IT Future in Egypt

(Model of workforce demand and supply in the IT field)

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Nowadays, the IT environment is becoming more and more attractive for Egypt's youth as a promising field which lead to increase the number of IT trainees therefore the number of IT workforce in Egypt's market is increasing too.

The question is: Does the IT market demand is equal to the increase in IT workforce supply in Egypt's IT market?

A very important factor we should take in consideration is how much the quality of the trainees meet the international quality of the IT to reach the goal of exporting and make a leap in IT industry. So it's important for us to have an overall and accurate understanding of the effects of excess training programs relative to the projects available in the IT market in Egypt. System dynamics is considered a methodology that bridges the gap between understanding the structures and understanding the behavior. System dynamics enable most people to describe and analyze a system, based on an intuitive system understanding, and more to use system dynamics promote our intuitive system understanding. So the purpose of our model is to use system dynamics to build a simulation model that will help us to understand the IT market situation in Egypt in next few years according to the market demand and supply.

1. Introduction

1.1 Historical background

Egypt, through its ancient history which extends over 3000 years BC has been witnessing massive information flows through different means since the era of the Pharaohs. Walking through history, life and development along the Nile was paralleled by a different type of an information society. This included inscription on stones, papyrus papers, Rosetta stones and the establishment of the library of Alexandria which was considered in ancient Egyptian history, the first largest and famous library world-wide. During the middle ages, Arabic manuscripts, documentation on Papyrus together with documentation on "Parchemin" which is a form of leather became one of the most common means for information dissemination. In the modern age, printing and publishing of paper started in Egypt during the 19th century which has witnessed the first publishing of the first Egyptian journal in 1826. A few years later in 1830, Egypt witnessed the establishment of the first national archive system.
During the 20th century and prior to 1985, a number of characteristics identified the status of the "information society" in Egypt. It was characterized and perceived as follows;

- data rich … information poor,
- accumulated bureaucracy … red tape,
- computers viewed as ends … not means,
- islands of innovation … no bridges,
- focus on technical issues … not decision out comes,
- poor multi-sectoral coordination,
- no synergy between information and socio-economic development strategies; and,
- Brain drain.

Since the mid 1980s, the government of Egypt has established a nation-wide information project targeting:
1. Achieve a leap in IT industry.
2. Exports.
3. Job opportunities for Egypt's youth.

Which achieved by:
1. The build-up of information infrastructure.
2. Focus on people as a vital resource in Egypt.

1.2 Building Egypt's Information Technology Human Resources

The focus on people were shaped and put into perspective through the establishment of several national and regional training and professional development institutions governed by the Cabinet of Egypt which encourage the private sector to join the training field. These institutions over the last decade helped design and deliver professional and academic educational development programs in information technology. The objective was to introduce and diffuse cutting-edge information technology into various organizational levels and

business development activities. Such effort has resulted in training over 50,000 individual in 5,200 professional and academic programs serving around 800 government, public and private sector entities.

1.3 The Purpose of the Research

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System dynamics is considered a methodology that bridges the gap between understanding the structures and understanding the behavior. System dynamics enable most people to describe and analyze a system, based on an intuitive system understanding, and more to use system dynamics promote our intuitive system understanding.

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2. Model Overview

2.1 Model Assumptions

Due to the limited project time, the following assumptions are made to simplify the model. Furthermore, this simplification can help us to focus on the main driving force and feedback structure in the IT market workforce demand and supply which presented by different sectors in the model.

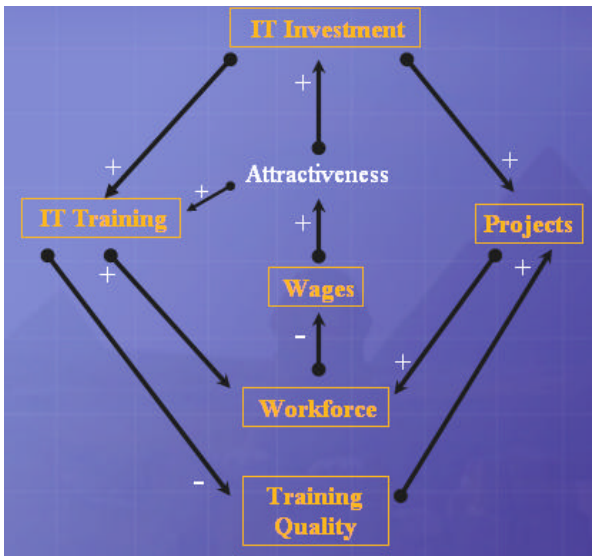
- GDP Growth Fraction is constant value and the fraction of IT investment is constant.
- The cost of each project will be considered as a constant. To be able to determine the number of projects available in the market each month.
- The Target Average Project Waiting Time is constant (Average time for a project to wait for implementing before attrition) to make us able to calculate the actual projects available in the market
- Minimum Project Completion Time is constant (Time needed to complete project implementation) to determine the projects completion rate
- Average Training Time is constant to determine the number of IT workforce graduated from the training programs.

2.2 Conceptual Model

To keep the underlying structure of this model clearly and understandable, a coarse causal loop diagram will be used in the following analysis. All the unimportant relationship in this model is hidden and only the most critical feedback structure will be shown.

2.2.1 Main sectors in the model

As shown in the figure below the model contains six main sectors that are interacting.



These Sectors are:

- IT Investment Sector
- Projects Sector
- Workforce Sector
- Wages Sector
- IT Training Sector
- Training Quality Sector

We will discuss those sectors in the next pages.

2.2.2 IT Investment Sector

IT Investment sector where we calculate how much we invest in the IT field. This value is calculated as a fraction of GDP of Egypt. Its important is to be used to determine the size of projects available in the market this done in the project sectors.

2.2.3 Projects Sector

Projects sector is the part of the model dealing with the available projects in the IT market and the projects currently implemented by the current workforce. So it is used to determine the workforce demand in the IT market.

2.2.4 Workforce Sector

The workforce sector is containing the total available workforce in the IT market and the desired workforce which the market demands for the available projects.
The Gap between them is the main consideration of our model because it is present the relationship between the IT market workforce demand and supply.

2.2.5 Wages Sector

This sector is the main effect of the training needs in Egypt because as wages increase as attractiveness to the IT field increase. The wages is determined by the ratio of available workforce to the desired workforce in the market. As this ratio increases the wages is decreases and vise versa.

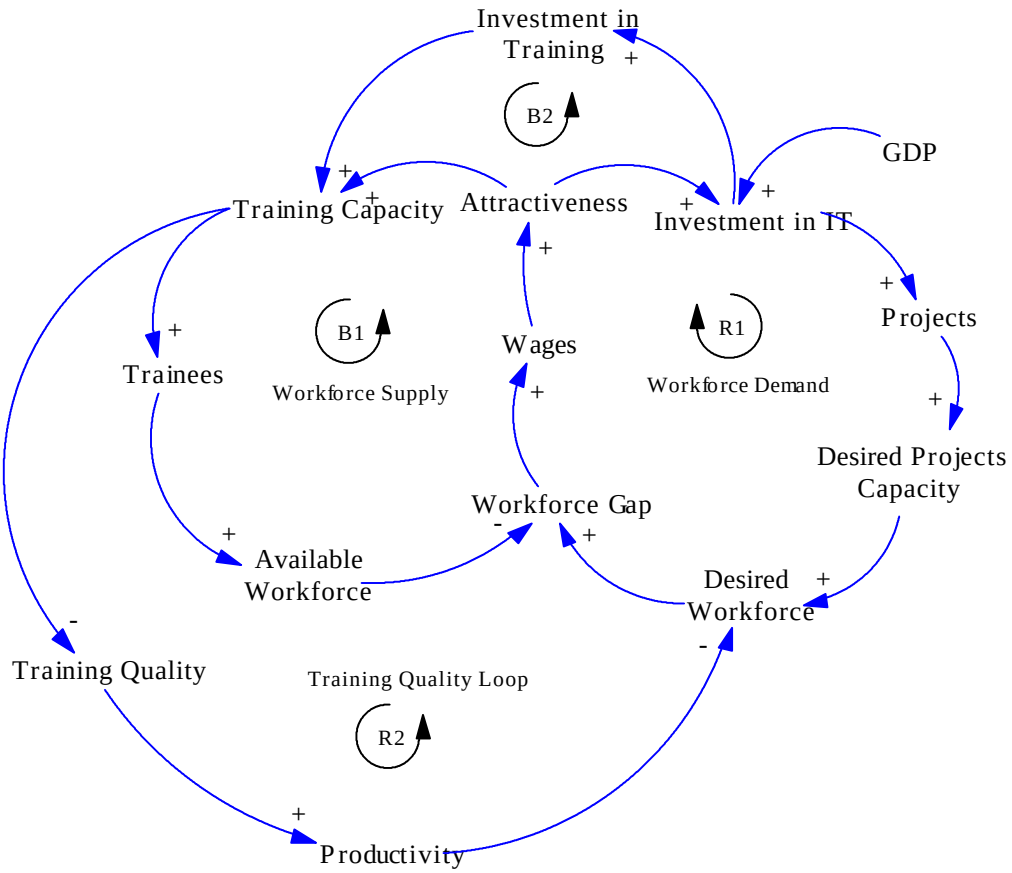
2.2.6 IT Training Sector

The training sector shows the effect of attractiveness on increasing the people demand on IT training. As we mentioned in Wages Sector attractiveness increases as wages increases and vise versa.
Also we take in our consideration the training capacity (maximum numbers of trainees can be trained in the market) and how long does the market take to change its training capacity according to the training demand. So, training sector is the source of IT workforce supply in the market.

2.2.7 Training Quality Sector

The training quality sector is measure the quality of graduated trainees relative to quality reference value. The training quality determines the productivity of the employee which affects the projects completion rate. It is considered as a factor to determine the desired workforce in IT market.

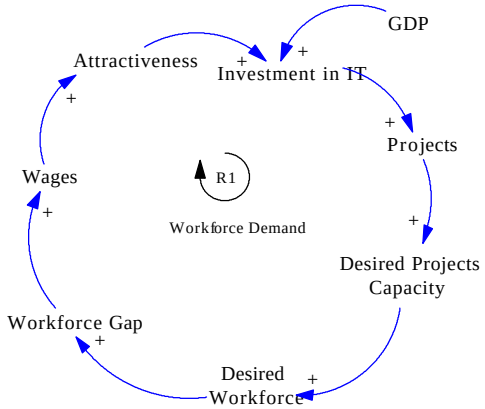
2.3 Causal Loop Diagram



In the causal loop diagram, there are mainly two reinforcing loops and one balancing loop. The reinforcing loop R1 is Workforce Demand. The higher the projects the market has, the more workforce demand, which raise the IT wages in the IT market. The balancing loop B1 is called workforce supply in which the IT training increases the available IT Workforce to fit the workforce demand. The third reinforcing loop R2, called training quality loop, which concern about the training quality and how it affects the productivity to determine the IT workforce demand. In the following we will mention them in more detailed.

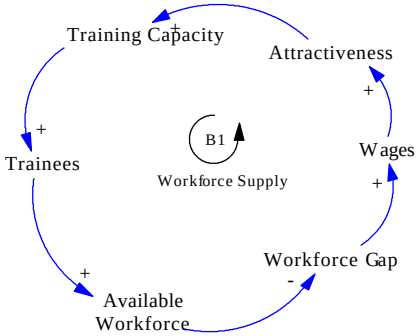
R1: Workforce Demand loop

The Investment in IT in our model is the factor that determines number of projects in the IT market. The more Investment in IT, the large number of Projects. Therefore Desired Projects Capacity in the market goes up, and also the Desired Workforce goes up. So the actual workforce demand pushed to a further high level and the Gap in workforce increases. As the demand of workforce increase Wages in IT field will increase relative to other careers which will affect the attractiveness of people to the IT field more and more and that will increase the Investment in IT field. So this is reinforcing process.



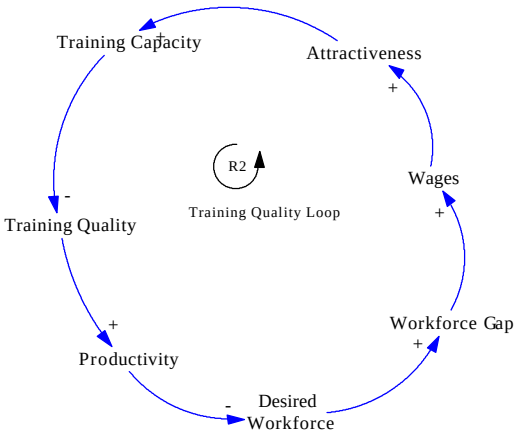
B1: Workforce Supply loop

This part is responsible of supplying workforce to the market after training. When people are attracted to the field they join training programs and also the government will help to increase the Training Capacity, so the Trainees will increase and the Available Workforce will increase. That will affect the Gap in Workforce because the IT market now is saturated or even overloaded so the Wages will decrease and according to that the Attractiveness to the IT field will decrease. So this is a balancing process.



R2: Training Quality loop

If people are attracted to the filed so much and the Training Capacity increase more and more that will affect the Quality of the Training process and the Quality of the Workforce in the market. So the Training Quality will decrease and the Productivity also will decrease. While the Projects development depends on the productivity, the Desired Workforce will increase. As in the Workforce Demand loop the Wages will increase and also the Attractiveness which affects the Training capacity and the Training Quality will decrease in reinforcing process.

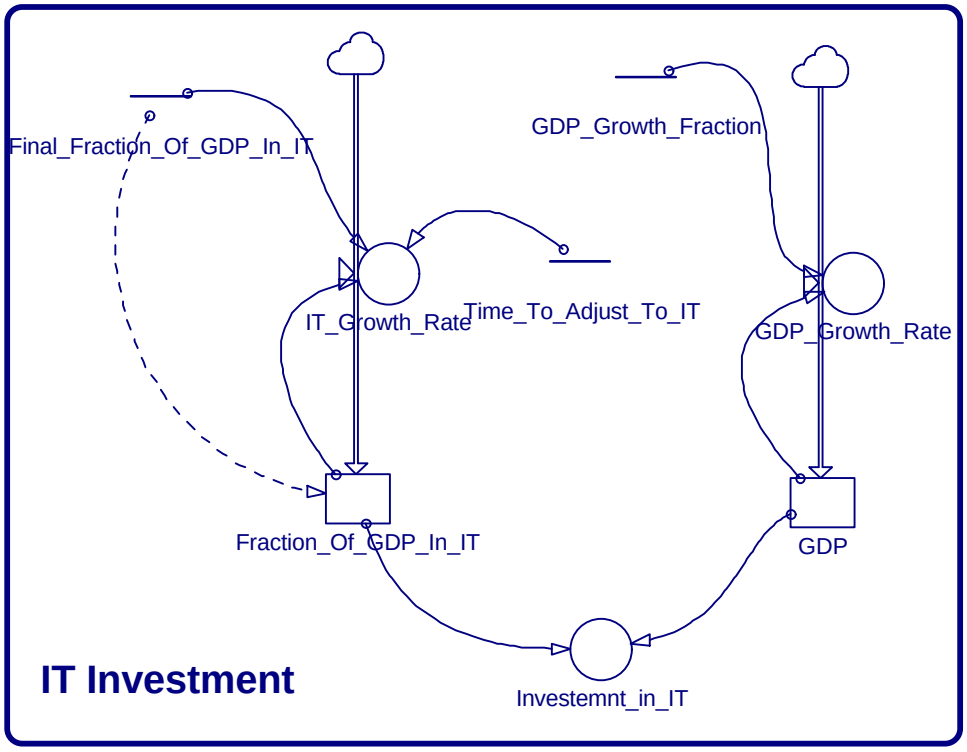


3. Stock and Flow Diagram

In our model we have the following sectors:

1. IT Investment
2. Projects
3. Wages
4. IT Training
5. Training Quality

1. <u>IT Investment</u>



Explanation of Concepts and Assumption

GDP

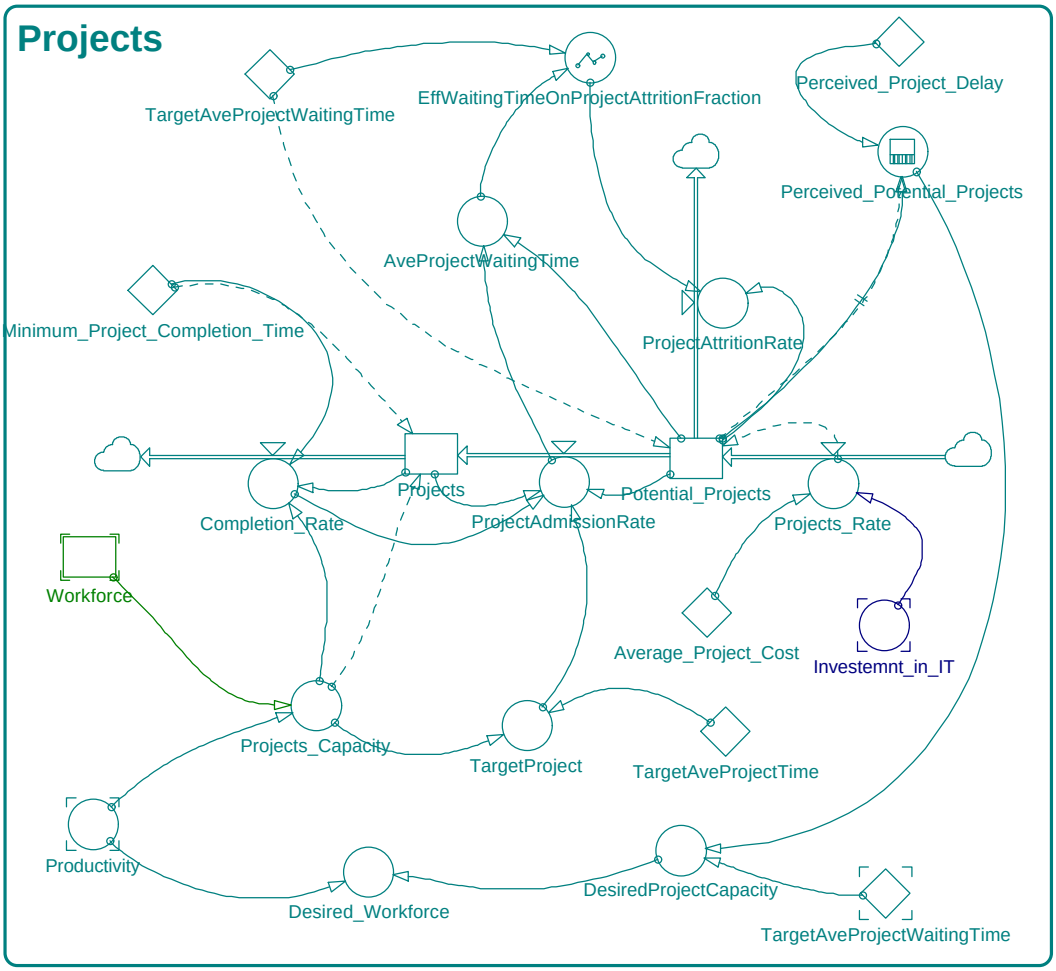
init =225*10^7
flow = +dt*GDP_Growth_Rate
unit $/month

Fraction_Of_GDP_In_IT

Fraction of GDP used in the IT investment
init = Final_Fraction_Of_GDP_In_IT
flow = +dt*IT_Growth_Rate
unit Dimensionless

Investment in IT
aux = GDP*Fraction_Of_GDP_In_IT
unit $/month

2- Projects



Explanation of Concepts and Assumption

Potential_Projects
The available projects in the IT market
init Potential_Projects = Projects_Rate*TargetAveProjectWaitingTime
flow Potential_Projects = -dt*ProjectAttritionRate
-dt*ProjectAdmissionRate
+dt*Projects_Rate
unit project

Projects
The current running projects by the working workforce
init Projects = Projects_Capacity*Minimum_Project_Completion_Time
flow Projects = +dt*ProjectAdmissionRate
-dt*Completion_Rate
unit project

Perceived_Potential_Projects
aux Perceived_Potential_Projects = DELAYINF(Potential_Projects, Perceived_Project_Delay)
unit project

Projects_Capacity
The number of projects that can be implemented with the available resources per month.
aux Projects_Capacity = Workforce*Productivity
unit project/month

Target Project
Number of projects can be implemented in the average project time
aux TargetProject = Projects_Capacity*TargetAveProjectTime
unit project

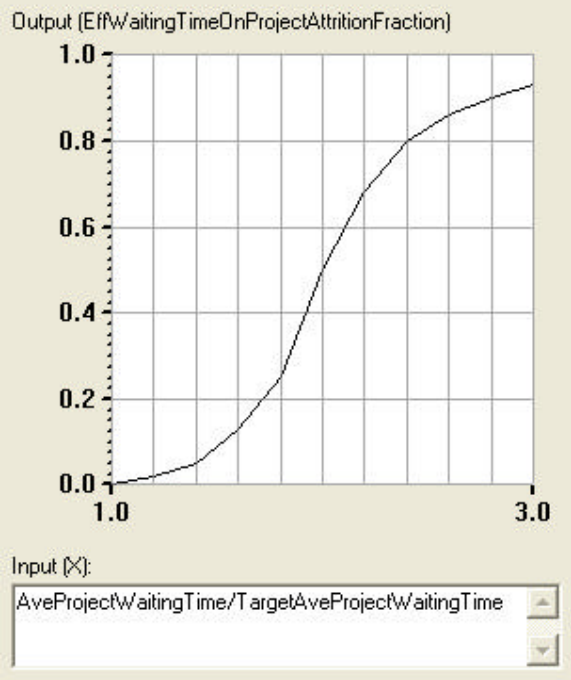
Desired Project Capacity
aux DesiredProjectCapacity = Perceived_Potential_Projects/TargetAveProjectWaitingTime
unit project/month

Desired_Workforce
The required workforce for the available projects in the market.
aux Desired_Workforce = DesiredProjectCapacity/Produtivity
unit person

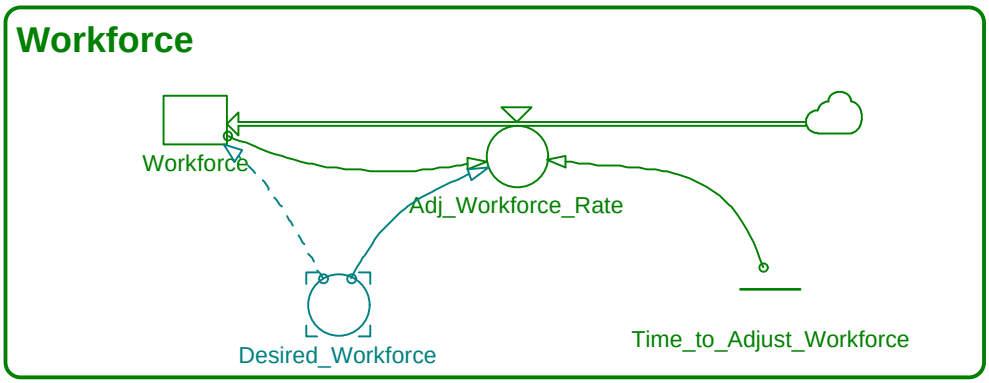
Average Project Waiting Time
Average time for a project to wait for development before its attrition .
aux AveProjectWaitingTime = Potential_Projects/ProjectAdmissionRate
unit month

Effect of Waiting Time On Project Attrition Fraction
aux EffWaitingTimeOnProjectAttritionFraction = GRAPH(AveProjectWaitingTime/TargetAveProjectWaitingTime,1,0.2,[0,0.02,0.05,0.13,0.25,0.5,0.68,0.8,0.86,0.9,0.93"Min:0;Max:1;Zoom"])

If the Average Project Waiting Time is more than Target Average Project Waiting Time, the Effect on Project Attrition Fraction goes up. If the ratio is 2 then 50% of projects will attrite. If the ratio is 3 then 90% of projects will attrite. And that is our assumption.



Now we want to adjust the actual IT Workforce according to the demand of Workforce In the market.



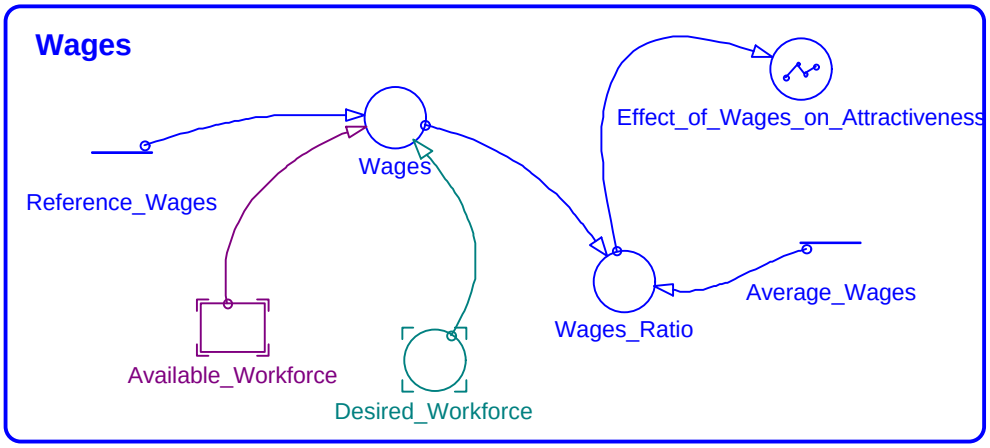
Explanation of Concepts and Assumption

Workforce

Number of workforce required for the current running IT projects in the market. Its value is a part of the Available_workforce.

init Workforce = Desired_Workforce
flow Workforce = +dt*Adj_Workforce_Rate
unit person

3- Wages



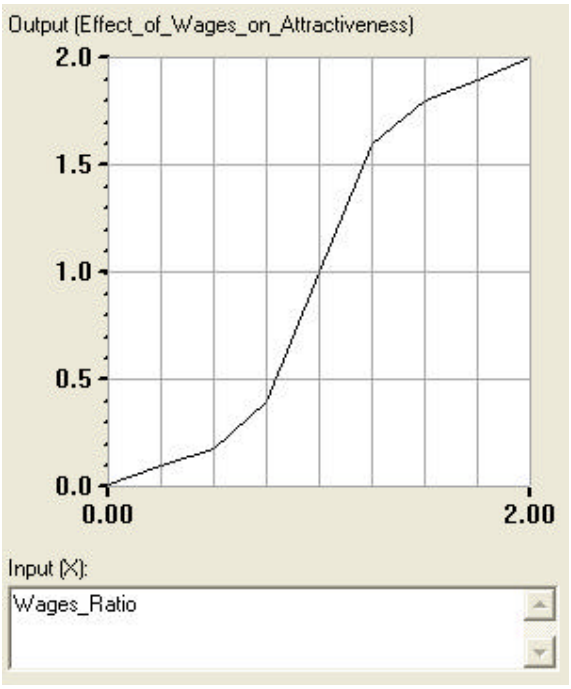
Explanation of Concepts and Assumption

Wages
Wages in the IT field which is determined by the demand and supply of IT Workforce in the market.
aux Wages = Reference_Wages*(Desired_Workforce/Available_Workforce)^1.2
unit $

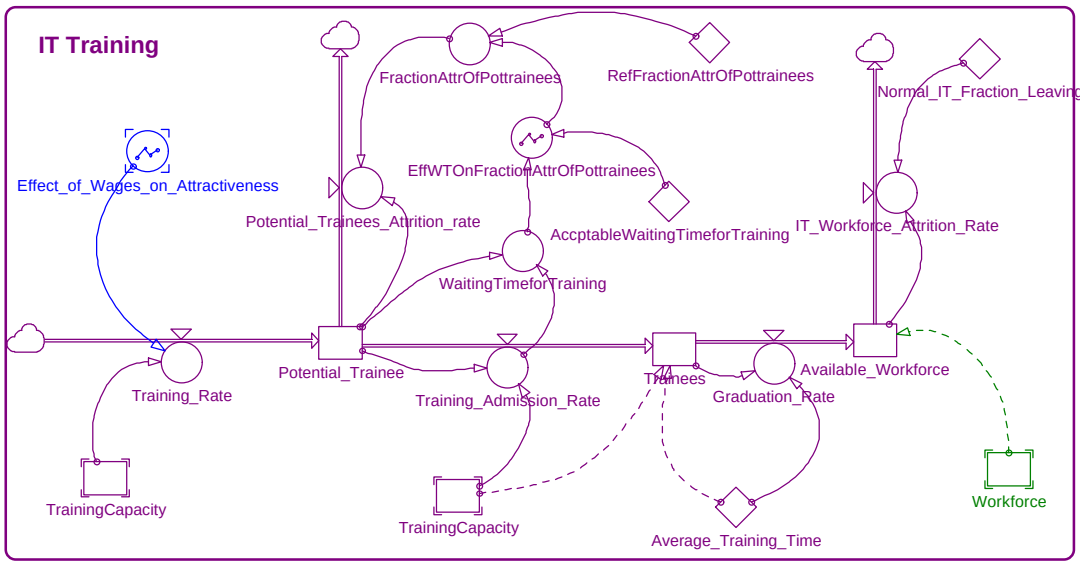
Wages_Ratio
aux Wages_Ratio = Wages/Average_Wages

Effect_of_Wages_on_Attractiveness
aux Effect_of_Wages_on_Attractiveness = GRAPH(Wages_Ratio,0,0.5,[0,0.3,1,1.3,1.44,1.59,1.75,1.85,1.92,1.96,1.98,1.98,1.99"Min:0;Max:2;Zoom"])

If Wages Ratio is greater than 1, Effect on Attractiveness goes up; If Wages Ratio is less than 1, Effect on Attractiveness goes down.



4- IT Training



Explanation of Concepts and Assumption

Potential_Trainees
Number of people wants to join the IT field and tend to join training programs.
init Potential_Trainee = 9
flow Potential_Trainee = -dt*Potential_Trainees_Attrition_rate

-dt*Training_Admission_Rate
+dt*Training_Rate
unit person

Trainees

The number of trainees each time unit which determined by the training capacity available in the IT market

init Trainees = Actual_Training_Capacity*Average_Training_Time
flow Trainees = +dt*Training_Admission_Rate
-dt*Graduation_Rate
unit person

Available_Workforce

Total IT workforce in the market which include the working workforce and unemployed workforce

init Available_Workforce = Workforce
flow Available_Workforce = +dt*Graduation_Rate
-dt*IT_Workforce_Attrition_Rate
unit person

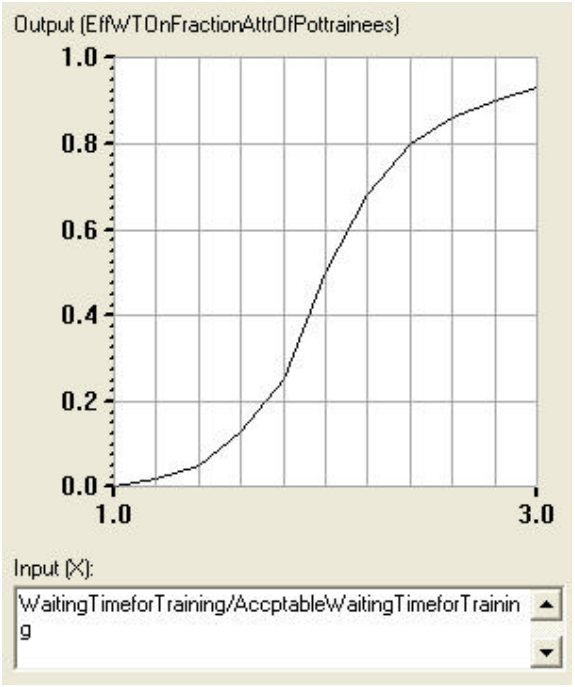
Fraction Attrition Of Potential Trainees

aux FractionAttrOfPottrainees = RefFractionAttrOfPottrainees*EffWTOnFractionAttrOfPottrainees

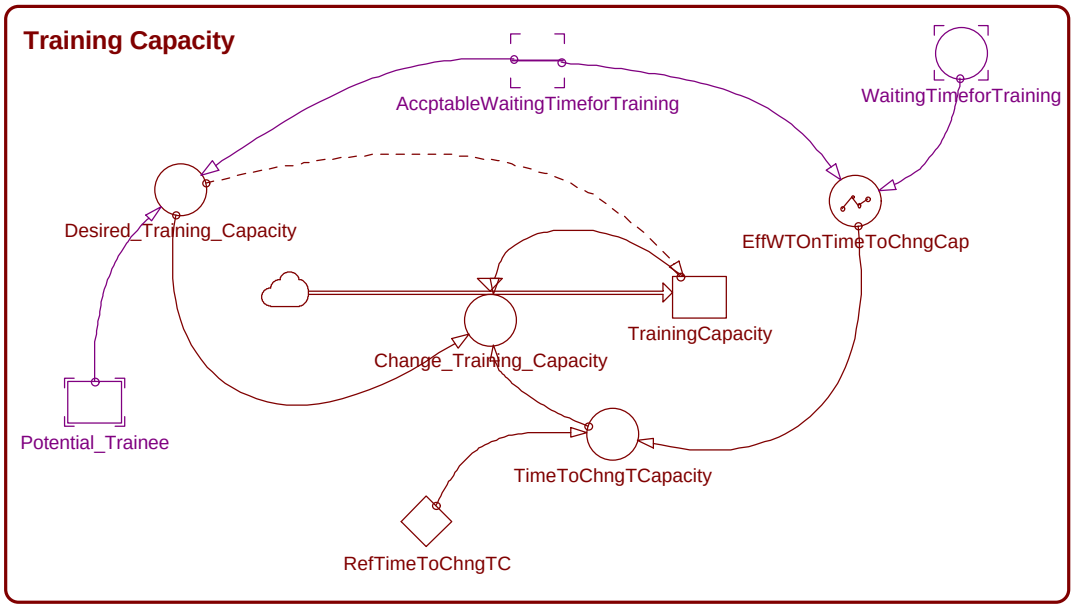
Effect of Waiting Time on Fraction Attrition of Potential Trainees

aux EffWTOnFractionAttrOfPottrainees = GRAPH(WaitingTImeforTraining/AccptableWaitingTimeforTraining,1,0.2,[0,0.02,0.05,0.13,0.25,0.5,0.68,0.8,0.86,0.9,0.93"Min:0;Max:1;Zoom"])

If the Waiting Time for Training is more than Acceptable Waiting Time for Training, the Effect on Fraction Attrition of Potential Trainees goes up. If the ratio is 2 then 50% of potential Trainees will attrite. If the ratio is 3 then 90% of Potential Trainees will attrite.



Now we want to adjust the Training Capacity according to the demand of training in the market. Here the most important parameters are the desired Training Capacity and the Waiting time for training.



Explanation of Concepts and Assumption

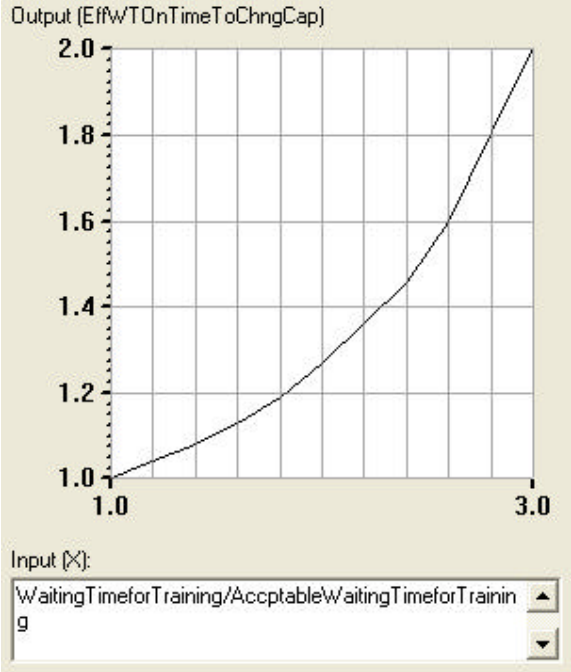
TrainingCapacity
Maximum number of IT trainees can be trained in the market

init TrainingCapacity = Desired_Training_Capacity
flow TrainingCapacity = +dt*Change_Training_Capacity
unit person

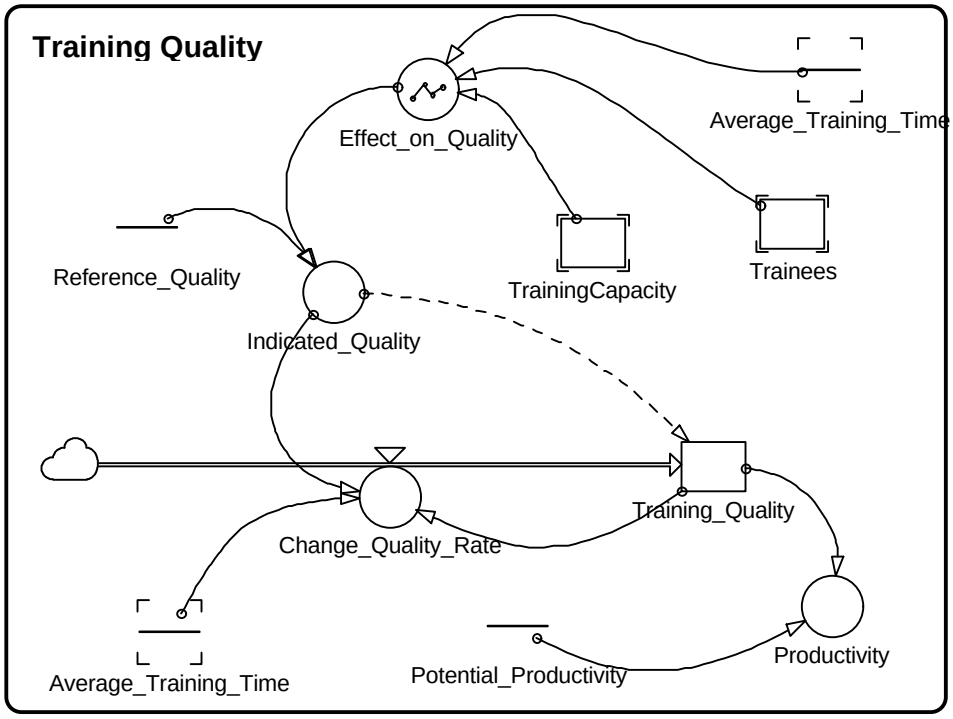
Desired_Training_Capacity
aux Desired_Training_Capacity =
MAX(0,Potential_Trainee/AccptableWaitingTimeforTraining)
unit person

Time To Change Training Capacity
aux TimeToChngTCapacity = RefTimeToChngTC/EffWTOnTimeToChngCap
unit month

Effect of Waiting Time on Time To Change Capacity
aux EffWTOnTimeToChngCap =
GRAPH(WaitingTimeforTraining/AccptableWaitingTimeforTraining,1,0.2,[1,1.04,1.08,1.13,1.21,1.27,1.36,1.46,1.6,1.81,2"Min:1;Max:2;Zoom"])
If the Waiting Time for Training is more than Acceptable Waiting Time for Training, the Effect on Fraction Attrition of Potential Trainees goes up exponentially.



5- Training Quality

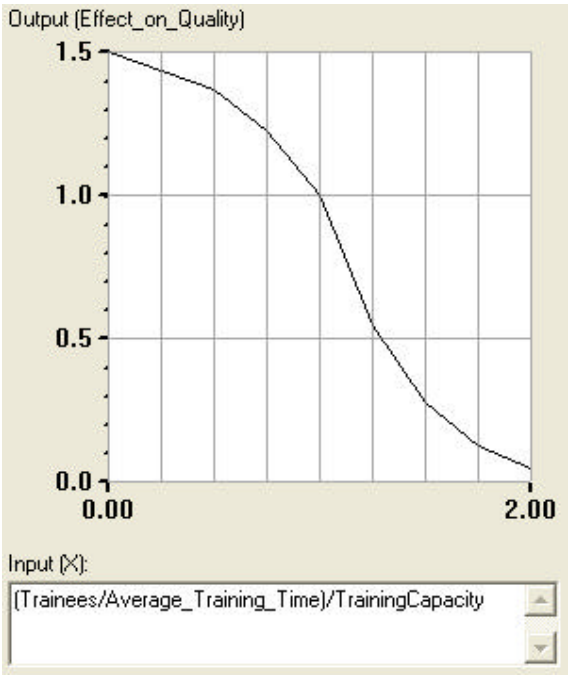


Explanation of Concepts and Assumption

Training Quality
Indicate the quality of Workforce
init Quality = Indicated_Quality
flow Quality = +dt*Change_Quality_Rate

Effect_on_Quality
The effect of the ration between the capacity of training and the actual trained persons on Quality.
aux Effect_on_Quality = GRAPH(Training_Ratio,0,0.25,[1.5,1.44,1.37,1.23,1,0.51,0.25,0.13,0.04,0.04,0.02"Min:0;Max:1.5"])

If Trainees/AverageTrainingTime “Graduation Rate” is greater than Training Capacity, Effect on Quality goes down;
If Trainees/AverageTrainingTime “Graduation Rate” is less than Training Capacity, Effect on Quality goes up. We assume that the maximum Effect of Quality is 150%.

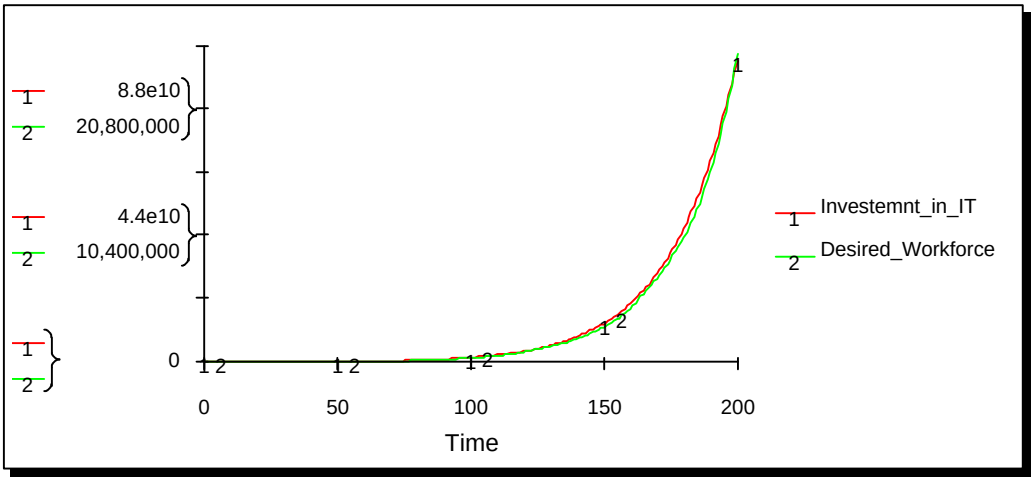


Indicated_Quality
aux Indicated_Quality = Effect_on_Quality*Reference_Quality

Productivity
Number of Projects a person is developing per month.
aux Productivity = Quality*Potential_Productivity
unit project/person/month

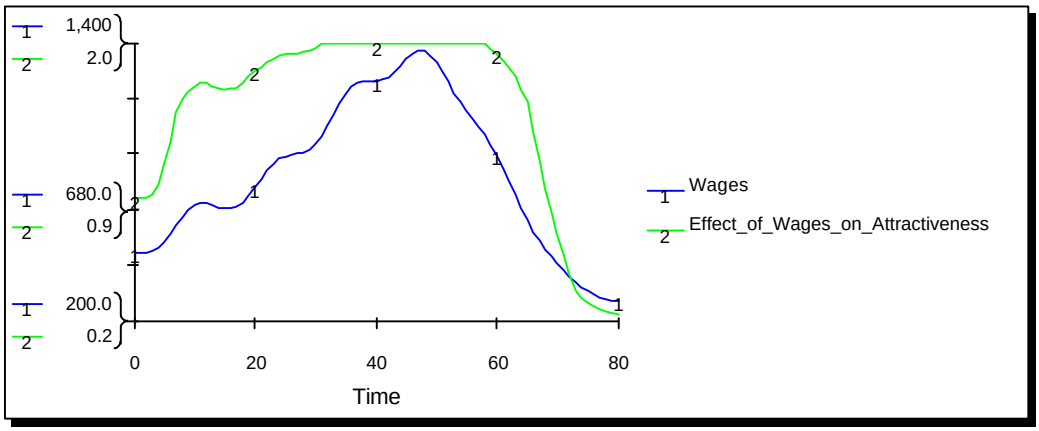
4. Simulation and Behavior Analysis

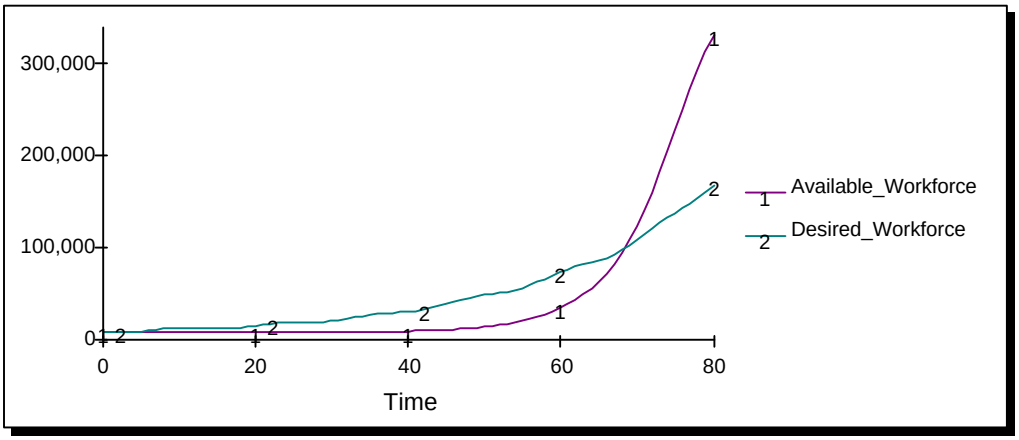
Our model focuses on the IT market situation in Egypt in next few years according to the workforce demand and supply. The workforce demand in the IT market (Desired IT workforce) depends on the investment in IT which determine number of IT projects in the market (see IT Investment and Projects Sector in the model). On the other hand the workforce market supply (Available IT workforce) is introduced by IT training which is affected by wages in IT field. The following graphs will show demand and supply in IT workforce:



This graph shows the investment in the market during the 200 months we can notice that the IT investment is going up because it is a fraction of the GDP as the GDP increases the Investment increases too especially it is a new field in Egypt and the market contains many projects need to implement. So, as investment in IT increases the projects in IT market increase according to this increase the desired workforce to implement these projects will increases too. In another word as investment increase the desired workforce increases as shown in the graph which represent the IT workforce demand.

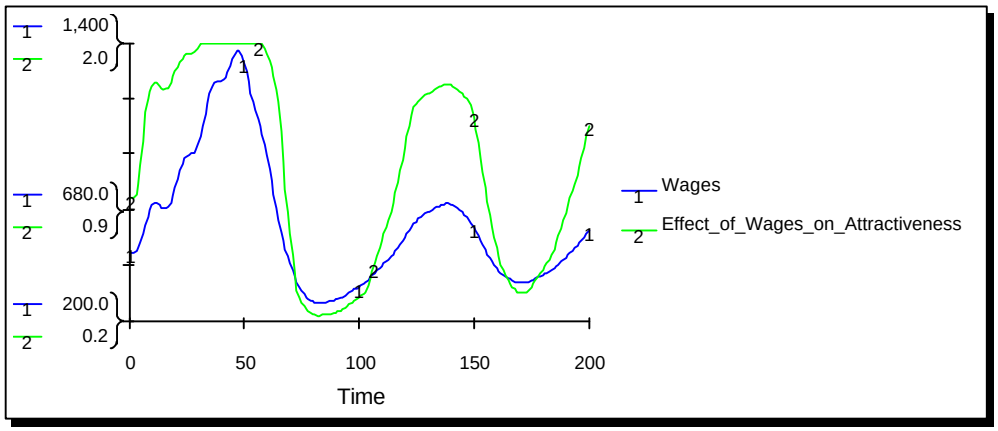
On the other hand, the main factor affect the attractiveness to the IT field to supply the market demand is the wages. As we mentioned before it is a new field in the Egypt market so the wages go up in that field relative to other fields in the market. This is shown in the next graphs:

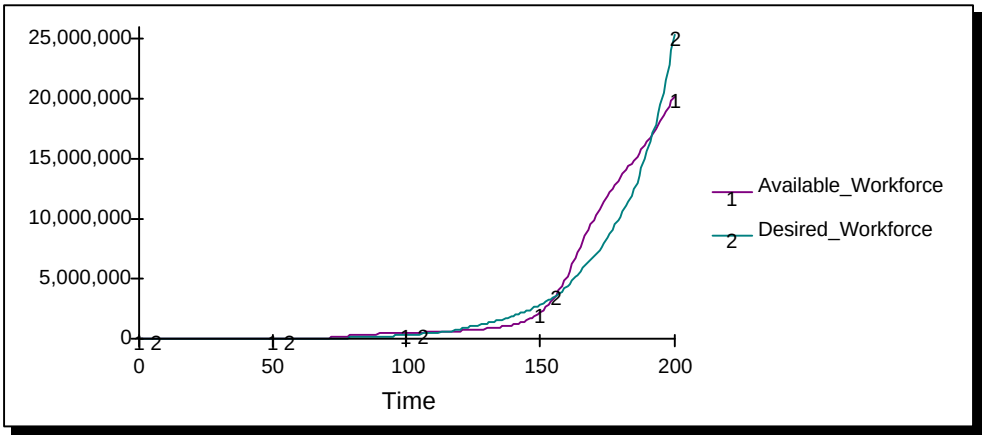




We can find from the graph that the wages is going up in the first 45 months this is because the desired workforce in the market is larger than the available workforce which mean the workforce demand is larger than the supply. From what we mentioned before as wages increases, the attractiveness increases so more people attend training programs to join the field which lead to increase the available workforce until it reach the desired workforce. But the available work force is keep going to exceed the demand. As the supply (Available workforce) is larger than the demand (desired workforce) the wages decrease after 70 months from the simulation and the effect of wages on the attractiveness decreases.

The previous results come from running the model for 80 months (where months are our time unit). When we increase our simulation time to 200 months we have the next graphs





We can find from the graphs that when the wages decrease, the attractiveness decreases. While the desired workforce is going up with the IT investment, and the available workforce is keeping go up but because of the attractiveness reduction it becomes less than the desired workforce leading to reduce workforce supply than the demand. So

the IT wages will increase again causes attractiveness increases which increase available workforce (workforce supply) to meat desired workforce (workforce demand) after 120 month.
If we compare the wages curve with the available workforce, we can see that the changes of available workforce always occur later than do the changes of wages. This is due to the delay between these two variables. Also this delay causes wages to oscillate.

As a result of wages oscillation the curves of available and desired workforce keep going up and crossing each other several times when the workforce demand and supply are equal.

5. Conclusion

The model presented in this paper was designed to show the usefulness of the system dynamics approach in investigating the IT market future in Egypt. The paper shows the integration of feedback depending decision variables into IT market demand and supply. The Attractiveness to the field which is affected by wages plays an effective role in the IT market.

The Attractiveness to the field affects the supply of workforce so that the supply goes up to reach the demand. And as the gap goes down the wages goes down too which affect the Attractiveness to the IT field and that in turn will reduce the supply and build the gap again.

Finally, When the workforce supply becomes more than the demand that may cause crises in the IT market in Egypt so the training should be planed according to the market demand.

6. References

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Back to the Top