



Designing a dynamic foreign trade system model to investigate the effect of customs during the Covid 19 Disease

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ARTICLE INFO

Article history:

Date of submission: 23-04-2023

Date of acceptance: 29-07-2023

JEL Classification:

C02

C61

C63

F12

Keywords:

Foreign Trade

Dynamic System

Control Engineering

Covid-19

ABSTRACT

Today, the outbreaks of epidemic diseases such as Covid19 is one of the most important challenges that facing the world economy. Therefore, the study of the effects of epidemic diseases on the economy is of particular importance. The studies showed there is a close relationship between trade, economy and production. In this paper, we will focus on the effect of the epidemic on macroeconomics, especially foreign trade. To achieve this goal, a new dynamic system model of the supply chain in foreign trade, is mathematically modeled. In this model, the parameters affecting the macroeconomy in the field of foreign trade and domestic production have been considered. Since epidemic diseases affect market demand and factory performance, they will have a direct impact on commodity prices and trade volume. Studying this effect is important during and after the epidemic. On the other hand, this model is simulated using time-varying behavior and input with time. Using a new method and utilizing the science of control engineering, an optimal tariff estimation system will be developed. Within system, it is possible to use policymakers to make the right decision in different situations.

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DOI: <https://doi.org/10.48308/jep.4.2.279>



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1. Introduction

*I*n the age of technology, countries were in close competition in various fields. In 2019, the developing economy and technology were affected by the epidemic. General and very strict quarantine of cities and countries, and preventing the entry of citizens of different countries by the governments, which changed the economic situation. Due to this epidemic, large factories and industries were closed and imports and exports decreased, which practically failed to predict the economic policy makers. Therefore, how to control and deal with the wide prevalence of this disease, which has a high infectivity ratio, was one of the most important issues. Governments played a key role in countering Covid-19, all of which signaled a widespread epidemic of the new disease. The rapid spread of Covid-19 and the steps that governments have taken to curb it have serious consequences for the world's major economies. Many manufacturing activities have been disrupted, first in Asia and then in Europe, North America and the rest of the world, and the closure of borders has increasingly affected this issue. This led to a sharp rise in unemployment, resulting in reduced demand for goods and services. Given this, global GDP is the strongest contraction since World War II (Word Bank, 2019). The global value chain was the main channel for transmitting the effects of Covid-19 to global trade. The measures taken by China in January (temporary closure of Hubei Province and national borders) meant a suspension of inbound exports to industries such as the automotive, electronics, pharmaceutical and medical equipment industries. It forced factories in North America, Europe and other Asia to close for a few weeks because they had no other suppliers, Because China is the major exporter of parts and components in the world until 2018 and accounts for about 15% of global shipments. Since March 2020, China has gradually reopened its economy and taken steps to normalize exports. However, the initial supply shock in world trade gradually intensified with the demand shock as a result of measures to limit the expansion of Covid-19 in Europe and later in North America and the rest of the world (United Nation, 2020).

According to data released by the General Administration of Customs of China (GACC 2020). China's exports as the world's largest export economy in January to February 2020 decreased by 17.2% compared to the same period last year. With a share of agriculture in 7.19% of China's GDP (World Bank, 2019), China is one of the most important agricultural production and consumption countries in the world. Governments impose tariffs on imported goods for purposes such as revenue and to support domestic production. This tariff increases the price of imported goods, which also affects domestic prices. Some imported goods are used as raw materials and intermediates in the production of domestic goods, while others are used directly for final consumption. Which category of goods is subject to tariffs has different effects on the price index. (Sharifi and Jafari, 2016). According to the mentioned points, it is clear that the dynamism and variability with the time of the tariff, which is one of the most important parameters of foreign trade, can help countries in times of crisis. The lack of tariff dynamics as an important factor in determining the price of goods in the export and import sector has very important effects on the market. The strictness of customs, including the time of clearance of goods, the electronicity of the process of registration to clearance, and similar cases can have important effects on the increase or decrease of the price of goods in the market. Now, in order to determine the importance of decisions at the macro level in order to achieve the maximum increase in the exchange of goods and the reduction of the price of basic goods, we can mathematically model the trade system using the system dynamics method. Countries with electronic customs with a coherent structure will perform much better in this situation. Policy makers can make correct decisions based on the behavioral systems of trends by relying on their arguments and defining different scenarios. One of the advantages of such systems is the ability to run even with very little initial data to determine the trend, but it has the ability to adapt to real conditions.

This article consists of six parts. In the first part, the problem is stated, then in the second part, the research records are examined, in the third part, the

mathematical modeling of the epidemic and the dynamic system of foreign trade is done. In the fourth section, the mathematical controller is introduced as a regulator of the customs effect on trade facilitation and tariff rate. Then, in the fifth section, the computer simulation is discussed using the scenario applied to the model, and the conclusion of the article is discussed in the last section.

2. Theoretical literature and research background

In general, one of the important control items in the field of foreign trade is tariffs. Nevertheless, there are positive signs. In the midst of the Corona pandemic, the EU has temporarily abolished tariffs and VAT on free imports of goods by government or charities, as well as disaster relief agencies involved in fighting the epidemic. In addition, some countries have imposed export restrictions on certain items, such as medical supplies. The European Union (EU) has banned the export of medical equipment to destinations outside the EU without a license. Items including mouth, nose, gloves and other protective clothing, goggles and face shields, but as of April 26, 2020, only masks fall into this category. Member States will be required to consult with the European Commission when assessing the issuance of export licenses or export licenses for emergency supplies required for humanitarian aid. (Hood, 2020)

Trade and services in the economy are mainly affected by the epidemic. Quarantine measures have a negative effect on the volume of exports and imports, meaning that they have a negative impact on the economy (a decrease in exports means a decrease in the supply of currency, while a decrease in imports means a decrease in tax revenue. (Nordea, 2020). Exporting countries face additional challenges as trade and exports deteriorate as countries become more isolated. With the strengthening of long-term quarantine measures, the risks of devaluation of the national currency may also be predicted in the currencies of countries with significant balance of payments deficits (Ukraine, Moldova, Belarus). In the end, the deficit may widen due to the negative trend in exports, as these countries are heavily dependent on capital inflows, which have become increasingly

scarce in the epidemic. Prolonged mass quarantine is causing a recession in the economies of Eastern European countries that are unable to withstand harsh measures such as authoritarian China. Therefore, we can assume that the quarantine epidemic there will be longer and the economic crisis will worsen. Wealthy western countries will be able to borrow large sums of money and create tax incentives, but many emerging markets (including Eastern Europe) will not be able to do so. (Vasiljeva et al.,2020). Budget cuts require tighter fiscal policies, a deepening recession and timely and effective preventive measures to keep the economy afloat. The role of the International Monetary Fund (IMF) and other international lenders will also play a role (Vasiljeva et al.,2020).

In recent decades, the use of interdisciplinary methods for forecasting, behavioral and other science processes, especially in the field of engineering and economics, has become more widespread. One of the most well-known sciences that is used in most scientific and industrial fields is control engineering. Methods such as system dynamics are very important tools to be used in this regard. Today it is used to solve problems in a variety of academic disciplines, including economics (MICHAEL,2008). In dynamic system modeling, the ((real)) behavior of the underlying system is conceptualized and manifested over time. Similarly, mathematically, a system dynamics model is a typical differential equation model. Differential equations are used to approximate the solution of the model of ordinary continuous time differential equations in digital (discrete) computers. Unlike traditional differential equation modeling in economics, where an increase in time is chosen to match economic data, an increase in time is available in modeling the system dynamics to provide an accurate solution to the chosen problem (MICHAEL,2008).

A joint study between control engineering and economics by Arya Alasti et al. In 2009 discussed the turmoil in corporate sales systems in the economy, which has been able to achieve good results by using the development sliding mode method. However, this method has a poorer performance compared to standard sliding mode control. In this paper, the problem of controlling chaos

in uncertain economic models is investigated. For this purpose, a delayed slip-mode controller has been used to stabilize the unstable fixed points of the economic system. In 2014, Hawkins et al. Noted the similarities between PID controllers and macroeconomic regulation policies in the use of central banks (Hawkins, 2014). This article does its job with another type of control: Full-mode feedback. Full-mode feedback offers several key advantages over other control strategies in that it allows the user to control the behavior of derived parameters and allows the direct adjustment of various system features such as pole position. The proposed method is based on economic law by Taylor, a contemporary economist. (Taylor,1993a). Now, due to the proximity of the PID controller function, and since most PID controllers are set in place, various methods have been proposed for the rules for setting them in the text. By applying these tuning rules, PID controllers can be skillfully and accurately tuned in place. Auto-tuning methods have also been developed, and some PID controllers may have on-line auto-tuning capabilities. The usefulness of PID controls in features is their general application in most control systems. Using analytical design, PID controls have become very useful (Ogata, 2009). In 2020, Arasteh Rad and Badi used control methods in an article entitled controlling the expansion of Covid 19 and by introducing parameters and matching with reality, they were able to model a pandemic expansion in Malaysia to model, (ArastehRad and Badi, 2020). Also the wind in the reference (Badi et al., 2021) using an import-based model was able to control tariffs to support domestic production. One of the improvements in this research compared to previous works is to consider the complete model of import and export. In recent decades, mathematical models in epidemiology have been an important tool in analyzing the spread and control of infectious diseases. The dynamic complexity of each disease dictates the use of simple mathematical models to gain insight into the spread of disease and to test control strategies (Brauer And Castillo, 2011), since the first application of optimal control in biomedical engineering was in the 1980s (Naidu And Other, 2011), several vaccination strategies for Infectious diseases have been

successfully modeled as optimal control problems. So-called computational models have been widely used in this field.

3. Modeling

In this article, using the SEIR model (Labadin And Hong, 2020), we will discuss the creation of a control solution using mathematical tools:

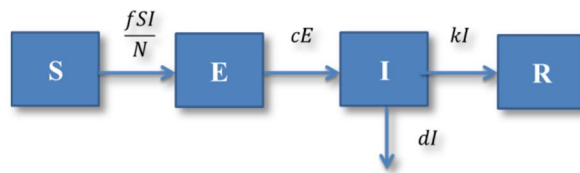


Fig.1 SEIR model based on reference (Labadin and Hong, 2020)

The transmission model is based on the epidemiological aspects of the disease. (Labadin and Hong, 2020):

- In this study, the Malaysian population is divided into SEIR models, which consist of four parts: susceptible (S), exposed (E), infected (I), and recovered (R). And the population is assumed to be unchanged. It is assumed that at first the whole population is susceptible, hence $S_0 = N$.
- Due to the growing number of cases around the world in a short period of time, the disease is assumed to be contagious enough.
- Birth and natural death rates have not been seen in this model.
- It is assumed that 2019-nCoV is capable of transmitting between humans.

Differential equations (equations (1) - (4)), which describe the dynamics of 2019-nCoV in the human population, are formulated based on a diagram first described in Figure (1). (Labadin and Hong, 2020)

$$\frac{dS}{dt} = -\frac{fSI}{N} \tag{1}$$

$$\frac{dE}{dt} = -\frac{fSI}{N} - cE \quad (2)$$

$$\frac{dI}{dt} = -cE - dI - kI \quad (3)$$

$$\frac{dR}{dt} = kI \quad (4)$$

In the above figure model, since zero of the patient may be infectious and moving and freely interact with susceptible humans, therefore, susceptible humans are exposed to this disease at the rate of transmission (f). After exposure, the latent period begins, and after this period, these infections and contaminants are then transferred to the infected area at a rate of (c) and when they recover from the disease, they are transferred at an improved rate (k).

Once exposed, the incubation period begins, and after this period, these motions and groups that are exposed to contamination are transferred to the infected part at a rate of (c) and when they recover from the disease, at a rate of (k). Are transferred to the improved part. However, there are some contaminated items that may die due to disease with a certain rate (d), (Labadin and Hong, 2020) and (Biswas and Pavia, 2014).

3.1. Mathematical model of foreign trade

Dynamic model of domestic production support using the model presented by (Arsham,2013),(Razin And Vosgerau,2011) and (Katayama And Ursprung,2012), taking into account the temporary factors in international trade based on equations (5 to 8) Dynamics The government budget shows the demand curve, import profits and smuggling profits. According to the introduced regulations, the amount obtained from the equations, which includes customs duties and taxes, will be allocated to the state budget.

$$S = \tau qy + sxp + \alpha zp + \tau_{exp} \cdot X \cdot e \cdot p_{exp} \quad (5)$$

$$p(x + y + z) = M \quad (6)$$

$$D = y(p - q - \tau q) \quad (7)$$

$$G = z[(1 - \alpha)p - q] \quad (8)$$

α the effectiveness of customs, p the price of the product within the country, x the amount of domestic production, y the amount of import of goods, q the price of the product abroad, y the volume of imports and z the volume of smuggling, X the volume of exports, p_{exp} the price of goods abroad, e The exchange rate in the domestic market (for simplicity we consider its rate constant (1)). M A fixed amount that people pay for a given product and no substitute for imported goods, D Import profits, the purpose of such regulations is often revenue from taxes and customs payments or the growth of the domestic production sector in sales volume. Customs duties are called tariffs τ , VAT is set as s and export tax τ_{exp} . G The profit from the import of goods is smuggled. E The profit from the export of goods is considered abroad. Motives for changing the volume of domestic production can be different: job creation, formation of the country's export potential, strengthening production related to national security, and so on. In any case, a change in the amount of domestic production and its price will depend on market conditions.

According to Equation (9), the price changes according to the demand in the domestic import sector.

$$\frac{dP}{dt} = f \cdot (Y_d - x - y - z) \quad (9)$$

In the above equation, f is the cross-sectional increase in price and Y_d is the amount of domestic demand, which is considered according to the optimal scenario.

4. Design controller

PID control is one of the most popular types of controllers used in industrial applications, and more than 90% of all controllers enforce PID or PI (unproductive) regulations.(Åström And Hägglund, 2004-2006) Therefore, a desired state (ie, a set of points, reference, target) indicates the ultimate goal of the adjustment process.

PID controllers are based on closed-loop strategies with negative feedback mechanisms that track the actual state of the environment. In the most traditional implementation of negative feedback methods, the difference between the measured mode of the variable for adjustment (such as real temperature in a room) (e.g., real temperature in a room) and the target value (For example, 25° C) creates a prediction error that minimizes the controller output, e.g. If the temperature is too high, it will decrease and if it is too low, it will increase. Mathematically, we have the error as equation (10):

$$e(t) = I_r - I(t) \tag{10}$$

Where $e(t)$ is an error, y_r is the reference or setting point (for example, the desired temperature) and $y(t)$ is the observed variable (for example, the actual room temperature). This mechanism is unstable under very normal conditions, especially when a steady state compensation is added (such as sudden, unpredictable changes in external conditions that affect room temperature that we do not control) or when fluctuations are needed. Suppressed (such as over-oscillations, while temperature regulation may be undesirable). PID controllers Add shape 1 to the standard negative feedback architecture, here called the so-called P term, with an integral or I and derivative or term D, beautifully dealing with both problems, see Figure 1. Accumulates predictive error over time to deprive errors due to unstable input from computational mode, while minimizing predictive error derivatives leads to a reduction in the range of fluctuations of the controlled signal. The general shape of the $u(t)$ control signal generated by a PID controller is usually determined by Equation (11).

$$u(t) = k_p e(t) + k_i \int_0^t e(\tau) d\tau + k_d \frac{de(t)}{dt} \tag{11}$$

In the above equation $e(t)$, the prediction error and k_p, k_i, k_d are proportional, integral, and derivative, respectively, a set of parameters used to regulate the relative resistance of conditions P, I, and D. It can be said that the popularity of PID controllers is largely due to their simple formulation and implementation. Another important challenge is to adjust the parameters k_p, k_i, k_d , which must be compatible with the various (often contradictory) limitations in the adjustment process. (Åström And Hägglund, 2001) And (Åström,1995).

In Figure (2) we see a complete model of the foreign trade system, most of the factors involved in this system include import, export, government budget, VAT, domestic demand, foreign demand, domestic commodity prices, active population model and disease Covid-19 which affects the system indefinitely. Control engineers use robust control methods to deal with such uncertainties. In these methods, the system is prepared to deal with the most difficult conditions.

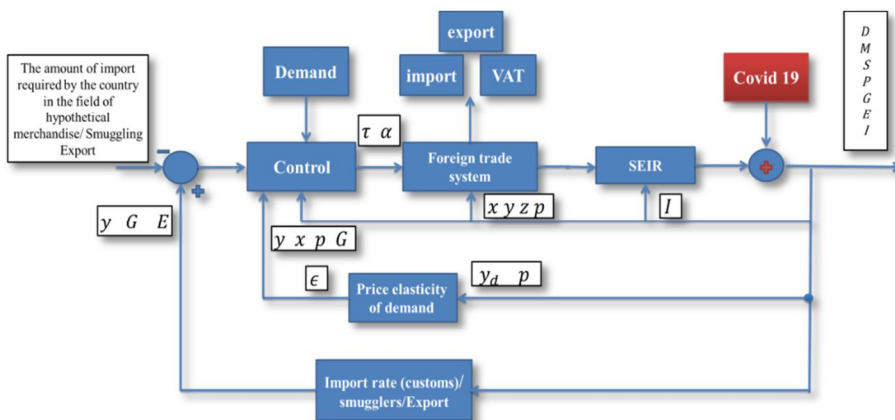


Fig 2. Dynamic system of foreign trade with uncertainty

5. Simulation

For simulation we use the Simulink toolbox of MATLAB 2017 software, the controller acts as a decision maker (government). The executive tools of this issue are the executive apparatus within a country such as the Ministry of Economy, Customs and related organizations. It should be noted that in real circumstances, costly decisions cannot be made because it may have economic and social consequences. That is, a controller with a high control effort becomes practically useless.

The first confirmed case of Malaysia infection started on January 23, 2020 when returning from Singapore.(The Star,2020) Therefore, the initial time of January 23, 2020 is considered positive. In Tables (1, 2 and 3) we see the fixed and initial parameters of the SEIR model, the parameters of the foreign trade model and the controller, respectively.

Table 1. Parameters of the SEIR model

Parameter	Title	Value	Reference
N	Total human population	32600000	(DOSM,2019)
$\frac{1}{c}$	Incubation Period	6.5	(Backer et all,2020)
f	Transmission rate of I to S	1.07	(Read et all,2020)
$\frac{1}{k}$	Infectious Period	3.6	(Read et all,2020)
d	Death rate of 2019-nCoV	0.03	(Labadin & Hong,2020)
E_0	Exposed	0	(Labadin & Hong,2020)
I_0	Infected	1	(Labadin & Hong,2020)
R_0	Recovered	0	(Labadin & Hong,2020)

Table 2. Foreign trade model parameters

Description	Symbol	Value
Production Rate	x	5500000
Initial Demand	Y_{d0}	Based on the rate of infection and susceptible individuals
Tax	s	0.01

Description	Symbol	Value
Product Prices Abroad	y_0	200000
Initial Price Of The Product in The Country	p_0	400000
Proportional Controller Gain	P	0.0001
Integral controller gain	I	0.001

Arastehrad and Badi (2020)

Table 3. Controlling parameters

Assumption	Parameter	Value
Equivalent to the early implementation of government protection policies	k_p	0.1
Ability to implement and quickly adapt to the application of tariff policy	k_i	0.1
Customs effect coefficient	α	0.1,0.5,1

- Simultaneous impact of customs facilitation and tariff control on foreign trade during epidemic outbreaks

One of the highlights of the epidemic is the disruption of foreign trade. Therefore, the need for adaptability of customs processes and timely variability in terms of factors affecting foreign trade is very important. Using the coefficient of influence of customs on the dynamic model of foreign trade, the effect of this parameter in different conditions on the model is measured and then by applying the initial input, we will consider the behavior of the system to examine this effect. The coefficient of customs effectiveness is the set of activities resulting from trade facilitation and the provision of services for the transfer of goods. As can be seen, this factor directly plays an important role in motivating the smuggling of goods. For this purpose, by considering the coefficient (α) in different ways, we will examine its effect on the system. In addition, we consider a scenario based on control engineering. The use of the controller according to the section is used to control the coefficient of customs effect and customs tariff.

As can be seen in Figure (3), in accordance with the application of the initial conditions of the table, by applying a coefficient of 0.1, which is the

lowest rate of customs impact, the amount of smuggling of goods and profits from it has increased over time. This indicates that if the role of customs in foreign trade is reduced, the desire to smuggle goods will gradually increase, which will hit domestic production. Considering the coefficient of 0.5, the amount of smuggling is significantly reduced. This issue is quite evident by choosing the coefficient of 1. Of course, it should be considered that increasing restrictions and enforceability without and maximum implementation of laws requires a very coherent device, up-to-date information systems that can support customs as an economic frontier, taking into account all these interpretations and using The control engineering method was applied to the legal control design according to the possibility of fulfilling the maximum number of orders in accordance with

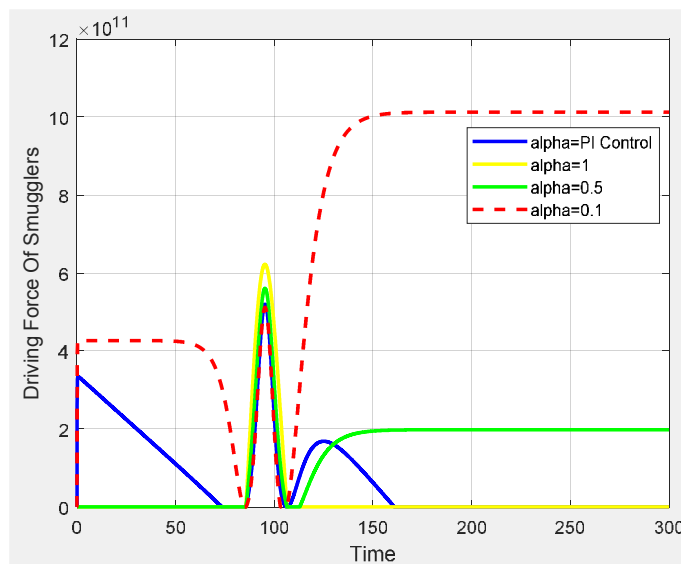


Fig 3. The rate of smuggling of goods by applying different coefficients of customs effect on foreign trade

Source: research findings

the conditions of the desired business system. The mentioned controller operates in the tariff and efficiency department of the customs and acts with the most optimal control effort to guide the system. To a large extent, the control effort is definitely not feasible in practice, so the controller makes an important decision regarding tariffs and customs effectiveness by having information on the initial conditions and output. As it can be seen, after the beginning of the system's operation, the amount of desire for trafficking has gradually decreased, however, this reduction does not enter the system as a shock, and considering the optimal conditions, the correct decision is made to apply to the system.

Also in the government's revenue budget, given the importance of customs effectiveness, the government should use its policy to comprehensively support the correct customs policies (Figure (4)).

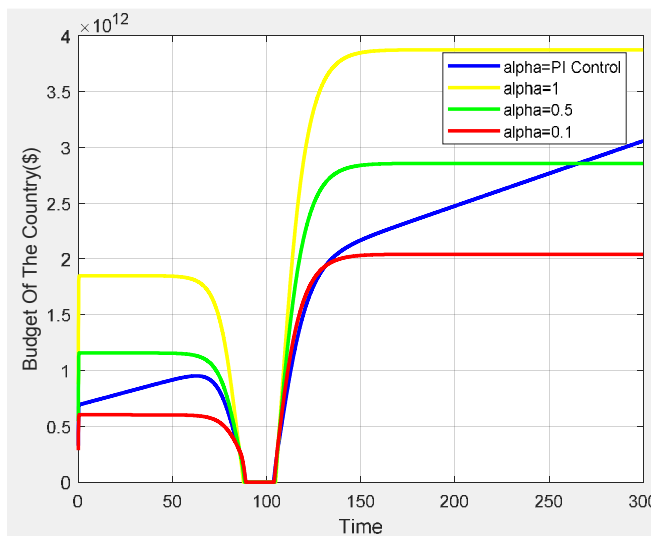


Fig 4. The amount of government revenue when changing laws and the effectiveness of customs

Source: research findings

In Figure (5-a and b) we see the rate of tariff changes and the effect of customs on foreign trade, respectively. As can be seen, the tariff has a low rate due to the prevailing market conditions in the early days of the outbreak, but due to the prevalence and pandemic of the virus, we are witnessing an increase in imports for some goods due to a decrease inside. Which is regulating policies with the aim of supporting domestic production, after controlling the rate at the highest rate in order to motivate the domestic producer to have more quality and increase competition will control the rate by less than 30% . The customs effect factor in the figure decreases sharply due to the increase in pandemics per 100 days, this issue is due to the trade facilitation policy in pandemic conditions, for example, some countries by creating a green path during the outbreak of Covid19 import permits Many vital goods were imported to meet demand. Therefore, in this situation, the controller has responded to this need by receiving and observing information from the relevant devices, and then in order to prevent the impact on domestic production and the desire to form smuggling, the method of determining and changing its direction has changed so that The controller's recommendation and the current situation of increasing customs strictness after the epidemic wave is very important to maintain domestic production.

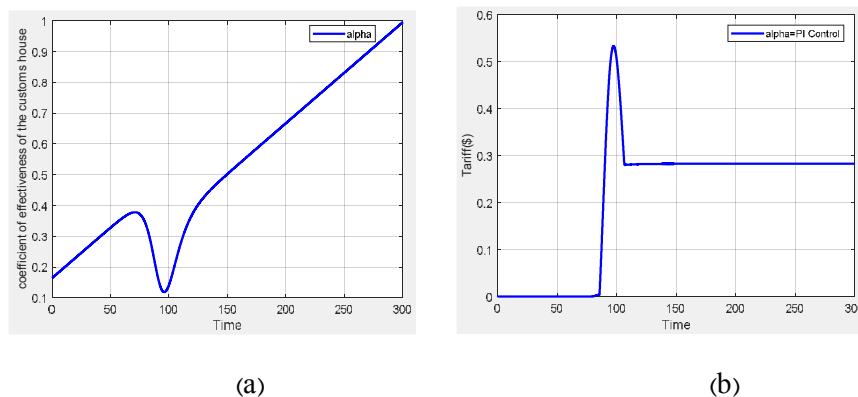


Fig 5. A) Tariff rate, B) Customs effectiveness rate

Source: research findings

In Figure (6-a and b) we will also see a change in prices based on demand, which will increase the relative level of prices after the epidemic. It is observed due to the impulse impulse to increase imports due to shortages in peak conditions. We are a country that is gradually approaching a stable state, but there is also an important point that due to the decline in domestic production due to lack of raw materials, closure and increased demand for imports of goods has increased compared to the pre-epidemic period.

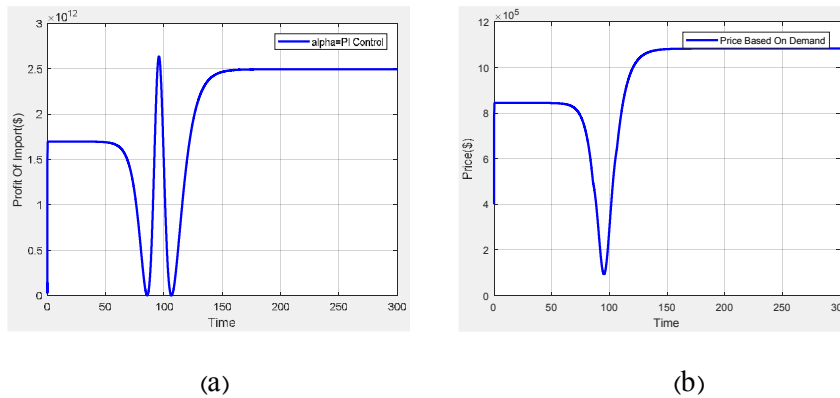


Fig 6. A: The rate of change in prices, **B:** The amount of profit from imports

Source: research findings

6. Conclusion

Customs is the economic frontier of countries and plays an important role in controlling prices, increasing trade and the level of welfare of communities. Trade facilitation is an important matter that is determined by customs. In this paper, foreign trade system modeling with a controller in the form of customs tariff system was discussed. As shown in the simulated model, in normal circumstances, customs tariffs are used as a tool to support domestic production, but this tool can also play an important role in unpredictable economic conditions such as epidemics. In this situation, the amount of demand is significantly reduced due to household involvement by the virus. Therefore, in these conditions, the price of imported goods and domestic

production decreases sharply due to the lack of applicants, but it was found that in the post-epidemic period, after the epidemic subsides the price of goods increases from the previous stable level, as well as if the customs tariff is properly proportionate. If the price of goods not changed, it could create more difficult conditions for domestic consumers. The controller that is used in this article has been able to successfully obtain the optimal amount of goods, imports and importers' profits, so customs tariffs can play an important role in macroeconomics, especially in foreign trade.

With models foreign trade and examines the effect of customs tariffs and trade speed in the context of the prevalence of Covid-19 as a strong uncertainty using the system dynamics model. The use of such mathematical tools makes it clear that countries need to develop a customs-focused foreign trade in order to achieve sustainable growth, even in difficult circumstances. Therefore, the variability and adaptability of processes with information technology tools is one of the requirements of modern customs.

Funding

This study received no financial support from any organization.

Authors' contributions

All authors had contribution in preparing this paper.

Conflicts of interest

The authors declare no conflict of interest

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