FEDERAL STUDENT LOAN DEBT AND THE INDIVIDUAL'S PROPENSITY TO DEFAULT

Sara Christensen
Department of Economics
Pacific Lutheran University

Abstract

Given the 3.9 million individuals currently in default on federally funded student loans, this research seeks to understand why an individual may choose to enter default, given the common economic assumption that defaulting represents a suboptimal choice. While previous research has focused primarily on identifying characteristics of loan borrowers in default, this research attempts to expand the literature regarding how those borrowers behave once they enter loan repayment. Specifically, the research seeks to answer the question of whether instances exist in which it is in the individual borrower's best interests to default on their federal student loan debt. To answer this, a game theoretic model is utilized to observe the individual borrower's potential payoffs from making payments versus defaulting under a variety of adjustable parameters. These parameters include measures of total debt, length of repayment, and severity of the penalty for defaulting. After observing these scenarios and their associated potential payoffs, it is concluded that instances exist in which an individual's highest expected payoff may come from defaulting on their federal student loan debt. Additionally, a significant penalty for default above the cost of the loan must be assessed in order to discourage loan default by a wide range of borrowers. These results are important for policy formation as they help explain why a borrower may default on their student loan debt. It also assists in identifying areas of repayment schemes that, if adjusted, may have the potential to lower rates of student loan default.

December 2016

I. Introduction

As the number of college enrollees rises, paying for college becomes an increasingly important decision for many and what happens to the debt incurred while in school becomes an issue requiring national attention. To that end, this paper will investigate the decision to default at the individual level in order to better equip individual borrowers and policy makers with the knowledge and tools necessary to make informed decisions about federal student loan debt. Over the past near half-century student loan debt levels have grown precipitously in the U.S as more student flock to college campuses and tuition rates rise. Total postsecondary enrollment rose by 44% from 1995 to 2015 and of the 2014-2015 graduating class, 61% of bachelor's degree recipients had incurred an average of $28,100 in total student loan debt. (Ma, Baum, Pender, and Welch, 2016). Student loan debt now ranks as the largest class of non-housing consumer debt, with more than $1.1 trillion currently tied up in higher education related debt (Mezza and Sommer, 2015). Many economists now consider this a rising debt crisis with a growing bubble containing the potential for dramatic fallout for the U.S. economy. As such, it becomes increasingly important to understand the influence of student loan debt on the U.S. economy. Yet, at both public and private institutions yearly tuition increases have slowed in the last decade and annual federal student loan borrowing has declined for the fifth consecutive year (Ma et al., 2016). This has led to questions of whether student borrowing behavior is following traditional lending assumption as closely as might have been expected. The major consideration of this investigation is an attempt to acquire a better understanding of what leads individuals to default on their student loans. To many in both the economics profession and in everyday life, it is commonly assumed that defaulting on a loan is a suboptimal choice that will not yield the highest benefit for the individual and should thus not be utilized. Yet, 28% of all borrowers

default on their student loans at some point during the first five years of repayment (Baum, Ma, Pender, and Welch, 2016) begging the question, what circumstances lead an individual to believe, whether correctly or incorrectly, that defaulting on their student loans is the optimal choice?

This research will attempt to answer this question by considering individual decision-making surrounding the propensity to default on federally funded student loan debt. Specifically, through a behavioral economics and game theoretic approach, consideration will be given to the progression of events leading to the choice to default on student loan debt. These events may include factors such as a change in income that leads to an increased constraint on the borrower's consumption or an adjustment to the loan conditions, such as a change in repayment length. The intention here is to illustrate a model of behavior given a set of circumstances that prompts an individual to choose to default.

A growing body of research including the work of Cunningham and Kienzel (2011), Dynarski (2015), Dynarksi and Scott-Clayton (2013), and Lochner and Monge-Naranjo (2014) has identified predictors for which individuals are most likely to default on their student loan debt. Researchers have also attempted to identify characteristics of borrowing systems that generate efficiency within the student loan market and create the greatest welfare for both the borrower and lender. Much of this analysis however, is focused on empirical research to better understand the demographic characteristics of higher education and financial aid as well as identify certain subsets of individuals who may be more likely to default on their student loans and what makes them more apt to do so. This research diverts from the empirical approach and instead attempts to fill a void in the literature concerning decisions at the individual level in order

to identify circumstances that may lead an individual, in an effort to maximize their utility, to decide to default.

Given that individual decision making surrounding federally funded student loan defaults is an area lacking both clarity and depth in current literature, this research will attempt to provide insight into this issue. A game theoretic approach to behavioral modeling, using a decision tree, will be utilized to analyze how an individual's utility function behaves under certain, specified conditions and what characteristics 'trigger' an individual to default. This approach is intended to identify the decision making process that leads to default rather than simply reporting points at which default is likely to occur. The intention is to provide a better understanding of what influences individual's loan repayment decisions thereby informing policy makers attempting to optimize federal loan repayment schemes and assist borrowers in avoiding default.

II. Background

In an effort to encourage college enrollment and help curb expenses for students, the federal government introduced the first federal student loan program, known as the Federal Family Education Loan Program, under the Higher Education Act of 1965. Under this program, private lenders provided capital and handled the disbursement and repayment of the loans while the Department of Education defined eligibility requirements for such loans, paid interest on certain loans while students were enrolled, and guaranteed lenders against default (Avery and Turners, 2012; Dynarski, 2015). Student loans continued to be provided in this way until the mid-1990s when the federal government introduced its Direct Loan program which allowed borrowers to obtain a student loan directly from the Department of Education without having to go through a private lender. Institutions opted into the Direct Loan program, so students' loan options were dependent upon the institution they attended. In 2010, the Health Care and

Education Reconciliation Act eliminated the Federal Family Education Loan program, making the federal government the sole provider of federal student loans, under the Direct Loan program (Dynarski, 2015). Private lenders continue to provide student loans, however, these loans are not guaranteed by the federal government and do not have the same loan terms as federal student loans. Though private loans are an important aspect of college financing, their implications and loan default behaviors are not considered within this paper.

The Department of Education specifies a number of terms and conditions for federally funded student loans including interest rates, annual and aggregate loan maximums, and repayment options. For the purposes of this paper it is important to note how the federal government defines loans in default status. Specifically, a federal student loan is considered to be in default if the borrower has failed to make payments on the loan for a period of 270 consecutive days. The federal government has the ability to exercise a number of consequences, both directly and indirectly, on those borrowers who enter default status. These include: loss of eligibility for additional federal financial aid, wage garnishment and withholding of tax refunds, late and collection fees, and reduction in credit score. In total, defaulting on a federal student loan can have severe implications for a borrower for years after the default has occurred.

III. Literature Review

A wide body of research exists with regard to student loans and financing for higher education. Much of this research serves to quantify the landscape of higher education in terms of who is attending college and how they are financing their educational endeavors. A substantial body of research also attempts to determine whether current and historical structures for college funding and financial aid are to the benefit of the consumer (the student), the government, and the general U.S. economy. In its relationship to individual decision making surrounding student

loan defaults, the literature can be divided into several areas which include, (1) characteristics of those who default, (2) the efficiency of student loan programs, (3) future investment and time-horizon relationships, (4) repayment reform, (5) the existence of a student loan debt bubble and finally, (6) rational decision making.

Characteristics of Those Who Default

The notion that certain demographic characteristics increase the likelihood that an individual will default on their student loans is largely supported by the economic literature. Cunningham and Kienzel (2011) find specifically that those borrowers most likely to default included individuals who left school without obtaining a degree, last borrowed after attending one year of college or less, and attended a public two-year or for-profit institution. These findings are supported by further research which notes that in addition to institution type and borrower behavior, an individual's propensity to default is also significantly influenced by the borrower's age, gender, race/ethnicity, and college success, as measured by college GPA and degree completion (Steiner and Teszler, 2005). Greene-Knapp and Seaks (1992) divert from much of the literature, however, in their findings that while improving graduation rates are beneficial for a college seeking to lower their default rates, individual characteristics are much more significant for predicting default rates. Currently, individual institutional default rates are calculated by the federal government and reported to the school. Institutions are expected to keep their default rates low or risk losing their federal financial aid eligibility. These findings divert significantly from the Department of Education's assumption that an institution's default rate is a direct reflection of the quality of the institution and should be used as a key determinate for the institutions' federal financial aid eligibility. This suggests that the practice of penalizing institutions for high default rates may not be as advantageous an approach as is commonly

believed. This paper will not consider this particular practice of penalizing institutions; however, it is useful for considering who bears the burden of high federal student loan default rates.

Efficiency of Student Loan Programs

Given the costs associated with both an individual's collegiate expenses and the federal government's financing of higher education, significant research has been conducted to consider whether student loan programs and federal financial aid is structured in such a way that maximizes student benefits while minimizing public and private costs. The theory behind government funded financial aid for college is largely based on the basic principle that if the price of a good, in this case college tuition, can be lowered then an increased number of consumers will purchase the good, thus leading to more students enrolling in college (Dynarksi and Scott-Clayton, 2013). Yet, despite this potential reduction in costs, grant based financial aid, in which the borrower is not required to pay back the provided aid, cannot defray the entirety of the costs associated with attending college. In this case, student loans serve a slightly different, yet still useful purpose, by spreading the burden through time. As a result, a market for student loans develops. However, because most student loans can often only be 'secured' based on the future earnings of the borrower, federal student loans have been created to correct a market failure that rising enrollment rates presents. This market failure is based on the fact that though college is a good investment for enrollees, the private loan sector is unwilling to fully fund these investments, given the lack of capital to back such investments (Dynarski, 2015). The logic, that economic literature supports, follows that the federal student loan market is beneficial in its elimination of market inefficiencies. Additionally, such human capital investment leads to positive externalities for society based upon the benefits associated with a better educated

population. The gain from these assumed potential benefits thus encourages investment in college, often through federal loans.

Current literature, however, finds that though the concepts used to create federal student loan programs are sound, the current loan structure has become limited in its effectiveness in providing access to students seeking loans to fund their education. In particular, findings suggest that annual federal loan limits have not kept up with rising tuition rates and the subsequent increased credit needs of loan borrowers (Lochner and Monge-Naranjo, 2014; Avery and Turner, 2012; Glater, 2016). Research suggests that, in fact, many borrowers, particularly those who are both high need and high achieving, are unable to borrow a sufficient amount to finance their education. Further, researchers have identified that the repayment aspect of the federal student loan structure has failed to fully capture the post-graduation earning trends of borrowers (Dynarski, 2015). Research finds the existence of a cost-benefit mismatch in which the costs associated with attending college, including the repayment of student loans, do not align with the benefits of a college degree as reflected in the steady growth in earnings over the course of an individual's life (Dynarski, 2015, Dynarski and Kreisman, 2013). Specifically, a timing mismatch exists in which the costs associated with attending college, often represented through the repayment of student loans, occur early in an individual's career, typically within ten years of graduation. Yet, college graduates tend to reach peak earnings and thus the time frame in which they are most able to pay back their loans after this repayment time has already elapsed. This suggests that loan repayment schemes are not devised in a way that most benefits the borrower in relation to their ability to pay. Possible inefficiencies regarding the repayment aspect of federal loan programs will be discussed in detail in subsequent sections.

Future Investments and Time-Horizon Relationships

Considering the decision to borrow student loans is largely an investment in the future, researchers have also sought to understand if and how future investments are influenced by student loan debt. While traditional life-cycle consumption smoothing models suggest that student loan debt levels should have very little influence on future decisions or consumption patterns, empirical literature finds that this is not always the case (Rothstein and Rouse, 2011, Dora Gicheva, 2011). For example, Rothstein and Rouse (2011) find that when the burden of student loan debt is removed, individuals are more likely to become employed in the public sector and have a higher propensity to give alumni donations to their alma mater. Gicheva (2011) also discovers that for every additional $10,000 in student loan debt, the probability of an individual marrying decreases by seven percentage points. Both of these findings suggest that student loan debt may have a greater negative impact on an individual's future decisions than is traditionally expected. Houle and Berger (2015) show different results, however, by noting that with regard to the housing market, student loan debt levels are very limited in their influence on the decision by young adults to purchase a house. Factors such as the recent economic downturn and the transition into adulthood are found to have a much stronger relationship with the decision to purchase a home. These findings suggest other factors, such as those cited in Houle and Berger's (2015) research may be contributing to future decisions more significantly, and loan debt less significantly, than previously literature has implied.

Regardless, given the influence decisions such as career choice and marriage have on the U.S. economy as a whole, it is important to understand these effects in relation to the implications of rising student loan debt. For the purposes of this paper, it will be assumed that an

individual's decisions, at least to a certain degree, are influenced by the level of outstanding student loan debt they possess.

Repayment Reform

As mentioned previously, repayment options for federal student loans present one area in which loan programs fail to efficiently manage student loan debt and avoid unnecessary loan defaults. The literature is largely divided, however, with regard to which aspects of repayment are ineffective and which, if any, potential reform options should be implemented. Several researchers find that an income-contingent plan, in which monthly loan payments adjust dynamically with one's income, provides the greatest benefit to borrowers by lowering their payments, while simultaneously keeping default rates low (Dynarski, 2015; Dynarski and Kreisman, 2013; Lochner and Monge, 2014). Dynarski and Kreisman (2013) go as far as to suggest an entirely new student loan system, which they title Loans for Educational Opportunity, in which repayment periods are extended to 25 years (traditional repayment periods are ten) and monthly payments are automatically deducted from an individual's paycheck in a way similar to Social Security. Johnstone's (2009) findings, however, point out that the success of such income contingent plans is often over emphasized, such that characteristics that make the program successful can be found in other repayment options as well or do not require an income-contingency element to be produce.

Other research does not go as far as to propose a new income-contingent plan but rather evaluates the implementation of or changes to current income-based-repayment plans. Many of these findings conclude that of the repayment options and reforms that have been implemented, several have unintended negative consequences or do not significantly benefit the group of borrowers, typically those with low to middle income, that the reform was intended to help

(Delisle and Holt, 2012; Ionescu, 2008; Lochner and Monge, 2014). Ionescu (2008), for example, finds that when the option for borrowers to consolidate their loans and lock in an interest rate was eliminated in 2006, default rates increased by 22%, particularly among lower-income borrowers.

Despite these discrepancies, however, there exists much consensus among researchers that most current repayment plans, particularly standard 10-year repayment options, create a significant cost benefit timeline-mismatch, as described earlier, that places an unequal debt burden on the individual over the course of their life (Dynarski, 2015; Dynarski and Kreisman, 2013).

A Student Loan Debt Bubble

The popular media has spent a significant amount of time reporting on the notion that a student loan debt bubble is forming with potential fallout similar to that of the 2008 housing crisis and economists have investigated the possible evidence supporting this possible crisis. Largely, researchers have come to refute the notion that a student loan debt bubble exists and instead support the idea that students are borrowing at levels on par with the large premium surrounding higher education earnings or perhaps, at times, may not even be borrowing enough (Dynarski and Kreisman, 2013; Avery and Turner, 2012; Glater, 2016). Glater (2016) does, however, argue that while a debt crisis may not exist, an access crisis does exist, such that the federal government has not kept grant and loan aid on pace with rising tuition costs, thus leading to limited access to college, particularly for students of lesser means. While student loans do not directly lower the costs of attendance, they do help spread costs over a larger period of time, giving the borrower an opportunity to invest in college based on their future earnings when they might not otherwise be able to. In a similar tone, Dynarski and Kreisman (2013) argue that a

repayment crisis is occurring in which the current loan repayment structure does not give borrowers adequate options for repaying their loans and thus leaves them unable to pay and forced to default. Which of these potential crises is more applicable or significant, or if both exist in the current student loan climate, is an area of research yet to be addressed. While understanding the characteristics of various 'bubbles' or lending crises and how they have arisen is beneficial for understanding the full impact of student loans on the U.S. economy; that is beyond the scope of this paper which is focused on the individual borrowers' decisions.

Rational Decisions Making

Though limited in its scope, researchers do support the notion that it is important to understand the decision making process of both the lender and the borrower in an effort to understand why various loan outcomes occur; specifically why borrowers default. Much of the literature finds that when financially constrained and faced with a menu of options, default can, at times, become the optimal decision (Jiseob, 2015; Kim, 1991; Boyd, 1997; Seiler, 2015). Additionally, in the general conceptualization of loan repayment, Lacker (1991) finds that while most loans are made contingent upon a borrower's future resources, this contingency is constrained by the borrower's ability to conceal their future resources. This can be seen particularly clearly regarding student loans given that a borrower's future resources (their earnings) are often uncertain. This suggests a degree of asymmetric information that in this case benefits the borrower. Conversely, Seiler (2015) finds a degree of asymmetric information that negatively impacts the borrower's ability to make a rational optimal decision due to inadequate understanding on the part of the borrower regarding the consequences of default.

Researchers also finds that student loan borrowers may strategically choose to default on their loans, despite default not being perceived as the optimal choice (Boyd, 1997) For example,

Boyd (1997) finds that given the expectation that they will be discriminated against when attempting to obtain a home mortgage loan, for some Africa-American student loan borrowers, the economically rational decision becomes to default on their student loans. This is because the borrowers' expectation becomes that they will be unable to obtain a home loan regardless of their credit worthiness given the assumed racial discrimination in the housing market. Based upon this assumption, the borrower chooses to never pursue a home loan and as a result is unconcerned by the effect a student loan default might have on their future credit worthiness.

These findings are further supported by the research of Collins, Harrison, and Seiler (2015) with regard to the housing market. Through a game theory approach utilizing a decision tree to illustrate the decision to default on a home mortgage loan, they find that at times it may become strategically optimal for the individual to default on their home loan. In particular, as a borrower's budget becomes increasingly constrained, their utility may be optimized by defaulting on the loan rather than by continuing to make mortgage payments that the individual cannot afford. Their findings suggest that there may be instances in which loan default becomes the optimal choice for the borrower. The research within this paper will attempt to expand upon this particular area of the literature by examining whether the assumption that default is a sub-optimal choice is valid.

IV. The Model

The model this paper explores to illustrate strategic student loan default is an adaptation of a model first introduced by Collins, Harrison, and Seiler (2015) in order to explain instances of strategic default in the home mortgage market. Their work attempts to identify the economic and behavioral incentives that lead a borrower to default on their mortgage and subsequently lead a lender to decide whether or not to modify the mortgage. Through the use of a sequential,

extensive–form, game theoretic model they are able to identify instances in which it becomes optimal for a borrower to default on their mortgage and subsequently for the lender to modify the defaulted mortgage.

Collins, Harrison, and Seiler (2015) create a game in which there are two players: the mortgage borrower and the lender. For this paper, the two players will be identified as the student loan borrower and the student loan lender, which in this case will be the Department of Education. The game is modeled sequentially over a finite number of periods with each period representing one month. The original model sets a maximum of 600 months (50 years) for a given node chain, however this model will use a maximum of 120 months in order to replicate the standard, ten-year student loan repayment scheme. This condition will relaxed in subsequent sections in order observe how potential payoffs change when repayment length is adjusted.

For the game to end, one of two conditions must be met. Either a) the borrower pays off the loan in its entirety or b) the loan is removed from the repayment scheme. Removing the loan from the repayment scheme indicates that the loan was never fully repaid on the borrower's own accord.

This model follows assumptions similar to those put forth by Collins, Harrison, and Seiler (2015). These assumptions include:

1) If the borrower decides to bring his or her loan out of default they will be required to make up all missed payments, accrued interest, and any penalties associated with the loan's default.
2) If an 'external termination event occurs' in which the borrower can no longer make loan payments, the ability to bring the loan out of default no longer exists. An 'external termination event' will be defined shortly.

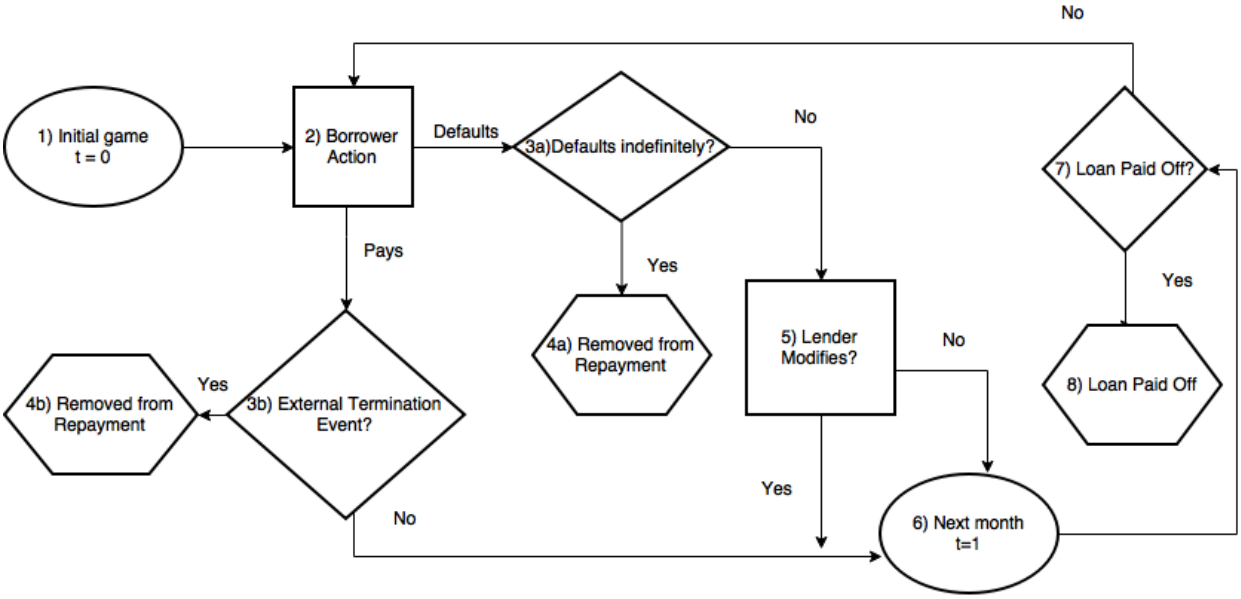
3) The game begins at the onset of the borrower's repayment period. Specifically, in the first month the borrower has not yet made any loan payments and is in month one of repayment.
4) The loan's interest rate is fixed and is based upon average interest rates as provided by the Department of Education.
5) The borrower's loan debt is equivalent to the average loan debt for the institution in which they attended, as reported by the Department of Education.
6) The college degree for which federal student loans were incurred was successfully completed by the borrower.
7) Only federal student loan debt is considered, any private student loans incurred by the borrower are excluded.
8) Payments are made once per month.

Given these conditions, the game begins in month 1 (t=0) in which the borrower must decide whether to default on his or her student loan. If the borrower chooses to make their monthly payment, the next node will serve as a check for an 'external termination event' (Collins, Harrison, and Seiler, 2015). This external termination event is a randomly determined event that produces a significant income shock for the borrower either preventing them from ever repaying the loan or allowing them to pay off the loan in full. Examples of these events include, a prolonged illness or death of the borrower or, alternatively, a sudden spike in household income. In either case, the external termination event removes the borrower from the repayment scheme and ends the game. If an external termination event does not occur the game moves onto the next time period (t=1). Here, a check is first made to evaluate whether the loan has been paid

off in full or not. If the loan has been paid off the game ends. If the loan has not been paid off the borrower is presented with their next action.

If instead of making the monthly payment the borrower chooses to default it must next be determined whether the borrower defaults indefinitely. Indefinite default means that the borrower will never become current on their loan payments or payoff the loan. This will result in the borrower being removed from the repayment scheme and the game ending. If the borrower does not default indefinitely a check is made to determine whether the loan is modified at this time by the lender. If the borrower meets certain qualifications the Department of Education may grant a modification of the loan. This modification may include loan consolidation or a movement to a different repayment plan. In this model, the loan modification has no influence on the borrower's potential payoffs, but is included to denote the opportunity on the part of the borrower to request a loan modification. Regardless of the loan modification, the game will continue onto the next period. The game continues sequentially until one of the aforementioned conditions is met and the game ends. Figure 1 provides an illustration the decision tree for one period of the game.

Figure 1. Flow Diagram of the Game Theoretic Model



The different shapes represent different node types within the diagram:

- Circle: indicates a deterministic event.
- Square: Represents a decision that needs to be made by the borrower or lender.
- Rhombus: indicates a test on the environment.
- Hexagon: indicates a terminal node.

Based on these conditions, backward induction is used to determine the Nash Equilibrium strategy for each player for various iterations of the game. By virtue of the sequential nature of the game, a set of subgame perfect equilibrium strategies can also be identified. Different games are created based on several adjustable parameters that produce different payoffs for the borrowers. These parameters will be described in detail subsequently. The derivation of these available payoffs are produced by the utility functions of each player, as described below. Based on the payoffs for each choice as modeled by the borrower's expected utility, the borrower will always choose the option that gives them the highest expected utility and thus the greatest payoff. This, of course, assumes a degree of rationality on the part of the borrower, such that they are expected to behave rationally and always choose the option with the highest payoff.

In order to create the utility functions for the various branches of the game, a few equations must first be established. Similar to Collins, Harrison, and Seiler (2015), the game begins with the borrower at debt level 'D_0' on a student loan with a monthly interest rate of $'\lambda_I'$ and 'n' total possible monthly loan payments. This allows us to create an equation for a fixed monthly payment 'P_t' as shown in equation (1):

$$P_t = D_0 \frac{\lambda_I(1+\lambda_I)^n}{(1+\lambda_I)^n - 1} \qquad (1)$$

A time period 't' is included on the monthly payment variable to denote the potential for payments to vary over time under certain repayment plans. For simplicity, it will be assumed in this model that monthly payments do not vary over time.

From here we can produce an equation for the total payments paid 'TP' by the borrower as shown in equation (2) in which 'M_{n-DM}' denotes the months in which payments are made such that the number of months in default 'DM' is subtracted from the total monthly payments 'n'.

$$TP = P_t * M_{n-DM} \qquad (2)$$

The borrower's total debt balance and current debt balance can also be quantified. The borrower's total debt balance 'D' is described as the monthly payment multiplied by the total number of loan payments 'n' as denoted in equation (3):

$$D = P_t * n \qquad (3)$$

The borrower's current debt balance 'CB' is shown in equation (4) in which 'M_D' denotes the month in which the individual defaults on their loan debt.

$$CB = D - (P_t * M_{D-1}) \qquad (4)$$

If the borrower defaults on their student loan debt, a default penalty 'DP' will be assessed. This default penalty represents the collection charges associated with default as defined by the Department of Education as a percentage 'λ_{DP}' of the current debt balance 'CB'. Equation (5) represents the default penalty:

$$DP = \lambda_{DP} * CB \qquad (5)$$

In addition to the negative effects associated with defaulting on a student loan, the borrower also yields some benefits from defaulting. Namely, because the borrower is no longer

making a monthly payment on their student loan, this increased income can be allocated to different areas. This benefit is defined as a proportion 'λ_P' of the monthly payment for each month in which the borrower is in default. The total default benefit 'DB_1' to the borrower from defaulting is represented below in equation (6a):

$$DB_1 = \lambda_P(P_t * M_{DM}) \qquad (6a)$$

Similarly, if the borrower choose to default indefinitely, their default benefit 'DB_2' will be a proportion of their total debt balance minus payments made, as denoted in equation (6b):

$$DB_2 = \lambda_P[(P_t * n) - (P_t * M_{D-1})] \qquad (6b)$$

Now that we have established the above equations, we can create utilities functions for each of the game's end nodes through which the potential payoffs to the borrower can be ascertained.

Utility if the student loan is paid off in full without a period of default:

If the game ends with the borrower pay off their student loan in full without ever defaulting, then the borrower will leave the game with the following utility function in which 'V_t' represents the individual's valuation of their loan debt. This loan value may include increased lifetime earnings associated with obtaining a college degree or other positive effects gained from a college education. The loan value is assumed to be a fixed amount that remains constant over the life of the loan and is shown below in equation (7);

$$V_t - TP \qquad (7)$$

Here, the individual's potential payoffs equate to their loan valuation minus the total payments paid to pay off the loan debt.

Utility if the student loan is paid off in full after a period of default:

If the game ends because the borrower pays off the loan in full after defaulting for a period of time, then the borrower will leave the game with the following utility function, as denoted by equation (8):

$$V_t + DB_1 - TP - DP \quad (8)$$

For this utility function, the borrower receives the positive utility related to their valuation of the loan plus the benefits incurred from defaulting minus the total payments made and the default penalty incurred.

Utility if the borrower defaults indefinitely:

If the game ends because the borrower chooses to default indefinitely, then the borrower will receive a potential payoff similar that in which the borrower pays off the loan in full after default. However an additionally penalty 'P' has been introduced. This penalty represents a fixed amount imposed upon the individual for defaulting indefinitely on their student loan debt. The penalty may include wage garnishments and tax refund withholdings imposed by the federal government as well as declines in credit scores and reductions in credit worthiness. The borrower's utility function in this scenario is denoted below in equation (9):

$$V_t + DB_2 - TP - DP - P \quad (9)$$

Thus, the individual's potential payoff becomes their valuation of the loan plus the benefits received from the added income associated with defaulting minus the total payments the borrower made, the collection costs, and the penalty amount.

Given these potential payoffs, a number of parameters have also been established which when adjusted allow for the observance of changes to the individual's payoff potentials based upon different repayment scenarios. These adjustable parameters include: institution type,

repayment length, interest rate, month in which default occurs, number of months in default, and default penalty amount. It should be noted that institution type serves as a proxy for the borrower's total loan debt, given the above assumption that the borrower's debt level is equivalent to the average debt level of a given institution. Table 1 of the appendix provides a breakdown of the parameters and their values.

The next section will outline various simulations of the game, resultant potential payoffs and the borrower's decisions based off of them. This will be done by establishing certain parameters and observing how changes to these parameters impact the borrower's potential payoffs in order to determine instances in which a borrower will choose to default. This will help determine points at which it is in the strategic best interests for the borrower to default on their student loan debt and thus help explain why a borrower may make the decision to default.

V. Results

A number of simulations of the game were conducted in which different parameters were adjusted in order to observe how changes to the repayment scenarios may impact the potential payoffs of the borrower. Specifically, it was observed that, for all institution types, the potential payoffs from defaulting indefinitely are reduced over time as the borrower moves farther into their repayment scheme. For example, the potential payoffs from indefinite default are lower for a borrower defaulting in the 60^{th} month of repayment than for a borrower default in the 36^{th} month of repayment. This is because earlier in the repayment scheme the borrower has the potential to retain a greater benefit from defaulting, in the form of an increase to their income, than they can later on. As the borrower progresses farther into repayment they will have made a larger portion of their total possible payments, thus reducing their potential payoff for defaulting indefinitely. This also provides reasoning for why as many as one-third of all borrowers default

in the first five years of repayment (Baum, Ma, Pender, and Welch, 2016). Given that the potential payoff for default declines overtime, we would expect most borrowers who plan to default to do so early on, which current trends support. Figure 2 of the appendix provides a full breakdown of the payoff potentials based on varied default months. Similarly, simulations further indicate that the penalty required to make the borrower indifferent between paying in full and defaulting indefinitely, such that their potential payoffs from each are equivalent, may be lowered over time as the borrower gets closer to paying off the loan balance. This is a result, as discussed above, of the potential payoffs from defaulting reducing over time.

Additionally, it is discovered that an increase to the loan's interest rate leads to an increase to the potential payoff for defaulting indefinitely and a reduction to the potential payoff for paying in full. This result is an illustration of how an increase to the monthly payment, based on the higher interest rate, makes defaulting more attractive given that the higher monthly payment will be associated with a greater increase to income in the months in which the borrower defaults. Table 3 of the appendix provides the borrower's potential payoffs when the interest rate is varied. Increases to the repayment length produce a similar effect. Table 4 of the appendix provides these values. Further, while lower penalties are required for lower initial debt levels, the overall ranking of borrower options remains unchanged bases on initial debt level alone. Meaning, regardless of the institution in which the borrower attends, all else held constant, their highest potential payoff will be yielded from defaulting indefinitely unless a suitable penalty is assessed. Table 5 of the appendix provides the potential payoffs for each institution tested. Finally, it is observed that at no point does the borrower yield the highest potential payoff from defaulting for a period of time before paying off the loan debt in full. This is because the collection costs associated with defaulting in addition to paying the full loan debt cannot be off

set by the benefit received from the months in which the borrower defaults. Likewise, the number of month in which the borrower is in default is not found to significantly change the potential payoffs available to the borrower.

VI. Conclusion

The game theory model originally put forth by Collins, Harrison, and Seiler (2015) allows us to illustrate the way in which individuals make decisions surrounding the repayment of their student loans. Further, this conceptualization allows for the identification of certain circumstances that may 'trigger' an individual to default on their student loans. From these findings, the conclusion can be drawn that there exist instances in which an individual's optimal choice may become to default on their student loans depending on the default penalty imposed upon them. This conclusion contradicts the common assumption that defaulting on a loan is a sub-optimal choice and has clear implications for policies surrounding loan repayment. In particular, given it has been established that there may be circumstances under which it is in the borrower's best interests to default on their student loans, then policy adaptations that help assist borrowers when these circumstances arise may be beneficial in order to avoid loan defaults.

Additionally, it is concluded that a significant penalty is appropriate for discouraging borrowers from defaulting on their student loan debt. This finding serves as support for the Department of Education's current practice of severely penalizing individuals who default. However, it is also found that the optimal penalty amount should decrease overtime as the borrower successfully pays down their loan balance. This serves to discourage borrowers from defaulting on their student loan debt while simultaneously ensuring that they are not being over penalized. This also suggests that it may be beneficial for current penalty schemes to be revaluated to assess whether they are adjusting properly based on the given repayment scenario.

Finally, further research should begin by quantifying the individual's valuation of their loan debt. For the purposes of this research, loan value was assumed to be an undetermined fixed amount. However, quantifying this value would allow for the potential payoffs available to the borrower to become more individualized. For example, an individual with degree X may value their loan higher than an individual with degree Y based off of the different earnings potentials of the two degrees. Accounting for these qualities would allow for the creation of more specific payoff potentials that reflect individual characteristics and decisions. Quantifying loan value may also allow for loan value to vary over time, since it is reasonable to assume that an individual may value their loan debt differently at different points in their life. Relaxing the assumption that monthly payments are fixed would also be a logically continuation of the research given the existence of several repayment options in which loan payments vary over time. Allowing for these changes in monthly payments would provide an opportunity to observe how an individual's potential payoffs vary by repayment option. Furthermore, it may be useful to parametrized the penalty for defaulting in order to analyze how the different components of the penalty should be allocated or may influence default decisions. For example, is a reduction in credit worthiness enough to discourage default or do wage garnishments prove more effective? Finally, while this research focuses on the behavior of borrowers of federally funded student loans, how borrowers behave in the private student loan market is an area that has yet to be adequately investigated. A model similar to this could be applied to the private market to observe individual default decisions.

VII. References

Avery, Christopher, and Sarah Turner. 2012. "Student Loans: Do College Students Borrow Too Much – Or Not Enough?" *Journal of Economic Perspective* 26(1): 165-192.

Baum, Sandy, Jennifer Ma, Matea Pender, and Meredith Welch. 2016. "Trends in Student Aid" The College Board 1-36.

Collins, Andrew J, David M. Harrison, and Michael J. Seiler. 2015. "Mortgage Modification and the Decision to Strategically Default: A Game Theoretic Approach." *Journal of Real Estate Research* 37(3): 439-470.

Cunningham, Alisa, and Gregory S. Kienzl. 2011. "Delinquency: The Untold Story of Student Loan Borrowing." Institute for Higher Education Policy 4-36.

Delisle, Jason, and Alex Holt. 2012. "Safety Net or Windfall? Examing Changes to Income-Based Repayment for Federal Student Loans." New America Foundation www.newamerica.net

Dynarski, Susan and Judith Scott-Clayton, (2013). "Financial aid policy: lessons from research." *Future of Children 23*(1), 67-91.

Dynarski, Susan, and Daniel Kreisman. 2013. "Loans for Educational Opportunity: Making Borrowing Work for Today's Students." The Hamilton Project 2-27. http://www.brookings.edu/research/papers/2013/10/21-student-loans-dynarski

Dynarski, Susan. 2015. "An Economist's Perspective on Student Loans in the United States." *CESifo Working Paper* no. 5579

Gicheva, Dora. 2011. "Dos the Student-Loan Burden Weigh into the Decision to Start a Family?" University of North Carolina at Greensboro Department of Economics Working Paper Series

Glater, Jonathan D. 2016. "Student Debt and the Siren Song of Systemic Risk." *Harvard Journal on Legislation* 53: 99-146.

Greene-Knapp, Laura, and Terry G. Seaks. 1992. "An Analysis of the Probability of Incentives." *The B.E. Journal of Macroeconomics* 8(1): 1-35.

Ionescu, Felicia A. 2008. "Consolidation of Student Loan Repayments and Default Default on Federally Guaranteed Student Loans." *The Review of Economics and Statistics* 404-411.

Johnstone, Bruce. 2009. "Conventional Fixed-schedule versus Income Contingent Repayment Obligations: Is There a *Best* Loan Scheme?" *Higher Education in Europe* 34(2): 189-199.

Lochner, Lance, and Alexander Monge-Naranjo. 2014. "Student Loans and Repayment: Theory, Evidence and Policy." *Federal Reserve Bank of St.Louis Working Paper Series.*

Ma, Jennifer, Sandy Baum, Matea Pender, and Meredith Welch. 2016. "Trends in College Pricing." The College Board 1-36.

Rothstein, Jesse, and Cecilia Elena Rouse. 2011. "Constrained after college: Student loans and early-career occupational choices." *Journal of Public Economics* 95: 149-163.

Steiner, Matt, and Natali Teszler. 2005. *The Characteristics Associated with Student Loan Default at Texas A&M University.* Austin, TX: Texas Guaranteed in association with Texas A&M University.

Appendix

Table 1. Adjusted Parameters and Their Value Ranges
This table denotes the individual parameters that were adjusted to produce different repayment scenarios and the range over which these values were adjusted. Here, principle balance is reflective of the institution type attended.

Parameter	Range
Principle balance	$9,962 - $34,722
Repayment length	60 months – 360 months
Interest rate	2.99% - 8.99%
Default month	12 months – 96 months
Months in default	1 month – 24 months

Table 2. Default Month Adjusted

This table denotes changes to the borrower's potential payoffs when the month in which the borrower defaults is varied, all else held constant**.**

Repayment length	Institution type	Interest rate	Default month	Months in default	Principle balance	Monthly Payment	No default	Defaul then pay	Indef. Default	Penalty
120	2yr, public	0.0399	12	3	9962	$100.81	$12,097.57	$14,102.95	$2,228.76	$14,326.33
120	2yr, public	0.0399	24	3	9962	$100.81	$12,097.57	$13,808.26	$708.83	$12,806.39
120	2yr, public	0.0399	36	3	9962	$100.81	$12,097.57	$13,513.56	($811.11)	$11,286.46
120	2yr, public	0.0399	48	3	9962	$100.81	$12,097.57	$13,218.86	($2,331.05)	$9,766.52
120	2yr, public	0.0399	60	3	9962	$100.81	$12,097.57	$12,924.17	($3,850.99)	$8,246.58
120	2yr, public	0.0399	72	3	9962	$100.81	$12,097.57	$12,629.47	($5,370.93)	$6,726.64
120	2yr, public	0.0399	96	3	9962	$100.81	$12,097.57	$12,040.08	($8,410.81)	$3,686.76
120	4yr, public	0.0399	12	3	26946	$272.69	$32,722.45	$38,146.78	$6,028.54	$38,750.99
120	4yr, public	0.0399	24	3	26946	$272.69	$32,722.45	$37,349.66	$1,917.29	$34,639.74
120	4yr, public	0.0399	36	3	26946	$272.69	$32,722.45	$36,552.54	($2,193.96)	$30,528.49
120	4yr, public	0.0399	48	3	26946	$272.69	$32,722.45	$35,755.42	($6,305.21)	$26,417.24
120	4yr, public	0.0399	60	3	26946	$272.69	$32,722.45	$34,958.30	($10,416.46)	$22,305.99
120	4yr, public	0.0399	72	3	26946	$272.69	$32,722.45	$34,161.18	($14,527.71)	$18,194.74
120	4yr, public	0.0399	96	3	26946	$272.69	$32,722.45	$32,566.94	($22,750.21)	$9,972.25
120	4yr, private	0.0399	12	3	29214	$295.64	$35,476.65	$41,357.53	$6,535.95	$42,012.59
120	4yr, private	0.0399	24	3	29214	$295.64	$35,476.65	$40,493.31	$2,078.66	$37,555.31
120	4yr, private	0.0399	36	3	29214	$295.64	$35,476.65	$39,629.10	($2,378.62)	$33,098.02
120	4yr, private	0.0399	48	3	29214	$295.64	$35,476.65	$38,764.89	($6,835.91)	$28,640.74
120	4yr, private	0.0399	60	3	29214	$295.64	$35,476.65	$37,900.68	($11,293.20)	$24,183.45
120	4yr, private	0.0399	72	3	29214	$295.64	$35,476.65	$37,036.47	($15,750.48)	$19,726.16
120	4yr, private	0.0399	96	3	29214	$295.64	$35,476.65	$35,308.05	($24,665.05)	$10,811.59
120	4yr, for-profit	0.0399	12	3	34722	$351.38	$42,165.40	$49,155.06	$7,768.23	$49,933.64
120	4yr, for-profit	0.0399	24	3	34722	$351.38	$42,165.40	$48,127.91	$2,470.57	$44,635.98
120	4yr, for-profit	0.0399	36	3	34722	$351.38	$42,165.40	$47,100.76	($2,827.09)	$39,338.32
120	4yr, for-profit	0.0399	48	3	34722	$351.38	$42,165.40	$46,073.62	($8,124.75)	$34,040.65
120	4yr, for-profit	0.0399	60	3	34722	$351.38	$42,165.40	$45,046.47	($13,422.41)	$28,742.99
120	4yr, for-profit	0.0399	72	3	34722	$351.38	$42,165.40	$44,019.32	($18,720.07)	$23,445.33
120	4yr, for-profit	0.0399	96	3	34722	$351.38	$42,165.40	$41,965.02	($29,315.40)	$12,850.01

Note on Table 2: Numbers in parentheses are used to denote a negative value to illustrate the trend in which defaulting indefinitely begins with a positive potential payoff which is *added* to the value of the loan. Over time this value becomes negative and is *subtracted* from the loan value. All other potential payoff and penalty values remain negative over the entire game and are subtracted from the loan value. Penalties are calculated in order to produce indifference between defaulting and paying in full.

Table 3. Interest Rate Adjusted

This table denotes changes to the borrower's potential payoffs when interest is varied, all else held constant.

Repayment length	Institution type	Interest rate	Default month	Months Defaulted	Principle	Monthly Payment	No default	Defaul then pay	Indef. Default	Penalty
120	2yr, public	0.0299	36	3	9962	$96.15	$11,537.74	$13,000.51	$885.88	$10,651.86
120	2yr, public	0.0399	36	3	9962	$100.81	$12,097.57	$13,513.56	$811.11	$11,286.46
120	2yr, public	0.0499	36	3	9962	$105.61	$12,673.65	$14,041.51	$734.18	$11,939.48
120	2yr, public	0.0599	36	3	9962	$110.55	$13,265.83	$14,584.22	$655.09	$12,610.74
120	2yr, public	0.0699	36	3	9962	$115.62	$13,873.91	$15,141.49	$573.88	$13,300.03
120	2yr, public	0.0799	36	3	9962	$120.81	$14,497.67	$15,713.13	$490.58	$14,007.09
120	2yr, public	0.0899	36	3	9962	$126.14	$15,136.86	$16,298.92	$405.22	$14,731.64
120	4yr, public	0.0299	36	3	26946	$260.07	$31,208.19	$35,164.79	$2,396.19	$28,811.99
120	4yr, public	0.0399	36	3	26946	$272.69	$32,722.45	$36,552.54	$2,193.96	$30,528.49
120	4yr, public	0.0499	36	3	26946	$285.67	$34,280.69	$37,980.59	$1,985.86	$32,294.83
120	4yr, public	0.0599	36	3	26946	$299.02	$35,882.47	$39,448.53	$1,771.94	$34,110.52
120	4yr, public	0.0699	36	3	26946	$312.73	$37,527.25	$40,955.89	$1,552.28	$35,974.96
120	4yr, public	0.0799	36	3	26946	$326.79	$39,214.44	$42,502.12	$1,326.96	$37,887.48
120	4yr, public	0.0899	36	3	26946	$341.19	$40,943.37	$44,086.59	$1,096.06	$39,847.31
120	4yr, private	0.0299	36	3	29214	$281.96	$33,834.93	$38,124.55	$2,597.88	$31,237.05
120	4yr, private	0.0399	36	3	29214	$295.64	$35,476.65	$39,629.10	$2,378.62	$33,098.02
120	4yr, private	0.0499	36	3	29214	$309.72	$37,166.04	$41,177.35	$2,153.01	$35,013.04
120	4yr, private	0.0599	36	3	29214	$324.19	$38,902.63	$42,768.85	$1,921.08	$36,981.55
120	4yr, private	0.0699	36	3	29214	$339.05	$40,685.85	$44,403.08	$1,682.93	$39,002.92
120	4yr, private	0.0799	36	3	29214	$354.29	$42,515.05	$46,079.45	$1,438.65	$41,076.40
120	4yr, private	0.0899	36	3	29214	$369.91	$44,389.50	$47,797.29	$1,188.31	$43,201.19
120	4yr, for-profit	0.0299	36	3	34722	$335.12	$40,214.16	$45,312.54	$3,087.68	$37,126.48
120	4yr, for-profit	0.0399	36	3	34722	$351.38	$42,165.40	$47,100.76	$2,827.09	$39,338.32
120	4yr, for-profit	0.0499	36	3	34722	$368.11	$44,173.32	$48,940.92	$2,558.93	$41,614.39
120	4yr, for-profit	0.0599	36	3	34722	$385.31	$46,237.33	$50,832.48	$2,283.28	$43,954.04
120	4yr, for-profit	0.0699	36	3	34722	$402.97	$48,356.75	$52,774.82	$2,000.23	$46,356.52
120	4yr, for-profit	0.0799	36	3	34722	$421.09	$50,530.83	$54,767.26	$1,709.89	$48,820.94
120	4yr, for-profit	0.0899	36	3	34722	$439.66	$52,758.69	$56,808.98	$1,412.36	$51,346.33

Note on Table 3 and subsequent tables: Payoff and penalty values are negative and are therefore subtracted from the value of the loan.

Table 4. Repayment Length Adjusted
This table denotes changes to the borrower's potential payoffs when repayment length is varied, all else held constant.

Repayment length	Institution type	Interest rate	Default month	Months in default	Principle balance	Monthly Payment	No default	Defaul then pay	Indef. Default	Penalty
60	2yr, public	0.0399	20	3	9962	$183.42	$11,005.23	$12,307.90	$1,302.67	$9,702.56
120	2yr, public	0.0399	40	3	9962	$183.42	$22,010.45	$22,419.50	$409.04	$21,601.41
240	2yr, public	0.0399	80	3	9962	$183.42	$44,020.91	$42,642.70	$1,378.20	$42,642.70
300	2yr, public	0.0399	100	3	9962	$183.42	$55,026.13	$52,754.30	$2,271.83	$52,754.30
360	2yr, public	0.0399	120	3	9962	$183.42	$66,031.36	$62,865.91	$3,165.45	$62,865.91
60	4yr, public	0.0399	20	3	26946	$496.13	$29,767.80	$33,291.36	$3,523.56	$26,244.24
120	4yr, public	0.0399	40	3	26946	$496.13	$59,535.60	$60,642.02	$1,106.42	$58,429.18
240	4yr, public	0.0399	80	3	26946	$496.13	$119,071.20	$115,343.33	$3,727.87	$115,343.33
300	4yr, public	0.0399	100	3	26946	$496.13	$148,839.00	$142,693.98	$6,145.02	$142,693.98
360	4yr, public	0.0399	120	3	26946	$496.13	$178,606.80	$170,044.64	$8,562.16	$170,044.64
60	4yr, private	0.0399	20	3	29214	$537.89	$32,273.31	$36,093.44	$3,820.13	$28,453.17
120	4yr, private	0.0399	40	3	29214	$537.89	$64,546.61	$65,746.16	$1,199.54	$63,347.07
240	4yr, private	0.0399	80	3	29214	$537.89	$129,093.23	$125,051.59	$4,041.64	$125,051.59
300	4yr, private	0.0399	100	3	29214	$537.89	$161,366.53	$154,704.30	$6,662.24	$154,704.30
360	4yr, private	0.0399	120	3	29214	$537.89	$193,639.84	$184,357.01	$9,282.83	$184,357.01
60	4yr, for-profit	0.0399	20	3	34722	$639.30	$38,358.11	$42,898.49	$4,540.38	$33,817.73
120	4yr, for-profit	0.0399	40	3	34722	$639.30	$76,716.22	$78,141.92	$1,425.70	$75,290.51
240	4yr, for-profit	0.0399	80	3	34722	$639.30	$153,432.43	$148,628.78	$4,803.65	$148,628.78
300	4yr, for-profit	0.0399	100	3	34722	$639.30	$191,790.54	$183,872.21	$7,918.33	$183,872.21
360	4yr, for-profit	0.0399	120	3	34722	$639.30	$230,148.65	$219,115.64	$11,033.01	$219,115.64

Note on Table 4: In this scenario default month has been parametrized so that the borrower defaults one-third of the way through the repayment period, regardless of repayment length.

Table 5. Institution Type Adjusted

This table denotes changes to the borrower's potential payoffs when institution type is varied, all else held constant. This parameter is used to illustrate how payoffs vary based upon level of debt.

Repayment length	Institution type	Interest rate	Default month	Months in default	Principle balance	Monthly Payment	No default	Defaul then pay	Indef. Default	Penalty
120	2yr, public	0.0399	36	3	9962	$100.81	$12,097.57	$13,513.56	$811.11	$11,286.46
120	4yr, public	0.0399	36	3	26946	$272.69	$32,722.45	$36,552.54	$2,193.96	$30,528.49
120	4yr, private	0.0399	36	3	29214	$295.64	$35,476.65	$39,629.10	$2,378.62	$33,098.02
120	4yr, for-profit	0.0399	36	3	34722	$351.38	$42,165.40	$47,100.76	$2,827.09	$39,338.32