Exploring the impacts of Bolsa Familia program on household livelihood in Amazon estuary region of Brazil--an agent-based simulation

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Abstract: Small farm households in the Brazilian Amazon estuary region have been adapting to urbanization and climatic events, by joining in off-farming activities. However, children from well-off families have better chances to receive education resulting in a higher probability of finding an off-farming job. Bolsa Familia program (BF), a conditional cash transfer program, enhances children's school attendance in poor households. We conducted an agent-based model to interpret the impact of the BF program on eligible households' livelihood and on income distribution.

Introduction

Government cash transfer programs, such as old age pensions or child education subsidies, play an important role in influencing household livelihood and resulting in the changes in the vulnerability of human systems. The influence of these programs on economic growth and labour allocation has been studied (Sadoulet et al. 2001; Bertrand 2003; Barrientos 2012; Boone et al. 2013), but its role in the influence on household livelihood needs further attention. Bolsa Familia (BF), launched in 2003, is one of the largest conditional cash transfer programs in the world (Oliveira et al. 2007; Paes-Sousa and Santos 2009; Soares et al. 2010), with its purpose of mitigating poverty and increasing human capital. It offers a monthly payment to eligible households with school age children. Before BF, children from poor families were more likely to drop out of school than children from well off families. Empirical studies have confirmed that BF can increase the percentage of children receiving education from poor households (Melo and Duarte 2005; Oliveira et al. 2007). It is important to explore the impact of the BF program and its consequences on the livelihood of individual households in the long run, in order to test the policy effectiveness and to investigate its use as future policy design.

Caboclos are small farming households who have lived in Amazon estuary region for centuries. Their traditional livelihood includes growing agricultural crops and managing forest products, as well as fishing and shrimping. However, this subsistence living has been altered by substantial urbanization and increasing climatic risks. Many households, therefore, become multi-sited or depend on off-farm activities. This extra income from

off-farming activities, as an additional resources and a safety net, reduces these Caboclos' vulnerability and increases their adaptive capacity to climate change related events. However, not all households are able to maintain a multi-sited household or obtain an off-farming job. We have found specifically that the probability of having an off-farming job is positively correlated to the education level of the household head and the average number of female family members among Caboclos (Dou et al.). BF improves the school attendance of children from eligible households; however, how BF will increase the off-farming job income and improve their livelihood in poor households, and thus reduce the income inequality between poor and well-off families in a long temporal scale needs further exploration.

To investigate the impact of BF on household livelihood, especially on eligible households, we use an agent-based model (ABM) to simulate the dynamics of household livelihood with and without BF. Using ABM, we are able to answer the following questions:

(1) Will BF fulfill its long-term goal: to reduce poverty by increasing human capital?
(2) Will BFP help increase beneficiary households' livelihoods and reduce their income inequality with better-off households?

By answering the above questions, we can 1) investigate the impact of BF on eligible households; and 2) calculate the income inequality between eligible households and well-off households.

Data and method

A household survey of 635 Caboclo households was accomplished in 50 communities of Abaetetuba municipality, Pará, Brazil in 2012. Information including household demographic and livelihood characteristics was collected. We then constructed an ABM to represent these households and their interactions with the environment. This model is an updated version of MARIA (Cabrera et al. 2010), a Java application written in the RePast multi agent simulation platform (http://repast.sourceforge.net/). The update is the extension of human decision-making regarding BF program and calibrated employment probability. The rest of MARIA is unchanged.

Probability of employment in a household: Income from off-farming jobs is a great source for households to cope with money shortage and diminish negative impact from other shocks. However, only a few households are able to obtain off-farming jobs. These jobs, mostly labour-required, are limited for households who have particular skills or somewhat basic education. To estimate the probability of a household having employment, we applied a binomial logistic regression. In this regression, the independent variables are: household head age (hage), household head education (hedu), and average education level of female members (avewomenedu); while the dependent is the probability of employment. The main reasons for choosing these three variables are that they are not correlated to each other and are highly correlated with other factors (Dou et al.)

The logistic regression is

$$\log\left[\frac{p}{(1-p)}\right] = \beta_1 \bullet hage + \beta_2 \bullet hedu + \beta_3 \bullet avewomenedu + a \qquad \textbf{Equation 1}$$

where β is the log likelihood of independent variables, and p is the probability of employment. If any family member has an off-farming job, there is employment of this household. BF will produce a larger employment probability with a better education quality.

Experiment Design: We implemented 15 household agents in each simulation. Households vary at the listed attributes at initialization, as shown in Table 1. The distribution of each attribute is based on the survey data.

Table 1: Model initialization

Household characteristics	Initialization (calibrated by the survey data)
Number of HHD	15
Number of HHD members	120
Number of off-farm jobs	5
HHD structure	1-12
Age of adult male	18-80
Age of adult female	18-80
Adult education level	0-12
Age of kids	1-17
Initial capital	2500-12500
Land property	0.5-10 ha
Repetition	50

Results

A few direct and indirect impacts are expected from the BF program. In our simulation, we analyze: 1) the direct impact on education and 2) the indirect impact on salary income and overall livelihood. One of the main objectives of BF is to reduce future poverty and inequality by improving human capital. By analyzing the direct and indirect impacts from BF, we can evaluate the effectiveness of BF.

The direct impact on education in beneficiary households is one of the main purposes of the BF program. This government provided monthly stipend subsidizes children attending school (Hall 2006). Influenced by multiple factors, such as insufficient means to pay tuition or a need to compensate family labour, children in poor households who are eligible for BF, are less likely to attend school; on the contrary, children from well-off families are able to attend school and receive better education. Therefore, the gap in human capital in these families will grow bigger if no intervention happens, resulting in higher inequality among household overall livelihood. The BF program, fortunately, offers children in poor families the chance to advance in education. Furthermore, this improvement in education will also boost their off-farming job

opportunities and livelihood. We ran MARIA under scenarios with and without BF, and analyzed the results between the two scenarios.

1) Direct impact

We compared the average school years of female members under the two scenarios (No_BF and With_BF). We compared the effect of factor A (BF program availability), factor B (household eligibility), and their interaction effect on average female education, and constructed a two-way crossed ANOVA model. All three factors are statistically significant in improving female education. Additionally, we grouped households into six categories, based on years that they are eligible for this BF program (Figure 1). It is noticeable that the education-improving effect is correlated with the number of years one's been utilizing the BF program: households who receive BF for more than 40 years (the group with label 40) have the biggest growth in female member education (4.74 years in the end); the average female school year among households who receive BF between 20-30 years has improved by almost 2.88 years by the end of the simulation. Meanwhile, households who are never eligible for BF have no significant differences in female education between our two scenarios.

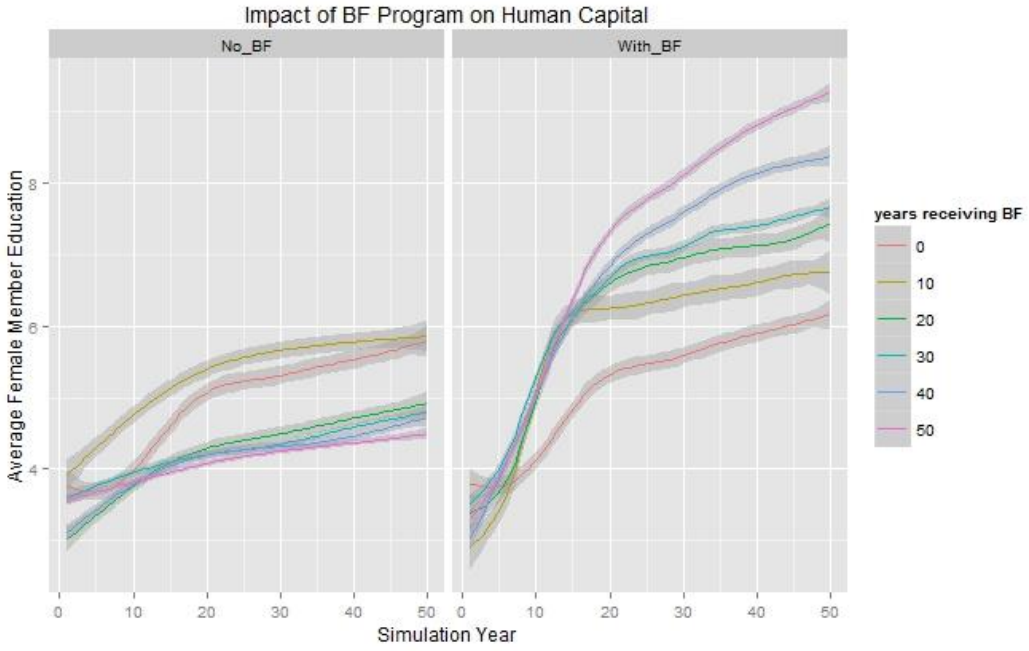

Figure 1 Impact of BF Program on Average Female Education

Two-way crossed ANOVA test: H0=null hypothesis that factor A, or factor B, or the interaction of both, does not affect the average female member education; Ha= the alternative hypothesis that the average female education is affected by the corresponding factor. P-value is smaller than 0.01 in all three cases, so reject null hypothesis.

2) Indirect impact on household salary and overall income

We then compared the salary income that households receive under different scenarios (Figure 2). When there is no BF program, well-off households (group 0) and households who most times are above the poverty line (group 10) have the highest salary income, which is around 200 (monetary unit in MARIA). However, in the

scenario that BF is implemented, their salary income drops significantly. Households whose salaries increase most significantly under the BF program are in the group who are often under the poverty line (group 40 and 50): their salary income is around 200 by the end compared to 150 in the no BF scenario. Households who are below the poverty line half the time don't show significant growth in salary size between the two scenarios.

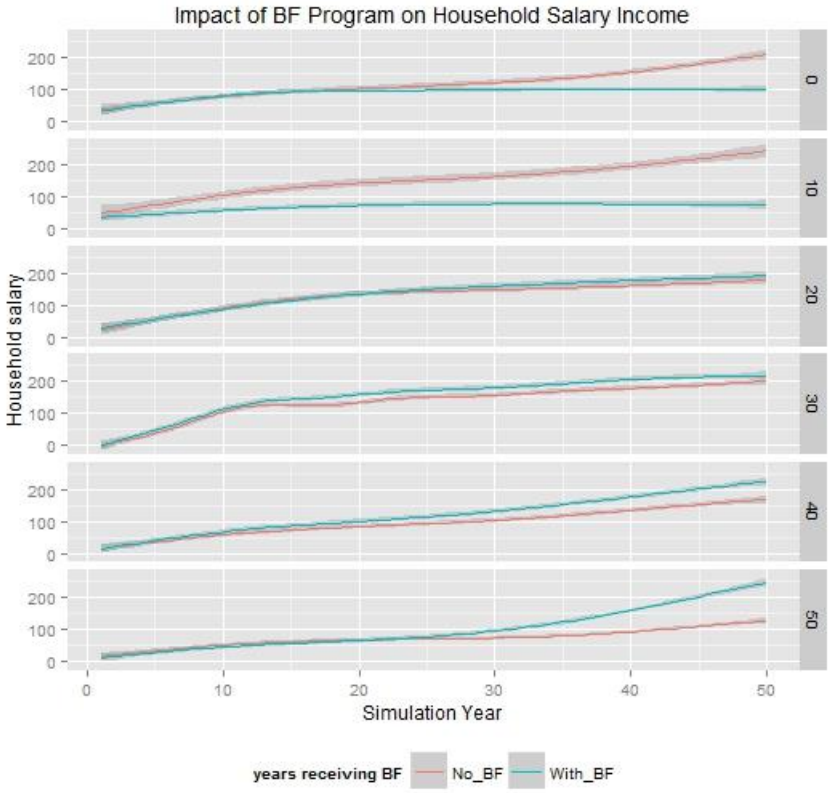

Figure 2 Impact of BF on Household Salary Income

Salary is one of the three main livelihood income sources for households. The growth of salary among poor households caused by the BF program also contributes to their overall livelihood increase and income inequality reduction between beneficiary households and poor households (Figure 3). The gap of per capita income between beneficiary households and non-beneficiary households has decreased from 369 in the no BF scenario to 311 in the BF scenario with a gap of 550 at the beginning. This 58 model monetary unit increment accounts for 5% of the average capital among non-beneficiary households. The slight decline in per capita income in non-beneficiary households can be explained by our model assumption: there is only a number of constant job offers, so that jobs go to poor households with improved education under BF scenario. Beneficiary households, which count for 90% of the overall households, have higher income with the existence of BF; moreover, the inequality between well-off households and poor households has been reduced by the BF program.

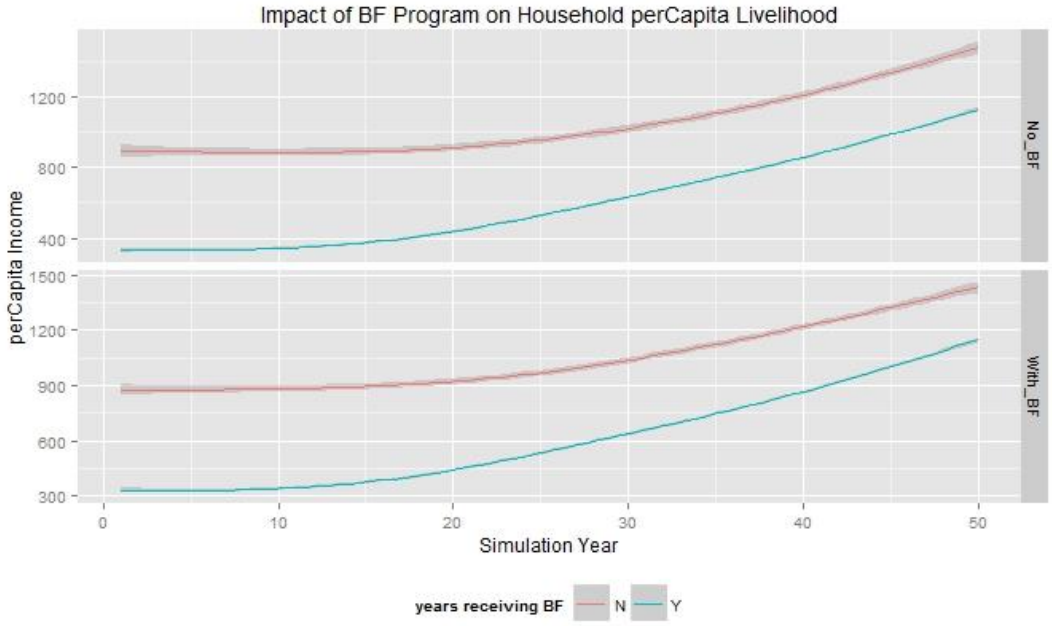

Figure 3 Impact of BF on Household per capita Livelihood

Conclusion

In this paper, we present an agent-based simulation to evaluate the effects of the BF program, based on the extracted relation between education and job probability from survey data. The direct impact on education and the indirect impact on salary and income inequality with the availability and absence of the BF program and between beneficiary households and non-beneficiary households are analyzed from our model results. Our model results show that the BF program has a significant impact in improving education among poor households. It also increases their off-farming salary income, as well as the overall average livelihood. The improved probability of getting off-farming jobs largely boosts the adaptive capacity among poor households. Moreover, the income gap between well-off households and poor households is reduced by implementation of the BF program in our model.

Acknowledgement

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