INTERELATIONS BETWEEN DEMOGRAPHY AND ECONOMY: THE DECLINE OF FERTILITY RATE. AN ANALISYS WITH SYSTEM DYNAMICS

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Abstract
The main aim of this paper is to study the impact on the birth rate of specific policies of public spending. The analysis is framed in an developed economy in which fertility choices and economic decisions are interconnected. In particular, the study relies on overlapping generations, habits in consumption and endogenous birth rate. This last factor is directly explained by the preference for children, the economic capacity of young people and the stylized fact of unemployment. The outcome is a versatile system dynamics model that is calibrated for the Portuguese economy from 2000 to 2011. A counterfactual exercise with different alternatives of public spending is implemented in the simulation model. The results show two divergent aspects: the births do not vary if the public consumption increases but, they increase when young people receive subsidies for their offspring even when the public consumption is high. These results also indicate that the subsidies are not sufficient to curb the decreasing trend of births. In addition to that a sustainable economic growth is required.

Key words: Fertility, Consumption, Unemployment, System Dynamics, Simulation

INTRODUCTION

The exponential population growth, that was one of the central concerns in Malthusian' theory, is not a current issue in many developed countries. Nowadays, these countries face the opposite situation because their fertility rates have fallen below the replacement

level. In addition to this fact, a steady increase of longevity has imbalanced the population in these countries. The causes and the consequences of this new composition require to be interpreted since many economic solutions adopted in a specific demographic context become invalid when the parameters vary.

Many researchers agree that economies are affected through several channels by a growing of population aging. Lee et al. (2001) point out some effects: high costs of providing benefits for Social Security and Medicare; problems to ensure the intergenerational equity of social benefits and political power as consequence of concentrating great amount of voters on elderly people[1]. Hock et al. (2012) assert that population aging will have dramatic effects on government finances and fertility rates due to maintenance of the pay-as-you-go pension system. The seminal paper of Zhang et al. (2002) emphasizes more effects on the economy: negative impact on national savings and delays in bequests because they are received later and their amount is diminished due to longer consumption. Later, Zhang and Zhang in 2005 found, considering a cross-section analyses, that life expectancy has significant positive effects on the saving rate, and also on the growth rate of per capita income, although it also presents an important negative effect on fertility.

The fertility decline has also attracted the attention of literature though the analyses are mainly focused on its causes rather than on its consequences. One of them is the possible shortage of labour force. The issue is not banal since the quick economic growth of certain countries could be explained to a large extent by its working-age population. The situation can be checked on East Asia's economies where the working-age population has soared, from 47 percent in 1975 to 64 per cent in 2010, according to the United Nations World Population Prospects for 2005-2010 (http://www.un.org/esa/population/). The effects of fertility decline on the savings are studied by Heijdra et al. (2006) and Lee (2001) alerts about the burden of pensions: the projections of global population are to grow from about 7 billion today to 9.3 billion in 2050 and 10.1 billion in 2100, while the Old Age Dependency Ratio (the population aged 65 and over divided by the population aged 20 to 64) doubles by 2050 and triples by 2100.

According to UN projections[2], the rest of major areas in the world, except for Africa, will not have a substantial increase of population this century. This fact could be foreseen because of the evolution of fertility rates in the world: about 44 percent of the world population in 1950 had a total fertility of 6 or more children. In 2010, only 1.7 percent of the world population reached that value. The population with sub-replacement fertility was almost 48 percent of the world population in 2010, which represented 34 percent of 196 countries. By areas, Africans countries present the highest rates whereas Asians will face the most significant decrease of population in the 21st century. On the other hand, according to Eurostat statistics (2011), only three European countries, Ireland, Iceland and Turkey are not below the replacement level in 2009.

The demographic literature appeals to social, economic and cultural causes to justify the low fertility rate in many countries during the last decades. Nevertheless, most authors usually focus on one or two factors to handle the complexity around the question. The

[1] As regards of the last aspect, Dang et al. (2001) check that spending components sensitize to the age structure represent between 40 and 60 per cent of the total public spending.
[2]World Population Prospects, the 2010 Revision (http: //esa.un.org/unpd)

most significant factor for Nauck (2006) and Tobing (2012) is the direct cost of childrearing. Galor and Weil (1993) identify the opportunity cost because of incompatibilities between employment and childrearing. Modern literature suggests that these costs would be affected by certain elements. Hock et al. point out a growing old age dependency ratio. Hoorens et al. (2011) include the influence of several aspects of society, such as economic conditions, legal provisions and governmental programmes. The difficulty of combining paid work with familiar responsibilities has been studied by Begall et al. (2011) where the intensions of having offspring is estimated in 23 European countries depending on the type of women's job. Schäfer et al. (2011) enumerate other explanations for low fertility: technological progress, the trade-offs between quality and quantity of children[3] or the so-called Caldwell hypothesis associated with changes of patters in intergenerational transfers. Bork (2011) finds that the differences of fertility rates in regions depend on the elasticity of substitution between offspring and consumption.

This paper constructs a system dynamics model attempting to explain the influence of certain public policies on the birth rate in a generic society of a developed country. The structure of the model takes advantage of the interrelations between demography and economy. Simultaneously, people ages and make decisions of consumption. Also, young people determine the new births endogenously. Firms set wages and the interest rates. Moreover, a government levies taxes to finance pensions, unemployment benefits, public consumption and subsidies encouraging childbearing. Whereas the public budget always includes pensions and unemployment benefits, the other two items could be combined or not. Hence, four alternatives, differenced by the allocation of the public finances, are implemented in the simulation model to check their potential on the birth rate. The calibration collects some time series and data for the Portuguese economy from 2000 to 2011.

In the causal structure, both the government and the productive sector are modelled as usual in the economic literature. However, some aspects related to households are not so general. People are distributed by age groups in according to the scheme of the overlapping generations' models[4], which is mainly accepted. Though, unlike most papers analysed, the consumption[5] of each cohort is determined by accepting habits formation. It means that agents make current consumption decisions depending on their past consumption choices, which is consistent with certain researches (Schäfer et al., Alonso-Carrera et al.[6] (2007), de la Croix et al.[7] (1999), Guariglia et al.[8] (2002)). On the other hand, the fertility choices, which depend on young people exclusively, are made by combining three factors: the economic capacity of young people, the preference for

[3] These authors support that technological progress reverses the relation between income and population growth. The trade-offs between quality and quantity in offspring is consequence of parents' decisions that introduce a bias against quantity due to parent's aspirations.

[4] Roughly, 90% of cited papers above use overlapping generation's models.

[5] Consumption is usually determined by solving a dynamic optimization problem in which each cohort maximizes over a horizon, which can be finite or not, an expected utility subject to its lifetime budget constraint. Generally, the result is that the consumption is described by the Euler equations. In particular, Zhang and Zhang using this procedure obtain a savings level proportional to labour income.

[6] These authors defend habits formation in consumption assuming that the offspring form their aspirations taking into account the standard of living achieved by their parents.

[7] The paper analyses inherit tastes presenting empirical evidence of the existence of involuntary transmission of tastes from one generation to the next one.

[8] The authors derive a particular Euler equation establishing that the consumption depends on labour income and lagged consumption in addition to other elements.

having children and the stylized fact of unemployment. Whereas the first two factors are usually handled by the literature when the fertility rate is modelled endogenously, the third factor introduces the young people's prospects on their future income[9]. Observing statistics about the European countries, the importance of this factor is clear which is summarized by Hoorens (2011): *with economic growth being associated with higher fertility rates.* By considering this third factor, the model is assuming pro-cyclical fertility that implies an increase of fertility in prosperity and a falling during recessions.

The rest of the paper is organised as follows. First, it presents the justification of the causal interrelations between the agents' decisions taking part in the economy. Then, it is characterized a benchmark simulation model. The analysis of simulation results is carried out in the fourth section. The last section contains some final comments and remarks.

THE STRUCTURE OF THE MODEL

In any economy, households, a productive sector and a government make several decisions that affect each one of the others and, in turn, everyone responds to new situations by adopting new decisions. Therefore, the agents' behaviour over time could be explained using causal relationships. This section details the framework in which the agents act. Figure 1 shows the different causal relationships arising in the decision making processes.

Population

In order to systematize certain characteristics of population, people are assembled in four cohorts corresponding to various stages of lifetime. The cohorts will be referred to childhood, young age, middle age and old age. The first cohort collects people from the birth to 20. The second one picks up people from 20 to 45. People from 45 to 65 years old are together in the third cohort and, finally, the people aged 65 and over are in the fourth cohort. People progress through the age structure. Nevertheless, anyone could leave the system at any time according to a death probability that is the unit when people reach the end of the last cohort.

Nobody within a cohort is special. Everybody make the same decisions and they are affected, in the same way, by the decisions of the rest. Nevertheless, decisions are not permanent and can change at any time. Likewise, people belonging to different cohorts could adopt different decisions.

Birth rate

Only people belonging to the second cohort are capable of having children who are incorporated into the first generation. The model assumes that the fertility choices are based on three elements: the economic capacity of young people to face the costs of childrearing, the preference for having children and the young people's prospects about the future. Whereas the first and the second factor influence positively on the flow of births, the third one is formed by using the stylized fact of unemployment.

Although the literature considers several factors to explain the behaviour of the fertility rate, the three selected aspects can explain to a large extent its evolution. In fact, most authors agree that the cost of childrearing and the preference for children are essential to

[9] As far as we know, all studies model fertility considering that labour market is in equilibrium, there is no unemployment and the economy does not go through recessions and expansions.

characterize the fertility rate. The consensus about their importance is clear although the relative influence of each one of them can change even considering the same author[10]. The inclusion of the third factor tries to capture the influence of the economic situation on the decision of having offspring. Admitting pro-cyclical fertility if the economy has high unemployment, which characterizes phases of recession, the families' prospects about current and future disposable income decrease. That uncertainty encourages people to postpone childbearing. The opposite situation will appear with a low unemployment rate.

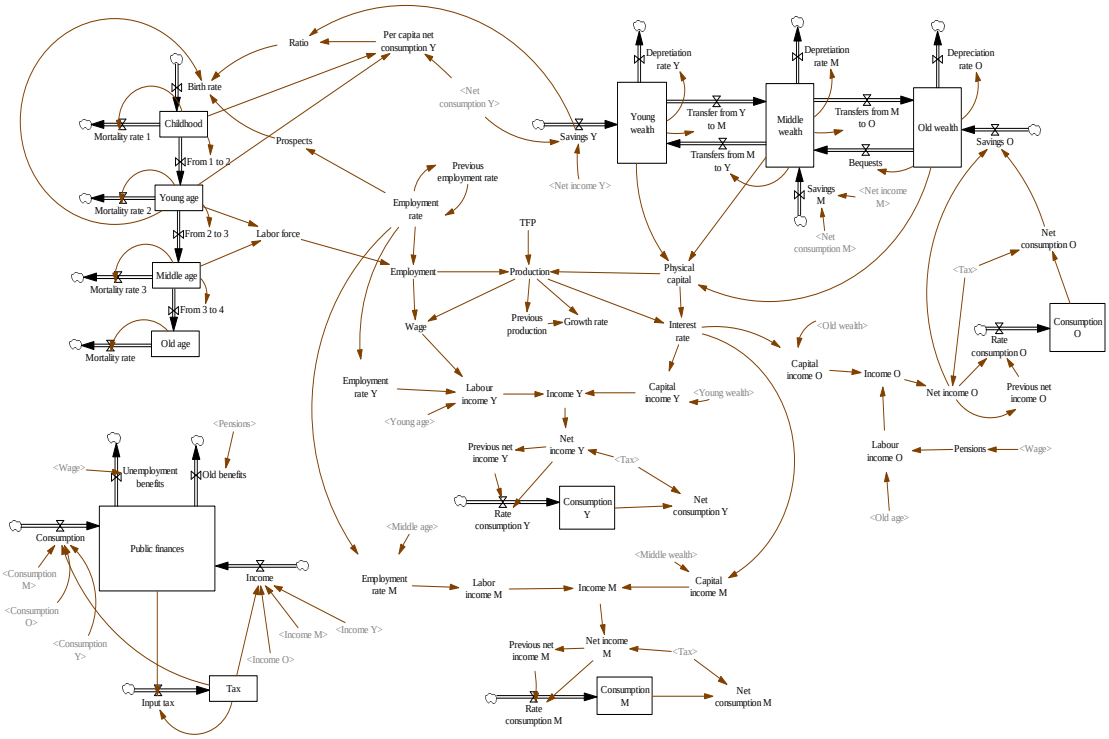

Figure 1: Interrelations among the decision making processes

The preference would indicate both the maximum and the minimum number of children that parents would like to have under realistic terms. Goldstein et al. (2003) assert that parents desire at least two or more children. This affirmation is the most recurrent response in the surveys across Europe. However, these answers contrast with the statistics (see Eurostat) where the decline of the fertility rates is evident. On the other hand, the preference must be considered as a collective characteristic. This feature is not difficult to justify because the parents' desires tend to be shared. In fact, people in a same territorial, social and economic environment tend to behave in a similar way. There are multiple examples. Hoorens et al. point out a fact related to immigration: *The data reveal that the fertility trends of many groups of foreign-born women tend to converge with the average of native women. In Sweden, this happened typically within two years of arriving, although with some different responses among specific countries of origin.*

[10] For example, Hock et al. formulate two fertility rates. One designates the private fertility rate and the other one is chosen by a social planner. Both include the childbearing cost and the preference for children though the relative weight of each element is different in the two formulations.

Mortality rates

All generations face mortality risk and consequently, each element of a cohort can die before it reaches the next cohort. Unlike the studies that set the survival probabilities endogenously[11], the model establishes these probabilities exogenously except for that associated to the elderly assuming constant medical advances for this cohort.

Productive system

Firms yield a final good by using a technology that requires capital and labour. Additionally, the outcome depends on how efficient the factors are used. The final good can either be consumed by households or the government or it can also be invested in the productive system. The labour force is the population belonging to the second and third cohort. The physical capital coincides with the wealth saved by the population. Besides, it is assumed that the physical capital suffers depreciation. The time dedicated (hours worked) to the productive sector is remunerated by a wage whereas the price of capital is the interest rate. These prices are determined by firms at its contribution to the final production.

Unemployment

It is clear that unemployment is an omnipresent feature of modern economies. There are numerous theories that try to explain its causes. Rigidity of the wages is one of the most recurrent to interpret the phenomenon. However, the wages in this model are paid at marginal product, then there are no rigidities and, therefore the wages cannot be the cause of unemployment. Its existence in the model could be justified by the occurrence of different kind of shocks as in Givens (2011) or Hann et al.[12] (2010), though the analysis of that formation is out of scope of this paper. Nevertheless, in spite of considering the unemployment as an exogenous variable, its behaviour might be modelled by using feedback processes in which unemployment generates a response of unemployment to its own past[13]. The formulation of that process might require the construction of a specific econometric model for each specific unemployment rate time series.

Unemployment benefits and pensions

Both young people and middle aged people dedicate a fraction of time to the productive system. Consequently, they receive a wage that is set by the productive system. However, certain percentage of these people could be unemployed. In that case, they would receive unemployment benefits whose amount is set by the governement. On the other hand, people belonging to the fourth cohort do not work; they are retired and receive a pension that is set by the government as well.

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[11] Jones (2001) sets the survival probabilities depending on income per capita and other measures of development.

[12] Givens considers several shocks. One is a technological shock that affect family's capital, another one influences the productive system and the last one impact on the family preferences. In Haan et al. the shocks affect productivity and unemployment.

[13] It is observed by both empirical and theoretical studies that the unemployment rates have an asymmetric behavior: unemployment rate grows faster during recessions than it decreases during expansions. That dynamics, which is evidenced in certain European unemployment rates, is explained by means of feedback processes by Akram (2005) for Norway, Burgess (1992) for UK and Franchi et al. (2011) for Spain.

Wealth

Individuals belonging to the first stage of life do not have any wealth. Their expenses are covered by their parents. Nevertheless, the government might subsidize a fraction of these expenses depending on the public budget. Their parents, who belong to the second cohort, allocate their net income to three items: their own consumption, the consumption of their offspring and their saving. People in the third and fourth cohort allocate their net income to their own consumption and their saving. The wealth accumulated by the population in the second, third and fourth cohort is lent to the productive sector. That is why these people receive capital income. On the other hand, when people progress from one generation to next, their wealth goes in the same direction. However, when people die, their wealth is inherited by their offspring who belong to the previous cohort. There are exceptions for these transfers of wealth. One corresponds to the individuals who are in their first stage of life that cannot either transfer or receive any wealth. The second one is when an individual in the second generation dies. In that case, their wealth is transferred to their own generation. This assumption should not be considered exceptional but rather as an altruist intergenerational transfer from parents, belonging to the third cohort, to their offspring.

Savings

Apart from people in the first cohort, the population tries to accumulate wealth. The assumption is not a controversial matter because all countries around the world save. However, the savings rates vary among them, even in the same country they may change dramatically over time. According to the statistics cited by Tobing, from 1980 to 2000, the differences became too big: *the average gross domestic savings rates in Benin and Burkina Faso were 1% and 2.6%, while Malaysia and Singapore were 36% and 45.1%, respectively.* In spite such differences, *the mean and standard deviation of gross domestic savings rates for 109 countries during the period were relatively constant, around 19% and 9%, respectively.*

Although people try to save, it does not mean that the cohorts will actually save. During certain periods of time they could (dis)save. In this model such situation would occur when people is adapting their consumption level to a drop of disposable income. On the other hand, the model also assumes that the third cohort is the stage in life where people are wealthier. The reasons are simple because this generation have been accumulating wealth during their stay in the second cohort. Additionally, they earn a wage and do not have to support their offspring expenses. Therefore, the third generation would accumulate more wealth than the second generation and the fourth generation since a pension is considered lower than a wage.

A controversial aspect is related to whether the elderly save or not. Furthermore, in case they do it, why do they do it? In this regard, Bloom et al. (2003) state that people save when they are young to finance consumption during their retirement. Therefore, the elderly (dis)save. However, these same authors point out that aged people might save too[14]. That possibility is corroborated by the evidence in many countries. For example, in East Asia, from 1950 to 1990, the savings rate increased at every age (OCDE statistics).

[14] The authors state that there is a boost to savings when life expectancy increases, but this boost is temporary and is subsequently offset by a rising old-age dependency rate as people age. They also assert that when the age structure reaches equilibrium, net savings should be zero.

A recurrent motive used by the literature to explain the observed saving patterns in elderly people is the parental altruism. In this instance, Laitner and Juster (1996) find that 50 percent of individuals save in order to leave an estate. Alonso-Carrera et al. include more motives such as strategic behaviour, joy-of-giving or existence of incomplete annuity markets. Nevertheless, Nishiyama (2002) and Blackburn (2005) point out that bequest could be only accidental from precautionary savings behaviour in an uncertainty environment.

The model assumes that elderly people save and bequests are accidental. Therefore, it is required to determine the amount saved by each cohort. That can be done by specifying the consumption levels because of the relationship between consumption and saving. Admitting habits in consumption, the current consumption of each cohort will depend on two factors: the past consumption level and the current disposable income. Fluctuations in consumption are due to variations in disposable income, which includes not only the net capital but also the net labour income.

Fiscal Policy

The government levies taxes on consumption, capital and labour income. The periodic payments obtained by these items finance the public spending, which is integrated by pensions, unemployment benefits, and possibly, public consumption and subsidies aimed at childbearing. It is assumed that the public budget must be balanced over time to avoid deficit.

The next section formulates the causal relationships defined by means of non-linear expressions. Likewise, it specifies the set of parameters and the initial conditions of levels.

SIMULATION MODEL

The calibration considers some data from the Portuguese economy[15]. The initial distribution of population by age has the same percentages as Portugal had in 2000 (see Table 1); the employment rates coincides with the quarterly historical time series for this country from 2000 to 2011 (OECD). This time series is modelled by an autoregressive moving average process[16]. In this way, the employment rate is explained by a feedback process in which certain past values of employment determine the current value. By using that econometric model, the time series is extended for two more years[17]. These adjustments make that the simulation model has to select the quarter as the unit of time and a temporal horizon of 56 quarters, 48 quarters from 2000 to 2011 and eight quarters from 2012 to 2013.

The model does not distinguish between males and females and the population pyramids are symmetric. The parameters linking each generation with the next assume that people within each cohort is distributed by the age homogeneously. Admitting that the mortality rate affecting elderly people could vary during the simulation horizon, the

[15] The Portuguese economy has certain characteristics that the model reflects: the birth rate has gone declining progressively in this century though the population grows as consequence of an increase of longevity.

[16] Programs TRAMO and SEATS have been employed (www.bde.es) for the econometric time series analysis.

[17] TSW, a Windows version of TRAMO-SEATS, provides three forecasts with different trends. This paper considers the medium option.

model decreases the data provided by Lee (2011) slightly. This author asserts that *the record's country life expectancy for females has been increasing linearly from 1840 to 2000 at the pace of 2.4 years per decade or 24 years per century, and similarly for males*. The mortality rates affecting the rest of cohorts are common values in development economies in 2000.

Table 1: Portugal population by age groups

Años	Total	Children	Young	Middle	Elderly
2000	10 225 838	2 340 621 22.8%	3 815 962 37.3%	2 413 173 23.6%	1 656 082 16.3%
2001	10 293 000	2 311 052	3 848 124	2 440 896	1 692 928
2002	10 368 410	2 290 113	3 882 780	2 473 455	1 722 062
2003	10 441 070	2 272 814	3 909 668	2 510 123	1 748 465
2004	10 501 970	2 255 498	3 924 965	2 545 540	1 775 967
2005	10 549 420	2 240 304	3 922 789	2 586 012	1 800 315
2006	10 584 340	2 229 183	3 906 113	2 629 690	1 819 354
2007	10 608 330	2 217 710	3 882 549	2 668 851	1 839 220
2008	10 622 000	2 205 000	3 853 000	2 704 000	1 860 000
2009	10 632 000	2 190 000	3 817 000	2 736 000	1 889 000
2010	10 637 713	2 182 410	3 818 542	2 737 500	1 899 261
2011	10 636 979	2 175 460 20.4%	3 819 622 35.9%	2 740 300 25.7%	1 901 597 18%

Source: Eurostat (2000-2009) and Instituto de Estatista Portugal

The working hours per worker are the unity. The technology of production is Cobb-Douglas[18] with elasticity for labour 0.65. The total productivity factor is taken from the time series for Portugal from 2000 to 2011[19] (AMECO Database-ECFIN-European Commission[20]). This time series is also modelled by an autoregressive moving average process and extended for two more years.

Labour income includes unemployment benefits (30% of a quarterly wage). A pension is 40% of a quarterly wage. The benchmark model assumes that the jobless are distributed equally between the second and the third cohort. The initial levels of wealth are set in order to achieve a value close to 3% of interest rate. The initial Gini index is 0.34 indicating an appropriate wealth distribution though slightly below Portugal index in 2000 (0.35).

The initial consumption in the cohorts is set as linear functions of the initial disposable income (0.95 for young people, 0.75 for middle aged people and 0.85 for the fourth cohort). The assumption about the habits in consumption specifies the values during the

[18] The Cobb-Douglas production function is the most widely used by demographic literature.
[19] The Portuguese productivity was modelled by an autoregressive moving average process and extended for two years in the same way it was done for the unemployment rate.
[20] http://ec.europa.eu/economy_finance/db_indicators/ameco

remainder of the simulation: the current consumption coincides with the consumption in the previous period unless the net income varies. In this case, the consumption will vary a percentage of the variation suffered by the net income.

The three factors influencing the fertility rate are grouped in two elements which are taken in conjunction. The first one indicates the minimum percentage specified by the preference. The second element is adding to the first one. It is defined by a function, which is limited by the maximum value of the preference. The function depends on two components affecting young people: the prospects about the future and their current economic capacity. The prospects are formulated by means of an exponential smoothing of the unemployment rate. The economic capacity is quantified by the savings-per capita consumption ratio. The variables that define the ratio are referred to young people thought the per capita consumption also includes the population in the first cohort. The underlying fact is that young people are able to have as many children as the ratio determines. In this way, it is not necessary to specify the cost of a new child as in Hock et al. since it coincides with the current cost of childrearing.

Finally, the government uses an only tax rate that guarantees surplus in the public finances during the simulation. In the benchmark model, the public budget is allocated to the pensions and the unemployment benefits.

Validation

During the different stages of model's development, various possibilities for parameters and functions were researched. Those analyses proportionate an effective knowledge of the responds of model and its sensitivities. Several validations were carried out: the structure assessment test, the dimensional consistency test, the extreme conditions under bounds[21] and sensitivity (see Barlas (1996), Sterman (2000)). Additionally, the population percentages by age groups provided by the benchmark simulation model are closely Portuguese data. In accordance with these results, the model was considered a useful tool for the analyses.

COUNTERFACTUAL EXERCICES

The benchmark model shows a slow but constant decline of the population in the first and second cohort, in the same way as Portugal. Likewise, the same pattern as Portugal for the rest of the cohorts is observed: a gradual increase of both middle age people and the elderly people. In particular, the elderly grow faster than the middle age ones. Summing up, the population grows slowly during the simulation.

Taking the benchmark model as reference, a simulation exercise is proposed to find out whether an increase of public spending varies the population in the first cohort. Three new scenarios are considered. In the first one, the government earmarked 25% of GDP to public consumption; in the second one, subsidies encouraging childbearing are implemented (10% of wage per child) and finally, the third scenario includes both items together. It is clear that the financing of the new policies requires an increase of taxes since the public finances must remain without deficit. Figure 2 contains the paths of the population percentages in the first cohort for the four scenarios and the tax rates that ensure public surplus during the simulation. Figure 3 shows the evolution in the cohorts

[21] The model cannot hold arbitrary extreme conditions because it does not consider special circumstances which require particular policies.

of the standards of living, which is quantified by the per capita net consumption (Y stands for first and second cohort, M for the third cohort and O for the fourth cohort).

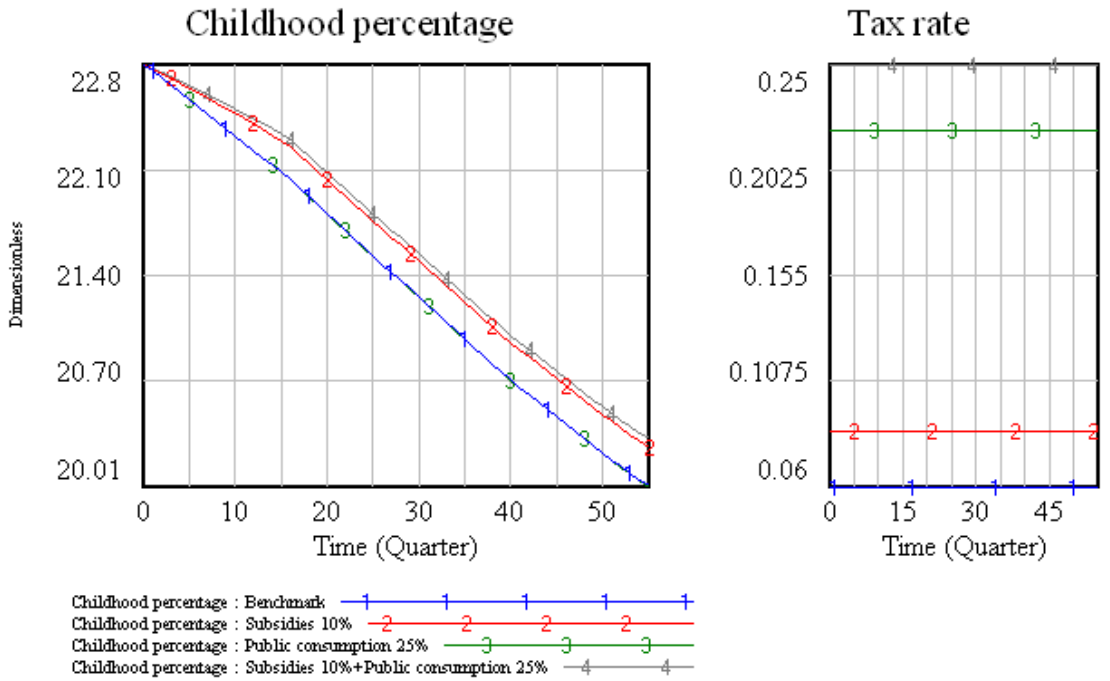

Figure 2: Population percentages in the first cohort and tax rates

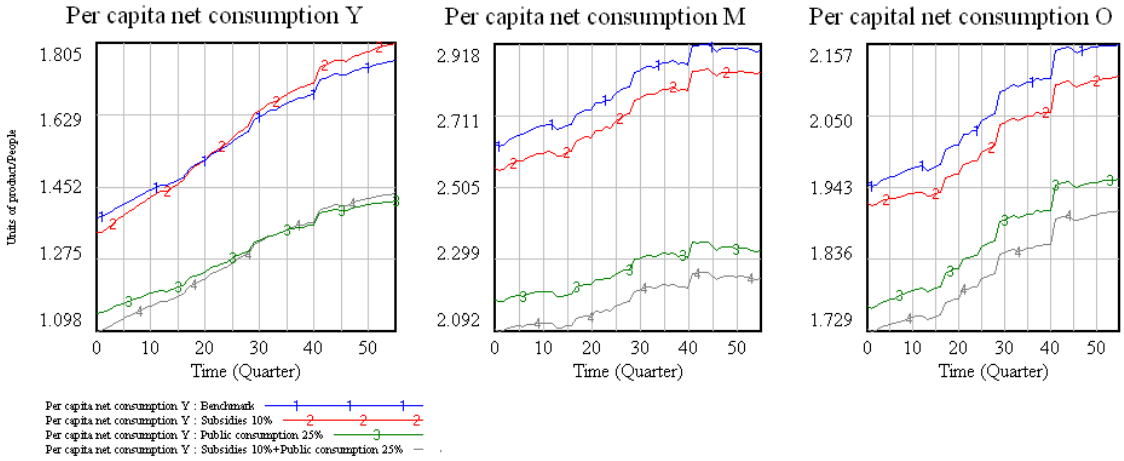

Figure 3: Standards of living in the cohorts

Public consumption

The introduction of the public consumption does not alter the population percentages reached in the benchmark model (see Figure 2). This behaviour could be consequence of the tax rate that grows as the public consumption does it. The growth of taxes entails a decrease of net consumptions and, consequently, the savings also decreases in all cohorts. That reaction has more consequence to young people because the savings-per capita consumption ratio affecting the birth rate remains more or less constant. Therefore, young people would have the same number of children as the benchmark

model since the costs of childrearing decrease with the same pace as the available resources decrease as well. Figure 3 shows that the standards of living in all cohorts (paths 3) are lower than the benchmark model (paths 2) due to the taxes growth.

Subsidies

Subsidizing childbearing and certain aspects linked to childrearing is a common policy in many countries, including Portugal. For example, people could receive direct subsidies to lighten the costs of childrearing, to finance the offspring education, to proportionate medical services, etc.

Without modifying the public consumption level of the benchmark model, the third scenario increases the public spending by implementing direct subsidies, which are received by young people. The simulation results show that the subsidies stimulate the births as long as they are perceived by young people as savings. On the contrary, if subsidies are an additional item of the young people's disposable income, then the population in the first cohort does not vary significantly with regard to the benchmark model. The financing of subsidies require a little growth of taxes and, then the standards of living in the third and the fourth cohort decrease slightly. Although both the taxes and the births increase, the standard of living for young people and their offspring increase progressively. That fact is consequence of two aspects: subsidies improve the young people's wealth and the payments must increase as the births grow. Figure 4 collects the evolution of the population percentage in the first cohort for different percentages of the wage. The paths show that the birth rate increases as the payment earmarked to subsidies is higher.

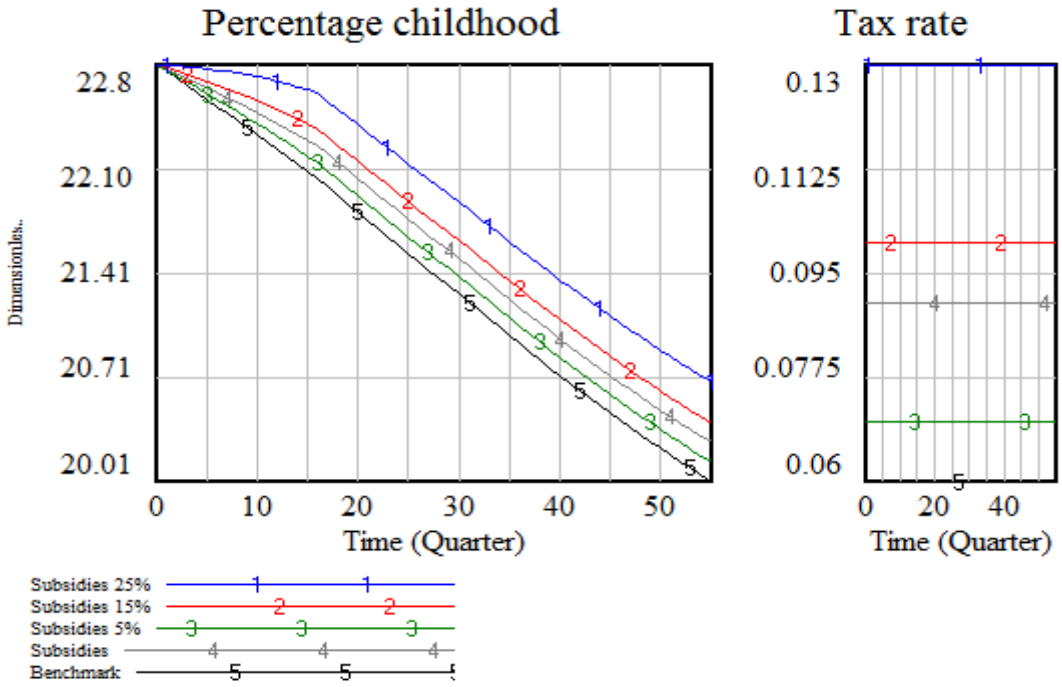

Figure 4: Population percentages in the first cohort and tax rates with different subsidies

Public consumption and subsidies

The fourth scenario includes both public consumption and subsidies in the benchmark model. The percentages dedicated to them as well as the treatment are the same as those

given individually. The simulation results show an improvement in the birth rate that exceeds the values attained when the benchmark model only includes subsidies. This last fact could be explained from the reaction of the birth rate to different feedback loops affecting the making decision processes of the young people. On the one hand, the highest level of taxation makes the standard of living in all cohorts diminish and, therefore, the savings reacts in the same direction. Consequently, the birth rate moves in the same direction as the ratio. On the other hand, when subsidies are implemented, the young people's savings increase because they consider them as savings. Therefore, the births grow. The final result is a growth of births since per capital net consumption has fallen, which is know from the results of the second scenario. Moreover, the process of growth is reinforced over time because more births entail higher payments for subsidies. Figure 5 shows that if the policy of subsidies is maintained, then an increase of public consumptions determines a slight growth of births. However, the growth of births is higher when the subsidies increase. Comparing it with the benchmark model, the standards of living in all the cohorts decrease; they are inversely classified to the tax rates associated.

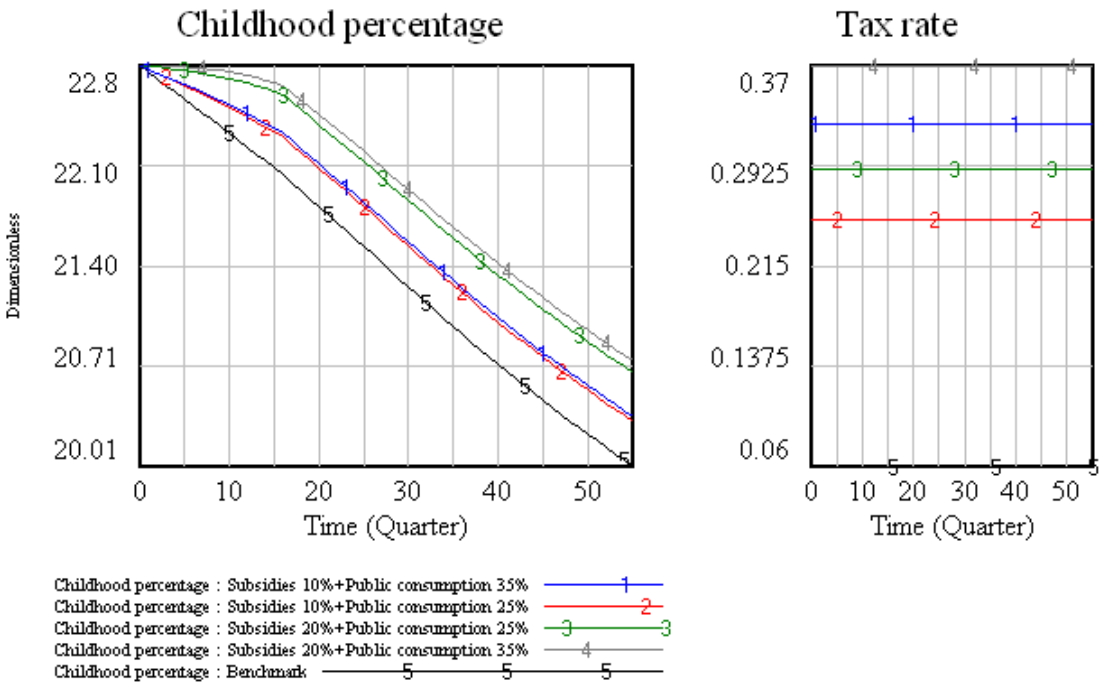

Figure 5: Population percentages in the first cohort and tax rates in the fourth scenario

If it is pretended that workers finance the public pensions, the burden of taxes could become unbearable for them when generations are not balanced. Due to the discouraging results provided by the scenarios, new counterfactual conditions were analysed. Imagining an ideal situation without unemployment and high productivity, the benchmark model still responds with decreasing births. However, in this ideal environment, the introduction of subsidies achieves an increase of the population in the first cohort.

CONCLUSIONS

When the demographic process in developed countries is tackled, the decline in fertility is probably the most studied stylized fact. Although there are a wide variety of reasons, generally the explanations for that include the preference for having children and the

cost of childrearing. Whereas the former element depends on cultural and ideological characteristics, the last one clearly relates economy and demography. These economic and demographic feedbacks are the starting point to analyse the birth rate from a multi-causal approach. In the economy, four population age groups, a government and a productive sector take part. Depending on the age group, the population makes choices of fertility and consumption; the government levies taxes, makes decisions about public consumption and sets unemployment benefits and pensions. The productive sector determines the wages and the interest rates. In addition to these features, the model assumes that the economic activity could not be stable over time and the unemployment rate would be an index of the situation. The articulation of the making decision processes produces a versatile system dynamics model in which is possible to analyse the responses to different scenarios in a simple and tractable way.

Although, the decline of fertility is very common fact in many developed countries, each country has a different pace and reacts in a different way to incentives. Knowing that aspect, the model adopts the behaviour of two real variables from Portuguese economy: quarterly unemployment rates and productivities. Likewise, the simulation model is initiated with percentage distribution of Portugal in 2000. Taking into account these time series and initial values, four situations with different public spending are implemented. The simulation results show intuitive facts though also some counterintuitive ones. It is clear that births could be adversely affected by an increase of public consumption since it involves a tax rise that, in turn, would decrease the net consumption. It is also understandable that subsidies positively affect the birth rate as they increase the savings rate in the second cohort. However, if the model considers both outputs jointly, it responds with a growth of births higher than expected with that level of subsidies. Moreover, if the amount dedicated to subsidies grows, the impact of the public consumption on the births is higher. These results as well as the option of explaining them from a feedback processes view show the potential of system dynamics in this kind of analysis.

The versatility of the model would allow anyone interested to introduce additional elements in the economy. For example, in order to shorten the distance with Portugal households and government could have certain level of debt. Likewise, the calibration might be adjusted for other countries or the idea can be widen considering the framework of an open economy.

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