A system dynamics model about public corruption: the influence of bribes on economic growth

Soto-Torres, M.D., Fernandez-Lechon, R.

Faculty of Economic
University of Valladolid (Spain)
lolasoto@eco.uva.es, ramonfer@eco.uva.es

Fernandez-Soto P.

PriceWaterHouse&Cooper, Madrid (Spain)
pedro.fernandez.soto@es.pwc.com

Abstract

This paper builds a system dynamics model to study the impact of some activities of public corruption on economic growth. The model is articulated around a generic economy in which a public and a private sector take part. The sectors produce different goods using the same available economic resources. Both use labour and could employ different criteria for remunerating their workers. The difference between the private and public wage allows the model to justify the introduction and the persistence over time of public corrupt activities in the economy. The causal structure collects the decisions and the rules of behaviour of the economic agents. It reflects the normal economic activities and the interactions between them and the new causal relationships arising from the corruption activities. The feedback processes totally explains why corruption modifies both the public and private production as well as the wealth of some citizens. After formulating the decision rules of the economic agents, calibrating the values of the parameters and the initial conditions of the levels, a simulation exercise is carried out to characterize the growth attained by the economy under different scenarios taking into account different degrees of corruption and different ways of fighting against it.

Key words: Corruption, Government wage policy, System dynamics modelling.

Introduction

Over the past few years, corruption has become a major issue in political, social and economic spheres. Various international organisations, such as the World Bank, the International Monetary Fund, the United Nations or the Organisation for Economic Cooperation and Development (OECD), motivated by the negative effects of corruption on the environment, human rights, democratic institutions, economic development, poverty and freedoms, among others aspects, have developed strategies in order to combat it. In spite of international agreements, corruption is persistent and pervasive around the world. In a lesser or a greater degree, it exists in all societies independently of its stage of development and the type of political-economic regime.

These facts can be checked using corruption data compiled by different organisations. For instance, Political Risk Services Incorporated is a private firm that annually publishes the International Country Risk Guide, which analyses the degree of corruption prevailing in a certain country based on a survey among foreign investors; Transparency International (TI) publishes the annual Corruption Perceptions Index (CPI), first

released in 1995, formed from expert assessments and opinion surveys. This index is available for over 150 countries in the period 2004-2006. The IMD index of corruption is published by the Institute for Management Development in the World Competitiveness Yearbook and is based on a survey among local managers in up to 50 countries.

Although the meaning of corruption can vary from one country to the next due to cultural differences and legal regulations, TI defines corruption in a wide context as the abuse of public office for private gain. Some authors argue why the public corruption impregnates societies. For example, Blackburn et al. (2006) maintain that corruption in public office is an inevitable aspect of state intervention which typically entails some transfer of responsibility from the government to a bureaucracy in a principal-agent type relationship. Pope (2000) asserts that corruption can take place where there is a combination of opportunity and inclination. He explains that corruption can be initiated from either side of the transaction: a bribe being offered to an official, or the official requesting an illicit payment. Those offering bribes may do so either because they want something they are not entitled to, and bribe the official to bend the rules, or because they believe that the official will not give them their entitlements without some inducements being offered. On the other hand, officials may refuse to serve clients unless a bribe is paid. In this case, it is possible to differ between small bribes practised by civil servants and the great corruption of high public officials involving large and hidden bribes in overseas bank accounts.

Paolo Mauro (1997), maybe the author more widely cited in literature about corruption, claims that many governmental decisions may encourage the public corruption: trade restrictions, government subsidies, price controls, multiple exchange rates or low wages in the civil service relative to wages in the private sector. In addition to these causes, the author also identifies some consequences that corruption provokes. He checks that corruption decreases private investment, retards economic growth, reduces taxes collection, increases the level of public expenditure and distorts the composition of government expenditure. Particularly, he notices that government spending on education are negatively correlated with corruption whereas a larger proportion of the public spending could finance huge infrastructures on which is easier to levy bribes.

Mauro's results are not isolated, other authors in corruption literature, Gyimah-Brempong (2002), Li et al. (2000), or Keefer and Knack (1997) agree that corruption affects negatively to economic growth through different channels. Blackburn et al. widen the previous positions when indicate that corruption and economic growth are led by a feedback process: bureaucratic malpractice not only influences, but is also influences by the level of prosperity in countries. Treisman (2000) affirms that a certain percentage of the variations in corruption indexes could be explained by variations in per capita income levels. Consequently, following the previous assessment, it seems possible to confirm that without sufficient punishment the corrupt activities in an economy could follow an exponential growth led by a positive feedback loop. The extortion might become a normal activity in the daily life provoking the restriction of the investment processes necessary for stimulating the growth. The lack of economic growth together with the incidence of corruption would cause the fall of the economies in the poverty trap from which there is no easy escape.

The aim of this paper is to build a system dynamics model to study the impact of some activities of public corruption on economic growth. Though there are different public

activities causing corruption, this paper focuses exclusively on corrupt public practises carried out by bureaucrats in the development of their public responsibilities. The germ and the prevalence over time of the corrupt performances will be a consequence of the different remunerations in the public and private sector.

In accordance with Dudley (2002) System Dynamics should provide an ideal approach for examining corruption dynamics because it avoids the necessity of setting up models in a purely mathematical manner. Nevertheless, mathematical tools are frequently used in the treatment of models about corruption and, instead of ignoring them, the underlying ideas could help to form a systematic perspective of the matter. In this regard, Dudley affirms that those models may provide suggestions for specifying components in a System Dynamics model.

The system dynamics model is constructed using a generic economy in which a public sector and a private sector take part. The economic relationships between both sectors, specifically the determination of the private wage, are modelled considering some hypothesis suggested by Turnovsky et al. (2006). Likewise the modelling of certain elements of the labour market, in particular the division of the citizens into bureaucrats and households is based on the approach of Blackburn et al. Nevertheless, unlike Turnovsky et al., the modelling provides certain advantage to the public sector with regard to the capital utilization since this sector tries to obtain a priority aim of growth, and unlike Blackburn et al., the model considers that all workers have the same fiscal treatment since it is a more realistic possibility.

The causal structure of the model is supported by the rules of behaviour and decisions that the economic agents take over time. The private sector determines the private wage and the interest rate in the economy; the public sector levies taxes to finance its productive costs of labour and capital, sets the level of public production and determines the public wage. Finally, workers, taking into account their income, decide the percentage of private production that they consume. The public corruption arises when bureaucrats realize differences between the public and the private wage in spite of comparable responsibilities. If the economy suffers corruption activities, any investment process will imply a bribes payment. Corruption reduces the available capital for the productive processes of both sectors and, consequently, the extortion will affect the economic growth. The introduction of corrupt activities increases the complexity of the feedback structure of the economic system since they add new causal relationships connected to those supporting normal decisions of the economic agents. The whole feedback structure can fully explain why the corruption activities influence the public and the private production as well as the wealth of some citizens.

The modelling justifies why certain causal relationships are formalised in non-linear terms and likewise, it considers different information delays in order to take into account that certain agents' decisions are not instantaneous. After constructing a flows and levels diagram, a simulation exercise is carried out to characterize the evolution over time of both the private production and the wealth per capita. Four different scenarios are considered, each one undergoing different degrees of corruption. Two of them assume that, at the beginning of the simulation, the level of corruption in the economy is low, whereas the remainder presumes the contrary. For each pair of scenarios, two public policies regarding the remuneration of public labour are considered. These different initial conditions and policies provoke a different evolution of corruption over time and as a result different paths of growth in the economies.

The remainder of the paper is organized as follows. Section 2 describes the economic environment in which the agents take decisions. Section 3 studies how the corruption affects the economic development. Section 4 calibrates parameters and initial conditions of levels and shows the results attained by the simulation. Finally, section 5 offers some concluding remarks.

Structure of the model without corruption

The system dynamics model proposed to study the effects of corruption on economic growth is constructed considering a generic economy in which a public sector and a private sector carry out different activities of production. The private sector produces private production using labour, capital and public capital, while the public sector produces public capital employing the same factors as the private sector. Thereby, the public production influences both the private and public production. In this regard, Barro (1991) states that public sector must be envisaged as a public services provider for both citizens and private sector and a producer of infrastructures; these activities contribute to the efficiency of private and public production. The participation of the public sector in activities of production is not infrequent, Smithtz (2001) argues that in many economies, particularly Egypt, and a lesser degree India and Turkey, the vast majority of investment good are produced by the government.

Both the public and private production requires the contribution of all and each one of the factors for the effectiveness of the processes. If the quantity of an input grows, the productions increase. Nevertheless, if both sectors employ the same quantity of a factor, the growth undergone by the productions could be different due to differences in their productive processes; for example, the production of the public sector could be either more or less intensive capital than does the production in the public sector. In addition, it is realistic to assume that the influence of the productive resources on both productions is non-linear and as a result, the growth of any factor does not provoke the same growth on them. In this regard, Forrester (2003) affirms: almost every characteristic that one examines in the economic system is highly non-linear.

Labour, capital and public capital

One of the necessary elements in the production processes of both sectors is labour, which is totally divided into two groups: households who work in the private sector and bureaucrats who work in the public sector. The percentage of bureaucrats, lower than the percentage of households, is set exogenously by the public sector.

Another necessary element of the private and public production is the capital. Its accumulation depends on decisions adopted by workers which, in turn, are influenced by actions of both the public and private sector. This fact is due to various aspects. In the first place, households and bureaucrats accumulate wealth, i.e. capital. A fraction of capital is consumed whereas the remainder is lent to both sectors and used in their productive processes. The fraction of wealth dedicated by workers to consumption is decided exogenously; the parameter associated to that decision is the marginal propensity to consume. Consequently, there is a negative causal relationship between consumption and capital: if consumption grows, the stock of capital decreases and, thereby the accumulation of capital is affected directly by decisions of the workers.

In the second place, the variation of the wealth accumulated by households and bureaucrats depends on their income. The workers have two sources of income: capital

income and labour income. The former is received by workers due to the capital lent to the productive sectors and the latter, is received as consequence of the time dedicated by workers to the productive system. Then, the influence of both sectors on the accumulation of capital is clear since the private sector determines the interest rate of the economy, which is an element necessary to determine capital income, and in addition, both sectors set the wages, which influence labour income.

Finally, certain decisions of the public sector influence the accumulation of capital since this sector levies taxes on consumption, capital income and labour income to finance its productive costs of labour and capital.

Therefore, the wealth of households and bureaucrats grows if their income grows and it diminishes as consequence of an increase of taxes or consumption. Likewise, the model assumes that the capital depreciates, at a specific rate, over time.

The third element that takes part in both productions is the stock of public capital, which is produced by the public sector. Then there is a positive feedback loop between the public capital and the public production, though the public capital decreases by depreciation. It should be noted that the depreciation rate of the public capital could be different than the depreciation rate of the capital because they are produced by different sectors. As it was mentioned above, in spite of fact that both sectors use the same productive factors, the growth rate of the public sector can be different than the economic growth rate, which is identified with the private sector growth rate.

Figure 1 summarizes some of the causal relationships mentioned until now. It shows explicitly the productive factors used by the sectors and the accumulation of capital.

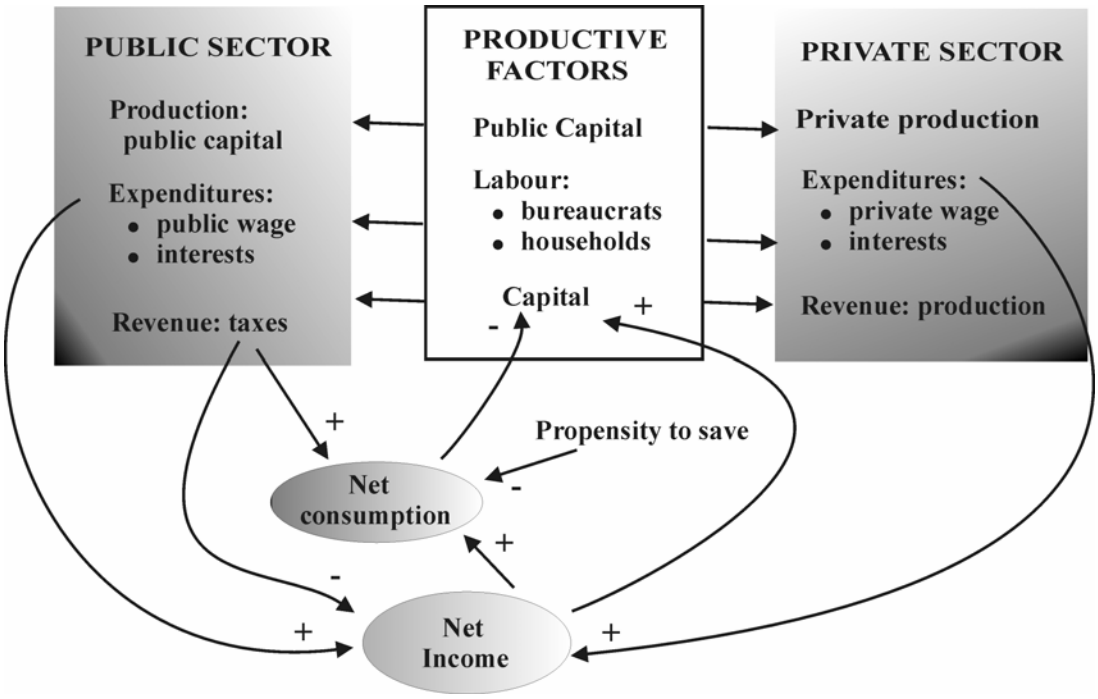

Figure 1: The production factors and the capital accumulation

Wages and interest rate

The participation of workers in the accumulation of capital will be totally specified if the model states how the labour income and the capital income are determined.

The private sector settles the price of a unit of capital, the interest rate of the economy, and the price of a unit of private labour, the private wage. These prices are settled considering the marginal contribution of the factors to the private production and consequently, the private sector distributes totally its production for paying its productive factors. In terms of causality the previous rule can be expressed: if the private production increases, both the interest rate and the private wage grow; although if the capital grows, the interest rate diminishes and likewise, when the number of households grows, the private wage decreases.

As concerns the participation of the public sector in the formation of the capital income and the labour income, the public sector sets the public wage and pays the interests of the capital used in its productive process using the interest rate of the economy.

The auxiliary variables, capital income and labour income, collect the income received by workers of both the public and private sector.

Expenditures and public revenue

The public capital is a public good, which is used in the public and private production. It can be neither consumed nor distributed in the same way than the private production does. Because of that, the public sector finances the costs of its production using the aggregate tax revenue earned on capital income, labour income and consumption.

The model assumes that taxes are fixed exogenously by the public sector. However, the public sector could have a surplus or a budget deficit and the model analyses both possibilities. In this instance, if the public sector cannot face its costs, due to low taxes, workers will have to finance the public sector. In that case, a fraction of the capital accumulated by workers will be employed to eliminate the budget deficit. On the other hand, if taxes are too high, the budget surplus could be used by the public sector at its own discretion. In this last possibility, the model assumes that public sector takes a neutral position between both sectors. Therefore, if the difference between the revenue and the public spending is positive, the public sector will add that difference to the capital stock. This possible lump sum will benefit to both sectors and implicitly, it would mean a decrease of taxes.

Distribution of capital between sectors

Regarding the three productive factors, the model assumes that public capital is shared by both sectors while labour is distributed between them exogenously; however, the capital is distributed between the sectors endogenously. This fact is a consequence of supposing that the public sector wishes to maintain a balance between the public investment rate and the size of the economy, which is a common assumption in many macroeconomic models. In this case, the public investment must be proportional to the private production. In order to attain this aim, in each productive period, the public sector will request a fraction of the available capital in the economy taking into account two different aspects: firstly, its production capacity, and secondly, the productive result attained by the private sector in the previous productive period. With respect to the

consideration of this information delay, Sterman (2000, pp. 426) affirms that all beliefs, expectations, forecast, and projections are based on information available to the decision marker at the time, which means information about the past. He adds that it takes time to gather the information needed to form judgments, and people do not change their mind immediately on the receipt of new information. Reflection and deliberation often take considerable time.

Nevertheless, there is a difference between the desired capital by the public sector and the requested capital, that is, the capital that the public sector finally uses in each productive period. This difference is consequence of assuming that a moderate aptitude is adopted by the public sector that instead of requesting the desired capital, it will demand a quantity, which gradually adjusts to the current value of the desired capital. Because of that, in the diagram of levels and flows, the capital demanded by the public sector is a level variable with an explicit aim: attain the desired capital. The net change of the level is governed by the discrepancy between its current value and the desired value. An adjustment time determines the speed of the adjustment.

The remainder of the capital, the total capital of the economy minus the capital demanded by the public sector, will be used by the private sector in its own production.

Figure 2 illustrates the causal influence of taxes on other variables related to decisions of consumers as well as on the public budget following the above exposition.

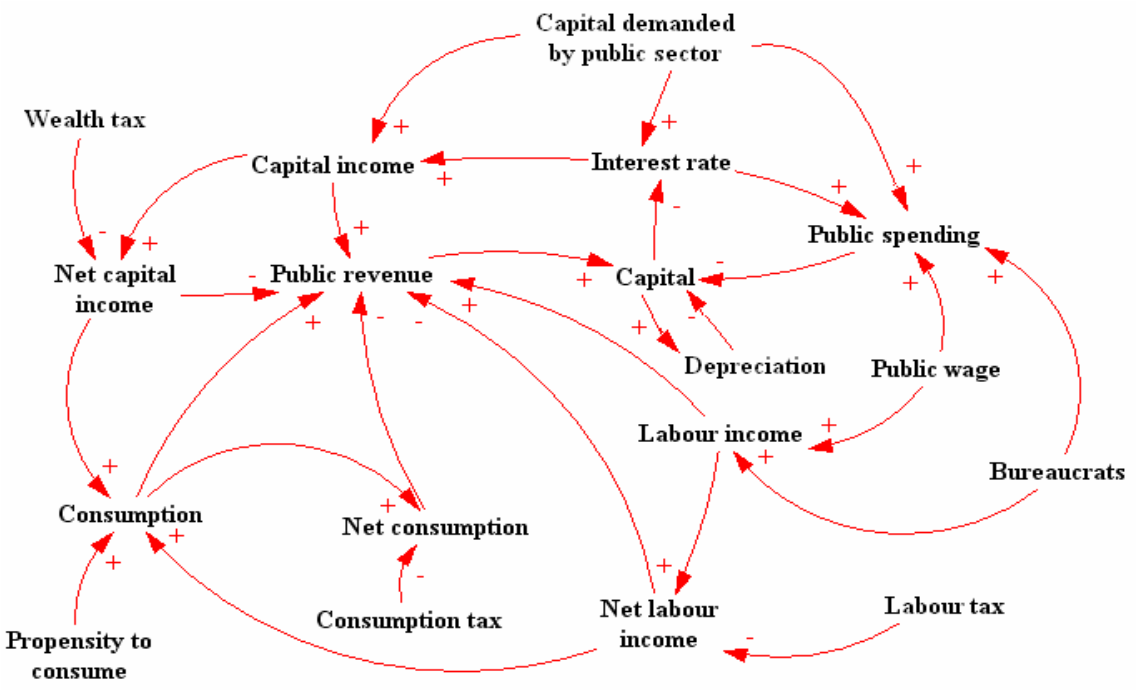

Figure 2: Revenue and public spending

In this figure it is possible to observe that the policy adopted by the public sector with regard to the treatment of the difference between the revenue and the public spending generates three feedback loops linked by the interest rate; one of them is positive and the others are negative. Then, in spite of fact that the interest rate, to priori, is fixed in

function of the private production, the public sector influences its value as a result of the adopted taxes policy.

Incorporating activities of corruption

Corruption appears in the economy if the private wage is higher than the public wage. In a setting of corruption, any investment process will imply a bribe payment since bureaucrats feel unfairly remunerated. Moreover, they can be bribed since are legally in charge of licenses, inspections or regulations over both public and private investments. In this scenario, there is a gap between the capital accumulated by workers and the capital used in the productive processes. The difference between both quantities is the bribes payments, which will not take part directly in the productive system.

Public wage

The private sector and the public sector have different aims from an economic view because the private performance pursues to maximize profits whereas the public sector produces public capital in order to attain a public policy. In this regard, the public sector will deal with activities that the private sector will never carry out because of lack of benefits. The differences in aims might provoke that both sectors set their wages in a different way. As it was discussed earlier, the private wage is determined depending on the private production while the public wage can be set using a different criterion. For example, the public sector might behave as the private sector and set the public wage according to the contribution of labour to the public production. Other possibilities could also be considered and the public sector could set the wage proportionally to the private wage or mix both previous criteria.

Assuming that the public sector has an aim of wage more than a policy clearly defined about the public wage, in the flows and levels diagram the public wage is considered a level variable with an explicit aim. A first order linear negative feedback structure is used for modelling its evolution, where the desired wage is the wage selected by the public sector.

Regarding public wages, Van Rijckeghem and Weder (2001) indicate that large increases in wages would have been required in order to eliminate corruption in a sample of 31 developing and low-income OECD countries (the date cover the period 1982-1994). Hillman (2004) confirms that government wages are low because, in many countries, governments feel that they do not have to pay more because of the income from corrupt activities. He continues saying, the conclusion is that high increases in public sector wages appear to be required if significant reductions in corruption are to take place.

Corruption index

The model assumes that if bureaucrats are aware of their wage is lower than the private wage, some of them would engage in malfeasance behaviour. Nevertheless, the economy could have different degrees of corruption since greater differences in wages should provoke a greater degree of corruption. If the differences in wages increase, the same number of corrupt might request a larger bribe payment or might increase the number of corrupt bureaucrats or even both things might happen simultaneously.

In order to take into account this matter, the model defines a corruption index, which is associated to the relation between the public and private wage. Nevertheless, the formation and the evolution of the corruption imply a comparison of wages that takes time because corrupt bureaucrats need time to become aware of the differences. Then, the index of corruption instead of being tied to the relation between the public and private wage will be fixed using an information delay of the ratio of public to private wage.

Figure 3 shows that the available capital to both the private and public sector differs from the capital used by the sectors in their productive processes as consequence of corruption, which is quantified by means of the corruption index. In the figure, it is also possible to observe different feedback loops, which condition the dynamics of the model. For example, a positive feedback loop links both productions; other positive cycle connects the saving and the capital accumulated by workers and a negative feedback loop relates consumption and capital. Observe that the structure feedback of the system increases if the causal relationships connecting the shared variables in figure 2 and figure 3 are considered jointly.

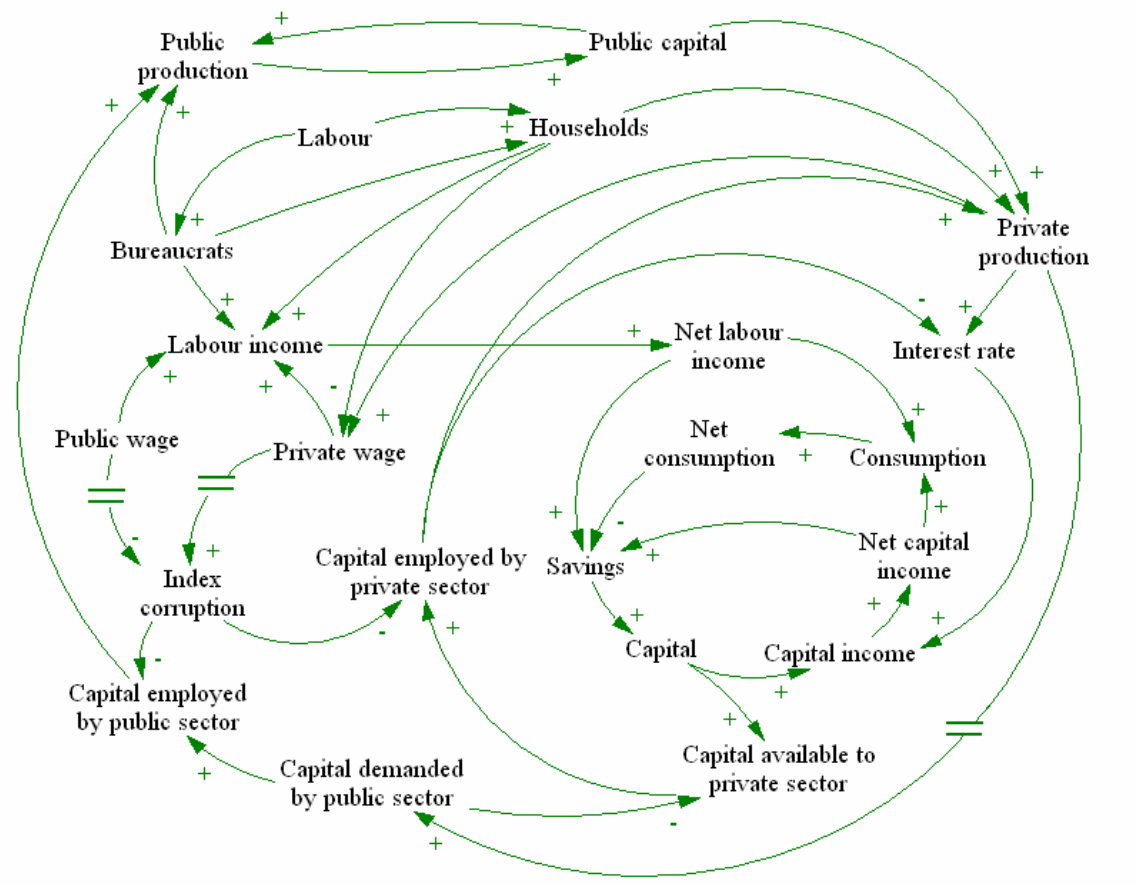

Figure 3: Feedback processes with corruption

Features of the corruption index

In order to avoid sharp variations of the corruption index, which would not be justified by the evidences, the index will be modelled by means of a level variable, dimensionless, with an explicit aim: attain the current value of the delayed ratio of

public to private wage. In addition, its evolution has to keep certain characteristics in order to correctly quantify the degree of corruption in the economy and likewise, to reflect other evidences.

Firstly, its range of variation is selected to be from zero to one and like the CPI index, the more the index is, the lesser corruption is. In particular, if the index reaches the unit, the economy will not have corruption; but the index cannot be null, because in that case, the whole bureaucracy will be corrupt, which is not a realistic fact.

Secondly, different evidences justify that corruption could be led by a feedback process, mainly if the corruption is high due to the perceptions that individuals have to act corruptly. In this regard, Guerrero et al. (2006) assert the higher the frequency of corruption, the higher the propensity to replicate such acts, even affecting young generations' attitudes, and possibly behaviour, as they are signed with no incentives to be honest.

Consequently, the index has to be always positive and also, inferior or equal to the unit even when the delayed public wage could exceed to the delayed private. In addition, it should reflect the facts suggested by Guerrero, i.e. its variations have to depend on the current level of corruption. Then, if at a different time, the economy has two different levels of corruption and in both cases, the delayed ratio is the same, the variation of the level has to be higher when the index of corruption is lower, this is, when the economy has more corruption.

In the flows and levels diagram, two flows are associated to the level of corruption to guarantee clearly that the index is robust; although firstly, it seems necessary to define the auxiliary variable:

$$Unit = \begin{cases} 1 & if \quad Index < Delayed\ ratio, \\ 0 & if \ \ Delayed\ ratio \le Index, \end{cases}$$

in order to determine when each flow acts. The inflow and the outflow are formulated by the expressions:

$$Inflow =$$
$$Unit * \min\{Effect\ of\ current\ \ corruption\ \ on\ inflow, 1 - Index\} * Index / Adjustment\ \ time,$$
$$Outflow =$$
$$(1 - Unit) * \min\{Effect\ of\ \ current\ corruption\ \ on\ outflow, Index\} * Index / Adjustment\ \ time,$$

where the parameter *Adjustment time* (years) controls the speed whereby the corruption index changes of value over time. The auxiliary variables included in the definitions of the flows, are formulated by means of the functions:

$$Effect\ of\ \ current\ corruption\ on\ inflow = (Delayed\ \ ratio + Index)^{0.5}$$

$$Effect\ of\ \ current\ corruption\ on\ outflow = (-1.5 + 0.5 * Delayed\ ratio + Index)^2 .$$

in order to the index reflects the characteristics required.

The value of the minimum between the auxiliary variable, *Effect of current corruption on inflow* and the variable, 1-*Index*, controls the growth of the level, whereas the minimum between *Effect of current corruption on outflow*, and *Index*, controls the decrease of the index.

Observe that, at each interval of time, at most one flow associated to the level can be active. Likewise, the corruption index always changes except when its value, in the previous period, is equal to the unit and moreover the delayed wage ratio is superior or equal to it. It is also possible to observe from the definition of the flows associated that the index stays always positive and it is inferior or equal than the unit.

If the delayed ratio is given, the auxiliary variables included in the definition of each flow are functions depending exclusively on the corruption index. Figure 4 illustrates the overlapped graphs of these effects as functions of the corruption index; the graph of the *Effect of current corruption on outflow* is considered with negative sign in order to represent the evolution of the level.

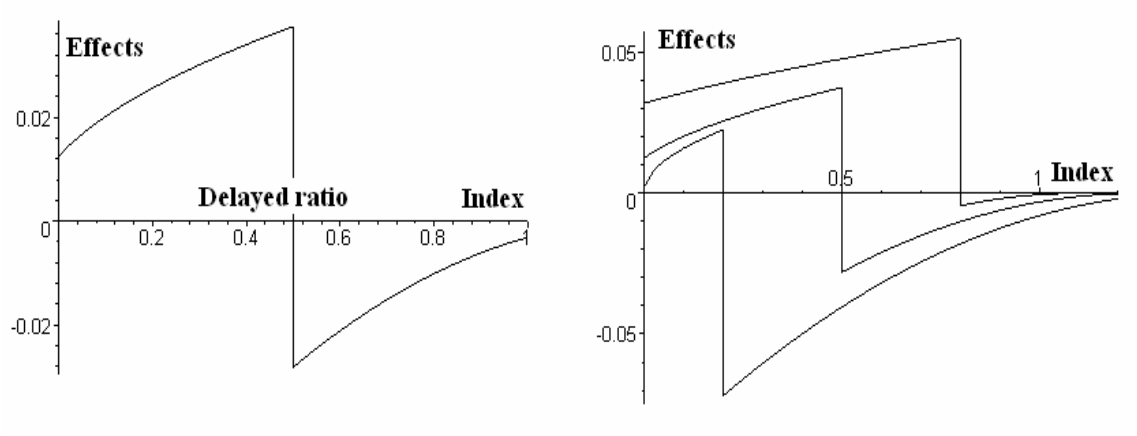

Figure 4: Graphs of the effects as functions of the corruption index

The graph on the left side assumes that the delayed wage ratio is equal to 0.5 while the graph on the right side, illustrates the different variations that the level could undergo depending on the value of the corruption index and under different values of the delayed wage ratio.

The description of the model will be complete if it is specified both the quantities paid for bribes and the treatment given to the undeclared earnings.

Black money

In the economy, the capital accumulated is invested by either the public sector or the private sector. As it was mentioned before, in an economy with corruption, a fraction of the quantities devoted to these investments is received by the corrupt bureaucrats. In order to determine the amounts actually invested in the productive process, it seems realistic to assume that if corruption increases, i.e. if the corruption index decreases, the bribes payments grow. Then, the model defines a percentage, as a linear function of the variable 1-*Index*, which is applied on both investments to determine the bribes payments. Though the percentage is not easy of estimating since most corruption is notoriously clandestine, Mauro observed that an improvement in the corruption index by one standard deviation is estimated to increase private investment by as much as 3% of output.

As previously it was said, the capital obtained by bribes does not participate directly in the productive system; however, it participates indirectly in the process. This fact is a

consequence of two aspects. Firstly, the model assumes that the corrupt bureaucrats use a fraction of the capital accumulated by bribes for consuming in their own economy and the rest remains as black money, which might be saved in some tax haven. Then this fraction of black money consumed in the economy is taxed and consequently finances the public sector. Secondly, it is assumed that the public sector has mechanisms to control corruption and a part of the bribes payment is captured every productive period. Then this captures also finance the public sector since they have the same treatment as taxes. These two aspects together with the amounts devoted to investments determine the accumulation of black money. These considerations imply that the capital accumulated by corrupt bureaucrats grows if the index of corruption diminishes and it decreases because of consumption and captures.

Results of simulation

The levels and flows diagram contains seven level variables: capital demanded by public sector (output), capital (output), public capital (output), labour (workers), public wage (output/worker), black money (output) and corruption index (dimensionless). The unit of time in the model is set equal to a year; the step of simulation is 0.25 years. The time horizon is selected equal to 20 years which is a period sufficiently long for showing how corruption affects to the tendency of the paths of economic growth as well as for verifying the necessity to fight against corruption.

The capital demanded by the public sector is initialised in its equilibrium value. The same criterion is used for initializing both the public capital and the public wage. The initial value of capital is selected in order that the interest rate is closed to 5%.

The initial value of the black money is defined by multiplying the capital accumulated by a linear function of the corruption index. Consequently, an economy starting with corruption has more private capital than the economy beginning without corruption since it is realistic to assume that corrupt bureaucrats had gone accumulating black money in that situation. This fact has not consequences at the beginning of simulation since the capital used in the productive processes does not depend on the amount accumulated in black money; however, if corruption is eliminated progressively during the simulation, the amount of black money diminishes and the productive capital grows in the economy as consequence of that decrease of black money.

It is assumed that labour grows at annual rate of 2%. The percentage of labour in public sector varies across countries and within a country varies over time. For example, in Norway (2006) the percentage was 26.7%, whereas in Finland (2006) was 17.3%; in UK (2005) was 20.4% and the percentage in 2006 was 20.9%. The value selected by the model is 20%.

The contribution of labour, capital and public capital in the public and private production is assumed identical. If labour increases by about one percent, each production increases 0.65%; similarly, if capital increases by about one percent, each production grows 0.35% and finally, each production increases 0.20%, if public capital increases by about one percent. The first two values are usual in economic literature and the last one lies within the range of the consensus estimates (see Gramlich, 1994).

Given the complexity of taxes in different countries, the same value is selected for them; so labour tax, consumption tax and wealth tax are set equal to 10%. The

propensity to consume is set equal to 80%. Likewise, it is assumed that 4% of private production is dedicated by public sector for investments; the annual depreciation rate of public capital is 3% whereas that rate is 5% in the private sector. All those values are plausible and generally consistent with recent empirical evidence (see Turnovsky et al.).

In order to represent two different initial situations of corruption in the economy, two initial values of the corruption index are considered. One case assumes that the initial value of the corruption index is next to one, which means that the economy is practically upright. According to the data published by TI[1], all the countries have a certain level of corruption, very slightly corrupt countries as Finland, New Zeeland, Iceland, Denmark or Singapore, have index closed to ten, but not exactly ten. The other case assumes that, at the beginning of simulation, the economy has an intermediate level[2] of corruption with an index equal to 0.5. Countries such as Italy, Hungary, South Korea, Jordanian or Malaysia would be representative of that level of corruption since its average CPI index (2001-2006) is practically five.

The policy supported by the public sector about the public wage combined with the two possibilities about the initial value of the corruption index allows the exercise of simulation to characterize the behaviour of four economies over time. Two different policies regarding remuneration of the public labour during the simulation are considered. One case assumes that the public sector wants a public wage equal to the private wage. The second one assumes an aim of public wage determined by the maximum between a public wage, which would be obtained using the same criteria as the private sector, and a percentage of the private wage. This second in the economy, which initiates the simulation with corruption, allows the model to find an evolution over time of the corruption index without strong variations, which is a characteristic of the CPI indexes by each country.

Summarizing these assumptions, the exercise of simulation characterizes four economies, the economies 1 and 2 start the simulation practically upright whereas the economies 3 and 4 initiate the simulation with corruption; the economies 1 and 3 have an aim of public wage equal to the private wage during the simulation whereas the economies 2 and 4 support the other public policy regarding the public wage. The paths generated by the economy 1 are considered as trajectories benchmarks.

In order to complete the initial conditions for the levels that take part in the flows and levels diagram, in the four scenarios, labour is initialised with the same value which is selected to attain a benchmark trajectory rather stable regarding the rate of wealth per capita.

It is easy to check that the behaviour generated by the model does not change significantly under small variations of the parameters or the initial conditions of the levels. However, though the model is rather robust, the interest rate could show an exponential growth. This fact appears when the economy suffers strong corruption due mainly to two factors: firstly, the economy might have lack of productive capital as a result of the bribes payments, and secondly, the public sector might not obtain enough

[1] www.transparency.org

[2] Here intermediate level should be understood as the half of the interval in which the corruption index can vary in the model. However, with regard to CPI index (2006), just 26% of countries have an index superior or equal than five, the intermediate value in the scale of this index.

capital to face its costs of production since the taxes do not change in the different scenarios or during the simulation.

Figure 5 shows the annual rates of economic growth, the corruption indexes, the annual rates of growth of capital per capita, without including the capital deposited in black money, and the percentages that the bribes payment represent respect to the whole production for the four scenarios.

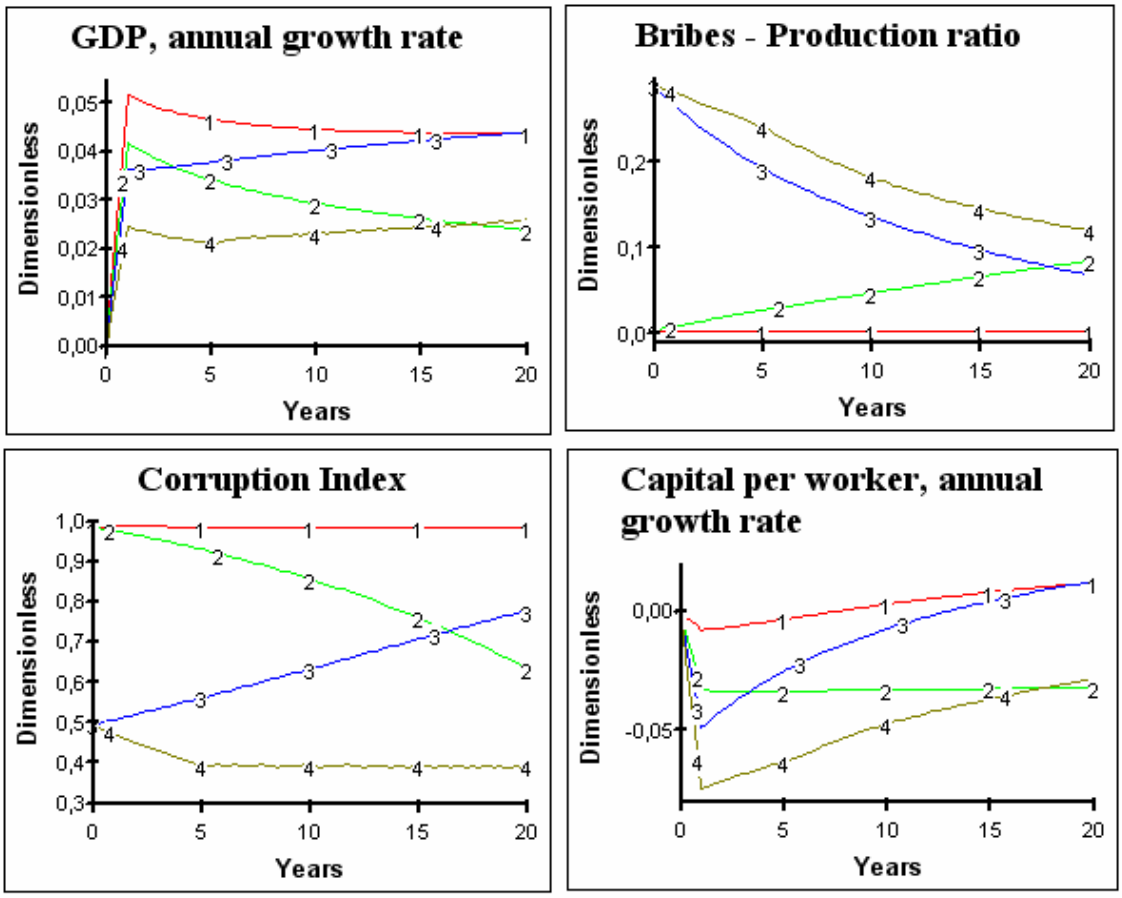

Figure 5: Results of simulation

Observe that, the different evolutions over time showed by the corruption index in figure 5 clearly identify the economy simulated.

It seems necessary to emphasise some features showed by the paths in figure 5. Firstly, observe that although the four economies have the same technology of production, the same fiscal regime and the same number of workers, they face the activities of corruption in a different way. During the period of simulation, the economy 2 enables corruption to grow; the economies 1 and 4 maintain a wage policy that does not permit its growth, while the economy 3 fights against it.

Secondly, the influence of corruption on the economic growth can be observed by means of the evolution of the corruption index and, in addition, comparing the paths 1 and 2 or the paths 3 and 4. Figure 5 shows that, at the end of simulation, the differences between the rates of growth are approximately of two points by each couple of paths, which is consequence of the different ways of facing to corruption activities. Moreover,

the incidence of corruption on economic growth can be checked noticing that, at the end of simulation, in spite of fact that corruption index in the economy 2 does not yet have attained the corruption index of the economy 4, their growth rates are practically the same.

Also, it seems important to observe that whereas the level of corruption in an economy stays stable, during a certain period of time, that economy maintains a level of growth practically stationary during that period. Therefore, the variations showed by the rates of economic growth might be explained by the modifications in the level of corruption rather than by corruption itself.

Thirdly, it does not seem ventured to assert that due to the behaviour showed by the paths of capital per capita, workers are extremely damaged by corruption. However, somebody, after observing the paths showed by the percentages of the bribes payments, could specify that corruption is totally unfair for the workers of the private sector rather than for the corrupt bureaucrats. In spite of this, it seems necessary to take into account additional information that the results of simulation provide. In the economy 2 and 4 the public wage is the half of the private wage during the simulation. Also, at the beginning of simulation, in the economy 2 and 4, bureaucrats bribe 7 per cent of capital; 1 per cent of the capital accumulated corresponds to the costs of labour in the public sector whereas 12 per cent of the capital corresponds to these costs in the private sector. Nevertheless, independently of belonging to the public sector or the private sector, all workers lose wealth under corruption because both economy 2 and economy 4 have a strong deficit budget during the simulation.

Regarding the last result, literature about corruption justifies in part that corruption exists. Mauro asserts that low wages in the civil servant relative to wages in the private sector are source of corruption. He continues, when civil servant pay is too low, civil servant may be obliged to use their position to collect bribes as a way of making ends meet, particularly when the expected cost of being caught is low.

Finally, the parallel behaviour between the paths showed by the economy 3 and 4, except those corresponding to the corruption index, could be explained precisely from the differences between both economies. The economy 3 decreases corruption progressively and consequently the bribes payment decreases too; likewise, the capital per worker grows even rather than this variable grows in the economy 1 because the black money decreases and therefore, the capital grows. Then the economic growth rate in the economy 3 tends to the stationary situation showed by the economy 1. Regarding the economy 4, the amounts paid by bribes diminish as consequence of the strong fiscal deficit that, in turn, influences the evolution of the capital per capita. The economic growth rate in the economy 4 tends to a stationary situation, different of that showed by the economy 1, because the economy 4 has less capital than the economy 1 due to the continuous payments of bribes.

Conclusions

The aim of this paper was to analyse how the corruption could influence the economic growth and if the matter could be explained in terms of feedback processes. According to different references that studied the issue of corruption and various evidences, a model about a generic economy was proposed. Three agents took decisions in the economy: a public sector, a private sector and workers. The economic decisions of any

of them provoke reactions on the actuations or results of the others. As a result, the economic process, involving elements of public corruption, was supported by a clear structure feedback, which justified how and why the corruption influenced the economic growth. However, it seemed important to quantify the degree of influence of corruption on the economic growth. Because of this a levels and flows diagram was build in which was necessary to incorporate additional feedback structure in order to justify certain hypothesis of behaviour of some agents as well as of certain facts. The responses of the model checked those empiric studies that assert the direction of causality between corruption and economic growth and showed how and why corruption can lead the economies to stagnation.

The problem of corruption in societies is undoubtedly very complex and involves different sociological, cultural and even religious aspects that were out of the scope of this paper. Though the model sustains its conclusions on the differences in wages between workers of the public and private sector, there are many more aspects of public corruption that were not considered. In this regard, Schaffernicht (2006) argues that system dynamics proposes to construct a useful understanding of a situation via the elaboration, validation, exploitation and interpretation of a simulation model, based heavily on mental models. He continues, during a modelling endeavour, the modellers will go through a series of tentative models that finally stabilize-temporarily-in the form of the validated model. In the longer run, experience from acting in the real world will lead to remodelling, bringing about new validated versions.

The issue of corruption is very wide and the study of particular questions or approaches to fight against it undoubtedly provides new ways for its study. In particular, the proposed model admits refinements. Some of them would be merely technical and other would be related with the introduction of new questions that will imply to consider new variables. Among the first ones there are various alternatives. For example, the model might eliminate the condition of which both productive sectors have the same technology; consider variations in taxes or take into account unemployment. Among the second ones, it would be possible to compare the effects of corruption on countries with a different level of development or relate corruption with the level of education of the population for checking certain empiric evidences which assert more educated people are less corrupt.

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