AMoSI

An ACE Model to Study Inequality[1].

[Preprint to be submitted to the Journal of Economic Inequality]

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Abstract – Inequality is present in many forms in most of today's societies at a scale that hinders their economic growth and the lives of the people who are part of it. This study has its focus on income inequality and aims to create a means for analyzing how inequality evolves given a model of an economic system. Our approach was to create an agent-based simulation that implements a given economic model and that is able to explain the emergence of its macroeconomic outcomes by means of the agents' interactions, as advocated by ACE. The simulation was built by means of a Java toolkit called RePAST that provides graphics that thoroughly describe the state and evolution of the simulated economy with different parameter configurations, and that calculates metrics to assess its inequality rate (e.g. Gini Index). Thus, we were able to build a platform equipped with a series of features that allows the user not only to study and validate the emergence and the dynamics of inequality in the economic system, but also to analyze, compare and measure the effect that different policy settings have in the inequality rate.

Keywords - Agent-based Simulations, RePAST, Income and Wealth Inequalities, Computational Economics**,** ACE models.

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1. Overview on Economic Inequalities

The increase of inequality rates has had its impact on the overall economy throughout the years, thus giving rise to one of the main challenges of our time. Low economic growth and poor economic performance in the EU, as well as worldwide, have aggravated our concerns about wage disparity, income inequality and social exclusion (Brandolini et al. 2010; Atkinson et al. 2011). Advanced economies have observed top income earners taking a larger share of the total income generated by the economy (Piketty et al. 2003). In fact, the top 10% of income earners get 9 times more income when compared to the bottom 10% (OECD, 2014). In contrast, a significant growth in the middle class for EMDC economies, along with redistribution efforts, lowered the income inequality (Lakner et al. 2013; Tsounta et al. 2014). The following Figure depicts the distribution of economic disparities across the globe.

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[1] This project was developed in collaboration with José Maria Santos Soares, Master's student of Engineering and Management at Instituto Superior Técnico.

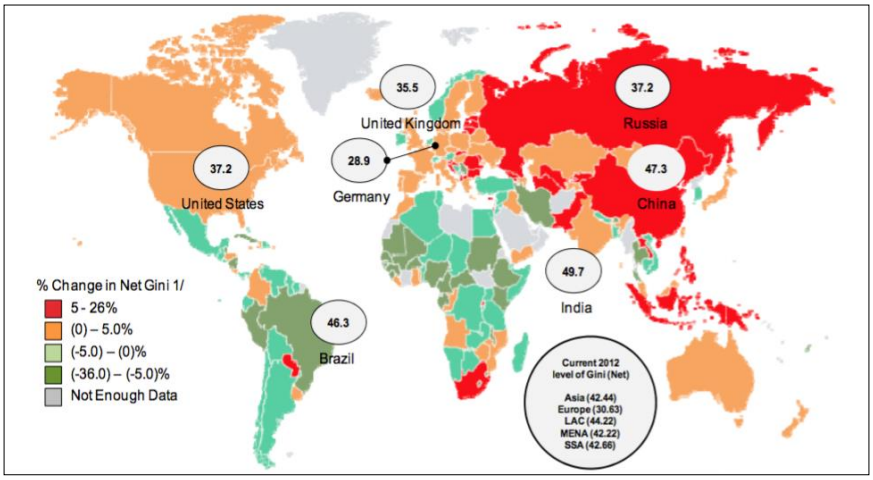

Figure 1. Net income inequality variance from 1980 to 2012 (Ostry et al, 2014)

The implications of economic inequalities are vast. From damaging trust and social cohesion, to precluding economic growth, promoting macroeconomic instability, enhancing concrete political and decision making power in the hands of few, suboptimal use of human resources, raising risks of crisis, among many others (Lichbach 1989; Alesina et al. 1996; Rodrik, 1999; Bardhan, 2005; Picketty, 2014; Saez et al. 2015; Kopczuk, 2015). In fact, there is a growing consensus that economic inequality leads to more fragile and less sustainable growth, while more equal economies sustain an ongoing growth (Berg et al. 2011; Ostry et al. 2014).

Kierzenkowski et al. (2012) indicates three main causes for economic inequalities: i) **technology changes** and crowding out of routinized work; 2) **globalization**, free trade and outsource and 3) **diminishing labour market institutions** and minimum wage. Technology changes increase the demand for a properly skilled labour force, raising a gap between these and lower skilled labour. Yet, at the same time, they eliminate job posts due to the process of automation (Card et al. 2002; Acemoglu, 1998). In advanced economies, offshoring manufacturing and the ability of Firms to implement labour-saving techniques have driven unemployment to increase along with inequality (Feenstra et al. 1996). Finally, higher labour market flexibility, present in more deregulated working environments, results in lower incomes because of the reduced bargaining power by lack of unionized workers (Frederiksen et al. 2010).

In order to undermine the impact of economic inequalities, primary preference is given to one major policy vector: welfare policies through **redistribution packages**. However, when it comes to wealth redistribution policies it is possible to find different opinions: while Benabou (2000, 2002) and Bleaneyet al. (2001) say that public expenditure in infrastructure, health, education and social insurance provisions might be pro-growth, Okun (1975) argues that redistribution hurts growth due to lower labour and competition incentives. Thus, our study gathers the prior discussions to formulate an economic model that covers these concepts and build an agent-based simulation that provides us with results that can help us understand and analyse their implications on inequality.

2. The AMoSI

The ACE paradigm serves as a framework to help us conduct the analysis on the impact of wealth redistribution policies and education levels of a society. Therefore, the development of our model – AMoSI (Agent-based Model for Studying Inequalities) – followed some of the premises advocated by ACE that are more carefully explained in the investigations held by Tesfatsion (2005), Oeffner (2008), Ciarli et al. (2008), Riccetti et al. (2013), Dawid et al. (2013) and Lengnick (2013). AMoSI comprehends three classes of agents, as denoted by the square boxes in Figure 2: the Firms that produce consumables, the Households that consume goods and work for the Firms[2], and the Government that regulates the economy's money flow by applying taxes and paying subsidies/benefits. In order to avoid excessive complexity, the model assumes that the economy is closed, *i.e.*, there is no money coming in or out of the system, and that there is only one type of goods. Moreover, the economy's goods are not perishable, which means that they do not deteriorate over time and can, therefore, be stored as long as one wishes, and are also not essential to the survival of the Households. In order to support all these interactions, AMoSI implements two markets denoted by a circle, one that deals with unemployed Household agents and another one that deals with consumer goods – the Labour and the Goods Market, respectively.

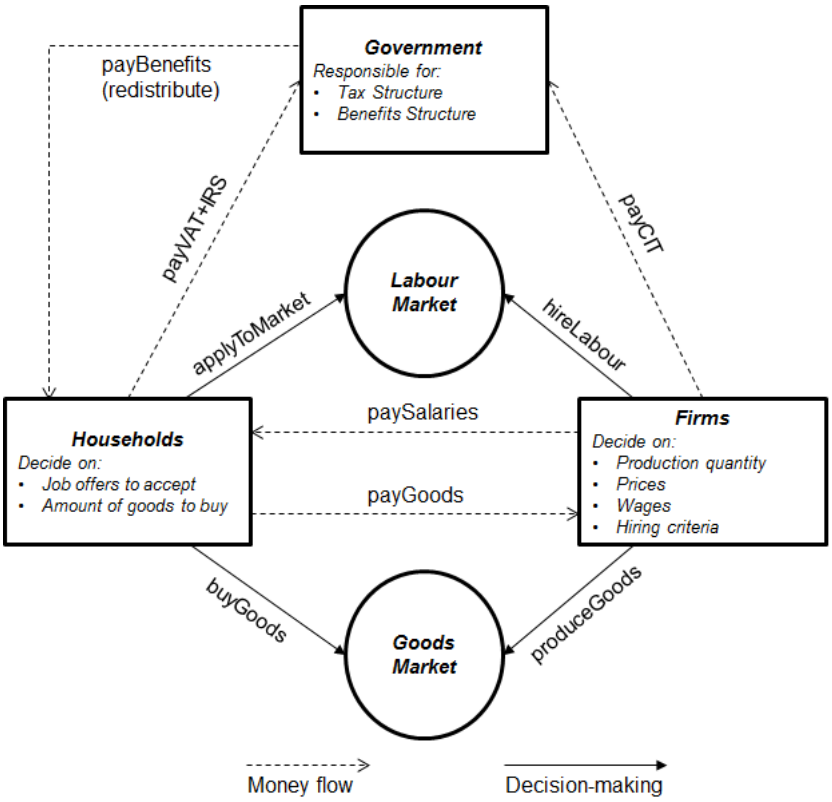

Figure 2. AMoSI

[2] The Firms' costs depend exclusively on the number of employees (Households) they have working for them.

The **Households'** consumption patterns are heterogeneous among the population, that is, they have different inherent propensities to consume (and therefore to save). Thus, the amount of goods consumed by each Household depends on the *utility* that it assigns to each good. From this perspective, it would only make sense that as the number of bought goods increases, the utility in buying the next good decreases. Moreover, the less money that a Household has available for spending (disposable income), the less it should be willing to spend it. As such, the utility of each good varies according to the following formula (j stands for the jth good to consume and r_h is a heterogeneous discount parameter):

$$utility_h(j) = disposable\_income_h(T) \cdot {r_h}^{j-1}, \quad j > 0 \ \wedge \ 0 < r_h < 1 \tag{1}$$

Then, based on the measured utility:

$$\begin{aligned} &if\ utility_h(j) \geq market\_price_f \rightarrow \boldsymbol{h}\ buys\ \boldsymbol{j^{th}}\ consumer\ good\ from\ firm\ \boldsymbol{f} \\ &if\ utility_h(j) < market\_price_f \rightarrow \boldsymbol{h}\ does\ not\ buy\ \boldsymbol{j^{th}}\ consumer\ good\ from\ firm\ \boldsymbol{f} \end{aligned} \tag{2}$$

Unemployed Households subscribe to the *Labour Market* so that Firms may perform their selection on which Households they wish to employ. These agents accept or reject a job offer based on their reservation wage (res_wage_h), which represents the minimum amount of money they are willing to work for. This means that, if a Firm is offering less that its reservation wage, then the Household will not accept the Firm's proposal. This factor also varies with their employment status; as long as a Household remains unemployed it will keep decreasing its reservation wage in order to also decrease the chance of discarding a job offer. The following equations describes the explained behaviour (φ_h is a heterogeneous variance parameter):

$$\begin{cases} \quad if\ \boldsymbol{h}\ is\ unemployed\ and\ \boldsymbol{unemployment\_time_h} > \boldsymbol{\varpi}: \\ res\_wage_h(T) = max[\ res\_wage_h(T-1) \cdot (1-\varphi_h)\ ;\ min\_wage\ ] \end{cases}$$
$$\begin{cases} \quad if\ \boldsymbol{h}\ is\ unemployed\ and\ \boldsymbol{unemployment\_time_h} \leq \boldsymbol{\varpi}: \\ res\_wage_h(T) = max[last\_wage_h * v\ ;\ res\_wage_h(T-1) \cdot (1-\varphi_h)\ ;\ min\_wage\ ] \end{cases} \tag{3}$$
$$\begin{cases} \quad if\ \boldsymbol{h}\ is\ employed: \\ res\_wage_h(T) = wage_{f,h}(T) + \ earn\_\text{tax}\_benefit_{g,h}(T) \end{cases}$$

The minimum wage that every single Household will be allowed to work for is set by the parameter min_wage, which means that they cannot decrease their reservation wage below the established minimum wage. The variable $last\_wage$ refers to the Household's last gross salary when employed.

Another characteristic that defines the Households as heterogeneous agents is their level of education. The Households' education levels dictate their respective labour productivity (λ_h) which is the input for the Firms to calculate the real amount of goods they will be able to produce (production quantity). AMoSI defines three education levels (edu_tier_h) that are

exogenously determined by configuring the simulation's parameters: *basic* (or secondary), *technical* and *superior*. Thus, higher education levels lead to a faster learning speed and, consequently, they will result in more productive Households. Nevertheless, regardless of its education level, an unemployed Household loses its individual skills at a constant rate $(prod\_decrease)$, which means that, during the time it is unemployed it will lose productivity. The previously described phenomena are explained by the following algorithm:

$$\begin{aligned} &if\ \boldsymbol{h}\ is\ employed\ \rightarrow \lambda_h(T) = \lambda_h(T-1) + \frac{edu\_tier_h}{\lambda_h(T-1)} \\ &if\ \boldsymbol{h}\ is\ unemployed\ \rightarrow \lambda_h(T) = \lambda_h(T-1) \cdot (1 - prod\_decrease) \end{aligned} \tag{4}$$

Firms decide on their production output and respective pricing. These actions are analogous in the sense that both depend on the number of sales they were able to achieve in the previous *move*. If they were able to sell more than a given percentage of their inventory, then then they should increase their production, as well as their prices. Contrarily, if the sales could not achieve a given percentage, then they should decrease the production and the prices. The following equations, (5) and (6), explain this relation inherent to the decision-making of the production output and pricing, respectively (γ_f/ σ and δ_f/ μ refer to the upper and lower inventory limits and β/θ_f the actual variance parameter):

$$\begin{cases} if\ sold\_goods_f(T-1) \geq Stock\_before\_market_f(T-1) \cdot (1-\gamma_f) \\ \quad Target\_production_f(T) = Production_f(T-1) \cdot (1+\beta) \end{cases}$$
$$\begin{cases} if\ sold\_goods_f(T-1) \geq Stock\_before\_market_f(T-1) \cdot \delta_f \\ \quad Target\_production_f(T) = Production_f(T-1) \cdot (1-\beta) \end{cases} \tag{5}$$

$$\begin{cases} if\ sold\_goods_f(T-1) \geq Stock\_before\_market_f(T-1) \cdot (1-\sigma) \\ \quad price_f(T) = price_f(T-1) \cdot (1+\theta_f) \end{cases}$$
$$\begin{cases} if\ sold\_goods_f(T-1) \geq Stock\_before\_market_f(T-1) \cdot \mu \\ \quad price_f(T) = price_f(T-1) \cdot (1-\theta_f) \end{cases} \tag{6}$$

However, no matter the production that the Firms attempt to achieve, it will always be constrained not only by the amount of labour available in the Labour Market but also by the budget that they can spend in hiring. This means that, if they do not get the number of employees needed to achieve a given target production, or pay for those employees, then the production will be readjusted according to the resources that they can dispose of. Moreover, during the pricing decisions they need to guarantee that the price they set for their goods covers at least the unitary costs of production (labour costs), as explained by Equation (7), otherwise Firms would get into debt (which our model does not foresee).

$$\begin{cases} price_f(T) \geq unit\_costs_f(T) \\ unit\_costs_f(T) = \dfrac{1}{workforce_f} \displaystyle\sum_{i=1}^{workforce_f} wage_{f,i}(T) \end{cases} \tag{7}$$

In the previous equation, $workforce_f$ stands for the number of Households working for a Firm f and $unit\_costs_f$ for the production's unitary costs. Additionally, once a year, Firms perform a sales discount by a factor τ (Table 1) on their products. This is to prevent that unsold goods from previous rounds that Firms have accumulated in their stock are not being sold at an absurdly high price when compared to the current prices. Otherwise, Firms would hardly get rid of their stock because their prices would not much the current reality of the market.

Finally, Firms also decide to increase or decrease their wage offers depending on whether or not they were able meet their needs of labour, as described in Equation (8). Nevertheless, when the economy reaches such a state in which the rates of employment have surpassed the 95% of employed Households, then all Firms will increase their current employees' wages in 5% in order to prevent the Firms from overruling the Labour Market.

$$\begin{cases} if\ all\ labour\ needs\ were\ met\ in\ the\ last\ labour\ market \\ \quad \rightarrow wage\_offer_f(T) = wage\_offer_f(T-1) \cdot (1-\varepsilon_f) \end{cases}$$
$$\begin{cases} if\ all\ labour\ needs\ were\ not\ met\ in\ the\ last\ labour\ market \\ \quad \rightarrow wage\_offer_f(T) = wage\_offer_f(T-1) \cdot (1+\varepsilon_f) \end{cases} \tag{8}$$

As previously introduced, the **Government** obtains funds from collecting three types taxes: the **value-added tax** (VAT), the **corporate income tax** (CIT) and the **income tax** (IRS). The VAT is applied upon the price of each good bought by the Households; the income tax is applied to the wage they are paid by the Firms; and the corporate tax is an annual fraction of the Firms' profits that is only paid to the Government if the profits are greater than zero. The following equations allow us to translate the previously stated relations:

$$market\_price_f(T) = price_f(T) \cdot (1 + VAT) \tag{9}$$

$$net\_wage_{f,h}(T) = wage_{f,h}(T) \cdot (1 - income\_tax) \tag{10}$$

$$net\_profit_f(T = 12) = (1 - corp\_tax) \cdot \sum_{T=1}^{12} profits_f(T) \tag{11}$$

The market price ($market\_price_f$) is the final price that Households must pay to purchase a consumer good after the VAT has been applied to the base price set by the Firms ($price_f$). The base price is then paid to the producer and the remaining is paid to the Government. The net wage ($net\_wage_{f,h}$) is the wage that Households actually receive after the IRS has been paid to the Government ($wage_{f,h}(T) \cdot income\_tax$). Finally, since the CIT is only applied once a year, the Firm has to sum the profits of each month so that the tax is applied to the annual profit of the Firm ($\sum_{T=1}^{12} profits_f(T) \cdot corp\_tax$) resulting in its net profit (net_profit_f).

Finally, the Firm redistributes the revenue obtained from tax collection by means of three main benefits: **earned income tax credit**, **unemployment benefit** and **minimum (wage) benefit**. The logic underlying the distribution of these benefits is described by the following

algorithms ($\boldsymbol{\varpi}$ stands for the period of unemployment time under which a Household is protected by the unemployment benefit):

$$\begin{cases} \quad if\ \boldsymbol{h}\ is\ unemployed\ and\ \boldsymbol{unemployment\_time_h} > \boldsymbol{\varpi}: \\ \rightarrow min\_benefit_{g,h}(T) = min\_wage \cdot (1 - income\_tax) \end{cases}$$

$$\begin{cases} \quad if\ \boldsymbol{h}\ is\ unemployed\ and\ \boldsymbol{unemployment\_time_h} \leq \boldsymbol{\varpi}: \\ \rightarrow unemployment_{benefit_{g,h}}(T) = \min[\ last_{wage_h} \cdot \nu\ ;\ \min\_wage \cdot (1 - income\_tax)\ ] \end{cases} \tag{12}$$

$$\begin{cases} \quad if\ \boldsymbol{h}\ is\ employed: \\ \rightarrow earn\_tax\_benefit_{g,h}(T) = \begin{cases} 1{,}5 - \left(\dfrac{wage_{f,h}(T)}{2}\right), & 1 \leq wage_{f,h}(T) \leq 3 \\ 0, & wage_{f,h}(T) > 3 \end{cases} \end{cases}$$

Lastly, the markets structure has a few peculiarities worthy of mentioning. The **Goods Market** is constrained by asymmetric information, that is, each Household sees a different portion of the goods that are available in the market (defined by a visibility factor ϑ). Since the goal of every Household is to attempt buying the cheapest goods possible this would lead to a scenario where the entire class of agents would always buy from the same Firm that is selling the cheapest goods. This way, there is a higher probability that Households may buy goods from a Firm that is not necessarily practicing the lowest price in the market.

As previously explained, the **Labour Market** establishes a bridge between the Households that are looking for a job and the Firms that are looking for new employees. During the Firms' hiring process, the candidates are sorted by decreasing order of productivity, which means that highly educated Households will be more easily employed. Moreover, since one of the Government's benefits targets employed agents – the earned income tax credit – Households will take into account the benefit they will be paid if they accept a given job offer. Thus, the criteria of acceptance of a job for the Households is defined by the two following inferences:

$$final\_wage\_offer_{f,g,h}(T) = wage\_offer_{f,h}(T) + earn\_\text{tax}\_benefit_{g,h}(T) \tag{13}$$

$$\begin{cases} if\ final\_wage\_offer_{f,g,h}(T) \geq res\_wage_h(T) \rightarrow h\ accepts\ job\ offer \\ if\ final\_wage\_offer_{f,g,h}(T) < res\_wage_h(T) \rightarrow h\ rejects\ job\ offer \end{cases} \tag{14}$$

3. Model Validation

For the present paper, two particular scenarios were chosen to demonstrate the features that AMoSI provides to study anti-inequality policies. The first scenario (S0) consists of an economy free from any kind welfare redistribution system, which means there are no taxes nor benefits to be distributed by the Government. The second scenario (SR) represents an economy where there is an active redistribution system, with VAT, income and corporate taxes at a rate of 10%, 40% and 15% respectively. Additionally, all the three existing benefits available in the AMoSI model are also distributed. In both scenarios the population of Households is divided into three tiers of education where the first, second and third one consist of 5%, 15% and 80% of the overall Household population, respectively.

The Household sector consists of a population of 500 individuals whereas there are only 50 Firms. The following table comprises the initial set of parameters chosen to initiate the simulations.

Notation	Definition	Value
H	Number of households.	500
F	Number of firms.	50
$inicial\_wealth_h$	Initial households' funds (at $T = 0$).	0
$inicial\_wealth_f$	Initial firms' funds (at $T = 0$).	250
$inicial\_wealth_g$	Initial funds from government (at $T = 0$).	0
r_h	Utility reduction factor by household h.	$random(0{,}4; 0{,}6)$
res_wage_h	Reservation wage of household h.	3
φ	Reservation wage reduction factor.	$random(0{,}05; 0{,}2)$
$intial\_target\_production_f$	Initial target production by firm f.	10
γ	Stock lower limit for production increases.	$random(0{,}85; 0{,}95)$
δ	Stock upper limit for production decreases.	$random(0{,}45; 0{,}55)$
β	Production increase/decrease factor.	$0{,}05$
$initial\_price_{b,f}$	Price of the initial batch of goods by firm f.	3
σ	Stock lower limit for price increases.	$0{,}9$
μ	Stock upper limit for price decreases.	$0{,}8$
θ	Price increase/decrease factor.	$random(0{,}08; 1{,}2)$
τ	Yearly sales discount factor	$0{,}6$
λ	Households' productivity.	2
$initial\_wage\_offer_f$	Initial proposed wage by firm f.	5
ε	Wage offer increase/decrease factor.	$random(0{,}08; 0{,}15)$
ϑ	Visibility constraint in the goods market.	$0{,}3$
η	Visibility constraint in the labour market.	1
$\min\_wage$	Minimum wage offer possible.	1
ν	Percentage of the last wage paid in unemployment benefits.	1
ϖ	Maximum unemployment time under unemployment benefits (months).	9
edu_tier_h	Productivity associated with respective education level from household h.	$\{0{,}75; 0{,}45; 0{,}20\}$
$prod\_decrease$	Productivity decrease factor for unemployed households.	$0{,}1$

Table 1. Initial parameter settings for the post-baseline model.

Each scenario was ran 100 times and the data was extracted in a window of 2400 simulation ticks, where the first 1200 ticks are discarded, which is in average the number of ticks necessary for the business cycles of our simulation to stabilize. The data considered for analysis is then extracted from the remaining 1200 ticks deemed sufficient for analyzing the outputs, where one tick corresponds to a month.

The AMoSI's results regarding both these scenarios must be properly validated so that we can state that the model produces reliable results. Thus, AMoSI must generate **endogenous business cycles** and comply with the **Phillips** and the **Beveridge curves** (Delli Gatti et al. (2008)).

Endogenous Business Cycles

The first validation criterion used in this process is the model's ability to independently generate endogenous business cycles. Figures 3 and 4 present the wealth distribution among the three classes of agents in both scenarios, S0 and SR, for a period of 50 years (sub-window of 1200 ticks).

Figure 3. GDP, Households' and Firms' Wealth for S0 scenario.

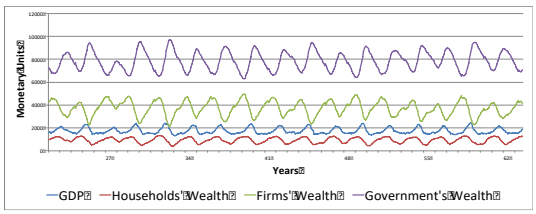

Figure 4. GDP, Households', Firms' and Government's Wealth for the SR scenario.

From the last two figures it becomes clear that the GDP and the Households' Wealth are positively correlated, while the GDP and the Firms' Wealth are negatively correlated. The GDP fluctuates over periods of expansion and depression in line with the Households' purchasing power at a given moment. This means that when the Household's wealth is at its maximum they are able to buy more goods which actively contributes to the increase of the GDP. In fact, our economy's GDP is calculated according to the following equation:

$$GDP\ (T) = \sum_{h=1}^{Employed\ Households\ (T)} wage_h(T) + \sum_{good=1}^{Sold\ Goods\ (T)} price_{good}(T) \tag{16}$$

Therefore, the GDP is a function of 2 main variables: goods' prices and wages, which in turn directly influence the aggregate consumption and employment rates. The next two graphs attempt to deliver a few important insights on the influence of these variables in the GDP outlook and the generated business cycles. The graphics are only with respect to the S0 scenario, since the behaviour is analogous to the SR's.

Figure 5. GDP, Number of Households Employed and Average Wages for S0.

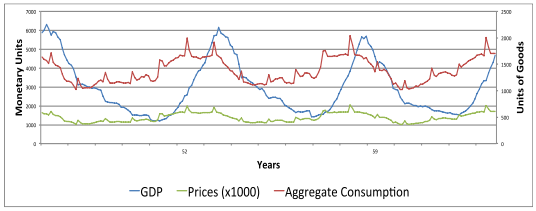

Figure 6. GDP, Aggregate Consumption and Average Prices for S0.

The previous graphics allow us to draw conclusions regarding the emergence of business cycles generated by the model. When both employment (and consequently the production output) and consumption reach their peak, the prices are still increasing because, contrarily to the Firm's production that is constrained by the number of Households that are willing to work

for the wage they are offering, the only thing that stops prices from increasing is the Household's consumption to start decreasing. Wages also increase in response to high employment rates, since it gets harder for Firms to find Households to work for them. These two phenomena reach their limit when prices are unsustainable and Households do not have enough utility in purchasing at such high values (Equation (2)), which culminates in the business cycle's turning point. The opposite chain reaction occurs in the negative slope phase of the cycle.

Since GDP is driven by the Households consumption, as concluded by analysing Equation (16), it is also highly influenced by inflation and deflation. Note that, even though real GDP is often the most used metric to compare different economies, it fails to measure the general welfare of the population when there is a rapid variation of the prices and salaries, as happens in this overly simple economy with only one industry sector (one type of good).

Phillips and Beveridge Curves

In order to complete the validation process we assessed whether the model complies with the Phillips and the Beveridge curves or not (Delli Gatti et al. (2008)). The Phillips curve is an empirical economic relation that states an inverse correlation between the unemployment rate and inflation, which means that unemployment decreases as inflation increases. The Beveridge curve is the graphical representation of the relationship between the number job vacancies and the unemployment rate. According to Beveridge, there is a negative feedback between the unemployment rate and the number of job vacancies, that is, when the unemployment increases the number of vacancies decreases. As a matter of fact, the data extracted from AMoSI allowed us to rebuild the stated relations. Thus, the following four figures present the graphical representations of these empirical laws in both scenarios under assessment.

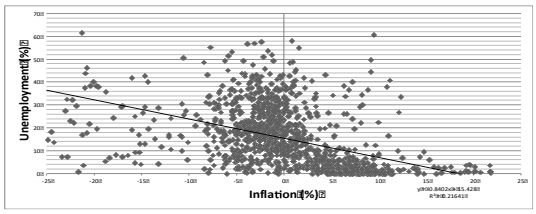

Figure 7. Phillips Curve for S0.

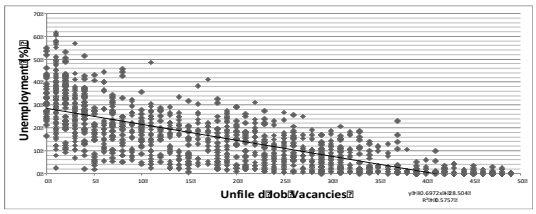

Figure 8. Beveridge Curve for S0.

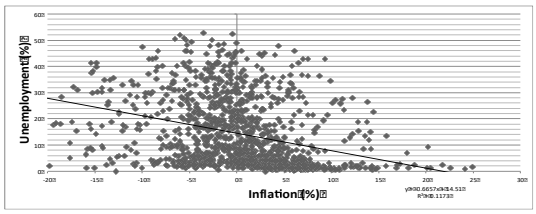

Figure 9. Phillips Curve for SR.

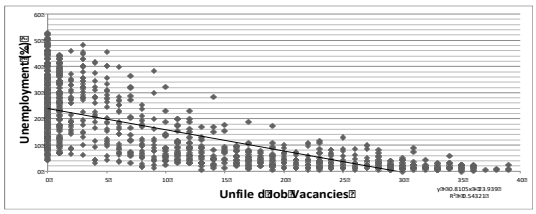

Figure 10. Beveridge Curve for SR.

4. Economic Inequality Analysis

As previously mentioned, the main goal of AMoSI is to create a platform to study normative understanding (Tesfation, 2006) and policy analysis upon economic inequalities. In this chapter, the core inequality dynamics are presented and, further ahead, both the S0 and SR scenarios are compared in order to assess whether the welfare redistribution policy is, in fact, beneficial for this artificial society.

Understanding how income inequality emerges in a society is one of the primary goals of AMoSI. The following graphics are only with respect to the S0 scenario, since the results for the SR are analogous to the one being illustrated.

Figure 11. Income Inequality and Aggregate Consumption for S0 scenario.

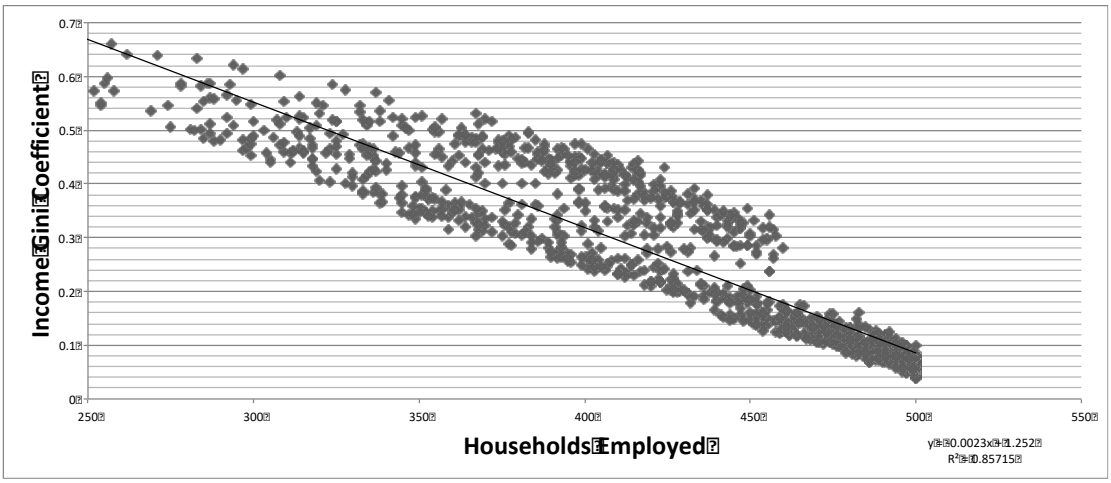

Figure 12. Income Inequality and Employment correlation for S0 scenario.

From both the previous figures, it is possible to observe a positive correlation between equality and consumption. In fact, higher consumption levels lead to higher employment and employment is highly correlated to economic equality with almost 86% *goodness-of-fit*. In this scenario, unemployed Households do not have any source of income, which prevents them from purchasing their desired quantities of consumer goods. Contrarily, the employed

Households are the only ones with enough purchasing power to consume. The gap between unemployed and employed Households' income only starts to diminish when aggregate consumption increases, which forces the aggregate production to increase and, consequently, so does employment rate. This dynamics changes when other sources of income are added to the economic system or when Households have different incentives to work. In the SR scenario, Households are entitled with a minimum wage and an unemployment benefit if unemployed, which allows them to purchase consumer goods even when they are not receiving a salary. Also, Households receive from the Government a supplement for being employed, which enhances the purchasing power of employed agents and translates into an incentive to work. Firms also benefit from the earned income tax benefit because it becomes easier for them to hire new Households, since the responsibility of satisfying the Households' reservation wage is no longer only of their own but also an indirect responsibility of the Government. All these benefits will be paid to the Households through the Government's tax revenue.

The goal of studying policies is to reach a conclusion on which the most beneficial scenario for the whole society is and, therefore, the necessary Key Performance Indicators (KPIs) must be chosen to undertake this assessment. As mentioned above, GDP is largely used to compare different economies, but it seems to be too sensitive to inflation and deflation phenomena, which will not account for the welfare of the population in question. On the other hand, aligning aggregate consumption with income inequality will provide a much better understanding on the population's general welfare and equality.

Table 2 comprises the average of the two metrics previously mentioned. Also, the following two figures present both scenarios under study regarding its aggregate consumption and income inequality dynamics.

	S0	SR
Average Aggregate Consumption	1486	**1532**
Average Income Inequality	0,244	**0,064**

Table 2. Average Aggregate Consumption and Income Inequality for S0 and SR scenarios.

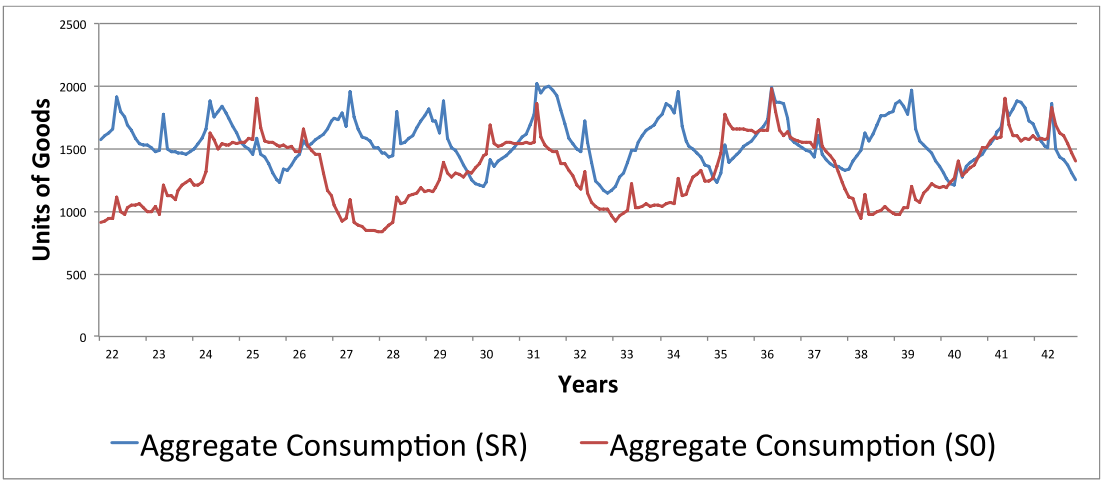

Figure 13. Aggregate Consumption for the SR and S0 scenarios.

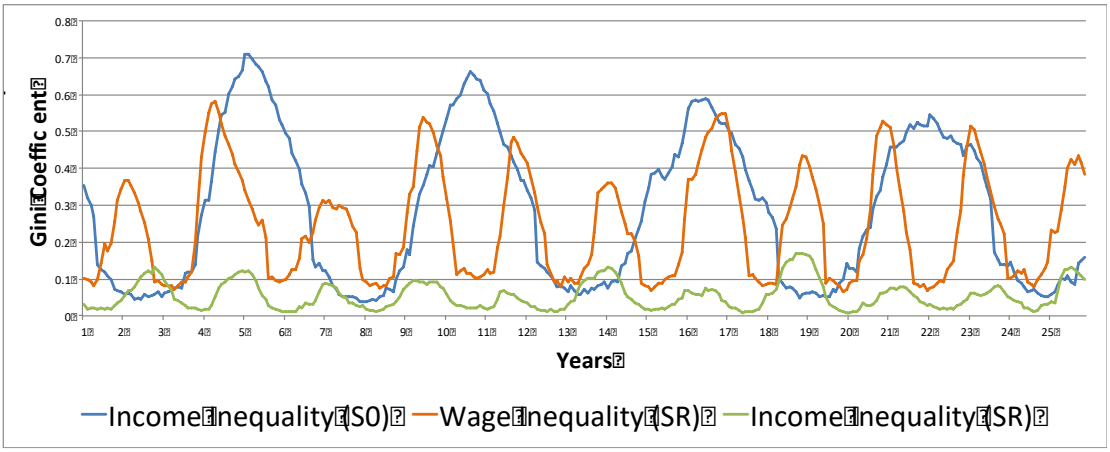

Figure 14. Income and Wage Inequality for the SR and S0 scenarios.

From Table 2, it is possible to conclude that, in average, Households consume more in the SR scenario when compared to the S0 scenario. At the same time, the SR scenario results in a more equal society due to its lower income Gini coefficient. In the S0 scenario, income and wage overlap because wages are the only income source of the Households, while in SR the practice of the Government distributing three types of benefits completely changes this behavior. In fact, from Figure 11, it is possible observe the gap between wage and income inequality for the SR scenario, which is due to the presence of the welfare redistribution policy.

From the previous graphics and Table, it is possible to assess that a simple economy, such as the one implemented by AMoSI, displays a better performance when there is an active welfare redistribution policy with three taxes and benefits included. AMoSI did not only allow us to assess the simulation's outcomes but also to formulate other insights on how economic inequalities emerge in a modern society. It is built to easily and fluidly display all the variables and KPI mentioned throughout this analysis and analyze the economy's evolution in an organized way by grouping them in different views. This aspect is most beneficial for policy makers to tackle this issue since they can rapidly adapt the model's parameters and analyze the results in the most adequate way possible.

4. Conclusions

Economic inequalities have been in the center of the Economists' attention throughout the years. They threaten social and economic cohesion while also precluding future growth. The present work presented a new approach to the study of economic policies and aimed to find a means to tackle this issue. As such, a multi-agent simulation constituted by Households, Firms and a Government was developed in order assess the impact of different economic policies on the system, giving birth to the AMoSI.

This model relied on the traditional welfare redistribution policy to assess whether or not this policy builds towards a more reasonable and equal society, while at the same time not

precluding the system's economic performance. In order to perform this assessment, two main metrics were chosen to help guide our analysis: the Households' aggregate consumption and the Gini coefficient of their income. Throughout the simulation runs, the system showed consistently higher levels of aggregate consumption as the income Gini coefficient decreased, meaning that the higher the consumption levels, the lower the inequality rate of the system tends to be. Moreover, the AMoSI allows the user to study the microeconomic dynamics behind the emergence of inequality in this economic model, which can pose as a major benefit for policy makers trying to create a policies set to attenuate the inequality rates. Therefore, the AMoSI is successful in both creating new insights on the dynamics of inequalities while also permitting the analysis of specific economic policies.

On the other hand, there are also some drawbacks regarding the AMoSI's architecture. The simulation runs over a fair amount of parameters, which translates into an overwhelming task to configure the initial values of its parameters. The AMoSI is still a quite simplistic model of a modern economy, which has its main focus on the Firms' and Households' behavior and interactions. In fact, introducing a financial system, active Government constraints regarding the public budget, more product variance and economic sectors will add a significant amount of extra complexity to the model but, on the other hand, it will converge into an even more realistic version of an economy. Nevertheless, our model does pose as a valid initial framework for economic policies analysis.

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