Entrepreneurial Activity Creation in Debt Vs PLS Financing of Sustainable and Non-Sustainable Crowdfunding Projects : An Artificial Intelligence Approach using Agent Based Simulation

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Abstract

In this paper we try to assess the performance of sustainable and non-sutainable crowdfunding projects under debt and Profit and Loss sharing financing. Although there are many facets to contrast both methods in terms of financing, we are specefically intersted in entrepreneurial activity creation in short and long term projects. To do so we use an Agent Based Simulation Via Netlogo. Under short term sustaibale projects We found theoretical evidence that debt financing outperform PLS in terms of entreprenial ativity growth. On the other hand, PLS finacing ouperform Debt financing for long term sustainable projects. When it comes to short term non-sustainable projects, PLS financing maintained its entreprenerial creation activity (similar to sustainable projects) and outperformed debt financing. From the long term aspect , there was a deterioriation in both financing mecha-

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nisms in terms of entrepreneurial growth creation in nonsustainable projects.

Keywords: Entrepreneurial Finance, Crowdfunding, Sustainability, Debt Finance, Profit and loss sharing contracts, Artificial Intellegence, Agent Based Simulation.

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1. Introduction

In this paper we try to assess the performance of sustainable and non-sutainable crowdfunding projects under debt and Profit and Loss sharing financing. Although there are many facets to contrast both methods in terms of financing, we are specefically intersted in entrepreneurial activity creation in short and long term projects

Debt financing by conventional banks has experienced crises both in the 1930s , 1980s and and more recently in the 2007-2008 financial crisis with the savings-and-loan (S & L) and banking crises in the United States. in the 1930's , and 10980's the U.S. answer was to institute deposit insurance in order to eliminate or at least minimize bank runs Akacem and Gilliam (2002) while more regulatory rules (Basel III) were introduced to face up to the last financial crisis of 2007-2008. However, that has caused both banks and S & Ls to assume more risk at the cost of greater taxpayer exposure because they lacked the incentive to be risk averse. The current U.S. banking model of debt finance together with an implicitly unlimited3 deposit insurance results in the socializing of loss and the privatizing of gain Akacem and Gilliam (2002). Recessions has shown an increase in the number of firms filing for bnackrupcies . For example the increase was substantially steeper during the great recession (60,837 in 2009, from 28,322 in 2007) Skeel (2020). Debt overhang creates a distortion leading these firms to fire workers, forgo expenditures that maintain enterprise value and therfore filing for banckrupcies Brunnermeier et al. (2020) . The problem with debt financing, in our opinion , lies in its biased, rather unfair treatment of the participants. First debt financing charges intersts which are fixed periodic paymnets that do not take into consideration the worsening economic conditions. The financier , such as a bank, is guranteed a fixed payment , if economic conditions are prosperous. The finnacier is also guranteed a collteral if the economic conditions are worsening.

Under profit and loss (PLS) contracts, both the supplier of the capital and the entrepreneur share in the risks: both prosper when returns are favourable and suffer together when returns are poor Ahmed (2008).

One of the studies done in indonesia using a two year data set scale , has

shown that , equity financing , such as profit and loss sharing contracts performed better than debt-based financing . On eof the reasons that could be atrbuted to this is the fact that under equity finnacing entrepreneurs could benefit from the expertise of equity providers , such as Angels or VCs, Casamatta (2003) compared to other forms of financing such as debt or angel financing. Of course equity , such as PLS contracts, financing comes with its own risks to providers of funds. First PLS financiers face uncertain circumstances, called external risks as cited by Kaplan and Strömberg (2004). These include, demand for new products, competitors' response to new product, perception of financial markets when it comes to selling the project stakes at exit stage. These problems are obvious in times of crisis such COVID 19. Second Equity , such as PLS, in general face agency problemsSahlman (1990), Amit et al. (1990),Cochrane (2005), Baierl et al. (2002), Hall and Lerner (2010)MacIntosh and Cumming (1997),Gompers and Lerner (1999) Gompers and Lerner (1999), Jain (2001) Jain (2001), and Kaplan and Strömberg (2003) and Tykvová (2007). Casamatta (2003) Elitzur and Gavious (2003) Keuschnigg and Nielsen (2003b), Keuschnigg and Nielsen (2003a) And Neher (1999). There are multiple sources of agency problems. One of them is moral hazards in the form of the entreprenur shirking. The shirking of entreprenurs during econoic crisis could even make the prformance of PLS financing worse. The shirking of the entreprenur in debt financing is less of a concern to the lender as the latter's funds are secured through guranteed interstr payments or , in the worst case, throughseizing of a collateral.

The analysis above tackle a contrasting of both financing mechanisms but does not invlove the nature of the projects being undertaken nor the duration of the projects. In our analysis we look at sustainbale and non-sustinable projects performance from a short and long term performnace in terms of entrepreneurial activity creation .

Based on the logit findings of Arias Fogliano de Souza Cunha and Samanez (2013) , it is revealed that specific social values and norms play an important role. Investor groups with strong considerations of norms by the social environment with respect to SRI and especially with high feelings of warm glow from SRI, a strong environmental awareness, and an affinity to left-wing parties have a substantially higher estimated mean willingness to pay for sustainable investments.

On the other hand a study by Arias Fogliano de Souza Cunha and Samanez (2013)show that although sustainable investments have presented some interesting characteristics, such as increasing liquidity and low diversifiable risk, they did not achieve satisfactory financial performance in the analysis period (2005-2010). This , according to, Arias Fogliano de Souza Cunha and Samanez (2013), indi-

cates that the constraints imposed by this type of investment in capital allocation may be harming their return and risk attractiveness.

So given the above arguments which method of financing could perform better in the long and short run for sustainable and non-sustainable projects?.

To answer this question , we provide an Artificial inteelligence model using an agent based simulation platform. We will compare PLS financing and Debt financing in terms of their entrepreneurial ability to create entrepreneirila activities. Our benchmark of resilience will be the number of entreprises created , final to initial entrepreneurial activity ratio and year on year entrepreneuoal activity growth.

Our model is based on the sharing of profits and losses. Therefore, it is implemented through the model that Profit is determined based on expected future profits and not as a fixed amount or as a percentage of investment. i.e. there should be no guaranteed returns to the financier as in the case of debt standard VC contracts and there should be no guaranteed return to the entrepreneur as in the case of fixed wages.

The rest of the paper is organized as follows:
Section 2 proposes our model. Section 3 presents the methodology. Section 4 represents the results and discussion. Finally, section 5 concludes with a summary and possible extensions.

2. The model

We will try to compare the number number of entreprises created , final to initial entrepreneurial activity ratio and year on year entrepreneuoal activity growth in the long and short run for sustainable and non-sustainable projects. The entreprenur is in need of funds to complement the funding of a project costing 'I'. He is endowd with an initial wealth of A and a collateral K. Therfore he needs I – A.

3. Debt financing model

The entreprenur can get the funding from a bank , through debt, costing him interst rate : i. In order to isolate the effect of projects return 'R' on the model , we assume that it is the same whther it is undetaken using debt or PLS financing. this with respect to the fisher's theorem which separates investment from the financing activity.

If the project fails the entrepreneur loses his funds A and a collateral K. We assume that the entrepreneur would excecise a high effort under debt financing since he would lose his initial wealth A and collateral if the project fails. Therfore there is no moral hazards in this case.

$$E(R|\gamma_i) = \int_0^R Rf(R|e_i)dR \tag{1}$$

where the share of the manager is R_m and the share of the financier is R_f such that R = R_m+ R_f . This output can take upper values $\overline{R} \geq I$ and lower values $0 \leq \underline{R} \leq I$ suc that:

$$E(\overline{R}|\gamma_n) = \int_I^R Rf(R|\gamma_n)dR \tag{2}$$

and

$$E(\underline{R}|\gamma_c) = \int_0^I Rf(R|\gamma_c)dR \tag{3}$$

4. PLS financing model

In this model we add the extra layer of risk , entrepreneur's shirking, besides the risk of an economic crisis . As we explained before, in contrast to debt financing , beacuse the finacier would share the losses in case of project failure, ther is more of a temptation for the entrepreneur to shirk. The model therfore would strives to reduce the moral hazard problem in a PLS context. The success of the project, therfore, not only depend on the economic conditions γ but also on the entrepreneurs effort, (high or low), $e_i : i \in \{l, h\}$ of the manager. The project is estimated to result in a stochastic verifiable output R conditional on a high or low managerial effort e_i: $i \in \{l, h\}$:

$$E(R|e_i, \gamma_i) = \int_0^R Rf(R|e_i, \gamma_i)dR \tag{4}$$

where the share of the manager is R_m and the share of the financier is R_f such that R = R_m+ R_f . This output can take upper values $\overline{R} \geq I$ and lower values $0 \leq \underline{R} \leq I$ suc that:

$$E(\overline{R}|e_i) = \int_I^R Rf(R|e_i)dR \tag{5}$$

and

$$E(\underline{R}|e_i) = \int_0^I Rf(R|e_i)dR \tag{6}$$

Accordingly the share of the manager and the financier respectively are $\overline{R}_m$, $\overline{R}_f$ in case of success and $\underline{R}_m$, $\underline{R}_f$ in case of project failure. It is worth to note that a high return can result even if a lower effort is being undertaken by the manger. However, the chance of achieving a higher profit is augmented if the manager performs a high effort. Therefore, it can safely be noted that the cumulative density function conditional on e_i first-order stochastically dominates the cdf conditional on e_l under any economic condition:

$$F(R|e_h, \gamma_i) \leq F(R|e_l, \gamma_i) \text{ for all R} \in [\underline{R}, \overline{R}]$$

and therfore the expected return under the high effort is greater than that under low effort. i.e.

$$E(R|e_h, \gamma_i) = \int_0^R Rf(R|e_h, \gamma_i)dR > E(R|e_l, \gamma_n) = \int_0^R Rf(R|e_l, \gamma_i)dR \quad (7)$$

We can note $\theta_h \geq$ the probability that the manger will excerse a high effort . This probability itself is drawn from a normal probability distribution $g(\theta_h)$ Without contracts, the financier has an opportunity of 0. While the manager receives his reservation payoff U.

The profits are shared according to a predetermined rate α given to the PLS financier. On the other hand losses are shared according to each partners's capital contribution ratio. In this case β is the share of the financier in the invested capital. This a very big distinction between PLS financing and Debt financing. Indeed under debt financing , the entrepreneur could lose more than his ratio of the capital. While under PLS he would not.

5. Results

While the payoffs to the participants under debt financing are straightforward, the payoffs under PLS financing are not. In the latter not only economic conditions are taken into considerations but also entrepreneurial moral hasard (shirking). Therfore the determination of the profit share needs to take into consideration these factors

5.1. Case 1: The model under observable effort

Under this scenario, the manager can't deviate from providing his commitments of high effort and therefore the financier is in a comparative advantage in

terms of profit sharing ratio negotiations. In other words, the objective of the financer is to minimize the remuneration R_m of the manager subject to the manager breaking even. Formally:

$$\min_{R_m(R)} \int_I^R \overline{R}_m f(R|e_h,\gamma_i)dR + \int_0^I \underline{R}_m f(R|e_h,\gamma_i)dR$$

S.t

$$\int_I^R \overline{R}_m f(R|e_h,\gamma_i)dR + \int_0^I \underline{R}_m f(R|e_h,\gamma_i)dR - D(e_h) \geq U$$

Taking the First order derivative with respect to $\overline{R}_m$ and applying lagrange multiplier λ. we get:

$$-\int_I^R f(R|e_h,\gamma_i)dR + \lambda \int_I^R f(R|e_h,\gamma_i)dR = 0$$

this gives

$$\lambda = 1 \tag{8}$$

we can then conclude that the participation constraint can be set to equality:

$$\int_I^R \overline{R}_m f(R|e_h,\gamma_i)dR + \int_0^I \underline{R}_m f(R|e_h,\gamma_i)dR - D(e_h) = U \tag{9}$$

One of the essential consideration is that the profit and loss sharing ratios have to be fixed in advance in our PLS contract before the signature of the contract. Therfore, those terms can't be changed during the projects. So we can replace $\overline{R}_m$ by $(1-\alpha)\,\overline{R}$ and $\underline{R}_m$ by $(1-\beta)\,\underline{R}$ So we can reset equation 3 and taking off the fixed ratios from the integrals:

$$(1-\alpha)\int_I^R \overline{R} f(R|e_h,\gamma_i)dR + (1-\beta)\int_0^I \underline{R} f(R|e_h,\gamma_i)dR - D(e_h) = U \tag{10}$$

We can then extract a closed formula for the financier profit sharing ratio:

$$\alpha = 1 - \frac{U + D(e_h) - (1-\beta)\displaystyle\int_0^I \underline{R} f(R|e_h,\gamma_i)dR}{\displaystyle\int_I^R \overline{R} f(R|e_h,\gamma_i)dR} \tag{11}$$

we can give a shorthand formula using equation 1:

$$\alpha = 1 - \frac{U + D(e_h) - (1-\beta)E(\underline{R}|e_h,\gamma_i)}{E(\overline{R}|e_h,\gamma_i)} \tag{12}$$

5.2. Case 1: The model under unobservable effort

In this case the financier is facing a situation with regards to the type of the manager. In other words the financier is questioning wether the manger is going to excercice a high effort or not while undertaking the project. The financier then works out his payoff taking into consideration two probabilities:

- type probabilities θ_h: regarding the probability that a manger is going to perform a high effort. this itself is drawn from a normal probability distribution.
- performance conditional probabilities: regarding the probability that the project will be successful conditional on the manager's effort. This is reflected through the probability distribution of return $f(R|e_i, \gamma_i)$

This situation give rise to private benefits S drawn by the manager if he performs a lower effort. Taking this into consideration, the financier is in a competitive disadvantage and therefore his objective will be to at least break even.

The contract being assigned need to take into consideration three main constraints:

- Participation constraints PCF and PCM: where both participants (Financier Manger) are at least breaking even.
- Incentive compatibility constraints ICM: where only the manager is Offred a profit sharing ratio that will encourage him to exert high effort rather than shirking.

So, the objective of the financier is to maximize his return subject to the above mentioned constraints. Formally:

$$\max_{R} \int_0^1 \theta_i g(\theta_i) d\theta_i \int_0^R R_f f(R|e_i, \gamma_i) dR \tag{13}$$

subject to constraints:

$$PCF : \int_0^1 \theta_i g(\theta_h) d\theta_i \int_0^R R_f f(R|e_i, \gamma_i) dR \geq \beta I \tag{14}$$

$$PCM : \int_I^R \overline{R}_m f(R|e_h, \gamma_i) dR + \int_0^I \underline{R}_m f(R|e_h, \gamma_i) dR - D(e_h) \geq U \quad (15)$$

$$ICM : \int_I^R \overline{R}_m f(R|e_h, \gamma_i) dR + \int_0^I \underline{R}_m f(R|e_h, \gamma_i) dR - D(e_h) \geq \int_I^R \overline{R}_m f(R|e_l, \gamma_i) dR + \int_0^I \underline{R}_m f(R|e_l, \quad (16)$$

In this case we proceed by solving for he sharitng ratio α using game theory.

The bottom line is first to identify the minimum acceptable ratio ,α_{pcm}, for the agent to break even. i.e. to fulfil his participation constraints:

$\int_I^R \overline{R}_m f(R|e_h, \gamma_i) dR + \int_0^I \underline{R}_m f(R|e_h, \gamma_i) dR - D(e_h) \geq U$ Replacing $\overline{R}_m$ by $(1-\alpha)\overline{R}$ and $\underline{R}_m$ by $(1-\beta)\underline{R}$. We get:

$$\alpha \leq 1 - \frac{U + D(e_h) - (1-\beta) \int_0^I \underline{R} f(R|e_h) dR}{\int_I^R \overline{R} f(R|e_h) dR} \quad (17)$$

We can give a shorthand formula using equation 1:

$$\alpha \leq \alpha_{pcm} = 1 - \frac{U + D(e_h) - (1-\beta) E(\underline{R}|e_h, \gamma_i)}{E(\overline{R}|e_h, \gamma_i)} \quad (18)$$

The second step is to identify α_{icm} that motivates the manager to engage in high effort. To simplify the process, we first transform the integrals in the incentive compatibility equation to expectation forms. we get

$$(1-\alpha)E(\overline{R}|e_h) + (1-\beta)E(\underline{R}|e_h, \gamma_i) - D(e_h) \geq (1-\alpha)E(\overline{R}|e_l, \gamma_i) + (1-\beta)E(\underline{R}|e_l, \gamma_i) - D(e_h) + S \quad (19)$$

solving for α we get:

$$\alpha_{inc} \leq 1 - \frac{S + \Delta D - (1-\beta)\Delta \underline{R})}{\Delta \overline{R}} \quad (20)$$

where: $\Delta D = D(e_h) - D(e_l)$; $\Delta \underline{R} = E(\underline{R}|e_h) - E(\underline{R}|e_l)$; $\Delta \overline{R} = E(\overline{R}|e_h, \gamma_i) - E(\overline{R}|e_l, \gamma_i)$

So, for α to be both fulfil the incentive and participation constraints of the manger we must have:

$$\alpha \leq \min\{\alpha_{icm}; \alpha_{pcm}\} \tag{21}$$

Now, we turn to the less competitive participant in this game, the financer. He needs a sharing ratio α_{pcf} that enables him to at least break even. We extend the integrals of the financier participation constraints as follows:

$$\int_0^1 \theta_h g(\theta_h) d\theta_h [\int_0^I \underline{R}_f f(R|e_h, \gamma_i) dR \int_I^R \overline{R}_f f(R|e_h)$$
$$+(1 - \int_0^1 \theta_h g(\theta_h) d\theta_h) [\int_0^I \underline{R}_f f(R|e_l, \gamma_i) dR \int_I^R \overline{R}_f f(R|e_l) \geq \beta I$$

We should note that $\int_0^1 \theta_h g(\theta_h) d\theta_h$ is the expected probability $E(\theta)$ that the agent is of a high effort type. now we formalize our integrals using expected values and replacing $\overline{R}_f$ by $\alpha \overline{R}$ and $\underline{R}_f$ by $\beta \underline{R}$. we get:

$$E(\theta_h)[\beta E(\underline{R}|e_h) + \alpha E(\overline{R}|e_h, \gamma_i]) + (1 - E(\theta_h)[\beta E(\underline{R}|e_l) + \alpha E(\overline{R}|e_l, \gamma_i]) \geq \beta I$$

Solving for α we get:

$$\alpha \geq \alpha_{pcf} = \frac{B[I - \theta_h \Delta \underline{R} - E(\underline{R}|e_l, \gamma_i)}{\theta_h \Delta \overline{R} + E(\overline{R}|e_l, \gamma_i)} \tag{22}$$

the final step is to find the span of negotiation between the financier and the manager. We can notice that this is achievable as α has to lie down between two values α_{pcf} and $\min\{\alpha_{inc}; \alpha_{mpc}\}$. In other words, the optimal contract should respect the following profit sharing ratio:

$$\alpha_{pcf} \leq \alpha \leq \min\{\alpha_{icm}; \alpha_{pcm}\} \tag{23}$$

The span of negotiation is then

$$\min\{\alpha_{icm}; \alpha_{pcm}\} - \alpha_{pcf} \tag{24}$$

We asume that the sharing ratio given to the entrepreneur is the average of the span. i.e

$$\alpha_{average} = [\min\{\alpha_{icm} + \alpha_{pcm}\} - \alpha_{pcf}]/2 \tag{25}$$

We also assume that regardless of the type of the project , Sustainable or not , then the sharing ratio from PLS and the interst rate charged from debt are the same for both projects. In the simulation that follwos the sharing ratio is found at 32 percent while the interst rate charged is found at 10 percent for both type of projects.

6. Agent Based Simulation

In this section we presents the results of the agent based simulation. Our approach is based on an artificial intelligence platform called Netlogo. We simulate the results under four scenarios. 1) Short term nonsustainable projects 2) Short term sustainable projects 3) Long term sustainable projects 4) Long term sustainable projects.

Figure 1: The model under Short term nonsustainable projects

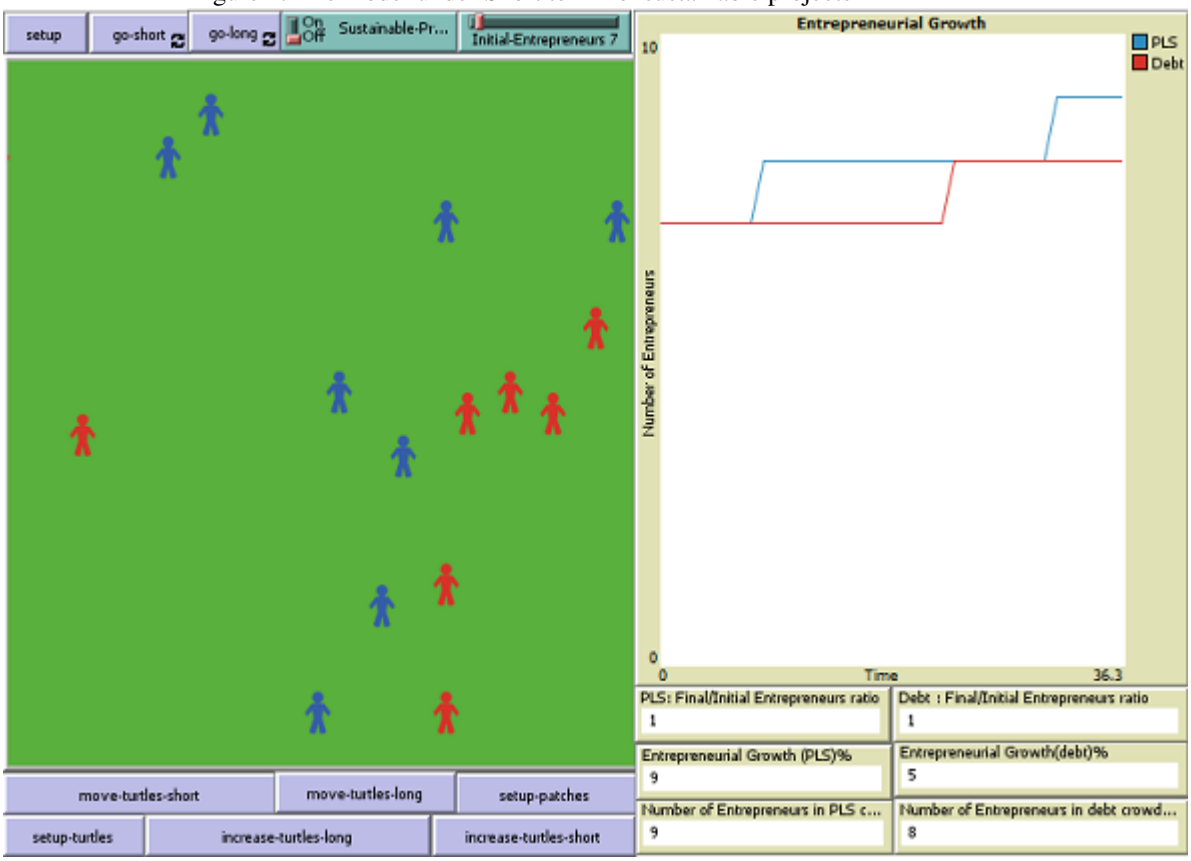

Figure 2: The model under Short term sustainable projects

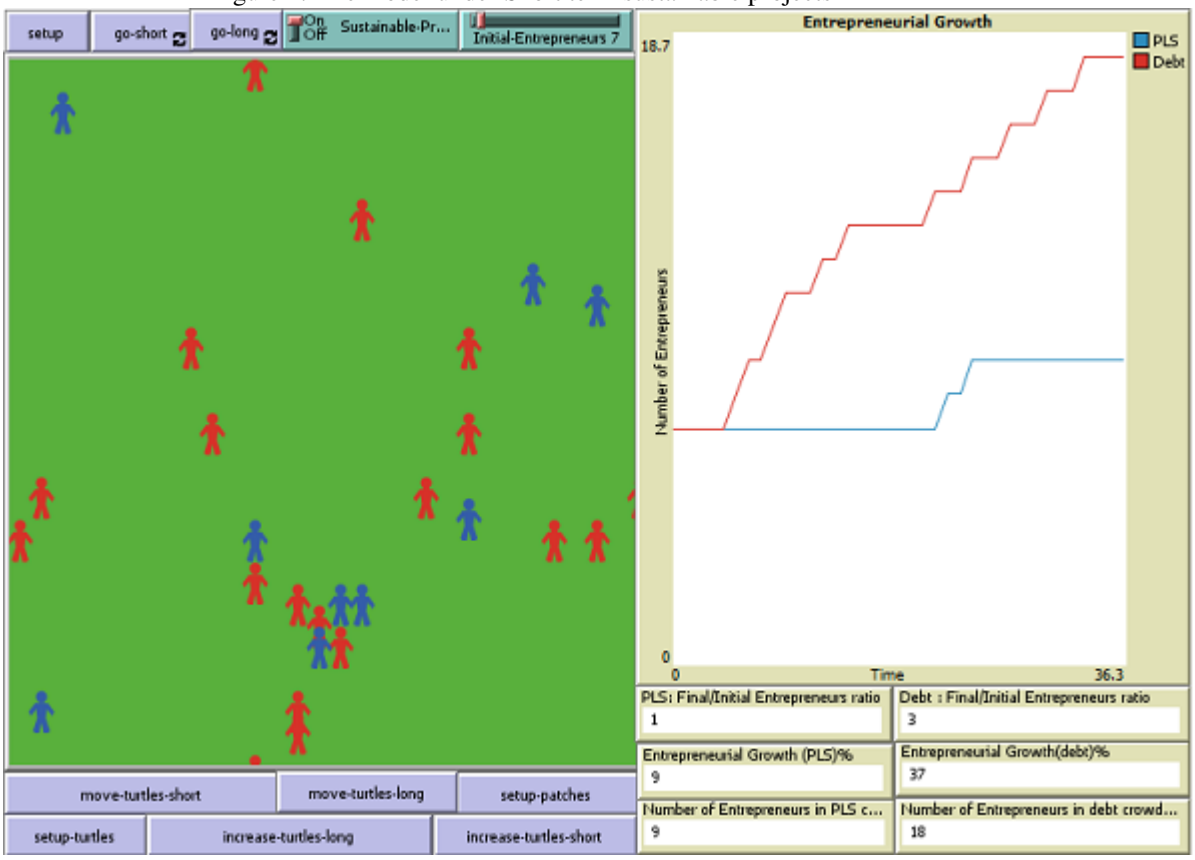

Figure 3: The model under Long term nonsustainable projects

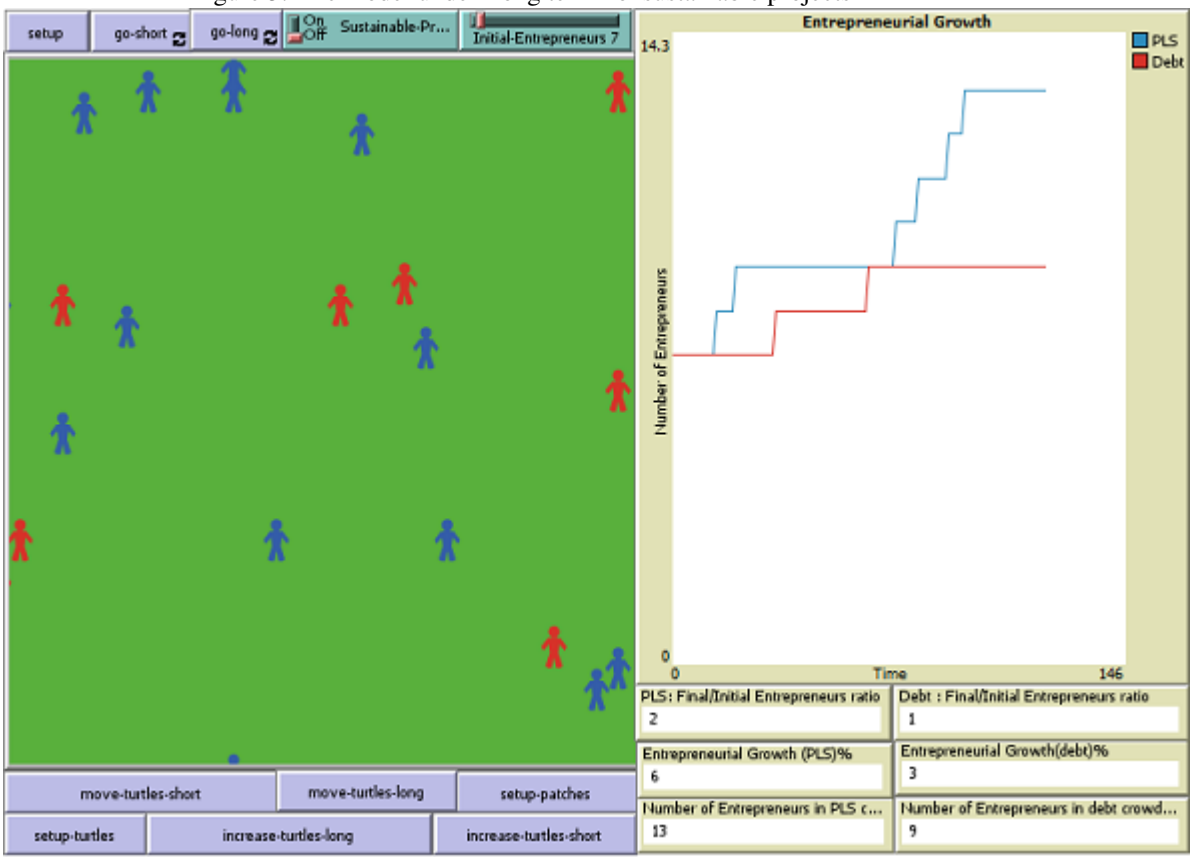

Figure 4: The model under Long term sustainable projects

The simulation shows 4 important findings. Under short term sustaibale projects We found theoretical evidence that debt financing outperform PLS in terms of entreprenial ativity growth. On the other hand, PLS finacing ouperform Debt financing for long term sustainable projects. When it comes to short term non-sustainable projects, PLS financing maintained its entreprenerial creation activity (similar to sustainable projects) and outperformed debt financing. From the long term aspect , there was a deterioriation in both financing mechanisms in terms of entrepreneurial growth creation in nonsustainable projects.

The results have should have importnat implication on investors and finacial investors and policy making alike.

First The simulatio shows , that debt finnacing have an edge when it comes to financing short terms sustainable projects. with an ability to have on average 29 percent growth in entrepreneurial activity , debt providers would have more

demand in terms of financing short term sustainable projects. Therfore, it is imperative that these providers provide incentive mechanisms to promote these kind of projects. Equity provideers, in the form of PLS, aiming at long term returns should aim instead for long term sustainable projects. while thee is a clear cut under sustainable projects in terms of prefered mode of finnacing (PLS for long and debt for short term projects), we canot have a clear cut from the non-sustainable project side. Indeed, a low entrepreneurial activity is created in both modes whther it is for long or short term projects. The lower performance is much more apparent in the long run projects tha it is for short term projects. This means that non-sustainable type of projects are indeed 'not sustainable' in the long run leaving more demand for sustainable kind of projects in the future ahead.

7. Conclusion

In this paper we have tried to compare two modes of financing for both sustinable and nonsustainable type of projects under short and long term. We are specefically intersted in entrepreneurial activity creation in short and long term projects. To do so we use an Agent Based Simulation Via Netlogo. Under short term sustaibale projects We found theoretical evidence that debt financing outperform PLS in terms of entreprenial ativity growth. On the other hand, PLS finacing ouperform Debt financing for long term sustainable projects. When it comes to short term non-sustainable projects, PLS financing maintained its entreprenerial creation activity (similar to sustainable projects) and outperformed debt financing. From the long term aspect , there was a deterioriation in both financing mechanisms in terms of entrepreneurial growth creation in nonsustainable projects.

This paper provides extra venues for extentions. One venue is to collect real data about sustinable and nonsustainable projects in order to add more realism to the results. indeed the real projects data form these type of investments could be compared to the simulation results model. The results of the comparison would suggest further improvments to the model.

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