Essays on Legal Financial Institutions

by

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Abstract

An important focus of the financial literature has been the role of legal institutions in the development of financial markets, and its impact on the long-run economic growth and welfare.

This work contributes to this literature by studying the impact of three legal institutions on asset prices, the decisions of firms and households, and the sustainability of regulated markets. The first legal institution considered in this thesis is the personal bankruptcy code. Specifically, I study how the protection that this institution provides to households impacts the loan market equilibrium. The second legal institution is the total allowable catch (TAC) in the fishing industry. This institution limits the annual catch of a renewable resource (fish) in a geographic area. I research how to define the exploitation limits incorporating financial incentives to the problem, and if this institution can help to achieve a financially and ecologically sustainable harvest. Finally, the third legal institution studied in this thesis is the tax code, specifically, how the treatment of corporate losses, and the possibility of carrying them forward in time, ties in with the future equity risk and return of a firm.

All institutions are described in detail and discussed empirically and theoretically. The results of my research show that they have a significant impact on the decisions of market agents and in the determination of asset prices. From the study of the personal bankruptcy code, I find that higher household protection at bankruptcy relates to a lower quantity of loans to households, and lower delinquency rates, indicating that riskier households are being priced out of the market, affecting their welfare. With respect to the TAC regulation, I find that for a representative fishery it is optimal to preserve a significant part of the resource for future harvesting, even in the presence of multiple sources of uncertainty. Finally, after evaluating the effect of Tax Loss Carry Forwards on the firms' risk and returns, I find that its magnitude is highly significant in positively forecasting standard equity risk measures, that they significantly predict equity returns, even when accounting for standard measures of risk.

Lay Summary

This thesis studies the impact of three legal institutions on asset prices, the decisions of firms and households, and the sustainability of regulated markets. First, I study the personal bankruptcy code, and how it affects the household's and lenders' loans decisions, and consequently, the equilibrium of loan markets. Second, I study the regulation of the harvest of fish and how the use of a total allowable catch can help to achieve a financially and ecologically sustainable exploitation. Finally, I study the tax code, specifically, how the treatment of corporate losses and the possibility of carrying them forward in time ties in with the equity risk and return.

The overall results of my research indicate that these legal institutions have a significant impact on the decisions of economic agents and that their implications are relevant for investors, households, lenders, and governmental institutions.

Preface

The research project in Chapter 2 was solely performed and identified by the author.

The research included in Chapter 3 is based on unpublished research with Eduardo S. Schwartz (Simon Fraser University). In this co-authored project, both authors worked on all aspects of the paper. My personal share of contribution to this research amounts to about one half.

The research included in Chapter 4 is based on unpublished research with Jack Favilukis (University of British Columbia) and Ron Giammarino (University of British Columbia). In this co-authored project, all authors worked on all aspects of the paper. My personal share of contribution to this research amounts to about one third.

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Chapter 1

Introduction

An important focus of the financial literature is the study of the role of law in the development of financial markets, and its impact on long-run economic growth and welfare of the agents. As Beck and Levine (2005) mention:

"... financial markets in countries where legal systems enforce private property rights, support private contractual arrangements and protect the legal right of investors, savers are more willing to finance firms and financial markets flourish. In contrast, legal institutions that neither support private property rights nor facilitate private contracting inhibit corporate finance and stunt financial development".

The objective of this thesis is to study the impact of three legal institutions on asset prices, the decisions of firms and households, and the economic sustainability of regulated markets. These institutions directly define property rights, support contractual arrangements, and define the tax payment of a firm, key legal regulations in place for financial markets around the world.

The first legal institution I study is the personal bankruptcy code, in particular, how the characteristics of this institution affect the households' and lenders' loans choices, and consequently, the loan market equilibrium. The second legal institution that I study is the regulation of the harvest of natural resources, with a focus on the potential of this institution to help achieve a financially and ecologically sustainable exploitation of renewable natural resource (e.g. fish). The third legal institution I study is the tax code, specifically, how the treatment of corporate losses for tax shield benefit interacts with the firm's equity risk and return.

The results of my research show that these legal institutions have a significant impact on the decisions of market agents and in the determination of asset prices, that they are relevant not only for academics, but also for investors, households facing financial distress, lenders evaluating granting policies, and governmental institutions designing regulations.

The first studied legal institution is the U.S. personal bankruptcy code. Whitin the code there are several exemption laws that determine how much of the household's wealth will be shared with the lenders in case of default on their unsecured obligations. Specifically, the bankruptcy code allows the household to keep a fraction of its wealth, and in the case that its wealth is fully exempted, their unsecured loans will be fully discharged providing them with a fresh financial start.

In the personal bankruptcy code, the most important form of protection for the household assets - and the main focus of my research - is the homestead exemption[1], which protects the household's home equity and varies widely at state level across the U.S. For example, if a household's home equity is below the state's homestead exemption, the household will keep the full value of its home equity [2] and its unsecured debt will be discharged. On the other hand, if the household's home equity is above the state's homestead exemption, the house will be liquidated to repay (fully or partially) the unsecured loans. Therefore, the magnitude of the homestead exemption is extremely important to determine the outcome of the personal bankruptcy procedure for the household and the lender. A more detailed example and discussion of the legal aspects of the homestead exemption is included in Chapter 2.

Based on its impact on the outcome of the bankruptcy procedure, the homestead exemption affects the households demand for unsecured loans, its housing consumption and financing choices, as it determines the housing net wealth that the household will have at bankruptcy. On the other hand, lenders will act rationally accordingly to the homestead exemption magnitude in the state that the household is located. As a higher exemption affects the recovery that the lenders will have at bankruptcy, the lender will incorporate the magnitude of the homestead exemption into their pricing decisions and supply of loans, potentially affecting the access that households will have to loans.

One may conjecture that a higher exemption will increase moral hazard on the part of the households, leading to a higher demand for loans from riskier borrowers, and to higher delinquency rates. The lenders will respond with higher interest rates, therefore, it is not clear what the aggregate effect of a higher homestead exemption magnitude will be in equilibrium as these two effects will compete in opposite directions. Chapter 2 of this thesis is an empirical and theoretical analysis of the impact of the homestead exemption on the secured and unsecured loan markets.

The empirical analysis shows that states with a higher homestead exemption have lower loans to households, and lower delinquency rates. For the interest rates I find that they are lower in states with higher homestead exemption, but the effect is not statistically significant. These results are interesting and somewhat counter-intuitive, because a higher protection may be expected to increase both delinquency and loan rates as the default punishment shrinks and riskier households increase their loan demand.

In the theoretical analysis I show that personal bankruptcy is a complex option, whose value and execution depends on house prices, secured and unsecured loans, their respective interest rates, and the homestead exemption. Most importantly, the empirical findings are explained by a theoretical model

[1] The homestead exemption also exists in other countries, for example, in Canada it varies from \$0 in Ontario to \$40,000 in Alberta

[2] The housing net wealth is the difference between the market value of the primary residency of the household and the mortgage outstanding balance.

in which an increase in the lender's monitoring results in a change from a pooling to a separating equilibrium, that is, from an equilibrium on which households are pooled by loan type regardless of their riskiness, to one on which they are separated by loan type and default riskiness. The change in the equilibrium characteristics ends up reducing the loans to riskier households and consequently reducing both the overall loans granted and the delinquency rate. The model also shows that a higher homestead exemption relates to a higher demand for housing, resulting in higher housing prices in the equilibrium. The model also implies a reduction of overall social welfare as the protection becomes more generous.

The second legal institution I study in this thesis is the total allowable catch (TAC) for fisheries, which regulates the annual limit of the total harvest for a natural resource, specifically a fish specie, in a defined geographical region. My co-author and I propose and calibrate an economic model to define the optimal limit to the annual harvest. We evaluate the consequences of the proposed approach by simulating the dynamics of the resource if the proposed methodology is implemented. The results of this exercise indicate that our approach is economically sustainable in the long run.

The fishing industry is an interesting and important example of a regulated natural resource with strong implications for employment and sustainability, as it provides a living for 10 percent of the world's population (Greiff (2017)). Beyond its clear importance, Ye and Gutierrez (2017) document that more than 30% of the fish stocks have been overfished during the last decade, even with several regulation efforts in place. This persistent problem is the main motivation of our work.

This research is presented in Chapter 3 and has two main components. First, we theoretically develop a stochastic optimal control approach to determine the harvest policy that maximizes the value of the resource, we model a fishery as a complex function on the variables underlying the value of the industry, in this case, the resource stock (biomass) and the fish price. Uncertainty is introduced in the analysis by allowing these variables to follow dynamic stochastic processes.

The practical implications of the proposed model are also addressed in this work by applying it to the British Columbia halibut fishery. The required data to calibrate and implement the model is obtained combining multiple sources of information and includes time series for the halibut biomass (stock), total harvest (landings), and the whole sale price for commercial fishing boats.

The model results show that for the representative halibut fishery in British Columbia it is optimal to preserve the resource for future harvesting, and that if the significant negative shocks occur to the resource then it is optimal to drastically reduce exploitation, even fully stopping the harvest in some states.

Our results also show that the optimal harvesting policy exhibits strong financial incentives to avoid the extinction and preserve the natural resource for future extraction. These results are not only useful for fisheries, but most importantly, they are also useful for governments and regulators, as it formalizes a quantitative model to determine the total allowable catch (TAC), based on real available data, that balances sustainability and economic incentives.

The final legal institution studied in this work is the corporate tax code. My co-authors and I focus on the Tax Loss Carry Forwards (TLCFs), which arise because the corporate tax code does not allow Net Operating Losses (NOLs) to automatically generate payments from the government to the firm. Instead, the tax coded allows operational losses to generate immediate refunds if the firm can apply the losses to prior taxable income (Tax Loss Carry Backs), or if this is not possible, to carry them forward. The consensus, starting with Modigliani and Miller (1963), is that corporate taxes and tax shields reduce a firm's equity risk. In this work we show that this is not necessarily the case.

This research is presented in Chapter 4 and is also separated in two main components. First, a theoretical study of the relationship between TLCFs and the firm's equity return. We start with a one period binomial model and show that the relationship between risk and TLCFs is non-monotonic. We then show that if the firm has existing non-TLCF tax shields, then the relationship between TLCFs and risk may be strictly positive rather than non-monotonic. We then solve a realistic, dynamic model of a firm, and calibrate it to the data. In this model, the relationship between TLCFs an risk is positive and quantitatively important for risk.

In the second part of this work, my co-authors and I empirically study the relationship between the Tax Loss Carry Forward and asset prices. We show that TLCFs are positively related to standard measures of risk, like factor betas and future volatility. We then show that TLCFs are also positively related to equity returns. Importantly, in our regression analysis of return and TLCFs we find that TLCFs can predict future returns even when we condition on standard measures of risk. Hence, our study shows that the TLCF is indeed significant for the firm's equity return and risk and that the inclusion of standard measures of risk account for some but not all the risk generated by TLCFs.

The remainder of this thesis is organized as follows. The research on the personal bankruptcy code is presented in Chapter 2. The research on the total allowable catch (TAC) for fisheries is presented in Chapter 3. Chapter 4 includes my research on Tax Loss Carry Forwards and finally, Chapter 5 concludes.

Chapter 2

Personal Bankruptcy, Loan Market Equilibrium, and House Prices

2.1 Introduction

The corporate bankruptcy code has been an important focus of the financial literature, but recently the personal bankruptcy code has drawn significant attention, as its importance became clear during the Great Recession (Mian and Sufi (2010)). During this period of economic downturn, the households ability to meet their financial obligations eroded, consequently making the option to file for personal bankruptcy valuable for them, as it provides protection to the households' assets from the lenders collection.

In particular, a household can file for either Chapters 7 or 13 of the personal bankruptcy code. For both chapters all the lenders' collection efforts must stop. If it chooses Chapter 13, the household proposes a repayment schedule, and its liabilities are reorganized without seizing any assets. If the household chooses to file for Chapter 7 instead, it keeps a fraction of their assets, while a fraction of their unsecured loans may be discharged.

Under Chapter 7, the households will keep a fraction of their assets determined by state-specific laws called exemptions. Exemptions can be classified into two main categories: personal exemptions, which protect the household's personal belongings[1], and the homestead exemption, which protects the household's home equity[2] of its primary residence.

As Berkowitz and Hynes (1999) show, the homestead exemption is the most important protection for the households at bankruptcy, in magnitude and use. However, it is important to notice that the magnitude of this exemption varies significantly across states, thus directly affecting the financial

[1] The personal exemption protects cash, jewelry, clothes, furniture, and other personal property.

[2] The home equity is defined as the net value between the real estate fair value and the outstanding balance of the loans secured by this property.

benefit from this legal procedure for similar households in different locations[3]. Thus, the homestead exemptions has the potential to significantly affect the behavior of households and lenders, as the outcome of the bankruptcy procedure drastically changes depending on the location of the household.

For the households, a more generous homestead exemption increases the households' home equity that they will keep after bankruptcy, while increasing the possibility of a significant discharge of unsecured loans.

For the lenders, a more generous homestead exemption increases the credit risk of these loans, given that the recovery after bankruptcy will be lower, and consequently they may increase the charged rates or monitoring in order to reduce their expected credit losses[4].

In this work I study the personal bankruptcy procedure. Specifically, how the magnitude of the homestead exemption affects the households demand for loans, their housing consumption and financing choices. I also study how the magnitude of the homestead exemption relates to the lenders' decisions, specifically how it affects their incentives to monitor in the presence of asymmetric information.

To fulfill my goal I develop an empirical and theoretical analysis of the impact of the homestead exemption on the secured and unsecured loan markets.

In the empirical analysis, I look to quantify the relationship between the magnitude of the homestead exemption, household secured and unsecured loans and house prices[5]. The results indicate that there is a positive and significant correlation between housing prices and the homestead exemption. Additionally, in states with a higher homestead exemption, banks issue fewer loans to households, and these loans exhibit lower delinquency ratios.

Although the FFIEC data includes interesting information of the mortgage loans in the banks' balance sheet at state level, unfortunately no information is provided on if they are securitized. Although this procedure affects the mortgage interest rates and the bank's granting policies, as Ghent

[3]Consider a household whose sole asset is its home, valued at $100,000, with a mortgage outstanding of $70,000. Hence, the home equity, the net between the house value and the mortgage debt is $30,000. The household also owes $30,000 from an unsecured loan. If the household decides to file for Chapter 7 and happens to be situated in North Dakota, the homestead exemption will then be $100,000, and the home equity will in turn be fully protected. In such a case, the household will keep its house, and the unsecured loan will be fully discharged despite having wealth to repay. If the same household is located in Missouri, were the homestead exemption is $15,000 (as the home equity is not fully exempted), the house is sold for $100,000, the secured lender receives $70,000, and the remaining $30,000 are shared between the household (who keeps the exempted amount of $15,000), and the unsecured lender, who recovers the remaining $15,000.

[4]Although secured loans have priority during bankruptcy, there are several costs related to foreclosing the property in such situation, hence making the repossession process longer and more expensive, as Berkowitz and Hynes (1999) documented. In turn, the riskiness of the secured debt is also affected by the personal bankruptcy procedure, even if these loans are finally repaid.

[5]In order to address this goal, I constructed both a state- and national-level panel database for the U.S., combining lending data from the Federal Financial Institutions Examination Council (FFIEC) with the household characteristics from the Bureau of Economic Activity, the Census Bureau, the American Community Survey, and the Panel Study of Income Dynamics. It is important to mention that significant changes to the personal bankruptcy procedure were made by the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA). This act increased the filing cost to be paid by the households, made credit counseling mandatory, and, most importantly, allowed only households whose income is below the state median to be able to file for Chapter 7. Based on these significant changes within the bankruptcy code, the empirical analysis presented focuses on the ten-year period between 2006 and 2016.

(2011) shows, my work focuses on cases on which the households have positive home equity, so they file for Chapter 7 to protect their house. In such case, the mortgage loan is fully repaid by either the household or the trustee, as positive home equity implies that the value of the house is enough to repay the mortgage. My analysis focuses mostly on the effects of the homestead exemption in unsecured loans and house prices, as the recovery after bankruptcy of these loans is directly determined by the homestead exemption.

Although the FFIEC data includes interesting information of the mortgage loans in the banks' balance sheet at state level, unfortunately no information is provided on whether or not they are securitized. Although securitization affects the mortgage interest rates and the bank's granting policies, as Ghent (2011) shows, my work focuses on cases on which the households have positive home equity, so they file for Chapter 7 to protect their house. In such cases, the mortgage loan is fully repaid by either the household or the trustee, as positive home equity implies that the value of the house is enough to repay the mortgage. My analysis focuses mostly on the effects of the homestead exemption in unsecured loans and house prices, as the recovery after bankruptcy of these loans is directly determined by the homestead exemption.

This findings are interesting as the homestead exemption makes bankruptcy more attractive to households, so an increase in the exemption should increase the demand from households with higher default probability, thus negatively affecting the riskiness of the loan pool, but it will also affect the incentives of the lender, as the loans delivery becomes riskier and lower on expectation. To understand the economic forces behind these results, I develop a theoretical model.

For the theoretical analysis, I follow Mitman (2016) in terms of constructing an equilibrium model; I include households facing idiosyncratic income risk as well as a representative lender (bank) who competitively supplies loans. Households get utility from non-durable and housing consumption, and use secured and unsecured loans in order to finance consumption. The households have the option to file for bankruptcy with a homestead exemption that protects their home equity.

The lender is assumed to be initially unable to observe the riskiness of the household's income, however it has the option to invest in a monitoring technology, and eliminate this information asymmetry[6]. If the bank does not invest in the monitoring technology, the lending market corresponds to a pooling equilibrium, on which the households pay the same interest rate for secured and unsecured loans. If the bank invests in the monitoring technology it will deviate to a separating equilibrium. This is, the bank will offer a unique contract to each household type, for secured and unsecured loans.

The economic mechanism of the model indicates that a more generous homestead exemption will increase the demand for housing, as the household will keep a greater amount of its home equity during financial distress. The exemption increase also makes unsecured loans more likely to be discharged at bankruptcy, in turn boosting the lender's potential credit losses.

[6]These choices are consistent with the concern expressed by the New York Bankers Association in regards when an increase in the state's exemption was discussed: *"Increasing exemptions will cause creditors to re-examine their underwriting guidelines, limiting the numbers of consumers and small businesses deemed credit-worthy". New York Bankers Association 2012 (Cerqueiro et al. (2016))*

If the bank lends without knowing the household's type, households with higher income risk pool with the less risky ones. If the homestead exemption rises, the risky households' demand for unsecured loans increases, as the bankruptcy benefit increases. On the other hand, the low risk households' unsecured loans demand goes down, as the bank increases the interest rate charged. Consequently, for a higher homestead exemption, the pooling total amount will increase, as does the interest rate, and the delinquency ratios. This results are inconsistent with the findings of my empirical analysis.

Now, if the bank optimally invest in the monitoring technology, the bank will offer a unique unsecured loan contract for each household type. The low risk households' interest rate will fall in comparison to the pooling equilibrium, as they are no longer priced together with riskier households, so safer households will increase their demand for unsecured loans. In contrast, the risky households will now face a higher unsecured loan rate, and consequently will reduce their leverage. The model results show that for most of the tested parametrizations, these combined effects generate an overall decrease in the amount of loans, with an improvement in the overall credit quality of the loan portfolio. This reduction is consistent with the empirical evidence showing that a higher exemptions is related to lower fraction of secured loans issued, with lower interest rates, lower delinquency, and higher overall housing prices.

To conclude, this paper contributes to the literature by studying the impact of the magnitude of the homestead exemption on the household's and lender's problem, by presenting a deeper analysis of the lenders' problem and incentives, by including information asymmetry and household heterogeneity in a theoretical setting, and by finding that the observed cross-sectional patterns on the secured and unsecured loan markets are consistent with an increase in the lenders' monitoring efforts.

2.1.1 Legal and Institutional Background

Laws covering personal bankruptcy were last modified in formulating the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA), which started from a presumption of abuse presented by the lenders. BAPCPA made several changes, specially to the filing process, increasing its cost and complexity, and making financial counseling mandatory.

My work focuses on Chapter 7, which starts when the household visits a state licensed financial counselor. The couselor evaluates the household's asset and liabilities, and the overall eligibility for each personal bankruptcy chapter. Among the eligibility requirements, the most important is the state income mean test, design to allow only households whose income is below the state's income mean to file.

If the financial counselor concludes that the household is eligible for Chapter 7, it will collect the required documentation and file its case with the state legislature. A state Trustee will be assigned to the case, and will notify all the involved lenders that their collection efforts must stop.

In Chapter 7 the secured lenders can enforce claims against assets that they directly financed. The situation is more complex for the unsecured lenders, as their recovery after default will be directly related to the magnitude of the non-exempted assets. Then the Trustee evaluates the value of the household's assets, and based on the state specific exemption laws, the Trustee determines the unexempt value of the asset. If this unexempt value is large enough to generate a positive recovery to the lenders, the asset is liquidated. The distribution of the unexempted value among the lenders is defined by the Trustee, based on the outstanding loan amount and seniority.

In particular, for the focus of my work, the homestead exemption, if the household's home equity value of its primary residency is above the homestead exemption, the residency will be liquidated, the secured lender is fully repaid first, then the household receives the exempted value, and finally, the remaining unexempted value will go to the unsecured lenders.

After the Trustee finalizes the valuation and distribution of the household assets, the case is closed and all unpaid unsecured debt is discharged. Under Chapter 7 the household's future earnings are competently protected, and, if required, the household will be allowed to file again for Chapter 7 after 8 years.

Although it is beyond the scope of my work, I briefly describe the Chapter 13 of the personal bankruptcy code. In this chapter, the Trustee does not liquidate any of the household's asset, but evaluates a 3 to 5 years repayment plan, calculated using estimations of the household's expected future income and living expenses. At the end of the proposed plan, any remaining unsecured debt is discharged. If the repayment plan is in place, any failure to meet the agreed payments will withdraw the case and the lenders will be allowed to reinstate their collecting efforts.

After the personal bankruptcy case is closed, the household credit report will record the Chapter 13 case information for seven years, and the Chapter 7 information for ten years.

2.1.2 Related Literature

My work contributes to the literature studying the relation between the homestead exemption magnitude and the unsecured lending to households. Gropp et al. (1997) find that in states with higher homestead exemptions, households with lower wealth are more likely to be denied unsecured loans. Severino and Brown (2017) use the Federal Reserve Bank of New York Consumer Credit Panel/Equifax (CCP) debt balances from 1999 to 2005, and the changes to the homestead exemption at state level, finding that an increase in the homestead exemption relates to higher credit card debt holdings by the households. Grant (2010) use data from the consumer expenditure survey (CEX) from 1980 to 2003, finding that an increase in the homestead exemption reduces the average level of unsecured debt held, and such effect disappears for homeowners. All of these works use data for the pre-Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA) period, where debtors of all incomes levels could file for bankruptcy under Chapter 7. This paper presents novel results by focusing on how the lenders' behavior is affected by the exemption magnitude, and by the study of the post-BAPCPA period.

The relationship between the homestead exemption and the households' secured debt has also been studied, Lin and White (2001) use data from the Home Mortgage Disclosure Act (HMDA), from 1992 to 1997, to show that the probability of acceptance of a mortgage application is negatively related with the homestead exemption magnitude. Using similar data Pence (2006) finds that smaller mortgages are originated in states with more friendly foreclosure laws. Chomsisengphet and Elul (2006) use a random sample of the HMDA data, from 1999, to show that the use of a credit score to infer the applicants quality, reduces the probability of receiving a mortgage loan for low score households, and that after controlling for the credit score, the homestead exemption magnitude becomes not significant. Berkowitz and Hynes (1999) and Severino and Brown (2017) find no significant impact of the magnitude of the homestead exemption over the secured lending. My work contributes to this literature by evaluating the impact of the homestead exemption on secured bank lending for the post-BAPCPA period, and also by presenting a model on which secured lending is available for households while also house prices are an equilibrium result.

The effect of the homestead exemption on the secured and unsecured debt is a relatively new stream in the literature. Mitman (2016) studies the effect of the Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA) and the Home Affordable Refinance Program (HARP) on the bankruptcy rates and foreclosures. He finds that higher exemptions are related to lower bankruptcy rates but higher foreclosure rates. Hintermaier and Koeniger (2016) build a structural model to study the debt-portfolio choices over the life cycle, focusing on matching the observed cross-sectional distributions of secured and unsecured debt. The model is calibrated using the Survey of Consumer Finances (SCF), showing that home equity of unsecured debtors remains in most cases under the exempted amount. In both cases the lender problem does not incorporate any monitoring nor information asymmetry, and house prices are risky but exogenous. My work contributes by providing an analysis on how the lender's behavior and incentives are affected by the magnitude of the homestead exemption in the presence of information asymmetry, while also evaluating its effects on the lending market equilibrium and the house market equilibrium.

The model presented in the following sections shares several features with the literature that studies the macroeconomic effects of the personal bankruptcy code. In these models, the unsecured loan market is modeled following the work of Livshits et al. (2007) and Chatterjee et al. (2007). The secured loans model presented in my paper shares features with Athreya (2006), studied the role of bankruptcy exemptions, in a model with secured and unsecured credit, all households are homeowners. Jeske et al. (2013) construct a model on which households optimally consume housing, financed with a mortgage loan, which is priced incorporating default risk. My model shares several features with Mitman (2016), which includes a set of heterogeneous households facing idiosyncratic income risk. They use secured and unsecured loans to purchase real estate and non-durable consumption. As in my model, households default separately on unsecured and secured loans, at the cost of giving up their housing wealth, but as mentioned, my work contributes to the literature by analyzing the effect of higher homestead exemption on the lender's behavior and incentives, and consequently, on the loan market equilibrium.

Corradin et al. (2016) study the relationship between the homestead exemption and the demand for real estate. They use data from 1996 - 2006 and find that demand for real estate is relatively high, if the marginal investment in home equity is covered by the exemption. My work contributes to this topic as I provide a novel economic model on which real estate prices are determined in equilibrium, and therefore, it allows to analyze the impact of the magnitude of the homestead exemption on equilibrium house prices.

Recent work from Indarte (2019) revisits the relationship between the debt relief generosity and bankruptcy filings, using a extensive database on mortgage borrowers. Her results indicate that an increases in the homestead exemption only weakly incentivize further filing. Although in this work I study the lending market before the household filing for bankruptcy, my results relate to those in her work, as I show that a higher exemption reduces the lending to riskier households, as the delinquency ratios[7] of the loan portfolio indicate. Henceforth, the weak effect on filings may be the consequence of a more severe granting policy, that restricts the riskier households at the moment of entering the market, limiting the expected credit losses and bankruptcy filings.

A potential issue that the empirical analysis of the relation between the homestead exemption magnitude and house prices is reverse causality, as higher house prices could lead to the set of higher homestead exemptions. However, Hynes et al. (2004), and the novel work of Auclert et al. (2019), show that the historical homestead exemption magnitude is the best predictor of its current level, even when compared to contemporaneous economic indicators, which alleviates these concerns. This result is consistent with the evolution of the homestead exemption presented in Table 2.2, as it shows that many states have adjusted in few occasions the homestead exemption magnitude in the last 20 years, and in most cases it was an inflation adjustment, despite the significant changes in the real estate prices, and risk characteristics, observed during the same period.

Finally, my paper contributes to the extensive literature in credit monitoring and loan allocation. Stiglitz and Weiss (1981) show that lenders could set an upper limit to the increase in interest rates, leading to a decrease in the equilibrium rates and loans. In my model the economic mechanism is consistent with credit rationing, as it will be optimal for the lender to identify the riskiness of the borrowers, raising the loan rates to riskier households, generating an equilibrium on which a lower total amount of loans, with lower rates, and delinquency. The influential work of Bester (1985) revisits the screening problem in credit markets, shows that if the banks can screen investor riskiness, there is no credit rationing, although safer households will require a higher amount of collateral.

Credit allocation, lending standards, and information asymmetries has been studied in the banking literature, although most works focus on contracts, market competition, and mechanism design. Dell'Ariccia and Marquez (2004) perform a theoretical analysis on competition among financial intermediaries, and its effects on credit allocation under asymmetric information. They show that banks

[7]The delinquency ratio show the fraction of the total loans hold by bank that exhibit more than 90-days overdue payments. Usually at this point the bank will evaluate the initiation of legal collection of the loans, will finally may push the households to file for bankruptcy.

do not finance risky borrowers in markets with strong information asymmetries. Dell'Ariccia and Marquez (2006) show that lower information asymmetries lead to banks screening out bad borrowers, by demanding a high amount of collateral, in equilibrium. I present a model on which heterogeneous borrowers use two different type of loans, one with requires collateral (secured) and one unsecured, and the option to default on each loan, to smooth consumption, while the lender optimally price debt in the presence of information asymmetry, showing that riskier borrowers exhibit lower debt if the lender identify them.

The rest of the paper is organized as follow, Section 2.2 includes the Data Description and Summary Statistics, the empirical study of the relation between Real Estate Prices and the Homestead Exemption, and Household Loans and the Homestead Exemption. Section 2.3 presents the economic model, a scheme of the equilibrium computation, the model calibration, and the numerical results. Finally, Section 2.4 present the main concussions of this paper.

2.2 Empirical Analysis

2.2.1 Data and Summary Statistics

To test the empirical relation between the magnitude of the homestead exemption, house prices, and banks lending to households, I perform a series of panel regressions using a database that combines multiple sources and covers the period from 2006 to 2016, post the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA).

The data employed in this analysis is obtained from multiple sources. First, House prices are obtained from the Federal Housing Finance Agency (FHFA). The House Price Index (HPI) is defined as: *"a weighted, repeat-sales index measuring the average price changes in repeat sales or re-financings on the same properties using single-family house prices"*[8]. To complement this data I use the Zillow Home Value Index (ZHVI) as an alternative house price measure. This index is defined as: *"a time series tracking the monthly median estimated sale prices (Zestimates) value in a geographical region"*[9].

The lending data is obtained from the Federal Financial Institutions Examination Council's (FFIEC) Uniform Bank Performance Report (UBPR)[10] defined as *"a multi-page financial analysis of a commercial bank or savings bank that files the Consolidated Reports of Condition and Income (Call Report)"*. These reports are periodically filed by U.S. banks, state-chartered banks members of the Federal Reserve System, and saving associations regulated by the Federal Deposit Insurance Corporation.

The FFIEC data is obtained at state-level, and the reports include performance and credit allocation ratios, calculated using the information of all the insured banks operating in the state. Among the

[8] https://www.fhfa.gov/DataTools/Downloads/pages/house-price-index.aspx
[9] https://www.zillow.com/research/data/
[10] https://www.ffiec.gov/ubpr.htm

Table 2.1: FFIEC Performance Report Summary Statistics

This table presents the summary statistics for the FFIEC Uniform Bank Performance Report. The analyzed loans are separated into the categories Secured Loans (which are the total real estate loans as a fraction of all loans issued by the bank), unsecured household loans (loans to individuals, which include personal loans, credit card debt, and auto loans), and Commercial Loans (loans to business). Secured loans are dis-aggregated into household secured loans (family real estate loans which includes loans to finance family residences and home equity loans), and commercial secured loans (commercial real estate). Panel A shows the median, 10th percentile and 90th percentile for the fraction of total loans, Panel B shows the average category loan yield, which is the average interest paid by the loans in each portfolio, and finally Panel C present the delinquency ratio for each portfolio, which is the ratio of overdue payments to the total amount of loans in the portfolio.

Panel A: Loan Allocation (As a fraction of Total Loans)

	N	Median	10th	90th
Secured Loans	672	72.60	52.89	82.81
- Household Secured Loans	672	27.06	11.41	41.13
- Commercial Secured Loans	672	41.71	31.59	59.27
Unsecured Households Loans	672	5.86	1.88	11.19
- Credit Card Loans	672	0.06	0.01	0.27
Commercial Loans	672	14.17	10.21	19.40

Panel B: Loans Annual Yield (Interest payments over the total loans in the category)

	N	Median	10th	90th
Secured Loans	672	3.92	2.03	5.00
- Household Secured Loans	672	4.88	0.00	6.58
Unsecured Households Loans	672	8.09	6.60	9.29
- Credit Card Loans	672	10.23	7.95	13.27

Panel C: Loan Delinquency Ratio (Past due payments over the total loans in the category)

	N	Median	10th	90th
Secured Loans	672	1.07	0.46	1.89
- Household Secured Loans	672	1.35	0.53	2.46
Unsecured Households Loans	672	1.50	0.59	2.40
- Credit Card Loans	672	1.60	0.69	3.26

full set of reported ratios, I focus on the loan portfolio, which is categorized into secured loans and unsecured loans to households. Beside the credit allocation, I use the information on annual interest payments (denoted annual yield), and the delinquency ratio for each loan type.

Demographic data is obtained from the U.S. Census Bureau, the American Community Survey (ACS) and the Economic Census databases, and includes population, education, age, gender, and marital status. Data on income and employment is obtained from the U.S. Bureau of Economic Analysis (BEA) database.

With respect to the bank lending data, the Federal Financial Institutions Examination Council's (FFIEC) Uniform Bank Performance Report includes the median loan portfolio of all the bank operating in each U.S. state, from 2006 to 2016. This dataset is summarized in Table 2.1.

Panel A of Table 2.1 presents the average loan portfolio for banks operating in each U.S. state. The three main categories correspond to 93% of the total loans (the rest are allocated in the category "other loans", which include loans to governmental institutions, or other financial institutions). The main category is secured loans (real estate loans), and within the category, 27% of the total loans are allocated to secured loans to households (residential mortgage loans). Unsecured loans to households are almost 6% of the total loans.

Panel B of Table 2.1 shows that credit card loans are associated with a higher annual yield, and the spread in the yields between secured and unsecured loans to households are more than 3%. Finally, Panel C shows the delinquency ratios, where the highest past due percentages are in the unsecured loan portfolio.

The Homestead Exemption

The homestead exemption defines the amount of home equity that a household will keep after filing for personal bankruptcy under Chapter 7. Here, I present its historical values, obtained from several publications of the manual "How to File for Chapter 7 Bankruptcy" by Nolo Legal (Elias and Renauer (2001,2009,2016)).

There are U.S. states that allow the households to choose between the federal exemptions or the state exemptions. For the empirical analysis I will assume the household will choose the code providing greater homestead exemptions[11].

Table 2.2 presents the respective homestead exemption (in USD), from 2001 to 2016. At the end of the table I include the federal homestead exemption. Two main characteristics of the homestead exemption are noticeable from this Table, first, that there is a significant heterogeneity across states, going from unlimited in states like Arkansas, Florida and Texas, to zero in New Jersey. The second homestead exemption characteristic is that several states have adjusted their exemption level in a limited number of times, during the last 20 years, as in the cases of Alabama, Arkansas, Connecticut, Florida, and Illinois.

With respect to the cross-sectional value, the median state is Maine with a $95,000 exemption, the 10th percentile is $15,000 in Missouri, and the 90th percentile is $500,000 in Massachusetts.

[11]The states that allow households to select the exemption set are Alaska, Arkansas, Connecticut, District of Columbia, Hawaii, Kentucky, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Texas, Vermont, Washington, and Wisconsin.

Table 2.2: Homestead Exemption by State, 2001-2016

Homestead Exemptions (in USD) from 2001 to 2016, obtained from the manual ”How to File for Chapter 7 Bankruptcy” manual, published by Nolo Legal (2001, 2009, 2016).

State	2001	2007	2011	2016
Alabama	$10,000	$10,000	$10,000	$30,000
Alaska*	$64,800	$67,500	$70,200	$72,900
Arizona	$100,000	$150,000	$150,000	$150,000
Arkansas*	Unlimited	Unlimited	Unlimited	Unlimited
California	$75,000	$75,000	$100,000	$100,000
Colorado	$60,000	$90,000	$120,000	$150,000
Connecticut*	$150,000	$150,000	$150,000	$150,000
Delaware	$0	$50,000	$100,000	$125,000
Florida	Unlimited	Unlimited	Unlimited	Unlimited
Georgia	$10,000	$20,000	$20,000	$43,000
Idaho	$50,000	$50,000	$100,000	$100,000
Illinois	$30,000	$30,000	$30,000	$30,000
Indiana	$30,000	$30,000	$35,200	$38,600
Iowa	Unlimited	Unlimited	Unlimited	Unlimited
Kansas	Unlimited	Unlimited	Unlimited	Unlimited
Kentucky*	$10,000	$10,000	$10,000	$10,000
Louisiana	$25,000	$25,000	$25,000	$35,000
Maine	$25,000	$70,000	$95,000	$95,000
Maryland	$0	$0	$21,625	$22,975
Massachusetts*	$100,000	$500,000	$500,000	$500,000
Michigan*	$34,850	$31,900	$35,300	$37,775
Minnesota*	$200,000	$200,000	$360,000	$390,000
Mississippi	$75,000	$75,000	$75,000	$75,000
Missouri	$8,000	$15,000	$15,000	$15,000
Montana	$120,000	$200,000	$500,000	$500,000
Nebraska	$12,500	$12,500	$60,000	$60,000
Nevada	$125,000	$350,000	$550,000	$550,000
New Hampshire*	$60,000	$200,000	$200,000	$240,000
New Jersey*	$34,850	$0	$0	$0
New Mexico*	$120,000	$120,000	$120,000	$120,000
New York*	$20,000	$100,000	$150,000	$165,550
North Carolina	$20,000	$37,000	$70,000	$70,000
North Dakota	$80,000	$80,000	$100,000	$100,000
Ohio	$10,000	$10,000	$43,250	$265,800
Oklahoma	Unlimited	Unlimited	Unlimited	Unlimited
Oregon*	$33,000	$39,600	$50,000	$50,000
Pennsylvania*	$34,850	$40,400	$43,250	$47,350
Rhode Island*	$34,850	$300,000	$300,000	$500,000
South Carolina	$69,700	$100,000	$106,750	$116,510
South Dakota	Unlimited	Unlimited	Unlimited	Unlimited
Tennessee	$7,500	$7,500	$7,500	$7,500
Texas*	Unlimited	Unlimited	Unlimited	Unlimited
Utah	$40,000	$40,000	$40,000	$60,000
Vermont*	$150,000	$150,000	$150,000	$125,000
Virginia	$10,000	$10,000	$10,000	$10,000
Washington*	$40,000	$40,000	$125,000	$125,000
West Virginia	$30,000	$50,000	$50,000	$50,000
Wisconsin*	$40,000	$40,000	$150,000	$150,000
Wyoming	$20,000	$20,000	$20,000	$20,000
Federal exemption	$34,850	$40,400	$43,250	$47,350

*: States in which households are allowed to choose between the federal or state homestead exemption.

2.2.2 Household Loans and The Homestead Exemption

To study the effect of the homestead exemption on the credit market, I use the FFIEC Uniform Report, specifically the state level data including credit allocation, yield rates and delinquency ratios for all banks operations. Unfortunately these reports only include ratios, so no information over dollar amounts is available.

An advantage of this data is that it provides information from banks. Most of the prior literature has focused on the household. In my work I will analyze the lender's problem in more detail, understanding how they choose to allocate their loans among unsecured and secured debt, highlighting how the difference in risk and the magnitude of the homestead exemption will relate to the lender's incentives for monitoring. This is a novel feature of my database, and an important contribution of my work.

To analyze the relation between the homestead exemption and the bank's credit allocation I start by estimating the empirical correlation between the magnitude of the homestead exemption and the fraction of the total bank's loan allocated to households. The baseline specification is:

$$L^h_{st} = \alpha_s + \alpha_t + \beta \log\left(Homestead\right)_{st} + \Gamma X_{st} + \varepsilon_{st} \tag{2.1}$$

where L^h_{st} denotes the median bank allocation to households loans type h as a fraction of total loans in its portfolio, located in state s, at year t. α_s and α_t denote the state and year fixed effect respectively. $\log\left(Homestead\right)_{st}$ is the logarithm of the dollar amount of the homestead exemption in state s at year t. X_{st} denotes economic and demographic controls for county i, at year t.

Among the economic and demographic controls, I include the state average age of the head of household, education level, family size, income, unemployment among others. All regressions include year and state fixed effects, and in all standard errors are robust.

Taking into account the changes in the personal bankruptcy code induced by the 2005 BAPCPA act, the panel is constructed from 2006 to 2016. The appendix for this section includes regressions using categorical variables to separate states by the magnitude of their exemption, showing that the main results presented in Table 2.3 are also obtained using such specification.

Table 2.3: Loans to Households and Homestead Exemption

This table present the estimations for FFIEC Loans to Households at state level. The total loans to household are the sum of the FFIEC loans categories residential mortgages to families (denoted household secured loans) and individual loans (denoted household unsecured loans). The LHS variable is the median over all the commercial banks insured by the FFIEC. The main control is the logarithm of the Homestead Exemptions. All regressions include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households under poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as controls. Standard errors are heteroskedasticity-robust.

	(1) Household Loans % of Total Loans	(2) Household Unsecured Loans % Total Household Loans
log (Homestead Exemption)	-0.96	0.01
(t-stat)	(-2.17)	(0.21)
House Price Index	0.00	-0.01
(t-stat)	(-0.36)	(-1.69)
log (Income)	-14.41	-0.15
(t-stat)	(-1.99)	(-2.67)
High School	0.12	0.00
(t-stat)	(1.32)	(-2.14)
Unemployment	0.56	0.00
(t-stat)	(2.76)	(-1.55)
Under Poverty	-1.77	-0.07
(t-stat)	(-0.71)	(-2.41)
Married Couples	0.63	0.03
(t-stat)	(1.13)	(0.06)
Female Householder	0.34	0.46
(t-stat)	(0.51)	(0.79)
Families with Child	0.09	-0.02
(t-stat)	(0.31)	(-0.14)
Age	-0.05	0.02
(t-stat)	(-0.08)	(4.29)
Race	-0.81	-0.13
(t-stat)	(-3.32)	(-5.75)
Year-FE	Yes	Yes
State-FE	Yes	Yes
Adj. R-Squared	0.96	0.95
Observations	433	433
Sample	2006-2016	2006-2016

Table 2.3 indicates that the overall amount of loans allocated to households decrease as the homestead exemption increases, but the relative amount of secured to unsecured loans are not affected by the magnitude of the exemption.

These results are surprising because one may expect that as the homestead exemption increases, households will feel more protected, and household demand for loans will rise. Instead, I find an overall reduction in the amount of loans, pointing to a supply effect. This is also why a careful analysis of the lender's incentives, and how they are affected by the magnitude of the exemption. To better understand the lender's behavior, in the next two subsections I focus on just the secured, and then just the unsecured loans.

Household Secured Loans and The Homestead Exemption

The households secured loans studied here include the FFIEC 1 to 4 family residential mortgages and multifamily (more than 5) family residential mortgages. Home equity loans are reported as part of 1 to 4 family residential mortgages. Table 2.4 shows the results for the regressions specified in Equation (2.1) for the household's secured loans.

Table 2.4: Household Secured Loans and Homestead Exemption

This table present the estimation for household secured loans (FFIEC Family Real Estate Loans). The LHS variables are the median percentage from the total loans, the loan annual yield, and the delinquency ratio. All correspond to the median value over all the FFIEC insured banks at state level. The main control is the logarithm of the Homestead Exemptions. All regressions include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households under poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as controls. Standard errors are heteroskedasticity-robust.

	(1) Household Secured Loans % of Total Loans	(2) Household Secured Loans Yield	(3) Household Secured Loans Delinquency Ratio
log (Homestead Exemption)	-0.98	-0.07	-0.14
(t-stat)	(-2.67)	(-1.41)	(-3.09)
House Price Index	0.00	0.01	-0.11
(t-stat)	(-0.17)	(7.6)	(-1.66)
log (Income)	-6.70	-2.23	-0.68
(t-stat)	(-1.08)	(-2.91)	(-1.02)
High School	0.17	0.00	0.01
(t-stat)	(2.45)	(0.03)	(1.05)
Unemployment	0.55	-0.04	0.04
(t-stat)	(3.6)	(-1.47)	(1.95)
Under Poverty	4.00	0.13	7.73
(t-stat)	(1.91)	(0.38)	(2.92)
Married Couples	0.61	-0.05	0.11
(t-stat)	(1.28)	(-0.84)	(2.1)
Female Householder	0.17	0.03	0.10
(t-stat)	(0.31)	(0.44)	(1.42)
Families with Child	0.09	0.04	0.02
(t-stat)	(0.37)	(1.6)	(0.92)
Age	0.01	-0.14	0.00
(t-stat)	(0.01)	(-2.32)	(0.07)
Race	-0.35	0.09	-0.03
(t-stat)	(-1.9)	(3.54)	(-1.73)
Year-FE	Yes	Yes	Yes
State-FE	Yes	Yes	Yes
Adj. R-Squared	0.94	0.98	0.87
Observations	433	433	433
Sample	2006-2016	2006-2016	2006-2016

Column (1) of Table 2.4 shows that the amount of loans allocated to secured debt for households is negatively correlated with the magnitude of the homestead exemption. Column (2) shows that the correlation between the secured loans annual yield and the homestead exemption is negative, but not significant. Column (3) shows that the delinquency ratio is negatively, and significantly, related to the homestead exemption. These three effects combined are surprising. One may have expected that a higher bankruptcy protection would be related to a higher demand for loans, driven by riskier households, leading to higher interest rates and a higher delinquency ratio.

The economic mechanism presented in my model relates these empirical findings with the supply side of the lending market equilibrium, specifically, with the lender's behavior. As the lender's credit risk exposure increases with the homestead exemption, the lender will be better off by identifying and pricing each households accordingly to their risk, therefore their incentives to monitor become more important, even if monitoring is costly. This supply response to a higher homestead exemption will cause a reduction in the secured loans to households, while improving the overall quality of the portfolio. Because of the reduction of loans to riskier households, the higher quality portfolio will have lower delinquency rates, and therefore lower interest rates, although this last effect is not significantive.

In relation to previous work, my results are consistent with the pre-BACPAC analysis presented in Lin and White (2001) and Chomsisengphet and Elul (2006) which use HMDA data, but differ from the ones reported in Severino and Brown (2017) who find no significant effect over the secured lending in a the FRBNY/Equifax panel for the same period.

The appendix for this section includes regressions using categories for the homestead exemption to explicitly include the unlimited states, having no significant effect over the discussed results.

Household Unsecured Loans and The Homestead Exemption

Unsecured loans to households are included in the FFIEC reports as "loans to individuals for household, family, and personal expenditures" and include credit card loans, revolving credit plans other than credit cards, automobile loans, and other consumer loans. Table 2.5 shows the results for the regressions specified in Equation 2.1 for the households unsecured loans.

Table 2.5: Household Unsecured Loans and Homestead Exemption

This table present the results for regressions of the Household Unsecured Loans (FFIEC loans to individuals), including ratio of household unsecured loans to the total bank loans, the loan category annual yield, and the delinquency ratio. The main control is the logarithm of the homestead exemptions, but also include the logarithm of per-capita income, the percentage of the population with high school diploma, the unemployment level, the percentage of households under poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, and the number of households with children. Standard errors are heteroskedasticity-robust and clustered at the state level.

	(1) Unsecured Loans % of Total Loans	(2) Unsecured Loans Yield	(3) Unsecured Loans Delinquency Ratio
log (Homestead Exemption)	0.02	-0.21	-0.16
(t-stat)	(0.09)	(-0.90)	(-2.41)
House Price Index	0.00	0.00	0.00
(t-stat)	(-0.57)	(-0.75)	(-2.63)
log (Income)	-7.71	7.18	-1.60
(t-stat)	(-2.39)	(1.78)	(-1.86)
High School	-0.05	0.01	0.01
(t-stat)	(-1.3)	(0.52)	(0.46)
Unemployment	0.01	0.11	0.01
(t-stat)	(0.07)	(1.37)	(0.19)
Under Poverty	-5.77	2.74	0.15
(t-stat)	(-4.51)	(1.96)	(0.35)
Married Couples	2.08	23.15	-2.49
(t-stat)	(0.09)	(0.75)	(-0.42)
Female Householder	0.17	0.54	-0.02
(t-stat)	(0.58)	(1.44)	(-0.26)
Families with Child	0.00	0.15	0.01
(t-stat)	(0.01)	(1.37)	(0.23)
Age	-0.06	0.53	-0.04
(t-stat)	(-0.24)	(2.27)	(-0.57)
Race	-0.46	0.05	-0.01
(t-stat)	(-3.75)	(0.48)	(-0.41)
Year-FE	Yes	Yes	Yes
State-FE	Yes	Yes	Yes
Adj. R-Squared	0.67	0.98	0.66
Observations	433	433	433
Sample	2006-2016	2006-2016	2006-2016

The results presented in Table 2.5 indicate that there is no significant correlation between the homestead exemption and the unsecured loans to households (Column (1)). The relationship between the homestead exemption and the unsecured loan annual yield is negative, but not significant (Column (2)). The delinquency of the unsecured loans is negatively and significantly related to the homestead exemption magnitude. Thus, although the loan allocation and interest payments are not significantly related the exemption magnitude, the unsecured loans portfolio has a better creditworthiness in states with higher bankruptcy protection.

My results are interesting as a positive, and significant, effect on the loan allocation and interest paid might have been expected. Specifically, in states with higher homestead exemptions, the unsecured loans become more likely to be discharged at bankruptcy, henceforth, households would increase their demand for this type of loans. This would also lead to higher interest rates and higher delinquency since the higher loan demand is due to moral hazard. However, this is not consistent with the empirical results. Thus the presented results are more likely related to the lender's supply of loans, as in the case of a higher possibility of discharge, the lender may decide to reduce the loans to riskier households to avoid further losses, overall improving the credit worthiness of the loan portfolio.

2.2.3 Lending Expenses and The Homestead Exemption

The results for secured and unsecured loans results indicate that the loan market equilibrium is potentially affected by the lender's supply of loans. In states with a higher exemption, the lender may decide to reduce the loans to riskier household to avoid further losses, overall improving the credit worthiness of the loan portfolio.

The proposed economic mechanism behind my empirical findings is related to the monitoring efforts from the lender. To explore the empirical evidence for this channel, I use as a proxy for monitoring three different bank expenditure measures, the average expenditure in personnel, the efficiency ratio[12], and the total salary expenses as a percent of the total assets.

Table 2.6: Lending Expenses and Homestead Exemption

This table present the results for regressions for different measures of bank expenditures at state level obtained from the FFIEC database, and include the average expenditure in personnel, the efficiency ratio, and the total salary expenses over the total assets. The main control is the logarithm of the homestead exemption, but the regressions also include the logarithm if the per-capita income, the percentage of the population with high school diploma, the unemployment level, the percentage of households under poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, and the number of households with children. Standard errors are heteroskedasticity-robust and clustered at the state level.

	(1) Average Expenditure in Personnel	(2) Efficiency Ratio	(3) Total Salary Expenses Over Total Assets
log (Homestead Exemption)	1.33	0.29	0.55
(t-stat)	(0.82)	(0.64)	(1.48)
log (Income)	-0.97	1.79	-1.94
(t-stat)	(-0.16)	(2.00)	(-2.60)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Adj. R-Squared	0.41	0.94	0.77
Observations	433	433	433
Sample	2006-2016	2006-2016	2006-2016

Table 2.6 shows that although the correlation between the homestead exemption and various measures of bank expenditures is positive, although the effect is not significant. This evidence, although

[12]Defined as the total bank expenses (excluding interest expense) over the total bank revenue.

weak, points in the direction of higher monitoring in states with higher exemptions. Currently most of the monitoring is done using technological tools, e.g. credit scores and data analysis, unfortunately, the limitations in the available data prevent a more thorough analysis of this hypothesis, as a more detailed information of the bank operations is required to be conclusive here.

2.2.4 House Prices and The Homestead Exemption

This section studies the empirical correlation between the magnitude of the homestead exemption and house prices. Specifically, I estimate county level panel regressions, including the logarithm of the homestead exemption value in dollars. To address for county level specific characteristics, I include economic and demographic controls, age of the head of the household, education level, family size, income, unemployment among others. All regressions include year fixed effects, and standard errors are clustered at state level.

The baseline specification is:

$$hp_{it} = \alpha_s + \alpha_t + \beta \log\left(Homestead\right)_{st} + \Gamma X_{it} + \varepsilon_{it} \tag{2.2}$$

where hp_{it} denotes the house prices index in county i, located in state s, at year t. α_s and α_t denote the state and year fixed effect respectively. $\log\left(Homestead\right)_{st}$ is the logarithm of the dollar amount of the homestead exemption in state s at year t. X_{it} includes economic and demographic controls for county i, at year t.

As mentioned, the changes introduced by the Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA) at 2005 into the bankruptcy procedure are significant, hence the presented results focus on the 2006 to 2016 period.

Table 2.7: House Prices and Homestead Exemption

This table presents the results for regressions of two house price indexes, the FHFA House Price Index (HPI) and the Zillow Home Value Index (ZHVI) per Sq.Ft. The main variable of interest is the logarithm of the homestead exemption. Controls also include the per-capita Income, the percentage of the population with high school diploma, the unemployment level, the percentage of households under poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, and the number of households with children. Standard errors are heteroskedasticity-robust and clustered at the state level.

	(1) FHFA House Price Index	(2) Zillow Home Value Index (ZHVI) per Sq.Ft.
log (Homestead Exemption)	0.29	0.11
(t-stat)	(2.89)	(3.76)
log (Income Per Capita)	5.16	2.91
(t-stat)	(4.60)	(4.60)
High School	-1.19	-6.02
(t-stat)	(-0.43)	(-2.35)
Unemployment	-1.02	-1.14
(t-stat)	(-2.62)	(-0.91)
Under Poverty	-4.50	0.43
(t-stat)	(-2.58)	(0.28)
Married Couples	-0.99	-0.68
(t-stat)	(-2.30)	(-0.17)
Female Householder	-0.83	-0.22
(t-stat)	(-1.48)	(-0.67)
Families with Child	0.30	0.12
(t-stat)	(1.30)	(3.04)
Age	-9.24	-7.43
(t-stat)	(-4.13)	(-2.28)
Year-FE	Yes	Yes
Adj. R-Squared	0.46	0.15
Observations	12,612	6,267
Sample Available	2006-2016	2006-2016

Table 2.7 shows that the magnitude of the homestead exemption is positively and significantly correlated with the house price levels at county level. Although the magnitude of the correlation, considering the variation in house prices observed during the last decade, is modest. This result is interesting, and the model results are consistent with this positive price effect, however this is not the main result of my work.[13]

To conclude this section, I summarize the empirical results. An increment in the magnitude of the homestead exemption is related to higher house prices, fewer loans to households, specially focused on lower secured loans. These loans exhibit better credit quality, as a higher homestead exemption relates to lower delinquency ratios on secured and unsecured loans. Finally, there is a negative effect on the secured and unsecured loan interest rates, but these effects are not statistically significant.

[13]Although I abstract from modeling and discussing the supply of housing, is possible to think that it might be related with the homestead exemption magnitude. In the appendix of this section I show that states with higher exemptions also issued fewer housing permits and fewer loans to real estate development. To analyze this effect in detail a deeper model of the housing market is required, and at the moment, this goes beyond the scope of this work.

2.3 Model

Consider a model of a credit market with two types of households $i \in \{g, b\}$, who live for two periods, $t \in \{0, 1\}$, and differ in their income distribution at $t = 1$. In each period the households consume a non-durable good and a durable good, interpreted as housing.

Households finance their consumption through secured and unsecured loans. These loans are offered by a perfectly competitive representative lender (the bank). Loans are issued at $t = 0$, and mature at $t = 1$, moment at which the households also decide whether to exercise their option to default in each one of these loans.

The credit market is assumed initially to exhibit asymmetric information, as the households know their type, but the bank does not. Although the bank has the option to invest in monitoring technology, at a fixed exogenous cost Ψ, that allows it to perfectly observe the household type. If the bank does not invest, it will offer a pooling contract for secured and unsecured loans, this equilibrium is denoted the pooling equilibrium, as a unique interest rate is offered for the aggregate pool of secured and unsecured loans. Now, if the bank invests, it will offer a unique contract for secured and unsecured loan, and for each type of household, this market equilibrium is denoted the separating equilibrium.

The model operates in the following way. In the first period the bank evaluates the pooling equilibrium in the credit market, and based on its estimations, decides whether to invest in the monitoring technology or not. The bank then posts the secured and unsecured loan interest rates for any level of the households' demand. The households consider the available loan contracts, and select those which maximize their expected utility. In the second period, the household income is realized, and if eligible, the households decide whether to file for personal bankruptcy, consequently defining the loan payments, which are finally collected by the bank.

The details of the model are presented in the following subsections. First, the households' problem is detailed, including their consumption, repayment and default choices for all loans. Then, the bank's problem is described, including the pooling equilibrium, the separating equilibrium and the conditions under which each equilibrium will be observed. Finally, the model is solved, and the results are contrasted with the empirical findings previously presented.

2.3.1 The Households' Problem

The economy is inhabited by a set of households of mass 1, who consume housing, a durable good assumed to be housing, supplied in fixed quantity $\bar{h}$, and a non-durable consumption good, supplied exogenously in perfectly elastic manner, with a price of one. The households are located in a state with a homestead exemption of K dollars.

At $t = 0$ all households have the same income y_0, but at $t = 1$ the households may receive an employed income, $y_1 = y_e$, or become unemployed (u), and receive $y_1 = y_u$, $y_u < y_e$. Households can be either type g or type b, being the difference between these types the probability of transitioning to employed at $t = 1$, π^i. Households type b are assumed to be riskier as $\pi^g > \pi^b$, this is, households type

b have a greater probability of becoming unemployed. The fraction of households type g is denoted α.

At $t=1$ households can be identified by their emplyment status and their type, this is (i,j) where $i \in \{g,b\}$ and $j \in \{e,u\}$.

The households demand one-period secured loans from the bank M_0^i, using the housing stock as collateral, and one-period unsecured loans B_0^i, to finance consumption at $t=0$. R_M^i denotes the gross secured loaninterest rate, R_B^i the gross unsecured loan interest interest rate.

At $t=0$ household $i \in \{g,b\}$ maximizes:

$$\max_{c_0^i, h_0^i, B_0^i, M_0^i} \left[u\left(c_0^i\right) + \phi u\left(h_0^i\right)\right] + \mathbb{E}_0 \left\{\beta \left[u\left(c_1^{(i,j)}\right) + \phi u\left(h_1^{(i,j)}\right) + \beta\delta u\left(p_1 h_1^{(i,j)}\right)\right]\right\} \tag{2.3}$$

where $u\left(c_0^i\right)$ is the utility from the consumption of the non-durable good c_0^i, $\phi u\left(h_0^i\right)$ denotes the utility from the service flow derived from the housing stock h_0^i, β is the household's discount factor, and $\delta u\left(p_1 h_1^{(i,j)}\right)$ is the utility derived from bequest the housing stock at the end of $t=1$. Households are risk-averse, with a Constant Relative Risk Aversion (CRRA) utility function:

$$u(c) = \frac{c^{(1-\gamma)}}{(1-\gamma)}$$

At $t=0$, the households purchase their housing stock at price p_0. As housing is a durable good, households maintain their stock until $t=1$, when they can trade their stock at price p_1.

The maximization in Equation (2.3) is subject to the $t=0$ flow budget constraint:

$$c_0^i + p_0 h_0^i \leq y_0 + B_0^i + M_0^i \tag{2.4}$$

The secured loan is subject to the collateral constraint:

$$0 \leq M_0^i \leq p_0 h_0^i \tag{2.5}$$

then the loan-to-value is allowed to be 1, but its value will be an equilibrium result.

The unsecured loan is subject to the constraint:

$$-y_0 \leq B_0^i \leq y_0 \tag{2.6}$$

then the maximum loan-to-income ratio is 1, and households may save as much as their income if desired[14].

[14]The interest rate on deposits is r_L, fixed, exogenous, and assumed as the opportunity cost of the bank.

At $t = 1$, households type i will be part of the set $(i, j) \in \{(i, e), (i, u)\}$, and will maximize:

$$\max_{c_1^{(i,j)}, h_1^{(i,j)}, d_B^{(i,j)}, d_M^{(i,j)}} u\left(c_1^{(i,j)}\right) + \phi u\left(h_1^{(i,j)}\right) + \beta \delta u\left(p_1 h_1^{(i,j)}\right) \tag{2.7}$$

$d_B^{(i,j)}$ and $d_M^{(i,j)}$ denote the default choices for unsecured and secured loans. $B_1^{(i,j)}$ and $M_1^{(i,j)}$ denote the unsecured and secured loan repayments.

The flow budget constraints at $t = 1$ is:

$$c_1^{(i,j)} + p_1 h_1^{(i,j)} \leq y_1^{(i,j)} + p_1 h_0^{(i,j)} - M_1\left(p_1, h_0^i, M_0^i, R_M^i\right) - B_1\left(p_1, h_0^i, M_0^i, R_M^i, B_0^i, R_B^i, y_1^{(i,j)}, K\right) \tag{2.8}$$

Equation (2.8) shows durable nature of the housing stock, as it remains as part of the households' wealth at $t = 1$. The right-hand-side of the budget constraint corresponds to the cash-on-hand that the households have after deciding if filing for personal bankruptcy, and will be denoted by:

$$W_1^{(i,j)} = y_1^{(i,j)} + p_1 h_0^i - M_1\left(p_1, h_0^i, M_0^i, R_M^i\right) - B_1\left(p_1, h_0^i, M_0^i, R_M^i, B_0^i, R_B^i, y_1^{(i,j)}, K\right)$$

The households' optimal consumption and housing policies at $t = 1$ are solved analytically, as a function $W_1^{(i,j)}$, and are included in the appendix.

A useful economic quantity for the analysis of the the households' default choices, and loan payments, is the home equity:

$$E_1^{(i,j)} = p_1 h_0^i - M_0^i R_M^i \tag{2.9}$$

The following subsections present the debt payments and default policies for the secured and unsecured loans, which lead to the solution of the household problem at the last period, based on the the cash-on-hand, and the rest of the economic quantities of the model.

Secured Loan Payments and Default

Households will repay their secured loans if the home equity is positive ($E_1^{(i,j)} \geq 0$), otherwise, they will default on their secured obligations, and the housing stock will be foreclosed by the bank. Thus, the households' secured loan default policy is:

$$d_M\left(p_1, h_0^i, M_0^i, R_M^i\right) = \begin{cases} 1 & \text{if } E_1^{(i,j)} < 0 \\ 0 & \text{if } 0 \leq E_1^{(i,j)} \end{cases}$$

and the debt repayment is:

$$M_1\left(p_1, h_0^i, M_0^i, R_M^i\right) = \begin{cases} p_1 h_0^i & \text{if } E_1^{(i,j)} < 0 \\ M_0^i R_M^i & \text{if } 0 \leq E_1^{(i,j)} \end{cases} \tag{2.10}$$

Unsecured Debt Payments and Default

The unsecured debt payments are directly related to the financial benefit of filing for personal bankruptcy. Beside this point, and as previously mentioned, an important change that the 2005 BAPCPA introduced is that only households whose annual income is below the state median are allowed to file for bankruptcy. Thus, I assume that employed households (income above the state median) will always repay their unsecured loans, and unemployed households will evaluate if filing for bankruptcy.

Employed Households Unsecured Loan Payments and Default

Employed households $(i,j) \in \{(g,e),(b,e)\}$ will repay their unsecured loans, then their default and repayment policies are:

$$d_B\left(p_1, h_0^i, M_0^i, R_M^i, B_0^i, R_B^i, y_1^{(i,j)} = y_e, K\right) = 0$$

$$B_1\left(p_1, h_0^i, M_0^i, R_M^i, B_0^i, R_B^i, y_1^{(i,j)} = y_e, K\right) = B_0^g R_B^g \quad \text{if } (i,j) = \{(g,e),(b,e)\} \tag{2.11}$$

The employed households cash-on-hand after repaying their unsecured loans is:

$$W_1^{(i,j)} = y_e + \max\{p_1 h_0^g - M_0^g R_M^g, 0\} - B_0^g R_B^g \qquad \text{if } (i,j) = \{(g,e),(b,e)\} \tag{2.12}$$

Unemployed Households Unsecured Loan Payments and Default

For the unemployed households, $(i,j) \in \{(g,u),(b,u)\}$, the unsecured debt payments are determined by the financial benefit from filing for bankruptcy. Thus, unemployed households will file for bankruptcy if their cash-on-hand after bankruptcy is greater than after fully repaying their unsecured loans.

If an unemployed household files for bankruptcy, the state Trustee evaluates the liquidation of the household's assets, specifically its house. If the home equity is below the homestead exemption, $E_1^{(i,j)} \leq K$, then the Trustee does not liquidate the house, and fully discharges the unsecured loan. Now, if the home equity is above the homestead exemption, $E_1^{(i,j)} > K$, then the Trustee liquidates the house, repays the secured loan, gives the household the exempted value K, and the remaining value, $\min\{E_1^{(i,j)} - K, B_0 R_B\}$, goes to repay the unsecured lender. These cases are detailed in the rest of this subsection.

Case 1: $E_1^{(i,j)} < 0$

In this case, as the household does not have home equity, it will default on its unsecured loan if the payment is greater than a fixed filing cost $C \in [0, y_u]$, which is associated to legal fees. Formally:

$$d_B\left(p_1, h_0^i, M_0^i, R_M^i, B_0^i, R_B^i, y_1^{(i,j)} = y_u, K\right) = \begin{cases} 1 & \text{if } B_0^i R_B^i > C \\ 0 & \text{if } B_0^i R_B^i \leq C \end{cases}$$

and the unsecured loan payment is:

$$B_1\left(p_1,h_0^i,M_0^i,R_M^i,B_0^i,R_B^i,y_1^{(i,j)}=y_u,K\right)=\begin{cases}0 & \text{if } B_0^iR_B^i>C\\ B_0^iR_B^i & \text{if } B_0^iR_B^i\leq C\end{cases} \tag{2.13}$$

The cash-on-hand of the unemployed household $(i,j)\in\{(G,u),(B,u)\}$ with negative Home Equity, $E_1^{(i,j)}<0$ is:

$$W_1^{(i,j)}=\begin{cases}y_u-C & \text{if } B_0^iR_B^i>C\\ y_u-B_0^iR_B^i & \text{if } B_0^iR_B^i\leq C\end{cases} \tag{2.14}$$

Case 2: $0\leq E_1^{(i,j)}$

In this case, the household's cash-on-hand after bankruptcy is the sum of its income, plus the home equity after bankruptcy, $\min\{E_1^{(i,j)},K\}$, minus the bankruptcy cost. If this amount is greater than the cash-on-hand after paying the unsecured loan, $y_u+E_1^{(i,j)}-B_0^iR_B^i$, the household files for bankruptcy, thus the default policy is:

$$d_B=\begin{cases}1 & \text{if } y_u+\min\{E_1^{(i,j)},K\}-C\ \leq\ y_u+E_1^{(i,j)}-B_0^iR_B^i\\ 0 & \text{if } y_u+\min\{E_1^{(i,j)},K\}-C\ >\ y_u+E_1^{(i,j)}-B_0^iR_B^i\end{cases}$$

and the unsecured loan payment is:

$$B_1=\begin{cases}\min\left\{B_0^iR_B^i,\max\{E_1^{(i,j)}-K,0\}\right\} & \text{if } y_u+\min\{E_1^{(i,j)},K\}-C\ \leq\ y_u+E_1^{(i,j)}-B_0^iR_B^i\\ B_0^iR_B^i & \text{if } y_u+\min\{E_1^{(i,j)},K\}-C\ >\ y_u+E_1^{(i,j)}-B_0^iR_B^i\end{cases} \tag{2.15}$$

The unemployed households, $(i,j)\in\{(G,u),(B,u)\}$, cash-on-hand after filing for personal bankruptcy is:

$$W_1^{(i,j)}=\max\left\{y_u+\min\{E_1^{(i,j)},K\}-C,y_u+E_1^{(i,j)}-B_0^iR_B^i\right\} \tag{2.16}$$

To summarize this subsection, Figure 2.1 shows the cash-of hand, for the described cases, as a function of the household's home equity $E_1^{(i,j)}$:

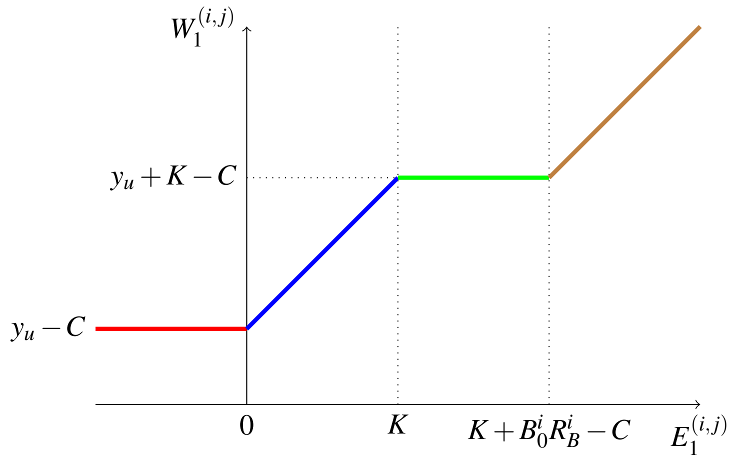

Figure 2.1: Cash-on-Hand for unemployed household $(i, j) = \{(i, u)\}$, as a function of the home equity $E_1^{(i,j)}$, for the Homestead Exemption K.

The green line in Figure 2.1 illustrates the Case 1, as in this case, if the household has no home equity to protect, it will file for bankruptcy if the unsecured loan amount is greater than the filing cost, as the unsecured loan is discharged for sure. The remaining lines in the figure illustrate Case 2. The blue line shows the case when the home equity is fully protected by the homestead exemption, thus the unsecured loan is discharged. The red line represents the case on which the home equity is above the value of the homestead exemption, then the household keeps the exempted value K, and the remaining home equity goes to repay a fraction of the unsecured loan. Finally, the brown line shows the case on which the household fully repays its unsecured loan, as there is no financial benefit in filing for bankruptcy.

Figure 2.1 shows a strong non-linearity in the households' cash-on-hand, induced by the personal bankruptcy procedure. This non-linearity will required the use of numerical techniques to solve the model.

2.3.2 The Bank's Problem

There is a competitive representative bank, which supplies one-period secured and unsecured loans to the households. Loans are granted at $t = 0$, and payments are collected at $t = 1$.

Initially, the bank faces imperfect information about the households' type, that is, the bank cannot identify if the household is either type g or b, so it first evaluates the pooling equilibrium. The concept of pooling assumed here follows Dubey and Geanakoplos (2002), as it implies that the bank offers a unique rate consistent with the expected aggregate payment of the pool. These contracts are observed in several markets as they reduce the information needed to quantify the risk of the loan, as no bilateral negotiations are sustained and the bank only looks to characterize the aggregate pool repayment.

Perfect competition in the model relates to the deterrence principle introduced by Riley (1979) informational equilibrium, and in its application to credit markets as presented in Milde and Riley

(1988). This refinement indicates that any potential defector from the pooling equilibrium is likely to be deterred, if predictable reactions by others will make its initial defection unprofitable, making the zero-profit contract the only one observed in equilibrium.

A key characteristic of the model is that the loan repayments are not only affected by the household type - idiosyncratic income risk - but also by the magnitude of the homestead exemption K, the focus of analysis of this work. As shown in the household's problem, a higher homestead exemption increases the financial benefit from filing for personal bankruptcy, thus increasing the default probability and reducing the loan payments. Therefore, the expected pool payments are negatively affected by the moral hazard and adverse selection problems present in the pooling equilibrium. In such case, the bank incentives to invest in monitoring, and migrate from a pooling equilibrium to a separating equilibrium, will increase as the credit losses from riskier households escalate.

The monitoring technology is included in the model as an option owned by the bank. If the bank pays a fixed cost Ψ, it will be able to identify the households' type at $t = 0$. If the bank invests, it deviates from the pooling equilibrium by offering separating contracts. A key assumption is that the bank will only accept household in their respective contract, as attempt from riskier households to mimic with safer households will be immediately rejected.

Formally, the bank's decision at time zero involves two steps. In the first the bank evaluates the investment in monitoring based on the equilibrium it thinks will prevail. If the bank believes that the pooling equilibrium will prevail, then the bank's best action should be not to invest, as monitoring is unprofitable. Now, if the bank considers that the separating equilibrium will prevail, then the bank's best action should be to invest in monitoring, and not monitoring should be unprofitable. In the second, based on the monitor/don't monitor decision. the bank posts interest rate offers to borrowers. Then, the households solve their maximization problem considering the available loan contracts, choosing the one that maximizes their expected utility. In the second period of the model, the household's risky income is realized, and the option to file personal bankruptcy evaluated, consequently defining the loan payments, which are finally collected by the bank.

The option to invest in the monitoring technology, and deviate from the pooling equilibrium to the separating equilibrium, is determined by the profitability of the alternative separating contracts. If the cost of the monitoring technology is greater than the benefit of deviating to the separating equilibrium, then the bank will stay on the pooling equilibrium. Now, if the cost is lower, then the bank will have a clear incentive to pay for the monitoring technology and offer the separating contracts. As the other banks in the market will also recognize the same profit opportunity, all banks in the market will deviate, and the only contract that will remain is the zero-profit separating contract (which includes the cost of monitoring technology).

The profit from investing in the monitoring technology is measured as following. If a bank invests in the monitoring technology, it deviates from the pooling equilibrium by offering an alternative separating contract. This contract is only available for safer households - type g - and charges a slightly lower interest rate than the pooling secured, and unsecured, loan contracts. As the riskier households are not accepted in these new contracts, and the charged interest rates are almost the same, these deviation contracts will exhibit positive profits, while the previously offered pooling contract become costly.

The relationship between the cost and the deviation benefit is fundamental for the existence of a pooling equilibrium, as if the monitoring cost is low, the separating equilibrium will be observed always, as if any bank offers the pooling equilibrium, only risky households will demand such contracts, leading to losses. On the other hand, if the monitoring cost is high, the banks will not have significant incentives to deviate from the pooling equilibrium, as all the potential benefit from such deviation will be paid in monitoring.

To understand how the monitoring technology modifies the bank's problem, I present the pooling equilibrium and the separating equilibrium, and formalize the conditions under which it will be profitable for a bank to deviate.

The Pooling Equilibrium

If the bank decides not to invest in the monitoring technology, it will face imperfect information about the households' type, thus the bank will charge the same interest rate for each loan type. The interest rates will be determined by the aggregate loan demands, and expected loan repayments. As the lending market is competitive, the expected return on each type of loan will equate to the bank's opportunity cost[15], $R_L = 1 + r_L$.

For the secured loans M_0^i, the bank solves for the interest rate R_M that satisfies the market equilibrium condition:

$$\sum_{i=\{g,b\}} f_i M_0^i = \frac{1}{(1+r_L)} \mathbb{E}_0 \left[\sum_{(i,j)=\{(g,e),(g,u),(b,e),(b,u)\}} f_{(i,j)} M_1 \left(p_1, h_0^i, M_0^i, R_M \right) \right] \tag{2.17}$$

where f_i and $f_{(i,j)}$ are the mass of each set of households:

$$f_i = \begin{cases} \alpha & \text{if } i = g \\ (1-\alpha) & \text{if } i = b \end{cases} \tag{2.18}$$

$$f_{(i,j)} = \begin{cases} \alpha \pi^g & \text{if } (i,j) = (g,e) \\ \alpha(1-\pi^g) & \text{if } (i,j) = (g,u) \\ (1-\alpha)\pi^b & \text{if } (i,j) = (b,e) \\ (1-\alpha)(1-\pi^b) & \text{if } (i,j) = (b,u) \end{cases} \tag{2.19}$$

For the unsecured loans B_0^i, the bank solves for the interest rate R_B that satisfies the equilibrium condition:

[15] The opportunity cost can be interpreted as the deposit rate paid by the bank

$$\sum_{i=\{g,b\}} f_i B_0^i = \frac{1}{1+r_L}\mathbb{E}_0\left[\sum_{(i,j)=\{(g,e),(g,u),(b,e),(b,u)\}} f_{(i,j)} B_1\left(p_1, h_0^i, M_0^i, R_M, B_0^i, R_B, y_1^{(i,j)}, K\right)\right] \tag{2.20}$$

These market equilibrium conditions reflect the pooling loan contract and the competitive lending assumption, as there are no expected profits beyond the opportunity cost.

The Separating Equilibrium

If the bank decides to invest in the monitoring technology, it pays the fixed cost Ψ and it is able to identify the households' type. The technology is assumed to be paid once at the first period, $t = 0$. This cost is transferred to the loan interest rates, and it reduces the expected profits from lending, thus it affects the interest rates charged for each loan.

As in the imperfect information problem, the lending markets are competitive, but in this case each rate has to individually satisfy the equilibrium conditions. For the secured loan M_0^i, the interest rates R_M^g and R_M^b are found individually for each household type $i \in \{g,b\}$ by solving the following equilibrium condition:

$$f_i M_0^i + \frac{\Psi f_i M_0^i}{\sum_{i=\{g,b\}} f_i\left(M_0^i + B_0^i\right)} = \frac{1}{(1+r_L)}\mathbb{E}_0\left[\sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} M_1\left(p_1, h_0^i, M_0^i, R_M^i\right)\right] \tag{2.21}$$

For the unsecured loan B_0^i, the interest rates R_B^g and R_B^b are found by solving:

$$f_i B_0^i + \frac{\Psi f_i B_0^i}{\sum_{i=\{g,b\}} f_i\left(M_0^i + B_0^i\right)} = \frac{1}{(1+r_L)}\mathbb{E}_0\left[\sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} B_1\left(p_1, h_0^i, M_0^i, R_M^i, B_0^i, R_B^i, y_1^{(i,j)}, K\right)\right] \tag{2.22}$$

From these equilibrium conditions, it is possible to notice that if the total expected profit of the bank is computed, this is, the sum of Equations (2.21) and (2.22) for both households' types, the total cost paid for the monitoring technology is the fixed cost Ψ.

Conditions to Invest in the Monitoring Technology

Based on the information available before investing in the monitoring technology, that is, preferences, distributions, but not the households' type, the bank estimates the expected loan demands for the credit pool. The bank uses these estimations to compute the potential profit from investing in the monitoring technology. This profit is measured as follows, first the bank pays the fixed cost Ψ, and offers an hypothetical alternative contract with a slightly lower interest rate than the estimated pooling contract, but in this new contract only type g households will be accepted.

As the type g households have a lower default probability than the riskier households (type b), the alternative separating contract is profitable, being the upper bound of the investment profit induced by the same pooling contract, but just including safe households. Formally:

$$\Pi^g = \frac{1}{(1+r_L)}\mathbb{E}_0\left[\sum_{(i,j)=\{(g,e),(g,u)\}} f_{(i,j)}M_1^{(i,j)} + B_1^{(i,j)}\right] - f_g\left(M_0^g + B_0^i\right) \tag{2.23}$$

where $\{M_1^{(i,j)}, B_1^{(i,j)}\}$ are the loan payments, for the pooling equilibrium loans to the safe household (type g), $\{M_0^g, B_0^g\}$.

Then, the bank will invest in the monitoring technology if $\Pi^g > \Psi$, that is, by an amount sufficient to at least cover the monitoring costs[16]. In such case, the market equilibrium observed will be a separating equilibrium.

Notice that in the separating equilibrium the only contracts offered by the bank are those with zero-profit[17]. If the bank offers a profitable separating contract, there is a "reaction" from the rest of the market that will take the safer households away from the bank, by offering an alternative separating contract. This is the reactive equilibrium introduced by Riley (1979), as the deviating bank will be deterred from offering the potentially profitable separating contract by the possibility that the rest of the market will underbid it out of the market.

2.3.3 Equilibrium

To find the equilibrium of the presented model, it is important to define the strategies to be considered by the households and the bank. The optimal households' strategy is the amount of secured and unsecured debt to demand. Their beliefs are constructed over the interest rates that the bank will charge them for any amount of debt. For the bank, its strategy concerns whether to invest in the monitoring technology or not, and what interest rate to charge for any amount of debt requested by the households. The bank's beliefs are constructed over the market competition and the household behavior, and are fundamental to estimate the household's loan payments.

Specifically, the bank believes that the credit market is perfectly competitive, as the representative bank behavior and offered contracts are determined by the notion of deterrence. This concept is important as it will discipline the market, as any potential defector from an equilibrium is likely to be deterred if predictable reactions by others will make his initial defection unprofitable.

For the separating equilibrium, as the bank can identify the riskiness of the households, it will offer secured and unsecured loan contracts to each household type, so the off-equilibrium path beliefs for the households that support the separating equilibrium and solve the incentive compatibility problem, are that only safe household are accepted in the low-risk household contract, so riskier households are rejected for sure if they apply to the safer household contract, deterring them from trying to mimic. Now, given that the high-risk contract will have a higher interest rate than the low-risk contract, the

[16]Notice that in the definition of Π^g the monitoring cost is not included. If this cost is included the investment condition becomes $\hat{\Pi}^g = \Pi^g - \Psi > 0$

[17]This net profit will include the monitoring cost Ψ

safer households will never apply to such loan as it will reduce their expected utility through higher future payments.

Formally, the equilibrium of the presented model are the households' policy functions for non-durable consumption $\left\{c_0^i, c_1^{(i,j)}\right\}$, housing stock consumption $\left\{h_0^i, h_1^{(i,j)}\right\}$, borrowing policies $\{M_0^i, B_0^i\}$, loan repayments $\left\{M_1^{(i,j)}, B_1^{(i,j)}\right\}$, the house prices $\{p_0, p_1\}$ and the interest rates for the secured and unsecured loans $\{R_M^i, R_B^i\}$ such that:

1. $\left\{h_0^i, h_1^{(i,j)}\right\}$, $\left\{c_0^i, c_1^{(i,j)}\right\}$, $\{M_0^i, B_0^i\}$, and $\left\{M_1^{(i,j)}, B_1^{(i,j)}\right\}$ are the optimal decision rules for the household problem, Equations (2.3) and (2.7), subject to the the constraints, Equations (2.4), (2.5), (2.6) and (2.8).

2. The housing market clears:

   (a) $t = 0$:

$$\sum_{i=\{g,b\}} f_i h_0^i = \bar{h}$$

   (b) $t = 1$:

$$\sum_{i=\{g,b\}} \sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} h_1^{(i,j)} = \bar{h}$$

3. The interest rates $\{R_M^i, R_B^i\}$ solve the lender's problem for the optimal households' borrowing policies $\{M_0^i, B_0^i\}$ and loan repayments $\left\{M_1^{(i,j)}, B_1^{(i,j)}\right\}$.

   (a) Pooling Equilibrium:

      i.

$$\sum_{i=\{g,b\}} f_i M_0^i = \frac{1}{1+r_L} \mathbb{E}_0 \left[\sum_{i=\{g,b\}} \sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} M_1\left(p_1, h_0^i, M_0^i, R_M^i\right) \right]$$

      ii.

$$\sum_{i=\{g,b\}} f_i B_0^i = \frac{1}{1+r_L} \mathbb{E}_0 \left[\sum_{i=\{g,b\}} \sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} B_1\left(p_1, h_0^i, M_0^i, R_M, B_0^i, R_B, y_1^{(i,j)}, K\right) \right]$$

   (b) Separating Equilibrium:

      i. For each $i \in \{g,b\}$:

$$f_i M_0^i + \frac{\Psi f_i M_0^i}{\sum_{i=\{g,b\}} f_i \left(M_0^i + B_0^i\right)} = \frac{1}{(1+r_L)} \mathbb{E}_0 \left[\sum_{i=\{g,b\}} \sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} M_1\left(p_1, h_0^i, M_0^i, R_M^i\right) \right]$$

      ii. For each $i \in \{g,b\}$:

$$f_i B_0^i + \frac{\Psi f_i B_0^i}{\sum_{i=\{g,b\}} f_i \left(M_0^i + B_0^i\right)} = \frac{1}{(1+r_L)} \mathbb{E}_0 \left[\sum_{i=\{g,b\}} \sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} B_1\left(p_1, E_1^{(i,j)}, B_0^i, R_B, y_1^{(i,j)}, K\right) \right]$$

4. The aggregate non-durable consumption is exogenously supplied, and defined as:

(a)

$$C_0 = \sum_{i=\{g,b\}} f_i c_0^i$$

(b)

$$C_1 = \sum_{i=\{g,b\}} \sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} c_1^{(i,j)}$$

The supply is assumed to be perfectly elastic, thus the aggregate non-durable consumption at each period $\{C_1, C_2\}$ are always at equilibrium and sold at unit price.

2.3.4 Model Calibration

Following Athreya (2006) , Jeske et al. (2013), and Mitman (2016), the preference parameters are $\beta = 0.95$, $\phi = 0.1$, $\gamma = 3.9$, and $\delta = 2$. The bequest parameter δ has a wide range of values in the related literature, I assume it to be 2, which gives the bequest motive relevance, but it is not the main driver of the results.

I assume that the fraction of good households is $\alpha = 0.713$, which resembles the U.S. state average of prime lenders. This distribution can be related to the model as I distinguish between good and bad credit households. The transition probabilities are set up to make the fraction of unemployed households in the second period similar to the fraction of bad households (type b) in the first period.

$$\begin{pmatrix} \pi^{g,u} & \pi^{g,e} \\ \pi^{b,u} & \pi^{b,e} \end{pmatrix} = \begin{pmatrix} 0.83 & 0.17 \\ 0.42 & 0.58 \end{pmatrix}$$

The households' income at $t = 1$ can either be $y_e = 3$ or $y_u = 1$. These values are selected to generate a sizable income risk for both household's types. The income at $t = 0$ is set to equal the aggregate income at $t = 1$, so there is no aggregate uncertainty in the model.

$$y_0 = \frac{\sum_{i=\{g,b\}} \sum_{(i,j)=\{(i,e),(i,u)\}} f_{(i,j)} y_1^{(i,j)}}{\sum_{i=\{g,b\}} f_i} = 2.64$$

Finally, the lender's discount rate is set to $r_L = 0.03$, which is similar to the historical U.S. Treasury Bills annual return, a common proxy for the deposit rate. The personal bankruptcy cost is set to be zero for simplicity. The model was solve for positive dead-weight costs, and if this value is positive and not large enough to deter all households from defaulting, the presented conclusions remain.

To resume, Table 2.8 presents all the selected parameters.

Table 2.8: Model Parameters

This table presents the parameters used to solve the model, obtained from Athreya (2006), Jeske et.at. (2013), and Mitman (2016).

Parameter	Description	Value	Comment
β	Time discount factor	0.95	Mitman (2016)
γ	Risk aversion	3.91	Jeske et al. (2013)
ϕ	Housing consumption utility	0.10	Mitman (2016)
δ	Bequest motive	2.00	
α	Household Distribution	0.713	Mian and Sufi (2011)
y^e	Employed income	3	
y^u	Unemployed income	1	

In the next section I include a brief description of the solution algorithm.

2.3.5 Equilibrium Computation

The model equilibrium is computed in two steps, first the bank posts pooling contracts that the households use to compute their optimal consumption and borrowing policies. As a function of the aggregate house prices and the posted interest rates for the secured and unsecured loans $\{\tilde{p}_0, \tilde{p}_1\}$, and $\left\{\tilde{R}^i_M, \tilde{R}^i_B\right\}$.

The household's optimal policies are computed using backward induction. For a given $\tilde{p}_1$, households' housing stock $\tilde{h}^i_0$ and loans $\left\{\tilde{M}^i_0, \tilde{B}^i_0\right\}$, the optimal consumption and debt repayment policies at $t = 1$ can be solved analytically. Using these optimal policies, the households searches over the set of feasible loans, housing and non-durable consumption at $t = 0$ until their utility is maximized.

Once the households' problem is solved for the given aggregate prices, their optimal demand for loans $\left\{\tilde{M}^i_0, \tilde{B}^i_0\right\}$, and the expected loan repayments $\left\{\tilde{M}^{(i,j)}_1, \tilde{B}^{(i,j)}_1\right\}$, are used to evaluate if these quantities satisfy the bank's conditions presented in Equations (2.21) and (2.22). If for the initial loan rates $\left\{\tilde{R}^i_M, \tilde{R}^i_B\right\}$ the equilibrium conditions are not met, the lender will either raise or reduce the rates depending on the excess or lack of expected excess profit for each type of loan.

With respect to the housing market, if for the initial prices $\{\tilde{p}_0, \tilde{p}_1\}$ there is an excess or lack of housing demand, these prices are increased or decreased respectively.

Once the house prices and interest rates are updated, the household's problem is solved using the new market prices, their consumption and borrowing policies are re-calculated, and the equilibrium conditions are re-checked individually. This process is repeated until the described market equilibrium is achieved.

Once that the pooling equilibrium is computed, the bank evaluates the profit from deviating to the separating contract using Equation (2.23). If the deviation is profitable the bank repeats the equilibrium computation but now solving the separating equilibrium following the same described procedure, but the interest rate of each loan type, for each household type, is computed independently.

2.3.6 Numerical Results

To understand the effects of the magnitude of the homestead exemption on the loan market equilibrium, and to the incentives of the bank to monitor, I solve the presented model using the presented parameters and methodology.

The model is solved for two levels of the homestead exemption, $K = 1$, and a $K = 3$. These values are selected so the homestead exemption is in most cases above, or below, the home equity.

In the first stage the bank decides whether to invest or not in the monitoring technology. This choice is made using the estimated deviation profit as presented in previous sections. Based on the estimated deviation profits, I identify the values of the monitoring technology cost Ψ that support each potential equilibrium. Then, in the second stage, I find the market equilibrium for several monitoring costs in the identified ranges, and the results are discussed, specifically its relation with the empirical results.

Stage 1: The Bank's Investment Decision

As the bank initially faces imperfect information about the households' type, it cannot identify if the households are either type g or b, so it first evaluates the option to invest in the monitoring technology.

As mentioned, the bank uses the estimated pooling equilibrium to decide whether to invest in the monitoring technology. In that case, the households enter the loan pool, they commit to an identical interest rate payment per loan unit demanded, however, different households will have a different payment policy, as they payments are related to their future income (which is risky and different for each type), the option to file for personal bankruptcy, and their previously made payment commitments.

For the selected parameters, the estimated pooling equilibrium is:

Table 2.9: Loans and interest rates - Estimated pooling equilibrium for $K = 1$ and $K = 3$

This table presents the equilibrium results of the lending market for the pooling equilibrium. The key characteristic analyzed is the value of the homestead exemption K. The rest of the model parameters are presented in the calibration section.

Panel A: Equilibrium Demand for Loans

	$K=1$	$K=3$
$M_0(g)$	0.58	0.00
$M_0(b)$	0.64	0.00
$B_0(g)$	0.29	0.66
$B_0(b)$	0.47	1.51
D_0	0.95	0.91

Panel B: Equilibrium Loans Gross Rates

	$K=1$	$K=3$
R_M	1.03	-
R_B	1.51	1.64

For the estimated pooling equilibrium, the bank's profits from investing in the monitoring technology, as shown in Equation (2.23), are $\Pi^g(K = 1) = 0.05$ and $\Pi^g(K = 3) = 0.15$, therefore its incentives to invest in the monitoring technology increase with the magnitude of the homestead exemption. Specifically, if the monitoring cost Ψ is lower than $\Pi^g(K = 1)$, then the bank will deviate to the separating equilibrium for both levels of the homestead exemption, and consequently the pooling equilibrium will not be observed.

If Ψ is greater than $\Pi^g(K = 1)$, but lower than $\Pi^g(K = 3)$, then the bank will deviate from the pooling to the separating equilibrium just for the high exemption level. Then the pooling equilibrium will be observed for low exemption, but the separating equilibrium will be observed for the high exemption.

Finally, if Ψ is greater than $\Pi^g(K = 3)$, then the pooling equilibrium is observed in the loan market, as the separating contract profitability is not large enough to compensate the monitoring technology cost.

In the following section, the separating equilibrium is computed using the different values of Ψ, that are relevant for the described cases, this is, on which the bank has incentives to deviate effectively from the pooling equilibrium.

Stage 2: Loan Market Equilibrium

In this section, and based on the level of the monitoring cost, I identify three different potential loan market equilibriums. In the first, the monitoring cost Ψ is lower than $\Pi^g(K = 1)$, then the separating equilibrium is observed for both levels of the homestead exemption. In the second, Ψ is greater than $\Pi^g(K=1)$ but lower than $\Pi^g(K=3)$, which implies that the separating equilibrium is only observed for the high homestead exemption level. Finally, in the third case Ψ is greater than $\Pi^g(K=3)$, thus the bank does not invest in the monitoring technology, so for both homestead exemption levels the loan market equilibrium is the pooling equilibrium.

Case: $0 \leq \Psi < \Pi^g(K=1)$

For the selected parameters, this case happens for a monitoring cost in the range $0 \leq \Psi < 0.05$. Several values in this range where tested, but the main intuitions are the same as in the case $\Psi = 0.00$, which will be presented next.

In this case, as monitoring is profitable for both levels of the homestead exemption, the bank will always invest and the pooling equilibrium will not be observed, then for both levels of the exemptions a different interest rate is charged for each household type, and loan type.

The separating equilibrium in the loan market for $\Psi = 0.00$ is:

Table 2.10: Loans and interest rates - Separating equilibrium for $K=1$ and $K=3$ - $\Psi = 0.00$

This table presents the numerical results for the equilibrium in lending market. The key characteristic subject of analysis in this table is the value of the homestead exemption K..

Panel A: Equilibrium Demand for Loans

	$K=1$	$K=3$
$M_0(g)$	0.54	0.00
$M_0(b)$	1.04.	0.00
$B_0(g)$	0.39	1.21
$B_0(b)$	0.00	0.78
D_0	0.96	1.09

Panel B: Equilibrium Loans Rates

	$K=1$	$K=3$
$R_M(g)$	1.03	-
$R_M(b)$	1.03	-
$R_B(g)$	1.20	1.23
$R_B(b)$	-	2.35

Table 2.10 shows that for the separating equilibrium, with monitoring cost in the range $0 \leq \Psi < 0.05$, the total amount of loans increases. This increment is driven by loans to safer households, thus, for the selected parameters, the presented separating equilibrium shows an increment in the total

amount of loans, with a reduction in the riskiness of the loan portfolio, as the fraction of loans to the risky households goes from 31% to 21%.

The separating equilibrium is not consistent with the empirical findings, as it shows a counter-factual increment in the total amount of loans, driven by the safer loans, as the riskier households experience a a reduction on their loans. For alternatives values of Ψ in the presented range, the total amount of loans still increases as in the presented case, although the difference between the low and high homestead exemption cases is smaller.

It is important to remark that as the bank is able to identify the riskiness of the households after investing in the monitoring technology, it will offer a contract to each household type for secured and unsecured loans. This off-equilibrium path beliefs solve the incentive compatibility problem, as it is clear that the riskier households (type b) will be better off mimicking the safer households.

The key assumption is that as the bank has already perfectly identified the households, so it will only accept safe households in the low-risk contract, so riskier households are rejected if they apply to the low-risk contract. For the high-risk contract, the bank accepts any household in the pool. The interest rate in the high-risk contract is calculated for risky households, so accepting a safe household will make the contract profitable, although, because this contract is not optimal for safer households, this case will not happen in equilibrium.

Case: $\Pi^g(K=1) < \Psi \leq \Pi^g(K=3)$

For the selected parameters, this case happens for a monitoring cost in the range $0.05 < \Psi \leq 0.15$. As in the previous case, several values in this range where tested, but the presented results are calculated for $\Psi = 0.10$, the mid point of the range.

In this case, monitoring is profitable only for the higher level of the homestead exemption, thus the bank will invest only in such case, and the pooling equilibrium will be observed for low homestead exemption, as in this case, the profit of deviating from the pooling equilibrium does not compensate the cost of the monitoring technology.

Table 2.11 presents the pooling equilibrium for $K = 1$, and compares it with the separating equilibrium in the loan market for $K = 3$, and $\Psi = 0.10$.

Table 2.11: Loans and interest rates - Pooling equilibrium for $K = 1$, separating equilibrium for $K = 3$ - $\Psi = 0.10$

This table presents the numerical results for the equilibrium in lending market. The key characteristic subject of analysis in this table is the value of the homestead exemption K..

Panel A: Equilibrium Demand for Loans

	$K=1$	$K=3$
$M_0(g)$	0.58	0.00
$M_0(b)$	0.64	0.00
$B_0(g)$	0.29	1.03
$B_0(b)$	0.47	0.71
D_0	0.95	1.09

Panel B: Equilibrium Loans Rates

	$K=1$	$K=3$
$R_M(g)$	1.03	-
$R_M(b)$	1.03	-
$R_B(g)$	1.51	1.35
$R_B(b)$	1.51	2.59

Table 2.11 shows that for the separating equilibrium, with a monitoring cost in the range $0.05 < \Psi \leq 0.15$, the total amount of loans decreases, and this reduction is focused on the loans to riskier households, thus, for the selected parameters, the separating equilibrium shows a decrease in the total amount of loans, with a reduction in the riskiness of the loan portfolio, as the fraction of loans to the risky households goes from 34% to 22%.

For this case, as the homestead exemption increases, the bank's incentives to monitor also rises, making the bank deviate to the separating equilibrium. The observed results of this deviation are consistent with the empirical findings, as it shows a reduction in the total amount, mainly focused on the secured loans, complemented with a reduction of the loans to riskier households.

In comparison to the previous case, the increment in the cost of the monitoring technology becomes important for the loan demands. The monitoring cost makes loans more expensive to the households, as the bank transfers the monitoring technology cost to the rates. This is the channel behind the reduction in the total amount of loans, in comparison to previous case on which the cost of the technology is lower.

In this line, for alternatives values of Ψ in the presented range, the total amount of loans still increases (as in the previous case) if the cost of the technology is among the smallest values of the interval, but for values near the center of the interval and up, the decreases in loans described is consistently observed. A separating case with a monitoring cost larger that the higher bound of the identified range was tested. In such case, households are observed to only demand secured loans and do not default, as just by the transfer of the monitoring costs, the loan interest rates become high enough to avoid increasing them further by defaulting, even for the safer households.

Therefore, the results of this case indicate that, from the presented alternatives, the observed empirical evidence is consistent with a bank choosing optimally to monitor for a higher homestead exemption magnitude. The magnitude of the monitoring cost is important not only to determines the incentives of the bank to deviate to the separating equilibrium, it also affects the loan interest rates that the households will pay. As the bank transfer the investment cost, the interest rates raise and the total amount of loans decreases, in comparison to the pooling equilibrium observed for the low homestead exemption.

Now, as this case matches the main empirical findings presented, it is useful to review the equilibrium of the housing market observed for this case. Table 2.12 presents the housing equilibrium for the pooling equilibrium with $K = 1$, and compares it with the housing market equilibrium for the separating equilibrium with $K = 3$, and $\Psi = 0.10$.

Table 2.12: Housing Equilibrium - Pooling equilibrium for $K = 1$, separating equilibrium for $K = 3$ - $\Psi = 0.10$

This table presents the numerical results for the equilibrium in the housing market. The key characteristic subject of analysis in this table is the value of the homestead exemption K..

	$K = 1$	$K = 3$
$h_0(g)$	5.06	5.47
$h_0(b)$	4.85	3.83
P_0	0.31	0.37

Table 2.12 shows, as in most of the parametrizations tested, that a higher homestead exemption relates to higher prices (P_0), as type g households increase their demand for housing. These households have a lower probability of becoming unemployed and a higher expected income, hence, they exchange future income for the possibility of having a greater housing sock, that will provide them insurance against negative income shocks, through their option to file for personal bankruptcy. This increment in the type g households' housing demand is the channel behind the positive relation between the homestead exemption and house price, and is driven by the increment in their loans, as they have a higher amount of wealth in the first period available to invest, while at the same time, riskier households are more constraint, being forced to reduce their housing consumption to sustain their non-durable consumption. Another factor to remember here is that the safer households constitute a bigger fraction of the total of households, so smaller changes in their behavior will have a higher effect in the market price.

Case: $\Pi^g(K=3) < \Psi$

In this case, the bank does not invest in the monitoring technology, hence the market equilibrium is the same as the pooling equilibrium presented in Table 2.9.

Table 2.9 shows that for the low homestead exemption $K = 1$, the households favor secured loans as their interest rates are lower. For a low homestead exemption, the financial benefit from personal bankruptcy is limited, as the households will keep only a small fraction of their wealth at default. This said, they will not demand high amounts of unsecured loans, as most of its home equity will be collected to repay them.

For a higher homestead exemption $K = 3$, the financial benefit from filing for personal bankruptcy is higher than for $K = 1$, consequently, the households will demand a higher amount of unsecured loans, as in most cases, if they file for personal bankruptcy they will keep most of their home equity. This increment in the unsecured loan demand is stronger for riskier households, as they have a higher probability of becoming unemployed, and therefore, of filing for bankruptcy and do not repay their unsecured loan.

This effect is also reflected in the change in the aggregate loan demand, as for $K = 1$ the loans to risky households correspond to 34% of the portfolio, while for $K = 3$ its loan share rises to 48%, showing the traditional result that as the increment of the homestead exemption (or the benefit from bankruptcy) relates to a reduction of total amount of loans, but in the pooling equilibrium, the riskiness of the portfolio rises. These results are not consistent with the presented empirical evidence, as I found that the the loan portfolio becomes safer as the homestead exemption increases.

In this case, the increment in the moral hazard and adverse selection increase the bank's incentives to deviate from the pooling contract, by investing in the monitoring technology. Investing allows the bank to offer a new separating contract just for the safer household. As this contract will only accepts households with a higher probability of repayment, it generates positive profits, and the previously offered pooling contract exhibit loses, as only the riskier, higher default probability households, are left in it.

2.4 Conclusion

In this paper I study how the magnitude of the homestead exemption relates to the supply and demand for loans. As the homestead exemption specifies the amount of home equity that a household will be entitled to keep at bankruptcy, one might expect that a higher exemption will increase the moral hazard on the part of the borrowers, leading to higher demand for loans, with higher delinquency ratios, while the lenders will respond with higher interest rates. Surprisingly, I find the opposite in the state-level panel that I constructed, as the regression analysis shows that states with a higher homestead exemptions relates to fewer secured loans granted, lower delinquency ratios on secured and unsecured loans, lower interest rates, and higher house prices.

To understand the economic mechanism behind these empirical results, I follow Mitman (2016) and construct an equilibrium model on which a set of households face idiosyncratic income risk. These households get utility from non-durable and housing consumption, financing them with their income, secured and unsecured loans, and have the option to file for bankruptcy in a process that captures the main features of the personal bankruptcy code. Loans are provided by a competitive lender that price default risk using the overall debt position and assets holdings of the household. Lenders are assumed to initially be unable to observe the riskiness of the future households income, but can invest in a costly monitoring technology to eliminate this information asymmetry.

The mechanism of the model is as follows. A more generous homestead exemption increases the household benefits after filing for bankruptcy, providing implicit insurance to the households against negative income shocks. The loan demand increases as the financial benefit of bankruptcy increases, while the demand for housing also increases pushing house prices up. These bankruptcy benefits for the households are mirrored by a rise in the credit losses faced by the lender. As unsecured debt is partially or fully discharged, the lender price each loan accordingly to its specific credit risk.

Although, in the case on which the lender can pay for the monitoring technology, the low risk households no longer provide subsidies to the riskier households, eroding their potential pooling advantage as they are now subject to higher interest rate as the exemption increases and the monitoring costs are transferred. For the theoretical results consistent with the empirical findings, this effect produces an aggregate reduction in the secured loans, as the bank deviates from the pooling equilibrium observed for low levels of the homestead exemption, to a separating equilibrium for a higher exemption, on which low risk households increase their demand for unsecured loans, while the total aggregate amount of debt is reduced. This mechanism is consistent with the empirical evidence indicating that higher exemptions lead to a lower fraction of secured loans issued, with lower rates and delinquency, with higher overall house prices.

Chapter 3

The Valuation of Fisheries Rights with Sustainable Harvest

3.1 Introduction

The economic sustainability of fisheries is an ongoing concern for consumers, fishers, governments, intergovernmental organizations, and academics. Overfishing occurs when more fish are caught than the natural population growth, and as Ye and Gutierrez (2017) indicate, during the last decade the worldwide percentage of stocks classified as overfished remained stable at 30%, pointing to a failure of self-regulation and a misalignment between economic incentives and conservation. This is the starting point of several efforts from governments and institutions around the world to regulate these markets and achieve a sustainable equilibrium.

The Food and Agriculture Organization of the United Nations (FAO (2008)) indicates that an important part of solving the overfishing problem is to "adjust fishing capacity to sustainable levels through policy and regulations, including judicious use of subsidies and eradication of illegal, unreported and unregulated fishing." Nowadays one of the most used policy devices is the Individual Vessel Quota (IVQ) system, an allocation of extraction rights of the total annual fish catch (TAC) in the form of transferable quota shares which limits not only the total catch, but also controls the individual fisher's landings.

Although the IVQ policy has been successful in limiting overexploitation, there is still an ongoing discussion on the optimal economic level of the quota. This paper develops a methodology in a dynamic setting to determine the total annual fish catch which maximizes the value of the natural resource. This optimal TAC not only maximizes the value of the resource, but also assures the sustainability of the resource.

This chapter develops and implements a stochastic optimal control approach to determine the harvest (the control) that maximizes the value of the resource by modeling fisheries as a complex function on the variables underlying the value of the industry, in this case, the resource stock (biomass) and the fish price. Uncertainty is introduced in the analysis by allowing these variables to follow dynamic stochastic processes. The model has some features similar to Morck et al. (1989) for forestry but in this case the resource growth is specific for a fish population, and operational cash flows are modeled as an explicit function of the biomass and the total harvest. In addition, we allow for a more general price specification. For the biomass growth uncertainty we follow Pindyck (1984) and use a logistic growth function which explicitly captures the possibility of overpopulation and depletion. For the price of fish, we use a general log-normal price dynamics and let the data determine the particular form to use in our implementation of the model.

To make the problem tractable we consider the case where several competitive price taking fisheries can be represented by a single fishery endowed with the total annual fish catch (TAC) whose property rights are well defined. To simplify the model we also assume that the fishery faces no taxes and that production can be opened and shut down at no cost; though these features could be easily incorporated in the model.

The model is solved using a value-function iteration algorithm instead of the more traditional partial differential equation approach. The solution approach solves for the optimal dynamic harvesting policy of a representative fishery, and then uses this policy to value the marine harvesting rights. The solution also allows us to study how the optimal level of harvesting relates to the two state variables in our model, the biomass and the fish price, and how these rights will optimally evolve with stochastic changes in the state variables. Based on the optimal policy it is possible to simulate the dynamics of the biomass subject to stochastic shocks and optimal harvesting, illustrating how the biomass will evolve over a specific time horizon.

Most of the current literature on fisheries assumes that prices are constant or evolve deterministically (Clark and Kirkwood (1986), Sethi et al. (2005)). A significant improvement of our model is that it includes stochastic prices which turns out to be an important issue. Our analysis also expands the literature by including in the cost function not only fixed operational costs, but also variable costs which are related to the biomass through the fisheries efficiency (catchability), and a quadratic component which incorporates an increasing marginal cost.

To examine the model implications, we apply it to the British Columbia halibut fishery. Combining multiple sources of information, we constructed time series for the halibut biomass, total harvest (landings), and price, and using this data all required parameters of the model are estimated. Our estimates show that the volatility of the fish price growth is comparable in size to the estimated volatility of the biomass growth, showing that when previous literature assumed that the fish price followed a deterministic path the fishery's valuation problem is significantly underestimating the uncertainty faced by the fishers.

The model results show that it is optimal for the representative fishery to preserve the biomass for future harvesting, and that if the biomass suffers significant negative shocks then it is optimal to drastically reduce exploitation, even fully stopping the harvest in scenarios of low biomass or low resource prices. That is, the optimal harvesting policy exhibits strong financial incentives to avoid the extinction of the natural resource.

The valuation of natural resources under uncertainty is a problem in which the Real Option approach has proven to be appropriate in other contexts, as the work of Brennan and Schwartz (1985) and the significant body of work that followed indicate, but until now it has not been fully applied to marine fisheries[1].This paper is also related to the research on the valuation of marine resources using Real Options. The closest paper to ours are Murillas (2001) and Poudel et al. (2013), in which this approach is used to value capital investments in fisheries using a model with uncertainty in the growth of the fish and in the capital, a linear production cost function with no fixed cost, but no uncertainty in the resource price.

Finally, this paper contributes to the marine fisheries literature by presenting empirical estimations for all the parameters required to solve the model. Data for the British Columbia halibut fishery is used because of its availability. Data was collected from several sources including the International Pacific Halibut Commission (IPHC) and Fisheries and Oceans Canada (DFO). Cost data is hard to find, as Clark et al. (2009) already indicated, so we use the two available financial surveys performed for the DFO by Nelson (2009) and Nelson (2011) to identify the parameters of the modeled cost function.

In summary, this paper presents an approach for valuing fisheries under the optimal harvesting policy, including a full parameter estimation for its implementation to study the optimal policies and value marine fishery rights for the British Columbia halibut. This approach is not only useful to value extraction rights for a current level of our state variables, it also allows us to understand how it evolves over time and presents evidence for the value of conservation of the natural resource and the possibility of achieving an economic sustainable equilibrium.

This section proceeds as following. The valuation model is presented in section 3.2. Section 3.3 provides a detailed estimation of the model parameters for the British Columbia halibut fishery. Section 3.4 shows the numerical result for the estimated calibration and quantifies the impact of the inclusion of price volatility into the model. Finally, Section 3.5 gives our concluding remarks. Details on the solution algorithm, the estimation and selection of the stochastic price model, a sensitivity analysis for the cost function parameters, and the impact of the use of a social discount rate on the harvesting policy are provided in the Appendix.

3.2 A Valuation Model of Marine Fisheries Rights

In this section we develop a dynamic stochastic economic model to study how fisheries should optimally harvest the resource. The value of the marine fishery is assumed to depend on two stochastic variables: the biomass and the price of fish.

Following Pindyck (1984) the dynamic of the biomass of the resource is assumed to follow:

$$I_{t+1} = I_t + G(I_t) - q_t + I_t \sigma_I \varepsilon^I_{t+1} \tag{3.1}$$

[1]Exception are Nøstbakken (2006) and Kvamsdal et al. (2016)

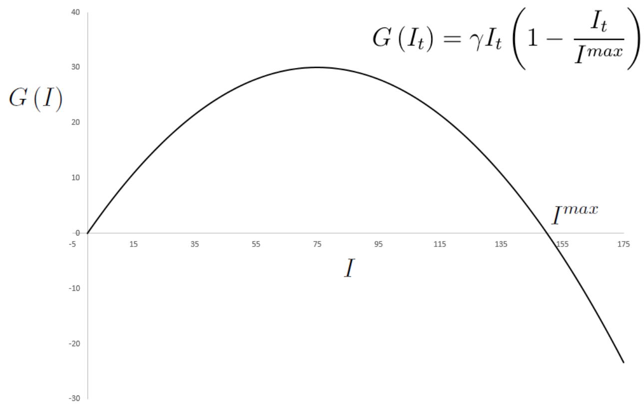

Figure 3.1: Logistic Natural Growth Function for for the parameters $\gamma = 0.8$, $I^{max} = 150$

where I_t is the biomass at year t, $G(I_t)$ is the annual expected rate of growth of the biomass, q_t is the annual harvesting rate and the stochastic control in the model, σ_I is the volatility of the unanticipated shocks to the resource stock ε_t^I, which are assumed to be i.i.d. standard normal.

As in Clark (2010) and Nøstbakken (2006), the growth rate of the biomass is assumed to follow a logistic function and is presented in Equation 3.2. This function explicitly captures the fact that if the biomass approaches its carrying capacity I^{max}, resources in the environment become scarce, reducing the natural growth to zero[2].

$$G(I_t) = \gamma I_t \left(1 - \frac{I_t}{I^{max}}\right) \tag{3.2}$$

Figure 3.1 shows the previously mentioned logistic function features for the parameters $\gamma = 0.8$, $I^{max} = 150$:

The second source of uncertainty is the resource price, which we assume follows the stochastic process:

$$\ln P_{t+1} = f(P_t) + g(P_t)\,\varepsilon_{t+1}^P \tag{3.3}$$

Where P_t is the unit fish price at year t, $f(P_t)$ is the expected annual rate of change in the logarithm of the price, $g(P_t)$ is the volatility of the unexpected price shocks ε_t^P which are assumed to be i.i.d. standard normal. We assume that the price and biomass shocks are uncorrelated, that is $E\left[\varepsilon_t^I \times \varepsilon_t^P\right] = 0$ for all t. [3]

Consider an infinitely-lived value maximizing fishery, with the enough installed capacity for the range of harvests considered, and the right to harvest a particular fish specie. Then, the fishery's annual

[2]If the biomass becomes larger than the carrying capacity the natural growth becomes negative.

[3]This assumption was initially made for computational convenience and can be easily relaxed, although we tested the independence of the historical realizations of both stochastic processes finding that the correlation between them is 0.01, and not statistically different from zero.

cash flow from harvesting is equal to:

$$\pi(I_t, P_t, q_t) = P_t \times q_t - c\left(I_t, q_t\right) \tag{3.4}$$

$c\left(I_t, q_t\right)$ is the operating cost function of harvesting q_t given by the quadratic equation:

$$c(I_t, q_t) = \begin{cases} c_0 + c_1 \times \frac{q_t}{I_t} + c_2 \times q_t^2 & if\ q_t > 0 \\ c_3 & if\ q_t = 0 \end{cases} \tag{3.5}$$

where c_0 is the fixed cost, c_1 is the variable cost, c_2 is the quadratic cost reflecting an increasing marginal cost. The cost function parameter c_3 reflects the fact that there is a fixed cost paid by the fishery to remaining open in years without harvest.

The increasing marginal cost is included to capture expenses required for harvesting beyond the current levels. Examples of these costs may be increasing the fleet capacity, finding new personal or investing in new technology. Function (3.5) is a simple way to include this realistic feature into the modeled cost function.

The present value of the fishery's future expected cash flows for a given harvesting policy $q_t = q\left(I_t, P_t\right)$, assuming an infinitely lived representative fishery, is defined as:

$$H\left(I_t, P_t, q(I_t, P_t)\right) = E_t\left[\sum_{\tau=t}^{\infty} \frac{1}{(1+r)^{\tau-t}} \pi\left(I_\tau, P_\tau, q(I_\tau, P_\tau)\right)\right] \tag{3.6}$$

where r is the fishery's risk-adjusted cost of capital. Equation 3.6 can be re-written as:

$$\begin{gathered} H\left(I_t, P_t, q(I_t, P_t)\right) = \\ \pi\left(I_t, P_t, q(I_t, P_t)\right) + \frac{1}{(1+r)} E_t\left[\sum_{\tau=t+1}^{\infty} \frac{1}{(1+r)^{\tau-(t+1)}} \pi\left(I_\tau, P_\tau, q(I_\tau, P_\tau)\right)\right] \end{gathered} \tag{3.7}$$

Therefore,

$$\begin{gathered} H\left(I_t, P_t, q(I_t, P_t)\right) = \\ \pi\left(I_t, P_t, q(I_t, P_t)\right) + \frac{1}{(1+r)} E_t\left[H\left(I_{t+1}, P_{t+1}, q(I_{t+1}, P_{t+1})\right)\right] \end{gathered} \tag{3.8}$$

A value maximizing fishery will choose the optimal harvesting policy $q^*\left(I_t, P_t\right)$, that is, the harvesting policy that maximizes the value of the fishery, by solving the following Hamilton–Jacobi–Bellman (HJB) equation:

$$\begin{gathered} V\left(I_t, P_t\right) = \max_{q(I_t, P_t) \geq 0} \left\{\pi\left(I_t, P_t, q(I_t, P_t)\right) + \frac{1}{1+r} E_t\left[V\left(I_{t+1}, P_{t+1}\right)\right]\right\} \\ V\left(I_t, P_t\right) = \pi\left(I_t, P_t, q^*(I_t, P_t)\right) + \frac{1}{1+r} E_t\left[V\left(I_{t+1}, P_{t+1}\right)\right] \end{gathered} \tag{3.9}$$

were $V(I_t, P_t)$ is the value of the fishery under the optimal policy $q^*(I_t, P_t)$. As the present value of the

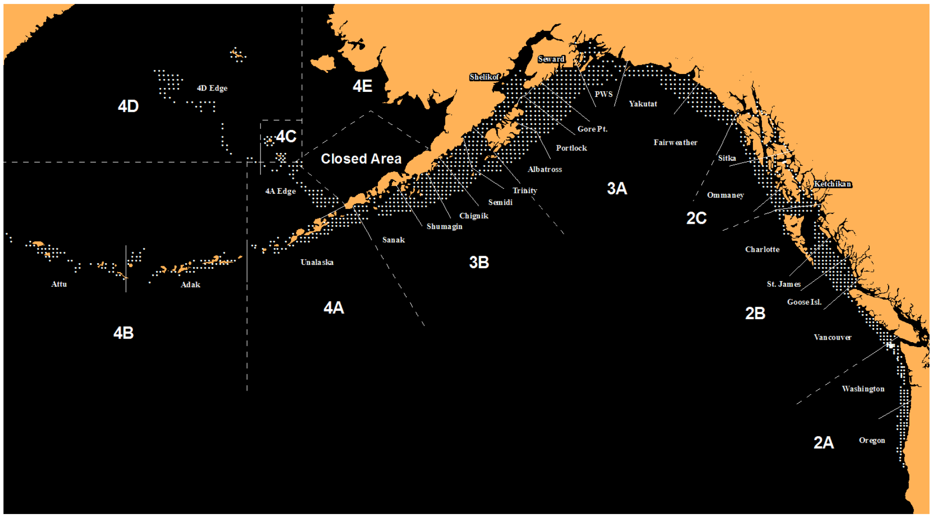

Figure 3.2: International Pacific Halibut Commission Regulatory Regions. Source: International Pacific Halibut Commission (IPHC).

cash flows is maximized over the set of feasible harvesting policies it is not dependent of this function anymore.

In Section 4.3.1 we present the model solution using data of the British Columbia halibut fishery, including estimation of the relevant parameters, the harvesting policy, and the fishery's value.

3.3 Parameter Estimation for the British Columbia Halibut Fishery Case

To illustrate the implementation of the methodology proposed in this article we calibrate and solve the model for the case of the British Columbia halibut. We use data from the International Pacific Halibut Commission (IPHC), established in 1923 by a convention between Canada and the U.S. for the preservation of the Pacific halibut fishery. The IPHC provides recommendations to these governments on the total catch limit and monitors the resource over the regulatory areas presented in Figure 3.2. We focus on the area 2B corresponding to British Columbia.

Our second source of data is the Department of Fisheries and Oceans of Canada (DFO), agency responsible for *"...sustainably manage fisheries and aquaculture and work with fishers, coastal and Indigenous communities to enable their continued prosperity from fish and seafood."*[4] Specifically, we use the British Columbia halibut landing price data and financial reports published on their site.

In the following subsections we present the estimations for the parameters of the BC halibut biomass dynamic, price dynamic, cost function, and risk adjusted discount rate.

[4] http://www.dfo-mpo.gc.ca/about-notre-sujet/org/mandate-mandat-eng.htm

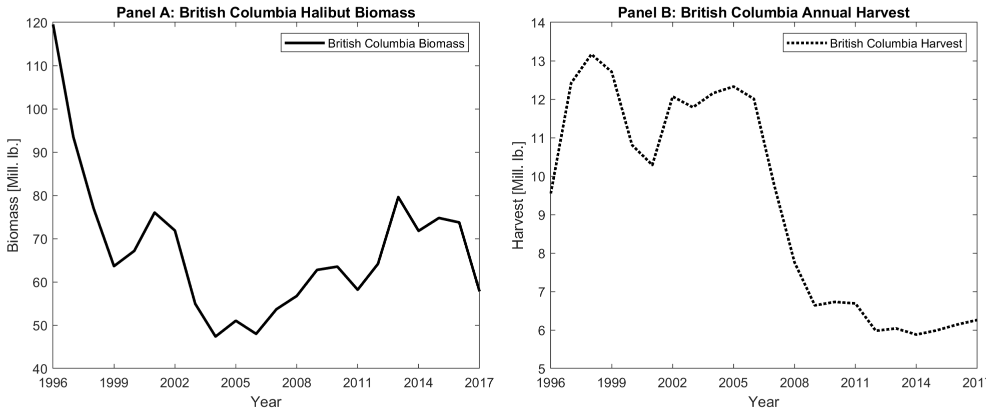

Figure 3.3: British Columbia halibut stock assessment and landings, 1996-2017. Source: International Pacific Halibut Commission (IPHC).

3.3.1 British Columbia Halibut Biomass Dynamic Parameters

Although the biomass is not perfectly known, the stock assessment provided by Stewart and Hicks (2017) and Stewart and Webster (2017) is the closest proxy to its true magnitude. As detailed in the cited documents the biomass estimation is the result of a combination of several models which use short and long term data. Figure 3.3 shows the time series for the biomass and the landings of halibut for the British Columbia region, for the period 1996-2017.

Panel A of Figure 3.3 shows that the biomass exhibited a strong decline between 1996 and 2000, period also characterized by high harvesting as Panel B of Figure 3.3 exhibits. By 2010 the biomass was almost half of the 1996 level and harvesting was reduced to levels that remain controlled.

Using this data we estimate the parameters of the biomass logistic growth function, and the volatility of the random shocks. Combining Equations (3.1) and (3.2) we obtain the non-linear regression:

$$I_{t+1} + q_t = I_t \left(1 + \gamma \left(1 - \frac{I_t}{I^{max}}\right)\right) + I_t \sigma_I \varepsilon^I_{t+1} \tag{3.10}$$

Equation (3.10) is a non-linear function of the required parameters, so the estimation is done using the Nonlinear least-squares technique[5], the results of this approach are presented in Table 3.1.

Figure 3.4 illustrates the goodness of fit of the estimation by comparing the biomass natural historical growth rate (L.H.S. of Equation (3.10)) versus the growth (Expected value of the R.H.S. of Equation (3.10) calculated using the estimated parameters.

Figure 3.4 shows that the estimated parameters are effective in capturing the relation between the biomass level and its growth, although there is a significant level of biological uncertainty captured by σ_I, which explains the overall difference between the fitted model and the data.

[5]A technical description of the method can be found in Heer and Maussner (2009)

Table 3.1: Estimated Parameters for the Biomass Dynamic, 1996-2017

The parameters are estimated using Nonlinear least-squares (Levenberg-Marquardt algorithm). The data covers from 1996 to 2017 and is obtained from Stewart and Hicks (2017) and Stewart and Webster (2017). All coefficients are estimated simultaneously.

γ	0.59
(t-stat)	(5.80)
I^{max}	85.51
(t-stat)	(17.04)
σ_I	0.11
Adj. R^2	0.69

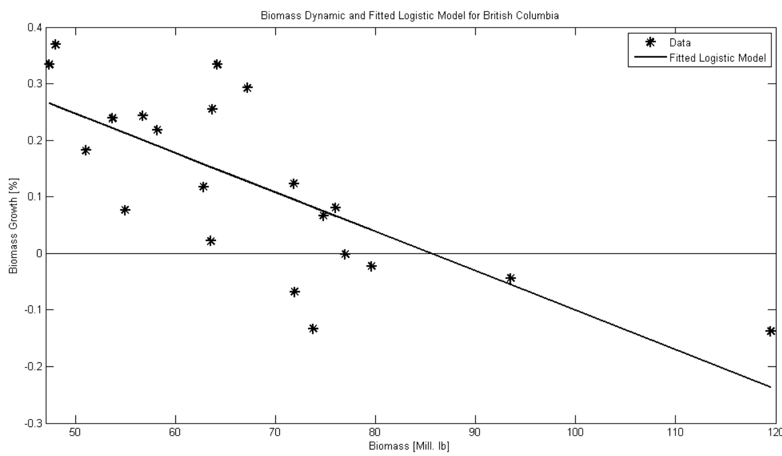

Figure 3.4: British Columbia Halibut Biomass Growth and the Non-Linear Least Squared Model Estimation

3.3.2 British Columbia Halibut Price Dynamic Parameters

From the Department of Fisheries and Oceans of Canada (DFO) website[6], we gather the halibut ex-vessel historical prices for British Columbia. The time series of prices covers from 1996 to 2017 and is used to test multiple models for the dynamic of halibut prices, this is, we test for different specifications for the functions $f(P_t)$ and $g(P_t)$ in Equation 3.3, and determine which of them fits the available data better.

The tested models for the dynamic of the halibut prices include mean reverting, autoregressive and moving average time series specifications. We conclude that for the period studied the log-normal model fits the data the best:

$$\ln P_{t+1} = \ln P_t + \nu_P + \sigma_P \varepsilon_t^P \tag{3.11}$$

In the appendix we provide the regression statistics for the models tested, including the values of the Akaike information criterion (AIC) used to determine the performance of the models surveyed.

As mentioned, we tested several alternative models, including one on which the price of the halibut

[6] http://www.dfo-mpo.gc.ca

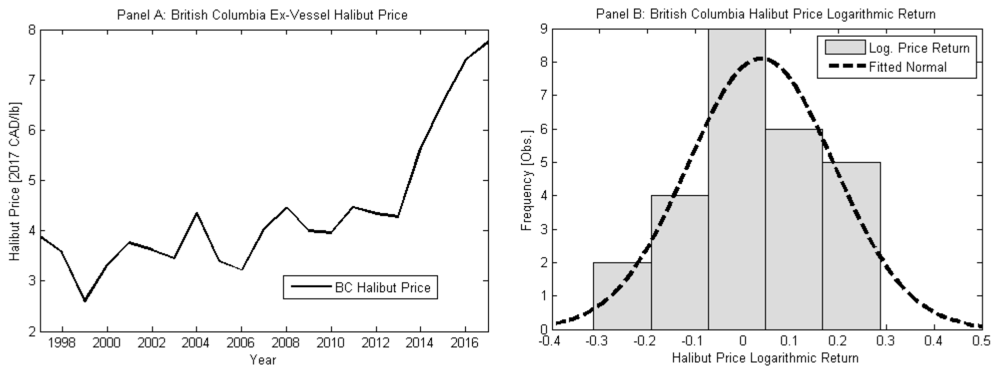

Figure 3.5: British Columbia Halibut Ex-Vessel Real Price and Logarithmic Returns, 1996-2017. Source: Fisheries and Oceans of Canada - Quantities and Values

Table 3.2: Ex-Vessel Real Price Dynamic Parameters, 1996-2017

The parameters are the mean and standard deviation obtained for the estimation of an ARIMA(0,1,0) model for the Logarithm of the British Columbia Halibut Ex-Vessel Price. The data covers from 1996 to 2017 provided by the DFO.

ν_P	0.038
(t-stat)	(0.94)
σ_P	0.154

is determined by a negatively sloped demand curve, but from all these alternatives, the best statistical fit is the selected log-normal model. From an economic perspective, the selected model implies that fisheries are price takers, that is, the modeled fishery's harvest does not affect the equilibrium price, as it is determined in a broader market, on which several alternatives goods and alternative producers participate. This market arrangement affects the problem of the fishery as it is possible to conjecture that in scenarios of extremely high prices, it may be optimal to harvest a significant fraction of the biomass, leading to the well known problems of the tragedy of the commons. Beyond this point, this possibility will be allowed in the model for academic purposes, as one of our goals is to evaluate the possibility of observing severe overfishing scenarios, so we can evaluate its consequences in the dynamic of the biomass.

Figure 3.5 presents the time series of the real halibut prices (Panel A) and the distribution of the real logarithmic price returns (Panel B). All prices are inflated using the CPI for the British Columbia province and expressed in 2017 Canadian dollars.

The estimated drift and volatility are presented in Table 3.2:

From Table 3.2 is possible to notice that the estimated drift is not statistically different from zero, hence for the model calibration we set this parameter to zero. [7]

[7] For convergence of the algorithm it is required that the discount rate used is higher than the drift of the price process. Since in the Appendix we analyze the solution of the problem with a real social discount rate of 1%, the drift of the price process needed anyhow to be below 1%.

Table 3.3: British Columbia Halibut Fishery Revenues, 2007 and 2009

The values are obtained from the reports prepared for the DFO-Pacific Region by Stuart Nelson of Nelson Bros Fisheries Ltd. (Nelson (2009) and Nelson (2011)), and provide estimates of the financial performance for vessels operating in British Columbia for the years 2009 and 2007. These reports are done with a combination of data from the DFO and consultant collected information through interviews/correspondence with fishermen and experts. The presented data corresponds to the group of vessels with the middle third of the individual landings. All values are expressed in 2017 CAD using the CPI for British Columbia.

	2007 (In 2017 CAD)	**2009** (In 2017 CAD)
Total Biomass [Mill. lb.]	53.69	62.78
Landings [Mill. lb.]	2.88	2.14
Vessel Price [CAD/lb.]	$5.56	$5.99
Gross Revenue [Mill. CAD]	$16.03	$12.85
Total Fishery Specific Expenses	$4.75	$3.77
Crew and Captain Shares	$4.78	$3.85
Total Vessel Expenses	$1.28	$0.99
Total Cost [Mill. CAD]	**$10.81**	**$8.62**
EBITDA [Mill. CAD]	**$5.23**	**$4.23**

3.3.3 British Columbia Halibut Fishery Costs Parameters

The model's cost function is presented in Equation 3.5 and includes a fixed operating cost, a linear harvesting cost which is related to the biomass through the fishery's efficiency (catchability), and an increasing marginal cost captured by the quadratic component. The parameters of this function are estimated using two surveys performed by Nelson Bros Fisheries Ltd. for the DFO (Nelson (2009) and Nelson (2011)). The survey separate the total vessels operating in British Columbia in three groups, depending on its harvest, we use the median group as it represents the average vessel production function. The surveys are summarized in Table B.3:

Table B.3 presents two years of costs and revenues for the mid level efficient vessels in the British Columbia halibut fishery. During 2007 the fisheries registered higher harvest and lower costs, per unit harvested, in comparison to 2009. All dollar values are inflated using the British Columbia CPI and expressed in 2017 Canadian Dollars (CAD), making all future costs estimations and values comparable.

The parameters of the cost function are determined solving an over-identified system of equations for the annual cost, that is, we solve Equation 3.5 by leaving one parameter free, in this case c_2, and then solve for the remaining two c_0, c_1, subject to $c_0 > 0$, $c_1 > 0$ and $c_2 > 0$, using the two years of available data.

The set of feasible values for the parameter c_2 is $(0, 0.6]$, that is, if $c_2 > 0.6 \implies c_1 < 0$. For the quadratic cost parameter we choose the median of the feasible values, that is $c_2 = 0.3$, implying that $c_1 = 54.87$ and $c_0 = 5.37$. Finally, we assume that if the fishery does not harvest it will only pay the fixed cost c_0, therefore $c_3 = c_0 = 5.37$.

This parametrization gives a balanced combination between the increasing marginal cost and the linear component of the harvesting cost. As mentioned, there are several cost parameters that solve the over-identified system of equations associated with the presented harvesting costs, so the main difference among the those solutions is the trade off between the weight of the quadratic and linear component of the cost, to generate the same total cost.

We implement the model using the cost function parameters estimated for the mid level efficiency vessels harvesting the British Columbia halibut. As we assume that there is a sole representative fishery harvesting the each year, we use these parameters for the whole annual harvest in the model. We also studied the model with alternative cost parameters, based on the high efficiency and low efficiency fisheries of the British Columbia halibut, the numerical results for these paremetrizations are available in the Appendix.

Although we are able to provide a calibration of the cost function, it is clear that more data is required to achieve a proper implementation of the model. Clark et al. (2009) already pointed out this issue, and unfortunately these surveys are not available for other years. Any effort to fully implement the model will have to deal with the lack of information of the production costs, which will require collecting and standardizing additional information.

3.3.4 Risk Adjusted Fishery Discount Rate

To estimate the risk adjusted discount rate for fisheries we look at the historical returns for companies classified as Fisheries using the SIC industrial classification, which codes are:

- 0912: Fisheries, Finfish
- 0913: Fisheries, Shellfish
- 0919: Miscellaneous Marine Products
- 0921: Fish Hatcheries and Preserves

Unfortunately not a significant number of firms are recorded on CRSP with the identified SIC codes. In Fama and French (1997) however, these firms are included in the macro-sector portfolio ”Agriculture”. We use this portfolio definition to obtain a robust estimation of the sector beta and the expected rate of return. The CRISP database is used to obtain the firm’s stock returns and the historical risk-premium is obtained from Kenneth R. French site[8].

For the returns of each firm registered in the ”Agriculture” portfolio, 60-months rolling betas are computed. The median beta for the Agriculture portfolio during the 1987-2016 period is 0.35. Combining this value with the historical risk premium and risk-free rate the estimated real rate of return for a fishery company is 2.9%. The detailed calculation is presented in Table 3.4

To get additional information about the appropriate risk-adjusted discount rate we also looked at the few fisheries included in CRSP. Table 3.5 presents the estimated rolling-betas and nominal returns.

[8] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/index.html

Table 3.4: Fishery's risk adjusted rate of return

The included beta is the annual average of the median 60-months rolling betas of the firms registered in the "Agriculture" portfolio. The risk premium and risk-free rate are obtained from the historical excess of return for the Canadian stock and bond market. The Bank of Canada inflation target of 2% is used to obtain the real rate using the continuous compounding Fisher equation. Data from CRSP and Ken French website. $R_{Fishery} = R_f + (R_m - R_f)\beta_{Fishery}$

Panel A: Estimated Rates and Fishery's Beta

β	0.349
$R_m - R_f$	0.055
R_f	0.030
$\mathbf{R^{Nom}_{Fishery}}$	**0.049**

Panel B: Fishery's Real Risk Adjusted Rate of Return

$$R^{Real}_{Fishery} = (1 + R^{Nom}_{Fishery})/(1+\pi) - 1 = 0.029$$

Table 3.5: Fishery Betas, Available Firms

The parameters are the average of the 60-months rolling betas for the firms in CRPS whose SIC code is 0912, 0913, 0919 or 0921. The risk adjusted returns are computed using the included beta and the risk premium presented in Table 3.4

Company	Period	**Beta**	$\mathbf{R_{Fishery}}$
Marine Harvest ASA	Feb. 2014 - Jun. 2016	**0.3503**	**0.0493**
Aquaculture Production Tech Ltd.	Jun. 2007 - Mar. 2011	**0.7470**	**0.0711**
Marine Nutritional Sys Inc.	Nov. 1996 - Jun. 2007	**0.8399**	**0.0762**

The range of nominal rates of returns for fisheries is $[0.049, 0.076]$. Marine Harvest ASA has the most recent data, and its rate of return is consistent with the estimation presented in Table 3.4, therefore, this will be the primary risk adjusted real rate of discount used in the model.

3.4 Numerical Results

3.4.1 The Value-Function Iteration Approach

To solve the Hamilton–Jacobi–Bellman equation for the fishery's value $V(I_t, P_t)$, we follow the Value-Function Iteration Approach as presented in Heer and Maussner (2009). We start from Equation 3.9:

$$V(I_t, P_t) = \max_{q \geq 0} \left\{ \pi(I_t, P_t, q(I_t, P_t)) + \frac{1}{1+r} \mathbb{E}_t \left[V(I_{t+1}, P_{t+1}) \,|I_t, P_t \right] \right\} \tag{3.12}$$

where $q(I_t, P_t)$ is the extraction policy, and (I_{t+1}, P_{t+1}) is the state at year $t+1$ for the two stochastic variables in the model, the resource biomass and price.

The solution approach starts by defining a discrete state space for the biomass and the resource price, (I_n, P_m), where $I_n \in \{I_1, I_2, ..., I_N\}$ and $P_m \in \{P_1, P_2, ..., P_M\}$. The optimal control is discretized to the set $q_j \in \{0, q_1, ..., q_J\}$. The $N \times M$ matrix $V = V_{nm}$ represents the value of the fishery for the state (I_n, P_m).

The biomass and the price stochastic shocks are denote by Z^I and Z^P respectively. As mentioned in the model section, these shocks are assumed to be i.i.d. standard normal. The shocks discretization is a finite Markov chain $Z_k^I \in \{Z_1^I, Z_2^I, ..., Z_K^I\}$ and $Z_l^P \in \{Z_1^P, Z_2^P, ..., Z_L^P\}$ for the biomass and the resource price respectively.

For the biomass growth shocks λ_k^I represents the probability of transition from the current shock of the biomass Z_0^I to a shock Z_k^I in the next period. For the price shocks λ_l^P represents the probability of transition from the current price shock Z_0^P to a shock Z_l^P.

Using this discretization of the state space, value function, harvest policy and stochastic shocks, Equation 3.12 can then be re-written as:

$$V_{n,m} = \max_{q_j \in \{0, q_2, ..., q_J\}} \left\{ \pi(I_n, P_m, q_j) + \frac{1}{1+r} \sum_{k=1}^{K} \sum_{l=1}^{L} \lambda_k^I \times \lambda_l^P \times V\left(I_n + \Delta I_n, P_m + \Delta P_m\right) \right\} \tag{3.13}$$

where $I_n + \Delta I_n$ and $P_m + \Delta P_m$ are the state of the biomass and price in the next period. These values are estimated using the stochastic processes defined in Equations 3.1 and 3.11, and for a specific policy q_j and stochastic shocks (Z_k^I, Z_l^P) are:

$$I_n + \Delta I_n = I_n + \gamma I_n (1 - I_n / I_{max}) - q_j + I_n \sigma_I Z_k^I \tag{3.14}$$

$$P_m + \Delta P_m = P_m e^{\nu_P + \sigma_P Z_l^P} \tag{3.15}$$

The solution algorithm follows Heer and Maussner (2009). It starts from a guess of the value-function $V_{n,m}^0$ and iterates over the defined state space. In each point of the two-dimensional state (I_n, P_m) the right-hand-side of Equation 3.13 is maximized using the stochastic optimal control q_j. If the optimized value of the current iteration is greater than the previous iteration value-function for the state, the old value-function is replaced by the current iteration maximized value. The process is repeated until no significant changes are made to the value-function in the latter iteration.

To complement this short description we present a formal scheme of the solution algorithm in the Appendix. The following section presents the results of the application of the value-function iteration approach for the British Columbia halibut fishery.

3.4.2 Model Parameters, Grids Dimensions and Limits

As previously mentioned the model is solved for the British Columbia halibut fishery. Since all the data used in the parametrization is obtained with annual frequency, we solve the model using a one-year time step. The parameters used to solve the model are summarized in Table 3.6.

The grids for the biomass, policies, and random shocks are constructed dividing a specified set in an equally-spaced discrete points. In the case of the halibut price, we use a log-linear grid to better capture the distribution of prices. The biomass grid boundaries are 0.1[9] and carrying capacity I^{max}. For

[9]Given that the cost function is undefined if the biomass is zero, we choose this small value to represent the depletion of

Table 3.6: Estimated Parameters for the British Columbia Halibut Fishery

This table is a summary of the parameters estimated on the previous subsections. Details on each parameter estimation can be found there.

Panel A: Biomass Growth Parameters

Parameter	Estimated Value	Description
I_0	57.82	2017 Biomass Assessment
I^{max}	85.51	Non-Linear Least Squares Biomass Growth Estimation
γ	0.59	Non-Linear Least Squares Biomass Growth Estimation
σ_I	0.11	Non-Linear Least Squares Biomass Growth Estimation

Panel B: Resource Price Parameters

Parameter	Estimated Value	Description
P_0	7.75	2017 Halibut Price
ν_P	0.00	Real Halibut Log Price Model Estimation
σ_P	0.15	Real Halibut Log Price Model Estimation

Panel C: Cost Function Parameters

Parameter	Estimated Value	Description
c_0	5.37	Annual Cost Function Estimation
c_1	54.87	Annual Cost Function Estimation
c_2	0.30	Annual Cost Function Estimation
c_3	5.37	Annual Cost Function Estimation

Table 3.7: Grid Dimensions and Limits for Numerical Solution

This table presents the limits and density of the discrete grids used in the value-function algorithm. Each grid used to solve the problem is a discrete set of equally spaced points within the specified interval.

Grid	Dimension	Interval	Units
Biomass Grid: I_n	75	$[0.1, 85.51]$	Million Pounds [Mill. lb.]
Price Grid: P_m	75	$[2.99, 20.07]$	CAD per pound [CAD/lb.]
Random Shock: Z_j	15	$[-2.33, 2.33]$	
Policy Grid: q_i	90	$[0, 20]$	Million Pounds per Year [Mill. lb.]

the price grid the boundaries are the 99% confidence interval, for a 10 year time horizon, constructed using the historical price distribution. For the policy grid we use a boundary of 20 million pounds per year, which is high in comparison to the current 7.45 million pounds harvest limit. The specific dimensions and boundaries for these sets are presented in Table 3.7:

In the following subsections we present results for the benchmark case and some sensitivity analysis to the uncertainty parameters. In the Appendix we provide additional sensitivity analysis with respect to costs and discount rates.

the resource.

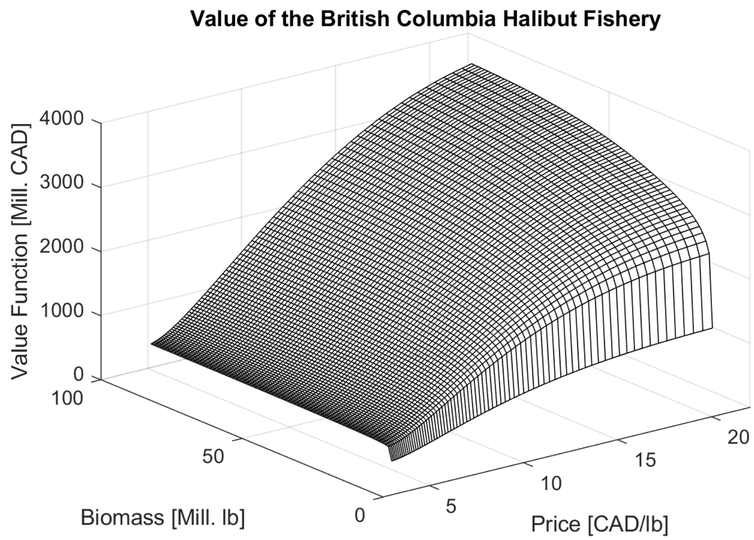

Figure 3.6: Value Function of the British Columbia Halibut Fishery

3.4.3 Value Function and Harvesting Policies for the British Columbia Halibut Fishery Parametrization

The value of the British Columbia halibut fishery for different values of the biomass and the price, under the optimal harvesting policy, is shown in Figure 3.6.

As the resource price increases, current revenues and the incentives to increase the harvest also increase. But this will diminish the biomass level, reducing the future resources growth and increasing the future marginal cost. This represents the main economic trade-off in the model and it can be observed in Figure 3.6. The marginal increment in the value of the fishery is positive when the price or the biomass increase. The marginal increment in the value over the state space is non-linear, however, an extra unit of biomass becomes more valuable in high price states in comparison to low price states, as in high biomass states an extra unit not only improves the the current and future profits in a high price state, it also reduces the extraction cost.

The optimal harvesting policy is chosen to maximize the value of the fishery, and their values are shown in Figure 3.7 for different values of the state variables.

Figure 3.7 shows that the annual optimal harvesting goes from zero, in states of low biomass and price, to 20 million pounds per year in states of high price and biomass[10]. The optimal harvesting policy is also a non-linear function of the state variables. For example, the harvesting policy in a high price state ($20 Canadian dollars per pound) goes from zero to 20 million pound per year as the biomass increases, but if the price is low ($4 Canadian dollars per pound) harvesting goes from zero to just 5.6 million pound per year.

[10]The upper bound set at 20 million pounds per year is not really binding. As we show in the next subsection, starting from the current state, the probability of reaching it is less than 1%.

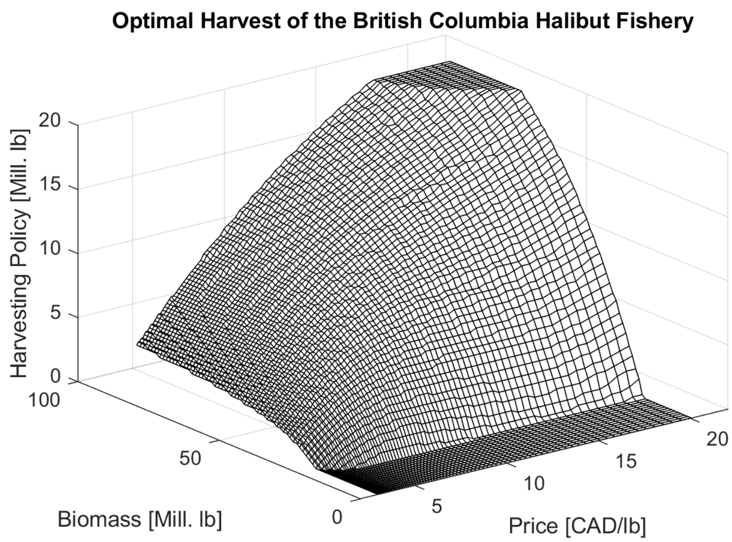

Figure 3.7: Optimal Harvesting Policy of the British Columbia Halibut Fishery

The model results indicate that for the current state of the British Columbia halibut fishery, that is a biomass of 57.8 million pounds and a halibut price of \$7.75 Canadian dollars per pound, the value of the resource is approximately \$1.81 billion Canadian dollars, and the optimal harvesting policy is 9.95 million pounds per year.

Figure 3.7 also indicates that the fishery should optimally reduce the harvest to zero in some states, most of them characterized by low biomass and low fish prices. In the following section we compute simulations for the estimated parameters of the British Columbia halibut fishery, and show that it is highly unlikely that the fishery would reach that situation, since it would optimally modify its harvest to avoid it.

Simulations of the Biomass and Harvesting Policies for the British Columbia Halibut Parametrization

To illustrate how the halibut biomass will evolve if the optimal harvesting policy is implemented, simulations of the price and biomass are generated combining their respective distributions with the optimal policy. We simulate $10,000$ different paths over an horizon of 10 Years for the biomass and the halibut price, all starting from the current state: $I_0 = 57.82$ million pounds and $P_0 = 7.75$ CAD per pound.

Figure 3.8 presents two different paths for the simulated fish price, biomass, and harvesting policy over a 10 year horizon.

Figure 3.8 shows a significant variability of the optimal harvest for the simulated paths. As the two states variables experience random shocks, the uncertainty faced by fisheries is significant, and the optimal harvesting policy adjusts reflecting those changes. ”Path A” is characterized by positive price

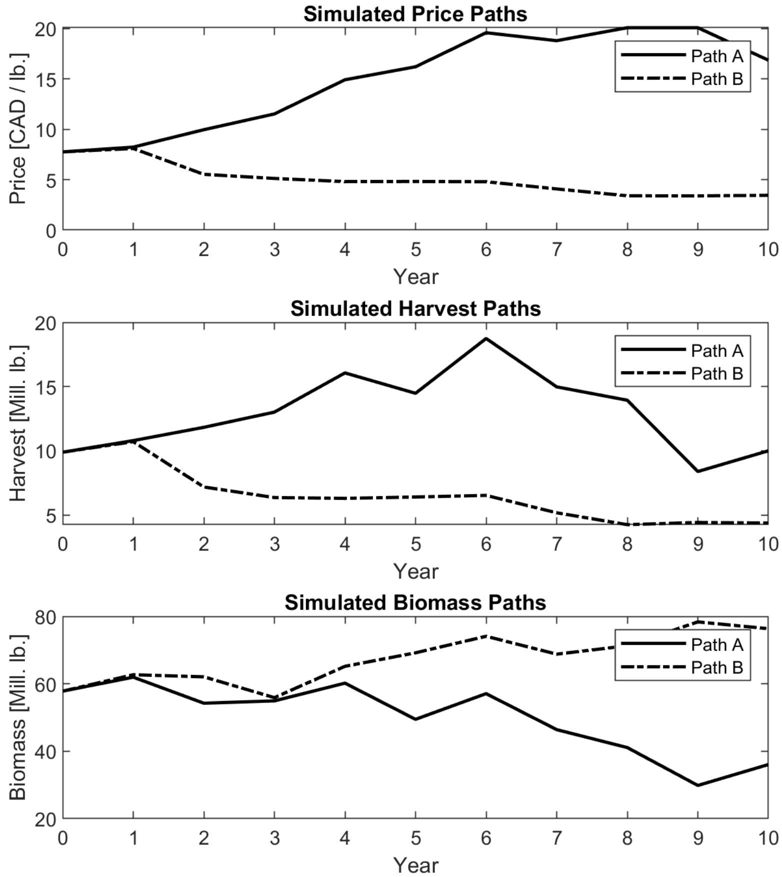

Figure 3.8: Simulated Paths for the Price, Optimal Harvesting Policy, and Biomass for the British Columbia Halibut Fishery

shocks during most of the simulated years, consequently the fishery starts increasing its harvest until year 6 reducing the total biomass of the resource. Then the fishery decides to harvest a smaller amount of the resource even after a new positive price shock, allowing the biomass to recover, indicating a clear financial incentive for conservation. ”Path B” differs by exhibiting negative shocks to the price for most of the simulation. As a consequence, the harvest is reduced in several periods, allowing the biomass to grow.

Figure 3.9 presents the median, 1^{th} and 99^{th} percentiles of the simulated $10,000$ different paths over an horizon of 10 years.

Panel A of Figure 3.9 shows the median, and the 1^{th} and 99^{th} percentiles, of the optimal harvest paths. The median harvest slightly decay during the 10 year simulation, and as shown in Panel B of the same figure, the biomass median grows reaching a higher level in comparison to the initial state. The 1^{th} percentile of the biomass shows that the there are several paths on which the biomass decreases, but it always remains away from depletion being above 35 million pounds in 10 years with 99% probability. The 99^{th} percent percentile illustrates that in paths of biomass growth will approach

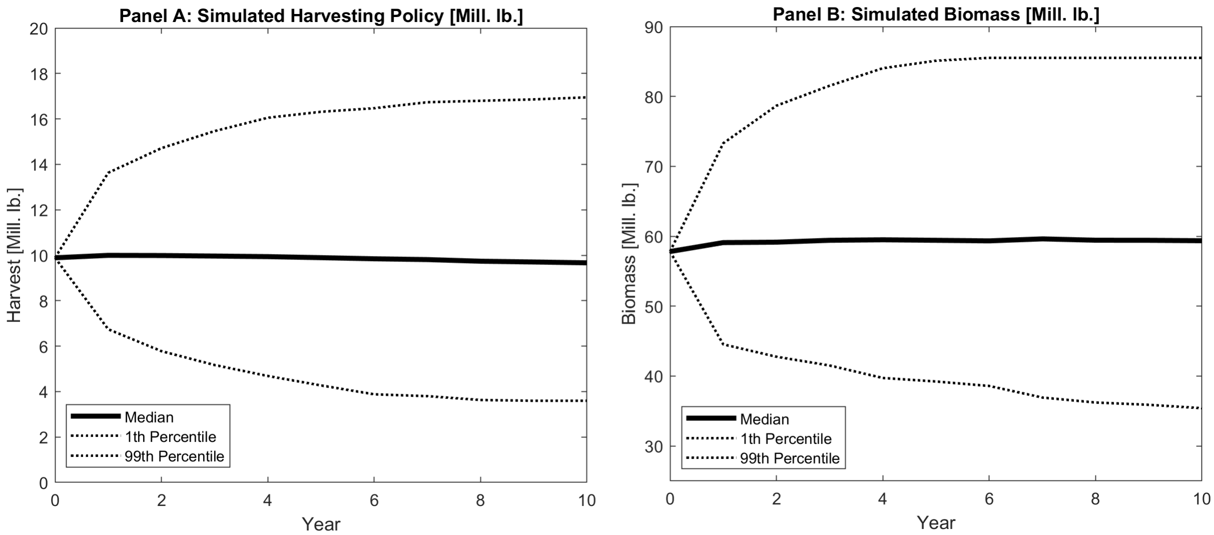

Figure 3.9: Median, 1^{th} and 99^{th} Percentiles of the Simulated Harvesting Policy and Biomass for the British Columbia Halibut Fishery

its carrying capacity (I^{max}).

These simulations exemplify the results of the model. First, we observe a significant amount of uncertainty and a harvesting policy which adjusts promptly. Second, we notice that the biomass will increase in most of the simulated paths and it will not reach levels close to extinction with 99% probability, presenting support for the intuition that conservation is economically optimal.

3.4.4 Multiple Sources of Uncertainty and their Impact on the Simulated Biomass and Harvest Dynamic

To asses the impact of uncertainty on our results we solved the valuation problem using different assumptions about the volatility of the price and biomass processes. Our first case is the benchmark case with full uncertainty as in the previous section. In the second case we set the volatility of the price process to zero and maintain the estimated volatility of the biomass process. In the third case we set the volatility of the biomass process to zero and maintain the estimated volatility of the price process. In the fourth and final case we set the volatilities of the two processes to zero.

For the estimated parameters for the British Columbia halibut we find that the differences between the first and the third case, that is between the benchmark case and the no biomass volatility case, are negligible. We also find that the differences between the second and the fourth case, that is between the case with only biomass volatility and no volatility, are negligible. This implies that for our parameters, only price volatility generates sizable differences between the cases. Therefore, in what follows we discuss only the differences between the benchmark case and the case with only biomass uncertainty, so that these differences can only be attributed to price uncertainty.

Table 3.8: Value Function for Different Levels of Uncertainty at the Current State

This table presents the numerical solution for the value function for models solved using only biomass uncertainty or price and biomass uncertainty.

Model	(1) Value Function [Mill. CAD]	(2) Optimal Harvest [Mill. lb.]	(3) $\frac{\Delta V}{V}$
Benchmark Case	\$1803.08	9.95	-
Biomass Uncertainty Case	\$1164.43	10.30	-0.35

We first look at the valuation effects. Column (1) of Table 3.8 shows that the value of the fishery falls from 1.8 billion Canadian dollars to 1.1 billion for the current state (biomass of 57.82 million pounds, halibut price of \$7.75 Canadian dollars); this is a drop of 35%. As we show bellow this significant difference comes from a non-optimal harvest policy if price uncertainty is not taken into account. That is, the fishery, for a given biomass, will have the same harvesting policy for any level of the price losing the opportunity to optimally react to changes in prices. In essence, in Real Options terms, assuming that there is no price volatility limits the flexibility of the fishery to adjust to changes in the state space.

Column (2) of table Table 3.8 show that the harvest only changes form 9.95 million pounds in the benchmark case to 10.30 million pounds in the case with biomass uncertainty. This is a 4% increase which is substantially smaller than the 35% decrease in value. This shows that the difference in value is generated by the flexibility in the optimal policy in cases when the price deviates from the expected value. This will become clear in the following simulation analysis.

The data supports a world where there is both biomass and price uncertainty. We want to quantify the effect of solving the model assuming that there is no price uncertainty in a world that has price uncertainty. In addition to the benchmark case discussed in the previous section we simulate a fishery that follows the optimal policy in the case of no price uncertainty but it is subject to shocks in the biomass and price. Figure 3.10 shows the 1% and the 99% of the simulated harvest for these to cases.

Even though the median values of the harvest in the two cases are relatively close, Figure 3.10 shows that the 1^{th} and 99^{th} percentiles are significantly different. This implies that abstracting from price uncertainty leads to a harvesting policy which very stable and close to its median value, without reacting to extreme price changes.

Panel A of Table 3.9 shows the numerical values of the harvest for the 1^{th} and 99^{th} percentile at 5 and 10 years into the future. For example, for the benchmark case at 10 year there is a 1% probability that the harvest rate will be below 3.6 million pounds, whereas this figure is 8.4 for the model without price volatility. This shows that for the benchmark case the flexibility of the harvesting policy is much higher resulting in higher valuation of the fishery.

Panel B of Table 3.9 shows that although the flexibility in the harvest is higher for the benchmark case, the effect on the biomass is much smaller. For example, for the benchmark case at 10 years there is a 1% probability that the biomass will be below 35.3 million pounds, whereas this figure is 39.7

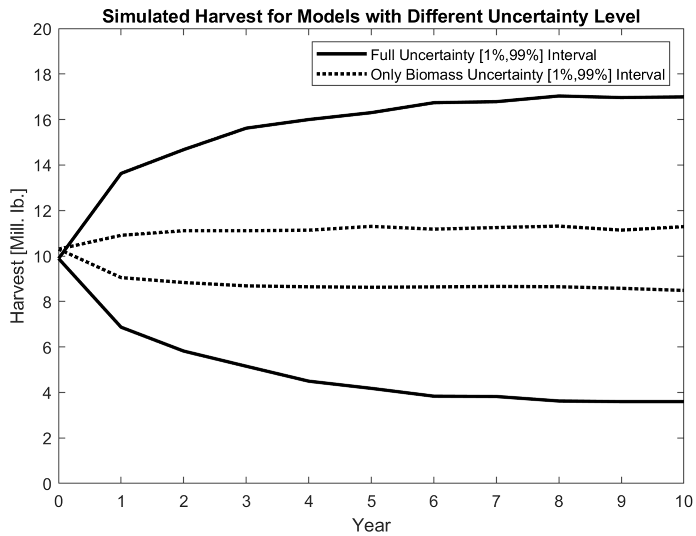

Figure 3.10: Percentile 1^{th} and 99^{th} of the Simulated Harvesting Policy for the Benchmark Case and the Only Biomass Uncertainty Case for the British Columbia Halibut Fishery

Table 3.9: Simulations for Models with Different Levels of Uncertainty

This table presents the 1^{th} and 99^{th} percentiles at 5 and 10 years, for the harvest policies simulated. Each curve is generated using the optimal harvesting policy for the case with uncertainty in biomass and price, and the case with no price uncertainty (or just Biomass Uncertainty, denoted as "Biomass Case" in the table).

Panel A: Simulated Harvest for Models with Different Levels of Uncertainty

Model	5 Years Simulation 1th Percentile	10 Years Simulation 1th Percentile	5 Years Simulation 99th Percentile	10 Years Simulation 99th Percentile
Benchmark Case	4.257	3.596	16.462	17.038
Biomass Case	8.681	8.418	11.246	11.313

Panel B: Simulated Biomass for Models with Different Levels of Uncertainty

Model	5 Years Simulation 1th Percentile	10 Years Simulation 1th Percentile	5 Years Simulation 99th Percentile	10 Years Simulation 99th Percentile
Benchmark Case	39.426	35.251	85.011	85.517
Biomass Case	40.835	39.717	81.797	82.331

million pounds for the model without price volatility.

It is to be expected that price volatility should have a large effect on the harvesting policy, since the price process is totally exogenous. The biomass process is partially endogenous, since in addition to the biomass shocks, the fishery can react to changes in the biomass with its harvesting policy, consequently influencing the future dynamics of the biomass process.

3.5 Conclusion

This article develops and implement an optimal stochastic control approach to value a renewable natural resource, in particular a fishery, with two sources of uncertainty: the biomass and the price. The solution of the model is obtained by solving a Hamilton-Jacobi-Bellman equation for the value of the Fishery using a value-function iteration approach. Overall, the results highlight the strong non-linear relation between the biomass and the resource price on the value of the fishery and the optimal harvesting policy.

The solution is implemented using the estimated parameters for the British Columbia halibut fishery. The model results are used to simulate the dynamic of the studied fishery, finding that the optimal harvesting policy is sustainable. For negative shocks to the biomass growth we obtain reductions of the resource stock, but the simulations show that with more than 99% probability we will not observe the extinction of the resource. For the current state $I_0 = 57.82$ million pounds, $P_0 = 7.75$ CAD per pound, we found an optimal annual harvesting policy is 9.95 million pounds per year.

We evaluate the impact of price uncertainty on the harvesting policy and compare it to the traditional approach which assumes that prices follow a deterministic path. We find that price volatility has a large effect on the value of the fishery and the harvesting policy. This is due to the fact that the price process is totally exogenous so that price shocks cannot be offset by changes in the harvesting policy.

The model solved for a realistic set of parameters suggests that an economically viable fishery is feasible, that overfishing is indeed not optimal, even in the presence of fish price and biomass uncertainty. This highlights the value of conservation and confirms that current efforts to control overfishing are indeed efficient from a social and a financial perspective.

Chapter 4

Tax Loss Carry Forwards and Equity Risk

4.1 Introduction

Corporate taxes are among the most studied of financial frictions. Corporate taxes are important determinants of value and, accordingly, have been used to explain corporate decisions such as capital structure, dividend policy, real investment and risk management.[1] In contrast to the wide range of studies documenting how corporate taxes affect corporate decisions and firm value, less is known about how corporate taxes are related to equity risk and return. The general consensus, starting with Modigliani and Miller (1963), is that corporate taxes and tax shields reduce a firm's equity risk. We study one particular component of corporate taxes - Tax Loss Carry Forwards (TLCFs) - and show that both empirically and theoretically, TLCFs are positively related to a firm's risk and return. Empirically, firms with high TLCFs have higher future returns, risk betas, and volatilities. Moreover, these higher returns are not fully explained by standard measures of risk.

TLCFs arise because tax codes do not allow firms to generally realize negative taxes, i.e. Net Operating Losses (NOLs) do not automatically generate payments from the government to the firm. Instead, tax codes only allow NOLs to generate immediate refunds if the firm can apply the losses to prior taxable income (Tax Loss Carry-backs). When this is not possible, NOLs may be carried forward. Subsequent positive taxable income can be reduced by applying some or all of the TLCF as an offset while subsequent losses are added to the TLCF portfolio. Hence, TLCFs form a valuable but risky corporate asset.

Figure 4.1 shows how significant TLCFs have become over the past 20 years, having increased from 1% to 5% of total book assets. Over the same time, the presence of TLCFs has become more widespread; the percentage of firms reporting TLCF has increased from 30% to 75% of all firms

[1] See Graham (2006) and Ravid (1988) for comprehensive surveys of the literature.

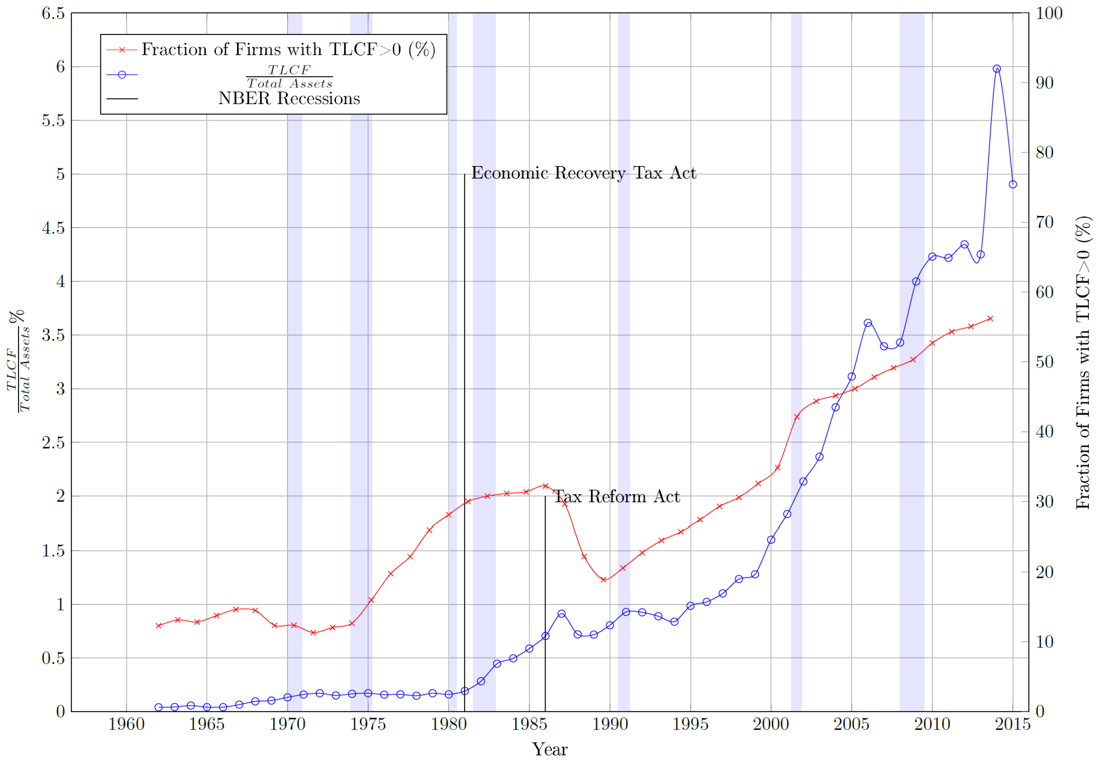

Figure 4.1: Tax Loss Carry Forward

in our CRSP-Compustat sample over this same period. The increase in TLCFs dominates cyclical factors and is not explained by two of the more significant legislated changes during this period; the Economic Recovery Act of 1981 that reduced some corporate taxes, and the Tax Reform Act of 1986 that reduced statutory tax rates.

While TLCFs and the sources of their growth has been studied by others,[2] our interest is in understanding how this significant corporate asset affects equity returns and risk.[3] Intuitively, a TLCF creates a contingent tax savings; taxes are reduced in some states but not others. Accordingly, it would intuitively be expected that this non-linearity would affect risk. Given the rising importance of TLCFs, the lack of previous research linking TLCFs and risk is surprising.[4]

[2]It seems that the primary explanation of the growth in operating losses over this period is lower returns to assets. See Altshuler et al. (2009) for an in depth discussion of the growth in corporate tax losses and Denis and McKeon (2016) for a recent discussion of losses and their relationship to R&D and cash holdings.

[3]In addition to being of theoretical interest to both asset pricing and corporate finance, we are motivated by the large and growing importance of TLCFs in the public finance literature. Auerbach (2006) shows that while the statutory corporate tax rate in the U.S. has fallen from 46% in 1983 to 35% in 2003, the average tax rate - the ratio of taxes paid to corporate income - has increased dramatically from 27% to 45% over the same period. Auerbach shows that, by far, the largest contributor to the increase in the average tax rate is the asymmetric treatment of tax losses and the increase in NOLs over this period. Tax loss carry forwards also became an important issue in the 2016 Presidential election due to Donald Trump's huge TLCFs, see Confessore and Applebaum (2016) for an account of the issue.

[4]There is, however, a literature that considers personal taxes and returns. This literature starts with Brennan (1970).

Our task of deriving a general understanding of how TLCF, risk, and return are related is made difficult by the fact that a firm's TLCFs result from complex, path dependent tax minimization decisions. For instance, Cooper and Franks (1983) show how operating decisions, asset allocations, lease or buy decisions and NOLs interact to determine value. Moreover, in any one year, non-operating deductions such as depreciation and interest payments, both of which are the result of endogenous corporate decisions, affect a firm's NOLs. Furthermore, firms can reduce taxable income by applying an existing TLCF and/or using Investment Tax Credits (ITCs) to pay for the taxes owed. Since both ITCs and TLCFs have specific maturities, the decision to use one or the other at any point in time is itself a complex decision.

The implications, therefore, of TLCFs for firm value, risk and return are, to some extent, history dependent and idiosyncratic. Still, some general features of the tax code emerge as important for equity risk. Our focus is on the convexity of the tax schedule and its implication for equity risk. We follow Majd and Myers (1985) and Green and Talmor (1985) by viewing a firm's equity as a claim to pretax operating cash flows plus a short position in a call option on corporate taxes. The asset that underlies the implicit call sold to the tax authorities is the tax revenue that would be paid if tax shields were zero. The strike price of the option is the tax shield times the tax rate; the tax authorities can collect taxes if they pay this amount. If corporate taxes are less than the tax shield, the option will expire unexercised, while if the taxes are higher the tax authorities will exercise their option, collecting taxes net of the exercise price.

Green and Talmor (1985) recognized that being short a risky derivative makes the firm's after tax equity safer than the underlying pretax cash flows. This intuition is similar to the 2nd proposition of Modigliani and Miller (1963), who show that interest tax shields make a firm safer. We add to this insight by showing that, while this is generally true, the risk reduction from additional tax shields is non-monotonic and that the relationship between TLCFs and risk is typically positive.

To see the intuition behind our results, consider a firm generating a distribution of future taxable income and, for ease of exposition, assume that the lowest possible taxable income is greater than zero. Suppose first that the firm has zero TLCFs and no other tax shields, so that, although the amount is uncertain, it pays some taxes with certainty. In this case the riskiness of the after tax cash flows is equal to the riskiness of the pre tax cash flows since there are no TLCFs to shelter income. Now consider adding a low level of TLCFs, less than the minimum taxable income. In this case, the full amount of the TLCFs will be used with certainty, providing the firm with a risk free tax saving that reduces the total risk born by equity holders. As the size of the TLCFs increases from this low initial level, the risk free asset increases and total equity risk falls, as long as the tax shield is used with certainty. Eventually, however, as the level of TLCF rises, a portion of the tax shield will only be used in high income states, and will be lost in low income states - some o the TLCFs become risky. This increases equity risk because the firm's post-tax cash flow rises in good states. Thus, equity risk as a function of TLCFs is non-monotonic, decreasing at low levels of TLCFs, and increasing at high levels of TLCFs. Now, suppose the firm has additional annual tax shields (i.e. interest or depreciation) which will be used before TLCFs. In this case, the relationship between risk and TLCFs may be purely positive because all of the TLCFs may end up unused.

Our study has two main components. First, we theoretically study the relationship between TLCFs and return. In a simple one period binomial model we show that the relationship between risk and TLCFs is non-monotonic. We also show that if the firm has existing non-TLCF tax shields, then the relationship between TLCFs and risk may be strictly positive rather than non-monotonic. We then solve a realistic, dynamic model of a firm, and calibrate it to the data. In this model, the relationship between TLCFs an risk is positive and quantitatively important for risk.

Second, we empirically examine the relationship between TLCFs and asset prices. We show that TLCFs are positively related to standard measures of risk, like betas and volatility. We then show that TLCFs are are also positively related to equity returns. Importantly, in our regression analysis of return and TLCFs we find that TLCFs are able to explain future returns even when we condition on standard measures of risk. Hence, studies that include standard measures of risk account for some but not all of the risk generated by TLCFs.

Additionally, we take advantage of a distinct policy change to add support to our results. The 1986 Tax Reform Act reduced the statutory tax rate from 46% to 34%, effective for tax years after July 1, 1987. Our theory shows that the theoretical impact of TLCFs on risk is increasing in the tax rate, hence a decrease in the tax rate will reduce the importance of TLCFs in explaining risk and return. Indeed, we find that the coefficient on TLCFs decreases in magnitude and significance after the tax reform, although it continues to be statistically significant.

Our paper builds on the work of Green and Talmor (1985) who explicitly recognize the call option structure of the tax claim on the firm. They use this insight to study investment behavior by firms and the debt-equity conflict of interest. Recently, Albertus et al. (2017) pick up on the study of asymmetric taxation and investment decisions in an international context. Streitferdt (2010) also builds on the insight of Green and Talmor (1985) to consider alternative more realistic stochastic process for the value of the underlying tax base but does not draw implications for risk.

Our focus is instead on the implication on equity risk and return. We know of no other study that has directly looked at the relationship between TLCF and equity risk.[5] Others have indirectly looked at the tax return relationship. Lev and Nissim (2004) consider the ratio of tax to book income as a measure of the quality of accounting information. They show that this ratio, which reflects tax deductions including TLCFs, forecasts firm growth but is not significant in forecasting returns.

The remainder of the paper is organized as follows. We present a theoretical analysis of the relationship of TLCFs and risk in Section 4.2. In this section the main intuition of our analysis is illustrated in a simple binomial model relating equity risk to TLCFs. We numerically explore a more realistic model in Section 4.3. Section 4.4 provides empirical evidence on the TLCF/risk relationship

[5]Somewhat relatedly, Schiller (2015) finds that firms with low average tax rates are safer and have lower expected returns. Since higher TLCFs could be associated with lower tax rates, this result may be in contrast to our study. In unreported regressions, however, we find that the coefficient on average tax rate when added to our regressions is negative, but that the significance of TLCFs is little change.

that is strongly supportive of the simple theory. Section 4.5 concludes.

4.2 Simple Binomial Model

Consider an all equity firm that at t_0 owns a future stochastic cash flow $\Pi_1 \in \left\{\Pi^u, \Pi^d\right\}$, $\Pi^u > \Pi^d$. The corporate tax rate is τ, and the firm is in possession of a non-cash tax deduction of Φ. Φ can be thought of as a tax-loss carry forward, depreciation, or any other non cash tax deduction[6].

The value of the all equity firm at t_0, V_E, is equal to the value of the expected pretax cash flows, V_Π, minus the value of expected taxes, V_T, i.e.

$$V_E = V_\Pi - V_T \tag{4.1}$$

Accordingly, the risk of the equity, β_E, is given by

$$\beta_E = \frac{V_\Pi}{V_\Pi - V_T}\beta_\Pi - \frac{V_T}{V_\Pi - V_T}\beta_T \tag{4.2}$$

where β_Π is the beta of the pre-tax cash flows and β_T is the beta of the tax payments.

Green and Talmor (1985) and Majd and Myers (1985) show that the expected tax payment is equivalent to a call option. The underlying asset is the tax payment with full tax offset, $\tau\Pi$, and the actual tax payments will be a call on this asset with an exercise price $\tau\Phi$, i.e. the tax payment will be

$$\max\{\tau\Pi - \tau\Phi, 0\}.$$

Since the firm is short the tax payment and, as we will show, $\beta^T > 0$, the risk of equity is lower than the risk of the pretax cash flows as long as $\Phi > 0$. Our theoretical contribution is to show that the risk reduction is non monotonic in Φ, first decreasing and then increasing. Hence, for many firms risk is increasing in TLCFs.

The relationship we will derive is graphically presented in Figure 4.2. Three cases are apparent in Figure 4.2: Case 1, $0 \leq \Phi \leq \Pi^d$; Case 2, $\Pi^d < \Phi < \Pi^u$; Case 3, $\Phi \geq \Pi^u$.

4.2.1 Case 1: $0 \leq \Phi \leq \Pi^d$

This case applies to firms that have positive taxable income but little or no tax deductions. As a result, the available tax shields Φ are used with certainty making the tax savings risk-free. Hence, the value of the tax payments is:

$$V_T = \tau V_\Pi - \tau V_\Phi \tag{4.3}$$

[6] Investment tax credits (ITCs) would play a similar role.

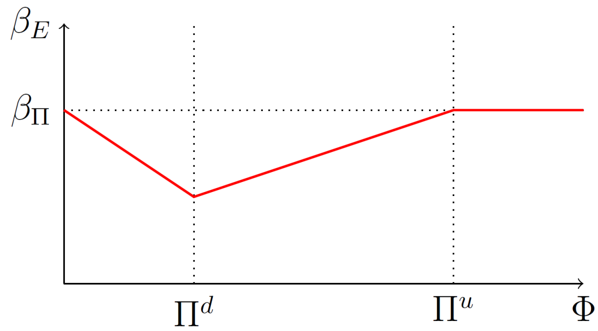

Figure 4.2: Firm Risk and Tax Loss Carry Forward

Using Equation (4.3) in the value of the equity claim, Equation (4.1), gives:

$$V_E = (1-\tau)V_\Pi + \tau V_\Phi$$

In terms of the risk of the equity, the after tax cash flow and pretax cash flow have the same beta while the value of the tax shield from Φ is riskless. That is, the firm has effectively sold an equity claim to the government but has received a risk free bond in return resulting in the following equity risk:

$$\beta_E = \frac{(1-\tau)V_\Pi}{(1-\tau)V_\Pi + \tau V_\Phi}\beta_\Pi \tag{4.4}$$

As Φ increases in this range, the value of the risk free bond, V_Φ, increases and the overall equity risk decreases.

4.2.2 Case 2: $\Pi^d \geq \Phi < \Pi^u$

In this region the tax payment depends on the state:

$$T = \begin{cases} \tau(\Pi^u - \Phi) & \text{if } \Pi^u \\ 0 & \text{if } \Pi^d \end{cases} \tag{4.5}$$

The t_0 value of the tax payment V_T is the value of the replicating portfolio, a levered long position in the underlying tax claim, τV_Π.

$$V_T = \Delta\tau V_\Pi - \Delta\tau\frac{\Pi^d}{(1+r_f)}$$

where Δ is:

$$\Delta = \frac{\Pi^u - \Phi}{\Pi^u - \Pi^d} < 1 \tag{4.6}$$

Using Equation (4.6) in Equation (4.1) gives the equity value:

$$V_E = (1 - \Delta\tau)V_\Pi + \frac{\Delta\tau\Pi^d}{(1 + r_f)} \tag{4.7}$$

which implies that the firm risk will be :

$$\beta_E = \frac{(1 - \Delta\tau)V_\Pi}{V_\Pi - V_\Phi}\beta_\Pi \tag{4.8}$$

The tax deduction Φ affects β_E through its impact on Δ and $V_E = V_\Pi - V_\Phi$. The net result can be shown to be strictly increasing in Φ in this range since

$$\frac{\partial\beta_E}{\partial\Phi} = \frac{\tau V_\Pi \beta_\Pi \Pi^d}{V_E^2(\Pi^u - \Pi^d)(1 + r_f)} \tag{4.9}$$

is positive.

4.2.3 Case 3: $\Phi \geq \Pi^u$

Since deductions are larger than the maximum taxable income the firm will not pay taxes with certainty. Hence $V_T = 0$ and:

$$V_E = V_\Pi \tag{4.10}$$

As a result, $\beta_E = \beta_\Pi$ for any level of Φ in this range.

This simple model demonstrates an important new insight. Prior studies have shown that firm risk is lower as a result of the asymmetric taxation of corporate earnings and losses. Essentially the government shares in the corporate losses by not collecting taxes when business is bad. To this we add an understanding of how this lower risk changes through the range of possible values of Φ relative to taxable income. For low levels of Φ risk is decreasing until $\Phi = \Pi^d$, at which point risk begins to increase up to a point where the firm pays no taxes, after which firm risk is constant as Φ increases.[7]

Next, suppose that the firm's total tax shields are composed of two pieces: $\Phi = \Phi^0 + \Phi^{TLCF}$. Here Φ^0 are non-TLCF tax shields available to all firms, such as depreciation or interest; Φ^{TLCF} are TLCFs which differ across firms. Also suppose that non-TLCF tax shields are used first; this designation is irrelevant in a one period setting but is true in a multi-period setting where many non-TLCF tax shields are available every year and disappear immediately if not used, but TLCFs can be carried to future years. In this case, if $\Pi^d < \Phi^0 < \Pi^u$, then the relationship between risk and Φ^{TLCF} is strictly increasing.[8] This can be seen by noting that the relationship between β_E and Φ in Figure 4.2 remains unchanged, however the point where $\Phi^{TLCF} = 0$ is now to the right of where $\Phi = 0$.

[7] In a multi-period setting risk could continue to change as Φ increases beyond Π^u since the excess in the single period will be carried forward to the subsequent period. This is incorporated in our numerical model of Section 4.3.

[8] Even if $\Phi^0 < \Pi^d$, as long as $\Phi^0 > 0$, then a firm with $\Phi^{TLCF} = 0$ is less risky than a firm with $\Phi^{TLCF} = \Pi^u$.

In reality the relationship of risk with tax deductions is much more complex. A multi-period setting implies that tax deductions not used in one period can be carried forward. Tax Loss Carry Forwards compete with period deductions such as depreciation and interest as well as with investment tax credits. The Tax Loss Carry Forward is made up of operating losses over various periods and each of these has a finite maturity. In Section 4.3, we show that the relationship described in this section is quantitatively important in a dynamic, realistically calibrated model.

4.3 Quantitative Model

The one period model in Section 4.2 provides qualitative intuition for why the relationship between TLCFs and risk or return should be either non-monotonic, first decreasing and then increasing, or strictly increasing if other tax shields are sufficiently important. In this section, we solve a dynamic model where the firm's cash flows, tax shields, and TLCFs behave in a similar way to the real world. In this model, we show that the relationship between TLCFs and risk tends to be positive, and quantitatively important.

Consider a multi-period, discrete time extension of the one period model. The firm owns capital $K_t = 1$ and its only capital expenditure is the replacement of depreciated capital $I_t = \delta K_t = \delta$. The firm produces pre-tax cash flows (EBITDA) of $\Pi(A_t)$, which is a function of an exogenous productivity shock A_t. The firm distributes all free cash flows to investors, hence dividends are equal to the pre-tax cash flow, minus its tax bill T_t, minus capital expenditure costs:

$$D_t = \Pi(A_t) - T_t - I_t$$

The firm's value is equal to the present value of its dividends, discounted by an exogenously specified stochastic discount factor M_{t+1}.

The firm pays taxes at a rate τ on taxable income $\Pi(A_t)$ minus any tax shields Φ_t. We also assume that the tax paid cannot be negative, thus the total tax paid is:

$$T_t = \tau \max\left(0, \Pi(A_t) - \Phi_t\right)$$

We assume that the firm has three types of tax-shields. First, non-depreciation and non-TLCF tax shields Φ^0. The real world analog of Φ^0 are interest tax shields (although we abstract from financial leverage), R&D tax shields, and any other general tax-shields; we assume these are constant. Second, depreciation tax shields $\Phi_t^{\delta} = \delta$, which are also constant in the model because depreciation is constant. Third, tax loss carry forwards $\Phi_t^{TLCF} = \delta$, which will be described below. The firm's total tax shields are $\Phi_t = \Phi^0 + \Phi^{\delta} + \Phi_t^{TLCF}$.

Because TLCFs are treated as in the real world, Φ_t^{TLCF} becomes a state variable which declines when TLCFs are used or expire, and increases when the firm incurs losses. Because of the rate of time preference, the firm always uses as much TLCFs as possible to reduce current tax liability. Define the

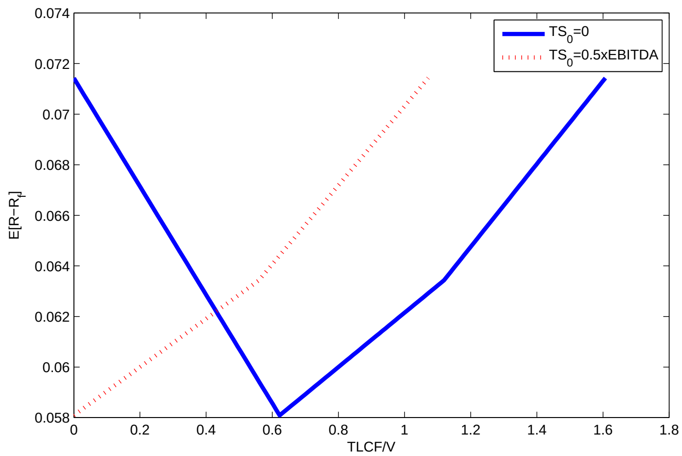

Figure 4.3: Expected return as a function of TLCF
This figure plots the expected return on the y-axis, against the amount of tax-loss carry forwards (TLCF) on the x-axis from the simple model. We compare a firm with no other tax shields (solid line) and existing tax shields (dashed line).

firm's tax liability, before using the TLCFs, as $\widetilde{T}_t = \Pi_t - \Phi^0 - \Phi^\delta$. If $\widetilde{T}_t < 0$, then the firm pays zero tax and no TLCFs are used; furthermore, the stock of TLCFs increases by $-\widetilde{T}_t$. If $0 < \widetilde{T}_t < \Phi_t^{TLCF}$, then TLCFs fully reduce the firm's tax liability to zero, and the amount of TLCFs remaining is $\Phi_t^{TLCF} - \widetilde{T}_t$. If $0 < \Phi_t^{TLCF} < \widetilde{T}_t$, then all of the TLCFs are used and zero remain; in this case, the firm's tax liability $T_t = \widetilde{T}_t - \Phi_t^{TLCF} > 0$. We also assume that TLCF's expire at a rate δ^τ so that:

$$\Phi_{t+1}^{TLCF} = (1-\delta^\tau)\max\left(0, \Phi_t^{TLCF} - (\Pi_t - \Phi^0 - \Phi_t^\delta)\right)$$

We can now formally describe the firm's value:

$$\begin{aligned}
&V(A_t, \Phi_t^{TLCF}) = D_t + E_t[M_{t+1} V(A_{t+1}, \Phi_{t+1}^{TLCF})] \text{ s.t.} \\
&K_t = 1 \\
&D_t = \Pi(A_t) - T_t - I_t \\
&I_t = \delta K_t \\
&T_t = \tau \max\left(0, \Pi(A_t) - (\Phi^0 + \Phi^\delta + \Phi_t^{TLCF})\right) \\
&\Phi_t^\delta = \delta K_t \\
&\Phi_{t+1}^{TLCF} = (1-\delta^\tau)\max\left(0, \Phi_t^{TLCF} - (\Pi_t - \Phi^0 - \Phi^\delta)\right)
\end{aligned} \tag{4.11}$$

This more realistic model preserves the basic insight of the simple binomial model. Figure 4.3 plots the expected return against the amount of TLCF implied by our quantitative model, but if the

Table 4.1: Calibration

This table presents the value for each of the parameters used in the model.

Preferences		
β	0.9	Time Discount Factor
γ	8	Risk Aversion
Cash Flows		
ψ	0.14	EBITDA-to-Total Assets
A^a	$\begin{pmatrix} 0.81 & 1.00 & 1.19 \end{pmatrix}$	Realizations of aggregate component of EBITDA/TA
P^a	$\begin{pmatrix} 0.9 & 0.1 & 0.0 \\ 0.05 & 0.9 & 0.05 \\ 0.0 & 0.1 & 0.9 \end{pmatrix}$	Tr. Prob. of aggregate component of EBITDA/TA
A^i	$\begin{pmatrix} 0.46 & 1.00 & 1.54 \end{pmatrix}$	Realizations of idiosyncratic component of EBITDA/TA
P^i	$\begin{pmatrix} 0.8 & 0.1 & 0.1 \\ 0.1 & 0.8 & 0.1 \\ 0.1 & 0.1 & 0.8 \end{pmatrix}$	Tr. Prob. of idiosyncratic component of EBITDA/TA
Taxes and tax shields		
τ	0.35	Corporate tax rate
δ	0.046	Depreciation tax shields-to-Total Assets
Φ^0	0.023	Interest tax shields-to-Total Assets
δ^τ	0.05	Expiration rate of TLCF

firm lives for a single period only.[9] Note that if the firm has no pre-existing tax shields (solid line), then the expected return is non-monotonic in TLCF. The expected return first decreases, as additional tax shields imply a safe cash flow (tax refund) relative to a zero-tax shield firm. The expected return increases for high levels of TLCF because the TLCF will be used in the good state of the world, when cash flows are already high, but will be lost in the bad state of the world, when cash flows are low. On the other hand, when there are enough pre-existing tax shields (dashed line), then the expected return can be strictly increasing in TLCF.

4.3.1 Calibration

This section describes our choices of the model's parameters. The model is solved annually.The actual parameters are listed in Table 4.1, and the target moments for both model and data appear in Table 4.2.

The productivity shock $A_t = A_t^a A_t^i$ consists of an aggregate and an idiosyncratic component, which are uncorrelated; the stochastic discount factor depends on the aggregate component only. Both the aggregate component A_t^a and the idiosyncratic component A_t^i are 3-state Markov chains. We choose the parameters of the aggregate shock to roughly match the volatility and autocorrelation of the aggregate component of EBITDA/TA. We choose the parameters of the idiosyncratic shock to roughly match the mean and volatility of our key variable, TLCF/EBITDA; as can be seen in Table 4.2, this choice

[9]To create this figure, we assumed that there are three equally likely states. The stochastic discount factor is $M_{t+1} = (1.2, 1.0, 0.8)$, the pre-tax cash flow is $\Pi(K_t, A_t) = (0.5, 1.0, 1.5)$, and the tax rate is $\tau = 0.3$.

also implies that the volatility and autocorrelation of the idiosyncratic component of EBITDA/TA are close to the data.[10]

We assume that the stochastic discount factor takes the form $M_{t+1} = \beta \left(\frac{A^a_{t+1}}{A^a_t} \right)^{-\gamma}$ with $\beta = 0.9$ and $\gamma = 8.0$. These numbers are chosen to target a risk free rate of 1.5% and a market return Sharpe ratio of 0.4. Although this is a partial equilibrium model and the SDF is exogenously specified, if aggregate productivity growth $\frac{A^a_{t+1}}{A^a_t}$ was equal to consumption growth, then this SDF would be consistent with one implied by a representative agent with CRRA utility where β and γ would correspond to time preference and risk aversion, respectively.

We assume that EBITDA is linear in capital multiplied by productivity, $\Pi(A_t) = \psi A_t K_t$, where $K_t = 1$. We set $\psi = 0.14$ to match the average EBITDA/TA, $\delta = 0.046$ to match the average Depreciation-to-EBITDA ratio, and $\Phi^0 = 0.023$ to match the average Interest-to-EBITDA ratio. We set the TLCF depreciation rate $\delta^\tau = 0.05$ because the U.S. tax code allows a firm to keep TLCF for 20 years before they expire. We set the corporate tax rate $\tau = 35\%$, matching the statutory tax rate in the U.S between 1993 and 2017.

We simulate the model for 1,000 years and 200 firms, we then repeat this procedure 100 times to compute model implied moments. Panel A of Table 4.2 reports target moments for the data and the model counter-parts.

4.3.2 Model results

The target moments, as well as some additional moments, for both model and data are presented in Panel A of Table 4.2. We first compute each moment, for each firm, using its time-series data; we then compute the average and median of each moment across all firms. For the model, we report the average only, but median and average are fairly close for most quantities.

The model fits the target moments (columns 1-2, 4, 6-9, 12-13) very well.[11] Note that we do not target individual firms' mean equity return or equity return volatility, but both are reasonably close to the data (columns 10-11). We also do not target the volatility and autocorrelation of the idiosyncratic component of EBITDA/TA (the idiosyncratic component is used to target the mean and volatility of TLCF/EBITDA), nevertheless, these two moments are close to their data counterparts (columns 3 and 5). We also solved a model where we target the volatility and autocorrelation of the idiosyncratic component of EBITDA/TA; in this case, the average TLCF/EBITDA ratio is somewhat too high (0.29

[10] We use the EBITDA-to-Total assets ratio instead of just EBITDA because in the data EBITDA is non-stationary and takes on negative values, therefore we scale it by a non-negative, co-integrated series. Note that Total assets is slower moving that EBITDA, thus EBITDA-to-Total assets still captures the key variation in EBITDA. We separate the volatility of EBITDA-to-Total assets into aggregate and idiosyncratic components by the following procedure. We define the aggregate component each year as the sum of all EBITDA that year, divided by the sum of all Total assets that year; we compute the volatility and auto-correlation of the aggregate component for 1962-2015. We then divide each firms EBITDA-to-Total assets by the aggregate component and define this as the idiosyncratic component. For each firm, we compute the volatility and autocorrelation of the idiosyncratic component and report the median, and the average weighted by the firm's number of annual observations.

[11] We have nine free parameters $\left(\beta, \gamma, \psi, A^a, P^a, A^i, P^i, \delta, \text{and } \Phi^0\right)$, and nine target moments.

Table 4.2: Model Results

This table reports results from the model and compares them to the data. The procedure for computing the aggregate and idiosyncratic components of EBITDA/TA is described in footnote 10. For the other moments, we compute each statistic for each firm individually using its time series data, and then report either the median, or the average across all firms. For the model, we report the average only. The reported statistics are: the EBITDA-to-total assets ratio; the volatilities of the systematic and aggregate components of EBITDA/TA; the autocorrelations of the systematic and aggregate components of EBITDA/TA; depreciation, interest expenses, and TLCF each as a share of EBITDA; the volatility of TLCF/EBITDA; the average excess stock return; the volatility of the excess stock return; the risk free rate; and the Sharpe Ratio. Panels B (model) and C (data) report the results of Fama and MacBeth (1973) regressions of future (1 year and 5 year) realized stock returns, volatilities, and market betas on firm characteristics. The key characteristic in our results is the ratio of TLCF-to-Total assets; each firm's size (market value) is also used as a control. Volatilities are computed based on monthly returns in the data. In the model, the one year volatility is defined as $\mid R^i_{t+1} - E_t[R^i_{t+1}] \mid$, and the five year volatility is computed using annual returns; both are divided by $\sqrt{12}$ to convert to monthly.

Panel A: Model and data accounting moments

	Cash Flows					Tax Shields				Returns			
	$\frac{E}{TA}$	$\sigma\left(\frac{E^a}{TA^a}\right)$	$\sigma\left(\frac{E^i}{TA^i}\right)$	$\rho\left(\frac{E^a}{TA^a}\right)$	$\rho\left(\frac{E^i}{TA^i}\right)$	$\frac{DEPR}{E}$	$\frac{INT}{E}$	$\frac{TLCF}{E}$	$\sigma\left(\frac{TLCF}{E}\right)$	$E[R^{i,e}]$	$\sigma[R^{i,e}]$	R^f	SR^m
Data (Avg.)	0.138	0.139	0.64	0.88	0.60	0.319	0.177	0.236	2.210	10.8	49.4	1.5	0.40
Data (Med.)	0.140	0.139	0.53	0.88	0.61	0.298	0.133	0.087	0.327	9.1	56.6	1.5	0.40
Model	0.140	0.134	0.44	0.89	0.69	0.329	0.164	0.108	0.316	12.2	36.9	1.5	0.38

Panel B: TLCF and equity risk, model

	$R_{t+1,t+k}$		$\sigma_{t+1,t+k}$		$\beta^{MKT}_{t+1,t+k}$	
	$k=1y$	$k=5y$	$k=1y$	$k=5y$	$k=1y$	$k=5y$
	Univariate					
$\frac{TLCF}{TA}$	0.277	0.750	0.369	0.178	0.274	0.532
	Bivariate					
$\frac{TLCF}{TA}$	0.024	0.046	0.121	0.062	0.018	0.027
ME	-0.067	-0.177	-0.091	-0.037	-0.093	-0.127

Panel C: TLCF and equity risk, data

	$R_{t+1,t+k}$		$\sigma_{t+1,t+k}$		$\beta^{MKT}_{t+1,t+k}$	
	$k=1y$	$k=5y$	$k=1y$	$k=5y$	$k=1y$	$k=5y$
	Univariate					
$\frac{TLCF}{TA}$	0.06	0.22	0.05	0.05	0.16	0.19
t-stat	(2.47)	(3.03)	(5.79)	(6.05)	(3.99)	(4.17)
	Bivariate					
$\frac{TLCF}{TA}$	0.06	0.21	0.05	0.05	0.15	0.18
t-stat	(2.56)	(3.03)	(5.82)	(6.10)	(3.96)	(4.21)
ME	-0.00	-0.10	-0.00	-0.02	-0.02	-0.06
t-stat	(-1.18)	(-2.32)	(-7.97)	(-8.63)	(-2.81)	(-3.47)

compared to a median of 0.087 and a mean of 0.236), and the volatility is too high (0.66 compared to a median of 0.327), nevertheless the key result - a positive relationship between TLCF and risk - remains unchanged.

In Panel B of Table 4.2 we report results from a Fama MacBeth regression of future realized equity returns, equity return volatilities, and market betas on the TLCF-to-Total Assets ratio. These regressions are done at 1 year, and 5 year horizons. Focusing first on the univariate results, all coefficients are positive, implying that firms with more TLCFs tend to be riskier. Panel C reports analogous regressions using data from CRSP/Compustat; Section 4.4 presents many more similar regressions with additional controls, but univariate and bivariate regressions are presented here for ease of comparison with the model. As in the model, there is a positive relationship between TLCF/TA and measures of equity risk.

Next, moving onto the bivariate regression. While in the data, there are multiple firm characteristics we can control for, in the model the only firm characteristic other than TLCF is the firm's value or size. Firms in the model may be valuable for one of two reasons: first firms with higher idiosyncratic productivity A^i are more valuable because they have higher expected pre-tax cash flows, second firms that have more TLCFs are also more valuable because they are expected to pay less taxes. We redo the same regressions, but adding firm size as a control. As in the data, firm size is negatively associated with risk,[12] however, the coefficients on TLCFs are still positive.

4.4 Empirical Evidence

The model in Section 4.3 suggests that we should see a positive relationship between TLCFs and measures of equity risk. In this section we study the empirical support for these implications. In particular, we examine the relationship between TLCF and standard measures of risk (betas, volatility, realized return), 12 and 60 months ahead. Our empirical analysis uses both portfolio sorts and Fama and MacBeth (1973) regressions. Since our return regressions condition on standard risk factors, the return regressions provide evidence of the extent to which priced TLCF risk is or is not captured in standard risk measures. As controls in the Fama and MacBeth (1973) regressions, we use size, book-to-market, profitability, EBITDA, interest tax credit, average tax rate, depreciation, leverage, and investment-to-assets. We also include controls for market, SMB, and HML betas.

To illustrate our regression analysis, consider our return regressions. Firm characteristics at year t are used to forecast the firm return from January to December in year $t+1$ ($k = 12$), or January to December in year t+5 ($k = 60$). Backward looking variables are computed with the same time window (k) as the forward looking returns. For each year in the sample, the following cross-sectional specification is estimated:

$$R^i_{t,t+k} = \alpha_t + \gamma_t \frac{TLCF}{TA}^i_t + \psi_t' \mathbf{X}^i_t + \varepsilon^i_t$$

Where:

$$R^i_{t,t+k} = \sum_{n=1}^{k} (r^i_{t+k} - r^f_{t+k})$$

is the realized return in the following k periods (i.e., 12 or 60 months), and $\mathbf{X}^i_t$ represent the year-firm characteristics. We also use this approach to investigate the risk/TLCF regressions.

[12] In this model, all firms, small and large, have the same risk in their pre-tax cash flows because all load in the same way on the aggregate shock A^a. However, even when there are no TLCFs ($\delta^\tau = 1.0$), small firms are riskier because their non-TLCF tax shields are higher than their cash flows, thus these non-TLCF tax shields can only be used in good states of the world. In the presence of TLCFs ($\delta^\tau < 1.0$), smaller firms will also have more TLCFs, therefore it is important to control for size before concluding that TLCFs affect risk positively.

Table 4.3: TLCF Summary Statistics

This table presents summary statistics for TLCF/TA [millions of dollars] available from Compustat. Statistics are presented by decade. N indicates the number of firms with positive TLCF, mean, standard deviation, and percentiles are computed over the firms with positive TLCF for the period.

	N	Mean	SD	10^{th}	50^{th}	90^{th}
1971-1980	2,954	$11.06	$46.68	$0.25	$2.13	$19.16
1981-1990	10,261	$24.09	$107.04	$0.50	$3.97	$39.50
1991-2000	13,294	$55.61	$222.69	$1.10	$12.02	$109.00
2001-2010	14,946	$235.34	$871.46	$3.81	$54.43	$464.00
2011-2015	8,920	$837.18	$15,486.14	$6.40	$106.09	$881.80

We begin our analysis in Section 4.4.1 with a description of the data.

4.4.1 Data

We use the merged CRSP-Compustat database from WRDS to combine financial and stock price information. The selected firm-year sample covers the period from 1971 to 2015. As seen in Figure 4.1, prior to 1971, very few firms had TLCFs, and TLCFs were relatively small in dollar value. Following Fama and French (1992) we exclude firms in the financial industry, firms that are in our sample for less than two years, and firms not incorporated in the U.S.

Our focus is on TLCF as reported in the Compustat data base and defined as[13] *"The portion of prior and current year losses, applied as a reduction of taxable income in the next succeeding year or years. When available and applicable, this item is usually reported in the notes to financial statements."* This measure includes the current Tax Loss Carry Forwards, TLCFs of both domestic and foreign consolidated subsidiaries, and TLCFs incurred prior to acquisition of a consolidated subsidiary.

Table 4.3 reports summary statistics for TLCFs. All statistics are in millions of dollars. The growing economic importance of this variable is apparent in both the increase in the number of firms with positive TLCF, and the increase in the size of the mean TLCF over time. Table 4.4 reports summary statistics and correlations for some of the variables used in our analysis. All variables are defined in this section appendix.

4.4.2 TLCF and risk

In this section, we test for a relationship between TLCFs and equity risk. We measure equity risk in several ways. Naturally, we consider the market beta (β_{Mkt}). Additionally, since the risk amplification is essentially due to option leverage, high TLCF firms should have a higher beta with respect to the

[13]Standard and Poor's (2017). "Xpressfeed Reference Data". Wharton Research Data Services (WRDS) at wrds.wharton.upenn.edu

Table 4.4: Summary Statistics

This table presents summary statistics for the equal weighted average, value weighted average, and standard deviation of the statistic for this period. We report the time-series average of each of these computations.

Panel A: Summary statistics

	$\frac{ME}{AvgME}$	$\frac{BE}{ME}$	$\frac{TLCF}{TA}$	$\frac{PROF}{TA}$	$\frac{EBITDA}{TA}$	$\frac{DEPR}{TA}$	$\frac{INT}{TA}$	$\frac{ITC}{TA}$
$E_{EW}[x]$	1.00	0.87	0.32	0.03	0.09	0.04	0.02	0.02
$E_{VW}[x]$	1.00	0.67	0.03	0.11	0.16	0.04	0.02	0.04
$\sigma[x]$	5.27	1.93	1.17	0.25	0.21	0.04	0.02	0.03

Panel B: Correlations

	$\frac{BE}{ME}$	$\frac{TLCF}{TA}$	$\frac{PROF}{TA}$	$\frac{EBITDA}{TA}$	$\frac{DEPR}{TA}$	$\frac{INT}{TA}$	$\frac{ITC}{TA}$
$\frac{ME}{AvgME}$	-0.03	-0.04	0.06	0.06	0.01	-0.01	0.14
$\frac{BE}{ME}$		-0.09	-0.09	-0.08	0.01	0.07	0.09
$\frac{TLCF}{TA}$			-0.49	-0.51	0.11	0.09	-0.14
$\frac{PROF}{TA}$				0.91	-0.16	-0.25	0.12
$\frac{EBITDA}{TA}$					0.07	-0.13	0.14
$\frac{DEPR}{TA}$						0.09	0.12
$\frac{INT}{TA}$							0.01

stochastic discount factor and anything that the SDF loads on, regardless of whether the true model is the CAPM or not. Therefore, the same relationship should be present in volatility, and other standard risk measures, such as β_{SMB}, and β_{HML}. Finally, we consider average realized returns. In all cases, the risk measures are forward looking, thus we are testing whether current TLCF is related to future risk.

We begin by looking a the risk of various TLCF to Total Assets portfolios. Specifically, we form one portfolio made of all firms with zero TLCF, labelled P_0. This portfolio makes up 60% of our overall sample. The remaining 40% of our firms are split into equally sized portfolios, P_1, P_2, and P_3, ranked in order of increasing TLCF-to-Total Assets. The results of this sort for various risk measures are presented in Table 4.5. The TLCF portfolios are all monotonically increasing in risk as measured by volatility, market beta, and SMB beta; however, there does not appear to be a relationship with HML beta. The relationship between TLCF and average return is not monotonic - first falling and then rising - though the overall relationship is positive as with the other measures of risk.

Portfolio sorts are suggestive of a positive univariate relationship between TLCF/TA and risk. Next, we use Fama and MacBeth (1973)regressions to confirm that this relationship is not jointly driven by an omitted variable. Table 4.6 reports the result of a Fama-MacBeth regressions where the dependent variable is the market beta over 12 and 60 month horizons. TLCF/TA has strong unconditional predictive power for 12 month ahead market betas with most controls, but becomes insignificant when past volatility is included. On the other hand, when forecasting 60 months CAPM betas, TLCF/TA is always significant, for any controls we have included.

Table 4.7 reports the result of a Fama-MacBeth regressions where the dependent variable is the volatility of returns over 12 and 60 month horizons. TLCF/TA predicts volatility positively for both

Table 4.5: Portfolio Sorts on TLCF and Standard Risk Measures

This table reports results from sorting firms into four portfolios based on TLCF/TA at t. Portfolio 0 contains all the firms with zero TLCF/TA; all other firms are sorted into portfolios 1, 2, and 3 such that each portfolio contains 1/3 of positive TLCF/TA firms. For each portfolio, we report forward looking statistics over the subsequent 12 months. The statistics are average return $Avg(R_{t+1,t+12})$, volatility $\sigma(R_{t+1,t+12})$, market beta $\beta^{MKT}_{t+1,t+12}$, SMB beta $\beta^{SMB}_{t+1,t+12}$, and HML beta $\beta^{HML}_{t+1,t+12}$, all computed using monthly returns.

	P_0	P_1	P_2	P_3
$Avg(R_{t,t+12})$	1.33	1.19	1.36	1.63
$\sigma(R_{t,t+12})$	3.53	3.85	4.83	6.39
$\beta^{MKT}_{t,t+12}$	1.07	1.18	1.27	1.40
$\beta^{SMB}_{t,t+12}$	1.28	1.42	1.70	1.97
$\beta^{HML}_{t,t+12}$	-0.70	-0.37	-0.36	-0.65

Table 4.6: TLCF and Future Market Beta

This table reports the results of Fama and MacBeth (1973) regressions of future realized market beta on firm characteristics. The key characteristic is the ratio of TLCF to Total Assets. The controls are size, book-to-market, profitability, past market, SMB, and HML betas, past stock return, and past volatility. We use annual accounting variables from Compustat 1971-2015. Accounting variables in year t are used to forecast the market beta of monthly returns from January to December in year $t+1$ ($k=12$) or in from January in year $t+1$ to December in year $t+5$ ($k=60$). Backward looking variables are computed with the same k as the forward looking returns.

	$k=12$					$k=60$				
$\frac{TLCF}{TA}$	0.16	0.14	0.09	−0.00	0.02	0.19	0.16	0.15	0.08	0.07
t-stat	(3.99)	(3.33)	(2.43)	(−0.03)	(0.55)	(4.17)	(3.90)	(3.48)	(3.00)	(3.16)
ME		−0.07			−0.02		−0.06			−0.02
t-stat		(−2.94)			(−1.32)		(−3.64)			(−1.91)
BE/ME		−0.10			−0.09		−0.09			−0.08
t-stat		(−3.89)			(−4.53)		(−4.20)			(−4.57)
$PROF/ME$		−0.01			−0.00		−0.01			−0.00
t-stat		(−1.35)			(−0.14)		(−2.48)			(−1.39)
INV/TA		0.06			0.10		0.06			0.09
t-stat		(0.41)			(0.85)		(0.74)			(1.22)
$\beta^{MKT}_{t-k,t}$			0.13		0.10			0.10		0.07
t-stat			(8.28)		(7.72)			(7.33)		(6.65)
$\beta^{SMB}_{t-k,t}$			0.04		0.03			0.04		0.02
t-stat			(2.04)		(2.51)			(3.22)		(3.27)
$\beta^{HML}_{t-k,t}$			−0.04		−0.03			−0.04		−0.02
t-stat			(−2.19)		(−2.43)			(−3.06)		(−3.04)
$E[R_{t-k,t}]$				−0.04	−0.06				−0.04	−0.07
t-stat				(−0.78)	(−1.27)				(−1.27)	(−2.26)
$\sigma[R_{t-k,t}]$				2.33	1.27				1.85	1.11
t-stat				(6.80)	(4.46)				(8.39)	(5.73)
R^2	0.01	0.02	0.05	0.06	0.09	0.01	0.04	0.09	0.09	0.14

Table 4.7: TLCF and Future Volatility

This table reports the results of Fama and MacBeth (1973) regressions of future realized stock return volatility on firm characteristics. The key characteristic in the ratio of TLCF to Total Assets. The controls are size, book-to-market, profitability, past market, SMB, and HML betas, past stock return, and past volatility. We use annual accounting variables from Compustat 1971-2015. Accounting variables in year t are used to forecast the volatility of monthly returns from January to December in year $t+1$ ($k=12$) or from January in year $t+1$ to December in year $t+5$ ($k=60$). Backward looking variables are computed with the same k as the forward looking returns.

	$k=12$					$k=60$				
$\frac{TLCF}{TA}$	0.05	0.05	0.05	0.03	0.02	0.05	0.05	0.05	0.03	0.03
t-stat	(5.79)	(5.73)	(5.97)	(5.11)	(4.83)	(6.05)	(6.10)	(6.13)	(5.58)	(5.51)
ME		−0.02			−0.01		−0.02			−0.01
t-stat		(−8.16)			(−7.96)		(−8.78)			(−9.24)
BE/ME		0.01			0.00		0.01			0.00
t-stat		(4.60)			(3.15)		(2.77)			(1.27)
$PROF/ME$		−0.00			−0.00		−0.00			−0.00
t-stat		(−5.08)			(−3.08)		(−3.99)			(−2.90)
INV/TA		0.02			0.01		0.02			0.01
t-stat		(1.75)			(0.91)		(2.57)			(1.86)
$\beta^{MKT}_{t-k,t}$			0.00		−0.00			0.00		−0.00
t-stat			(3.01)		(−4.50)			(2.68)		(−4.56)
$\beta^{SMB}_{t-k,t}$			0.00		−0.00			0.01		0.00
t-stat			(1.46)		(−0.72)			(3.11)		(0.31)
$\beta^{HML}_{t-k,t}$			−0.00		−0.00			−0.00		−0.00
t-stat			(−1.23)		(−1.15)			(−1.14)		(−0.83)
$E[R_{t-k,t}]$				−0.04	−0.04				−0.04	−0.04
t-stat				(−11.54)	(−11.60)				(−15.23)	(−15.41)
$\sigma[R_{t-k,t}]$				0.52	0.52				0.51	0.51
t-stat				(25.00)	(25.00)				(31.99)	(31.34)
R^2	0.08	0.11	0.13	0.30	0.32	0.08	0.12	0.15	0.32	0.35

the 12 and 60 month horizons. The relationship is even stronger than for the CAPM beta - it is not sensitive to controls, with most t-statistics ranging between 5 and 6 and the lowest being 4.78.

Tables 4.8 and 4.9 examine SMB and HML betas, respectively. TLCF is positively and significantly related to SMB betas for 12 and 60 month horizons. On the other hand, TLCF is not significantly related to HML beta.

Finally, we consider the relationship between current TLCF/TA and average realized future stock return. Table 4.10 reports results from Fama-MacBeth regressions, showing a positive relationship between TLCFs and the realized stock return. TLCF enters positively and significantly in all models that predict future returns for both the 12 and 60 month horizons, with t-statistics across specified cations ranging from 2.23 and 3.66. The predictive power of TLCF is little changed when Size and Book-to-Market, both of which enter significantly, are also included. It is also unaffected by including past betas or past volatility. It is interesting to note that existing measures of risk, either based on firm characteristics or (backward looking) loadings on factors do not drive away the significance of TLCF.

Table 4.8: TLCF and Future SMB Beta

This table reports the results of Fama and MacBeth (1973) regressions of future realized SMB beta on firm characteristics. The key characteristic is the ratio of TLCF to Total Assets. The controls are size, book-to-market, profitability, past market, SMB, and HML betas, past stock return, and past volatility. We use annual accounting variables from Compustat 1971-2015. Accounting variables in year t are used to forecast the SMB beta of monthly returns from January to December in year $t+1$ ($k=12$) or from January in year $t+1$ to December in year $t+5$ ($k=60$). Backward looking variables are computed with the same k as the forward looking returns.

	$k=12$					$k=60$				
$\frac{TLCF}{TA}$	0.57	0.54	0.43	0.22	0.23	0.52	0.49	0.44	0.23	0.22
t-stat	(2.88)	(2.82)	(2.70)	(1.93)	(1.98)	(4.16)	(4.14)	(3.97)	(3.67)	(3.70)
ME		−0.37			−0.23		−0.38			−0.25
t-stat		(−7.15)			(−7.90)		(−7.10)			(−7.99)
BE/ME		0.03			0.01		−0.00			−0.02
t-stat		(0.86)			(0.17)		(−0.19)			(−1.14)
$PROF/ME$		−0.02			−0.01		−0.02			−0.01
t-stat		(−2.79)			(−1.19)		(−3.26)			(−1.86)
INV/TA		−0.33			−0.37		−0.29			−0.28
t-stat		(−1.43)			(−1.66)		(−2.61)			(−2.69)
$\beta^{MKT}_{t-k,t}$			0.09		0.04			0.09		0.03
t-stat			(2.44)		(1.05)			(4.42)		(2.01)
$\beta^{SMB}_{t-k,t}$			0.11		0.06			0.11		0.06
t-stat			(3.01)		(2.61)			(4.60)		(4.83)
$\beta^{HML}_{t-k,t}$			−0.03		−0.01			−0.02		−0.01
t-stat			(−0.98)		(−0.57)			(−1.68)		(−1.14)
$E[R_{t-k,t}]$				−0.32	−0.30				−0.32	−0.30
t-stat				(−3.79)	(−3.73)				(−6.41)	(−6.25)
$\sigma[R_{t-k,t}]$				5.11	3.91				4.79	3.76
t-stat				(10.55)	(8.60)				(12.05)	(9.77)
R^2	0.01	0.04	0.06	0.08	0.11	0.02	0.06	0.10	0.15	0.18

This could be consistent either with mispricing - the market prices high TLCF firms too low relative to their true risk leading to high positive returns, or with the market pricing being correct but these measures of risk being incomplete.

We also ran unreported regressions that included firm fixed effects, time fixed effects, and industry fixed effects. In all cases the TLCF coefficients have the same sign and similar significance as reported above, indicating that the forecasting power of TLCF is not related to unobserved firm, industry or time characteristics. Results from regressions including the Fama and French (2015) 4 factor model betas, and Hou et al. (2015) 4 factor model betas were also essentially the same as those reported above. Similar results were found when we standardized TLCF by size, book asset value, book debt plus size, or revenues rather than total assets.

In summary, consistent with the model presented in Section 4.3, equity risk as measured by realized returns, volatility, market beta, and SMB beta, is positively and significantly related to TLCF in the cross-section of firms.

Table 4.9: TLCF and Future HML Beta

This table reports the results of Fama and MacBeth (1973) regressions of future realized HML beta on firm characteristics. The key characteristic is the ratio of TLCF to total assets. The controls are size, book-to-market, profitability, past market, SMB, and HML betas, past stock return, and past volatility. We use annual accounting variables from Compustat 1971-2015. Accounting variables in year t are used to forecast the HML beta of monthly returns from January to December in year $t+1$ ($k=12$) or from January in year $t+1$ to December in year $t+5$ ($k=60$). Backward looking variables are computed with the same k as the forward looking returns.

	$k=12$					$k=60$				
$\frac{TLCF}{TA}$	−0.00	0.05	0.04	0.05	0.07	−0.03	−0.01	−0.03	−0.02	−0.01
t-stat	(−0.01)	(0.63)	(0.41)	(0.54)	(0.86)	(−0.58)	(−0.14)	(−0.78)	(−0.77)	(−0.60)
ME		0.01			0.02		−0.00			0.01
t-stat		(0.20)			(0.81)		(−0.10)			(0.52)
BE/ME		0.40			0.33		0.29			0.24
t-stat		(9.24)			(7.53)		(13.67)			(10.56)
$PROF/ME$		0.00			0.00		0.00			0.01
t-stat		(0.21)			(0.46)		(0.56)			(1.66)
INV/TA		0.28			0.27		0.25			0.23
t-stat		(0.98)			(1.07)		(1.39)			(1.33)
$\beta^{MKT}_{t-k,t}$			−0.09		−0.07			−0.06		−0.04
t-stat			(−3.38)		(−2.34)			(−3.16)		(−2.79)
$\beta^{SMB}_{t-k,t}$			0.04		0.02			0.02		0.01
t-stat			(1.19)		(0.97)			(0.83)		(0.78)
$\beta^{HML}_{t-k,t}$			0.11		0.09			0.09		0.07
t-stat			(4.11)		(4.62)			(4.25)		(4.63)
$E[R_{t-k,t}]$				−0.27	−0.16				−0.16	−0.08
t-stat				(−3.09)	(−1.92)				(−2.70)	(−1.46)
$\sigma[R_{t-k,t}]$				−0.55	−0.21				−0.58	−0.31
t-stat				(−0.86)	(−0.38)				(−1.17)	(−0.77)
R^2	0.01	0.04	0.05	0.06	0.10	0.01	0.06	0.08	0.09	0.14

4.4.3 1986 Tax Reform Act

The Tax Reform Act of 1986 provides a clean test of our model. In our theory, the firm sells a call option written on tax revenues; i.e., the tax rate times taxable income. If the tax rate deceases, the value of this option, and the option leverage that is central to our theory, will both decrease. As described by Guenther (1994), the government "in September 1986, reduced the statutory corporate income tax rate from 46 percent to 34 percent, effective for taxable years beginning on or after 1 July 1987. This represents a reduction of 26 percent of the pre-reform tax expense".[14]

Our theory predicts that such a change in tax rates will reduce the relationship between TLCF, risk and return. Indeed, Table 4.11 provides evidence of the predicted decrease in the TLCF/return relationship[15]. The slope from regressing 12-month ahead returns on TLCF is 0.08 in the full sample, but it falls from 0.18 in 1971-1986 to 0.02 in 1987-2015, though it remains significant in both samples.

[14]The Omnibus Budget Reconciliation Act of 1993 increased the corporate tax rate to 35% on income above $18 million.
[15]We also repeated the TLCF/risk measure analysis and find similar results

Table 4.10: TLCF and Future Return

This table reports the results of Fama-MacBeth regressions of future realized stock returns on firm characteristics. The key characteristic is the ratio of TLCF to Total Assets. The controls are size, book-to-market, profitability, past market, SMB, and HML betas, past stock return, and past volatility. We use annual accounting variables from Compustat 1971-2015. Accounting variables in year t are used to forecast the sum of log monthly returns from January to December in year $t+1$ ($k = 12$) or from January in year $t+1$ to December in year $t+5$ ($k = 60$). Backward looking variables are computed with the same k as the forward looking returns.

	$k=12$					$k=60$				
$\frac{TLCF}{TA}$	0.06	0.07	0.07	0.07	0.08	0.22	0.23	0.21	0.16	0.17
t-stat	(2.47)	(2.95)	(2.96)	(3.47)	(3.49)	(3.03)	(3.32)	(3.27)	(3.34)	(3.66)
ME		−0.01			−0.01		−0.08			−0.05
t-stat		(−0.72)			(−1.37)		(−2.17)			(−1.83)
BE/ME		0.06			0.05		0.16			0.12
t-stat		(5.25)			(4.92)		(8.70)			(7.37)
$PROF/ME$		−0.00			−0.00		−0.01			−0.01
t-stat		(−0.14)			(−0.61)		(−2.31)			(−1.62)
INV/TA		−0.13			−0.15		−0.24			−0.24
t-stat		(−1.88)			(−2.43)		(−1.30)			(−1.49)
$\beta^{MKT}_{t-k,t}$			−0.01		−0.01			−0.03		−0.04
t-stat			(−1.23)		(−1.58)			(−1.62)		(−3.10)
$\beta^{SMB}_{t-k,t}$			−0.00		−0.01			0.02		0.00
t-stat			(−0.55)		(−0.87)			(0.90)		(0.09)
$\beta^{HML}_{t-k,t}$			−0.00		−0.00			0.00		−0.00
t-stat			(−0.30)		(−0.43)			(0.10)		(−0.15)
$E[R_{t-k,t}]$				−0.01	0.00				−0.23	−0.18
t-stat				(−0.62)	(0.05)				(−5.48)	(−5.26)
$\sigma[R_{t-k,t}]$				−0.02	−0.00				1.19	1.15
t-stat				(−0.12)	(−0.03)				(3.66)	(3.94)
R^2	0.01	0.03	0.03	0.04	0.07	0.01	0.05	0.03	0.05	0.08

For the 60-months ahead returns, the full sample slope is 0.17, but falls from 0.40 in the 1971-1986 sample, to 0.02 and is only marginally significant in the 1987-2015 sample.

4.5 Conclusion

This paper examines the implications of TLCFs for equity return moments. Although it has been previously argued that the presence of tax shields reduces a firm's risk, we show that this is not necessarily the case. Empirically, we show a clear positive relationship between TLCFs and returns, volatility, and the market and SMB betas. Our theoretical model, calibrated to the data, reproduces this relationship.

Overall, our results suggest that TLCF and other tax management assets are important determinants of risk and return. A more complete understanding of the complex tax management task that firm's faces will be the subject of future research.

Table 4.11: TLCF and Future returns, 1986 change in tax code

This table reports the results of Fama MacBeth regressions of future realized stock return on firm characteristics. The key characteristic is the ratio of TLCF to Total Assets. The controls are size, book-to-market, profitability, past market returns, SMB, and HML betas, past stock return, and past volatility. We use annual accounting variables from Compustat 1971-2015. Accounting variables in year t are used to forecast the firm returns from January to December in year $t+1$ ($k=12$) or from January year $t+1$ to December in year $t+5$ ($k=60$). Backward looking variables are computed with the same k as the forward looking returns.

	$k=12$			$k=60$		
	Full Sample	1971-1986	1987-2015	Full Sample	1971-1986	1987-2015
$\frac{TLCF}{TA}$	0.08	0.18	0.02	0.17	0.40	0.02
t-stat	(3.49)	(3.48)	(2.15)	(3.66)	(4.42)	(1.61)
ME	-0.01	-0.01	0.00	-0.05	-0.12	0.00
t-stat	(-1.37)	(-1.66)	(0.62)	(-1.83)	(-2.08)	(0.58)
BE/ME	0.05	0.04	0.05	0.12	0.14	0.10
t-stat	(4.92)	(4.50)	(3.50)	(7.37)	(8.86)	(4.19)
$PROF$	-0.00	0.00	0.00	-0.01	-0.02	0.00
t-stat	(-0.61)	(-0.09)	(-1.07)	(-1.62)	(-2.36)	(0.45)
INV/TA	-0.15	-0.16	-0.14	-0.24	-0.32	-0.19
t-stat	(-2.43)	(-1.88)	(-1.68)	(-1.49)	(-1.15)	(-0.95)
$\beta_{t-k,t}^{MKT}$	-0.01	-0.02	0.00	-0.04	-0.04	-0.03
t-stat	(-1.58)	(-2.01)	(-0.45)	(-3.10)	(-1.91)	(-2.44)
$\beta_{t-k,t}^{SMB}$	-0.01	0.00	-0.01	0.00	0.03	-0.02
t-stat	(-0.87)	(0.35)	(-1.38)	(0.09)	(1.97)	(-1.09)
$\beta_{t-k,t}^{HML}$	-0.00	0.00	-0.01	-0.00	0.00	-0.01
t-stat	(-0.43)	(0.35)	(-0.70)	(-0.15)	(0.25)	(-0.33)
$E\left[R_{t-k,t}\right]$	0.00	0.05	-0.03	-0.18	-0.14	-0.21
t-stat	(0.05)	(1.59)	(-1.08)	(-5.26)	(-2.26)	(-5.24)
$\sigma\left[R_{t-k,t}\right]$	-0.00	-0.11	0.06	1.15	1.11	1.18
t-stat	(-0.03)	(-0.46)	(0.36)	(3.94)	(1.77)	(4.45)
R^2	0.07	0.08	0.06	0.08	0.12	0.06

Chapter 5

Conclusion

In this thesis I studied the impact of three legal institutions over asset prices, the decisions of firms and households, and the economic sustainability of regulated markets. The three legal institution studied here are the personal bankruptcy code, the regulation of the harvest of natural resources (fish), and the tax code. These institutions directly define property rights, support contractual arrangements, and dictaminate the payment of taxes, key legal institutions in place for financial markets, with significant implications for the decisions of the agents involved.

In my study of the personal bankruptcy code I focused on how the magnitude of the homestead exemption relates to the supply and demand for loans. As the homestead exemption specifies the amount of home equity that a household will be entitled to keep at bankruptcy, one might expect that a higher exemption will increase the moral hazard on the part of the borrowers, leading to higher demand for loans, with higher delinquency ratios, while the lenders will respond with higher interest rates.

My results show that the magnitude of the homestead exemption is significant to explain the total amount of loans to households, its aggregate riskiness and the state level house prices. I find that states with a higher homestead exemption exhibit fewer secured loans granted, lower delinquency ratios on secured and unsecured loans, lower interest rates, and higher house prices.

To understand the economic mechanism behind these empirical results, I did a theoretical analysis using an equilibrium model on which a set of households face idiosyncratic income risk and use secured and unsecured loans to finance their consumption. The households have the option to file for bankruptcy in a process that resembles the personal bankruptcy code. Loans are provided in the model by a competitive lender that price default risk using the overall debt position of the households, and their assets holdings. Lenders are assumed to initially be unable to observe the riskiness of the household's income but can invest in a costly monitoring technology that eliminates this information asymmetry.

The model shows that the empirical results are consistent with the following economic channel. A more generous homestead exemption increases the household's benefits after bankruptcy. Benefits arise from the implicit insurance provided by the real estate, therefore the demand for housing increases endogenously pushing house prices up. These bankruptcy benefits for the households are mirrored by a rise in the credit losses faced by the lender. As unsecured debt is partially or fully discharged, the lender has incentives to increase monitoring, and price each loan accordingly to its specific credit risk. Although, monitoring benefits the low risk households as they no longer provide subsidies to the riskier households, eroding their pooling advantage as they are now subject to higher interest rate as the exemption increases. This effect produces an aggregate reduction in the secured loans as now low risk households increase their demand for unsecured loans, and reduce their overall leverage, therefore, the overall debt. This mechanism is consistent with the empirical evidence indicating that higher exemptions lead to a lower fraction of secured loans issued, with lower rates and delinquency, with higher overall house prices.

The second legal institution studied in this work is the regulation of the harvest of natural resources, with special focus on fisheries and the potential of this institution to achieve a financially and ecologically sustainable exploitation. My co-author and I constructed an optimal stochastic control approach model to value a fishery, with two sources of uncertainty: the biomass and the price. The solution of the model is obtained by solving a Hamilton-Jacobi-Bellman equation for the value of the Fishery by using a value-function iteration approach. Overall, the results highlight the strong non-linear relation between the biomass and the resource price on the value of the fishery and the optimal harvesting policy.

The solution is implemented using the estimated parameters for the British Columbia halibut fishery. The model results are used to simulate the dynamic of the studied fishery finding that the optimal harvesting policy is sustainable. For negative shocks to the biomass growth we obtain reductions of the resource stock, but the simulations show that with almost certainty the extinction of the resource will not occur.

The model solved for a realistic set of parameters suggests that an economically viable fishery is feasible, that overfishing is indeed not optimal, even in the presence of fish price and biomass uncertainty. This highlights the value of conservation and confirms that current efforts are indeed efficient from a social and a financial perspective, but can be improved.

The third legal institution studied is the tax code. I focus on how the treatment of corporate losses for tax shield benefit ties in with the firm's equity risk and return. This research examines the implications of Tax Loss Carry Forwards (TLCFs) for equity return moments. Although it has been previously argued that the presence of tax shields reduces a firm's risk, we show that this is not necessarily the case. Empirically, we show a clear positive relationship between TLCFs and returns, volatility, the market, High-Minus-Low (HML) and Small-Minus-Big (SMB) betas. Our theoretical model, calibrated to the data, reproduces this relationship. Overall, our results suggest that TLCFs and other tax management assets are important determinants of risk and return. A more complete understanding of the complex tax management task that firm's faces will be the subject of future research.

To conclude, the results of this thesis show that the three legal institutions studied here have a significant impact on the decisions of market agents and in the determination of asset prices, that they are relevant not only for academics, but also for investors, households facing financial distress, lenders evaluating granting policies, and governmental institutions designing regulations, henceforth they have the potential to help in the improvement of these legal institions directly related to the development of financial credit markets, the extraction of endangered natural resources, and the understanding of the impact of the tax code on the firm's financial decisions and the choices of investors.

5.1 Future Research

The first line of future research is related to my work on personal bankruptcy. My results show that the magnitude of the homestead exemption has implications on the real-estate market. I would like to explore this in greater depth. Specifically, there is a positive effect on house prices driven by an increase in the demand, however, it would be interesting to also incorporate the supply effect, not only in construction, but also in the access to loans for development. Also, I have noticed that the personal bankruptcy code exhibits similar features internationally. With this in mind, I would like to explore this problem using, for example, Canadian data, in order to understand whether the patterns and theoretical results are also relevant abroad.

With relation to the sustainable harvesting of natural resources, a significant body of the fisheries literature has concluded that the presence of overinvestment is behind the mentioned overfishing evidence (Clark (2010)). One interesting hypothesis that has yet to be explored is that there could be a relationship between the historical level of investment and the behavior of a firm adjusting its harvesting policy in the presence of shocks in the biomass and fish prices to maximize its value.

As my research shows, the optimal harvest policy requires a high degree of flexibility to respond to changes in price and biomass. This flexibility comes in the form of a high fishing capacity but at the cost of remaining unused at least part of the time. This channel could be even more important if the investment is highly irreversible. My co-author and I are already exploring this problem by developing a model of a firm harvesting a natural resource, which includes the real option for investment.

The goal is to revisit the investment problem in the presence of multiple sources of uncertainty and different levels of investment reversibility. The objective is to explore the new economic channels that may arise from these novel features, and compare the optimal capital investment policies with the traditional capital accumulation benchmarks, revisiting the overinvestment conclusion.

With respect to my research on Tax Loss Carry Forwards, an interesting problem related is the relation between TLCFs and the real option to invest. Following Auerbach and Poterba (1987), an hypothesis to explore is that when a firm that has has TLCFs invests in a new asset, the after-tax income will most likely decrease. As the project initial losses will be carried forward until the firm achieves a positive taxable income, some investments will be discouraged by the presence of unused tax benefits as they may be lost before used. My co-authors and I have preliminary empirical evidence consistent with this hypothesis, indicating that the valuation of the real option to invest for different levels of TLCFs is indeed an interest extension of our work.

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Appendix A

Appendix to Chapter 2

A.1 Complementary Literature

Several papers have also studied the relation between the homestead exemption and bankruptcy rates. Fay et al. (2002) used the Panel Study of Income Dynamics, from 1984 to 1995, to show that the financial benefit from bankruptcy is positively related with the debt discharge. Hynes et al. (2004) showed that state exemptions are correlated with bankruptcy filing, suggesting that the examination of the impact of bankruptcy laws should not treat protection levels as exogenous variables. Agarwal et al. (2003), White (2007) and White (2009) found that in the cross-section, state exemptions are positively correlated with higher delinquency in unsecured loans and bankruptcy rates.

Lefgren and McIntyre (2009) used zip-code-level data of bankruptcy filings between 1999 and 2001. They found that the homestead exemption (included as a High and Low dummy) does not explain the variation in bankruptcy filings across states, as the exemption only affects a small fraction of bankruptcies.

Miller (2011) constructed a data set of the 1,694 households that filed for bankruptcy in 2007. He showed that high homestead exemption levels encouraged households with higher asset to file for bankruptcy. Finally, Li et al. (2011) show that 2005 BAPCPA act had a positive effect in the prime and subprime mortgage default rates.

My paper also relates to the literature on legal institutions and asset prices. Mian et al. (2010) and Mian et al. (2015) study how the judicial requirement for foreclosures relate to real estate prices, finding that easier foreclosures enforcement led to a large decline in house prices, residential investment, and consumer demand from 2007 to 2009.

Monitoring efforts in secured lenders have been explored in the literature. Burke et al. (2012) show that, for secured loans, if the lender increases its screening efforts, it ends up rejecting the risky applicants. Mian and Sufi (2010) and Mian and Sufi (2011) show that lending standards dramatically weakened after 2004, which ended in lenders allocating resources to increasingly risky borrowers. Ambrose et al. (2016) study the effect of adverse selection in the mortgage market had during the

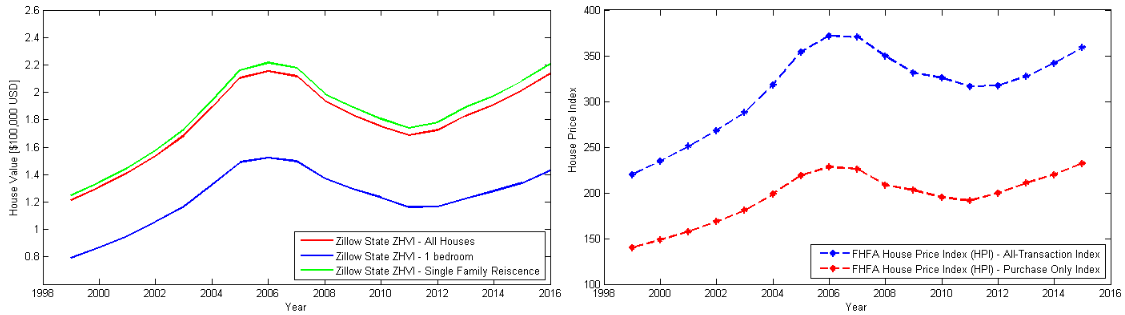

Figure A.1: House Price Index State Average, The Zillow Home Value Index (ZHVI) and the Federal Housing Finance Agency (FHFA) House Price Index (HPI). Data from 1999 to 2016.

rise in leverage previous to the Great Recession, showing that risky lenders where likely to inflate the reported income to improve their access to loans.

A.2 House Prices Trends 1999-2016

With respect to the house prices, the median value of a residential house for the 1999-2016 period was $179,537, with a range from $104,300 at the 10th percentile to $290,500 at the 90th percentile. The U.S. average cross-sectional house price are included in Figure A.1 illustrating the time trends of this market.

Figure A.1 shows the general house price behavior observed during the last 27 years. From 1999 to 2006 is characterized by a a sustained in house prices, which has been extensively discussed in the literature, and directly related to the Great Recession, that finally produced the decay in the prices observed from 2007 to 2011 (Mian and Sufi (2011)). Sustained growth is again observed from 2011 to 2016. As an opening illustration of the relation between the homestead exemption and house prices, Figure A.2 show the difference the house price average for states above and below the homestead exemption median of each year.

Figure A.2 shows that during the previous to the relation between high and low exemptions states was close, but it becomes positive and significant after the start of the great recession and remains until today, indicating that high exemption states exhibited higher house prices, although they did exhibited a decay in its level, after the start of the recession.

A.3 U.S. Court data on Chapter 7

U.S. Court data includes statistics for the non-business Chapter 7 filings from 2001 to 2016. During that period there was a total of 13,659,782 cases (11% of the total number of households in the U.S.), highlighting the importance of the institution. With respect to the 2005 BACPAC act, is possible to

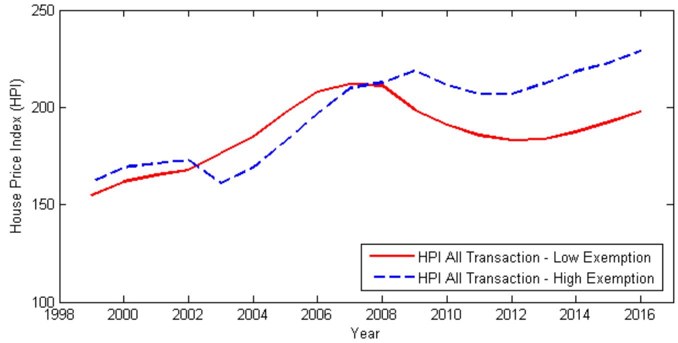

Figure A.2: House Price Index For States with High and Low Homestead Exemption, Federal Housing Finance Agency (FHFA) House Price Index (HPI). Data from 1999 to 2016.

Table A.1: Non-Business Chapter 7 Filings Summary Statistics

This table presents the state level summary the number of non-business Chapter 7 filings obtained from the U.S. Bankruptcy Courts. This information is obtained for the 12-month period ending in December. Data is available from 2001 to 2016.

year	N	Mean	SD	10th	90th
2001	50	20,455	21,207	2,185	46,650
2002	50	21,564	21,657	2,015	49,000
2003	50	22,944	22,214	2,162	52,761
2004	50	22,178	21,026	2,166	53,398
2005	50	32,368	31,755	3,158	84,170
2006	50	6,957	6,543	640	17,125
2007	50	9,934	10,222	975	25,281
2008	50	14,174	16,586	1,183	35,937
2009	50	20,033	25,321	1,472	48,241
2010	50	21,845	30,081	1,577	48,138
2011	50	19,003	26,539	1,363	41,552
2012	50	16,198	21,567	1,200	35,373
2013	50	14,008	17,263	1,097	31,701
2014	50	11,889	13,634	933	26,646
2015	50	10,261	11,090	849	23,768
2016	50	9,386	9,803	879	22,167

notice that there is a reduction on the average number of filings per year, a clear indicator of the more restrictive process induced by the act. Table A.1 presents the Chapter 7 fillings per year, and Table A.2 presents the summary of the assets and debts of the non-business Chapter 7 filings from 2007 to 2016.

The data resumed in Table A.2 is reported by the U.S. Bankruptcy Courts as part of the BAPCPA, and provides state level aggregate statistics of the assets and liabilities of the non-business Chapter 7 filed cases. Although the aggregate data loses part case heterogeneity, there are some aggregate features that will be useful to understand which households are going through the process, as that 76% of the household's assets are concentrated in real state, showing that this asset is the main wealth being

Table A.2: Non-Business Chapter 7 Assets and Liabilities Summary Statistics

This table presents the state level summary of the assets and liabilities reported by individual debtors in non-business Chapter 7 cases. This data is obtained from the U.S. Bankruptcy Courts website (BAPCPA Table 1A). Information is reported for the 12-month period ending in December. Data is available from 2007 to 2016.

	N	Mean	Median	SD	10th	90th
Cases (per State)	529	13,536	7,730	18,869	982	29,947
Total Assets (Per Case)	529	$99,262	$90,679	$41,359	$56,575	$149,193
Real Property (Per Case)	529	$75,126	$66,237	$37,318	$37,558	$121,010
Personal Property (Per Case)	529	$24,171	$22,460	$13,595	$16,486	$30,714
Total Liabilities (Per Case)	529	$192,500	$153,045	$376,399	$110,360	$243,849
Secured Claims (Per Case)	529	$89,548	$78,767	$41,097	$47,224	$146,621
Unsecured Priority Claims (Per Case)	529	$7,364	$2,873	$76,777	$1,900	$4,980
Unsecured Non-Priority Claims (Per Case)	529	$81,154	$68,398	$108,060	$55,426	$113,809

protected by the bankruptcy procedure. Is also noticeable that the unsecured non-priority[1] liabilities constitute 42% of the total household liabilities, showing that a significant amount of the household's debt may be discharge in bankruptcy.

A.4 PSID data of households' wealth portfolio and the magnitude of the homestead exemption

I include data from the Panel Study of Income Dynamics (PSID) of the University of Michigan to understand the U.S. households' wealth portfolio. Unfortunately several states are represented by a small number of households, making it difficult the use this data for inference over the cross-sectional differences at state level. All information is collected from 1999 to to 2016. Table A.3 summarizes the PSID data at state level, to show the wealth profile across states, and how it relates to the magnitude of the homestead exemption.

Table A.3 highlights the relevance of the "House Value" in the household's balance sheet, illustrating the importance of real estate as a wealth accumulation device. This Table also shows that there is a sizable, positive, home equity. This magnitude is fundamental to understand the financial benefit of filing for bankruptcy, as it will be the subject of protection of the homestead exemption.

Table A.4 presents the PSID state average of the unsecured loans and Home Equity.

Panel A of Table A.4 shows that the average home equity is positive, and that the unsecured debt is close to $10,000 dollars, smaller is several cases than the home equity. This shows that the homestead exemption will be extremely relevant for most of those households, as in the case of default on the unsecured debt, their housing value will be greater than their dischargeable debt, hence, if the home equity is below the exemption, they will see their house liquidated.

Panel B of Table A.4 complements the previous observation by showing that on average, 30.6%

[1]The unsecured priority claims include tax obligations, alimony and child support, and are non discharged, so they remain as part of the household obligations after bankruptcy

Table A.3: PSID State Level Average Wealth, Summary Statistics

This table presents the state level mean of the wealth components and total debt surveyed in the PSID household panel data. The information is obtained every two years and represent the current level of the surveyed variable. Data is included from 1999 to 2015.

	N	Mean	Median	SD	10th	90th
House Value	432	$113,116	$91,369	$66,254	$49,378	$253,390
Remaining Mortgage	432	$48,841	$40,980	$25,773	$15,205	$95,595
Other Real Estate	432	$22,632	$15,332	$23,913	$1,671	$71,375
Vehicles	432	$11,954	$12,875	$4,413	$8,803	$18,182
Business	432	$11,779	$21,268	$26,808	-	$78,565
Individual Retirement Account (IRA)	432	$26,749	$20,960	$24,783	$2,636	$57,238
Stocks (non-IRA)	432	$29,019	$16,913	$46,314	$289	$62,201
Transaction Accounts	432	$17,893	$13,723	$20,157	$4,325	$32,658
Other Assets	432	$7,533	$4,927	$11,851	$140	$14,955

Table A.4: PSID State Level Average Home Equity and Unsecured Debt, Summary Statistics

This table presents the state level mean of the wealth components and total debt surveyed in the PSID household panel data. The information is obtained every two years and represent the current level of the surveyed variable. Data is included from 1999 to 2015.

Panel A: Home Equity and Unsecured Debt

	N	Mean	Median	SD	10th	90th
Home Equity	432	$64,275	$48,315	$46,606	$25,465	$125,768
Unsecured Debt Value	432	$9,964	$9,170	$5,546	$4,400	$16,537

Panel B: State Level Fraction of Households with Positive Home Equity, Positive Unsecured Debt, and Exempted Home Equity and Positive Unsecured Debt.

	N	Mean	Median	SD	10th	90th
Home Equity and Unsecured Debt>0	432	30.6%	29.4%	11.1%	20.0%	40.7%
Home Equity < Homested Exemption	432	28.8%	24.9%	20.9%	4.4%	60.4%
Exempted Home Equity and Debt>0	432	17.3%	14.5%	13.3%	1.8%	35.0%

of surveyed households exhibit positive home equity and positive debt, these are households who may directly benefit from the homestead exemption at bankruptcy. On average 28.8% of the households have their home equity fully protected by the state homestead exemption, while 17.3% of those fully protected have unsecured debt. These households will see their unsecured debt discharged in case of filing for personal bankruptcy.

Although the PSID data is rich terms of the household information, there are several states in the U.S. with less than 10 households surveyed each year, for example, Rhode Island has 3 surveyed households in 1999, and 7 in 2015. The reduced number of observations for some states makes it difficult to draw robust inference for the cross-sectional effect of the homestead exemption over the household debt and home equity. Acknowledging this difficulty, I ran preliminary tests for the state average housing wealth and home equity, finding that a higher homestead exemption is related to higher housing wealth and higher home equity.

A.5 Final Period Optimal Policies

At $t = 1$ households is state $j \in \{(i,e),(i,u)\}$ maximize:

$$\max_{c_1^j, h_1^j, d_B^j, d_M^j, B_1^j, M_1^j} u\left(c_1^j\right) + \phi u\left(h_1^j\right) + \beta \delta u\left(p_1 h_1^j\right)$$

As $\{d_B^j, d_M^j, B_1^j, M_1^j\}$ are estimated by maximizing the cash-on-hand W_1^j for each of the previously discussed relevant cases, the household solves the maximization problem taking this account as given. This is equivalent to solve:

$$\max_{c_1^j, h_1^j} u\left(c_1^j\right) + \phi u\left(h_1^j\right) + \beta \delta u\left(p_1 h_1^j\right)$$

subject to:

$$c_1^j + p_1 h_1^j \leq W_1^j$$

Then, dropping the indexes of consumption and housing for notation simplicity, the Lagrangian of the presented problem is:

$$L = \frac{c^{(1-\gamma)}}{(1-\gamma)} + \phi \frac{h^{(1-\gamma)}}{(1-\gamma)} + \beta \delta \frac{(ph)^{(1-\gamma)}}{(1-\gamma)} + \lambda (W_1^j - c - ph)$$

The F.O.C. are:

$$c^{-\gamma} - \lambda = 0$$

$$\phi h^{-\gamma} + \beta \delta p (ph)^{-\gamma} - \lambda p = 0$$

Re-arranging:

$$h^{-\gamma}\left[\frac{\phi}{p} + \beta \delta p^{-\gamma}\right] = \lambda = h^{-\gamma} A(p)$$

Then:

$$h A(p)^{-1/\gamma} = c$$

Replacing in the budget constraint, the optimal policies as a function of the household wealth are:

$$h_1^j = \frac{W_1^j}{A(p_1)^{-1/\gamma} + p_1}$$

$$c_1^j = \frac{W_1^j A(p_1)^{-1/\gamma}}{A(p_1)^{-1/\gamma} + p_1}$$

A.6 Additional Tables

Table A.5: Credit Card Loans and Homestead Exemption

This table present the results for regressions for credit card loans to individuals obtained from the FFIEC database, and include the ratio of these loans to of total loans, the annual loan yield, and the delinquency ratio. The main control is the logarithm of the homestead exemption, but the regressions also include the logarithm of the per-capita income, the percentage of the population with high school diploma, the unemployment level, the percentage of households under poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, and the number of households with children. Standard errors are heteroskedasticity-robust and clustered at the state level.

	(1)	(2)	(3)
	Credit Card Loans % of Total Loans	Credit Card Yield	Credit Card Delinquency Ratio
log (Homestead Exemption)	0.14	-0.91	-0.24
(t-stat)	(1.60)	(-0.87)	(-1.4)
House Price Index	-0.01	-0.01	0.00
(t-stat)	(-1.10)	(-0.76)	(0.03)
log (Income)	-2.64	3.57	0.05
(t-stat)	(-2.48)	(1.44)	(0.02)
High School	-0.00	0.12	0.02
(t-stat)	(-0.66)	(0.35)	(0.33)
Unemployment	0.02	1.46	0.07
(t-stat)	(1.10)	(1.34)	(0.49)
Under Poverty	-4.90	7.96	3.40
(t-stat)	(-1.26)	(0.99)	(1.13)
Married Couples	-0.15	3.87	0.55
(t-stat)	(-2.00)	(1.88)	(1.35)
Female Householder	-0.19	2.61	0.55
(t-stat)	(-1.84)	(1.22)	(1.2)
Families with Child	-0.07	-1.00	-0.18
(t-stat)	(-1.60)	(-1.38)	(-0.69)
Age	-0.04	1.33	-0.06
(t-stat)	(-0.81)	(0.5)	(-0.16)
Race	-0.13	-0.28	0.35
(t-stat)	(-2.95)	(-0.95)	(2.8)
Year-FE	Yes	Yes	Yes
State-FE	Yes	Yes	Yes
Adj. R-Squared	0.53	0.37	0.28
Observations	433	433	433
Sample	2006-2016	2006-2016	2006-2016

Table A.6: House Price Index Summary Statistics

This table presents the state level summary different house price indexes. The Zillow Home Value Index (ZHVI) is used in all the respective measures and correspond to a smoothed, seasonally adjusted measure of the median estimated home value across a given region and housing type. It is a dollar-denominated alternative to repeat-sales indexes. The Federal Housing Finance Agency (FHFA) House Price Index (HPI) is a broad measure of the movement of single-family house prices. The HPI is a weighted, repeat-sales index, meaning that it measures average price changes in repeat sales or refinancing on the same properties. This information is obtained by reviewing repeat mortgage transactions on single-family properties. HPI All Transaction Index is 100 in 1980, HPI Purchase Only Index is 100 in 1991. Data is available from 1999 to 2016.

	N	Mean	Median	SD	10th	90th
Zillow State ZHVI Median Value Per Sqft	729	$122.95	$102.00	$67.95	$68.00	$187.00
Zillow State ZHVI - 1 bedroom	622	$123,454	$106,700	$64,765	$64,900	$204,700
Zillow State ZHVI - All Houses	714	$179,537	$151,350	$87,711	$104,300	$290,500
Zillow State ZHVI - Single Family Residence	714	$184,835	$153,200	$97,900	$103,800	$303,800
FHFA HPI All-Transaction Index	816	314.43	288.07	104.23	190.24	459.07
FHFA HPI Purchase Only Index	816	195.79	191.71	42.58	147.27	253.01

Table A.7: House Prices and Homestead Exemption Groups

This table present the results for regressions of the two house price indexes, the FHFA House Price Index (HPI) and the Zillow Home Value Index (ZHVI) per Sq.Ft. but using instead of the homestead exemption magnitude as a the main control categorical variables for high vs. low homestead exemption, and low vs. mid vs. high homestead exemption. All regressions also include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households bellow poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as the controls. Standard errors are heteroskedasticity-robust and clustered at the state level.

	(1)	(2)	(3)	(4)	(5)	(6)
	FHFA House Price Index			Zillow Home Value Index (ZHVI) per Sq.Ft.		
log (Homestead Exemption)	0.29			0.29		
(t-stat)	(2.89)			(2.89)		
High vs. Low Homestead Exemption		0.35			0.09	
(t-stat)		(1.59)			(1.17)	
Low vs. Mid Homestead Exemption			0.75			0.21
(t-stat)			(2.27)			(2.07)
Low vs. High Homestead Exemption			0.09			0.01
(t-stat)			(0.06)			(0.20)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	12,612	15,806	15,806	6,267	7,726	7,726

Table A.8: U.S. Census New House Units Permits and Homestead Exemption Categories

The following table presents a test for U.S. Census permits to build new 1-unit houses, at state level. The main control is the logarithm of the homestead exemption at state level. Regression include year and state fixed effects. Standard errors are heteroskedasticity-robust.

	U.S. Census New Unit Hoses Permits [100 Units]			
	(1)	(2)	(3)	(4)
	Full Sample (1999-2016)	1999-2005	2006-2010	2011-2016
log(Homestead Exemption)	-2.81	-5.31	-1.85	-1.33
(t-stat)	(-1.92)	(-1.55)	(-3.03)	(-2.76)
Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
R-Squared	0.19	0.03	0.19	0.09
N	697	328	164	205

Table A.9: Construction and Land Development Loans and Homestead Exemption Categories

The following table presents a test for the FFIEC Construction and Land Development Loans as a fraction of total loans, at state level. The main control is the logarithm of the homestead exemption at state level. Regression include year and state fixed effects. Standard errors are heteroskedasticity-robust.

	U.S. Census New Unit Hoses Permits [100 Units]		
	(1)	(2)	(3)
	Full Sample (2006-2016)	2006-2010	2011-2016
log(Homestead Exemption)	-0.55	-0.68	-0.26
(t-stat)	(-1.57)	(-0.75)	(-1.20)
Year FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
R-Squared	0.79	0.91	0.97
N	551	156	395

Table A.10: Household Secured Loans and Homestead Exemption Categories

This table present the estimation for the secured loans allocation as a fraction of the the total loans, the annual yield and the delinquency ratio. The main control in this case is the homestead exemption categories low, mid and high (low category si dropped), and all regressions include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households bellow poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as controls. Standard errors are heteroskedasticity-robust.

	(1) Family Real Estate Loans % of Total Loans	(2) Family Real Estate Effective Rates	(3) Family Real Estate Delinquency Ratio
Mid Homestead Exemption	0.31	0.03	-0.15
(t-stat)	(0.71)	(0.43)	(-1.78)
High Homestead Exemption	-1.35	-0.03	-0.27
(t-stat)	(-2.05)	(-1.39)	(-3.01)
House Price Index	0.00	0.00	0.01
(t-stat)	(0.55)	(-2.63)	(8.84)
log(Income Per Capita)	-0.06	-0.62	-1.25
(t-stat)	(-0.01)	(-1.1)	(-1.92)
High School	0.13	0.01	0.00
(t-stat)	(2.32)	(1.77)	(-0.08)
Unemployment	0.42	0.05	-0.03
(t-stat)	(3.47)	(2.77)	(-1.23)
Bellow Poverty	4.42	0.72	0.45
(t-stat)	(2.56)	(3.16)	(1.5)
Married Couples	1.00	0.09	0.03
(t-stat)	(2.72)	(2.02)	(0.6)
Female Householder	0.85	0.05	0.13
(t-stat)	(2.17)	(0.95)	(2.38)
Families with Child	0.18	0.03	0.03
(t-stat)	(0.91)	(1.22)	(1.57)
Age	0.71	-0.01	-0.09
(t-stat)	(1.7)	(-0.12)	(-1.7)
Race	-0.62	-1.32	7.80
(t-stat)	(-0.05)	(-0.85)	(3.9)
Year-FE	Yes	Yes	Yes
State-FE	Yes	Yes	Yes
Adj. R-Squared	0.96	0.70	0.89
Observations	510	510	510
Sample Available	2006-2016	2006-2016	2006-2016

Table A.11: Household Secured Loans by Type and the Homestead Exemption

This table present the estimation for the different type of loans that constitute the household secured loan portfolio, which are 1-4 families real estate loans, multifamily (more than 5) real estate loans, and home equity loans. The main control is the logarithm of the Homestead Exemptions, and all regressions include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households bellow poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as controls. Standard errors are heteroskedasticity-robust.

	(1) Household Real Estate % of Total Loans	(2) 1-4 Family RE % of Total Loans	(3) Multifamily RE % of Total Loans	(4) Home Equity % of Total Loans
log (Homestead Exemption)	-0.98	-1.26	0.16	0.13
(t-stat)	(-2.67)	(-3.81)	(1.19)	(1.40)
House Price Index	0.00	0.00	0.00	0.00
(t-stat)	(-0.17)	(-0.16)	(0.09)	(-0.17)
log (Income)	-6.70	0.00	-2.19	-4.51
(t-stat)	(-1.08)	(0.01)	(-1.30)	(-3.47)
High School	0.17	0.15	0.02	0.00
(t-stat)	(2.45)	(2.29)	(1.01)	(-0.03)
Unemployment	0.55	0.50	0.05	0.00
(t-stat)	(3.6)	(3.65)	(0.98)	(0.01)
Bellow Poverty	4.00	4.96	-1.45	4.86
(t-stat)	(1.91)	(2.44)	(-2.23)	(0.88)
Married Couples	0.61	0.91	-0.92	-0.21
(t-stat)	(1.28)	(1.88)	(-1.3)	(-1.94)
Female Householder	0.17	0.64	-1.16	-0.36
(t-stat)	(0.31)	(1.28)	(-1.23)	(-2.67)
Families with Child	0.09	0.22	-1.02	-0.03
(t-stat)	(0.37)	(0.87)	(-1.54)	(-0.61)
Age	0.01	0.57	-0.33	-0.23
(t-stat)	(0.01)	(1.21)	(-1.52)	(-2.57)
Race	-0.35	-0.22	-0.73	-0.06
(t-stat)	(-1.9)	(-1.32)	(-1.75)	(-1.27)
Year-FE	Yes	Yes	Yes	Yes
State-FE	Yes	Yes	Yes	Yes
Adj. R-Squared	0.94	0.96	0.86	0.95
Observations	433	433	433	433
Sample Available	2006-2016	2006-2016	2006-2016	2006-2016

Table A.12: Total Secured Loans and Homestead Exemption

This table present the estimations for the total secured loans (FFIEC Real Estate Loans for households and commercial) at state level. The L.H.S. variables is the median over all the commercial banks insured by the FFIEC of the real estate loans percentage of the total loans, and the separated of this ratio into household secured loans and commercial secured loans. The main control is the logarithm of the Homestead Exemptions. All regressions include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households bellow poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as controls. Standard errors are heteroskedasticity-robust.

	(1)	(2)	(3)
	Total Secured Loans	Household Secured Loans	Commercial Secured Loans
	% of Total Loans	% of Total Loans	% of Total Loans
log (Homestead Exemption)	-0.32	-0.98	0.89
(t-stat)	(-0.93)	(-2.67)	(2.3)
House Price Index	0.01	0.00	0.00
(t-stat)	(1.66)	(-0.17)	(0.57)
log (Income)	19.39	-6.70	14.85
(t-stat)	(2.92)	(-1.08)	(2.3)
High School	0.10	0.17	-0.13
(t-stat)	(1.39)	(2.45)	(-1.45)
Unemployment	0.35	0.55	-0.57
(t-stat)	(1.99)	(3.6)	(-3.01)
Bellow Poverty	7.29	4.00	1.35
(t-stat)	(3.06)	(1.91)	(0.49)
Married Couples	0.12	0.61	-1.20
(t-stat)	(0.25)	(1.28)	(-2.16)
Female Householder	0.06	0.17	-0.79
(t-stat)	(0.09)	(0.31)	(-1.29)
Families with Child	0.05	0.09	-0.26
(t-stat)	(0.27)	(0.37)	(-0.89)
Age	0.65	0.01	-0.26
(t-stat)	(1.24)	(0.01)	(-0.44)
Race	0.26	-0.35	0.42
(t-stat)	(1.2)	(-1.9)	(1.92)
Year-FE	Yes	Yes	Yes
State-FE	Yes	Yes	Yes
Adj. R-Squared	0.96	0.94	9.85
Observations	433	433	433
Sample Available	2006-2016	2006-2016	2006-2016

Table A.13: Commercial Loans and Homestead Exemption

This table present the estimations for FFIEC Commercial Loans at state level. The L.H.S. variables is the median over all the commercial banks insured by the FFIEC of the commercial real state and non-real estate loans as a percentage of the total loans. The main control is the logarithm of the Homestead Exemptions. All regressions include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households bellow poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as controls. Standard errors are heteroskedasticity-robust.

	(1)	(2)	(3)
	Total Commercial Loans	Commercial Real Estate	Commercial non-RE
	% of Total Loans	% of Total Loans	% of Total Loans
log (Homestead Exemption)	0.89	0.78	0.11
(t-stat)	(2.30)	(2.04)	(0.71)
House Price Index	0.00	0.01	-0.01
(t-stat)	(0.57)	(1.59)	(-2.50)
log (Income)	14.85	21.58	-6.74
(t-stat)	(2.3)	(2.99)	(-2.20)
High School	-0.13	-0.07	-0.05
(t-stat)	(-1.45)	(-0.87)	(-1.50)
Unemployment	-0.57	-0.20	-0.37
(t-stat)	(-3.01)	(-1.03)	(-4.57)
Bellow Poverty	1.35	3.77	-2.42
(t-stat)	(0.49)	(1.5)	(-1.55)
Married Couples	-1.20	-0.69	-0.51
(t-stat)	(-2.16)	(-1.32)	(-2.18)
Female Householder	-0.79	-0.47	-0.33
(t-stat)	(-1.29)	(-0.72)	(-1.15)
Families with Child	-0.26	-0.07	-0.20
(t-stat)	(-0.89)	(-0.26)	(-1.79)
Age	-0.26	0.41	-0.67
(t-stat)	(-0.44)	(0.69)	(-2.79)
Race	0.42	0.55	-0.13
(t-stat)	(1.92)	(2.26)	(-1.50)
Year-FE	Yes	Yes	Yes
State-FE	Yes	Yes	Yes
Adj. R-Squared	0.94	0.94	0.93
Observations	433	433	433
Sample Available	2006-2016	2006-2016	2006-2016

Table A.14: Household Unsecured Loans and Homestead Exemption Categories

This table present the estimation for unsecured loans to households (FFIEC Individual Loans). The L.H.S. variables are the ratio of household unsecured loans to total loans, the annual yield of the household unsecured loans, and the delinquency ratio. The main control in this case is the homestead exemption categories low, mid and high (low category si dropped), and all regressions include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households bellow poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as controls. Standard errors are heteroskedasticity-robust.

	(1) Loans to Individuals % of Total Loans	(2) Loans to Individuals Effective Rates	(3) Loans to Individuals Delinquency Ratio
Mid Homestead Exemption	0.03	-0.47	-0.59
(t-stat)	(0.48)	(-0.82)	(-2.01)
High Homestead Exemption	-0.14	-0.22	-0.36
(t-stat)	(-1.59)	(-0.52)	(-1.23)
House Price Index	0.00	0.00	0.00
(t-stat)	(-2.94)	(-1.09)	(-0.35)
Income Per Capita	-1.61	9.78	-7.71
(t-stat)	(-2.48)	(2.01)	(-2.9)
High School	0.01	0.02	-0.04
(t-stat)	(0.61)	(1.02)	(-1.3)
Unemployment	0.01	0.10	0.02
(t-stat)	(0.36)	(1.43)	(0.26)
Bellow Poverty	0.09	4.36	-4.92
(t-stat)	(0.26)	(2.25)	(-4.34)
Married Couples	-1.79	46.66	-8.77
(t-stat)	(-0.41)	(1.35)	(-0.51)
Female Householder	-0.01	0.71	0.07
(t-stat)	(-0.28)	(1.86)	(0.31)
Families with Child	0.01	0.25	-0.05
(t-stat)	(0.36)	(1.77)	(-0.57)
Age	-0.04	0.61	0.04
(t-stat)	(-0.67)	(2.68)	(0.18)
Race	0.01	0.10	-0.45
(t-stat)	(0.33)	(0.97)	(-4.76)
Year-FE	Yes	Yes	Yes
State-FE	Yes	Yes	Yes
Adj. R-Squared	0.51	0.91	0.77
Observations	510	510	510
Sample Available	2006-2016	2006-2016	2006-2016

Table A.15: Credit Card Loans and Homestead Exemption

This table present the estimation for FFIEC Credit Card Loans to Individuals. The L.H.S. variables are the ratio of credit card loans to individuals to total loans, the annual credit card yield, and the delinquency ratio. The main control is the ratio Homestead Exemptions to House Prices. All regressions include the house price index, the logarithm of the income per-capita, the percentage of the population with high school diploma, the unemployment rate, the percentage of households bellow poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, the number of households with children, the median state age, and the fraction of the state population of white race as controls. Standard errors are heteroskedasticity-robust.

	(1) Credit Card Loans % of Total Loans	(2) Credit Card Loans Yield	(3) Credit Card Loans Delinquency Ratio
$\frac{\text{Homestead Exemption}}{\text{House Price Index}}$	0.23	0.92	0.17
(t-stat)	(1.93)	(0.93)	(0.32)
$\log(\text{Income})$	-3.64	29.76	-0.83
(t-stat)	(-2.3)	(1.32)	(-0.26)
High School	-0.01	0.11	0.02
(t-stat)	(-1.18)	(0.35)	(0.32)
Unemployment	-0.01	1.44	0.05
(t-stat)	(-0.36)	(1.27)	(0.36)
Bellow Poverty	-0.94	6.94	3.40
(t-stat)	(-1.57)	(0.93)	(1.15)
Married Couples	-0.19	3.57	0.49
(t-stat)	(-1.72)	(1.82)	(1.21)
Female Householder	-0.21	2.27	0.47
(t-stat)	(-1.7)	(1.11)	(1.07)
Families with Child	-0.10	-1.13	-0.20
(t-stat)	(-1.7)	(-1.55)	(-0.74)
Age	-0.07	1.35	-0.10
(t-stat)	(-1.11)	(0.51)	(-0.24)
Race	-0.14	-0.37	0.30
(t-stat)	(-2.6)	(-1.29)	(2.42)
Year-FE	Yes	Yes	Yes
State-FE	Yes	Yes	Yes
Adj. R-Squared	0.49	0.36	0.29
Observations	450	450	450
Sample Available	2006-2016	2006-2016	2006-2016

Table A.16: Loans Yield and Homestead Exemption

This table present the results for regressions for Loans Yield obtained from the FFIEC, including the Family Real Estate Loans Yield, Individual Loans Yield, Credit Card Loans Yield, and the spread between them. The main control is the logarithm of the Homestead Exemptions, but also I include regressions including a dummy variable for high exemption vs. low exemption, and low exemption vs. mid exemption vs. high exemption. Alls regressions include the per-capita Income, the percentage of the population with high school diploma, the unemployment level, the percentage of households bellow poverty level, the percentage of households lead by married couples, the percentage of households lead by a female, and the number of households with children as controls, and standard errors are heteroskedasticity-robust and clustered at the state level.

	(1) Family Real Estate Yield	(2) Individual Loans Yield	(3) Credit Card Yield	(4) Family R.E. - Ind. Yield Spread	(5) Family R.E. - C.C. Yield Spread
log (Homestead Exemption)	-0.07	-0.21	-0.91	-0.14	-0.84
(t-stat)	(-1.41)	(-0.90)	(-0.87)	(-0.61)	(-0.80)
House Price Index	0.01	0.00	-0.01	-0.01	-0.01
(t-stat)	(7.6)	(-0.75)	(-0.76)	(-2.14)	(-1.31)
log (Income)	-2.23	7.18	35.67	9.41	37.90
(t-stat)	(-2.91)	(1.78)	(1.44)	(2.33)	(1.53)
High School	0.00	0.01	0.12	0.01	0.12
(t-stat)	(0.03)	(0.52)	(0.35)	(0.5)	(0.34)
Unemployment	-0.04	0.11	1.46	0.15	1.50
(t-stat)	(-1.47)	(1.37)	(1.34)	(1.86)	(1.38)
Bellow Poverty	0.13	2.74	7.96	2.62	7.83
(t-stat)	(0.38)	(1.96)	(0.99)	(1.85)	(0.96)
Married Couples	-0.05	0.23	3.87	0.28	3.92
(t-stat)	(-0.84)	(0.75)	(1.88)	(0.91)	(1.91)
Female Householder	0.03	0.54	2.61	0.51	2.58
(t-stat)	(0.44)	(1.44)	(1.22)	(1.35)	(1.21)
Families with Child	0.04	0.15	-1.00	0.11	-1.04
(t-stat)	(1.6)	(1.37)	(-1.38)	(0.97)	(-1.42)
Age	-0.14	0.53	1.33	0.67	1.47
(t-stat)	(-2.32)	(2.27)	(0.5)	(2.85)	(0.56)
Race	0.09	0.05	-0.28	-0.04	-36.62
(t-stat)	(3.54)	(0.48)	(-0.95)	(-0.44)	(-1.29)
Year-FE	Yes	Yes	Yes	Yes	Yes
State-FE	Yes	Yes	Yes	Yes	Yes
Adj. R-Squared	0.98	0.47	0.36	0.83	0.41
Observations	433	433	433	433	433
Sample Available	2006-2016	2006-2016	2006-2016	2006-2016	2006-2016

Table A.17: Ratio Homestead Exemption over House Prices: 2011 - 2016

This table presents the ratio of the state homestead exemption over the median house price value, reported by the Federal Housing Finance Agency (FHFA). The median price is calculated over a set of purchases of single- family homes and reported at state level.

State	2010	2016
Alabama	0.42	1.18
Arizona	6.33	4.49
Arkansas	Unlimited	Unlimited
California	2.05	1.51
Colorado	3.88	3.49
Connecticut	3.60	2.98
Delaware	1.54	3.27
Florida	Unlimited	Unlimited
Georgia	0.72	1.16
Idaho	4.03	3.03
Illinois	1.31	0.82
Indiana	1.77	1.62
Iowa	Unlimited	Unlimited
Kansas	Unlimited	Unlimited
Kentucky	0.48	0.31
Louisiana	1.04	1.18
Maine	4.12	3.40
Maryland	0.00	0.48
Massachusetts	13.56	8.64
Michigan	1.85	1.29
Minnesota	11.68	13.27
Mississippi	4.36	3.14
Missouri	0.77	0.54
Montana	18.94	16.01
Nebraska	3.26	2.54
Nevada	25.85	17.59
New Hampshire	8.41	6.46
New Jersey	0.00	0.00
New Mexico	5.20	4.73
New York	2.98	3.18
North Carolina	2.55	2.13
North Dakota	4.90	3.65
Ohio	1.90	9.81
Oklahoma	Unlimited	Unlimited
Oregon	1.56	1.20
Pennsylvania	1.61	1.39
Rhode Island	8.31	11.78
South Carolina	3.86	3.79
South Dakota	Unlimited	Unlimited
Tennessee	0.32	0.23
Texas	Unlimited	Unlimited
Utah	1.35	1.49
Vermont	9.39	4.01
Virginia	0.24	0.21
Washington	3.38	2.54
West Virginia	3.26	2.06
Wisconsin	6.32	5.43
Wyoming	0.70	0.63

Table A.17 shows that in most of the states the homestead exemption is greater than the average price of a single family house, highlighting that for most of the households the homestead exemption will be relevant, although not as strong in the margin as in most cases the home equity will significantly below the exemption magnitude. This values are consistent with those reported in Hintermaier and Koeniger (2016). A second observation from this table shows that there is also historical variation in this ratio, which is driven by changes in house prices, as the homestead exemption exhibits limited changes during the studied period.

Appendix B

Appendix to Chapter 3

B.1 Value-Function Algorithm Scheme

In this section we sketch the solution algorithm, describing the key steps, but abstracting from detailed calculations. Broadly, we start from an initial value function and iterate over the policy space until a maximum is attained. The outcome of the process is the maximized value-function, and the optimal policy, for each point in our two-dimensional state space.

Step 1: Initialize v_0.

To define the initial value of the value function, we use a coarse grid on the defined interval $[I_1, I_N] \times [P_1, P_M]$, and compute the optimal value using our algorithm. Then, we use our desired grid, interpolate using the coarse grid, and the estimated value function, to obtain an initial value function on the finer desired grid.

Step 2: Compute a new value function v_1, and the policy q_1.

For each $(n,m) \in \{(1,1),(1,2),..,(N,M)\}$ repeat the following steps:

Step 2.1: Initialize the policy $q^*(I_n, P_m) = q_1$

Step 2.2:Find the index i^* that maximizes:

$$w_{i^*} = \pi(I_n, P_m, q_{i^*}) + e^{-r\Delta t} \sum_{k,j} \lambda_k^I \lambda_j^P \hat{v^0} \left(I_n + G(I_n) - q_{i^*} + I_n \sigma_I \sqrt{\Delta t} Z_k^I, P_m e^{\mu_P \Delta t + \sigma_P \sqrt{\Delta t} Z_j^P} \right)$$

Where q_{i^*} is $q^*(I_n, P_m) = q_{i^*}$, and $\hat{v^0}$ is the interpolated value function, for the next period state, computed using the initial value function v_0. Piecewise Cubic Hermite Interpolating Polynomial are used to compute these values.

Step 2.3: Replace v^1 by the respective elements w_{i^*}, for each point in the state space (n,m).

Step 3: Check for convergence. If:

$$\max_{(n,m)\in\{(1,1),\dots,(N,M)\}} \mid v^1_{n,m} - v^0_{n,m} \mid \leq \varepsilon^{tol} \quad \varepsilon^{tol} > 0$$

stop iterating, else, replace v^0 with v^1, and return to step 2.

When the algorithm converges we have the optimal v and q for our problem.

B.2 Price Dynamic Estimation for the British Columbia Halibut

In this section we describe the price dynamic models and estimations for the time series of ex-vessel prices for the British Columbia halibut. In particular, we start from the general stochastic process:

$$\ln P_{t+1} = f(P_t) + g(P_t)\,\varepsilon^P_t$$

Where P_t is the unit fish price at year t, $f(P_t)$ is the expected annual rate of change in the logarithm of the price, $g(P_t)$ is the volatility of the unexpected price shocks ε^P_t which are assumed to be i.i.d. standard normal.

To identify which functional form of $f(P_t)$ is consistent with the time series of halibut prices from 1990 to 2016, we test 5 of the most used price stochastic dynamics in the literature. We test three time series models: the log-normal i.i.d. model or ARIMA(0,1,0) in the first difference, an ARIMA(1,1,0) or autoregressive of order 1, and a ARIMA(0,1,1) or moving average of order one. We use only first order lags as the first autocorrelation is the only statistically different from zero (Figure B.1 includes the estimated autocorrelations (black bars) and the respective 95% confidence interval (gray bands) being the fist lag the only estimated autocorrelation significantly different from zero).

Beside this time series models, we use two economic models, the first is a model of inverse demand on which the price dynamic is related to changes in the total harvest and an unobserved stochastic process that affects the demand for the halibut. Second, we test the mean reverting price model presented in Kvamsdal et al. (2016). Notice that in the last two models the price dynamics is not totally exogenous since it depends on the harvest. Formally the models to test are:

1. ARIMA(0,1,0): $\ln P_{t+1} = \ln P_t + \nu_P + \sigma_P \varepsilon^P_t$
2. ARIMA(1,1,0): $\ln P_{t+1} = \alpha + \rho \ln P_t + \sigma_P \varepsilon^P_t$
3. ARIMA(0,1,1): $\ln P_{t+1} = \alpha + \theta \sigma_P \varepsilon^P_{t-1} + \sigma_P \varepsilon^P_t$
4. Inverse Demand: $P_t = e^{\alpha + \sigma_P \varepsilon^P_t} q_t^{-\gamma} \implies \ln P_{t+1} = \alpha - \gamma \ln q_t + \sigma_P \varepsilon^P_t$
5. Mean-Reverting: $\ln P_{t+1} = \alpha + \ln P_t + \beta_P \frac{P_0}{P_t} + \beta_h \frac{q_t}{P_t} + \sigma_P \varepsilon^P_t$

The economic implications of the models impose restrictions on some of the parameters. Specifically, for the inverse demand model the estimated γ has to be positive. β_P also has to be positive as it is the speed of reversion from the price current price to the selected reference level P_0.

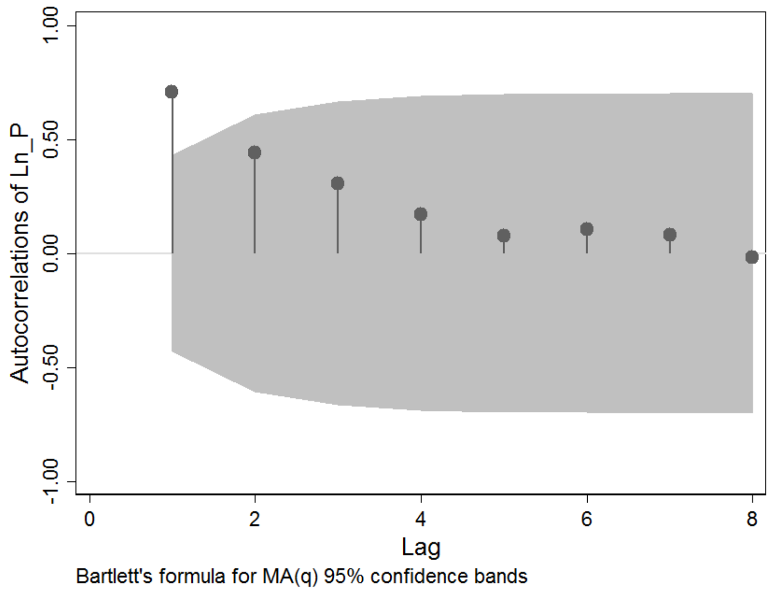

Figure B.1: Autocorrelation for the Logarithm of the British Columbia Halibut Price, 1996-2017. Source: DFO

The results from the time series estimations are presented in Table B.1:

Table B.1: Price Dynamic Estimation: Multiple Models

This table presents the results for testing three time series specifications plus two economic models for the price dynamic. The data for the halibut ex-vessel historical prices for British Columbia is obtained from the Department of Fisheries and Oceans of Canada (DFO) website http://www.dfo-mpo.gc.ca, for the period 1990 to 2016.

	(1)	(2)	(3)	(4)	(5)
	ARIMA(0,1,0)	ARIMA(1,1,0)	ARIMA(0,1,1)	Inverse Demand	Mean Reverting
ν_P	0.035				
(z-stat)	(0.94)				
ρ_P		0.865			
(z-stat)		(6.44)			
θ_P			0.729		
(z-stat)			(3.42)		
γ_P				0.685	
(z-stat)				(5.33)	
β_P					-0.706
(z-stat)					(-1.53)
β_h					0.071
(z-stat)					(0.73)
Wald χ^2	-	41.50	11.67	14.32	28.44
Log. Likelihood	8.79	8.62	4.69	13.36	7.77
AIC	-13.58	-11.24	-3.40	-8.11	-18.72
Sample	1996-2017	1996-2017	1996-2017	1996-2017	1996-2017

To select the best model for our halibut price data we use the Akaike information criterion (AIC) presented in Table B.1. The AIC takes into account the trade off between better fit and the number of estimated parameters. The best model is identified by the lowest value of the AIC. Among the proposed models, the lowest AIC is measured for the Mean-Reverting model, but there are two key issues that make the use of the AIC inappropriate in this case. The first and most important is that both estimated coefficients of the explanatory variables are not significantly different from zero, hence the proposed model is indeed failing to explain the dynamic of the halibut price for the selected period. The second issue with the mean reverting model is that the estimated speed of reversion is negative (althogh not significant), which we know is inconsistent with the technical requirements for convergence of the stochastic process. We conclude that although this model exhibits a high AIC, it is not adequate for the British Columbia halibut.

From the remaining models, we notice that models (2), (3) and (4) exhibit significant coefficients, their ability to explain the time series does not compensate the increment in the number of parameters. Model 1, the log-normal i.i.d model, has the lowest AIC and therefore is the one that best fits the Halibut price time series.

Table B.2: Summary Statistics for the Differences in the Harvesting Policy: Benchmark Case minus Social Discount Case

This table presents summary statistics for the differences in the harvesting policy between the benchmark case and the social discount case computed over the model state space, this is Biomass in the range $[0.1, 85.51]$ and the price in the range $[2.99, 20.07]$.

	Mean	Median	SD	10^{th}	25^{th}	75^{th}	90^{th}
$q_t^{\text{Benchmark}} - q_t^{\text{Social Discount}}$	0.17	0.13	0.18	0.00	0.00	0.32	0.44

B.3 Biomass and Harvest Dynamic for the British Columbia Halibut Using a Social Discount Rate

As fisheries are commonly regulated by governmental institutions and resources are publicly owned, it is useful to understand how the model results will change if a social discount rate is used (Clark and Munro (2017)).

To fulfill this goal we solve a version of the model on which we replaced the private discount rate for a social real discount rate of 1%, directly increasing the relative weight of future cash flows with respect to current cash flows, therefore the economic incentives for the conservation the resource. The model results indicate that the value of the fishery is higher with a social discount rate, which is expected as the future cash flows are discounted at a lower rate, although the most interesting variations in the models solutions are observed in the harvesting policy.

To compare the harvesting policies of the benchmark case and the social discount case we computed the differences among them over the state space. We find that this quantity can be significant in several states, specially in those of mid-low biomass and high prices, pointing to a clear trade-off between current profits and sustainability. For example, if the halibut price is $11 Canadian dollars and the biomass is 38 million pounds, the benchmark case fishery will harvest 12.4 million pounds per year, while the social discount case fishery will harvest 11.6 million pounds per year, hence a difference of 0.8 million pounds in the annual harvest. The summary statistics for the computed differences in the harvesting policy across the full space state are resumed in Table B.2:

Although Table B.2 shows that in 25% of the space state the benchmark case fishery harvests at least 0.3 million pounds more than the social discount case fishery, these high magnitude difference occur in highly unlikely states, as the fishery will optimally avoid the reduction of the biomass to levels on which the social discount case fishery harvest significantly less than in the benchmark case. Consequently, our simulation analysis shows that for the current state and estimated parameters, the effects of these differences in the harvesting policies are not quantitatively important for the simulated biomass dynamic.

Table B.3: British Columbia Halibut Fishery Revenues, 2007 and 2009

The values are obtained from the reports prepared for the DFO-Pacific Region by Stuart Nelson of Nelson Bros Fisheries Ltd. (Nelson (2009) and Nelson (2011)), and provide estimates of the financial performance for vessels operating in British Columbia for the years 2009 and 2007. These reports are done with a combination of data from the DFO and consultant collected information through interviews/correspondence with fishermen and experts. Group 1 is the group of vessels with the highest third individual landings, Group 2 is the group of vessels with the middle third individual landings, and Group 3 is the group of vessels with the lowest third individual landings. All values are expressed in 2017 CAD using the CPI for British Columbia.

	2007 (Expressed in 2017 CAD)		**2009** (Expressed in 2017 CAD)	
	Group 1	Group 3	Group 1	Group 3
Total Biomass [Mill. lb.]	53.69	53.69	62.78	62.78
Landings [Mill. lb.]	5.51	0.95	3.33	0.72
Vessel Price [CAD/lb.]	$5.56	$5.56	$5.99	$5.99
Gross Revenue [Mill. CAD]	$30.68	$5.29	$19.98	$4.30
Total fishery specific expenses	$8.43	$1.67	$5.63	$1.46
Crew and captain shares	$8.65	$1.37	$5.99	$0.86
Total Vessel Expenses	$1.28	$1.30	$1.23	$0.69
Total Cost [Mill. CAD]	**$18.36**	**$4.34**	**$12.85**	**$3.02**
EBITDA [Mill. CAD]	**$12.32**	**$0.95**	**$7.13**	**$1.28**

B.4 Alternative Cost Function Parametrizations for the British Columbia Halibut and their Impact on the Simulated Biomass and Harvest Dynamic

The model is solved using cost parameters estimated from the two surveys performed by Nelson Bros Fisheries Ltd. for the DFO (Nelson (2009) and Nelson (2011)). The survey separates the total vessels operating in British Columbia in three groups, depending on their harvest. The median group is assumed to represent the average vessel production function, hence it is used in the benchmark case included in the main text. In this Appendix we present the numerical results for the simulation of the model solved using the cost function parameters of the group of high efficiency vessels, and the low efficiency vessels, also included in the survey. The production costs for the high and low efficiency vessels are included in Table B.3:

Table B.3 presents two years of costs and revenues for the high and low efficiency vessels in the British Columbia halibut fishery. During 2007 the fisheries registered higher harvest and lower costs, per unit harvested, in comparison to 2009, but still the difference between these two groups is sizable within a year, and they also exhibit significant difference with the mid level efficiency group used in the benchmark case.

As mentioned, the parameters of the cost function are determined solving an over-identified system of equations for the annual cost, that is, we solve Equation 3.5 by leaving one parameter free, in this case c_2, and then solve for the remaining two c_0, c_1, subject to $c_0 > 0$, $c_1 > 0$ and $c_2 > 0$, using the two years of available data.

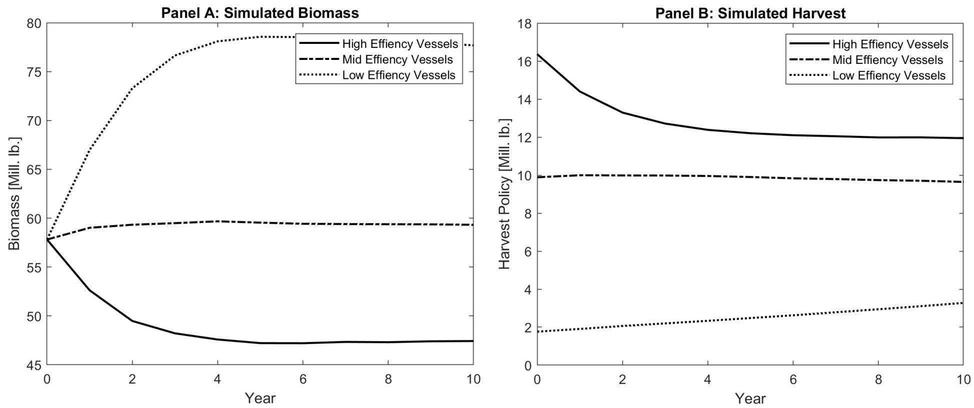

Figure B.2: Median Simulated Biomass and Harvesting Policy for Different Cost Function Parametrizations of the British Columbia Halibut Fishery

As in the mid level efficiency, for the quadratic cost parameter we choose the median of the feasible values for the high and low efficiency vessels. The calibrated parameters for the high efficiency group $\{c_0 = 8.39, c_1 = 52.65, c_2 = 0.15, c_3 = c_0 = 8.39\}$, and for the low efficiency group $\{c_0 = 0.94, c_1 = 105.21, c_2 = 1.70, c_3 = c_0 = 0.94\}$[1]. Notice that these groups have significant differences in their production efficiency, reflected on the variations in the estimated parameters. We use these parameters to solve the model and simulate its impact on the dynamic of the harvest and biomass. The results are presented in Figure B.2.

Figure B.2 shows a clear impact of the cost function parameters in the model results, and consequently in the expected dynamic of the harvesting policy and the biomass. For the high efficiency vessels parameters the harvest is higher than the benchmark case, starting from over 16 millions pounds for the current state. The harvesting decreases over time but it remains above mid level efficiency for the full period simulated. The higher harvest generates a biomass of approximately 47 million pounds in 10 years, 22% lower than the median biomass of the benchmark case at the same date, hence the high efficiency vessels increase their annual harvesting reducing the long-run biomass, but with no total depletion of the resource with 99% probability.

Figure B.2 also includes the simulations for the low efficiency vessels parameters. In that case the harvest is lower than the benchmark case, starting from approximately 2 millions pounds for the current state. The harvesting increases over time but it remains in levels bellow the natural growth of the biomass, so we observe a continuous growth of the resource until levels close to the carrying capacity are achieved. Therefore, the low efficiency vessels significantly decrease their annual harvesting, increasing the long-run biomass.

The significant differences observed for the different cost parametrizations of the British Columbia halibut fishery show how important these parameters are for the numerical solution of the model,

[1]In both cases c_3, the cost paid in case of no harvest, is assumed to be equal to fixed cost c_0.

providing a wide range of potential results, going from significant growth to a decrease of the biomass of the resource. Although different, these outcomes share a significant feature, the resource is not depleted in both scenario with 99% probability, pointing to a sustainable harvest even in cases on which the production is highly profitable.

As Clark et al. (2009) already pointed, unfortunately these surveys are scarce and not available for multiple years, hence any implementation effort of the model will have to deal with the lack of information for the production costs. This section shows how important theses parameters are for the numerical results, so any additional effort in collecting and standardizing additional information will be extremely useful and significant to improve the accuracy of the numerical results.

B.5 Impact of an increase in the Biomass Volatility on the Simulated Biomass and Harvest Dynamic for the British Columbia Halibut

In the main text of the paper we observed that for the estimated parameters, the effect of biomass volatility was substantially smaller than the effect of price volatility. In this section we illustrate how an increase in the biomass volatility affects the optimal harvesting policy of the fishery, and consequently the simulated biomass and harvest dynamic. To address this objective we solved a new case denoted increased biomass volatility case, on which the annual biomass shock volatility is set to $\hat{\sigma}_I = 4 \times 10.84\% = 43.36\%$ and assume no price volatility.

We mentioned that the data supports a world where there is both biomass and price uncertainty, so we simulate the model that assumes an increased biomass volatility but no price uncertainty in a world that has price uncertainty. This is, we simulate the fishery that follows the optimal policy in the case of no price uncertainty with an increased biomass volatility, but it is subject to shocks in the biomass and price. We then compare the simulated harvest moments obtained for this new case with those of the biomass volatility case and the benchmark case. These results are presented in Figure B.3:

Panel A of Figure B.3 shows the simulated harvest in a world where there is both biomass and price uncertainty, obtained using the policy of the biomass volatility case, or the harvest policy of the increased biomass volatility case. As expected, an increment in the biomass volatility produces and overall reduction in the median harvest, and an increment in harvest flexibility is observed in the difference between the 1^{th} and 99^{th} percentile in the 10 years horizon.

Although the increment in the harvest flexibility driven by the a higher biomass volatility appears to be sizable, Panel B of Figure B.3 shows that the flexibility in the optimal harvest is still higher in simulations generated using the harvest policy of the benchmark case, highlighting the high impact of the exogenous shock prices in the harvesting policy of the fishery.

To conclude, the drastic increment in the biomass volatility indeed increased the flexibility in the simulated harvest, but as mentioned, the biomass process is partially endogenous since in response to the biomass shocks the fishery can adjust its harvesting, incorporating the increase in volatility to its policy to react properly to modified dynamics of the biomass process.

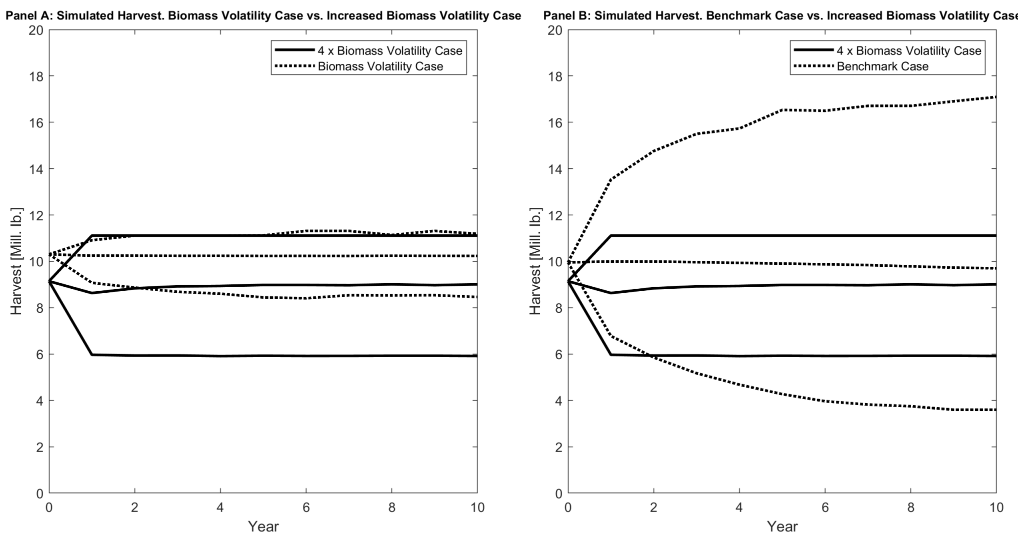

Figure B.3: Median, 1^th and 99^th Percentiles of the Simulated Harvest for the Biomass Volatility Case, Increased Biomass Volatility Case, and the Benchmark Case, For the British Columbia Halibut Fishery.

Appendix C

Appendix to Chapter 4

C.1 Variable Definitions

The variable definitions for those included in all the regressions presented in this paper are explicited below. Compustat variable names are denoted by their pneumonic between parenthesis.

- Market Value: Stock price at the end of the fiscal year (prcc_f), multiplied by the number of shares outstanding (csho).
- Size: Total assets (at), plus the Market Value, minus the stockholders equity (seq).
- Book Equity: Computed as defined in Davis, Fama, and French (2000) using the stockholders equity (seq), common equity (ceq), the value of preferred stock (pstx), total assets (at) among others.
- BEME: Book to Market, Book Equity as in Davis et al. (2000), market value is computed using the stock price at the end of the fiscal year (prcc_f) and the number of shares outstanding (csho).
- PROF: Profitability, defined as Pretax Income (pi) over Book Equity.
- EBITDA: (ebitda) over Total Assets (at).
- ITC: Interest tax credits (itc) over total assets (at).
- ATR: firm's average tax rate, computed as the Total Tax Expenses (txc) over (ebitda).
- DEPRE: Depreciation expenses (dp) over Total assets (at).
- LEVm: Leverage calculated using the Market Value of the Firm, and defined as the Debt in Current Liabilities (dlc), if positive, plus the Long-Term Debt (dltt), over the market value plus the value of the mentioned debt.

- AI: Investment-to-assets (Lyandres et al. (2007)) defined as the change in the total Property, Plant and Equipment (ppegt) in the last year, plus the change in the total Inventories (invt) in the last year, over the total assest (at) in the last year.
- TA_A: Total assets cross-sectional mean, over firm total assets (at).