BEPE Research Proposal

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Economic policies, income distribution and economic activity: an agent-based open economy model

Abstract

This research proposal aims to explore whether the relationship between economic policies, income distribution and economic activity depends on the economic structure (transmission mechanisms and social structure). The motivation for this research is that the recent Brazilian experience of economic growth with income distribution seems to suggest that the possibility of successfully combining both features depends on the combination of economic policies and the specific economic context. The selected economic policies are minimum wage adjustment rules, unemployment benefits, monetary policy rules and taxation policy. The main hypothesis is that, because each policy instrument tends to alter the income distribution in favor of certain groups and affect other macroeconomic variables differently, different combinations of economic policies will be more or less appropriate to combining economic growth with income distribution in different economic structures. In order to test this hypothesis, an agent-based model for an open economy will be developed and simulated. The importance of considering an open economy is that the exchange rate is considered to be an important determinant of the income distribution. This research aims to contribute to the understanding of the relationship between economic growth and income distribution from a new perspective. The literature review indicates that income distribution is a relevant research topic in agent-based models, but the proposed approach to the topic has not yet been undertaken, so this research can contribute to the existing literature by analyzing the topic from a new perspective, as well as by modeling an external sector and a more detailed labor market and analyzing the personal income distribution through different indexes. The results from this research may also help to assess the design of public policies that aim at conciliating income distribution with economic growth by highlighting which channels are expected to be stronger in specific contexts.

1 Introduction and justification

After the 2007/8 economic crisis, the harmful effects of income inequality became explicit and the need of sustaining a more equitable income distribution fostered the economic debate on the topic.[1] A question that follows from this debate is how this can be conciliated with economic growth.[2] Inspired by the recent Brazilian experience of economic growth and income redistribution and the possibility of generalizing this strategy to different contexts, the research problem herein presented concerns how economic policies can successfully combine economic growth and income distribution equality in different economic contexts characterized by different transmission mechanisms, including the external sector. To do so, an agent-based model (ABM) will be developed and and simulated. The effect of different combinations of economic policies will be tested in different economic contexts. While the ABM literature has extensively dealt with issues related to income distribution from

[1] See, for instance, Ostry et al. (2019).

[2] For developing countries, at least, economic growth is still considered required for their socioeconomic development.

different perspectives, the specific approach proposed in this research has not yet been undertaken, so the research aims to contribute to the existing literature by explicitly discussing the effect of different economic policies on income inequality and economic growth in an agent-based open economy model, as well as by modeling an external sector and a more detailed labor market and analyzing the personal income distribution through different indexes.

1.1 Research question and hypothesis

In the 2000s, the Brazilian economy experienced a period of income redistribution and economic growth. The income redistribution process, which led to an increase in the wage share and decrease in the Gini index, was associated with both the external scenario and the economic policies put in place to redistribute income. On the one hand, the increase in the value of the Brazilian exports and capital inflows led to a currency appreciation that lowered the inflation rate. The lower inflation rate is considered to have benefited workers insofar as it allowed nominal wage increases to become real wage increases. The domestic currency appreciation may have also contributed to the higher real wage due to its effect on domestic firms' mark-ups.[3] In addition, as the increase in the Brazilian exports increased its aggregate demand, it also had a positive effect on employment rates.

On the other hand, a set of economic policies were successfully put in place to redistribute income and, in particular, reduce poverty in the country.[4] The conditional cash transfer program had an important role in redistributing income to the poorest households and was the most progressive source of income, which, together with the pension benefits to poor households, had an expressive contribution in the reduction in the Gini index between 2001 and 2011 (Hoffmann, 2013). The minimum wage increases in line with previous GDP growth and inflation rates had a direct redistributive effect, as well as indirect effects through its effect on the lower public sector wages and workers' bargaining power (Baltar, 2015, Serrano and Summa, 2012).[5] As this process also led to a decline in wage inequality, besides an increase in the wage share, it had a stronger effect on aggregate consumption (Carvalho and Rugitsky, 2015).[6] It should also be noted that inflation accelerated in the period (Carvalho and Rugitsky, 2015), which, in a Kaleckian perspective (Rowthorn, 1997), can be explained by a tighter conflict over the income distribution due to stronger bargaining power of workers.

As a consequence of the income distribution process, among other factors, the Brazilian economy experienced higher growth rates in the period.[7] This experience is coherent with a wage-led, distribution-led economic growth process (Arestis and Baltar, 2017, Rolim, 2018), although it was not a sustained process over the years, which may be explained by the shortcomings of the economic policies put in place (Carvalho and Rugitsky, 2015) and by a demand regime switch (Rolim, 2018). Thus, one may argue that this combination of economic growth with income redistribution in Brazil relied on a specific

[3] See Ribeiro et al. (2019) for a discussion on the relationship between income distribution and real exchange rates. Note that the source of change in the real exchange rate matters for its relation with income distribution (Lima and Porcile, 2013).

[4] The success of these policies is partly put into question by Medeiros et al. (2015), who argue that tax income statements data shows that income redistribution remained constant in the period (as the upper class share of income did not fall). Yet, households surveys suggest that an improvement in the bottom of the distribution took place.

[5] Also, the minimum wage increases were made more relevant due to the increase in the formalization rates (Medeiros et al., 2015).

[6] This is consistent with the Kaleckian literature that argues that other measures of income inequality, such as personal income inequality and within-wage income distribution, may explain the observed effect of changes in the functional income distribution as different groups within a functional income class can have different propensities to consume (Carvalho and Rezai, 2015, Palley, 2017, Rolim, 2019).

[7] It should be noted that the credit boom, which was associated with the income distribution process, also had a role in stimulating growth in the period.

set of mechanisms that were present in the Brazilian economy in the period, preventing the generalization of this experience to other periods and economies. Indeed, the literature suggests that the outcome of these policies was related to which groups were relatively more benefited, as well as on the initial income inequality level. Also, in spite of the real exchange rate appreciation the country experienced higher growth rates, which may be explained by the positive effect of a lower real exchange rate on income distribution.[8]

Inspired by this debate, the research question proposed is whether the relationship between economic policies, income distribution and economic activity depends on the economic structure (transmission mechanisms and social structure). The selected economic policies are minimum wage adjustment rules, unemployment benefits, monetary policy rules and taxation policy as the first and second are expected to affect the bottom of the income distribution, the third is expected to affect the exchange rate and, consequently, the functional income distribution, and the fourth is expected to affect the top of the income distribution. The importance of undertaking such analysis in an open economy is that the the recent Brazilian experience described above and the empirical literature for other economies show that the real exchange rate exerts an important influence on the functional and personal income inequalities (Ribeiro et al., 2019, Rossi and Galbraith, 2016), so this may be a relevant transmission mechanism. The main hypothesis is that because each policy instrument tends to alter the income distribution in favor of certain groups and affect other macroeconomic variables differently, different combinations of economic policies will be more or less appropriate to combining economic growth with income distribution in different economic structures.

In order to test this hypothesis, an ABM for an open economy will be developed. The use of ABM is particularly interesting in this case because it allows the analysis of the personal and functional income distributions, which can be endogenously determined, as well as the inclusion of agents with different behaviors. Agents' heterogeneity is relevant for our purposes because workers' and firms' behaviors in the labor market can assume a variety of forms, as they do in reality, thus causing heterogeneous wage and price levels. More broadly, ABM is a relevant modeling strategy for the possibility of including more complex interactions, a larger number of endogenous variables, non-linearities and the analysis of emergent properties without the need of analytical solutions.

1.2 Income distribution analyses in the ABM literature

Several models in the ABM literature deal with issues related to income distribution and different research questions have been addressed by them. Although certain topics, such as the growth dynamics, permeate all contributions, they can be divided in four different groups which share similar research questions.

The first group of models deals with the relationship between income distribution and technology. Carvalho and Di Guilmi (2019) explore the effect of technological unemployment and household debt on functional and personal income distribution. Ciarli et al. (2010) explore the interaction between technological and organizational change, income distribution, consumption and growth. In their model, income distribution is affected by the firm organization because workers are distributed in different hierarchical tiers within a firm, which are associated with different wage levels. Also, managers

[8] While some authors argue that domestic currency appreciations have a detrimental effect on economic growth, Ribeiro et al. (2019) show that currency undervaluation has a negative impact on growth in developing countries due to its effect on functional income distribution and technological innovation.

receive part of profits as bonuses. Melo et al. (2016) analyze the effect of technological innovations on the functional income distribution.

The second group of models concern the relation between income distribution and credit. Cardaci and Saraceno (2018) analyze the impact of rising income inequality on output and financial instability under different credit availability scenarios to capture the effects of debt-led consumption motivated by greater inequality, as desired consumption is based on peer effects and imitation. Russo et al. (2016) also analyze the relation between increasing inequality and consumer credit and its effects on the macrodynamics and financial instability in a model where consumption is determined by disposable income, wealth, and past consumption and can be debt-financed.

The third group of models focuses on the effect of labor market institutions on income distribution. Ciarli et al. (2019) study the relation between income distribution and growth and compare two different regimes, the Fordist and post-Fordist regimes, which are characterized by different labor relations, competition and consumption patterns. Workers are organized in different hierarchical tiers within a firm, as in Ciarli et al. (2010). Similarly, Dosi et al. (2018) analyze the effects of labor market structural reforms in a extended version of the "Schumpeter meeting Keynes" model (Dosi et al., 2010) that considers explicit and decentralized interactions between firms and workers in the labor market. The effects of the two regimes, the Fordist and Competitive regimes, on unemployment and functional and personal income inequality are analyzed.

Finally, the fourth group of models is dedicated to exploring more specifically the relationship between growth and income distribution. Caiani et al. (2019) explore this relation in a model that splits workers into four classes and where firms' demand for each type of worker depends on their hierarchical organization (similarly to Ciarli et al. (2010)). It is assumed that workers have different propensities to consume and save, so redistributive policies can affect consumption. Dosi et al. (2013) analyze the effect of monetary and fiscal policies on growth under different patterns of income distribution. Their model is a credit-augmented version of the model in Dosi et al. (2010).

Is sum, the existing ABM literature discusses issues related to income inequality from different approaches. These contributions will be helpful for the development of the research herein proposed, which aims to contribute to the literature by bringing an innovative approach to the topic, in which an open economy, different economic policies and alternative economic structures are analyzed.

1.3 Justification

This research aims to contribute to the understanding of the relationship between economic growth and income distribution from a new perspective. As discussed above, the topic is a relevant research area in face of the understanding that an improvement in the income distribution is needed, as well as that certain economies need to conciliate this with economic growth. The results from this research may help to assess the design of public policies that aim at conciliating income distribution with economic growth by highlighting which channels are expected to be stronger in specific contexts.

In addition, the literature review presented above suggests that the proposed approach to the topic has not yet been undertaken, so this research can contribute to the existing literature in two specific ways. Firstly, it aims to incorporate the

effect of the external sector on the income distribution dynamics, as this was considered an important channel in the recent Brazilian experience and has not been considered so far in ABM that deal with income distribution issues. Secondly, it aims to incorporate a more detailed labor market, as the interactions between firms and workers therein are key determinants of the income distribution.

2 Objectives

The main objective of this research is to explore the relationship between economic policy instruments and income distribution, as well as their implications for economic activity in different economic contexts through an open economy ABM. The research currently under development at the University of Campinas concerns the development of detailed labor market interactions in a closed economy model. The model that will be developed at the *Scuola Superiore Sant'Anna* would incorporate this research and advance it in order to extend the model to an open economy. Therefore, three specific objectives follow from the main objective:

1. Identification of stylized facts for an open economy;
2. Development of an open economy ABM;
3. Analysis of the effects of different sets of policy instruments on the income distribution and economic activity in different economic structures.

3 Schedule and working plan

This research is part of an ongoing Ph.D. research at the University of Campinas, which is supervised by professors Carolina Troncoso Baltar and Gilberto Tadeu Lima. The research herein proposed will be undertaken at the *Scuola Superiore Sant'Anna* in Pisa (Italy) under the supervision of professor Andrea Roventini from May 2020 to April 2021 (twelve months). As mentioned, the research will incorporate the labor market interactions and the closed economy model currently being developed as part of the main project at the University of Campinas (Fapesp research project # 2018/21762-0). In order to fulfill the objectives outlined above, the research will be organized in the working plan and schedule reported in table 1. During the period of research preliminary results will be submitted to international conferences and by the end of the period the paper derived from the research will be submitted to an international journal.

Table 1: Working plan and schedule

Year	2020								2021			
Month	05	06	07	08	09	10	11	12	01	02	03	04
Literature review and identification of key stylized facts for an open economy	■	■										
Conceptualization: expansion of the closed economy model to an open economy		■	■									
Implementation: implementation of the model in the software				■	■	■	■					
Simulation: simulation of the implemented model								■	■			
Validation: comparison of the simulation properties with the identified stylized facts									■	■		
Analysis of the results: experiments to test the validity of the hypothesis										■	■	
Writing: writing of the research developed in the form of a paper											■	■

4 Method

In order to investigate the research question presented in this proposal, the research will consist in a literature review, the construction of stylized facts through the analysis of statistical data for open economies and the development of an agent-based model, which will be developed and simulated in the *Laboratory for Simulation Development* software.

The model's structure is inspired by the "agent-based macroeconomics" literature (Dawid and Delli Gatti, 2018). These models include different types of heterogeneous agents that follow certain decision rules and protocols and interact in different markets. Following the bottom-up approach, the macroeconomic results are obtained by summing the individual quantities. While the modeler is interested in analyzing the macroeconomic results, the concern about reproducing individual behavior and interactions at the micro level is also present. The models are validated through the comparison of the aggregate simulated results with empirical data. The key references for the model developed in this research are the "Schumpeter meeting Keynes" model (Dosi et al., 2010, 2013, 2018), the Jamel model (Seppecher et al., 2018), the micro-macro model (Dweck, 2006, Dweck et al., 2019, Melo et al., 2016), as well as the models developed by Caiani et al. (2016, 2019), Ciarli et al. (2010, 2019), and Oliveira (2018).

The model is composed of six types of agents: consumption goods firms, capital goods firm, bank, households, the government and an external sector. The capital goods, banking and external sectors are treated in aggregate, while the household and consumption goods sectors are agent-based. This type of simplification is adopted in other models in the literature (Cardaci and Saraceno, 2018, Carvalho and Di Guilmi, 2019, Dweck et al., 2019) and is consistent with the idea of keeping the model simple in the elements that are not essential to the main relations under analysis. The model will be structured to be stock-flow consistent and agents will have naive expectations and follow simple "rules of thumb". The parameters and initial values will be calibrated following the strategy in Caiani et al. (2016) to avoid initial asymmetries that may lead to bias in the simulation.

The model structure is reported in table 2. While this structure is similar to the referred models, there are three important aspects that differentiate it in important ways. Firstly, the bargaining process between firms and workers in the labor market will incorporate the process which is currently being developed in the Ph.D. research at the University of Campinas and will be improved during the period at *Scuola Superiore Sant'Anna*. The key intuition is to have it modeled in a more detailed manner, so that it reflects the conflict between workers and firms over the income distribution. This will make income distribution more dependent on the interactions between workers and firms and is likely to create some inflationary pressures, as in the conflicting-claims inflation model (Rowthorn, 1997). As our research question concerns the relationship between economic policies and income distribution, such focus on the labor market is justified insofar as we expect the economic policies to also operate through the bargaining process between workers and firms. Also, similarly to Ciarli et al. (2010, 2019) and Caiani et al. (2019), it will be assumed that workers are divided in three different social classes: capitalists, direct and indirect workers. The classes will differ in their role in the production process and bargaining power.[9]

[9]For simplicity, it will be assumed that there is no social mobility between the classes.

Table 2: Model structure

Agent type	Key characteristics
Consumption goods firms	Produce a single, homogeneous good Technology: vintage capital and labor (fixed capital-labor ratio) Price setting: mark-up pricing Production depends on expected demand and desired inventory Hire direct (proportional to production) and indirect (proportional to production capacity) labor Invest in new capital goods depending on expected demand Ask for credit from bank if financial resources are insufficient to cover production and investment
Capital goods firm	Monopolist firm Produces multiple vintages of capital goods Vintages are updated through a stochastic innovation process (Nelson and Winter, 1982) Technology: labor (coefficient updated in the innovation process) Price setting: mark-up pricing Production based on orders from consumption goods firms, delivery occurs after one period Hires direct (proportional to production) and indirect (proportional to average production) labor
Bank	Monopolist bank Endogenously creates credit demanded by firms and households Rations credit to agents not considered creditworthy Charges a spread over the central bank's interest rate Holds deposits, remunerated at the central bank interest rate
Households	Split between different classes: capitalists, direct and indirect workers Workers sell their labor force to firms and earn a wage Capitalists own the firms and bank and earn profit dividends Consume goods from the consumption goods firms Ask for credit from bank if desired consumption is higher than available income Hold savings in the bank as deposits
Government	Determines the base interest rate following a monetary policy reaction rule Sets the minimum wage Pays unemployment benefits to unemployed workers Levies taxes on firms' profits
External sector	Sells consumption goods to domestic consumers Imports consumption goods from domestic firms

Secondly, the model will include an aggregate external sector, similarly to the model in Dweck et al. (2019). The domestic economy will import/export consumption goods from/to the external sector with the volume of imported goods depending on the total demand for consumption goods from households and on the real exchange rate and the volume of exported goods depending on the real exchange rate. The nominal exchange rate will be a negative function of the nominal interest rate. The international interest rate and price level will be exogenously determined.[10] Based on the literature review, it is expected that the exchange rate will exert some impact on the income distribution and, as it will react to changes in the domestic interest rate, it is expected to be a transmission mechanism of monetary policy.

Finally, the third key difference of the proposed analysis is that, in line with the literature on income inequality measurement (Atkinson, 1970, Cowell, 2011), personal income distribution will be evaluated through different indexes, such as the Gini, Theil, Palma indexes, and the dispersion and variation coefficients. The importance of doing so is that each income distribution measure is based on a certain concept of what is socially fair, so the use of different indexes may indicate which groups are relatively more benefited by changes in the income distribution. Also, when possible, the decomposition

[10] A small open economy will be assumed. Also, specific assumptions will be made concerning the degree of international capital mobility, interest rate parity and interest rate expectations.

analysis may indicate how much of the inequality is due to within-group or between-groups inequality, thus relating the functional and personal income distributions.[11]

5 Analysis of the results

The model described in section 4 will be simulated and Monte Carlo experiments will be applied. The model validation will follow the steps suggested by Fagiolo et al. (2019): i) comparison between simulation results and empirical data; ii) calibration and estimation of parameters; iii) exploration of the parameter space.

The dynamics of the functional and personal income distributions, nominal and real interest rates, nominal and real exchange rates, inflation rate and economic activity level will be analyzed. In order to test the research hypothesis a few experiments will be applied. Different scenarios will be analyzed with different combinations of economic policies (i.e., minimum wage adjustment rules, unemployment benefits, monetary policy and taxation policy). Also, different economic structures will be modeled and they will differentiate themselves on the degree of innovation, on the responsiveness of net exports to the real exchange rate, on the responsiveness of the nominal exchange rate to domestic factors, and on the initial difference between direct and indirect workers' wages. The different combinations of economic policies will be applied in the different economic structures and the results will indicate whether their success in combining economic growth and income distribution differs depending on the economic structure.

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[11] It is worth mentioning that Carvalho and Di Guilmi (2019) also apply a decomposition technique to analyze the relative contribution of each income source to inequality and make use of the coefficient of variation and the Gini index to analyze the income inequality. Thus, our approach would extend their work by incorporating other income inequality indexes.

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