Dynamics in economic growth:

A perspective from System Dynamics

Mª Dolores Soto Torres, Ramón Fernández Lechón

Facultad de Ciencias Económicas y Empresariales
Universidad de Valladolid (España)
lolasoto@eco.uva.es, ramonfer@eco.uva.es

Pedro Fernández Soto

PriceWaterhouse&Coopers, Madrid (España)
pedro.fernandez.soto@es.pwc.com

Abstract

Evidence shows that the paths of growth followed by different countries are diverse. While some countries present a fast growth, other countries show a moderate or even, a slight growth. The first behavior could be justified by means of positive feedback loops that provoke strong accumulations while the second one could be explained through interrelationships of positive and negative feedback loops. To generate process of growth, this paper constructs a system dynamics model considering a causal structure that gathers decisions of consumers, firms and a government in an economy. A simulation exercise obtains different paths of growth taking into account both different governmental strategies and boom and bust cycles. Due to the possibilities that the model offers different political aspects tied to governmental strategies, such as distribution of wealth, degree of corruption or level of education, are examined.

Key words: Economic Growth, Inequalities, Wealth Distribution, System Dynamics, Modeling and Simulation.

Introduction

It is not difficult to check that countries show different paths of economic growth when it is assessed by their Gross Domestic Product (GDP). For instance, according to International Monetary Found[1] statistics from 1992 to 2008, countries such as China, Brazil, India, Russia, presented a strong growth; a growth less intensive was shown by countries such as Canada, Germany, Chile or Korea and very little growth or a decreased growth could be found in countries such as Zimbabwe, Guinea or Rwanda. Figure 1 illustrates the gross domestic product, at current prices, for different countries in which are included the previous ones.

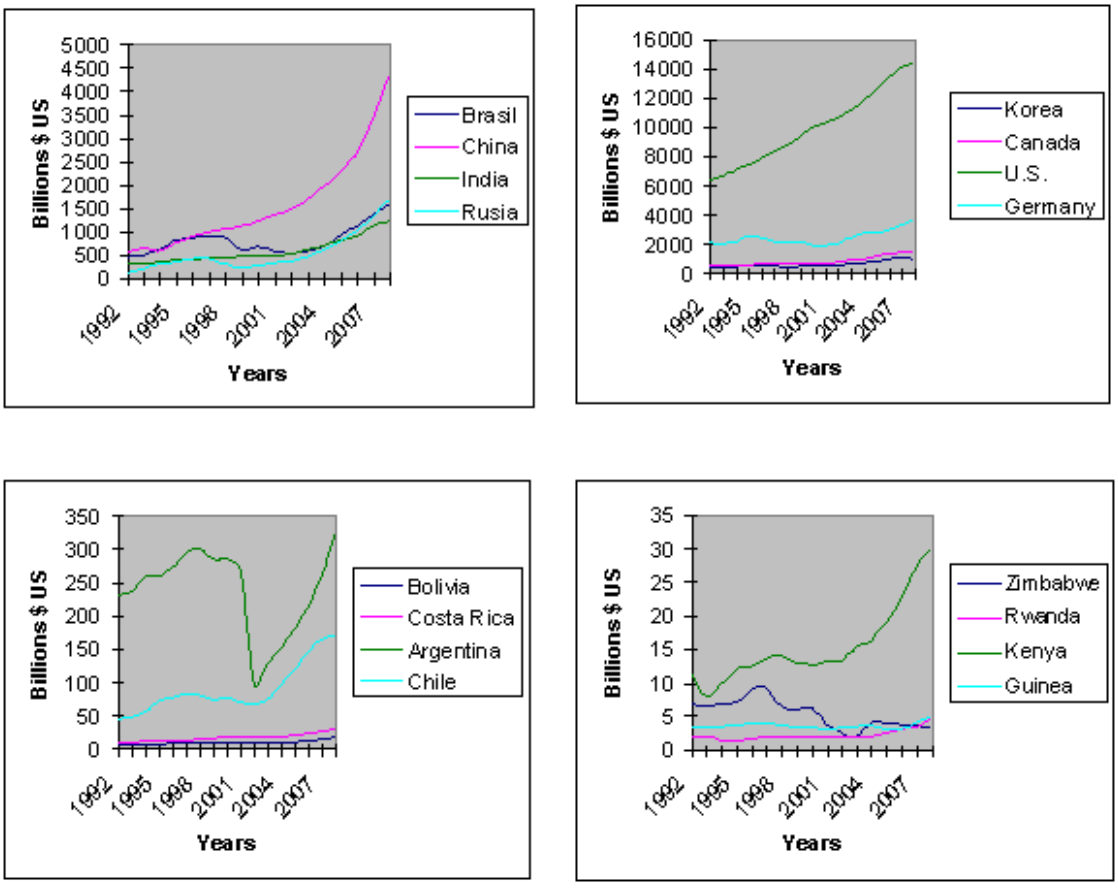

Figure 1: Different paths of growth

Many economic growth scholars agree that the differences among countries could be explained considering a wide variety of factors such as capital accumulation, level of education, population growth, level of investments in research, development and innovation in industries, good institutions, management of the public resources, initial conditions of the economy, fiscal policy, level of international trade, geographical factors, natural resources, governmental consumption, level of infrastructures, etc. Nevertheless, in spite of agreement about the process depends on many factors, the researches about the topic focus the issue on just a limited number of factors. For example, Levine et al. (1992) identify a positive, robust correlation between economic growth and the share of investment in GDP and between the investment share and the

[1] http://www.imf.org

ratio of international trade to GDP. Collier et al. (1999) examine geographical and institutional factors to explain why 32 countries in Sub-Saharan Africa were poorest in 1999 than in 1988. Owen et al. (2009) find strong evidence about quality of institutions, degree of law and order to explain why countries are in different regimes of growth. Acemoglu et al. (2000), Aghion et al. (1999) or Eicher et al. (2009) indicate the importance of human capital accumulation and good institutions to foster endogenous growth though the physical capital accumulation is also pointed out by them as an important factor.

Although there is a certain controversy about the relative influence of each factor on growth, literature agrees that some factors foster the prosperity of a country more than other ones. Moreover, it is pointed out that the misuse of certain elements would hamper the growth.

The different impact of disparate factors on the production could be employed to justify why countries can follow different paths of growth: countries with rapid and sustainable growth, countries with decelerated growth during certain intervals of time or countries caught in poverty traps. But these basic behaviors over time are well known by experienced in System Dynamics: a variable taken part of a positive feedback loop could present opposite behavior from an exponential growth to an exponential decay depending on the action that influences it (Sterman, 2000, p. 264). Nevertheless, not only the economic growth had to be led by positive feedback loops, but also in the process negative feedback loops could be involved. Such situation can be observed, for example, when police makers try to achieve certain goals, in particular, social goals like distribution of wealth or subsidize certain type of activities. In these cases, the policies adopted to attain them usually affect the process of growth. In this way, System Dynamics methodology would contribute to tackle the growth from other perspective than traditional one. In fact, from a System Dynamics view, the evolution of the economic growth in a country would arise from the interrelationships arising between nested positive and negative feedback loops; the dominant loop, during each spell, will determine the growth over that spell. As a result, the behavior over time of the output produced by a country would be just the evolution of the dominant feedback loop.

The basic aim of this paper is to construct a dynamic model for addressing heterogeneous growth in countries. The construction of the model is based on a feedback structure that is obtained considering the interrelationships arising among certain actions carried out by three agents in a small open economy: consumers, firms and a government. Specifically, the causal structure shows that consumers make decisions about human and physical capital accumulation. The consumers' decisions are linked to the productive system in which is produced an output and are set the wages. Finally, a government is considered. It levies taxes to achieve different aims such as subsiding education, subsiding unemployment and other social benefits; even, taxes could be employed to attain own enrichment in case the government is corrupt.

Nevertheless, although the causal structure of the model does not consider all the factors that influence the paths of growth according to literature, it takes into account a rich environment that is introduced in recent models: heterogeneous consumers, markets are competitive but incomplete, every worker faces an idiosyncratic income shock and aggregate productivity is uncertain. Models presenting similar environmental characteristics can be found in Den Haan et al. (2010) and Castañeda et al. (2003). The

new environmental characteristics increase the complexity of the model since both widen their nonlinear features and introduce certain degree of uncertainty.

The paper is organized as follows. The second section describes the relationships of the agents that take part in the economy. The third section illustrates the evolution of the population and the distribution of wealth. The fourth section specifies the parameters and initial conditions of the levels as well as the characteristics of the underlying environment of the dynamic model on which the simulation is carried out. The fifth section details the different scenarios and shows the results attained. Finally, taking into account the results achieved, some politics aspects are analyzed and then, some conclusions are presented where are emphasized the achievements that are thought more outstanding.

The feedback structure

The dynamic model is constructed considering a small open economy, which means that the economy is strongly influenced by exogenous policies whereas the influence of its decisions abroad is very limited. The country is populated by an overlapping generations in which individuals live for four periods. During the first period of life, people could choose whether to study or to work. During the second and third periods of life, people just work or are unemployed and, finally, during the fourth period of life, people do not work: they are retired. Then, except for the students, the retired and the unemployed people, individuals take part in the productive sector.

In accordance with the decision of investing in education or not during the first period of life, the economy has two types of workers: skilled and unskilled workers. The level of skill is important because every employee receives a wage depending on it. The wages are set by the firms taking into account the production. As regards the education, it is assumed that it is expensive and everybody cannot afford it. Because of this, the government could subsidize it in order to increase the number of skilled workers in the economy and, in that way, increase the production.

Likewise, all individuals consume and the fraction of wealth that is not consumed is saved. The wealth accumulated by the agents is lent to the firms. As a result, the individuals receive capital income that is valued considering the world interest rate because the economy is both open and small. Finally, it is assumed that people are altruists with regard to their offspring and they leave a bequest when they die.

The productive system uses a specific technology that combines labor and capital to obtain final production that is identified with the GPD. The productive system requires two type of skill and distinguishes between skill and unskilled workers. As far as the government is concerned, it levies taxes on final production and on the income of individuals that includes labor and capital income. The public resources obtained from the taxes are allocated by the government to get certain targets. In particular and following Eicher et al. (p. 210), the model assumes that the production requires a provision of a public good, which must be thought of as an infrastructure requirement necessary to obtain the production. Nevertheless, the infrastructure is not considered a productive factor. This public good is financed through taxes, implying that if the government tries to achieve other aims, then the tax rate must increase.

Accordingly, two positive feedback loops, R1 and R2, which are shown by Figure 2, influence the evolution of the economy. Loop R1 links five variables. One of them is the capital from which is obtained the capital income considering the world interest rate. The workers' income is the result of adding the capital income and the labor income. However, workers receive net income because of taxes. A fraction of the net income is consumed and the remainder is saved yielding an increase of capital. Loop R2 links seven variables, among them four variables also belonging to loop R1; this loop considers the causal relationship between the capital and the production that, in turn, influences the net production, this is, the production after taxes. From this last variable is possible to determine the wage that is an important element of the workers' income.

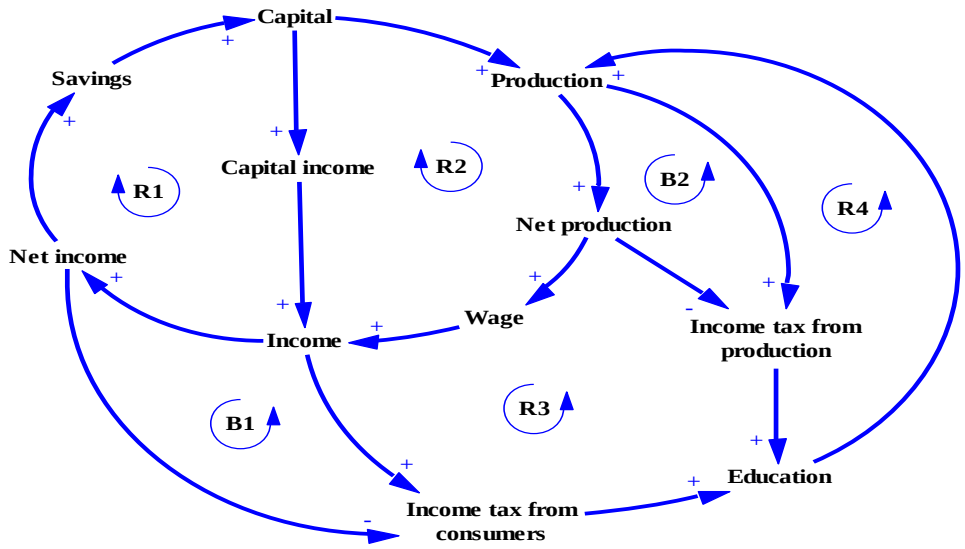

Figure 2: Feedback processes in growth

The government's actions can provoke new feedback loops if the public resources obtained from taxes are invested for boosting some stage of the productive sector or to improve workers' income. Figure 2 shows four new loops, two positive and two negative, linked to the loops R1 and R2. The new loops arise when a fraction of the public resources are used for subsidizing education. The new positive feedback loops indicate that the production progressively will improve because educate people would have higher productivity whereas the negative loops reflect that higher taxes depress the production because individuals have less available income. In fact, the loop B1 considers how the government increases the public resources from the consumption; but if these resources are invested in education then, the production grows when more educated become part of the productive system. The loop B2 collects the same idea but considering the public resources obtained from the production. The loops R3 and R4 are similar to B1 and B2, respectively, apart from B1 does not consider the net income and likewise, the net production does not belong to loop B2.

Notice that the causal structure collected by Figure 2 could be widen with new feedback loops if the government would finance by means of taxes the unemployment benefits and the Social Security to retirees. In fact, if the government allocates public resources in a way that the population's income increases, new loops sharing variables with the loops B1, B2 and R3 will appear.

Population and wealth

As a result of splitting up the workers in the economy depending on their level of skill, it is possible to study the evolution of wealth under different government's strategies. But firstly, it seems necessary to specify certain characteristics of the population just as the formation of their wealth.

Since the life of each individual is divided in four periods, the population can be allocated by age: the first generation would correspond to the young people; the second generation would include people from 26 to 45 years; the third generation would contain people from 46 to 65 years and finally, the fourth generation would consider people older than 65 years.

The model assumes that young people are born with an endowment of basic knowledge, which allows them to be unskilled workers. Nevertheless, if they decide to increase their human capital they will be able to become skilled workers when they attain the age of the next generation. Figure 3 shows population classified by skill and age. However, in the economy and according to Eicher (p. 210), education is expensive and nobody can borrow to finance it. Consequently only the wealthy individuals can finance the education of their children, which belong to first generation whereas their parents belong to third age group.

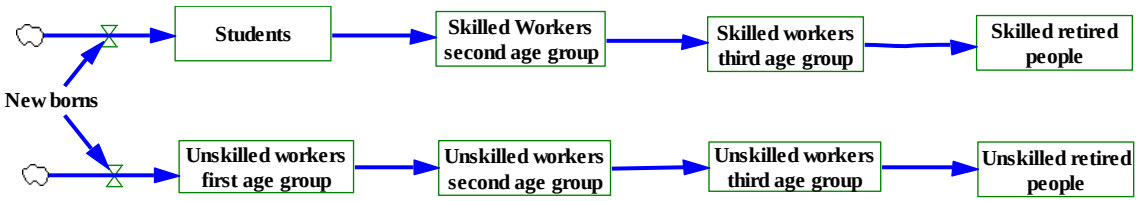

Figure 3: Individuals distributed by skill and age

When individuals reach the last generation, they do not work. The last generation's consumption is conditioned to their wealth; in addition, they leave a bequest, which is received by people belonging to third generation. All individuals in the economy make consumption-savings decisions apart from students. By simplification and according to Krusell et al. (1998, p. 873), it is assumed that the wealth, for each age group, is always non-negative.

As previously stated the economy is small and, consequently, is affected by external influence. Taking into account that fact, the causal structure is also surrounded by environmental conditions implying that its evolution depends on exogenous elements. In order to concrete such factors, it is assumed that the economy is immersed in cycles: a period of recession is followed by a phase of expansion continued with a new period of recession. Every stage of a cycle has its own characteristics. The demand of final production diminishes when the economy is in recession and the adjustment provokes an increase of unemployment rate. On the contrary, when the economy is in a phase of recovery, the demand of goods and services increases and the productive system requires more workers. Besides these aspects, it is assumed that the individuals cannot directly insure against the shocks though the savings can play a precautionary role in order to overcome idiosyncratic shocks. Figure 4 shows causal relationships arising in the phases of a economic cycle.

Finally, it also seems important to emphasize that the idiosyncratic shock determines whether a worker is employed or unemployed. The first earns a wage whereas every unemployed individual receives unemployed benefits, which are financed by taxes.

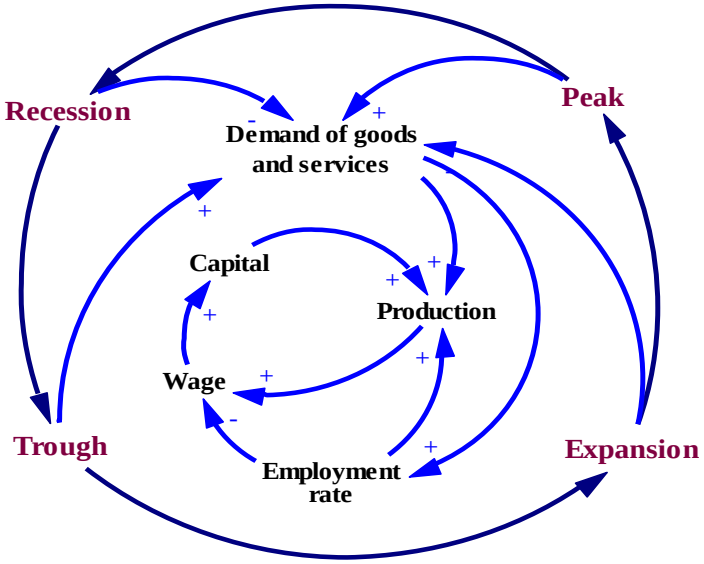

Figure 4: The influence of cycles in production and employment

Calibration

Most parameter selected for the economy are based on literature and the rest are set in order to ensure that the model stars out balanced.

The population stays constant during the simulation. When an individual enters in the first generation, he/she stays there for five years whereas if the individual reaches any other generations, he/she will stay there for twenty years. All the levels that are related to the second, the third and the fourth generation contain the same number of people. There are less people in the first generation because people stay there less time. The population is distributed unevenly with regards to the level of skill: at the beginning of simulation 25% of people are related to skilled workers and the rest are unskilled workers.

The interest rate, which is an exogenous variable because the economy is open and small, is equal to 3%. The share of capital in GDP takes a standard value equal to 0.36 considering a Cobb-Douglas production function for both skilled and unskilled sector. It is assumed that the technology used by skilled workers has higher productivity than that used by unskilled workers. Nevertheless, the differences about productivity depends on environmental conditions essentially in which the economy is immersed. In a trough, the productivity is 0.8 for skilled workers and 0.4 for unskilled workers; in a peak, the previous values are incremented by two points.

The unemployment rate is 4% in a peak and 10% in a trough. It is assumed that an unemployed receive 15% of the wage earned by an employee with the same level of skill. Similarly, retirees receive 20% of the wage earned by an employee with identical level of skill. The distribution of the production is as follows. After paying the return

on capital in each productive sector, the rest of the net production is earmarked by firms to the remuneration of workers. The tax rate for the benchmark is 12%.

The public resources are obtained from the production, the capital income and the labour income; they are earmarked to finance infrastructures, unemployment benefits and pensions. If the government subsidizes education, it could chose two types of strategies: one would be a universal subsidy; the other would be a targeted subsidy awarded only to the poor, so that the rich still had to face a cost of education. If the policy is adopted, the targeted subsidy would be considered. The grants would be received by students just in one payment, which would cover the whole cost of the education. Education cost is around 50% of the skilled worker's wage, per unit of time during the simulation.

The propensity to consume is equal to 90% of net income for skilled workers belonging to the second generation; 80% for skilled workers in third generation and the retired workers consume of their wealth 15%. Regarding unskilled workers, it is assumed that the first generation save of their net income 1%; the second and the third generation save 2%. Finally, the retired workers consume of their wealth 110%. Students do not consume, their parents finance their expenses. The levels of wealth corresponding to young people are null in the beginning of the simulation. The levels that accumulate the wealth of the rest of generations are initialised with the same value depending on whether they are related to skilled or unskilled workers. The skilled workers accumulate 75% of wealth at the beginning of the simulation.

Simulating the model

With the aim to obtain different paths of growth, the same economy is considered but is involved in different policies and environmental conditions, which are implemented at the beginning of the simulation. The unit of time and the step of the simulation are selected equal to a quarter of a year and the time horizon is 30 quarters that is thought as a long enough time for observing the influence of the policies to study.

Four different scenarios are considered whose features are synthesised as follows.

- Scenario 1. There is not aggregate uncertainty and the economy is immersed either in a peak or in a trough. The productivity, therefore, will be different depending on the environmental condition. When the economy is maintained in a trough it has an unemployment rate equal to 10% at the beginning of the simulation. During the simulation, the employment follows a first-order Markov processes characterized by the transition probabilities that determine the probability that the shock attains a value next step given that now the shock has a certain value. Table 1 collects the matrix of probabilities with two states: u^- indicates unemployment rate and u^+ employment rate.

  Table 1: Transition probabilities in a trough

t \ **t+1**	u^-	u^+
u^-	0.54	0.46
u^+	0.1	0.9

However, when the economy stays in a peak, it starts with an unemployment rate equal to 4% and during the simulation the unemployment-employment rates also follow a Markov stochastic process, but different than the case above. In this case the probability matrix is shown by Table 2.

Table 2: Transition probabilities in a boom

t \ **t+1**	u^-	u^+
u^-	0.46	0.54
u^+	0.025	0.975

Using the probability matrices, observe that the average time of unemployment is 2.5 quarters when the economy stays in a trough and it is equal to 1.5 quarters when the economy is in a peak. In addition, the scenario considers two different governmental policies regarding taxes: one assumes that the tax rate is equal to the benchmark case and the second one, the tax rate is equal to 25%.

- Scenario 2: The aim of this scenario is to promote human capital accumulation. Because of this the government subsidizes education to young people whose parents have low level of wealth. The characteristics of the scenario do not differ of those considered in scenario 1 apart from the fraction of public resources dedicated to finance the education: 20% of the public resources after paying the benefits for the unemployed and the Social Security for retirees. Similarly, with regard taxes the same possibilities than scenario 1 are considered.

- Scenario 3: According to Den Haan et al., it is assumed that the economy undergoes different processes that affect the aggregate production and the employment status for individuals. This scenario assumed that the aggregate shock follows a first-order Markov process characterized by the transition probabilities collected by Table 3. The table can be used to determine the situation inside the cycle of the economy: a^+ would indicate the percentage of peak of each point and a^- the percentage of trough. The table shows that the expected duration of staying in the same regimes is twelve quarters and also indicates that the business cycles are symmetric as shown by Figure 5.

Table3: Transition probabilities for the economic cycle

t \ **t+1**	a^-	a^+
a^-	0.75	0.25
a^+	0.25	0.75

To complete the characteristics of the economy, observe that at any step of the simulation, the economy has a degree of peak and trough. Adding both values one is obtained. Then, the unemployment rate and the productivity could be averaged using the degrees of peak and trough in which the economy is found. An example shows the calculation. For example, if the economy is in a stage

with 10% of peak and 90% of trough, the unemployment rate is equal to 0.094=(0.1)(0.04)+(0.9)(0.1). Similarly, the productivity could be determined.

Finally, this scenario considers the same possibilities, regarding taxes, than scenario 1.

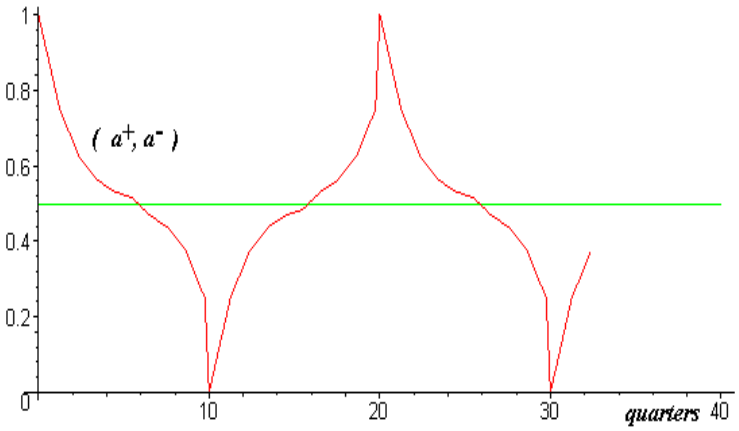

Figure 5: Amplitude and phase of the cycles

- Scenario 4. This scenario combines aggregate uncertainty with education subsidies. In this way, its features coincides with scenario 3 apart from the government invests in education. Once again, the same possibilities than scenario 1 are now considered regarding taxes.

Results of the scenarios

Figure 6 shows the production of the economy and Figure 7 the production of each sector, both under the first scenario. Figure 6 assumes that the economy is in a trough and Figure 7 in a peak. The paths collected by each figure are consequence of considering different tax rates. The benchmark rate is used to generate path 1, when the graphs are placed on the left hand, and paths 1 and 3 for graphs placed on the right hand.

The figures illustrate different paths of growth. A growth closer to zero when the economy stays in a trough and a growth that reaches a stationary regime when the economy is in a peak. The slight growth in the trough is mainly due to the growth of the output produced by the skilled workers since the other sector's production practically remains constant during the simulation regardless of taxes. On the contrary, the growth in the peak is consequence of the growth generated by unskilled workers, which strongly depends on the tax rate used. Likewise, the figures check the influence of taxes on growth, allowing us to obtain a simple conclusion: if the tax rate increases, then the production decreases. It is also possible to observe that the differences of growth, as consequence of differences in taxes, increase over time.

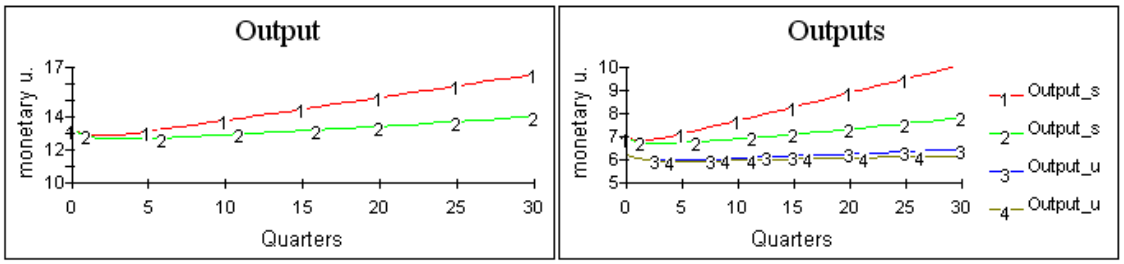

Figure 6: Growth in a trough

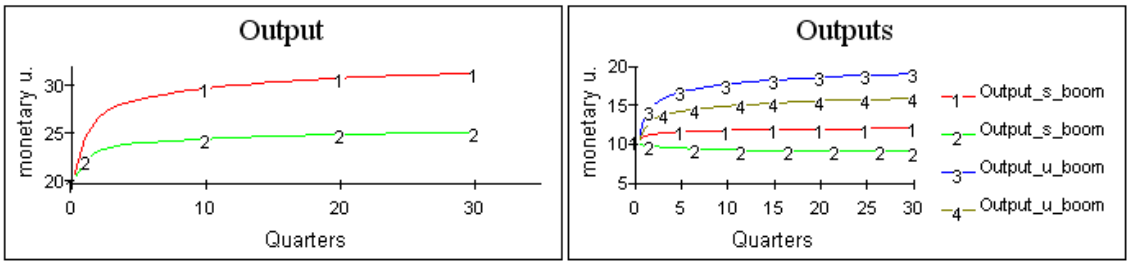

Figure 7: Growth in a peak

In the second scenario, when the economy is in a trough, the adoption of the education subsidy affects production because it slowly improves. Under that environment and regardless of the tax rate adopted by the government, the sector employing skilled workers increases the production whereas the production of the other sector declines or remains constant. These results can be checked on Figure 8. On the other hand, Figure 9 shows that the education subsidy does not affect perceptibly the growth when the economy stays in a peak. This fact can be verified easily if Figures 7 and 9 are compared.

Besides these outcomes, it is also possible to observe the differences in growth of the sectors as a result of the education subsidies as well as of the environmental conditions in which is involved the economy. In a trough, the education subsidy diminishes the growth of the two sectors; especially, the sector employing unskilled workers is very affected. In a peak, the changes promoted by the subsidy, which decrease the number of unskilled workers, and therefore, increases the number of skilled workers, cause a slow growth of the output in the sector employing skilled workers and a decrease of the production of the other sector. Under this situation, the transfer, from a sector to other one, achieves that the production of the sector employing skilled workers reaches the production of the other sector at the end of the simulation. Finally, it is possible to observe comparing Figures 6 and 7 with Figures 8 and 9 the influence of the governmental policies on the growth of the sectors. In a trough and with subsidies, the paths of growth of the sector requiring skilled workers are closer under different tax rate; however, the paths of the other sector are not specially affected by the different tax rates. In a peak and without subsidies, the paths of growth of the sector where unskilled workers develop their activity are closer and the other sector is not sensitive to changes of tax rates.

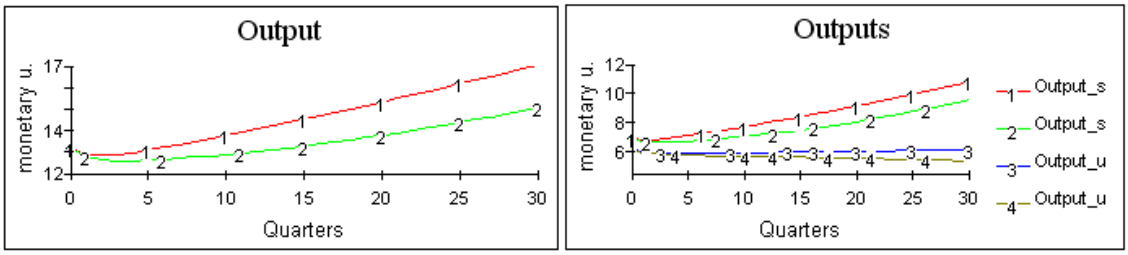

Figure 8: Growth in a trough and education subsidy

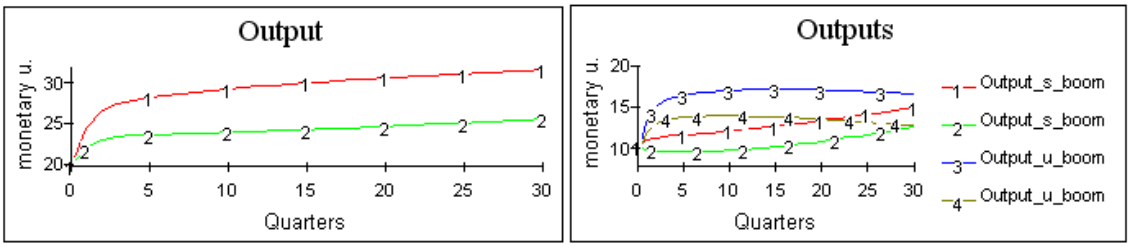

Figure 9: Growth in a peak and education subsidy

Figures 10 and 11 illustrate the growth of the economy as well as the growth of the two sectors, when the economy is immersed in cycles. Figure 11 assumes that the government subsidizes education to the poor whereas Figure 10 does not consider such possibility. From the figures, two characteristics can be observed in this scenario that does not appear on previous ones. First, the tax rate is not as important as previous scenarios because the paths associated with the same variable are closer. Moreover, the figures show that the environmental conditions have now a significant influence. To check that it may suffice to observe to the production of the economy and the production of each sector since the paths of growth show clearly the phase of the cycle in which the economy is involved.

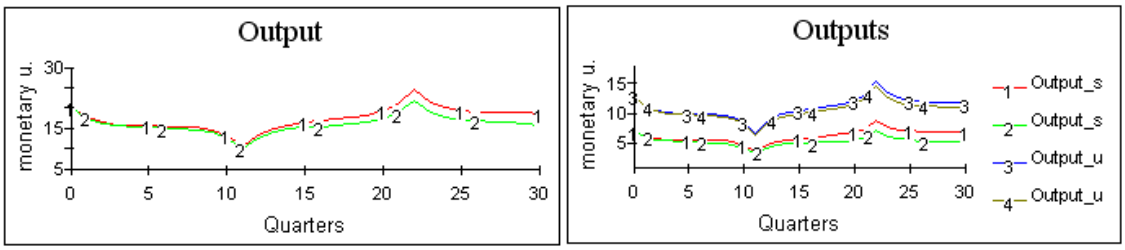

Figure 10: Aggregate uncertainty

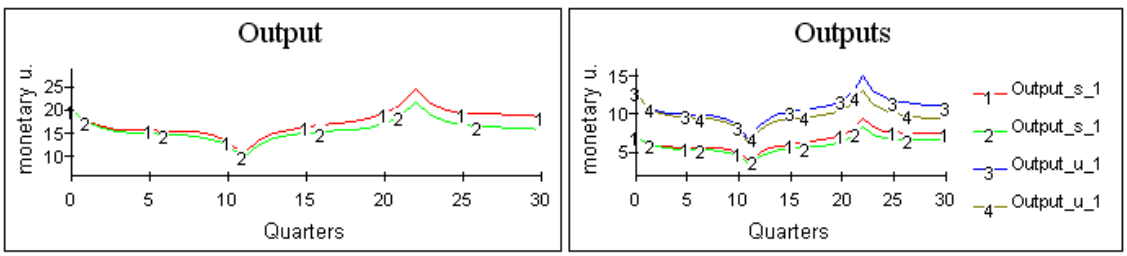

Figure 11: Aggregate uncertainty and education subsidy

Others aspects of politics

Due to the structural characteristics of the model, it could be used as a tool to examine new issues. Some of them are to a large extent related to the political aims of the party in power assuming that the country has implemented a democratic system where all individuals vote. In particular, the model allow us to study how the governmental policies interact with the distribution of wealth and even, it could be used to analyse the interaction between education and the re-election probability of the party in power.

The influence of each governmental strategy in the distribution of wealth could be assessed determining the Gini index for two temporary different situations: at the beginning and at the end of the simulation interval. That aspect can be studied because the model distributes the individuals' wealth by generations. Since the levels are initialised regardless of the strategy used by government, the Gini index is identical for all the scenarios at the beginning of simulation. Its value is equal to 0.22 and because of this there is no excessive concentration of wealth at that moment. At the end of simulation, under the first scenario the best index (0.03) is obtained when the economy is in a peak and the tax rate is low. Moreover, in that situation all generations have high levels of wealth. The index gets slightly worse when the tax rate increases, but it is higher to the initial value when the economy is in a slump. In the second scenario, the index attains almost equals values to those obtained in the first scenario. In the third scenario, the change of tax rate modifies slightly the index regarding its initial value: 0.21 with low taxes and 0.22 in the other case. Finally, the index does not change perceptibly when the model run under the fourth scenario compared to the third scenario: 0.18 with low taxes and 0.21 in the other possibility analysed.

One of the aspects that hitherto the simulation has not considered is the one related to infrastructures. Not even the calibration took into account that aspect, in spite of fact that the model assumes that the government has to use a certain fraction of public resources to face that expense. Nevertheless, all the scenarios show a surplus of public resources: the government spends fewer resources than it collects. Then, it could be thought that a fraction of the public surplus would cover the provision necessary for the infrastructures. However, the public surplus on different scenarios is different. Because of this, it is possible to associate infrastructures and corruption taking into account the public surplus obtained by the simulation for each scenario. In fact, if two scenarios offer different amounts of public surplus, it can be assumed that if the scenario with the lowest amount can provide the necessary funds for the infrastructure, the scenario with the highest amount of public surplus use the remainder for its own enrichment. Figure 12 shows the public surplus, for the first and second scenario when the economy is in a trough. Comparing the results it could be observed that the government corresponding to first scenario seems more corrupt than the second one because the public surplus in first scenario contains the fraction of public resources that the second earmarks to education. The increase of taxes would not be justified except in case the infrastructures really require a higher investment. Obviously, the previous observations connecting governmental corruption and public surplus can be generalized when the other scenarios are compared.

A new aspect can still be examined with the model if the skilled individuals can monitor the behaviour of the party in power. It is assumed that the skilled individuals are more motivated to have better information about the cost of infrastructures and, in this way, they can assess if the public resources are well-managed or not. In other words, they

would judge whether the government is corrupt or not According to Eicher et al. (p. 215) it will be assumed *that the probability that a corrupt party is caught increases in the number of educated individuals*. Therefore, when most of the people are educated and they realize that the party in power is corrupt, voters will not re-elect it. On the contrary, when the party is honest or is not caught, the probability of being re-elected is high.

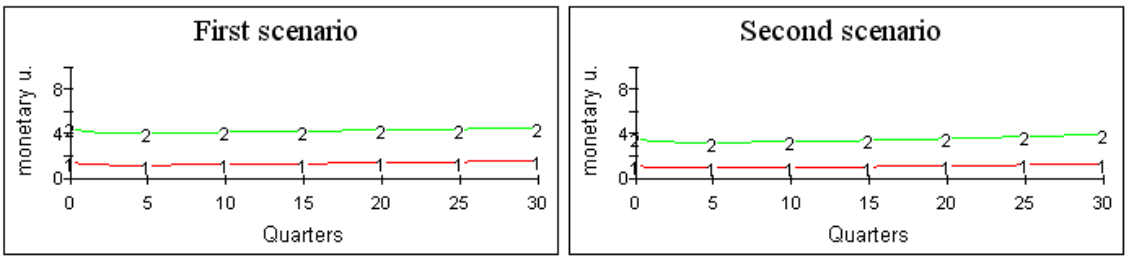

Figure 12: Public surplus in a trough

If the probability of re-election is proportional to the number of skilled individuals in the economy, the results of the simulation show that a corrupt government can stay in power even when education is subsidized. In fact, a government could subsidize education until certain threshold in order to achieve a certain percentage of educated people. With a suitable percentage, the government will always be re-elected and, in addition, the production increases. In this way, the government could achieve more enrichment by means of the taxes.

For instance, the increase of taxes both in the first and the second scenario could not be justified. The party in power would retain the power if the education is not subsidized because the number of skilled individuals does not vary. If the education is subsidized by the government, the number of skilled individuals increases but the increase is not enough to put in peril the power: 0.25 is the probability of losing elections at the beginning of simulation when the economy is in a trough whereas at the end of simulation that probability is 0.32 with low taxes and 0.33 with high taxes. In the case of a boom, the probabilities at the end of simulation are 0.32 with low taxes and 0.36 with high taxes. Figure 13 show the evolution over time of the number of students under the second scenario.

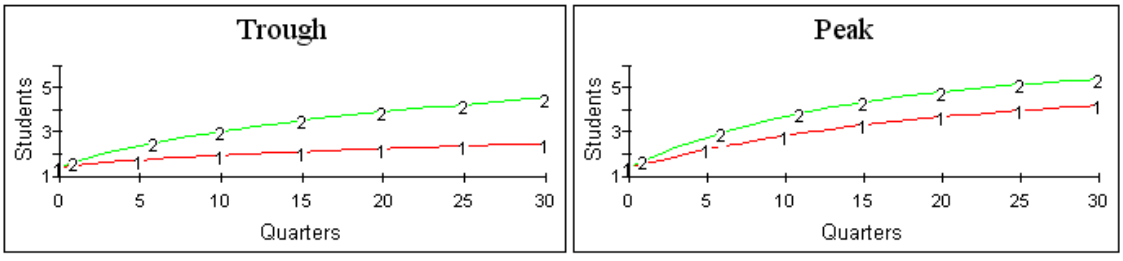

Figure 13: Number of students when run the second scenario

Figure 14 shows the evolution of the available public resources and the number of students in the fourth scenario. Once more, a certain degree of corruption can be perceived and also the education subsidies do not break the threshold since the number of students is always lower than that number in the second scenario.

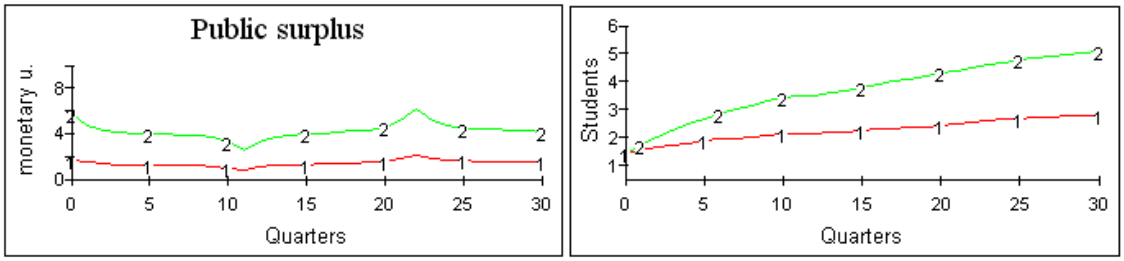

Figure 14: Some results in the third scenario

Conclusions

Taking advantages of the feedback processes that arise in an economy due to the different decisions made by economic agents, this paper constructed a dynamic model capable of generate different paths of growth. The differences in growth are justified by the influence of environmental factors as well as by the diversity of governmental strategies: adoption of different tax rates and whether to use education subsidies toward lower-income people or not.

The results indicate that the policy of maintaining a high tax rate brings about three consequences. First, the policy entails a low capital-labour ratio that depresses the production. Second, there is more risk of governmental corruption and finally, an increase of taxes does not imply a better distribution of wealth. The results suggest that the education subsidy lead to boost the level of skill but the inequalities in wealth continue. The population does not show a perceptible improvement of wealth with the governmental policies implemented; the wealth only boosts when the environmental economic situation is very good. Finally, it seems important to stand out that if the government is corrupt, the education subsidy diminishes the inequalities of skill but the improvement is not enough to allow a new party to seize power.

Since the economic growth is influenced by different factors that are not studied in this paper, the model can be widened in different directions. For example, it could be analysed the modification of the economic growth when more, or new, factors influence the production as well as the implementation of policies that control its desirable degree of use. Likewise, it could be possible to replace the cycles by asymmetric ones to pick up more realistic aspects; the model could reflect other type of economies if the levels of population are initialised with other values and likewise, the population could not be constant during the simulation to determine the effects in the economic growth.

References

Acemoglu, D. and J. A. Robinson. (2000) Why did the west extend the Franchise? Democracy, Inequality and growth in historical perspective. Quarterly Journal of Economics, 115, 1167-1199.

Aghion, P., E. Caroli and C. García-Peñalosa. (1999) Inequality and economic growth: The perspective of the new theories. Journal of Economic Literature, 37, 1615-1660.

Castañeda, A., J. Díaz-Giménez and J. V. Ríos-Rull. (2003) Accounting for the U.S. Earnings and Wealth Inequality. Journal of Political Economy, 111, 818-857.

Collier, P. and J. W. Gunning. (1999) Why Has Africa Grown Slowly? The Journal of Economic Perspectives, 13, 3-22.

Den Haan, W. J. D., K. L. Judd and M. Juillard. (2010) Computational suite of models with heterogeneous agents: Incomplete markets and aggregate uncertainty. Journal of Economic Dynamic and Control, 34, 1-3.

Eicher, T., C. García-Peñalosa and T. van Ypersele. (2009) Education, corruption, and the distribution of income. Journal Economic Growth, 14, 205-231.

Krusell, P. and A. A. Smith Jr. (1998) Income and Wealth Heterogeneity the Macroeconomy. Journal of Political Economy, 16, 5, 867-896.

Levine, R. and D. Renelt. (1992) A sensitive analysis of cross-country growth regressions. Quarterly Journal of Economics, 107, 407-437.

Owen, A. L., J. Videras and L. Davis. (2009) Do all countries the same growth process? Journal Economic Growth, 14, 265-286.

Sterman, J. D. (2000) Business Dynamics. System Thinking and Modeling for a Complex World. McGraw-Hill.