A Real Options Approach To Measuring Freedom In Sen's Capabilities Approach

Abstract

Sustainability has gained increasing prominence in research literature, with environmental and social issues becoming more important in economic issues. One of the normative approaches to addressing sustainability issues has been applying Sen's Capabilities Approach. One of the advantages of Sen's Capabilities Approach is that it is able to take into account a wider range of issues in decision making compared to alternative methods, such as the ethical importance of freedom.

A key problem in operationalising Sen's Capabilities Approach is providing a quantitative framework for measuring the freedom in decisions. In this paper we propose a method for operationalising Sen's Capabilities Approach by using the Real Options Analysis as a framework to quantifying the freedom in decisions. The Real Options Analysis is a well-established method of modelling economic decisions and using such an approach we propose quantifying the freedom in decisions in terms of the flexibility to exercise decision under the Real Options Analysis. In this paper we show how Real Options Analysis can be used to quantify and indicate the freedom of decisions in terms of Sen's Capabilities Approach. This paper provides a new framework for analysing decisions under Sen's Capabilities Approach and examples are provided.

Keywords: real options; capabilities approach; operationalising; freedom; welfare.

1. Introduction

Sustainability has been gaining increasing prominence in economics and research literature in general. This is because it is increasingly being understood that short term analyses of economies can lead to long term consequences, and threaten the long term survival of civilisations, as well as different ecosystems. According to (Soderbaum, 2008) sustainability in economics represents not just environmental and ecological variables, but is part of multidimensional perspective that involves social, cultural as well as health related issues. Consequently, there is a necessity to undertake economic analyses using a multidimensional approach, which takes into account a wider range of issues.

One of the normative approaches that has been adopted for sustainability has been Sen's Capabilities Approach; see for instance (Lessmann and Rauschmayer, 2014). In fact the Nobel Laureate and inventor of Sen's CA (Capabilities Approach), Amartya Sen, already addressed the relation between Sen's CA (Capabilities Approach) and sustainability in 2000 (see (Lessmann and Rauschmayer, 2014)). Sen's CA is an economic method of welfare analysis. The CA distinguishes itself from other welfare methods in that it emphasises the importance of freedoms in decisions; see for instance (Stewart, 2019).

The importance of freedom in decision making in CA has consequently led to considerable difficulty in measuring or 'operationalising' the CA in decision making (Anand et al., 2018); the current methods for operationalising CA have significant problems in their measurement of freedom. Firstly, freedom is not typically modelled as an endogenous or dependent variable, hence the relation of freedom with respect to other exogenous or independent variables (eg. health, income) is not incorporated. This is a fundamental problem since freedom is intrinsically dependent on other variables, hence modelling freedom as independent of other variables is highly unrealistic. Moreover, we cannot understand how changes in particular variables (eg. health, income etc.) impact freedom, yet freedom is a key component of understanding welfare in CA.

Secondly, freedom is typically measured by proxy variables, or indicators, that do not directly measure the freedom associated with specific decisions, rather they measure the freedom with respect to generic decisions. Also the freedom measures are not specific to a particular individual, but a measure that would apply to a generic group, hence the freedom measures can be misleading. For example, a proxy measure of freedom for an individual may be the national average standard of living, but this may not be an accurate measure of freedoms when considering individuals from ethnic minorities that face employment discrimination.

Although the issue of quantifying freedom (in decisions) has not been examined in detail in the CA literature, the issue of freedom of decisions has already been studied in economic literature where it is referred to as flexibility in business decisions. The flexibility of decisions represents the freedom aspect of decisions in CA, and in business the flexibility or freedom of decisions is valuable to firms

as it gives the ***opportunity*** to exercise particular decisions at a time that is most beneficial to the firm. In fact it can be observed in the real world that businesses are willing to pay additional amounts of money in order to gain such flexibility (or freedom) in business decision making.

In the economics literature the flexibility or freedom in decisions is most comprehensively modelled and analysed by Real Options Analysis. The ROA (Real Options Analysis) method provides a theoretical and quantitative technique for determining the value associated with the freedom to exercise a particular decision. The ROA method has been primarily applied to business decision making, as a method of quantifying the freedom (or flexibility) associated with the decision, however ROA can be applied to any decision making.

In this paper we show how ROA can be used to measure and quantify the freedom in Sen's CA. The ROA to measuring freedom in the CA allows the measurement of freedom that is not dependent on proxy measures, and so it is a more direct (but theoretical) measure of freedom in decisions. Secondly, the ROA allows us to model freedom as an endogenous variable and so enables us to quantify and understand the impact of changes in exogenous (or independent) variables upon freedom. Other freedom measurement methods do not allow this because they explicitly or implicitly rely on modelling freedom as an exogenous variable, that is not affected by other exogenous variables. In reality, exogenous variables affect freedom, and so it is highly unrealistic to model freedom as an independent variable.

The paper is organised as follows: first we introduce CA, providing a literature review and discuss the problems with current CA measurement methods, especially with respect to freedom measurement. In the next section we explain the ROA and explain its calculation method. We then explain how ROA can be applied to CA, using examples to demonstrate the application. We then conclude the paper.

2. Introduction To The Capabilities Approach And Literature Review

Sen's CA to welfare has gained increasing attention (Kato et al., 2017), it is considered a more comprehensive and multidimensional approach to welfare, which addresses fundamental issues in welfare. Moreover, the CA has distinguished itself from other welfare approaches due to its emphasis on freedom. The CA is evaluated in 2 parts: (1) actual achievement and (2) the freedom to achieve (Sen, 1995). Hence in CA we are concerned with achievement in terms of what is actually achieved, and secondly the freedom to pursue opportunities to achieve some outcome. Additionally, we are also interested in the Capability Set, which is the set of all opportunities available to the individual.

A more formal definition of Sen's CA can be defined as follows for person *i* (Dang, 2014):

$$b_i = f_i(c(x_i)|z_i, z_e, z_s),$$

for some $f_i(.) \in F_i$, $x_i \in X_i$, where b_i is the vector of achievements for person i (or more specifically referred to as 'functionings'), x_i is the vector of commodities for person i, X_i is the set of all possible x_i, $c(x_i)$ is the function converting the commodity vector x_i into a 'vector of objective characteristics' (see (Dang, 2014) for an explanation), $f_i(.)$ is the function converting $c(x_i)$ into functionings b_i, and z_i, z_e, z_s represent personal, environmental, and social factors, respectively, that convert resources into any achievements and freedoms.

A distinguishing feature of Sen's CA compared to alternative welfare analysis is its emphasis on freedom as a major component of welfare. This is because freedom has an intrinsic value in itself, but also freedom is important to providing opportunities for achievement. For example, consider 2 identical situations: a person that is starving in India out of lack of food and not from choice, and another person starving in the USA out of choice (e.g. hunger protest). The US person has the freedom to choose to starve, whereas the Indian person has no choice or freedom in his decision; the CA is able to distinguish between these 2 people by taking into account their freedoms of their choice. Hence CA can be considered to provide a more comprehensive analysis of welfare.

At present the literature on CA measurement is mainly focussed upon regression and indexing based methods; see for examples (Simon et al., 2013), (Mitchell et al., 2015), (Rippin, 2015) and (Chiapperio-Martinetti et al. , 2015) for a survey. The majority of CA methods take some proxy measures of achievement, and combine them into a weighted average to give a measure of capability. Consequently, the indexing and regression based approaches are heavily vulnerable to data biases. We note in passing that Sen was persuaded to adopt indexes to facilitate communication with the public (Fukuda-Parr, *2003*), rather than using them as a direct and theoretical analysis of CA. One of the most important CA measures is the United Nations Human Development Index, which is an average of 3 other indexes on life expectancy, income per capita and educational attainment. Other indexes include the human poverty index, gender-related development index and the genuine progress indicator.

In CA literature, innovative methods have been applied to improve measurement of capabilities. For example, the development of theoretical models (for example (D'Agata, 2007)), the utilisation of qualitative methods (Chiapperio-Martinetti et al. ,2015) such as interviewing experts and scholar, and application of modelling methods such as the fuzzy-set approach. For example in (Qizilbash and Clark, 2005) a 'fuzzy set theory' approach is used to measure CA, where the fuzzy set methodology allows values to take on a wide range (or fuzzy set) of values.

A key problem in operationalising Sen's CA is the measuring the freedom associated with decisions. Firstly, current measures do not enable one to measure freedom as an endogenous variable, that is freedom as a function of other variables. This is a fundamental problem because freedom is a key component of CA and many variables can directly impact the level of freedom in a decision in such a way that freedom must be an endogenous variable (rather than an exogenous variable). For example, an increase in a person's education can lead to an increase in a person's freedom, since increasing

education means a person will have greater choice of jobs. However, modelling education and freedom as independent variables would be unrealistic and lead to incorrect analyses.

Secondly, the current methods that attempt to measure freedom associated with decisions achieve this through proxy indicators. Such proxy measures attempt to measure freedom related to generic decisions, however such freedom measures can be completely incorrect for particular decisions or activities. For example, freedoms with respect to general employment may not be a good proxy measure of freedom with respect to particular occupations. Moreover, the proxy freedom measures fundamentally cannot measure freedom taking into account an individual's particular characteristics, they can only measure freedom with respect to a generic group. For example, proxy measures of freedom that may apply to a particular socio-economic class may not take into account freedom issues relating to individuals that may have unique disabilities. Hence such proxy measures of freedom can be misleading measures of freedom, implying freedoms may be increasing for an individual when they could in fact be decreasing.

3. Real Options Analysis Applied To The Capabilities Approach

In this section we show that ROA can be applied to CA, and specifically measure freedom in decisions. This freedom or flexibility in decisions has already been studied in management and financial literature for some time, hence ROA has been used to value such freedoms. The ROA provides a theoretical and quantitative method for determining the freedom value associated with exercising a particular decision. This method therefore provides a particularly useful theoretical modelling and measurement method for freedom, which is currently unavailable with other CA methods.

3.1 Introduction To Real Options Analysis

Real options analysis provides a method of valuing the freedom to pursue a particular decision. ROA's primary application has been in business (although there have been sociological applications such as in health treatment (Dangerfield et al., 2017), marriage and suicide (Dixit and Pindyck, 1994)). The 'options' in ROA are business ***decisions***, where we assume the person or firm has the right but not an obligation to pursue a particular decision. The ROA was a significant innovation in valuation theory compared to alternative methods (such as Net Present Value, Expected Value, Internal Rate of Return etc…) because ROA was able to value the freedom of decisions (see (Arnold, 2008)).

To illustrate the method of ROA we have a standard decision tree in figure 1; for simplicity we assume 2 possible future scenarios (at some future time point t=1), each scenario has a probability, an associated payoff, and the time now is denoted by t=0. We note that we could apply a discount factor to the payoffs (to account for risk and time) but for simplicity of exposition we ignore these factors.

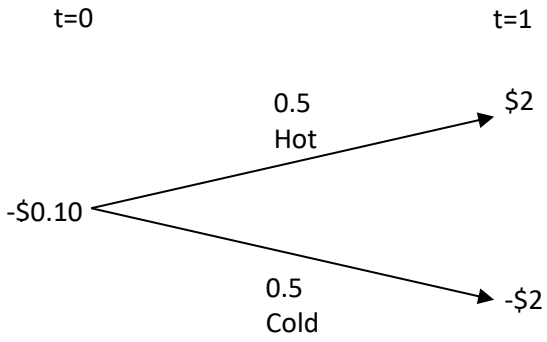

Figure 1: A Firm Selling Ice Cream Under Future Scenarios Of Hot and Cold Weather

Let us assume that figure 1 denotes a decision tree for a particular activity for a firm which is to sell ice-cream. We see that at t=0, the firm incurs a cost of $0.10 (e.g. setup costs to start trading ice-cream) and is faced with 2 future scenarios at t=1, with equal probability of 0.5. If at t=1 the future weather is hot then the firm gets a $2 payoff, however if the weather is cold then the firm makes a payoff of -$2 (firm loses money). To calculate the value of the decision *V*, in standard valuation analysis we calculate the expected value *E[V]* to determine the expected value of the decision. Hence the expected value of selling ice-cream *E[V]* is given by:

$$E[V] = 0.5x2+0.5x-2-0.10$$
$$=-\$0.10.$$

As the value of the decision is negative we would conclude that the decision is not profitable for the firm and so it should not sell ice-creams. However, this analysis ignores the freedom, and the value of the freedom, that decision makers possess; in ROA we take into account that the firm has freedom in decision making. So in ROA we take into account freedom: we would expect that the firm is not compelled to sell ice-cream in any weather scenario, so in the cold weather (or '-$2') scenario many firms in the real world would typically withdraw sales. In other words, we would expect the firm to have the ***option or freedom to choose*** to withdraw selling ice-cream in the cold weather scenario.

A consequence of the firm having the freedom to choose to withdraw selling ice-cream in cold weather implies that the payoff is no longer -$2 in the cold weather scenario; if we have cold weather and the firm withdraws its sales operation then let us assume for simplicity a $0 payoff in this scenario. Therefore *E[V]* would now be

$$E[V] = 0.5x2-0.1+0.5x0$$
$$=\$0.90.$$

Hence one can see that unprofitable decisions can actually become profitable once freedom in decisions is taken into account. The ROA approach takes into account the ability of decision makers to have freedom in decisions and therefore provides a different method of valuation compared to standard valuation methods.

The ROA also enables us to value the freedom or 'real option' associated with the decision, in the case of the ice-cream sales example it is the freedom to abandon selling ice-cream during the cold weather. This freedom value F_V is calculated by subtracting the expected value when the freedom (to abandon sales) is available $E[V_F]$, to the expected value when the freedom (to abandon sales) is not available $E[V_{NF}]$. In this case we have:

$$F_V = E[V_F] - E[V_{NF}]$$
$$= 0.90 + 0.10$$
$$= \$1.$$

Hence the value of the freedom F_V (to abandon selling ice-cream in cold weather) is worth \$1. This example demonstrates that freedom does in fact have a value in decisions, and is not non-existent. Secondly, the value of freedom in decisions can be very significant, in fact the value of freedom to sell ice-creams is worth half of the value of the payoff during hot weather, hence from a welfare perspective freedom is not insignificant. Moreover, if the firm were compelled to sell ice-cream during cold weather (that is a loss in freedom to withdraw selling) then it would lose a highly valued freedom and the loss of this freedom is equal to \$1.

3.2 Real Options Analysis Applied To The Capabilities Approach

The ROA method quantifies the freedom in decisions and this same method can be applied to quantifying decision in the context of CA. In other words in CA we have

$$F_V = E[V_F] - E[V_{NF}]$$

where $E[V_F]$ is the expected value of functionings with freedo, and $E[V_{NF}]$ is the expected value of functionings without freedom. We now demonstrate our method with examples.

3.2.1 Example 1: Real Options Analysis Applied To A Slave

Sen in (Sen, 1999) gives an example to illustrate CA measurement by giving the example of a slave. Sen argues that a slave's welfare and capability improves even if everything remains unchanged but works as a free man rather than as a slave; the addition of freedom in itself increases his welfare. Moreover, the slave's overall welfare and capability as a free man can improve even if his standard of

living actually decreases as free man compared to being a slave; the decrease in welfare by standard of living is offset by the increase in welfare obtained from increased freedom.

We now analyse Sen's slave example using ROA to measure the freedom gained as a free man, compared to working as a slave. In figure 2 we depict a decision tree where a slave is told today (t=0) to clean the garden tomorrow (t=1) and there are 2 possible weather scenarios at t=1, where the weather can be cold or warm. The weather can be warm with probability 0.5 and in this scenario the slave gains a functioning of 2, as the slave likes gardening in warm weather. However, there is also the scenario that the weather is cold with probability 0.5, and the slave gains a functioning of -5 as he does not like gardening in cold weather (a negative functioning value indicates a decrease in well-being or welfare). At t=0 we assume the slave also incurs a -0.1 functioning as he must clean all his gardening tools prior to gardening.

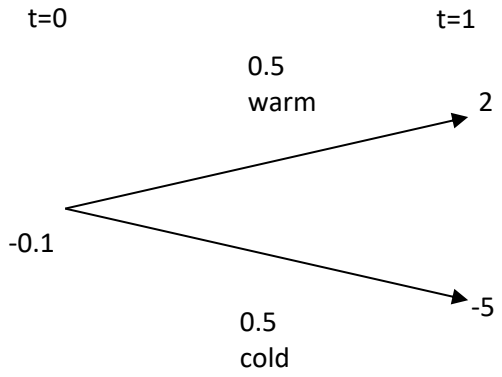

Figure 2: Slave Performing Gardening

We now calculate the expected value *E[V]* of the functioning of the slave in this activity:

$$E[V]=0.5x2+0.5x-5-0.1$$
$$=-1.6.$$

As the expected value is negative, the slave's well-being therefore is not improved from gardening. We note that, as the individual is a slave, he must perform gardening regardless of either weather scenarios and so ***must*** work in either scenario; there is no choice or freedom in the activity.

We now calculate the slave's well-being under identical circumstances but is now a free man (no longer a slave). At t=0 the individual decides to do gardening the next day on t=1, hence he still cleans his tools at t=0, and so encounters -0.1 functioning as before. We assume the weather probabilities and associated well-being payoffs remain the same at t=1. The next day at t=1, the individual observes the weather, and as a free man he now has the freedom to decide whether to perform

gardening or not. If the weather is warm, the individual will perform gardening as he gains a positive functioning payoff of 2 (same as before in figure 2). However, if the weather is cold, he is no longer forced to perform gardening as he is a free man, and so can refrain from it. In the cold weather scenario he will therefore avoid the -5 functioning payoff that he would have incurred as a slave, and instead we assume he has a functioning of 0 as he does nothing instead. This situation is depicted in figure 3.

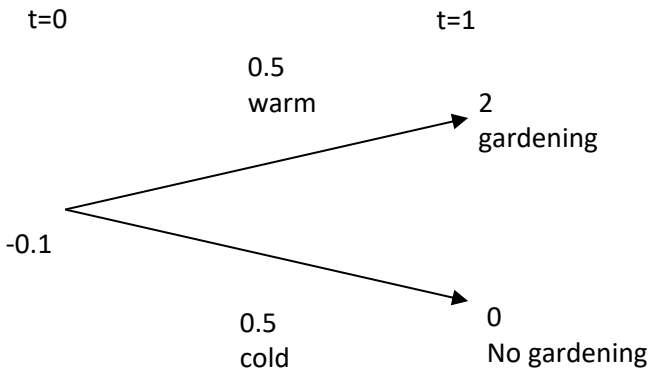

Figure 3: Free Man Performing Gardening

In the situation as a free man, the free man's expected value *E[V]* of the gardening activity is now:

$$E[V]=0.5x2+0.5x0-0.1$$
$$=0.9.$$

Hence the individual is better off in terms of CA if he is free. The ROA has ***quantitatively*** demonstrated that freedom leads to a numerically better outcome in welfare, and demonstrate this even when there is no change in all the factors except freedom. This would not be possible under comparable CA measurement methods.

We now may wish to quantify the freedom to garden, which is obtained by determining the difference between the decision trees when freedom exists and does not exist. Hence we have:

$$F_V = E[V_F] - E[V_{NF}],$$

where F_V is the value of freedom (to garden), $E[V_F]$ *is the e*xpected value of gardening with freedom (as a free man), and $E[V_{NF}]$ is the expected value gardening with no freedom (as a slave). Hence we have

$$F_V = E[V_F] - E[V_{NF}]$$
$$=0.9+1.6$$
$$=2.5.$$

Hence we see in this example that freedom leads to an increase in well-being (2.5), in fact this value is worth more than the well-being gained from gardening itself (2) and so demonstrates that freedom is not an insignificant component of welfare. This demonstrates the importance of taking into account freedom measurement in welfare (as originally proposed by Sen's view of emphasising freedom in welfare) and correctly measuring it. In fact, alternative methods may not recognise that a change in a person's status from slave to free man should lead to a significant change in well-being.

The quantification of freedom's value (in terms of freedom to garden) implies that it is beneficial to the individual to 'purchase' this freedom, provided the price does not exceed the value of the freedom. Let us illustrate this with an example by assuming now that the garden is a Government owned garden and the procedure for gardening is as follows: firstly the person must inform the Council 1 day in advance of the activity of gardening and after doing so the individual is legally compelled to perform gardening. An alternative arrangement is that at t=0, the person informs the Council of the activity of gardening 1 day in advance, but also purchases a flexibility permit at t=0 with a fee of 0.5. If a permit is purchased then the person is no longer legally compelled to garden at t=1, hence the 0.5 fee is the cost being imposed on the individual to have the freedom to choose to garden.

Let us assume that a monetary cost leads to an equivalent cost in functioning. As a free man, a person may wish to buy the flexibility permit and the decision tree changes to figure 4. At t=0, the person incurs a functioning cost of -0.1-0.5=-0.6, as he must now pay 0.5 for the flexibility permit.

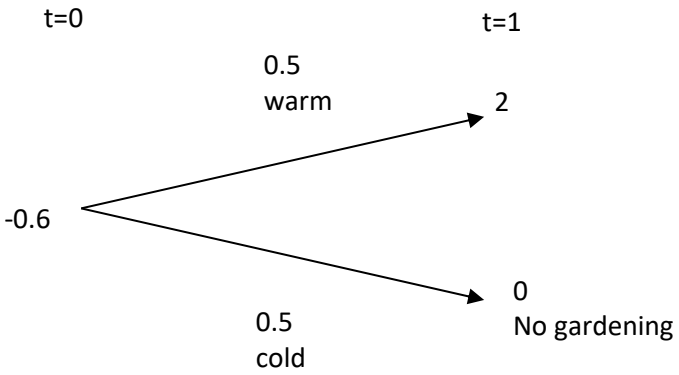

Figure 4: Gardening With Flexibility Permit Fee

The expected value *E[V]* in this decision tree is now

$$E[V]=0.5x2+0.5x0-0.6$$
$$=0.4.$$

As the person still has a positive functioning of 0.4, even with a permit of -0.5, the individual should purchase the permit. The value of freedom (to garden) F_V is now:

$$F_V = E[V_F]- E[V_{NF}]$$
$$=0.4+1.6$$
$$=2,$$

where $E[V_F]$ is the expected value with permit, and $E[V_{NF}]$ is the expected value without permit. We should also notice that our calculation for the freedom (to garden) takes into account the impact of the permit upon our freedom value: it has reduced from 2.5 to 2. This is to be expected because the permit costs 0.5 and reduces the freedom value accordingly. Hence our ROA method takes into account the impact of other variables upon freedom in a theoretically consistent way.

The example illustrates some important benefits of ROA for CA that would not be possible in other CA methods. Firstly, ROA enables direct measurement of freedom, and the freedom associated with a specific decision. In alternative CA methods, freedom is measured indirectly through proxies or indexes and there is no guarantee such measures will not be a misleading measure. Additionally, alternative CA method do not provide freedom measures associated with a specific decision, rather they provide freedom measures for a generic set of decisions. Consequently, there can be no comparison in freedom calculations between decisions which all fall under the same generic set.

Secondly, the ROA enables freedom to be measured as an endogenous or dependent variable. Freedom is typically dependent on other (exogeneous or independent) variables and so it is important that the CA method explicitly models freedom as a dependent variable. If freedom is not a dependent variable, it implies that other factors (eg health, education etc.) can vary without affecting freedom; this would not be realistic because it is known that freedom to work is dependent on many variables (eg health, education etc.).

In alternative CA methods freedom is explicitly or implicitly an independent variable, hence we cannot examine the impact of different factors upon freedom. In our ROA freedom is explicitly a dependent variable, and in our current example, we are able to examine how freedom is directly impacted by other factors eg flexibility permit fee. Consequently, we can see how freedom is directly increased or decreased by other factors. This is an important property because freedom is a distinguishing and important aspect of welfare in CA, hence it is important to be able to examine freedom correctly and with respect to other variables.

Thirdly, our ROA measure of freedom is able to assign a quantitative value to freedom without having to utilise large sets of data. Other CA methods do not directly calculate freedom but use large datasets on indicators of freedom, for example health, education etc. . Such methods are heavily affected by data bias and so can result in unusual results because the results are entirely data driven. In situations where appropriate data may not be available, such CA methods for freedom measurement may not be useful. In the ROA our measurement of freedom uses minimal data and so can be applied to a range of applications.

Finally, the ROA model is able to take into account person specific factors and so give a more specific calculation of freedom and functioning benefits. The ROA utilises the payoff or functions associated with each individual, rather than using information that applies to a generic group. Consequently, the ROA and the associated freedom calculations will vary depending on the person's specific characteristics. For example, the gain in freedom from slave to free individual may be significant or minor, and this can be reflected in the ROA calculation. Additionally, the functioning gained from different weather conditions will also depend on the individual and this can also be incorporated within the ROA.

3.2.2 Example 2: Real Options Applied To Microfinance Loan

We now apply ROA to a topical issue in sustainability and development economics: microfinance loans that enable businesses to expand in developing countries. Let us assume a person wants to set up a business, as depicted in figure 5: to set up the business at time t=0 he must spend $100 and we assume that $1 incurs -1 loss in functioning for convenience, hence he incurs a total loss of -100 at t=0. If we have a scenario that the market is growing with a probability of 0.5, then at t=1 he will gain a 110 to his functioning (as he will be running a more profitable business). We will also have another equally likely scenario of probability 0.5, where the market is decreasing and the functioning payoff is just 10 (as he will be running a less profitable business).

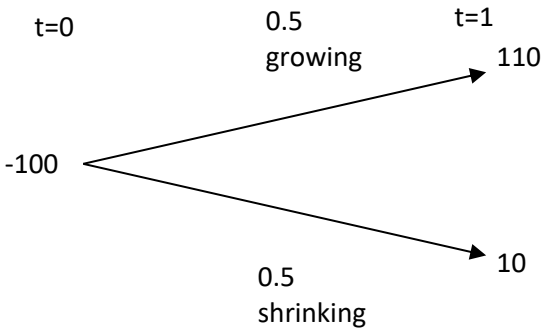

Figure 5: Business in Different Market Scenarios

If we now calculate the expected value *E[V]* from starting the business we have:

$$E[V] = 0.5x110+0.5x10-100$$
$$=-40.$$

Hence the individual will not pursue the business as the expected value *E[V]* is negative.

Let us now assume that the individual has access to a $50 microfinance loan that allows him to expand his business, so that in a growing market his functioning payoff is now 300 (see figure 6), and the shrinking market scenario payoff remains unchanged. At t=0 therefore the individual now incurs -150 (instead of -100) and for simplicity of exposition we assume the loan does not have any interest payments.

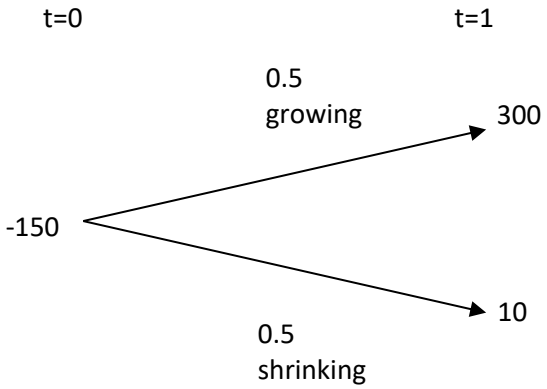

Figure 6: Business with Microfinance Loan

If we now calculate the expected value *E[V]* we find it is now:

$$E[V]=0.5x300+0.5x10-150$$
$$=5.$$

Hence with the aid of the microfinance loan the expected value of starting up the business is positive, and so the individual may now wish to setup the business. The microfinance loan provides the individual the freedom to expand the business.

To determine the freedom value F_V we calculate the difference in the 2 expected values

$$F_V = E[V_F] - E[V_{NF}],$$

where $E[V_F]$ is the expected value with expansion, and $E[V_{NF}]$ is the expected value without expansion. Hence we have

$$F_V = 5+40$$
$$=45.$$

Therefore the value of the microfinance loan to the bank is $50 but the freedom value obtained from the loan is 45 (which is equivalent to $45 as we are assuming $1 corresponds to 1 value in functioning).

Using ROA we are able to determine the freedom obtained from microfinance loans and this has a number of advantages compared to alternative CA methods. Firstly, we are able to measure the freedom gained from the loan directly, rather than having to utilise proxies or indexes that can be misleading. The advantage of a direct measure using ROA is that our measure of freedom is directly related to the decision or loan. Hence a larger loan would directly be reflected in the change in freedom, whereas proxy or index measures do not necessarily or accurately reflect the change in a large loan value.

Secondly, we are measuring the impact of the loan upon freedom where freedom is an endogenous or dependent variable. This means we can directly understand the impact of the loan upon freedom, and freedom is one of the key aspects of CA. Moreover, we are not modelling freedom as an independent or exogenous variable, which would be highly unrealistic because we expect freedom to change with access to loans. Consequently, our analysis is more realistic.

Thirdly, ROA is able to measure or quantify that one of the key welfare benefits of the loan is not just increased payoffs but also increased freedom. In fact ROA is able to show that the freedom value obtained is worth almost the same as the loan itself, in fact if we add the value of the loan and freedom together we have 45+50=$95. Hence ROA shows that the freedom value increases loan value by double to an individual, demonstrating the importance of microfinance in terms of welfare benefits.

5. Conclusion

The operationalising of Sen's Capabilities Approach is a fundamental problem due to the issue of measuring the freedom in decisions. In this paper we have shown that using the Real Options Analysis methodology (from economics) that we are able to quantify and measure freedom more satisfactorily. In particular, we can model freedom as an endogenous variable and model the impact of independent variables upon freedom. Hence we can better understand how

freedom is impacted, and this is particularly important given that freedom is a major aspect of the Capabilities Approach.

We have also shown that the Real Options Analysis does not need to rely on proxies or indexes to enable us to quantify freedom, hence we can compare changes in freedom as other variables change, and we are able to understand the relative importance of freedom in our decisions. We have shown how this can shed light on welfare in terms freedom for particular decisions and applications (e.g. microfinance) and shown that freedom is a major component of benefit to individuals. Our Real Options approach therefore can be a potentially useful policy analysis tool.

In terms of future areas of research, we would want to explore a wider range of real options from the financial literature and explore their potential applications in the Capabilities Approach, for instance the usage of switching options to value the Capability Set. We would also want to explore the implementation of our Real Options approach to enable better practical implementation with real world data. Finally we would like to explore more sustainability issues in applying the Real Options to real world problems.

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