Modeling Market Distortions and Moral Hazard

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Abstract

This paper explores the methods of modeling market distortions and elements of moral hazard. It also puts forward a ***Collision Balls Theory For Economics*** whereby the economy can be modeled as space where balls of different speeds, sizes and trajectories interact with one another to give out an aggregate speed/growth rate of an economy.

1.INTRODUCTION

In any economic system, the interaction between market forces and individual behavior plays a vital role in shaping the overall health and stability of the economy. However, the presence of market distortions and moral hazard introduces complex dynamics that can have far-reaching implications for market participants and society as a whole. These phenomena have gained significant attention from economists and policymakers alike due to their potential to disrupt efficient resource allocation, increase systemic risks, and erode the fundamental principles of fairness and responsibility.

Market distortions and moral hazard have profound implications for economic systems. Distortions occur when external factors disrupt supply and demand dynamics, leading to resource misallocation. Moral hazard arises when individuals or entities are shielded from consequences, encouraging risky behavior. These phenomena disrupt efficient resource allocation and increase systemic risks, eroding fairness and responsibility, [1].

Understanding their implications is crucial for policymakers and participants. This paper explores the relationship between market distortion and moral hazard, analyzing their impact on economic performance, inequality, and market efficiency. Through literature review and case studies, vulnerabilities are identified, and policy measures proposed to enhance resilience and restore market integrity.

In the third chapter, we introduce a collision balls economic theory to model how different factors factors interact to give rise to various phenomena seen in the economy.

2. Theory - Market Distortions

2.1 Aggregate Demand and Aggregate Supply Shifts

In general, price manipulation lead to shifts in the Aggregate Demand and Aggregate Supply Curves .When the price is set below/above the market equilibrium price, it can lead to a situation where aggregate demand exceeds aggregate supply and vice versa. This imbalance between aggregate demand and aggregate supply can have several effects on the economy,[2]. Some are :

- Shortages: With the price set below the equilibrium, the quantity demanded exceeds the quantity supplied. This results in shortages, as consumers demand more goods and services than what producers are willing or able to supply at that price level. Shortages can lead to unfulfilled consumer demand and potentially create imbalances in the economy.
- Inflationary pressures: Despite the presence of shortages, the high level of aggregate demand can create upward pressure on prices. As consumers compete for the limited available goods and services, sellers may raise prices to capture higher profits. This inflationary pressure can erode the purchasing power of consumers and introduce instability into the economy.
- Black market activity: When the price is artificially suppressed, it can create incentives for illegal activities, such as the emergence of black markets. Sellers may seek to sell goods and services at higher prices on the black market to take advantage of the increased demand. This can undermine formal market mechanisms and lead to inefficiencies and distortions.
- Allocative inefficiency: When the price does not reflect the equilibrium level, resources may be misallocated in the economy. Producers may not have the appropriate resources to facilitate production

2.2 Moral Hazard

Moral hazard is a concept in economics and finance that refers to the potential distortion of behavior and decision-making when individuals or entities are protected or insulated from the full consequences of their actions. In the context of the economy, moral hazard can have a significant influence on price dynamics,[3]

One way moral hazard can impact prices is through its effect on risk-taking behavior. When individuals or firms believe that they will be shielded from the negative consequences of their actions, they may be more inclined to take on excessive risks. This behavior can lead to increased volatility in markets, as participants are emboldened to engage in speculative activities or pursue ventures with higher potential returns but also higher risks. The presence of moral hazard can distort market mechanisms by encouraging imprudent decision-making, which may result in price bubbles, market crashes, or other forms of price instability.

Moral hazard in the economy has consequences that influence prices in the following ways:

- Increased risk-taking: Moral hazard can lead to higher levels of risk-taking behavior as individuals or entities believe they will be protected from the negative consequences of their actions. This can result in greater market volatility and the potential formation of price bubbles.
- Reduced accountability: When individuals or firms are shielded from the full costs or losses associated with their actions, they may lack the incentive to act responsibly. This can lead to inefficient resource allocation and distortions in pricing as market participants do not bear the full consequences of their decisions.
- Distorted market interventions: Government interventions, such as bailouts or guarantees, aimed at mitigating market failures or crises can create moral hazard. These interventions can distort price mechanisms by signaling that participants will be protected from losses, leading to mispricing of assets or goods.

3. Modelling

3.1 Collision Balls Economic Theory

In this chapter, I'll introduce the 'Collision Balls Economic Theory' which can also be called **Pseudo-Brownian Motion economic model** for Macroeconomics modelling.

This model was inspired by the Brownian motion of particles but rather than having particles with roughly uniform sizes and distribution, we can visualize the economy as being a space where there are different balls bouncing of each other. Some are rising while other are falling or moving in a horizontal direction. The collisions of the balls, in essence determine the trajectory of an business or sector.

Generally:

1. There is a rate R that represents the general growth(upward pull) of the system relative to some economic growth indicator r
2. The parameter G represents a downward economic pull inherent in the system. This can be attributed to psychology, competition outside the system and other negative pull factors.
3. There is a growth rate k where if $r = k$, the system is stagnant i.e $R - G = 0$ and that if $r < k$ then the system is growing negatively.
4. The parameter h denotes the height which represents the growth rate.

In an environment where $G = 0$ for some $r = r_1, r_2, \ldots, r_n$ then for some ball i,

$$\frac{dh_i}{dt} = \begin{cases} R & \text{with } R \propto r \\ \\ R + \sum_{j \neq i} F_{ij} = R + \hat{F}_i \\ \end{cases}$$

F_{ij} is :

$$F_{ij} = \frac{G \cdot m_i \cdot m_j}{|h_i - h_j|^2} \cdot \text{sgn}(h_i - h_j) \cdot \text{sgn}(\dot{h}_i - \dot{h}_j).$$

If $G \approx 0$ there's a need to use $\hat{F}_i$. The notation ***sgn*** above is indicating the direction after collision.

Suppose that now that G is a non-zero parameter then we would have something like :

$$\frac{dh_i}{dt} = R + \sum_{j \neq i} F_{ij}$$

To generalize the differential equations for all the balls in the system, we can use the index i to represent each individual ball. Here's the generalized form of the differential equations and incorporates our k value defined previously:

$$\frac{dh_i}{dt} = \begin{cases} R + (G - f(r_i)) + \sum_{j=1}^{n} F_{ij} & \text{if } r_i > k \\ 0 & \text{if } r_i = k \\ R - (G - f(r_i)) + \sum_{j=1}^{n} F_{ij} & \text{if } r_i < k \\ \end{cases}$$

where

- - $i = 1, 2, \ldots, n$ represents the index of each ball in the system.

  - h_i represents the height of ball i above a reference point.

  - $\frac{dh_i}{dt}$ represents the rate of change of height of ball i over time - R represents the average rate of ascent of the system.

  - G represents a downward force acting on the balls.

  - $f(r_i)$ represents a function that determines the proportionality in the upward motion, which can be specific to each ball i.This can be used represent something like the Aggregate Demand per capita driving the particular ball.

  - r_i represents the rate of ascent of ball i (i.e., the upward velocity).

  - k represents a threshold value for the rate of ascent, beyond which the system behaves differently.

- $\sum_{j=1}^{n} F_{ij}$ represents the cumulative effect of collisions and interactions with other balls in the system.

Macroeconimcs

To represent this, a generalized form of the differential equations for all the balls(the system as a whole) can be put as :-

$$\frac{dH}{dt} = R - (G - f(r_{\text{avg}}))$$

where :

- - R can be used to represent the Aggregate Demand

  - $f(r_{\text{avg}})$ is the average ball collisions and represents market activities like internal-competition, trade and innovation

  -G - the macroeconomic constant

  -H could be taken to represent the general height of the system- the net growth .

we can further generalize this into

$$\frac{dH}{dt} = R - \hat{G}_{\text{avg}}$$

Market Distortions

Consider that we have a market Distortion D, the result is :

$$\frac{dH}{dt} = R - \hat{G}_{\text{avg}} \pm D$$

Since the market distortion affects the average growth rate of the system and also the general interaction of the micro-economies(the balls) in the system, then we can define two functions $f_1(D)$ and $f_2(D)$ for each.

This then yields:-

$$\frac{dH}{dt} = (R - f_1(D)) - (\hat{G}_{\text{avg}} - f_2(D))$$

Observations

1. If $\hat{G}_{\text{avg}}$ represents a declining economy as a result of a shock, somehow the growth rate r, with $r \to k$, a good market distortion would require that $f_2(D) > f_1(D)$. This would give a positive net change.

2. Unintended consequences - On average the goal of a policy made is to stimulate R but following closely from (1) above is that :-

- i. The excerise impacts more the microeconomics(the i) as a result, since $\hat{G}_{\text{avg}} = (G - f(r_{\text{avg}}) - f_2(D))$, this can be turbulent in a delicate ecosystem.
- ii. An inefficient Distortion D can lead to a situation of negative growth i.e for $f_2(D) < f_1(D)$

Another Moral Hazard situation can be modeled by introducing a dampening function, Ψ whereby the system experiences a drag due to enterprises which are neither essential nor social to warrant their existence even when $k > r$ but continue to operate and even even grow. This means that resources have to be diverted from elsewhere, making the value of $\hat{G}_{\text{avg}}$ grow drastically.

$$\frac{dH}{dt} = R - \hat{G}_{\text{avg}} - \Psi$$

Other Models

3.2 Using Differential Equations of Demand and Supply Curves

Traditionally, this is the mainstream model in econometrics and applied mathematics .Let's consider a simplified model with a single product and assume that the demand and supply functions can be represented by differential equations, [4]

The demand function can be represented as:

$\frac{dQD}{dt} = f(P)$

The supply function can be represented as:

$\frac{dQS}{dt} = g(P)$

In these equations, QD represents the quantity demanded, QS represents the quantity supplied, P represents the price, and t represents time.

At market equilibrium, the quantity demanded equals the quantity supplied:

$$QD = QS$$

market distortion caused by a price alteration P_a:

$$P = P_a$$

We can incorporate these conditions into the differential equations:

$$\frac{dQD}{dt} = f(P_a)$$

$$\frac{dQS}{dt} = g(P_a)$$

By solving these differential equations, we can analyze the impact of the price ceiling on the rate of change of quantity demanded and quantity supplied over time.

This differential equation model provides a framework to understand how market distortions, introduced by a price alteration, affect the dynamics of quantity demanded and supplied. Further analysis and integration of additional factors, such as elasticity of demand and supply, can provide a more comprehensive understanding of the effects of market distortions on equilibrium dynamics and market efficiency.

3.3 Using Reliability Theory

Reliability theory is a branch of mathematics that deals with the analysis and modeling of the reliability or failure characteristics of systems and components. It provides mathematical tools and techniques to quantify the probability of a system or component functioning correctly over a specified period of time, [5].

Typically it normally involves :

1. Failure Probability (P): The probability that a system or component will fail within a given time period.
2. Reliability Function (R(t)): The probability that a system or component will function without failure until time t.

3. Failure Rate λ: The rate at which failures occur in a system or component, typically expressed as the number of failures per unit of time.
4. Mean Time to Failure (MTTF): The average time duration that a system or component functions correctly before experiencing a failure.
5. Hazard Function (h(t)): The instantaneous failure rate at time t, given that the system has survived until time t.
6. Reliability Block Diagrams: Graphical representations of a system's reliability model, allowing for analysis and calculation of overall system reliability based on component reliabilities and interconnections.

In an economic scenario, we can segment it in sectors, s_i, with $s = s_i$ called a state vector which indicates whether the component is functioning or not.

Furthermore we can define a function $f(s)$ which will tell us on aggregate whether a system is functioning basing on **s** above

In theory there are 3 types of structures:

- **i. Series Structure** This one only if and only if all of its components are functioning. Hence, its structure function is given by

  $f(s) = min(s_1, ..., s_n) = \prod_{i=1}^{n} s_i$

  This is not ideal in an economic state because one sector can collapse or slump in growth and not affect the rest of the economy

- **ii. Parallel Structure** A parallel system functions if and only if at least one of its components is functioning

  $f(s) = max(s_1, ..., s_n) = 1 - \prod_{i=1}^{n}(1 - s_i)$

  This is somehow not ideal in an economic state, we need more than 1 sector to function in our economy.

- **iii. k out of n Structure** This system functions if and only if at least k of the n sectors are functioning

  This is the best structure when it comes to modeling in an economic system , we have the liberality to choose our sectors and study them as we choose.

Example : a 2 out 4

Consider an economic system consisting of four sectors, and suppose that the system works if and only if components 3 and 4 both function and at least one of components 1 and 2 function. Its structure function is given by

$$f(s) = s_3 s_4 max(s_1, s_2)$$

Using the previous formuale for $max(s_1, s_2)$ then.

$$max(s_1, s_2) = 1 - (1 - \prod_{i=1}^{2}(1 - s_i))$$

$$max(s_1, s_2) = 1 - (1 - s_1)(1 - s_2) = s_1 + s_2 - s_2 \times s_1$$

hence

$$f(s) = s_3 s_4 (s_1 + s_2 - s_2 s_1$$

To make a generalization of our economic model, we can sort into two classes - those that must work, say k and a select others, $n - k$ which are optional. This gives the following equation for such a system.

$$f(s) = \prod_{i=1}^{k} s_i \times (\sum_{j=k}^{n} s_j - \prod_{j=k}^{n} s_j)$$

With this we can easily do any reliability problem including the example given

The reliability of the economic system be defined by r or $r(p)$ which simply mean the probablity that $f(s) = 1)$ i.e that our economic system is working.

$$r(p) = P\{f(s) = 1\} = E(f(x))$$

Suppose that our variables i have a distribution Z with reliability function $r(p)$, then we can let Probability that the lifetime of i is greater than t be $\bar{Z}_i(t)$. If it is continuous(a distribution where the random variable can take on any value within a specified range) then,

$$\lambda(t) = \frac{\frac{dZ(t)}{dt}}{\bar{Z(t)}}$$

where $\lambda(t)$ is the failure rate function. With this we can integrate for the hazard rate and model Increasing Failure Rate models.

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