

# Integration of Soft Systems Methodology and System Dynamics Modelling for Supply and Demand Analysis of the Rising Cost in Higher Education

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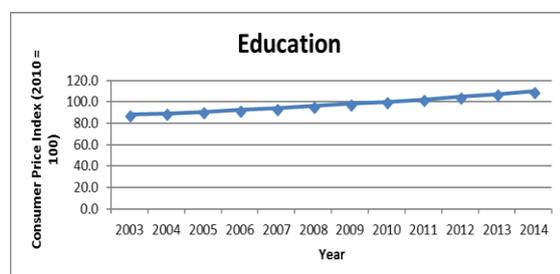
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**Abstract**— Consumer price index in Malaysia is showing the rising expenses on education. The rising cost in higher education provision is among factors that contribute to the rising expenses on education. This paper develops a model of supply and demand in higher education using the integration of soft systems methodology and system dynamics to analyse this issue. The findings from this research helps in gaining insight to understand the dynamic behaviour of supply and demand in higher education provision and the implication of the rising cost towards higher education supply and demand.

**Keywords**— Supply and demand, soft systems methodology, system dynamics, cost, higher education.

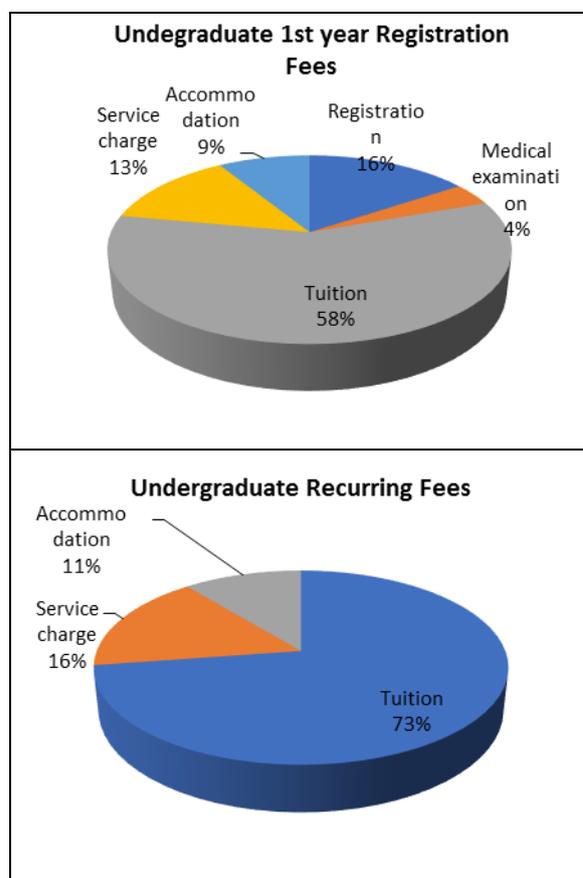
## 1. Introduction

Education is one of vital aspects in performing national building. However, the increasing cost in higher education provision is not only has become an issue in Malaysia, but also at global [1]. Figure 1 shows the rising expenses on education based on the consumer price index in Malaysia. The rising cost in higher education provision is among factors that contribute to the rising expenses on education.



**Figure 1.** Consumer Price Index (2010 = 100) by Main Groups (COICOP), Malaysia. [2]

Figure 2 shows the dispersion of the fees paid by the undergraduate student at the university under study. It shows that, more than half of the fees are paid to cover the tuition fees.



**Figure 2.** The non-recurring and recurring fees for undergraduate student.

Based on the interview with the university's chief assistant bursar, for the past ten years, the rate of the tuition fees is remained unchanged. The price of the fees changes is coming from the accommodation fees, the cost of material and supplies, and cost of labour. However, for

postgraduate studies, based on the interview with the university academic affairs' chief officer, there is increased in the tuition fees for postgraduates. In 2015, university has revised the tuition fees for the postgraduate studies. The increment is due to several factors for competitive advantage purposes.

The accommodation fees, the cost of material and supplies, and the cost of labour are the factors that determine the rising cost of higher education in Malaysia. As technology advancement has reduced costs and increase efficiency in manufacturing industries, higher education provision is a service industry which consists of expert worker. For competitive advantages, universities are paying a rising salary, hence costs increased. The price of higher education will increase if there is increase in cost but no increase in revenues from other sources. All these factors that contribute in the rising cost issue are interrelated and dynamic through time.

Existing in literature, there are few studies that analyse this issue, however these studies employed static and linear approaches which do not examine the problem holistically. Existing approaches analysed the issue partly due to problem complexity. Thus, this study analyses the root of problem of rising cost issue in higher education from the stakeholder perspectives. In this study, the impact of rising cost towards the supply and demand in higher education is analysed using the integration of soft system methodology and system dynamics modelling method.

There are many possible factors that determine the price of higher education provision. This study will first identify the factors that caused the price of higher education to rise using soft system methodology. Next, a system dynamics model is developed to analyse the relationship between factors. Later, implication of the rising cost in higher education towards supply and demand in higher education is assessed.

## 2. Literature Review

According to Charles and Rothschild [3], a university's supply is the enrolment spaces available. The price of higher education is most likely similar the prices of most service sectors which provides by highly educated staff; in example, law firms. This type of industries faced an increase in the cost and price of their service [1].

Existing in literature, there are few works have been done in analysing these issues of the rising cost in higher education, but mostly use static and linear approach, and analyse the system partly due to the problem complexity.

Soft systems methodology (SSM) is one of principal approaches in problem structuring methods introduced by Checkland in early 1970s [4, 5]. SSM took the form of an organized process of inquiry and learning. SSM used systems models approach towards problem under study and used the systems models developed as a conversation tool aiming at finding space between conflicting viewpoints. Thus, will enabled action to improve to be taken [6].

On the other hand, system dynamics (SD) is an approach to understand the behaviour of complex systems over time. SD incorporates internal feedback loops and time delays which caused dynamic behaviour of the system under study [7]. Due to the advantages of this approach in analysing complex and dynamic system behaviour through time, SD has been applied in various area such as healthcare [8], strategic planning [9], environment [10], and agriculture [11]. There are five iterative steps in system dynamics modelling which will be adopted in this research [12].

Thus, this research will integrate these two methods in analysing the impact of the rising cost towards supply and demand in higher education. The integration of soft system methodology and system dynamics methods enhanced the existing methods by simulating the impact of designed interventions towards system's behaviour and make certain the suggested interventions are culturally and systemically desirable as anticipated in real implementation. There are existing studies that highlights the advantages of combined use of SD and SSM under the Soft Systems Dynamics Methodology (SSDM) framework [13, 14], and recently applied to analyse citizen insecurity problem in Argentina [15].

## 3. Research Methodology

To analyse the rising cost issue in higher education and its impact towards supply and demand in higher education provisions, this study employs the integrated method of SSM and SD. By integrating the two methods, there is ten (10) stages of soft system dynamics methodology (SSDM). Table 1

shows the difference among the three methods.

**Table 1.** Comparison of SD, SSM and SSDM methods

System Dynamics (SD)	Soft System Dynamics Methodology (SSDM)	Soft Systems Methodology (SSM)
Stage 1: Problem Articulation	Stage 1: The Unstructured Problem Situation	Stage 1: Unstructured Situation
	Stage 2: The Structured Problematic Situation (Rich Picture)	Stage 2: Structured Situation
	Stage 3: Problem-Oriented Root Definitions	Stage 3: Root Definitions and CATWOE Analysis
Stage 2: Formulation of Dynamic Hypothesis	Stage 4: Building SD Model of the "Problematic Situation"	Stage 4: Conceptual Models
Stage 3: Formal Simulation Model		
Step 4: Model Testing	Stage 5: Validating Problem-Oriented CLD and SFD versus Real World	Stage 5: Comparison between Stage 4 and Stage 2
Stage 5: Policy Design and Evaluation	Stage 6: Systemically Desirable and Culturally Feasible Changes	Stage 6: Culturally Feasible and Systematically Desirable Changes
	Stage 7: Building SD Model of the "Solving Situation"	
	Stage 8: Solving-Oriented Consensual Root Definition	
	Stage 9: Implementing Culturally Feasible and Systemically Desirable Changes in the Real World	Stage 7: Implanting of Changes in the Real World
	Stage 10: Lesson Learned	

#### 4. Model Development

A simulation model of supply and demand in higher education system is developed using the integration of soft system methodology (SSM) and system dynamics (SD) methods. The integrated

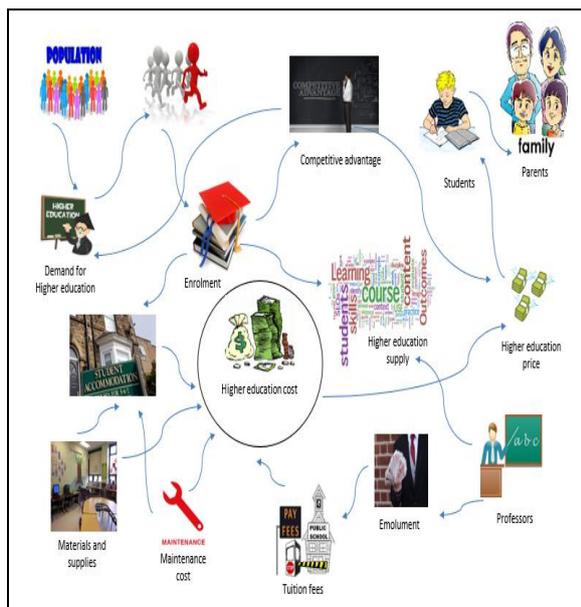
method of analysis for this research is organized into five stages as follows.

##### *Stage 1: The Unstructured Problem Situation*

Over the last few years, the expenses towards higher education is rising. Figure 1 shows the rising expenses on education based on the consumer price index in Malaysia. On the other hand, Figure 2 shows the dispersion of the fees paid by the undergraduate students at the university. From Figure 2, we acknowledged that more than half of the fees paid are to cover the tuition fees. Based on the interview with the university's chief assistant bursar, for the past ten years, the rate of the tuition fees is remained unchanged. The price of the fees changes is coming from the accommodation fees, the cost of material and supplies, and cost of labour. However, for postgraduate studies, based on the interview with the university academic affairs' chief officer, there is increased in the tuition fees for postgraduates. In 2015, university has revised the tuition fees for the postgraduate studies. The increment is due to several factors for competitive advantage purposes. As discussed earlier, there are many factors determine the cost of higher education provision. Based from analysis in this research, the complex nature of the problem could be more understood, and an effective intervention could be designed and evaluated before implementation.

##### *Stage 2: The Structured Problematic Situation (Rich Picture)*

To structure the problem under study, at this stage, by using soft system methodology approach, the problematic scenario is illustrated using rich picture. The rich picture (Figure 3) provides a fast and holistic view of the supply and demand in higher education and identifies the main aspect of the rising cost problem.



**Figure 3.** The rich picture of the supply and demand of the rising cost problem in higher education

*Stage 3: Problem-Oriented Root Definitions*

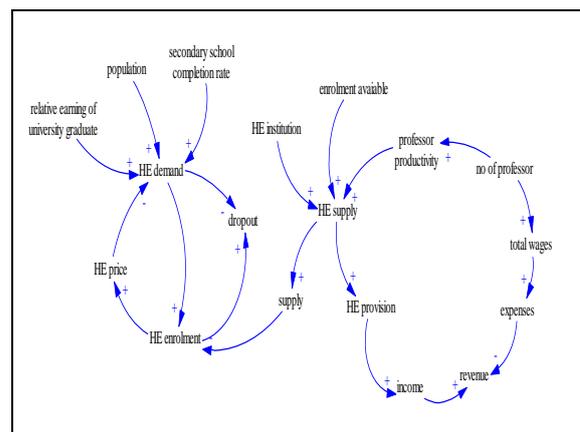
Based on the rich picture (Figure 3), problem-oriented root definitions; the CATWOE analysis produced the following findings:

- Customer (C): Beneficiaries: Higher education institutions. Victims: Students, parents, next generations (children).
- Actors (A): Student, academic staff, university management, government, supplier of educational technologies.
- Transformation (T): Rising cost in HE → Sustainability in HE provisions.
- Weltanschauung (W): Restraining the rising cost in higher education for sustainable higher education provisions.
- Owner (O): Government, higher education ministry, university management.
- Environment (E): Budget allocation, economic recession.

*Stage 4: Building SD Model of the “Problematic Situation”*

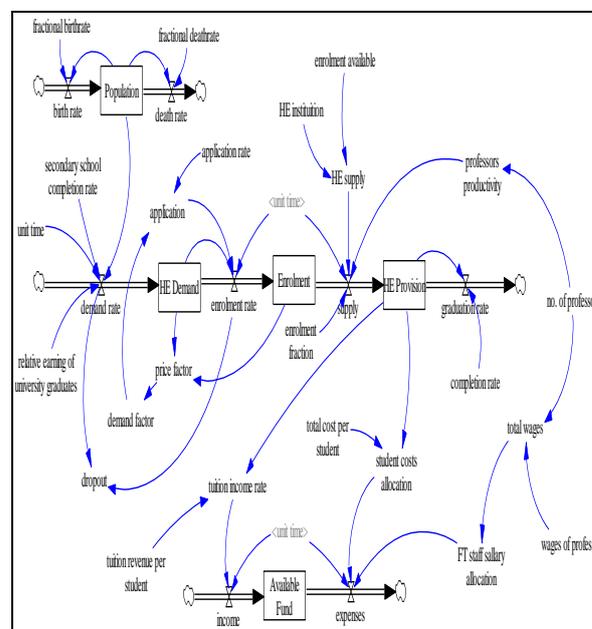
After we have obtained the consensual problem-oriented root definition, we develop the SD model of the problem-oriented causal loop diagram (CLD), and the problem-oriented stock flow diagram (SFD) that make up the problematic situation under study. These diagrams represent the model structure created at Stage 3. Figure 4 and Figure 5 depict the CLD and the SFD of the problematic situation.

i) Problem-Oriented Causal Diagram (CLD)



**Figure 4.** Problem-oriented causal loop diagram

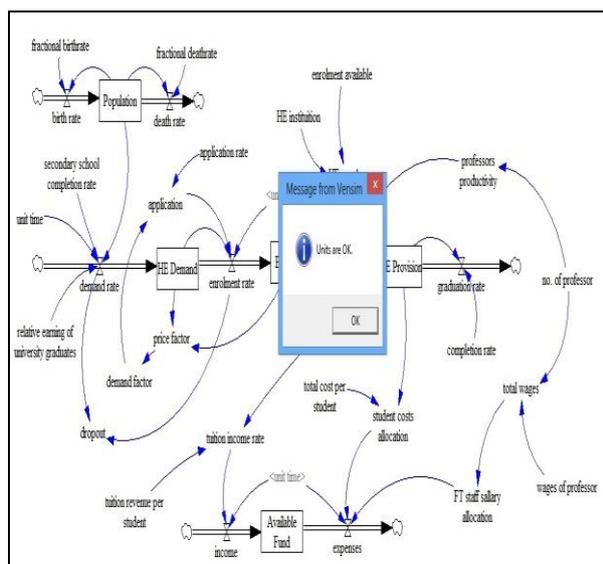
ii) Problem-Oriented SD Model (SFD)



**Figure 5.** Problem-oriented stock flow diagram

*Stage 5: Validating Problem-Oriented CLD and SFD versus Real World*

This stage involves validating the problem-oriented causal loop diagram and stock flow diagram. Figure 6 shows that the developed SD model has passed the dimensional consistency test under the structural validity test.



**Figure 6.** Units dimensional consistency test

### Stage 6: Systemically Desirable and Culturally Feasible Changes

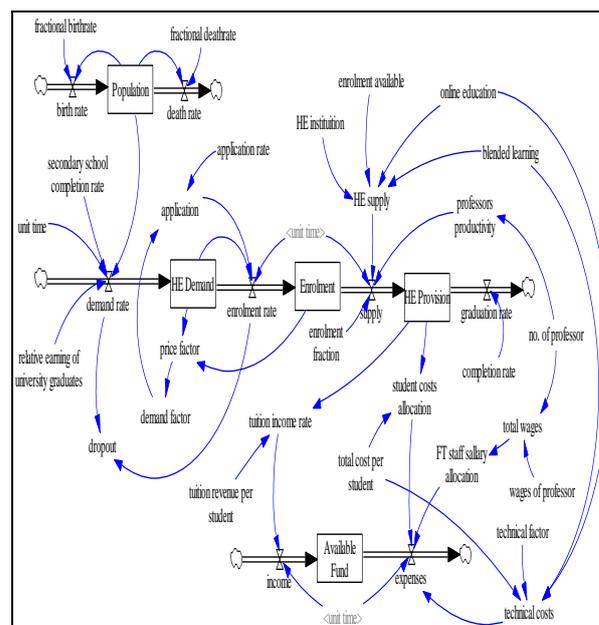
From discussion with few university personnel, few important points of view elevated. It is important to make certain the suggested interventions are culturally and systemically desirable as anticipated in real implementation for betterment. In this study, the main change is to sustain the higher education supply at practical cost. Stakeholders had also identified several variables they believed might play an important role in increasing and maintaining the higher education provision. The variables discussed are as follows:

- Introduces the online education to increase the higher education supply
- Introduces the “blended” learning to increase the higher education supply

All these variables are included in the problem-oriented SD model to examine their impact on the behaviour of the overall problem situation. This analysis will help in designing practical policies to be implemented for betterment.

### Stage 7: Building SD Model of the “Solving Situation”

In this stage, the behaviour of several important variables in the Problem-Oriented SD Model (Figure 5) with the same variables in the Solving-Oriented SD Model (Figure 7) is compared to observe the improvements that could be implemented in the overall model. Two decision variables are examined in the problematic situation, previously discussed in Stage 6.



**Figure 7.** Solving-Oriented SD Model

### Stage 8: Solving-Oriented Consensual Root Definition

Next, we use the Solving-Oriented SD Model to generate a solving-oriented root definition; the CATWOE analysis which produced the following findings:

- Customer (C): Beneficiaries: Government, higher education institutions, students, parents, next generations (children). Victims: future academic staff, supplier agencies, competitive private higher education institutions.
- Actors (A): Student, academic staff, university management, government, supplier of educational technologies.
- Transformation (T): Rising cost in HE → Sustainability in HE provisions.
- Weltanschauung (W): Restraining the rising cost in higher education for sustainable higher education provisions.
- Owner (O): Government, higher education ministry, university management.
- Environment (E): Economic recession, budget allocation, low recruitment of academic staff, trained staff.

### Stage 9: Implementing Culturally Feasible and Systemically Desirable Changes in the Real World

For implementation purposes, from the changes recognized in the solving-oriented SD model, we develop the action plan. In this study, by reflecting and observing the solving-oriented SD model (Figure 7), several changes must be executed:

- Introduces the online education: ways and

- techniques of implementation
- Introduces the “blended” learning: updating the curriculum syllabus
- An academic staff training program: holistic program that cover diversity of subjects
- Improve the information technology advancement of educational institution

Stage 10: Lesson Learned

Lessons learned from this experience that study the rising cost issue in higher education supply and demand and the use of Soft System Dynamics Methodology (SSDM) includes the following:

- Supply and demand in higher education is a complex problem that needs analysis from a systemic perspective to determine both the quantitative and qualitative factors and understand the dynamic interrelationships.
- Not many researches exist on the supply and demand problem in higher education especially analysing the impact of the rising cost in higher education, so this study has provided some information to develop more comprehensive models for analysis.
- The improvements proposed in higher education provision system for the rising cost issue must be culturally and systemically desirable.

5. Result & Finding

Based on analysis carried out using the developed model, there are few important findings from the results. Firstly, the increasing number in population did increase the demand for higher education (Figure 8).

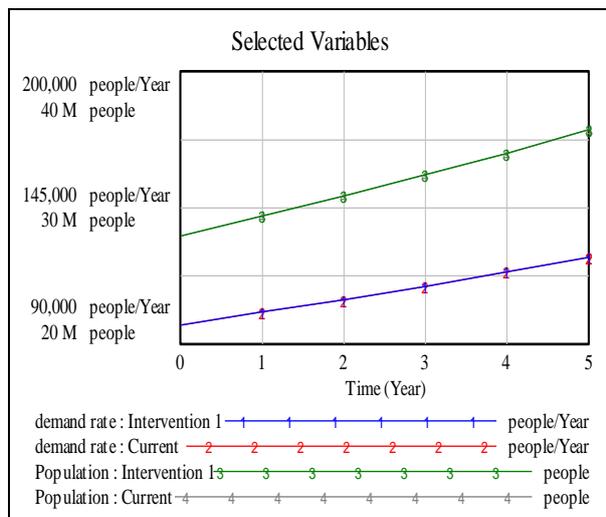


Figure 8. The number of population and demand for higher education

By introducing the online learning and blended learning, this has increased the number of enrolment and HE provisions (Figure 9 and Figure 10). When the enrolment rate is increasing, the number of dropout rate is decreasing (Figure 11).

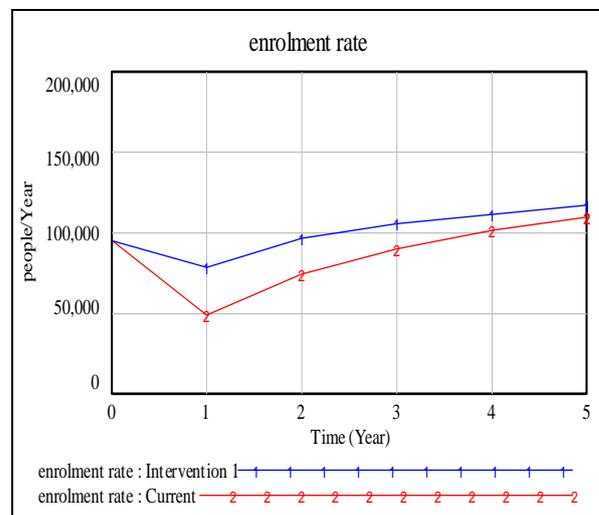


Figure 9. The enrolment rate in higher education

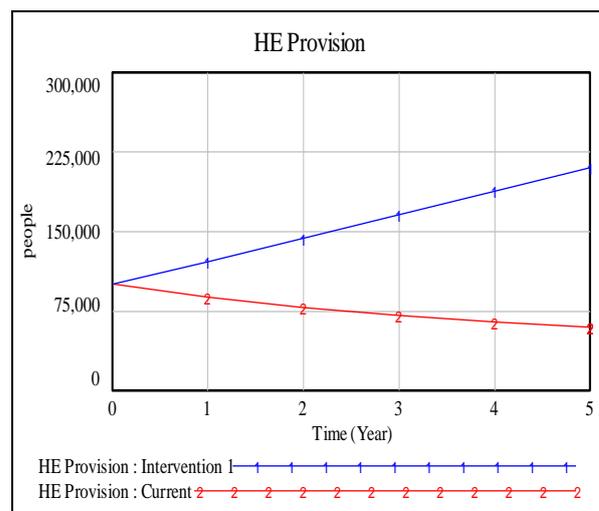
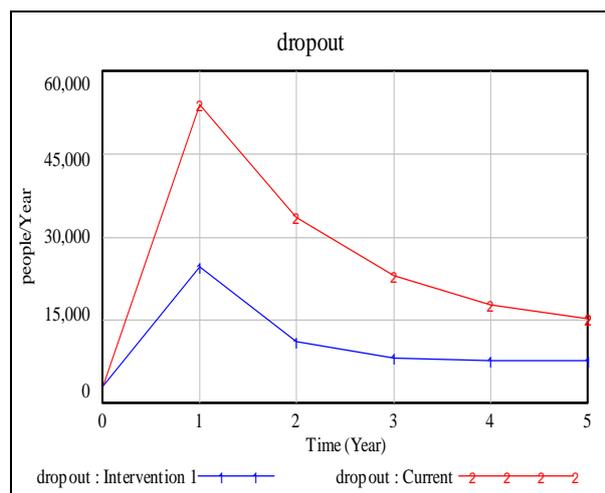


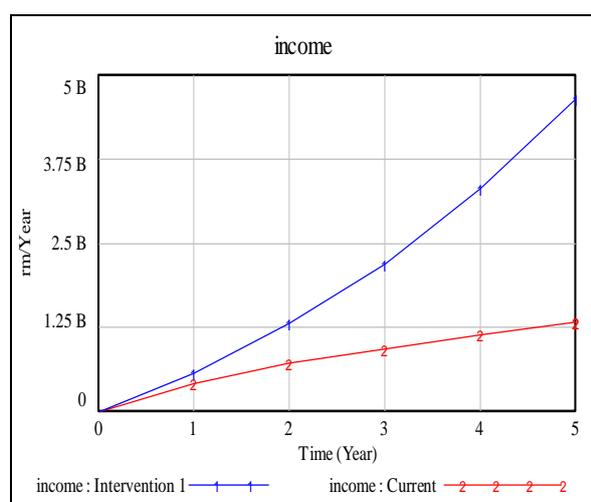
Figure 10. The number of higher education provision



**Figure 11.** The dropout rate in higher education

Based on this study, it is also found that if the number of demand is more than enrolment; which enrolment is affected by the number of higher education supply (HE provisions), there will be a price factor, which indicates that if demand is more than supply, there will be a competitive price factor, which in turn will reduced the number of application and increases the number of dropout rate.

From this study also, it is found that by introducing the online and blended learning, which eventually will increase the number of HE supplies, will also increase the higher education institution income (Figure 12). This results from the increasing number of student enrolled which pays the tuition fees.



**Figure 12.** The higher education institution income

Form this study, few important findings can be summarized.

- Firstly, increasing the number of supply of higher education by introducing the online and blended learning will be an important factor in improving the rising cost problem in higher education.
- Secondly, sufficient information technology to support online and blended learning enables the faculty and students to overcome the rising cost problem in years' time.
- Thirdly, the increasing number of higher education supply will lessen the number of higher education dropout.

## 6. Conclusion

This research has studied the rising cost issue in higher education and its impact towards supply and demand in higher education provision using the integration of the soft system methodology and the system dynamics modelling method. The integration of soft system methodology and system dynamics methods enhanced the existing methods by simulating the impact of designed interventions towards system's behaviour and make certain the suggested interventions are culturally and systemically desirable as anticipated in real implementation. The finding from this study has improve the rising cost problem in higher education. The developed system dynamics model comes from diverse environment determined using soft systems methodology is crucial importance to see the possibilities of the changes.

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