Analysis of the Turkish Education System: A System Dynamics Approach on Dropouts and Deficiencies in Job Market

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Abstract

The education system has always been a controversial issue in the Turkish Republic history. Contrary to developed countries, educational institutions, teaching activities and high school and university entrance exams are regularly changed disruptively by the authorities. Despite many interventions with the purpose of improving the public education system, it was found that education policies do not meet expectations: dropouts are still high and students do not gain necessary knowledge and skills to meet the industry needs. This study focuses on modelling the education system and job market while generating policies to increase the quality of the education system and meeting industry expectations. Simulation results point out to the fact that the government should invest on the improvement of current universities rather than opening new universities. Moreover, industry support to vocational schools should be stimulated to increase number of vocational school students and create new job opportunities for them. Finally, the policies are tested under uncertain parameters and their robustness is verified.

Key Words: Turkish education system, quality of education, vocational job market, high skilled job market, dropouts, system dynamics, simulation, policymaking

Word Count: 5645

1 | Introduction

Turkey has the youngest population amongst European countries and the population is still increasing rapidly [1]. From 2010 to 2015, the population increased by 4 million which is approximately a 5% increase while the half of the population is under the age of 30.7 [2]. According to the Ministry of Education, the significant increase in population brings the challenge of providing the young population with an adequate education. Indeed, the demographic conditions of Turkey are considered to be the cause of the problems occurring in quality and accessibility in education [1].

Due to especially low quality of education, Turkey does not comply with international standards [3]. According to the Programme for International Student Assessment (PISA) results in 2012, Turkey is in the 31st place among the 34 OECD countries. Furthermore, Turkey's 15 year old school children are below the average of OECD countries in all fields i.e. reading, mathematics and science [4].

The fact that Turkey has the largest young population in Europe brings the expectation of rapid development. Yet, the question is: Is Turkey successful in educating its young population appropriately and using its demographic conditions as an advantage? The ministry of education has attempted to improve the quality of education by implementing frequent changes in education system. However the intervention of the ministry did not have the expected effect. According to the World Bank report, dropout rates are still high in all levels of education. Besides, firms have pointed out low education and skill levels in workforce as a constraint on operations and growth [3]. In other words, the lack of quality of education affects job market negatively.

A previous study was already performed on the education system in Turkey. Bacaksizlar and Barlas discuss inconsistencies in the education system and (in)equality of educational opportunities. It also elaborated on the fact that the high quality of education is a prerequisite of acquiring a high skilled job [5]. However, in this study there is a strong focus on the relation between (in)equality of opportunities and poverty (i.e. accessibility).

To use the full potential of its young population, it is essential for Turkey to analyze discrepancies in Turkish education system. The goal of this study is finding policies to decrease dropouts and eliminate deficiencies in job market. To achieve this goal, System dynamics (SD) is decided to be an appropriate approach since "it is a virtual laboratory where the modeler can identify intended system changes and test them easily" [6]. Indeed, SD allows to describe, simulate and analyze dynamically complex issues and helps to re(design) the structures by having feedback and accumulation effects [6, 7].

This paper has four main sections. In section 2, model is described overall by presenting critical variables in the model, the assumptions, model boundaries and conceptual model. In order to identify causal relations, find out feedback loop systems and conceptualize the entire model, a causal loop diagram (CLD) is used. Then a Bull's Eye Diagram is sketched to distinguish exogenous and endogenous variables and to indicate the boundaries of the model. Later on, detailed model structure is discussed. Sub-models are constructed via stock flow diagrams (SFD) and merged in the end once it has been determined that the sub-models provide valid results. Actual modelling is performed in Vensim and the simulation run is set between the years 2016-2056. Next, exemplary simulation results are shown. In section 3, policy explorations are discussed. The policy impacts on the decreasing number of dropouts and meeting the needs in the job market are assessed by drawing graphs and conducting further analysis with the help of uncertainty analysis using the Exploratory Modelling and Analysis (EMA) workbench, which can be found in section 4 [8, 9]. Finally, conclusion and recommendations over the policies are provided in section 5.

2 | Model Description

To identify the effect of current education structure on dropouts and deficiencies in job market in desired level of detail, major drivers of the education system to be focused are selected. To achieve this, the SD model is limited by boundaries and assumptions and some critical variables are quantitatively defined in following sections.

2.1 Critical Variables Definition

Dropouts in all levels of education are mainly due to insufficient quality of education. In this sense, quality of education has to be quantified to be used in the model and observe its effect on dropouts. Factors that affect quality of education are determined to be student teacher ratio, proportion of facilities per student and student engagement as shown in Figure 1.

Student engagement variable, which is a determinant of quality of education, is affected by frequent changes in the education system variable. Student lose their sense of belonging to school with disruptive interventions in the education system, which causes less engagement and ultimately lower quality of education [10].

To quantify the deficiencies in the job market, two variables are defined:*gap in vocational job market* and *gap in high skilled job market*. The gaps are formulated as the difference between

Figure 1: Definition of gap in job market

employee demand from industry and supply of employees (vocational school graduates/university graduates) as shown in Figure 2.

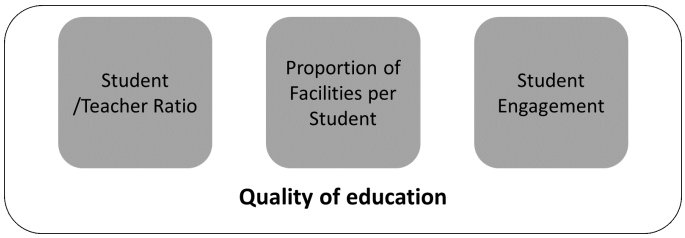

Figure 2: Definition of quality of education

2.2 Assumptions

The first assumption is that there is no difference due to gender or social parameters on enrolment or dropping out percentages. Reflecting on these differences is not of interest for this study since the cause of dropouts and gap in the job market is insufficient quality of education rather than inequality issues.

Another assumption is that high school graduates directly move to university or dropout. The dropout in high school means finishing studies and not continuing to university or discontinuing high school studies.

Last but not least, it is assumed that increasing the quality of education in school/university increases the attractiveness of the education and thus increases the number of students enrolling there.

2.3 Model Boundaries

In the model, private schools are excluded since 99% of the students in Turkey attend public schools [10]. It can be concluded that problems related to education system are in public schools. Also religious Imam Hatip schools are excluded since the related controversies are out of scope of this study.

When modeling the job market and defining the *gap* between employee *demand from industry* and *supply of employees*, only vocational school and university graduates are focused on. Low skilled employees and their job market are excluded from the model because in this study, deficiency in vocational and high skilled job market is of concern rather than unemployment of low skilled employees.The Bull's Eye Diagram shown in Figure 3 clearly shows the model boundaries.

2.4 Feedback Loops

An aggregated causal relations diagram is drawn in the purpose of identifying feedback loops. Positive feedback loops are the drivers while negative feedback loops represents the balancing dynamics in the education system. Feedback loops in Figure 4 can be described as follows:

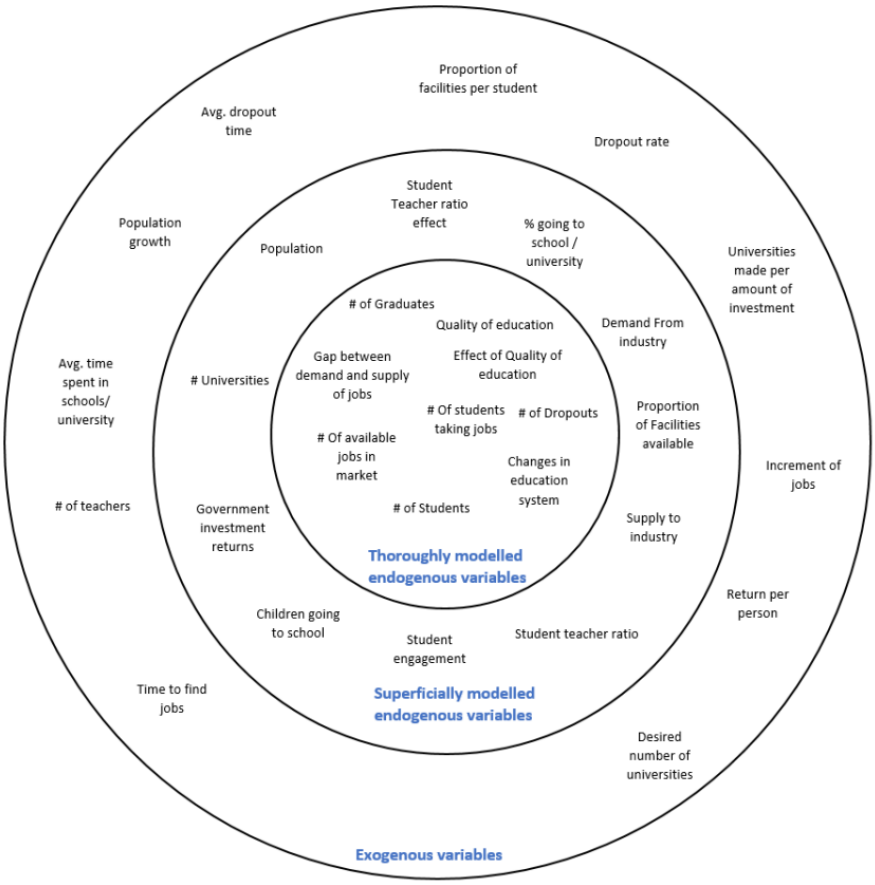

Figure 3: Bull's Eye Diagram

1. *Effect of quality on dropouts*: As quality of education decreases, students are less engaged to school/university thus dropouts increase. Increment in dropout decreases the number of students continuing their education; having a positive effect on proportion of facilities per student. Then quality of education is affected positively as well due to better facility opportunities.

2. *Quality and quantity tradeoff*: Similar to the idea in first loop, increasing number of students affect the quality of education negatively.

3. *Effect of government investment in number of universities*: The Turkish governments investment targets increase in number of universities. However, this increase leads to a decrease in the quality of education. When university students graduate, they cannot find high skilled jobs because they do not acquire the adequate skills at university. Ultimately, they do not join the high skilled job market, hence do not contribute in government investment via taxes.

4. *Payback mechanism of investment on quality of education*: When the government investment increases, the quality of education increases due to the improvement in proportion of facilities per student. This way, university students get high quality of education and find high skilled jobs. Later on, their contribution via taxes increases government investments positively.

5. *Effect of quality on vocational school students*: The same logic as in loop 2 applies to vocational schools as well. Increase in quantity decrease the quality of education.

6. *More dropouts leading less government investment*: When government investment is low, quality of education is affected negatively. Hence there will be more dropouts before university and students reaching to university level will decrease. As a result, there will not be tax coming from high skilled employees as contribution to government investment. In other words, this mechanism works in the opposite way of loop 4.

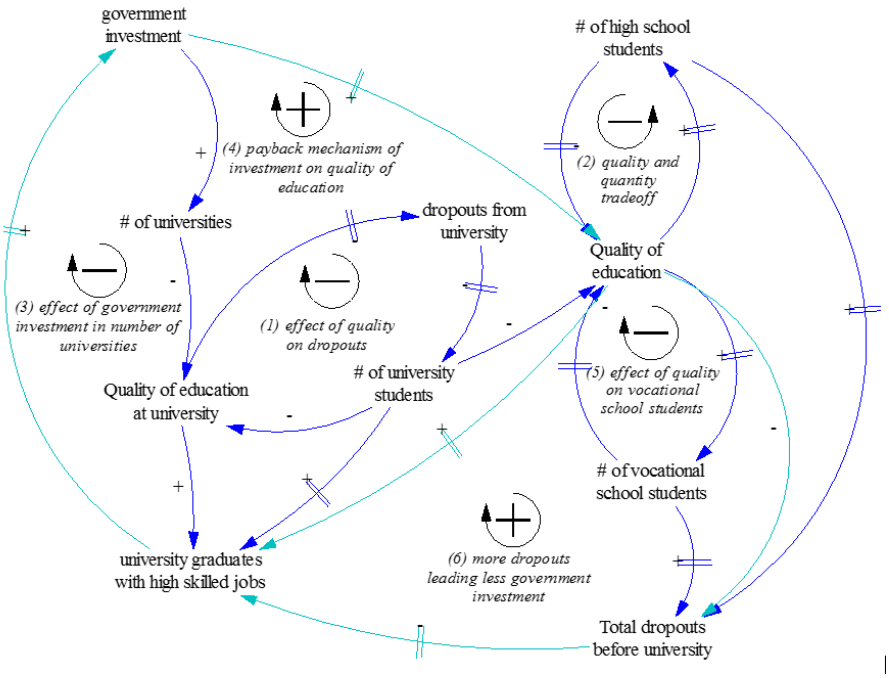

Figure 4: Aggregated closed loop diagram

2.5 The Simulation Model

The two cores of the Vensim model describing the educational institutions in Turkey and job market structure are presented with stock flow diagrams in Figure 5 and Figure 6 and discussed in following sections.

2.5.1 Submodel 1: Education System Structure in Turkey

School life starts with enrollment to primary and then to secondary school. In Turkey, primary and secondary school education is finished in 8 years. Even if it is legally obligatory to finish this level of education, some students already dropout in this stage.

After graduating from secondary school, students choose either going to high school or vocational school. There are also dropouts in this stage of education. Dropping out in high school means leaving school before finishing. In this model, dropouts also mean finishing but not continuing at a university. Students who do not drop out start to pursue university degree after high school.

If students choose a vocational school, then there are three possibilities: leaving school before graduating, graduating and continuing studying at university level or graduating and finding a job in vocational job market. As the final step, students who choose to go to university after high school or vocational school dropout or graduate. It is important to notice that not all university graduates are able to take a high skilled job, which is discussed in job market structure section

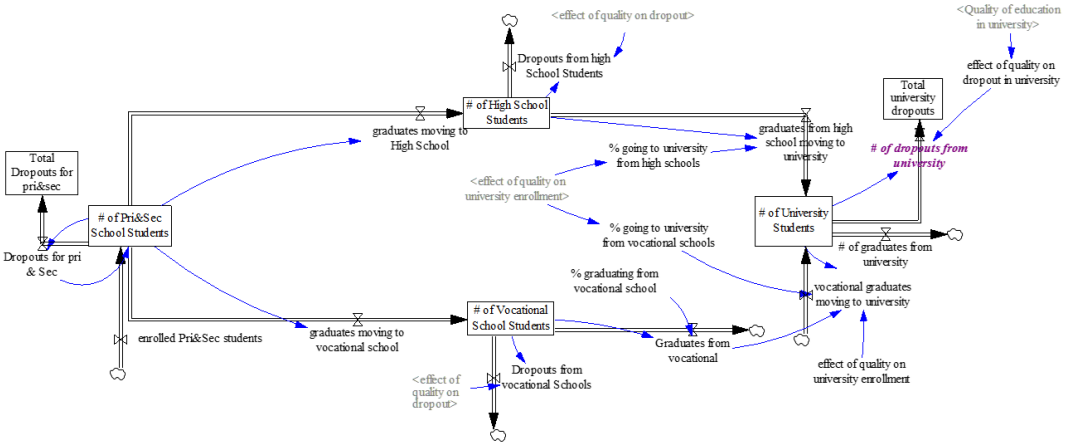

Figure 5: Education system structure in Turkey

2.5.2 Submodel 2: Vocational and High Skilled Job Market

In this study, job market is modelled separately for vocational and high skilled jobs. It is set that only vocational school graduates can get a vocational job and only university students can get a high skilled job. Number of vocational and high skilled jobs are increasing constantly every year. Every year, graduates find a job from the relevant job market depending on their educational background and the total number of available jobs are shown as stock variables in the model.

In high skilled job market, quality of education at university has significant importance since not all graduates have adequate skills to perform the jobs after graduation. In other words, graduating from university does not automatically guarantee a high skilled job.

The gap in vocational and high skilled job markets, explained in Figure 6 are used as key performance indicators (KPI) in order to identify if the job market for graduates is satisfying as well as if industry demand is met by sufficient number and quality of graduates every year.

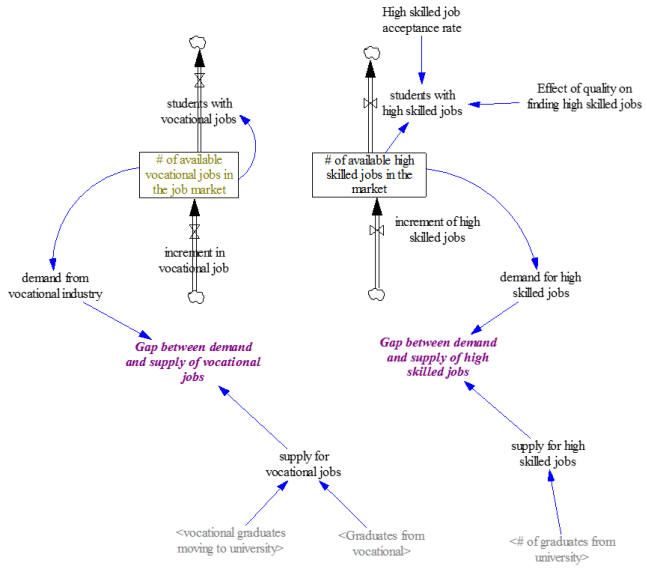

Figure 6: Vocational and high skilled job market

2.6 Exemplary Simulation Results

The exemplary simulation results depict the scenario with default assumptions and values. This model reflects a scenario very close to the reality of education system of Turkey. The validation results in the Table 1 in Appendix with historical and present data shows the resemblance of this model with reality. The exemplary simulation results focus over three important Key Performance indicators for the period of 2016-2056 which are namely *Gap between demand and supply of the high skilled jobs*, *Gap between demand and supply of vocational jobs* and *Dropouts*.

These KPIs are chosen because they reflect the issues in the education system faced by the students and the industries in Turkey and the policies focus around reducing these issues. As can be seen in Figure 7, the gap is positive for high skilled jobs which depicts that the number of students graduating are too less compared to the number of jobs in the market for high skilled jobs. Similarly, in Figure 8 vocational jobs have a negative gap because of higher number of graduates as compared to the demand from the industry. These terms are explicitly explained in Section 2.1. The number of dropouts as shown in Figure 9 comprises of the dropouts from primary and secondary school, dropouts from high school and dropouts from vocational school. The dropouts increase every year and the pulsating behavior shows effect of changes in education system on the number of dropouts. The results of the simulation for the KPIs can be seen from Figure 7 to Figure 9.

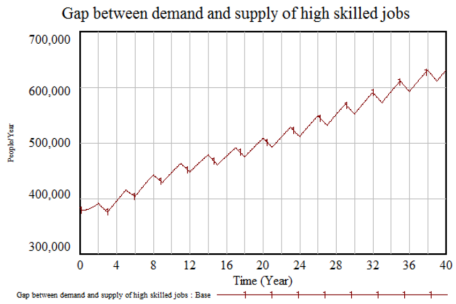

Figure 7: Exemplary simulation result of gap between demand and supply of high skilled jobs

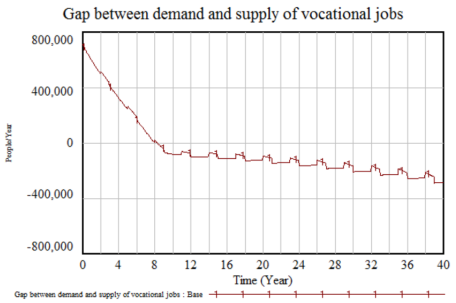

Figure 8: Exemplary simulation result of gap between demand and supply of vocational jobs

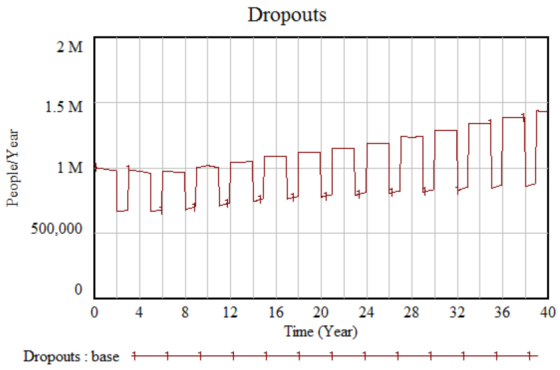

Figure 9: Exemplary simulation result of number of dropouts

3 | Policy Explorations

The exemplary simulation result has shown that the gap in the high skilled job market would be positive with a constant increment as seen in Figure 7 and gap in the vocational job market would stay highly negative as seen in Figure 8. Thus, it is necessary to control this gap with some policies. All theses policies would aim to bring both these gaps to behavior approaching a constant value near zero.

Policies are extracted from the ones which are currently established in other countries and from literature study over quality of education. Also, for better comparison of results, all of the policies are assumed to be implemented in 2016. The first policy revolves around reducing the gap in high skilled jobs by channelizing the money invested by government, which is under implementation at many developing countries [11]. The literature study revealed that it is always beneficial to invest in improving quality of education than quantity to have a good impact on the economic growth and education system [12] [13]. The second policy focusses on bringing the negative gap in vocational jobs near zero by making vocational schools attractive with industries supporting the vocational schools. This policy is inspired from the Germanys VET system [14]. Few other countries have had success with implementation of this policy, for example France and Tunisia [15]. The literature explicitly evaluates the benefit of such investment for the industries [16]. The final policy focuses on controlling changes in the policy of education and thus putting a control on the number of changes which significantly effects the quality of education [17] [18].

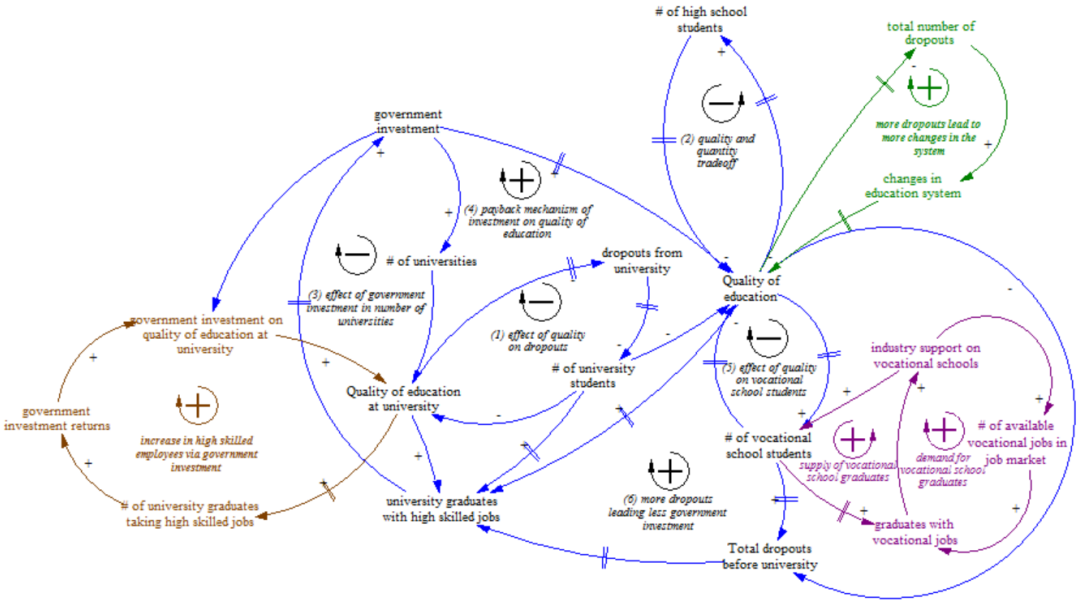

Figure 10: Policies affecting the system

3.1 Policy 1: Industrial Support in Vocational Jobs

Currently, there is over-supply of *vocational school graduates* since there is not enough *vocational jobs* in the market. A policy, focusing on creation on more vocational job opportunities is designed as shown in Figure 10 in purple color.

- *Industry support* to vocational school is stimulated by providing more facilities and trainings by the industry. To maintain the support, more vocational jobs in companies are created and *investments in schools* are initiated to improve facilities.

- As companies invest in schools to improve *facilities*, quality of education in vocational schools will increase and the *number of students* that choose to go to vocational schools will increase.
- When more *vocational jobs* are created, there are more *vocational school graduates* employed with vocational jobs. *Industry support on vocational schools* will continue because industry will benefits from these graduates much more due to higher quality and number of *vocational graduates*.
- Ultimately, *industry support* will lead to an increase in *number of vocational school graduates* as well as *vocational jobs*; which gives a closed loop policy.

The result of this policy can be clearly seen on the KPI of *gap for vocational jobs*. The result shows a reduced negative gap of around 50,000 from the exemplary simulation of 400,000. The negative gap depicts unemployment. The policy has been designed such that the gap value is not exactly zero, because to maintain a good economy the unemployment should always remain greater than zero [19]. The major focus has been to keep a decreasing unemployment rate, which is achieved. The minor issues that can be seen with higher gap till the first 16 years i.e. 2032, but it is acceptable considering that it will help in ensuring a lower gap in the future.

3.2 Policy 2: Channeling Government Investment

As mentioned in the above Section 3, this policy is derived from the VET system of Germany which has proved to be very beneficial for meeting the demands of job market and giving a high quality vocational education.

There are many *high skilled jobs* but there are not enough *university graduates* who have sufficient skills to get these jobs because of low quality of education in universities. A policy to increase the quality and decrease the *gap between demand and supply of high skilled jobs* is implemented as shown in Figure 10 in brown color.

- The *government spending* is channeled to improve *quality of education in universities* by investing in facilities (giving higher budgets for research laboratories, increasing the number of facilities, and investing on researchers) rather than increasing number of universities.
- The quality of university graduates and their chance to find high skilled jobs increase respectively. Due to this reason, the *gap in high skilled job market* decreases dramatically.
- Meanwhile, the contribution of high skilled employees on government budget (i.e. *government investment returns*) increases. By this way, government sources her spending for *quality of education* and the overall system is a closed loop policy.
- The consequence of this policy will be a very high increase in quality of education, leading to a very high number of students graduating in the following years. Thus to maintain the demand and supply again, one more measure included in this policy is that the *increment of the high skilled jobs* grows according to the number of graduates. Practically this can be implemented with attraction of more Foreign Investments or Multinational Companies or promoting entrepreneurship.

The impact of this policy can be seen as completely changing the behavior of the gap in high skilled job market in the future. This policy helps in a gap close to zero and it is difficult to reach the negative gap (unemployment >0, as discussed for above policy), the gap get a value of around 175,000, which is much lower than the exemplary simulation case of 600,000. As can be seen in section 6.4, the application of all policies bring this gap to a constant behaviour of around 25,000.

3.3 Policy 3: Controlled Number of Changes

Frequent changes in the education system have negative effects in quality of education, student engagement at school and job market. A policy is designed to make changes in education system based on number of dropouts as in Figure 10 with green color. The change is made when the gap in the job market is below a threshold value. Please note that this policy excludes the changes in the education system in university.

- The total number of dropouts is selected to be driver of changes in education system. When there are more dropouts, it will be indicator of adjustments needed in system.
- To avoid a big negative impact on job market due to change in education system, 100000 is selected to be the threshold value in making a change: changes in education system is allowed only if gap in job market is less than the threshold value.
- Ultimately, changes in the education system are only made when necessary and it is controllable within the system.

The individual effect of this policy is not visible in the KPIs significantly, but the combination of this policy with all the other policies help in better results as also shown in Figure 14 and Figure 15.

3.4 All Policies Implemented Together

All policies are implemented at once to check the results of their effectiveness when applied at the same time. For the KPIs reflecting the gaps, it can be seen that the policies applied together give much better results than policies applied individually. The results can be seen for all policies individually and together with comparison of the exemplary simulation case in Figure 11, Figure 12 and Figure 13.

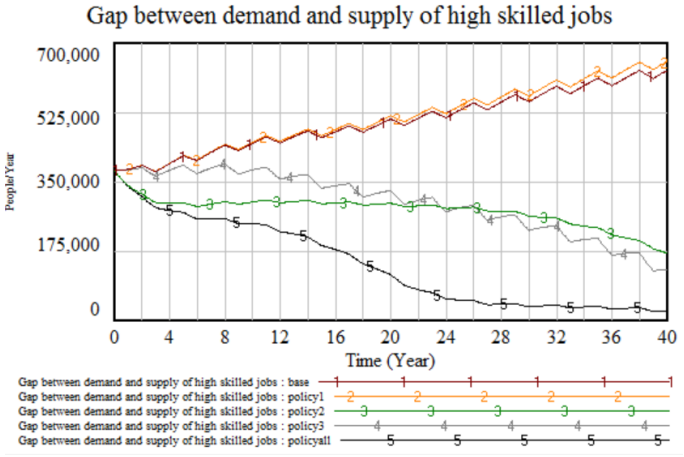

Figure 11: All policies effect on gap between demand and supply of high skilled jobs

4 | Policy Robustness Check

As this model is based on a lot of social factors for which values can only be estimated, it cannot be said that exemplary simulation run results are certain. Thus, the dynamics of these parameters need to be checked and their effect on the policies need to understood. In this study, the

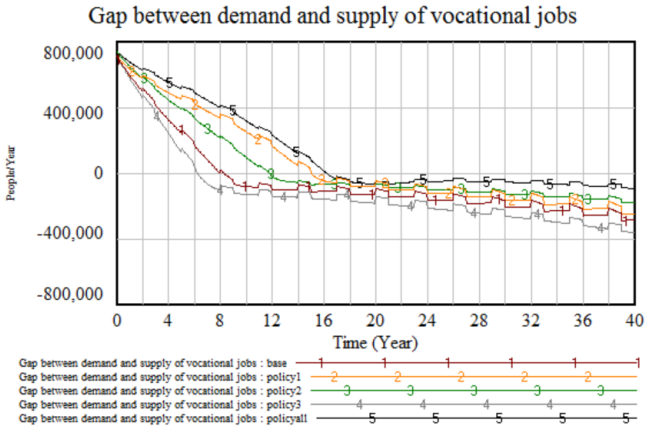

Figure 12: All policies effect on gap between demand and supply of vocational jobs

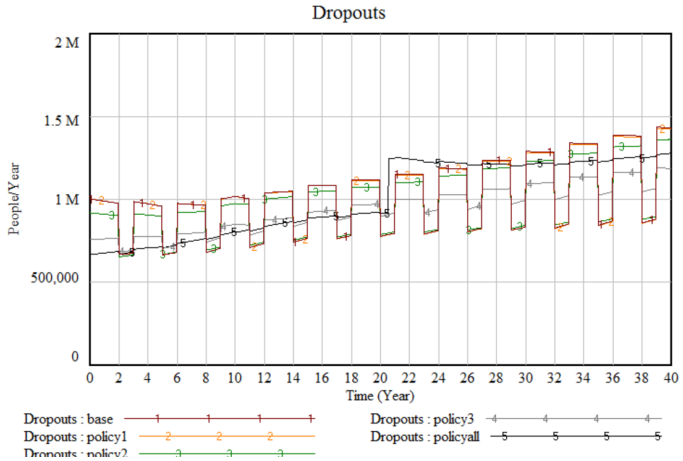

Figure 13: All policies effect on dropouts

Exploratory Modelling and Analysis (EMA) workbench has been used to study the effects of these uncertain parameters [8, 9].

In the following paragraphs it is discussed which major parameters are expected to be uncertain in both structural and value- based uncertainty. Table 3 in appendix shows the exact intervals of these parameters. 1000 simulation runs were performed for each policy with a different set of input values with their ranges selected from Latin hypercube sampling. The outcomes of these uncertainty analysis are illustrated with a visual ensemble inspection.

The changes in the education system have been uncertain and the government has an authoritative role in this case and thus as per the agenda of the government there is a high possibility of no changes to more than existing number of changes in the education system. Thus this parameter is changed from 1 to 3 changes per year, which is around 1 per year as of now.The references to all these claims have been mentioned in table 3 in appendix.

Another uncertain major parameter is the population growth rate which is not something that can be controlled easily. Three different scenarios are tested in this case where the population growth rate remains same, increases or decreases. All three uncertain situation arises considering Turkey's developing economic conditions with the effects of the recent refugee crisis. Also, the number of students starting vocational school highly depends on how the industry market changes worldwide. There is a possibility that in recent future all the vocational jobs would be replaced by

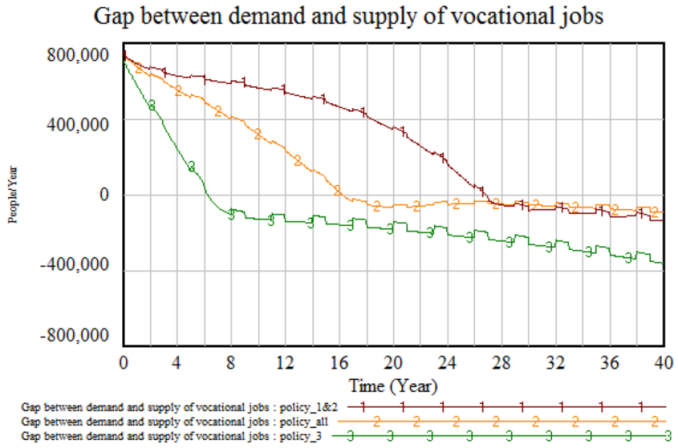

Figure 14: Effect of policies on vocational job market gap compared to individual or in pair

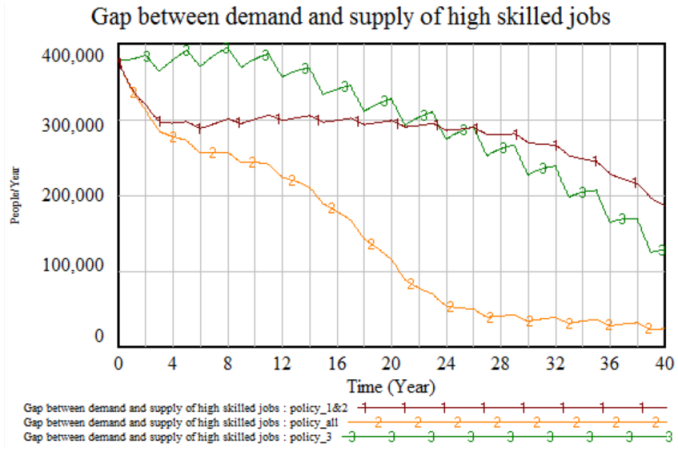

Figure 15: Effect of policies on high skilled job market gap compared to individual or in pair

automation or there is a possibility of more high tech jobs being heavily dependent on these jobs making vocational sector attractive. Similarly high skilled job acceptance rate can be explained.

The results in Figure 16, Figure 17 and Figure 18 shows the uncertainty analysis. Here the term *high skilled policy* means the policy 1 which directly affects the high skilled job markets by channeling the government investment. Whereas, *vocational policy* means the policy 2 affecting the vocational job market directly with higher investment of industries in vocational market.The gap indicator policy reflects the third policy which focus on controlling the number of changes based on the number of dropouts.

The graph of the gap in high skilled jobs market show a high dependence on the uncertain parameters and also the behavior changes with the uncertain parameters. Though this can be clearly seen that the vocational and the gap indicator policies do not affect the gap to be reduced as well as the high skilled policies do. The same can be concluded when all policies are applied together. It is no surprise that the probability distributions are similar for all of these policies.

No such behavioral sensitivity is present in the policies analysis for the vocational job market. In fact, the numerical sensitivity is also not so significant for this indicator with respect to all the policies. This means that in this aspect the policy is quite robust.The probability distribution is slightly different for high skilled policy and it can be expected considering that it does not affect

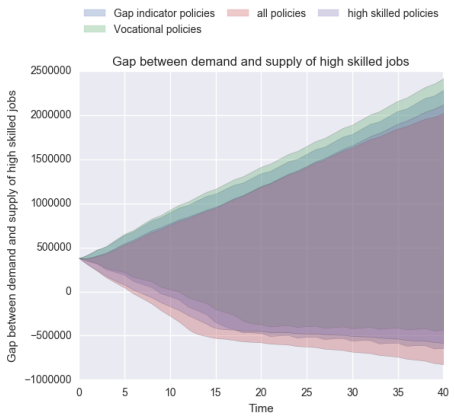

Figure 16: Envelopes of gap between demand and supply of high skilled jobs

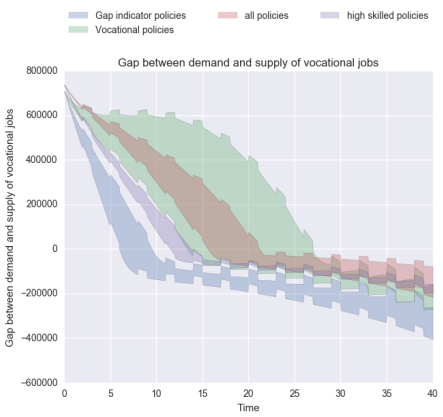

Figure 17: Envelopes of gap between demand and supply of vocational jobs

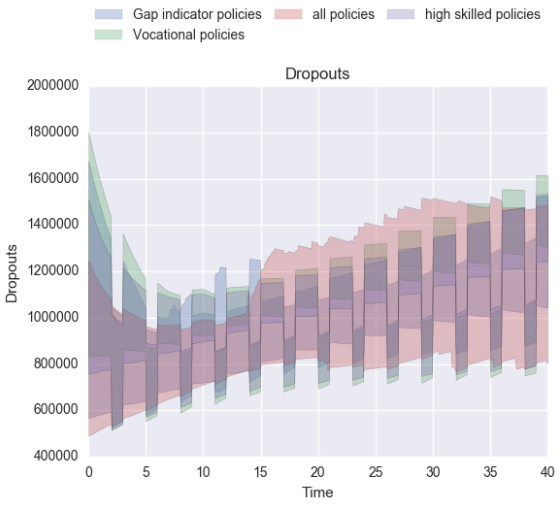

Figure 18: Envelopes of dropouts

the gap in vocational jobs as directly as others.

The dropouts show a numerical sensitive graph for all the policies except when all policies are implemented together (it also shows behavioral sensitivity then). This shows that when the policies are implemented together, the results can be fairly unexpected for the number of dropouts.

5 | Conclusion and Recommendations

This study shows that current education system in Turkey is not satisfactory to meet industry needs. The main reason is that skills and knowledge gained at university and vocational schools do not correspond the industry expectation. Currently, vocational schools are not attractive and there are not that many job opportunities for vocational school graduates. On the universities side, companies are not satisfied with university graduates capabilities; meaning that there are more job opportunities than number of high skilled graduates. Due to the mismatch, even though Turkey has a high potential for rapid development, education policies do not allow the country to benefit from the young population. That is why this study suggests three policies to eliminate

deficiencies in job market. It can be clearly seen in Figure 14 and Figure 15 that the policies if applied individually do not create a stable impact as the policies when implemented together do.

The policies significantly affect the gaps in the job market and thus are highly recommended. The policy robustness tests shows that the change in parameters might affect the behavior of the high skilled job market gap but the gap in the vocational job market remains fairly maintained near zero with same behavior when all policies are implemented. It can be seen that these policies are not so effective over the total number of dropouts, but this can be considered to be acceptable because the gap in the job market still gets maintained near zero. Also, it can be concluded that the number of changes in education system do not have such a huge impact as assumed in the preliminary analysis. This is concluded by observing the results from the policy which directly affects dropouts and revolves around the number of changes.

Future research based on this study would focus on the impact of the education system on the unemployment and the economic factors which affect the system. The study revolving inequality can also be considered to combine with this study over quality of education system and discrepancy in the job market.

References

[1] Necmi Aksit. Educational Reform in Turkey. *International Journal of Educational Development*, 27(2):129–137, 2007.

[2] Trading Economics. Turkey population. `http://www.tradingeconomics.com/turkey/population`, 2016.

[3] Human Development Sector Unit Europe and Central Asia region. Turkey higher education policy study, 2007.

[4] Muhammed Ertaç Atila and Ömer Faruk Özeken. Temel eğitimden ortaöğretime geçiş sınavı: Fen bilimleri öğretmenleri ne düşünüyor? *Ondokuz Mayıs Üniversitesi Eğitim Fakültesi Dergisi*, 34(1):124–140, 2015.

[5] N Gizem Bacaksızlar and Yaman Barlas. The feedback dynamics between poverty and education opportunity: Vicious circle of poverty.

[6] Erik Pruyt. *Small System dynamics models for big issues: Triple jump towards real-world complexity*. TU Delft Library, 2013.

[7] Robert K Holmes. System enquiry: A system dynamics approach: John wiley & sons, chichester, 1990, xi+ 238 pages,£ 16.50, isbn 0-471-92783-x, 1991.

[8] Jan H Kwakkel and Erik Pruyt. Using system dynamics for grand challenges: the esdma approach. *Systems Research and Behavioral Science*, 32(3):358–375, 2015.

[9] Jan H Kwakkel and Erik Pruyt. Exploratory modeling and analysis, an approach for model-based foresight under deep uncertainty. *Technological Forecasting and Social Change*, 80(3):419–431, 2013.

[10] Programme for International Student Assessment. *PISA 2012 Results:Ready to Learn*. OECD, 2012.

[11] The World Bank. How to improve quality of education in the caribbean for the next generation? `http://www.worldbank.org/en/news/feature/2013/09/18/caribbean-quality-education-improvements-next-generation`, 2013.

[12] Erick Hanushek. Why quality matters in education. *Finance and Development*, 42(2):l5–19, 2005.

[13] Gabriel Heller Sahlgren. *Incentive to Invest*. Research Institute of Industrial Economics, Sweden, 2015.

[14] Philippe Tissot. *Terminology of vocational training policy: a multilingual glossary for an enlarged Europe*. Office for official publications of the European Communities, 2004.

[15] AFD. *AFD and Vocational Training: Working at the core of development policies*. AFD, 2015.

[16] Keith Lewin. Investing in Technical and Vocational Education: a review of the evidence. *The Vocational Aspect of Education*, 45(3):217–227, 1993.

[17] Barcin Yinanc. Constant changes in Turkey's education system confounding all stakeholders. http://www.hurriyetdailynews.com/constant-changes-in-education-confounding-all-stakeholders.aspx?PageID=238&NID=54484&NewsCatID=338, 2013.

[18] Jale Cakiroglu Erdinc Cakiroglu. Reflections on teacher education in Turkey. *European Journal of Teacher Education*, 26(2):253–264, 2003.

[19] Stephen Simpson. Macroeconomics: Unemployment. http://www.investopedia.com/university/macroeconomics/macroeconomics8.asp, 2015.

[20] U. A. Salman. Ozendirmek Var Ozen Yok Meslek Liseleri. http://www.radikal.com.tr/turkiye/ozendirmek-var-ozen-yok-meslek-liseleri-1146743/, 2015.

[21] Worldometers. Turkey population. http://www.worldometers.info/world-population/turkey-population/, 2015.

[22] TRT Haber. Meb orgun egitim istatistiklerini acikladi. http://www.trthaber.com/haber/egitim/meb-orgun-egitim-istatistiklerini-acikladi-178127.html, 2015.

[23] OSYM Sinav. Turkiye'de universite okuyan ogrenci sayisi aciklandi. http://www.osymsinav.net/node/495, 2015.

[24] Enjoy Turkey. Turkish education system. {http://www.enjoyturkey.com/info/facts/Education.htm}, urldate = 2015, 2015.

[25] Aksakal. Arama suresi 1 yil mi? {http://www.capital.com.tr/insan-kaynaklari/arama-suresi-1-yil-mi-haberdetay-5217}, 2015.

[26] Ali TAŞ, Veysel Bora, Abdullah Selvitopu, and Yusuf Demirkaya. Reasons for dropout for vocational high school students. *Educational Sciences: Theory & Practice*, 13(3):1561–1565, 2013.

[27] Hurriyet Egitim. 235 bin ogrenci okulu terk etti. http://www.hurriyet.com.tr/235-bin-ogrenci-okulu-terk-etti-28369181, 2015.

[28] Education System. Study in Turkey. http://www.studyinturkey.com/content/sub/education-system.aspx, 2015.

[29] A Yalcintas. An Insight into Higher Education in Turkey, 2015.

[30] European Comission. Organisation of the education system in Turkey. http://www.etf.europa.eu/webatt.nsf/0/60E61005D5CC5AD1C1257AA30025212F/\$file/Organization\%20of\%20the\%20education\%20system\%20in\%20Turkey\%202009.2010.pdf, 2010.

[31] Serkan Aydin. Transformation of turkish vocational and technical education. *Scientific Journal of Education Technology*.

[32] M Sonmez. Alla turca commercialization of education amid university boom. http://www.hurriyetdailynews.com/alla-turca--commercialization-of-education-amid-university-boom.aspx?PageID=238\&NID=69368\&NewsCatID=344, 2014.

[33] OECD. Education gps. http://gpseducation.oecd.org/CountryProfile?primaryCountry=TUR, 2015.

[34] Aleksandra Jarosiewicz. Turkey's economy: a story of success with an uncertain future. http://www.osw.waw.pl/en/publikacje/osw-commentary/2013-11-06/turkeys-economy-a-story-success-uncertain-future, 2013.

[35] Aleksandra Jarosiewicz. 2000 turkish students drop out of school daily. http://www.hurriyetdailynews.com/default.aspx?pageid=438\&n=82162000-turkish-students-drop-out-of-school-daily8217-2011-09-22, 2011.

[36] World Bank. Turkey gross enrollment rate. http://data.worldbank.org/indicator/SE.PRM.ENRR/countries/TR-7E-XT?display=graph, 2012.

[37] Ministry of National Education: Republic of Turkey. Basic Education in Turkey: Background Report.

Appendix

Historical Validation and Uncertainity Analysis

Table 1 and Table 2 present the real values and their corresponding references and this helps in validation of the model by comparing the exemplary simulation run results with the real values.

Table 1: Historical data check input for validation

Parameter in the Model*	**Value & Reference**
% going to university from vocational schools	0.2 [20]
Initial population	63000000 [21]
Initial number of primary and secondary school students	6500000 [22]
Initial number of students in vocational school	1129000 [22]
Initial number of students in high school	5650000 [22]
Initial number of students in university	2000000 [23]
Time taken to join school	7 [24]
Time to find job	1 [25]
% going to university from high schools	0.5
Dropout rate in high school	0.05 [26]
Dropout rate in vocational school	0.094 [26]
Dropout rate in university	0.2 (2014)
Total number of dropouts in primary and secondary school students in 2013-2014	400000 [27]
Average time spent in high/vocational school	4 [28]
Average time spent in pri&sec school	8 [28]
Average time spent at the university	5 [28]
% graduating from vocational school	0.906 [26]
% graduating from university	0.8 (2014)
Initial number of universities	100 [29]

*The table lists only the constant parameters found in online sources and literature. Other constant parameters in the model are estimated based on the modelers insight on the topic.

Table 2: Parameter value & reference for the model

Variables in the Model	**Model Value**	**Value & Reference**
No. of pri&Sec school in 2009-10	10-11 Million	12.3 Million [30]
No. of vocational students in 2010	75	1 Million [31]
No. of University students in 2014	2.5 Million	2.9 Million [32]
No. of graduates from universities in 2006	386	390,000 [33]

Table 3: Parameter intervals and references for model robustness tests

Parameter	**Value**	**Range**	**Source**
Changes in the education system	1 per year	1 per year to 3 per year	[27]
Population growth rate	0.015	Lookup functions: a. The population growth rate increases b. the population growth rate decreases c. the population growth rate remains same	[34]
% of student going to vocational school	10%	0-30%	Assumed
Dropout rate in high school	5%	0-20%	[35]
% of population starting school	20%	20-40%	[36]
High skilled job acceptance rate	10%	5-20%	Assumed
Student engagement	1-0.4 (exponential decay)	Varied exponential decay	Assumed
# of university teachers	10000 - 50000 (linear rise)	a. Stays constant around 50000 b. Increases above 50000	[37]