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**THE ANALYSIS AND MODELING OF THE FEEDBACK PROCESS
OF THE LABOR MARKET – A DYNAMIC MODEL ON
PORTUGAL’S NATIONAL ECONOMY**

Abstract: *The present paper proposes a system dynamics approach to the feedback process of the labor market taking place at macroeconomic level. The model was constructed on Keynesian theory introducing into the model adjustment by quantity and the wage was modeled as an endogenous state variable. The objective of studying the functioning of the presented feedback process is that of understanding its role and effect in the real economy cybernetic system in order to make it a functional part of the system of models that capture the national economy as a whole to be used in macroeconomic governance. The analysis and simulations of the model were done on Portugal’s national accounts between 2005 and 2011 and the model is able to produce the behavior in time of the state variables wage and unemployed persons close to historical data.*

Key words: *Dynamic Model, Economic Cybernetics, Feedback Process, Labor Market, Macroeconomics, Regulating Process, Stock – Flow Diagram.*

JEL Classification: C61, E13, E17, E37, E61, J21, J31

1. Introduction

When dealing with the labor market, macroeconomic models are constructed with two main objectives. There are models concerned with explaining the long – run and cyclical behavior of the fundamental variables of the labor market, such as unemployment rate, number of hours worked or job vacancies[20]. To understand the movements of these variables is very important for evaluating the implications

of policies designed to introduce stability into the labor market. The second type of models looks at the labor market as being a key mechanism for the transference of the effects of the monetary and fiscal policies [16] into the economic system. These type of models are concerned with gathering information about the state of the economic system on which governments should base their decisions when developing policies. The model presented here is designed to fulfill such a function but it comprises auxiliary variables that may serve in observing the long-run behavior of the labor market variables. Nevertheless, its functionality remains in the framework of a performance instrument capable of offering insight on the system's states and it is designed to serve as an instrument in policy design and prevention for systemic problems.

Regarding the state of the art in labor market theories, the literature is divided between efficiency wages models ([1]) and search and job matching approaches ([12] – [15]). According to the efficiency wage hypothesis workers' productivities depend positively on their wages making it profitable to firms to pay high wages that exceed market clearing. In the presence of an excess supply of labor employers may avoid cutting wages, even, to avoid reducing worker's productivity that would decrease their profits. Paying higher wages would be a tactic firms use to circumvent shirking by employees, to increase their effort level, and to keep the best workers within the firm. In equilibrium it can be verified the existence of persistent involuntary unemployment.

Search models state that workers may choose to stay temporarily unemployed a fact that can explain the coexistence of free job vacancies and unemployment. Trading frictions and the need for time to find the best match between a vacancy and the skills of an employee are core features of unemployment.

Many studies merge both types of models introducing adjustments and even a mix of the two types of models [3]. There are studies where it has been shown that the effectiveness of the real business model can be much improved by introducing the search and job matching approach into it ([2],[10]). Other recommend the introduction of wage rigidity ([6],[19]) while in other models the wage rigidity is built endogenously by introducing asymmetric information about productivity ([8],[9]) even though in further models it have been argued that norms on wages can influence them to become nonresponsive in regard to changes in productivity [7].

Unemployment is a central macroeconomic problem and the way we conceive the labor market adjustment is determinant in our attempt of building proper instruments in order to capture and understand the functioning of the system of national economies. Either a result of a demand shortage as Keynesians would conceive it, either the result of a natural cyclic adjustment of the economy to supply shocks, the social and economic effects of unemployment are by far large

enough to deserve a proper investigation and inclusion as part of an integrated instrument of modeling the national economy as a cybernetic system.

2. Theoretical Framework on The Cybernetic System of the National Economy

The present study acts within the general theoretical framework of the cybernetic system of the national economy. We believe that a holistic approach in macroeconomic modeling is needed as a complementary alternative to the classical and neoclassical models due to the shortcomings of the economic thinking. Until now the results and reality interpretation given by neoclassical models lack the validation of economic events as they are unfolding. The shortage of a comprehensive introduction into the models of the interrelations that are forming between variables used for describing markets, economic systems and processes has been the signal that maybe a sustainable instrument in macroeconomic governance can be built by the study and modeling of complex adaptive systems and in particular by their fundamental characteristic of being ruled by their internal structure of interrelated feedback loops.

2.1 Redesign of the National Economy

One attempt of integrated macrodynamics was made by mixing traditional Keynesian theory with feedback mechanism (i.e. Metzlerian sales inventory adjustment, Mundell effect, Blanchard equity and bond dynamics) and it was made by considering a system build out of the money and financial market, the goods market and the labor market [4]. Nevertheless a comprehensive analysis would benefit by separation of the real economy and the monetary economy and by a new definition of the subsystems comprising the cybernetic system of the national economy. The macroeconomic subsystems, objective defined are a number of seven subsystems, each having a specific functionality within the bigger system. They were defined by Scarlat and Chiriță(2003) as follows [18]. The *Production Subsystem (S1)*, *The Aggregated Supply – Aggregated Demand Ratio Subsystem (S2)*, *Subsystem of The Market of The Labor Market (S3)*, *Profitability Subsystem (S4)*, *The Subsystem of Income Formation and Distribution (S5)* are the subsystems defining the cybernetic system of the real economy while *The Subsystem of The Financial Market (S6)* and *The Subsystem of The Capital Market (S7)* are the ones

comprising the cybernetic system of the monetary economy. For brief presentation of the functionalities of the subsystems of the real economy please see [17].

2.2 Feedback Mechanisms vs. Feedback Processes

Each subsystem mentioned before is comprised out of specific state variables and auxiliary variables designed to describe each economic problem at macroeconomic level. Between these variables a series of interrelations are forming and we can thus observe a series of transmission effects forming within the subsystem. For example, the subsystem of the aggregated demand – aggregated supply on the market for goods and services has in its structure two fundamental feedback loops, one negative corresponding to the AD – AS ratio which determines the reduction of the gap between supply and demand by adjusting the total output from the economy. The other feedback loop is positive and it will determine effects also on the aggregated demand by means of intermediate consumption which is an important component of aggregated demand. The two feedback loops function continuously and interconnected determining together a feedback mechanism comprised within the subsystem concerning the market of goods and services.

Each of the subsystems have in their structure a series of feedback mechanisms. When put together, the subsystems are interconnected with each other by auxiliary variables designed to assure the link between them. Unfolding in time in an interrelated and interconnected manner, the bigger system, thus the cybernetics system of the real economy will display a set of feedback processes which have into their composition feedback mechanisms of the subsystems happening at the layer of the subsystems but also feedback processes happening at the above level (i.e. national level). The Feedback Processes are comprised by variables included in more than one subsystem. For example, later in the paper we will make a comprehensive analysis of the subsystem of the labor market which has in its structure a negative feedback loop unfolding on each of the market comprising the aggregated labor market. The variables included in the mechanism are specific variables of the subsystem. Later on, when describing the functioning of the Feedback Process another fundamental feedback loop is presented comprised by variables of the Production Subsystem S1, The Profitability Subsystem S4 and The Subsystem of the Labor Market (S3).

Until now, there have been identified four fundamental feedback processes: The Feedback Process of Equilibrium Adjustment on The Market for Goods and Services, which has in its composition the subsystems S1, S2, S4, S5, The Feedback Process of The Labor Market formed between S1, S4 and S3, The Feedback Process of Disposable Income Allocation forming between S1, S2, S4

and S5 and The Feedback Process of Assuring Profitability formed between S1, S2 and S4 [17].

3. Analytical Discussion on The Feedback Process of Adjustment of The Aggregated Supply – Aggregated Demand of Work Force

As said before, the Feedback Process of The Labor Market is the one comprised by feedback mechanisms which determine transmission effects between the subsystem of the labor market, the production subsystem and the profitability subsystem. Due to the fact that the core economical problem which the feedback process aims to describe is that of the regulation of the labor market, we are to give an comprehensive analysis only of the subsystem of the labor market, the other being largely treated in other works [17].

3.1 Analytical Discussion on The Subsystem of The Labor Market

The production subsystem (S1) will use, beside the intermediate products also different types of labor. At some point in time it is rather simple to assume that the total quantity of labor force disposable into the economy is known thus it can be looked at in an undifferentiated way. Nevertheless, when trying to build a performant instrument in modeling the national economies as whole systems that meet the characteristics of the complex adaptive systems it is then very important to assume that into an economy there are more markets of specific labor types. These markets work interrelated and have different power into the system, depending on the characteristics of each national economy in relation to education, culture, mentalities and attitude towards work[5] or even depending of the government strategy in developing one industry or another.

If we are to consider the total number of employed individuals fulfilling one type of work and that they are available for employment then we are to say that this total amount represents the labor supply on the market for the specific type of work we are talking about. On the labor market, as in any market, the forces that act together are the labor supply and demand. The labor supply is continuously powered by the total work force disposable into the economy which we should not confuse with the labor supply which is only a part of the total work force. Throughout the model the total work force disposable into the economy will be considered as the total number of persons between 15 and 74.

Into the subsystem of the labor market, the formation of the work supply is developed taking into consideration the total volume of work force available into the economy, N^* , which is considered to be an exogenous data for the future model presented in the paper. This variable is dependent on the evolution of the population of the national economy that is in focus and also by the national system of education. Nevertheless we are not to introduce into the current study the characteristics of population growth and the way it influences the labor supply as the objective of the current study is to put the theoretical basis of the functioning and the role of the feedback process of the labor market has into the regulating processes that take place at macroeconomic level.

From the considered variable of total disposable work force a series of work occupations are separated – occupations of those individuals that are searching for a job on the labor market, N_j , with $j = 1, 2, \dots$ representing the number of occupation categories. The volume representing these individuals is to be considered the work supply, N_j . The ones that are not able to find a job on the labor market or the ones that have surpassed the maximum employment age will be considered again to be part of the total work force variable, N^* . From the categories of works available and having different qualifications, on different markets of labor are recruited workers that correspond to the respective occupations. Employed workers, L_j , with $j = 1, 2, \dots$ representing the number of occupation categories later mentioned, are to be considered the demand of work, a variable which in the framework presented earlier is a resulting variable of the subsystem S1.

The remaining volume of workers, $(N_j - L_j)$, that are unemployed is the variable we are considering as stock of unemployed individuals which will form on each of the labor markets within the national economy. This variable can take both negative and positive values and will denote in the first case an excess of demand on the labor market and respectively an excess of supply on the labor market. It will act as inventories on the market for goods and services but in reverse given the fact that on the labor market the supply of work is given by the household sector and the demand is given by the production sector. Nevertheless, the existent stock of unemployed individuals on a labor market of type j , will determine further the rate of the nominal wage, W_j , offered to the respective category of workers. According to the general theory of markets, including the labor market, as the stock of unemployed individuals is higher, the wage as it is the price on the labor market should drop. But this reaction of the wage is less obvious on the labor market, where the decrease of wages determined by the rise of unemployment is limited given the legal limitations and social protection of the studies national economy. Also, the drop in wages is lower limited by the minimum wage set by

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authorities. We are then to say that the wage rate, W , is lower limited by another variable, \overline{W} , representing the guaranteed minimum salary into the economy.

The level in salary earnings obtained by workers having different occupations will determine the orientation of work force available, $(N^* - N_j)$, to those types of occupations that will bring higher salary income, thus for those type of occupations for witch W_j is higher. This will determine also structural changes into the aggregated labor market but when analyzing short time periods, considering the length of education cycle, from 8 to 20 years, representing the number of years needed to achieve high school qualification to the number of years needed to achieve higher qualifications then we can leave aside the influence of those structural changes and focus on the changes into the production system.

The occupations that will determine a higher salary income are the ones for which the demand of work, L_j , is higher then the corresponding stock of unemployed $(N_j - L_j)$, is going to be smaller. If though, in this way the demand of work for the necessary occupations from the production subsystem is covered, the number of unemployed in those occupations that are not demanded or are less demanded is going to rise. This is why, the labor market will not empty at any time, into the economy being a permanent number of unemployed individuals. The number of unemployed individuals existing even when the demand of work is completely covered will determine the equilibrium natural rate of unemployment – NAIRU ([11], [21]).

Considering the work force utilized in the production subsystem, L_j , and the rate of nominal salaries, W_j we can determine the total cost of type j work utilization. Aggregating those costs in relation to j we can determine the total cost of employed work force into the economy, $W \cdot L$ which will be further transmitted to the subsystem of profitability S4.

Taking into account the relationships formed between the variables used in the above description of the functioning of the subsystem of labor market, S3, a feedback loops is forming and determining the dynamic behavior of the subsystem. The transmission effect of each loop forming on different markets of labor is the one determining the regulation of the type j work market in relation with the supply and offer of type j work and it can be described as follows:

$$(N_j - L_j) \uparrow \rightarrow W_j \downarrow \rightarrow (N^* - N_j) \downarrow \rightarrow N_j \downarrow \rightarrow (N_j - L_j) \downarrow$$

A rising in the number of unemployed on a certain labor market will determine a drop in the rate of nominal wages on that market or the maintaining the salaries at a certain level if the salaries are close to the level of minimum guaranteed wage from the economy. The reduction of the salaries from the considered labor market will determine that from the available work force from the economy even less individuals to choose the occupation considered thus determining the reduction of the supply of work force for the specific type of occupation. With the reduction of supply work force for type j , the stock of unemployed individuals on the specific labor market considered will start to decrease.

Thus the feedback loops formed within the subsystem of labor market are negative, having the essential roles in allocation the disposable work force from the economy to those occupations and qualifications for which there is a demand on the market and also it has the functionality of discouraging the orientation and even formal formation towards the types of occupations that are suppliers of unemployment. Obviously, the power of the feedback loops in their functionalities of assuring a certain equilibrium between the supply and demand of work force will be determined by the wage stickiness downwards but also the reduced flexibility of the work force between different types of occupations.

3.2 Analytical Discussion on the Feedback Process of Adjustment of the Aggregated Supply – Aggregated Demand of Work Force

The operational functioning of the feedback mechanism of adjustment on the Labor Market is to achieve a certain balance between labor supply and demand. The feedback process takes place between three subsystems of the cybernetic system of the real economy and some of the resulting variables of the Production Subsystem (S1) and The Profitability Subsystem (S4) and the central subsystem of the process – The Labor Market Subsystem (S3).

The intensities (S_{p1}, S_{p2}, \dots), at which different production processes function will determine the labor demand or the need of each type j of work, for each of these processes (L_{p1j}, L_{p2j}, \dots), with $j = 1, 2, \dots$ representing the number of occupations needed for each of the production process. The aggregated demand of work on the labor market, L , will be determined in this way by the aggregation of the work demands formulated at the level of each production process, $p1, p2, \dots$ from the economy. As already stated in the description of the subsystem of the labor market, the aggregated work supply, N , is an exogenous variable of the process, dependent on time and the total working age population N^* . Having the two aggregates we can determine in the same way as we discussed earlier, the

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stock of unemployed on the aggregated labor market and we will denote it as, $(N - L)$.

A brief analytical description of the Process leaving from the description of the principal states of that the market of labor can achieve and how the feedback mechanism can produce effects into the market is necessary in order to define the boundaries of the studied process in order to understand it and translate it into the dynamical model.

When the Labor Market is in equilibrium, unlike other aggregated markets from the economy, the labor market is described by a certain rigidity, that is when the price on the market – the wages reaches a certain downward level, then the wage will hardly go below that level while when considering rises of the wage the power of the stickiness is reduced. Because of the downward rigidity of wages and the structural problems described earlier, a perfect equilibrium is hard to reach and it is assumed to be when the unemployment has a balanced route close to the NAIRU rate. Into the economy, the stock of unemployed individuals, $N - L$, will have positive values as it cannot be totally absorbed by the production processes due to the structural characteristics.

On the labor market, the ratio between the demand of work and the supply, expressed by the stock of unemployed population can lead to a deficit of work force if $N < L$ and to an excess of work force if $N > L$. In relation to the value of this deficit, respectively excess of work force, the level of the rate of wages will be determined, for example by salary negotiations. The tendency of the salaries in the case of work force deficit is of going upwards. In on the Labor Market will be registered an excess of labor then the tendency of the salaries is to decrease slower, not to decrease or to decrease until a certain level. The distortion between the downward and upward behavior of the wages is given, in general, by the fundamental role of syndicates on this market but also by the government intervention for social protection.

From the micro perspective of the wages formation, the brut rate of wages is determined by the net profitability, $\bar{\pi}_{p1}, \bar{\pi}_{p2}, \dots$ of the different production processes within the economy. The processes that use expensive work force which imply higher salaries will be less profitable and it time they may be replaced by production processes that are or become more profitable for which the scales of production will grow in the same relation with the net profitabilities. The process is characterized by the following transmission effect:

$$S_{p1}, S_{p2}, \dots \uparrow \Rightarrow L \uparrow \Rightarrow (N - L) \downarrow \Rightarrow W \uparrow \Rightarrow, \bar{\pi}_{p1}, \bar{\pi}_{p2}, \dots \downarrow \Rightarrow S_{p1}, S_{p2}, \dots \downarrow$$

The effect is forming thus between variables of the three subsystems comprised in the feedback process and it is of negative polarity, thus having a balancing role. Due to this effect, the stock of unemployed population, thus also the unemployment rate (determined by the ratio between the total number of unemployed individuals and the total number of available work force from the economy) have the tendency to oscillate from one period to another. By these oscillations, the labor market tries to adjust to equilibrium moving towards a balanced route in time. Maybe the most important advantage in introducing this model in the system of models of the national economy is to have means by which we can determine routes of the unemployment rate of a national economy and test policies in order to assure a healthy level for it.

4. Modeling of the Feedback Process of Adjustment of the Aggregated Supply – Aggregated Demand of Work Force

The model associated with the Feedback Process of The Labor Market is a dynamical model constructed in STELLA 9.1.4 Modeling and Simulation Software. As we are dealing with a complex problem, unfolding in time and being dependent on interrelations we believe that the most suitable approach in modeling would be system dynamics. The software is based on Jay Forrester theory framework on system dynamics and permits the construction of links between state variables, inflows and outflows into and out of the state variables and auxiliary variables. The model benefits also by introduction of first and second order delays where it is necessary and even of logical functions IF-THEN-ELSE. The model was designed using the functioning of the feedback process described earlier and suffered slight modifications due to implementation needs.

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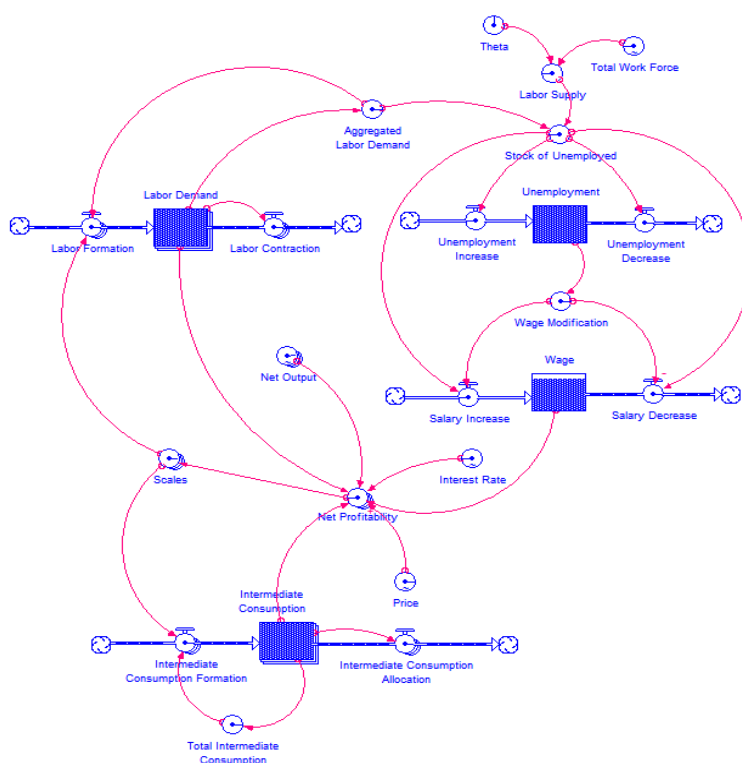


Figure 1 - Stock - Flow Diagram Implemented in STELLA 9.1.4 for the Model

The scales of production have been considered to represent at macroeconomic level the sectors of industries and we have introduced into the model twelve scales representing the NACE 10 Classification. The model considers 12 industries - Agriculture, forestry and fishing, Industry, Manufacturing, Electricity and Gas, Construction, Trade and Services, IT&C, Financial and Insurance Activities, Real Estate Activities, Professional, scientific and technical activities, Public Services, Arts Entertainment and Recreation.

As it can be seen in Figure 1, we have defined as state variables the *Intermediate Consumption*, the *Labor Demand*, the number of unemployed persons, *Unemployment* and the price on the labor market, *Wage* which is considered to be the average nominal wage. Due to data limitations, we are not able to introduce to the model the volume of labor supply on each industry considered and the level of unemployed persons and the wage are computed for the

overall economy. The data used for initialization of the state variables were taken from the official statistics of Portugal as they are reported on EURSTAT for the year 2005.

The exogenous variables, *Net_Output* (the domestic output), *Price* (the price on the market for goods and services considered as consumer price index), *Interest_Rate* (average interest rate) and *Total_Work_Force* were introduced as graphical functions of time with input values for each year of the studied period, 2005 – 2011. The levels of the interest rate were collected from the statistics of Bank of Portugal.

4.1 Dynamical Equations and Implementation

As it can be seen in Figure 1, representing the stock –flow diagram of the model, the variables that are constructed for each production process (i.e. industry sectors) are the net profitability, the intermediate consumption, the scales of production and the labor demand. The label [Industries] used throughout the equations of the model represents the set of the 12 industries – Agriculture, forestry and fishing, Industry, Manufacturing, Electricity and Gas, Construction, Trade and Services, IT&C, Financial and Insurance Activities, Real Estate Activities, Professional, scientific and technical activities, Public Services, Arts Entertainment and Recreation.

The equations [1] to [4] are the dynamical equations transformed by the software for the state variables mentioned above. Each equation of the state variables has sub points where (a) represents the inflow for the state variables and (b) represents the outflow.

$$\begin{aligned} \text{Unemployment}(t) & & (1) \\ &= \text{Unemployment}(t - dt) \\ &+ (\text{Unemployment_Increase} \\ &- \text{Unemployment_Decrease}) * dt \end{aligned}$$

$$\begin{aligned} \text{Unemployment_Increase} &= \text{If Stock_of_Unemployed} & (1a) \\ &> 0 \text{ THEN Stock_of_Unemployed ELSE } 0 \end{aligned}$$

$$\begin{aligned} \text{Unemployment_Decrease} &= \text{IF Stock_of_Unemployed} & (1b) \\ &< 0 \text{ THEN } - \text{Stock_of_Unemployed ELSE } 0 \end{aligned}$$

Market mechanisms were introduced when building the inflows for the state variable *Wage* to be depended on the market signal, the stock of unemployed persons that can take positive and negative values and being the signal of excess of

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labor supply respectively an excess of labor demand. The wage modification is dependent of an parameter and of the level of unemployment in a previous period, 1 *dt* step (see Equation [6]).

$$Wage(t) = Wage(t - dt) + (Salary_Increase - Salary_Decrease) * dt \quad (2)$$

$$Salary_Increase = IF Stock_of_Unemployed > 0 THEN Wage_Modification ELSE 0 \quad (2a)$$

$$Salary_Decrease = IF Stock_of_Unemployed < 0 THEN Wage_Modification ELSE 0 \quad (2b)$$

$$\begin{aligned} Intermediate_Consumption[Industries](t) & \quad (3) \\ & = Intermediate_Consumption[Industries](t - dt) \\ & + (Intermediate_Consumption_Formation[Industries] \\ & - Intermediate_Consumption_Allocation[Industries]) \\ & * dt \end{aligned}$$

$$\begin{aligned} Intermediate_Consumption_Formation[Industries] & \quad (3a) \\ & = Scales[Industries] \\ & * DELAY(Total_Intermediate_Consumption, 1) \end{aligned}$$

$$\begin{aligned} Intermediate_Consumption_Allocation[Industries] & \quad (3b) \\ & = DELAY(Intermediate_Consumption[Industries], 1) \end{aligned}$$

$$\begin{aligned} Labor_Demand[Agriculture](t) & \quad (4) \\ & = Labor_Demand[Industries](t - dt) \\ & + (Labor_Formation[Industries] \\ & - Labor_Contraction[Industries]) * dt \end{aligned}$$

$$\begin{aligned} Labor_Formation[Industries] & \quad (4a) \\ & = Scales[Industries] \\ & * DELAY(Aggregated_Labor_Demand, 1) \end{aligned}$$

$$Labor_Contraction[Industries] = DELAY(Labor_Demand[Industries], 1) \quad (4b)$$

Equations [5] to [10] represent the dynamical equations of the auxiliary variables used in the model.

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$$\text{Stock_of_Unemployed} = \text{Labor_Supply} - \text{Aggregated_Labor_Demand} \quad (5)$$

$$\text{Wage_Modification} = 0.15 * \text{DELAY}(\text{Unemployment}, 1) \quad (6)$$

The labor demand is considered to be generated by the production subsystem depending on the needs of production and it is constructed into the model as depending on the scales of production which change in direct relation with the evolution of net profitability. The total labor demand on the market is the aggregation of the labor demand generated by the scales of each industry sector.

$$\text{Aggregated_Labor_Demand} = \text{ARRAYSUM}(\text{Labor_Demand}[\text{Industries}]) \quad (7)$$

The aggregated labor demand is constructed by summation of the demands of labor on each industry sector (see Equation [7]). As for the labor supply (Equation [8]), the exogenous variable *Total_Work_Force* has been considered to be the active population between ages 15 to 74 years. The *Theta* parameter represents the share of employed active population and it can be developed into a control parameter of the model. The used value of *Theta* for the simulations presented in the paper is 0.709.

$$\text{Labor_Supply} = \text{Theta} * \text{Total_Work_Force} \quad (8)$$

$$\text{Net_Profitability}[\text{Industries}] \quad (9)$$

$$\begin{aligned} &= \text{Price} * \text{Net_Output}[\text{Industries}] - (1 \\ &+ \text{DELAY}(\text{Interest_Rate}, 1)) * \text{DELAY}(\text{Price}, 1) \\ &* \text{DELAY}(\text{Intermediate_Consumption}[\text{Industries}], 1) \\ &- \text{DELAY}(\text{Wage}, 1) * \text{DELAY}(\text{Labor_Demand}[\text{Industries}], 1) \end{aligned}$$

$$\begin{aligned} \text{Scales}[\text{Industries}] \quad (10) \\ &= \text{Net_Profitability}[\text{Industries}] \\ &/\text{ARRAYSUM}(\text{Net_Profitability}[*]) \end{aligned}$$

Scales were built for each sector in accordance with the net profitability calculated on each industry in relation with the overall net profitability of the system, as it can be seen in Equations [9,10].

4.2 Model Simulations and Validation

A series of model simulations and sensitivity analysis have been made on the model associated with the Feedback Process of The Labor Market with data on Portugal's national economy between 2005 and 2011.

When comparing the behavior of the model with the data evolution of the state variables Unemployment and Wage we have found that the model is able to produce simulated data near to historical data. The model has been tested for

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robustness to initial conditions. A modification of the initial value of the unemployed persons and as it can be seen in Figure [2], will not produce any distortion in the behavior in time of the state variables of the model. The unemployment curve simply shifts from one level to another while, not making any modifications to the initial conditions of the wage, its curve will only modify the steepness.

In order to calibrate the model parameters, the model associated with the labor market did not show significant changes in behavior on modifications of the Wage parameter. However, testing for different levels of the parameter the results show an amplification of the same behavior by augmentation the values of state variables.

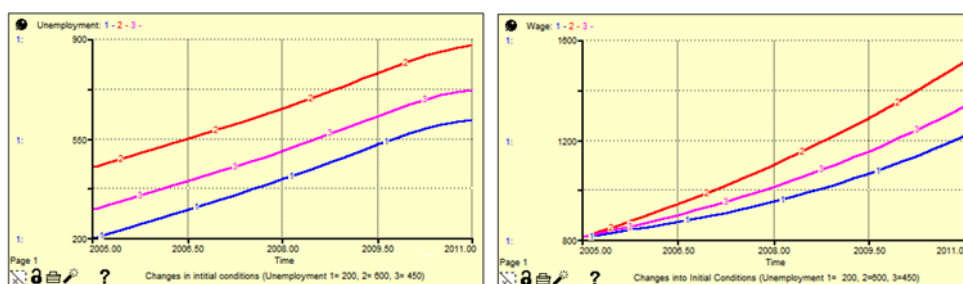


Figure 2- Sensitivity Analysis to Initial Conditions - Unemployment

The model shows robustness in relation to changing parameters and will not behave differently but will produce changes in levels of state variables values, thus emphasizing the behavior produced by the model. Simulated data for different thresholds of the wage parameter are presented in Table [1].

Table 1 - Simulated Data on Sensitivity analysis to Wage Parameter

Year	Wage Parameter = 0.05		Wage Parameter = 0.15		Wage Parameter = 0.2	
	Unemployment (thousand persons)	Wage (EUR/month)	Unemployment (thousand persons)	Wage (EUR/month)	Unemployment (thousand persons)	Wage (EUR/month)
2005	450	809.34	450	809.34	450	809.34
2006	517.92	831.84	517.92	876.84	517.92	899.34
2007	585.85	855.61	585.85	948.16	585.85	994.43
2008	657.85	882.78	658.44	1,029.67	658.71	1,103.11

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2009	737.53	913.39	740.17	1,121.50	741.36	1,225.56
2010	815.65	947.75	822.29	1,224.77	825.22	1,363.37
2011	858.76	986.15	876.36	1,340.57	883.07	1,518.12

What is of importance to us at this moment, is the fact that the model is able to compute simulated data close to historical values of the wage and number of unemployed persons, as it can be seen by comparing Figure [2] with Figure [4] which displays the evolution of the consumer price index and number of unemployed persons for Portugal between 2005 and 2011.

Source: tradingeconomics.com

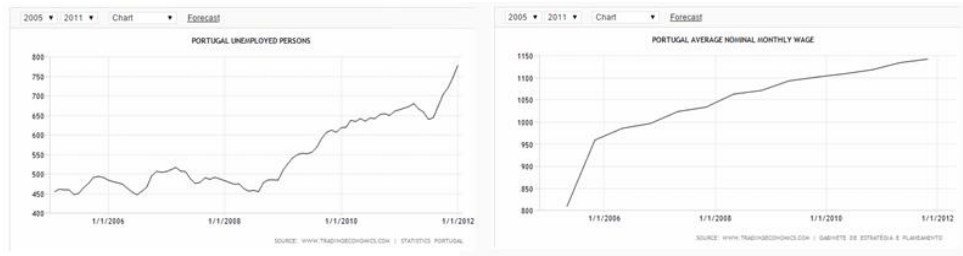


Figure 3 - Evolution of Unemployed Persons and Average Nominal Wage in Portugal 2005-2011

Leaving aside the evolution of state variables, the model also can give perspective on the overall economy of Portugal as it comprises the concept on profitability computed for each of the sectors of industry considered. Up to this point the model simulations have surprised some of the problems recorded by Portugal's economy during the crisis. Net profitability shows that it is more influenced in certain sectors while others recorded a stable behavior or even increased slightly.



Figure 4 - Evolution of Net Profitability on Industry Sectors - Simulated Data

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The most affected areas of the economy of the 12 considered, as were generated by the model are Public Service, Trade and Manufacturing which record an important decrease starting with 2008, the year when the economic crisis started to show its effects on European countries. The only sectors which are increasing slightly are Real Estate, explained the influence of tourism in Portugal and the Industry which is highly supported by the public sector.

Conclusions

The proposed model is one of the four models associated with the regulating feedback processes of a national economy and it is analyzed and modeled in closed boundaries using the resulting variable of the other three feedback processes as exogenous variables with data input of the official statistics of Portugal between 2005 and 2011.

A series of simulations have been run in order to analyze the model’s behavior and ability to display close behavior in time of the state variables with historical data. The simulated behavior of the *Wage* variable is close to the evolution of the average nominal wage in Portugal between 2005 and 2011 and for certain thresholds of the associated parameter it can compute simulated data close to the real data series. Also, the *Unemployment* variable displays the same behavior as the number of unemployed persons in Portugal for the studied period and while *Theta* parameters takes values between 0.7 and 0.715, the simulated data generates values close to the data series on unemployed persons supplied by Portugal’s Institute of Statistics.

Profitability behavior associated to each industry sector shows growth or maintenance of a balanced route until around 2008 after recording a rapid decrease surprising reaction to the economic crisis triggered in European countries in 2008.

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