect export growth rate. This section discusses its impact on export resilience from three aspects: trade comparative advantage, related diversity, and technological innovation level.

### **4.1. Comparative Advantages in Trade**

According to the theory of comparative advantage in trade,

manufacturers with comparative advantages in terms of cost, price, and product quality are more willing to export, resulting in an increase in export growth rate and increased export resilience. However, under external shocks, the comparative advantages of trade from both the supply and demand sides will be affected, such as Covid-19 causing factory shutdowns or a decrease in productivity due to personnel restrictions, and an increase in production costs due to the need to meet epidemic prevention requirements, resulting in an increase in product prices. On the demand side, Covid-19 affects the income of consumers in importing countries, leading to a decrease in demand for products from exporting countries. Countries require additional hygiene and virus testing for products from exporting countries, resulting in low trade efficiency. This indicates that significant external shocks will affect trade comparative advantages from both supply and demand sides, thereby reducing export resilience.

### **4.2. Product Relevance**

According to the principles of material mechanics, the stiffness and elasticity of materials are actually external reactions that cause changes in the positions and relationships of the atoms (ions) or molecules that make up the material. When extrapolated to export toughness, they are actually the relationships between all export products in the export system. The product space theory suggests that the higher the correlation of export products, the easier it is for the knowledge and technology contained between products to be transformed, improving efficiency while creating more related products. However, a strong correlation between export products means putting eggs in one basket. Once an external shock occurs, these highly correlated export products will have a chain reaction like dominoes, amplifying the impact and dealing a fatal blow to export resistance and recovery. However, if the correlation between products is low, it means that knowledge is difficult to transfer between products and efficiency is difficult to improve. Therefore, product correlation needs to be within a reasonable range, which can ensure efficiency without expanding risks and reducing export resilience when shocks occur.

### **4.3. Technology and Innovation Level**

For the export system, investment in technological innovation will increase production costs in the short term, reduce available funds, and hinder the expansion of reproduction. For example, the funds originally used for purchasing production equipment are used for research and development investment, but due to the long research and development process, it is impossible to obtain income in the short term, which affects the increase of enterprise productivity, thereby hindering export growth and affecting export resilience. According to the theory of heterogeneous enterprise trade, technological innovation occupies a core position in improving enterprise productivity. The endogenous growth theory suggests that the increase in technology leads to the expansion of product types and the improvement of product quality. Therefore, in the long run, technology and innovation will lead to productivity improvement, expansion of export product types, and improvement of export product quality, all of which will increase long-term trade comparative advantages and enhance export resilience. Especially, the driving force of export transformation comes more from the increase of technology and innovation.

## 5. Conclusion

Overall, there is an inherent connection between export toughness and toughness in material mechanics, especially in terms of export resistance and export recovery capacity. However, for the enhancement of export transformation, it needs to be considered from the perspective of the evolutionary economics school. For the measurement of export resilience, it should be gradual, first measuring resistance, then measuring recovery ability after exports stop declining, and finally measuring transformation and upgrading ability when exports recover to the level before the impact. Based on the relevant theories of international trade, export resilience is influenced by trade comparative advantages, export product relevance, and technology and innovation levels.

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