Social Sciences and Humanities Research Council of Canada

Conseil de recherches en sciences humaines du Canada

Application for a Grant

Internal use
899132

Identification

This page will be made available to selection committee members and external assessors.

Funding opportunity
Insight Grants

Joint or special initiative

Application title
Risk management

Applicant family name	Applicant given name	Initials
Cadenillas	Abel	

Org. code	Full name of applicant's organization and department
1480111	University of Alberta Mathematical & Statistical Sciences

Org. code	Full name of administrative organization and department
1480111	University of Alberta Mathematical & Statistical Sciences

Preferred Adjudication Committee
435-14

Does your proposal involve Aboriginal Research as defined by SSHRC?	Yes ○ No ◉
Does your proposal involve human beings as research subjects? If "Yes", consult the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* and submit your proposal to your organization's Research Ethics Board.	Yes ○ No ◉
Does any phase of the proposed research or research-related activity:	
A. Constitute a physical activity carried out on federal lands in Canada, as defined in sub-section 2(1), in relation to a physical work and that is not a designated project;	Yes ○ No ◉
B. Constitute a physical activity carried out outside of Canada in relation to a physical work and that is not a designated project;	Yes ○ No ◉
C. (i) Permit a designated project (listed in the CEAA 2012 Regulations Designating Physical Activities (RDPA)) to be carried out in whole or in part;	Yes ○ No ◉
C. (ii) Depend on a designated project (listed in the RDPA) that is, or will be, carried out by a third party?	Yes ○ No ◉

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Total funds requested from SSHRC	42,800	51,725	52,677	53,655	54,664	255,521

Personal information will be stored in the Personal Information Bank for the appropriate program.

Application WEB
2016/10/14

PROTECTED B WHEN COMPLETED

Canada

Participants

List names of your team members (co-applicants and collaborators) who will take part in the intellectual direction of the research. Do not include assistants, students or consultants.

Role
Co-applicant ○ Collaborator ○

Family name	Given name	Initials

Org. code	Full organization name

Department/Division name

Role
Co-applicant ○ Collaborator ○

Family name	Given name	Initials

Org. code	Full organization name

Department/Division name

Role
Co-applicant ○ Collaborator ○

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Family name	Given name	Initials

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Department/Division name

Role
Co-applicant ○ Collaborator ○

Family name	Given name	Initials

Org. code	Full organization name

Department/Division name

Family name, Given name
Cadenillas, Abel

Research Activity

The information provided in this section refers to your research proposal.

Keywords

List keywords that best describe your proposed research or research activity. Separate keywords with a semicolon.

Risk Management; Insurance; Management Sciences; Operations Research; Finance; Economics; Investment; Liability Ratio; Dividend Policy; Risk Constraints; Financial Crises; Government Debt Crises; Regime Switching.

Disciplines

- Indicate and rank up to 3 disciplines that best correspond to your activity.

Rank	Code	Discipline	If "Other", specify
1	62600	Management, Business, Administrative Studies	
2	62612	Finance, Banking, Insurance	
3	61023	Mathematical and Quantitative Methods	

Areas of Research

Indicate and rank up to 3 areas of research related to your proposal.

Rank	Code	Area
1	290	Management
2	210	Financial and Monetary Systems
3		

Temporal Periods

If applicable, indicate up to 2 historical periods covered by your proposal.

From			To		
Year	BC	AD	Year	BC	AD
1900	○	◉	2016	○	◉
	○	○		○	○

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Application WEB

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Family name, Given name
Cadenillas, Abel

Research Activity (cont'd)

Geographical Regions

If applicable, indicate and rank up to 3 geographical regions covered by or related to your proposal. Duplicate entries are not permitted.

Rank	Code	Region
1	1000	North America
2	3000	Europe
3	9001	International

Countries

If applicable, indicate and rank up to 5 countries covered by or related to your proposal. Duplicate entries are not permitted.

Rank	Code	Country	Prov./ State
1	1100	CANADA	
2	1200	UNITED STATES	
3	3206	GERMANY	
4	3224	SWITZERLAND	
5	3208	GREECE	

Family name, Given name

Cadenillas, Abel

Response to Previous Critiques - maximum one page

Applicants may, if they wish, address criticisms and suggestions offered by adjudication committees and external assessors who have reviewed previous applications.

Family name, Given name
Cadenillas, Abel

Summary of Proposal

The summary of your research proposal should indicate clearly the problem or issue to be addressed, the potential contribution of the research both in terms of the advancement of knowledge and of the wider social benefit, etc.

I want to model and solve risk management problems in insurance, finance and economics. These problems have been motivated by the 2007-2009 financial crises and/or by the recent government debt crises in USA and some European countries. I want to investigate the following six topics:
1) optimal investment, liability ratio and dividend policies when the external risk is negatively correlated with returns in the financial market;
2) optimal consumption-investment policies under risk constraints;
3) optimal debt ceiling for a country facing a debt crisis (equivalently, optimal ceiling for government debt for a country facing a debt crisis);
4) optimal strategy to rescue a country facing a debt crisis (similarly, optimal strategy to rescue a financial institution facing a debt crisis);
5) optimal government debt portfolio; and
6) optimal government stabilization fund management.

I will develop and apply methods of stochastic control to solve all these problems. My previous experience in developing and applying the theory of stochastic control will be very useful to solve the above problems. These six topics will be investigated in a continuous-time setting. All the results will be accompanied by an economic interpretation and analysis. In particular, I will examine how the solutions to the above problems depend on the different financial, insurance and economic parameters. The value function represents the best that can be achieved when one considers all the admissible policies.This function is a measure of the government well-being. I will also examine how the value function depends on the financial, insurance and economic parameters, which will provide a welfare analysis.

The proposed research will continue my work in Finance, Insurance, Economics, and Management Sciences conducted during the past years, in which I did research on optimal risk-sharing, optimal consumption-investment, optimal portfolio management when there are taxes and transaction costs, optimal control of the exchange rate, optimal manager compensation, optimal risk and dividend policies, optimal control of inventories, optimal production, optimal contracts, optimal insurance, optimal government debt management, regime switching, and business cycles.

My work supported by the Social Sciences and Humanities Research Council of Canada has been published in top scholarly journals, including the Journal of Financial Economics, the Journal of Economic Theory, Operations Research, and Mathematical Finance.

The proposed research will be useful to reduce the chances of future financial crises and future government debt crises. It will also be useful to mitigate their negative effects.

This research will be very interesting to the academic communities in Risk Management, Business, Management Sciences, Insurance, Finance, Economics, Operations Research, Mathematics, and Statistics. It will also be important to governments, Central Banks like the Bank of Canada, multilateral organizations like the International Monetary Fund, companies, firms, the insurance industry, and the financial industry.

DETAILED DESCRIPTION

Objectives

I want to model and solve risk management problems in insurance, finance and economics. These problems have been motivated by the 2007-2009 financial crisis, and/or the recent government debt crises in USA and some European countries. I want to investigate the following six topics: 1) optimal investment, liability ratio and dividend policies when the external risk is negatively correlated with returns in the financial market; 2) optimal consumption-investment policies under expected shortfall constraint; 3) optimal debt ceiling for a country facing a debt crisis; 4) optimal strategy to rescue a country facing a debt crisis (similarly, optimal strategy for a country to rescue a financial institution in crisis); 5) optimal government debt portfolio; and 6) optimal government stabilization fund management. I will develop and apply methods of stochastic control to solve all these problems. I will investigate these topics in a continuous-time setting. This research will be useful to reduce the chances of future financial crises and government debt crises, and to mitigate their negative effects.

The notation for the six contexts and methodologies below are independent. For instance, the "X" that appears in Context and Methodology 3 is different from the "X" that appears in Context and Methodology 5.

Context and Methodology 1

The 2007-2009 financial crisis and economic recession almost put the global financial system on the brink of collapse. To illustrate how severe this financial crisis was, we remember the staggering case of American International Group, Inc. (AIG), once one of the largest and most successful insurance companies in the world. As pointed out in Stein (2012, Chapter 6), one major mistake in the AIG case was to ignore the negative correlation between its liabilities and the returns in the financial market.

To overcome this drawback, Stein (2012, Chapter 6) proposed a diffusion model for the risk process that is negatively correlated with the stock price process. He obtained the optimal liability ratio when the objective is to maximize the expected logarithmic utility of terminal wealth. The model of Stein (2012, Chapter 6) was very interesting, but had some limitations. First, he did not consider regime switching in the model. Second, the insurer did not control investment decisions. Third, the risk was modeled by a diffusion process without jumps. Fourth, there was only one risky asset in the financial market. Last, the only utility function considered in Stein (2012, Chapter 6) was the logarithmic utility function. Zou and Cadenillas (2014a) improved that model by including investment as a control, and allowing jumps in the risk process. They obtained optimal investment and liability ratio strategies not only for logarithmic utility, but also under HARA, CARA, and quadratic utility functions. Recently, Zou and Cadenillas (2016) improved the model of Zou and Cadenillas (2014a) by allowing regime switching in the insurance and financial markets. They also allowed any finite number of risky assets in the financial market. They obtained optimal investment and liability ratio strategies for logarithmic and power utilities. In the models of Stein (2012, Chapter 6) and Zou and Cadenillas (2014a and 2016) the objective was to maximize expected utility of terminal wealth. It would be interesting to study those models under different objectives.

PROBLEMS 1.A. I want to study the model of Zou and Cadenillas (2016) when the objective is to maximize the expected total discounted dividend payments to be received by the shareholders. In this case, the control (π, κ, δ) will have three components. The first component

$\pi = (\pi_1, \cdots, \pi_K)$ is a vector that represents the proportions to be invested in the K risky assets of the financial market. The second component κ is the liability ratio (for the risk process). The third component δ is the dividend distribution. I will consider three models for the dividend policy: bounded and unbounded dividend rates (see Sotomayor and Cadenillas (2011) for a reference), and fixed costs and taxes (see Sotomayor and Cadenillas (2013), Cadenillas, Sarkar and Zapatero (2007), and Cadenillas, Choulli, Taksar and Zhang (2006) for references on the optimal dividend policy problems when there are fixed costs and taxes). After obtaining the solutions, I will compare them with the solutions obtained by Zou and Cadenillas (2016).

Context and Methodology 2

With the rapid development of sophisticated financial products, the losses of an investment can be dramatic. With the experience of failures of large financial institutions such as Barings Bank, risk control measures are essential. The value-at-risk (VaR) risk measure has become a standard tool to accomplish this purpose. It is a risk measure that is easily understood: it is the maximum loss of a portfolio over a given horizon, at a given confidence level. The Basel Committee on Banking Supervision requires U.S. banks to use VaR to determine the minimum capital required for their trading portfolios. Pirvu (2007), Yiu (2004), Basak and Shapiro (2001), Cuoco and Liu (2006), Cuoco, Hua and Issaenko (2008) have studied optimal portfolio management problems under the value-at-risk constraint.

Emmer, Kratz and Tasche (2015) claim that "Expected shortfall (ES) has been widely accepted as a risk measure that is conceptually superior to value-at-risk (VaR)". The "expected shortfall at q% level" is the expected return on the portfolio in the worst q% of cases. Optimal portfolio management problems under the expected shortfall (ES) constraint have been studied in one-period models (see, for example, Krokhmal et al (2002)), but have not been solved in continuous-time models. Miller and Yang (2015) do not study a consumption-investment problem under expected shortfall constraint.

PROBLEMS 2.A. I want to solve optimal consumption-investment problems under the expected shortfall (ES) constraint. I will solve these problems in continuous-time. I will compare my results with those results in the literature on optimal consumption-investment under the value-at-risk constraint and other risk constraints.

Context and Methodology 3

Some countries or a community of countries impose debt ceilings (upper bounds) to control their debts. For example, the debt ceiling in USA has been selected through a debate in Congress, in which Democrats wanted to increase the debt ceiling and Republicans opposed to increase it. In the European Union, the Maastricht Treaty set the debt ceiling at 60%. According to Chowdhury and Islam (2010), the 60% was simply the median of the debt ratio of some European countries to prepare for the formation of the Euro zone. In both cases (USA and the European Union), the debt ceiling has been selected without a rigorous optimality criterion that takes into account the welfare of the country. In contrast, I want to obtain the optimal government debt ceiling for such a country or community of countries.

The debt ratio $X = \{X_t, t \in [0, \infty)\}$ of a country is defined by

$$X_t := \frac{\text{gross public debt at time t}}{\text{gross domestic product (GDP) at time t}}.$$

I define debt ceiling as the maximum level of debt ratio at which fiscal interventions (in the form of tax increases or expenditure cuts) are not required (see Cadenillas and Huaman-Aguilar (2015b) for the definitions of other terms like "debt limit", "optimal debt" and "credit limit"). There are other theoretical models for public debt (such as Barro (1974, 1999), Bulow and Rogoff (1989), and Stein (2006, 2012)), but they do not study the debt ceiling.

Motivated by the government debt crises in the world, Cadenillas and Huaman-Aguilar (2015b) have recently developed a stochastic control model to obtain the optimal government debt ceiling. We considered a government that wants to control its debt by imposing an upper bound or ceiling on its debt-to-GDP ratio. We assumed that debt generates a cost for the country, and this cost is an increasing and convex function of debt ratio. The government can intervene to reduce its debt ratio, but there is a cost generated by this reduction. The goal of the government is to find the optimal control that minimizes the expected total cost. We obtained an explicit solution for the government debt problem, that gives in particular an explicit formula for the optimal government debt ceiling b. This number b depends on the economic parameters, and is characterized in the following way. If at any point in time the actual debt ratio of a country is below the optimal debt ceiling b, then fiscal intervention is not required; if the debt ratio is equal to b, then control should be exerted to prevent the debt ratio from being greater than b; if the initial debt ratio is above the debt ceiling b, then the government should intervene to bring immediately the debt ratio to the level b, and then continue as described above. That was the first theoretical model for the optimal government debt ceiling. Cadenillas and Huaman-Aguilar (2015b) also presented a very interesting economic analysis of the solution.

Motivated by how the debt ceiling has been selected in USA and the European Union, Cadenillas and Huaman-Aguilar (2015b) assumed that the ability of a government to reduce its debt ratio is unbounded. However, there is empirical evidence that the ability of a government to generate primary surpluses to reduce the debt ratio is bounded.

PROBLEM 3.A. I want to solve the problem solved by Cadenillas and Huaman-Aguilar (2015b), but assuming instead that the interventions of the government to reduce the debt ratio are bounded. I have already obtained some preliminary results.

Context and Methodology 4

I consider a country which is in danger of a debt crisis. A multilateral organization can inject capital to rescue the country, but this generates fixed and proportional costs. In addition, there is a big cost if the country is not rescued (for instance, this big cost could occur because of a contagion effect on other countries). The recent case of Greece and the International Monetary Fund is an example of this situation. To rescue a country has been addressed in the literature, but without a theoretical framework that considers a rigorous optimality criterion. I denote

$$X_t = \frac{\text{net external debt of the country}}{\text{GDP of the country}}$$

and assume that $X = \{X_t, t \geq 0\}$ satisfies a stochastic differential equation (I will investigate the most appropriate model for X). To rescue the country, the multilateral organization selects the times to inject capital as well as the amounts of capital injection. I denote ξ_n as the reduction at instant τ_n, $n \geq 1$, of X as a consequence of a capital injection. Thus, $T = \{\tau_n, n \geq 1\}$ is an increasing sequence of stopping times that represent the times at which the multilateral organization injects capital to the country, while $\xi = \{\xi_n, n \geq 1\}$ is a sequence of nonnegative

random variables that represent the reductions of X as a consequence of capital injections. I define the time of debt crisis of the country by $\Theta = \Theta_X := \inf\{t \geq 0 : X_t \geq C\}$, where $C > 0$. The multilateral organization selects the pair (T, ξ). Here, $\tau_1 = \infty$ means that the multilateral organization decides not to rescue the country. I assume that the multilateral organization pays both a fixed cost $K \in (0, \infty)$ and a proportional cost $k \in (0, \infty)$ for each intervention. The fixed cost is motivated by the empirical evidence that the interventions of the multilateral organization to provide liquidity to the country are more effective the shorter and the less frequent they are, which is compatible with a fixed positive cost. On the other hand, if the multilateral organization does not intervene, then the country will suffer from a debt crisis, and there is an associated big cost $M > K$. This cost is paid at the time of the debt crisis Θ.

The multilateral organization wants to select a control $(\hat{T}, \hat{\xi})$ that minimizes the functional $J_4(x; (T, \xi)) := E_x\left[\sum_{n\geq 1} e^{-\lambda \tau_n} (K + k\xi_n) I_{\{\tau_n < \Theta\}} + Me^{-\lambda\Theta}\right]$, that represents the expected total sum of all the discounted costs described above.

PROBLEM 4.A. I have modeled the problem of rescuing a country as a stochastic impulse control problem. After finding an analytical solution, I want to investigate how the parameters of the model affect the solution. Overall, I want to answer the following questions: Is it worth for the multilateral organization to rescue this country? When should the multilateral organization inject capital to this country? How much capital should the multilateral organization inject to this country in each intervention?

PROBLEM 4.B. From a mathematical perspective, I expect that the solution of this problem can be characterized by two constants $\beta < B$ (that depend on the economic parameters) such that the multilateral organization should rescue the country when its net external debt/GDP X reaches the level B. At that moment, the size of the intervention should be $B-\beta$. The level B is approximately the "debt limit" because the multilateral organization should intervene when the debt service payments/GDP of the country are unsustainable beyond that level. Thus, I want to study the first time at which X reaches B. I want to calculate its probability distribution, expected value, variance, et cétera. This will be helpful to predict a debt crisis.

PROBLEM 4.C. After solving Problem 4.A, I plan to model and solve the more general problem of a multilateral organization that wants to rescue a whole system of countries.

PROBLEM 4.D. Methods similar to those developed to solve the above problem can be applied to solve the problem of a country that wants to rescue financial institution(s). The recent case of USA and Lehman Brothers is an example of this situation. Thus, I want to solve the problem of a country that wants to rescue financial institution(s).

Context and Methodology 5

The government debt portfolio is, in most cases, the largest financial portfolio in a country. In particular, the currency composition of the public debt is an important variable that can exacerbate a currency debt crisis, such as in Mexico in 1994. High foreign currency debt in the portfolio (especially, short term) exposes the country to the fluctuations of the exchange rates, and this becomes dramatic when unexpected and huge devaluations of the relevant exchange rates occur. As Panizza (2008) points out, developing countries have been reducing consistently the proportion of foreign debt in their portfolios in favor of local currency debt. This empirical fact is happening in the context in which most developing countries have access to the international capital markets. That is, although the countries can borrow in external currencies, there is a deliberate tendency to borrow in domestic currencies. Some authors (see Borensztein et al.

(2008), for example) find that debt crises are the factors that have urged countries to pursue such strength in their domestic markets. In other words, the underlying factor that explains this tendency is the goal of reducing the exchange rate vulnerabilities, and hence the chances of a debt crisis. Thus, countries have become more risk averse.

I define the debt of a country as

$$X(t) := \text{Total government debt expressed in local currency at time t.}$$

Surprisingly, although the order of magnitude of the debt of a country can be of trillions of dollars and the government debt portfolio is in general the largest in the country, the theoretical literature has paid almost no attention to currency government debt portfolios. As far as I know, Giavazzi and Missale (2004) and Licandro and Masoller (2000) have been the only theoretical references that deal with government currency debt portfolios. These approaches have the following three weaknesses: (i) the debt ratio dynamics is not realistic because they consider only one-period models, (ii) the jumps in the exchange rates are not considered explicitly, and (iii) the role of the government risk aversion is not included. Thus, important elements of the currency debt analysis have been neglected.

Huaman-Aguilar and Cadenillas (2015a) have recently solved a problem for currency government debt portfolio that overcomes the three shortcomings mentioned above. We have studied the optimal currency portfolio and debt payments in a continuous-time model that considers debt aversion and jumps in the exchange rates. We have derived a realistic stochastic differential equation for public debt, and we have obtained the explicit solution for the currency portfolio and payments. We have shown that higher debt aversion and jumps in the exchange rates lead to a lower proportion of optimal debt in foreign currencies. In addition, we have shown that for a government with extreme debt aversion it is optimal not to issue debt in foreign currencies.

PROBLEM 5.A. Huaman-Aguilar and Cadenillas (2015a) assumed that the debts in the different currencies have the same maturity. I want to solve the problem above when the debts in the different currencies have different maturities. I will start with the simpler case in which the government has debt only in the local currency, and the problem is to obtain the optimal proportion of the different terms of debt. In a second step, I will consider debts in different currencies and allow these debts to have different maturities.

PROBLEM 5.B. I want to solve the problem studied by Huaman-Aguilar and Cadenillas (2015a) in the more general case in which I allow the exchange rates to be influenced by the level of government debt X.

Context and Methodology 6

The recent global and fiscal crises have led to more interest in countercyclical fiscal policies to mitigate the negative consequences of a crisis. That is why many governments have created stabilization funds, which is a mechanism of fiscal policy to save money in the good economic times to be used in the bad economic times. This balances the budget over the business cycle. According to Joyce (2001) and Vasche and Williams (2001), in many circumstances, it is the best way to handle fiscal disruptions, in comparison to other options. The stabilization funds have been implemented in a number of countries (such as Mexico, Russia, Venezuela, Peru, Chile, and Bolivia), and in most states of USA, in which they are called Budget Stabilization Funds (BSF) (or Rainy Day Funds). In general, the natural level of the stabilization fund is

associated with the price of a commodity and/or with the annual budget surplus (or deficit). As a result, the fluctuations of the natural level of the fund are closely related to the prices of such commodities and the government budget. The stabilization funds we want to study have in common that the government makes deposits in and withdrawals from the fund according to some predetermined rules (see Rodriguez-Tejedo (2012) for details). In other words, it intervenes to modify the natural level of the stabilization fund. Typically, there exists a band for the stabilization fund. For instance, in Russia a maximum level in terms of domestic currency units for the stabilization fund itself was established in 2007. The amount that exceeds such maximum is withdrawn in order to pay foreign public debt or cover part of the Pension Funds deficit. A minimum level of zero is implicitly being considered. As another example, Peru set up the stabilization fund minimum at zero and the maximum level at 4% of the GDP.

I want to develop the first theoretical model to compute the optimal bands for the government stabilization fund. Formally, I will model the uncertainty in the stabilization fund X by a Brownian motion W and by a continuous-time, finite state Markov chain ϵ. The process ϵ represents the regime of the economy. I will assume that there is a fund target $\rho \in (0, \infty)$. The cost of having too much stabilization funds (above the target ρ) is due to the fact that the funds can be used in the present to pay public debt or invest on any other government program with high social and/or private return. On the other hand, given the existence of macroeconomic fluctuations, having too little stabilization funds (below the target ρ) generates a cost associated with the fear of the government of facing the need of resources when the economy is going through bad economic times. I consider a government that wants to control the stabilization fund by depositing money in and withdrawing money from the fund. I will model this problem as a stochastic singular control problem with regime switching (see Sotomayor and Cadenillas (2011) for a reference). I will assume that the government knows the regime of the economy.

PROBLEM 6.A. I want to obtain explicitly the optimal stabilization fund control. In particular, I want to obtain the optimal bands, which will depend on the regime of the economy. As a result, I will know the optimal policy of deposits in and withdrawals from the stabilization fund in an expansion and in a recession. I will obtain a practical recommendation for the management of the stabilization fund based on the optimal bands. I have already obtained some preliminary results.

PROBLEM 6.B. I also want to solve the above problem when the government does not know the regime ϵ of the economy (see Cadenillas, Lakner and Pinedo (2013) for a reference on the solution of a stochastic control problem in which the regime of the economy is unknown).

Remark

My previous experience in developing and applying the theory of stochastic control will be very useful to solve the above problems. I will give a financial and/or economic interpretation and analysis of all my results. In particular, I will examine how the solutions to the above problems depend on the financial, insurance, and economic parameters. I also want to examine how the value function depends on the economic parameters, which will provide a welfare analysis. Whenever available, I will relate my results to the empirical financial, insurance, and economics literature.

LIST OF REFERENCES

[1] V.V. Acharya, L.H. Pedersen, T. Philippon and M. Richardson (2009): Regulating Systemic Risk. In V.V. Acharya and M. Richardson, Eds.: "Restoring Financial Stability. How to Repair a Failed System", John Wiley & Sons, New Jersey.

[2] V.V. Acharya, T. Philippon, M. Richardson and N. Roubini (2009): A Bird's-Eye View. The Financial Crisis of 2007–2009: Causes and Remedies. In V.V. Acharya and M. Richardson, Eds.: "Restoring Financial Stability. How to Repair a Failed System", John Wiley & Sons, New Jersey.

[3] S.R. Aiyagari and E.R. McGrattan (1998): The Optimum Quantity of Debt, *Journal of Monetary Economics*, vol 42(3), pp. 447–469.

[4] C. Atkinson and M. Papakokinou (2005): Theory of optimal consumption and portfolio selection under a Capital-at-Risk (CaR) and a Value-at-Risk (VaR) constraint, *IMA Journal of Management Mathematics*, vol 16, pp. 37–70.

[5] R.J. Barro (1999): Notes on optimal debt management, *Journal of Applied Economics*, vol 2(2), pp. 281–289.

[6] R.J. Barro (1974): Are government bonds net wealth?, *The Journal of Political Economy*, vol 82(6), pp. 1095–1117.

[7] S. Basak and A. Shapiro (2001): Value-at-risk based risk management: optimal policies and asset prices, *Review of Financial Studies*, vol 14, pp. 371–405.

[8] A. Bensoussan, A. Cadenillas, and H.K. Koo (2015): Entrepreneurial Decisions on Effort and Project with a Non-Concave Objective Function, *Mathematics of Operations Research*, vol 40(4), pp. 902–914.

[9] D. Bolder (2003): Towards a more complete debt strategy simulation framework, *Working paper 2012-13, Bank of Canada, Ottawa.*

[10] O. Blanchard (2009): *Macroeconomics.* 5th ed. Prentice Hall.

[11] O. Blanchard, J.C. Chouraqui, R.P. Hagemann and N. Sartor (1990): The sustainability of public policies: new answers to an old question, *OECD Economic Studies*, 15, OECD.

[12] O. Blanchard and S. Fisher (1989): *Lectures on Macroeconomics.* MIT Press, Cambridge, Massachusetts, London, England.

[13] N.P.B. Bollen, S.F. Gray and R.E. Whaley (2000): Regime switching in foreign exchange rates: Evidence from currency option prices, *Journal of Econometrics*, 94, pp. 239-276.

[14] E. Borensztein, K. Cowan, B. Eichengreens, and U. Paniza, eds. (2008): "Bond Markets in Latin America". MIT Press.

[15] C. Buescu (2004): "Optimal Portfolio Management When There Are Taxes and Transaction Costs". Doctoral Dissertation, University of Alberta.

[16] C. Buescu and A. Cadenillas (2007): Investors' Preference for a Positive Tax Rate Depends on the Level of the Interest Rate, *Mathematics and Financial Economics*, vol 1, pp. 163–180.

[17] C. Buescu, A. Cadenillas and S.R. Pliska (2007): A Note on the Effects of Taxes on Optimal Investment, *Mathematical Finance*, vol 17, issue 4, pp. 477–485.

[18] J. Bulow and K. Rogoff (1989): Sovereign debt: is to forgive to forget?, *The American Economic Review*, vol 79(1), pp. 43–50.

[19] A. Cadenillas (2002): A stochastic maximum principle for systems with jumps, with applications to finance, *Systems and Control Letters*, vol 47, issue 5, pp. 393–404.

[20] A. Cadenillas, J. Cvitanić and F. Zapatero (2007): Optimal Risk-Sharing with Effort and Project Choice, *Journal of Economic Theory*, vol 133, pp. 403–440.

[21] A. Cadenillas, J. Cvitanić and F. Zapatero (2004): Leverage decision and manager compensation with choice of effort and volatility, *Journal of Financial Economics*, vol 73, issue 1, pp. 71–92.

[22] A. Cadenillas, T. Choulli, M. Taksar and L. Zhang (2006): Classical and Impulse Stochastic Control for the Optimization of the Dividend and Risk Policies of an Insurance Firm, *Mathematical Finance*, vol 16, issue 1, pp. 181–202.

[23] A. Cadenillas and U.G. Haussmann (1994): The stochastic maximum principle for a singular control problem, *Stochastics and Stochastics Reports*, vol 49, pp. 211–237.

[24] A. Cadenillas and R. Huaman-Aguilar (2015b): Government Debt Control: Explicit Formula for the Optimal Government Debt Ceiling, *Annals of Operations Research*, published online in November 2015.

[25] A. Cadenillas and I. Karatzas (1995): The stochastic maximum principle for linear, convex optimal control with random coefficients, *SIAM Journal on Control and Optimization*, vol 33, number 2, pp. 590–624.

[26] A. Cadenillas, P. Lakner and M. Pinedo (2013): Optimal Production Management When Demand Depends on the Business Cycle, *Operations Research*, vol 61, number 4, pp. 1046–1062.

[27] A. Cadenillas, P. Lakner and M. Pinedo (2009): Optimal Control of a Mean-Reverting Inventory, *Operations Research*, vol 58, number 6, pp 1697–1710.

[28] A. Cadenillas and S. Pliska (1999): Optimal trading of a security when there are taxes and transaction costs, *Finance and Stochastics*, vol 3, number 2, pp. 137–165.

[29] A. Cadenillas, S. Sarkar and F. Zapatero (2007): Optimal Dividend Policy with Mean-Reverting Cash Reservoir, *Mathematical Finance*, vol 17, issue 1, pp. 81–110.

[30] A. Cadenillas and F. Zapatero (2000): Classical and impulse stochastic control of the exchange rate using interest rates and reserves, *Mathematical Finance*, vol 10, issue 2, pp. 141–156.

[31] A. Cadenillas and F. Zapatero (1999): Optimal Central Bank intervention in the foreign exchange market, *Journal of Economic Theory*, vol 87, pp. 218–242.

[32] R. Caldentey and M. Haugh (2006): Optimal Control and Hedging of Operations in the Presence of Financial Markets, *Mathematics of Operations Research*, vol 31(2), pp. 285–304.

[33] M. Caner, T. Grennes, and F. Koehler-Geib (2010): Finding the tipping point-when sovereign debt turns bad, in C.A.P. Braga and G.A. Vincelette, eds., *Sovereign debt and the financial crisis: will this time be different?*, World Bank.

[34] L.A.V. Catão and G.M. Milesi-Ferretti (2013): External Liabilities and Crises, *Working Paper 13/113, International Monetary Fund.*

[35] H. Chade and E. Schler (2012): Optimal insurance with adverse selection, *Theoretical Economics*, vol 7, pp. 571–607.

[36] A. Chowdhury and I. Islam (2010): An optimal debt-to-GDP ratio?, *Policy Brief 66, Inter-governmental Group of Twenty Four (G-24).*

[37] R. Cooper and B. Hayes (1987): Multi-Period Insurance Contracts, *International Journal of Industrial Organizations*, vol 5, pp. 211–231.

[38] Council of the European Communities (1992): Treaty on European Union (signed in Maastricht). Brussels-Luxembourg.

[39] D. Cuoco, H. Hua and S. Issaenko (2008): Optimal Dynamic Trading Strategies with Risk Limits, *Operations Research*, vol 56, pp. 358–368.

[40] D. Cuoco and H. Liu (2006): An analysis of VaR-based capital requirements, *Journal of Financial Intermediation*, vol 15(3), pp. 362-394.

[41] M.M. Dacorogna and M. Kratz (2015): Living in a Stochastic World and Managing Complex Risks, *Preprint.*

[42] U.S. Das, M. Papapioannou, G. Pedras, F. Ahmed, and J. Surti (2010): Managing public debt and its financial stability implications, *Working Paper 10/280, International Monetary Fund.*

[43] P.A. Diamond (1965): National debt in a neoclassical growth model, *The American Economic Review*, vol 55(5), pp. 1126–1150.

[44] G. Dionne, Ed. (2013): *Handbook of Insurance*, Springer-Verlag, New York.

[45] G. Dionne, N. Fombaron and N. Doherty (2013): Adverse Selection in Insurance Contracting. In G. Dionne, Ed.: "Handbook of Insurance", pp. 231–280, Springer-Verlag, New York.

[46] J.M. Eaton and M. Gersovitz (1981): Debt with potential repudiation: Theoretical and empirical analysis, *Review of Economic Studies*, vol 48, pp. 289–309.

[47] B. Égert (2015): Public debt, economic growth and nonlinear effects: Myth or reality?, *Journal of Macroeconomics*, vol 43, pp. 226–238.

[48] P. Embrechts, G. Puccetti, L. Rüschendorf, R. Wang (2014): An Academic Response to Basel 3.5, *Risks*, vol 2, pp. 25–48.

[49] S. Emmer, M. Kratz and D. Tasche (2015): What is the best risk measure in practice? A comparison of standard measures, *Journal of Risk*, vol 18(2), pp. 31–60.

[50] F. Giavazzi and A. Missale (2004): *Public debt management in Brasil*, *CEPR Discussion Paper 4293*, London.

[51] I. Gijbels and K. Herrmann (2015): Optimal Expected-Shortfall Portfolio Selection With Copula Induced Dependence. *Preprint*.

[52] R. Huaman-Aguilar (2015): "Stochastic Control for Government Debt Management". Doctoral Dissertation, University of Alberta.

[53] R. Huaman-Aguilar and A. Cadenillas (2015a): Government Debt Control: Optimal Currency Portfolio and Payments, *Operations Research*, vol 63(5), pp. 1044–1057.

[54] B. Holmström and J. Tirole (1998): Private and public supply of liquidity, *Journal of Political Economy*, vol 106(1), pp. 1–40.

[55] IMF (2002): Assessing sustainability. Prepared by the Policy Development and Review Department.

[56] P.G. Joyce (2001): What is so magical about five percent? a nationwide look at factors that influence the optimal size of the state rainy day funds, *Public Budgeting and Finance*, vol 21(2), pp. 62–87.

[57] I. Karatzas I (1996): "Lectures on the Mathematics of Finance". CRM Monographs 8, American Mathematical Society.

[58] I. Karatzas and S. Shreve (1991): "Brownian Motion and Stochastic Calculus". Springer-Verlag, New York.

[59] I. Karatzas and S.E. Shreve (1998): "Methods of Mathematical Finance". Springer-Verlag, New York.

[60] S.G. Kou and X.H. Peng (2016): On the Measurement of Economic Tail Risk, *Operations Research*, forthcoming.

[61] S.G. Kou, X.H. Peng and C.C. Heyde (2013): External Risk Measures and Basel Accords, *Mathematics of Operations Research*, vol 38, pp. 393–417.

[62] P. Krokhmal, J. Palmquist, S. Uryasev (2002): Portfolio optimization with conditional value-at-risk objective and constraints, *Journal of Risk* 4, pp. 43–68.

[63] H.J. Kushner (1997): Approximations and Computational Methods for Optimal Stopping and Stochastic Impulsive Control Problems, *Applied Mathematics and Optimization* 3, pp. 81–99.

[64] H.J. Kushner and P.G. Dupuis (1992): *Numerical Methods for Stochastic Control Problems in Continuous Time*. Springer-Verlag, New York.

[65] F.G. Licandro and O.A. Masoller (2000): The optimal currency composition of Uruguayan public debt. *Working paper, Central Bank of Uruguay.*

[66] L.R. Lima, W.P. Gaglianone and R.M.B. Sampaio (2008): Debt ceiling and fiscal sustainability in Brazil: A quantile autoregression approach, *Journal of Development Economics*, vol 86, pp. 313–335.

[67] X. Mei, V. DeMiguel and F. Nogales (2016): Multiperiod portfolio optimization with multiple risky assets and general transaction costs, *Journal of Banking and Finance*, vol 69, pp. 108–120.

[68] R.C. Merton (1969): Lifetime portfolio selection under uncertainty: the continuous-time case, *The Review of Economics and Statistics*, vol 51(3), pp. 247–257.

[69] R.C. Merton (1971): Optimal consumption and portfolio rules in a continuous-time model, *Journal of Economic Theory*, vol 3, pp. 373–413.

[70] C.W. Miller and I. Yang (2015): Optimal Control of Conditional Value-at-Risk in Continuous Time, *Preprint.*

[71] A.J. McNeil, R. Frey and P. Embrechts (2015): *Quantitative Risk Management: Concepts, Techniques, Tools; Revised Edition.* Princeton University Press: Princeton, NJ, USA.

[72] U. Paniza (2008): Domestic and external public debt in developing countries, *Discussion Papers 188, United Nations Conference on Trade and Development (UNCTAD).*

[73] T.A. Pirvu (2007): Portfolio optimization under the Value-at-Risk constraint, *Quantitative Finance*, vol 7(2), pp. 125–136.

[74] C.M. Reinhart and K.S. Rogoff (2009): *This Time is Different.* Princeton University Press, New Jersey.

[75] C.M. Reinhart and K.S. Rogoff (2010): Growth in a time of debt, *American Economic Review: Papers and Proceedings*, vol 100(2), pp. 573–578.

[76] C.M. Reinhart, K.S. Rogoff and M. A. Savastano (1993): Debt intolerance, in W.C. Brainard, G. L. Perry, eds., *Brooking papers on economic activity*, pp. 1-62.

[77] I. Rodriguez-Tejedo (2012): The determinants of the structure of rainy day funds, *Public Administrative Review*, vol 72(3), pp. 376–386.

[78] D. Romer (2002): *Advanced Macroeconomics, 2nd edition.* Mc Graw-Hill/Irwin.

[79] T.J. Sargent and N. Wallace (1981): Some unpleasant monetarist arithmetic, *Federal Reserve Bank of Minneapolis Quarterly Review*, vol 5(3), pp. 1–17.

[80] L.R. Sotomayor (2008): "Stochastic Control with Regime Switching and its Applications to Financial Economics". Doctoral Dissertation, University of Alberta.

[81] L.R. Sotomayor and A. Cadenillas (2013): Stochastic impulse control for the optimal dividend policy when there are business cycles, taxes and fixed costs, *Stochastics An International Journal of Probability and Stochastic Processes*, vol 85, issue 4, pp 707–722.

[82] L.R. Sotomayor and A. Cadenillas (2011): Classical and Singular Stochastic Control for the Optimal Dividend Policy When There Is Regime Switching, *Insurance: Mathematics and Economics*, vol 48, issue 3, pp 344–354.

[83] L.R. Sotomayor and A. Cadenillas (2009): Explicit Solutions of Consumption-Investment Problems in Financial Markets with Regime Switching, *Mathematical Finance*, vol 19, issue 2, pp. 251–279.

[84] J. Stein (2006): *Stochastic optimal control, international finance and debt crisis.* Oxford University Press.

[85] J. Stein (2012): *Stochastic optimal control and the U.S. financial debt crisis.* Springer-Science.

[86] M.I. Taksar (2000): Optimal risk and dividend distribution control models for an insurance company, *Mathematical Methods of Operations Research*, vol 51, pp 1–42.

[87] M. Uctum and M. R. Wickens (2000): Debt and deficit ceilings, and sustainability of fiscal policies: an intertemporal analysis, *Oxford Bulletin of Economics and Statistics*, vol 62, issue 2, pp 197-222.

[88] J.D. Vasche and B. Williams (2001): Optimal governmental budgeting contingency reserve funds, *Public Budgeting and Finance*, vol 7(1), pp. 66–82.

[89] Wikipedia (2015): List of countries by public debt. Online. URL http://en.wikipedia.org/wiki/*List_of_countries_by_public_debt*.

[90] C. Wyplosz (2005): Fiscal policy: institutions versus rules, *National Institute Economic Review*, vol 191, pp 64–78.

[91] Y. Xu, M. Pinedo, and M. Xue (2016): Operational Risk in Financial Services: A Review and New Research Opportunities, *Production and Operations Management*, forthcoming.

[92] K.F.C. Yiu (2004): Optimal portfolios under a Value-at-Risk constraint, *Journal of Economic Dynamics and Control*, vol 28, pp 1317–1334.

[93] F. Zampolli (2006): Optimal monetary policy in a regime-switching economy: the response to abrupt shifts in exchange rate dynamics. *Working paper, Bank of England*.

[94] B. Zou (2014): "Stochastic Control in Optimal Insurance and Investment with Regime Switching". Doctoral Dissertation, University of Alberta.

[95] B. Zou and A. Cadenillas (2016): Optimal Investment and Liability Ratio Policies in a Multidimensional Regime Switching Model, submitted to *Risks*.

[96] B. Zou and A. Cadenillas (2014b): Explicit Solutions of Optimal Consumption, Investment and Insurance Problems with Regime Switching, *Insurance: Mathematics and Economics*, vol 58, pp. 159–167.

[97] B. Zou and A. Cadenillas (2014a): Optimal Investment and Risk Control Policies for an Insurer: Expected Utility Maximization, *Insurance: Mathematics and Economics*, vol 58, pp. 57–67.

KNOWLEDGE MOBILIZATION PLAN

My knowledge mobilization plan has three components: publications, events, and teaching.

Previously, I have published my work in prestigious journals like *Journal of Economic Theory*, *Journal of Financial Economics*, *Mathematical Finance*, *Operations Research*, *Insurance: Mathematics and Economics*, *Mathematics of Operations Research*, *SIAM Journal on Control and Optimization*, and *Finance and Stochastics*. I plan to submit the results that I will obtain in my present research proposal to some of the following journals: *Management Science*, *Journal of Economic Theory*, *Econometrica*, *Mathematical Finance*, *Operations Research*, *Mathematics of Operations Research*, *Journal of Risk and Insurance*, *Journal of Financial Economics*, *Journal of Finance*, and *Insurance: Mathematics and Economics*. I also plan to write a self-contained book. In addition, the computer codes will be made available online.

I have often been invited to present my work in conferences of Mathematical Finance, Financial Engineering, Mathematical Economics, and Operations Research. I will present my results in those conferences, and in conferences of the *American Finance Association* (AFA), *Bachelier Finance Society* (BFS), *American Risk and Insurance Association* (ARIA), *Institute for Operations Research and the Management Sciences* (INFORMS), *Econometric Society*, and *Insurance: Mathematics and Economics* (IME). In addition, I will present my results at conferences organized by the Bank of Canada, International Monetary Fund, and European Central Bank. My students will present their works at some of the conferences above.

Professor Robert J. Elliott and I started the BSc and MSc programs in Mathematical Finance in the Fall of 1996, soon after my arrival at the University of Alberta. They were the first such programs in Canada. Due to the success of the MSc program in Mathematical Finance, the University of Alberta created in 1999 the PhD program in Mathematical Finance. It is still the only such program in Canada. I have been teaching courses for these programs. I have incorporated some of my research results into these courses. I plan to continue doing this. For instance, I plan to incorporate the solutions of Problems 2.A (see detailed description part of the research proposal) into the course Mathematical Finance II (MATH 520), and the solutions of Problems 1.A (see detailed description part of the research proposal) into the course Advanced Mathematical Finance (MATH 615).

Schedule for first year: Submit papers and teach Mathematical Finance courses at the University of Alberta.

Schedule for second year: Submit papers, present the results at conferences (such as the 2018 Bachelier Finance Society World Congress, the AFA Meeting January 2019, and conferences or workshops organized by the Bank of Canada, IMF or ECB), and teach Mathematical Finance.

Schedule for third year: Submit papers, present the results at conferences (such as the 2019 North American Summer Meeting of the Econometric Society, and the AFA Meeting January 2020), and teach Mathematical Finance courses at the University of Alberta.

Schedule for fourth year: Submit papers, present the results at conferences (such as the 2020 World Congress of the Econometric Society, 2020 Bachelier Finance Society World Congress, the AFA Meeting January 2021, and conferences or workshops organized by the Bank of Canada, IMF or ECB), and teach Mathematical Finance courses.

Schedule for fifth year: Submit papers, present the results at conferences (such as the 25th International Congress on Insurance: Mathematics and Economics, 2021 Annual Meeting of the American Risk and Insurance Association, the AFA Meeting January 2022, and conferences or workshops organized by the Bank of Canada, IMF or ECB), and teach Mathematical Finance courses. In addition, write a self-contained book based on the results of my proposed research.

Family name, Given name
Cadenillas, Abel

Expected Outcomes

Elaborate on the potential benefits and/or outcomes of your proposed research and/or related activities.

Scholarly Benefits

Indicate and rank up to 3 scholarly benefits relevant to your proposal.

Rank	Benefit	If "Other", specify
1	Knowledge creation/intellectual outcomes	
2	Enhanced theory	
3	Enhanced research methods	

Social Benefits

Indicate and rank up to 3 social benefits relevant to your proposal.

Rank	Benefit	If "Other", specify
1	Enhanced policy	
2	Training and skill development	
3	Economic outcomes, including enhanced commercialization	

Audiences

Indicate and rank up to 5 potential target audiences relevant to your proposal.

Rank	Audience	If "Other", specify
1	Academic sector/peers, including scholarly associations	
2	Professional and/or scholarly associations	
3	Postsecondary institutions	
4	Federal government	
5	Students	

Family name, Given name
Cadenillas, Abel

Expected Outcomes Summary

Describe the potential benefits/outcomes (e.g., evolution, effects, potential learning, implications) that could emerge from the proposed research and/or other partnership activities.

I expect to solve all the problems presented in my proposal. This research will be useful to reduce the chances of future financial crises and future government debt crises. It will also be useful to mitigate their negative effects.

My previous research supported by the Social Sciences and Humanities Research Council of Canada has been published in top scholarly journals, including the Journal of Financial Economics, the Journal of Economic Theory, Operations Research, Mathematical Finance, and Finance and Stochastics. I expect that my proposed research will be published in prestigious journals like Management Sciences, Operations Research, the Journal of Economic Theory, Econometrica, Mathematical Finance, Insurance: Mathematics and Economics, Journal of Risk and Insurance, Journal of Financial Economics, Journal of Finance, Review of Financial Studies, and Mathematics of Operations Research.

All my previous PhD students have been very successful. For instance, my first PhD student was Cristin Buescu, whom I supported with a previous SSHRC grant. He is currently a faculty member (tenured position) in Financial Mathematics at King's College, University of London. The QS World University Rankings 2016-2017 ranks King's College, University of London as 21st in the world (above all Canadian universities). All the doctoral dissertations that I have supervised during my career have led to publications in prestigious journals, including Mathematical Finance (the top journal in Mathematical Finance), Insurance: Mathematics and Economics (the top journal in Actuarial Sciences) and Operations Research (the top journal in Operations Research). All my former MSc students have also been very successful. The development of the next generation of highly qualified researchers is of paramount importance to me. As a result of the training environment and opportunities which I provide to my students, I expect that the students that I will support with this grant will be very successful as well.

The proposed research will be very interesting to the academic communities in Management Sciences, Business, Insurance, Finance, Risk Management, Economics, Operations Research, Mathematics, and Statistics. It will also be important to governments, Central Banks like the Bank of Canada, multilateral organizations like the International Monetary Fund, companies, firms, and the financial industry.

RESEARCH TEAM, PREVIOUS OUTPUT AND STUDENT TRAINING

A. Description of the Research Team

I am the only member of the research team. However, I plan to involve some graduate students in my research. All my former PhD students wrote outstanding doctoral dissertations under my supervision, and as a result were able to secure very good academic positions after graduation. My former MSc students have also been very successful in the job market.

I will spend 50% of my research time on this SSHRC project.

B. Description of previous and ongoing research results

My completed research since 2007 can be found in the following 19 publications:

[1] A. Cadenillas and R. Huaman-Aguilar (2015b): Explicit Formula for the Optimal Government Debt Ceiling, *Annals of Operations Research*, published online in November 2015.

[2] R. Huaman-Aguilar and A. Cadenillas (2015a): Government Debt Control: Optimal Currency Portfolio and Payments, *Operations Research*, vol 63(5), pp. 1044–1057.

[3] A. Bensoussan, A. Cadenillas, and H.K. Koo (2015): Entrepreneurial Decisions on Effort and Project with a Non-Concave Objective Function, *Mathematics of Operations Research*, vol 40(4), pp. 902–914.

[4] A. Cadenillas (2015): Cash Management, in Tariq Samad and John Baillieul (editors): *Encyclopedia of Systems and Control*, Springer - Verlag, New York.

[5] B. Zou and A. Cadenillas (2014b): Explicit Solutions of Optimal Consumption, Investment and Insurance Problems with Regime Switching, *Insurance: Mathematics and Economics*, vol 58, pp. 159-167.

[6] B. Zou and A. Cadenillas (2014a): Optimal Investment and Risk Control Policies for an Insurer: Expected Utility Maximization, *Insurance: Mathematics and Economics*, vol 58, pp. 57–67.

[7] A. Cadenillas, P. Lakner and M. Pinedo (2013): Optimal Production Management When Demand Depends on the Business Cycle, *Operations Research*, vol 61, number 4, pp. 1046–1062.

[8] L.R. Sotomayor and A. Cadenillas (2013): Stochastic Impulse Control with Regime Switching for the Optimal Dividend Policy When There Business Cycles, Taxes and Fixed Costs, *Stochastics: An International Journal of Probability and Stochastic Processes*, vol 85, number 4, pp. 707–722.

[9] L.R. Sotomayor and A. Cadenillas (2011): Classical and Singular Stochastic Control for the Optimal Dividend Policy When There Is Regime Switching, *Insurance: Mathematics and Economics*, vol 48, issue 3, pp. 344–354.

[10] A. Cadenillas (2011): Stochastic Control Methods for the Joint Optimization of the Risk and Dividend Policies of a Firm, in H.K. Koo (editor): *New Trends in Financial Engineering*, IOS Press, Amsterdam.

[11] A. Cadenillas, P. Lakner and M. Pinedo (2010): Optimal Control of a Mean-Reverting Inventory, *Operations Research*, vol 58, number 6, pp. 1697–1710.

[12] L.R. Sotomayor and A. Cadenillas (2009): Explicit Solutions of Consumption-Investment Problems in Financial Markets with Regime Switching, *Mathematical Finance*, vol 19, issue 2, pp. 251–279.

[13] A. Cadenillas, R.J. Elliott, H. Miao and Z. Wu (2009): Risk-Hedging in Real Estate Markets, *Asia Pacific Financial Markets*, vol 16, number 4, pp. 265–285.

[14] C. Buescu, A. Cadenillas and S.R. Pliska (2007): A Note on the Effects of Taxes on Optimal Investment, *Mathematical Finance*, vol 17, issue 4, pp. 477–485.

[15] C. Buescu and A. Cadenillas (2007): Investors' Preference for a Positive Tax Rate Depends on the Level of the Interest Rate, *Mathematics and Financial Economics*, vol 1, pp. 163–180.

[16] A. Cadenillas, J. Cvitanić and F. Zapatero (2007): Optimal Risk-Sharing with Effort and Project Choice (previous versions were titled "Dynamic Principal-Agent Problems with Perfect Information"), *Journal of Economic Theory*, vol 133, issue 1, pp. 403–440.

[17] A. Cadenillas, S. Sarkar and F. Zapatero (2007): Optimal Dividend Policy with Mean-Reverting Cash Reservoir, *Mathematical Finance*, vol 17, issue 1, pp. 81–110.

[18] A. Cadenillas and S.P. Clark (2007): Free Cash Flow and Managerial Entrenchment: A Continuous-Time Stochastic Control-Theoretic Model, *The B.E. Journal of Theoretical Economics*, vol 7, issue 1 (Contributions), article 33.

[19] A. Cadenillas, J. Cvitanić and F. Zapatero (2007): Stochastic Control Methods for the Problem of Optimal Compensation of Executives, in P. Baxendale and S. Lototsky (editors): *Stochastic Differential Equations: Theory and Practice. A volume in honor of Professor B.L. Rozovskii*, World Scientific Publishing Co.

In all the papers above (except for [4]), I have developed and applied advanced mathematical methods to solve problems in many different fields. That research experience will be very valuable for the present research project on risk management. The papers Cadenillas and Huaman-Aguilar (2015b), Huaman-Aguilar and Cadenillas (2015a), and Zou and Cadenillas (2014a) are specially relevant to the proposed research.

I was the only supervisor of the following PhD theses:

[1] Ricardo Huaman-Aguilar (2015): *Stochastic Control for Government Debt Management*. Doctoral Dissertation, University of Alberta.

[2] Bin Zou (2014): *Stochastic Control in Optimal Insurance and Investment with Regime Switching*. Doctoral Dissertation, University of Alberta.

[3] L.R. Sotomayor (2008): "Stochastic Control with Regime Switching and its Applications to Financial Economics". Doctoral Dissertation, University of Alberta.

[4] Cristin Buescu (2004): "Optimal Portfolio Management When There Are Taxes and Transaction Costs". Doctoral Dissertation, University of Alberta.

My former PhD student Ricardo Huaman-Aguilar is currently a Visiting Scholar (Postdoctoral Fellow) at the Department of Finance, Questrom School of Business, Boston University.

My former PhD student Bin Zou accepted a tenure-track position at the Assistant Professor level at the University of Connecticut. This is a position in Mathematical Finance and Actuarial Sciences. The University of Connecticut has been designated "Actuarial Center of Excellence" by the Society of Actuaries.

The first job after graduation of my former PhD student L.R. Sotomayor was an Assistant Professorship (tenure-track position) in the Department of Risk Management and Insurance, J. Mack Robinson College of Management, Georgia State University. The undergraduate Insurance program of Georgia State University has been ranked among the top four in the USA by U.S. News and World Report.

My former PhD student Cristin Buescu is currently a faculty member (tenured position) in Financial Mathematics at King's College, University of London, United Kingdom. The QS World University Rankings 2016–2017 ranks King's College, University of London as 21st in the world (above all Canadian universities).

My former student Kevin Wai defended the following MSc thesis on September 18, 2014:

[1] K. Wai (2014): "Optimal Regulation of Systemic Risk by Tax". MSc Thesis, University of Alberta.

After defending his MSc thesis, Kevin became a Quantitative Risk Analyst at Canadian Western Bank (Edmonton).

I was also the supervisor of many other Master students in the Mathematical Finance program at the University of Alberta. These were "course based" students and not "thesis based" students. They were required to write a project instead of a thesis. Thus, I supervised their projects.

I am currently the only supervisor of Wenyue Liu, who is a student in the PhD program in Mathematical Finance at the University of Alberta.

I received the "J.M. Mitchell Mentorship Award" in 2009. The Department of Mathematical and Statistical Sciences of the University of Alberta gives this award to its faculty members who have been excellent supervisors of PhD and MSc students.

My ongoing research includes the following papers:

[1] A. Bensoussan, A. Cadenillas, H.K. Kou and J. Sung (2016): Credit Risk with Selection of Effort and Volatility. *Preprint, University of Alberta.*

[2] A. Cadenillas, J. Cvitanić and F. Zapatero (2013): Executive Stock Options as a Screening Mechanism. *Preprint, University of Alberta*.

[3] A. Cadenillas and L.R. Sotomayor (2016): Optimal Central Bank Intervention When There Is Regime Switching. *Preprint, University of Alberta*.

[4] B. Zou and A. Cadenillas (2016): Optimal Investment and Liability Ratio Policies in a Multidimensional Regime Switching Model. *Preprint, University of Alberta*.

The paper Zou and Cadenillas (2016) is specially relevant to the proposed research.

The main contributions of my publications supported by SSHRC have been in the areas of Finance and Economics, while the main contributions of my publications supported by NSERC have been in the areas of Stochastic Processes and Control Theory. Except for the fact that my research in Finance and Economics uses advanced mathematical methods, there is no overlap between my research supported by SSHRC and my research supported by NSERC.

My previous work has resulted in the distinction "World Class University Distinguished Professor of Financial Engineering" awarded by the South Korean Ministry of Education, Science and Technology. There are less than 340 scholars in the world who have received a World Class University award (in many different fields). The group of World Class University scholars/researchers includes Nobel laureates (at least 9 of them), Fellows of the Royal Society (UK), members of the Academia Europeae, Humboldt Prize winners, Guggenheim Fellows, members of the National Academy of Sciences (USA), members of the National Academy of Engineering (USA), Fellows of the American Academy of Arts and Sciences (USA), and members of the French Academy of Sciences. As part of this distinction, I visited Ajou University during the summers of 2010, 2011, 2012 and 2013.

I was Visiting Professor of Information, Operations and Management Sciences at the Stern School of Business of New York University during the academic year 2008 - 2009; Visiting Professor, Department of Finance, Questrom School of Business, Boston University during the Fall of 2015; and Visiting Professor, ETH Risk Center, Swiss Federal Institute of Technology (Zurich) from March 1 to June 30, 2016. The Times Higher Education World University Rankings 2015-2016 and the QS World University Rankings 2015-2016 both rank ETH (Zurich) among the 9 best universities in the world.

C. Description of Proposed Student Training Strategies

I will involve in my research of this proposal a total of 3 students from the Department of Mathematical and Statistical Sciences of the University of Alberta: 2 students from the PhD program in Mathematical Finance and 1 student from the MSc program in Mathematical Finance. Their works will be part of their academic training.

I plan to provide financial support for these 3 graduate students (not necessarily the same PhD and MSc students during the five-year period). My PhD student Wei Liu will collaborate with me in solving Problems 2.A. This research will be part of her PhD thesis. Another PhD student will collaborate with me in solving problems 4.A and 4.B. This research will be part of her/his PhD thesis. One student (per year) from the MSc Program in Mathematical Finance will play an important role in the numerical computations associated with problems 1.A, 4.C, 4.D, 5.A, 5.B and 6.B. These numerical computations will be part of their MSc theses.

Family name, Given name
Cadenillas, Abel

Funds Requested from SSHRC

For each budget year, estimate as accurately as possible the research costs that you are asking SSHRC to fund through a grant. For each Personnel costs category, enter the number of individuals to be hired and specify the total amount required. For each of the other categories, enter the total amount required.

Personnel costs	Year 1		Year 2		Year 3		Year 4		Year 5	
	No.	Amount	No.	Amount	No.	Amount	No.	Amount	No.	Amount
Student salaries and benefits/Stipends										
Undergraduate										
Masters	1	9,900	1	10,197	1	10,503	1	10,817	1	11,142
Doctorate	2	20,900	2	21,528	2	22,174	2	22,838	2	23,522
Non-student salaries and benefits/Stipends										
Postdoctoral										
Other										

Travel and subsistence costs	Year 1	Year 2	Year 3	Year 4	Year 5
Applicant/Team member(s)					
Canadian travel	0	3,000	3,000	3,000	3,000
Foreign travel	0	3,000	3,000	3,000	3,000
Students					
Canadian travel	0	3,000	3,000	3,000	3,000
Foreign travel	0	3,000	3,000	3,000	3,000
Other expenses					
Professional/Technical services					
Supplies	8,000	8,000	8,000	8,000	8,000
Non-disposable equipment					
Computer hardware	4,000	0	0	0	0
Other					
Other expenses (specify)					
Total	42,800	51,725	52,677	53,655	54,664

Personal information will be stored in the Personal Information Bank for the appropriate program.

BUDGET JUSTIFICATION

1) Personnel Costs

I would like to support 3 graduate students (not necessarily the same PhD and MSc students during the five-year period) from the Department of Mathematical and Statistical Sciences of the University of Alberta. Specifically, I plan to support 2 students from the PhD program in Mathematical Finance, and 1 student from the MSc program in Mathematical Finance. One of the PhD students will be Ms. Wenyue Liu. These students will be working on risk management (the topic of this research proposal). Their works will be part of their theses.

Student salaries and benefits/Stipends

For each PhD student, I have budgeted $ 9,500 for the first year. This will cover summer support and a research assistanship. Adding 10% benefits, the total is $ 9,500(1.1)= $ 10,450 for each PhD student for the first year. Then, the total for all PhD students for the first year is $ 20,900.

Taking into account the 3% cost of living increase, I have budgeted $ 9,500 (1.03) = $ 9,785 for the second year for each PhD student. This will cover summer support and a research assistanship. Adding 10% benefits, the total is $ 9,785(1.1) = $ 10,764 for each PhD student for the second year. Then, the total for all PhD students for the second year is $ 21,528.

Similarly, I have budgeted $ 9,785 (1.03) = $ 10,079 for the third year for each PhD student. This will cover summer support and a research assistanship. Adding 10% benefits, the total is $ 10,079 (1.1) = $ 11,087 for each PhD student for the third year. Then, the total for all PhD students for the third year is $ 22,174.

Similarly, I have budgeted $ 10,079 (1.03) = $ 10,381 for the fourth year for each PhD student. Adding 10% benefits, the total is $ 10,381(1.1) = $ 11,419 for each PhD student for the fourth year. Then, the total for all PhD students for the fourth year is $ 22,838.

Similarly, I have budgeted $ 10,381 (1.03) = $ 10,692 for the fifth year for each PhD student. Adding 10% benefits, the total is $ 10,692(1.1) = $ 11,761 for each PhD student for the fifth year. Then, the total for all PhD students for the fifth year is $ 23,522.

For the MSc student, I have budgeted $ 9,000 for the first year. This will cover summer support and a research assistanship. Adding 10% benefits, the total is $ 9,000(1.1)= $ 9,900 for the MSc student for the first year.

Taking into account the 3% cost of living increase, I have budgeted $ 9,000 (1.03) = $ 9,270 for the second year for the MSc student. This will cover summer support and a research assistanship. Adding 10% benefits, the total is $ 9,270(1.1) = $ 10,197 for the MSc student (not necessarily the same MSc student of the first year) for the second year.

Similarly, I have budgeted $ 9,270 (1.03) = $ 9,548 for the third year for the MSc student. Adding 10% benefits, the total is $ 9,548 (1.1) = $ 10,503 for the MSc student (not necessarily the same MSc student of the first and second years) for the third year.

I have budgeted $ 9,548 (1.03) = $ 9,834 for the fourth year for the MSc student. Adding 10% benefits, the total is $ 9,834(1.1) = $ 10,817 for the MSc student for the fourth year.

I have budgeted $ 9,834 (1.03) = $ 10,129 for the fifth year for the MSc student. Adding 10% benefits, the total is $ 10,129(1.1) = $ 11,142 for the MSc student for the fifth year.

The above summer support, research assistanship, and amounts are standard in the Department of Mathematical and Statistical Sciences of the University of Alberta.

Non-student salaries and benefits/Stipends

This sub-section does not apply to my research proposal.

2) Travel and Subsistence Costs

Applicant/Team member(s)

I have budgeted $ 6,000 per year (for years 2, 3, 4, and 5) for travel and accommodation costs to present papers at two conferences ($ 3,000 for each conference). I would like to present my work at meetings of the Econometric Society; the American Finance Association (AFA); the Bachelier Finance Society (BFS); the Society for the Advancement of Economic Theory (SAET); the Institute for Operations Research and the Management Sciences (INFORMS); the American Risk and Insurance Association (ARIA); and the International Congress on Insurance: Mathematics and Economics (IME). I also want to present my work at conferences or workshops organized by the Bank of Canada, European Central Bank, and International Monetary Fund, which sometimes pay the travel expenses of the speakers.

Students

I have budgeted $ 6,000 per year (for years 2, 3, 4 and 5) for travel and accommodation costs for two of my PhD students to present papers at a conference (not necessarily the same PhD students during the period of this grant). That is one conference per student per year. They will present papers in years 2, 3, 4, and 5. This is travel for communication purposes. They will present their works at meetings of the above societies or organizations; that is, meetings of the Econometric Society, AFA, BFS, SAET, INFORMS, ARIA, and IME.

3) Other Expenses

Professional/Technical services

This sub-section does not apply to my research proposal.

Supplies

I have budgeted $ 1,000 for software and maintenance of computer and printer. For instance, my university does not provide computer software like *Maple*, *WinEdt* and *VMware* to faculty members, and I need such computer software for my research. I have also budgeted $ 1,000 for postage, telephone calls, books, photocopies, submission costs to journals, and fax transmissions. In addition, I have budgeted $ 6,000 for publication costs in open access journals, because I plan to publish 2 papers per year in top open access journals. Since I have already obtained some preliminary results, I am confident that I can publish 2 papers in top open access journals in the first year, as well as in the other years.

The total is $ 8,000 per year.

Non-disposable equipment

For the period of this grant application, I have budgeted $ 3,500 to buy a computer and $ 500 to buy a printer (my Department does not provide computer hardware to faculty members). The total is $ 4,000 for the whole period. The computer and the printer will be bought in the first year.

Other expenses (specify)

This sub-section does not apply to my research proposal.

Family name, Given name
Cadenillas, Abel

Funds from Other Sources

You must include all other sources of funding for the proposed research. Indicate whether these funds have been confirmed or not. Where applicable, include (a) the partners' material contributions (e.g. cash and in-kind), and (b) funds you have requested from other sources for proposed research related to this application.

Full organization name Contribution type	Confirmed	Year 1 Year 5	Year 2	Year 3	Year 4
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
Total funds from other sources		0	0	0	0
		0			

Personal infomation will be stored in the Personal Information Bank for the appropriate program.

Suggested Reviewers

List Canadian or foreign specialists whom SSHRC may ask to assess your proposal.
List keywords that best describe the assessor's areas of research expertise. Please refer to the Suggested Assessors section of the detailed instructions for more information on conflicts of interest.

Family name	Given name	Initials	Title
Kou	Steven		Professor

Org. code:
Full organization name: National University of Singapore

Keywords: Risk Management, Management Science, Financial Engineering, Operations Research

Department/Division name: Risk Management Institute

Address: Risk Management Institute
National University of Singapore
21 Heng Mui Keng Terrace, I3 Building
Singapore 119613, Singapore

	Country code	Area code	Number	Extension
Telephone number	65		6516 5062	
Fax number				

Country: SINGAPORE

E-mail: matsteve@nus.edu.sg

Family name	Given name	Initials	Title
Kratz	Marie		Professor

Org. code:
Full organization name: ESSEC Business School

Keywords: Risk Management, Insurance, Finance, Statistics, Economics.

Department/Division name: Information Systems, Decision Sciences and Statistics

Address: ESSEC Business School
Information Systems, Decision Sciences,
Av. Bernard Hirsch B.P. 50105
95021 Cergy Pontoise Cedex, France

	Country code	Area code	Number	Extension
Telephone number	33	1	34433000	
Fax number				

Country: FRANCE

E-mail: kratz@essec.edu

Family name	Given name	Initials	Title
DeMiguel	Victor		Professor

Org. code:
Full organization name: London Business School

Keywords: Management Sciences, Finance, Operations Research, Economics.

Department/Division name: Management Science and Operations

Address: Management Science and Operations
London Business School
Regent's Park, London NW1 4SA

	Country code	Area code	Number	Extension
Telephone number	44	0207	0008831	
Fax number				

Country: UNITED KINGDOM

E-mail: avmiguel@london.edu

Do not photocopy this page.

Internal use	CID (if known)
785255	73160

Identification

Only the information in the Name section will be made available to selection committee members and external assessors. Citizenship and Statistical and Administrative Information will be used by SSHRC for administrative and statistical purposes only. Filling out the statistical and Administrative Information section is optional.

Name

Family name	Given name	Initials	Title
Cadenillas	Abel		Professor

Citizenship - Applicants and co-applicants must indicate their citizenship status by checking and answering the applicable questions.

Citizenship status				Have you applied for permanent residency?
◉ Canadian	○ Permanent resident since (yyyy/mm/dd) _____	○ Other (country) _____		○ Yes ○ No

Statistical and Administrative Information

Birth year	Gender	Permanent postal code in Canada (i.e. K2P1G4)	Correspondence language	Previous contact with SSHRC? (i.e. applicant, assessor, etc.)
	○ F ◉ M	T6G2G1	◉ English ○ French	◉ Yes ○ No

Full name used during previous contact, if different from above

Contact Information

The following information will help us to contact you more rapidly. Secondary information will not be released by SSHRC without your express consent.

	Country code	Area code	Number	Extension
Primary telephone number		780	492-0572	
Secondary telephone number		780	452-9586	
Primary fax number		780	492-6826	
Secondary fax number				

Primary E-mail: abel@ualberta.ca

Secondary E-mail: abel@ualberta.ca

Personal information will be stored in the Personal Information Bank for the appropriate program.

Checked
Web CV
2016/10/14

Do not photocopy this page.

Family name, Given name

Cadenillas, Abel

Current Address

Use only if you are not affiliated with a department at a Canadian university. (If you are affiliated with a department at a Canadian university, the department's mailing address will be used.) If you wish to use another address, specify it under the Correspondence Address.

Address

City/Municipality | Prov. / State | Postal/Zip code

Country

Correspondence Address

Complete this section if you wish your correspondence to be sent to an address other than your current address.

Address

City/Municipality | Prov. / State | Postal/Zip code

Country

Temporary Address

If providing a temporary address, phone number and/or E-mail, ensure that you enter the effective dates.

Address

City/Municipality | Prov./ State

Country

Start date (yyyy/mm/dd)

End date (yyyy/mm/dd)

Temporary E-mail

Permanent Address in CANADA

Address

Department of Mathematical Sciences
University of Alberta
Central Academic Building 632

City/Municipality: Edmonton | Prov./ State: AB | Postal/Zip code: T6G2G1

Country: CANADA

Temporary telephone/fax number

Country code | Area code | Number | Extension

Do not photocopy this page.

Family name, Given name
Cadenillas, Abel

Research Expertise (optional)

The information provided in this section refers to your own research expertise, not to a research proposal. Filling out the following 4 sections is optional. This page will not be seen by selection committee members and external assessors. This section will be used for planning and evaluating programs, producing statistics, and selecting external assessors and committee members.

Areas of Research

Indicate and rank up to 3 areas of research that best correspond to your research interests as well as areas where your research interests would apply. Duplicate entries are not permitted.

Rank	Code	Area
1	290	Management
2	210	Financial and Monetary Systems
3		

Temporal Periods

If applicable, indicate up to 2 historical periods covered by your research interests.

From			To		
Year	BC	AD	Year	BC	AD
1900	○	◉	2016	○	◉
	○	○		○	○

Geographical Regions

If applicable, indicate and rank up to 3 geographical regions covered by your research interests. Duplicate entries are not permitted.

Rank	Code	Region
1	1000	North America
2	3000	Europe
3	9001	International

Countries

If applicable, indicate and rank up to 5 countries covered by your research interests. Duplicate entries are not permitted.

Rank	Code	Countries	Prov./ State
1	1100	CANADA	
2	1200	UNITED STATES	
3	3206	GERMANY	
4	3224	SWITZERLAND	
5	3208	GREECE	

Curriculum Vitae

Family name, Given name
Cadenillas, Abel

Language Proficiency

	Read	Write	Speak	Comprehend aurally
English	X	X	X	X
French	X			

Other languages
Spanish (fluent); German (basic knowledge).

Work Experience

List the positions, academic and non-academic, you have held beginning with the current position and all previous positions in reverse chronological order, based on the start year.

Current position
Full Professor

Start date (yyyy/mm)
2007/7

Org. code
1480111

Full organization name
University of Alberta

Department/Division name
Mathematical & Statistical Sciences

Position type: (●) Tenured ( ) Non-tenure ( ) Tenure-track ( ) Non-academic

Employment status: (●) Full-time ( ) Part-time ( ) Non-salaried ( ) Leave of absence

Position
Visiting Professor

Start date (yyyy/mm)
2016/3

End date (yyyy/mm)
2016/6

Org. code
9161106

Full organization name
Swiss Federal Institute of Technology Zurich

Department/Division name
ETH Risk Center

Position
Visiting Professor

Start date (yyyy/mm)
2015/9

End date (yyyy/mm)
2015/12

Org. code
9927101

Full organization name
Boston University

Department/division name
Finance and Economics

Position
World Class Univ Distinguished Professor

Start date (yyyy/mm)
2010/6

End date (yyyy/mm)
2013/8

Org. code
1

Full organization name
Ajou University

Department/Division name
School of Financial Engineering

Family name, Given name
Cadenillas, Abel

Work Experience (cont'd)

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Full Professor	2009/7	2011/6

Org. code	Full organization name
1480111	University of Alberta

Department/Division name: Finance and Management Science

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Visiting Professor	2008/9	2009/8

Org. code	Full organization name
9931108	New York University

Department/Division name: Leonard N. Stern School of Business

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Humboldt Research Fellow	2001/7	2002/8

Org. code	Full organization name
9147053	Humboldt University in Berlin

Department/Division name: Institute of Mathematics

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Associate Professor	2000/7	2007/6

Org. code	Full organization name
1480111	University of Alberta

Department/Division name: Mathematical & Statistical Sciences

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Assistant Professor	1996/7	2000/6

Org. code	Full organization name
1480111	University of Alberta

Department/Division name: Mathematical & Statistical Sciences

Family name, Given name
Cadenillas, Abel

Work Experience (cont'd)

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Full Professor	1995/8	1996/6

Org. code	Full organization name
9837111	Instituto tecnologico autonomo de Mexico

Department/Division name: Business Administration

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Rosenbaum Visiting Fellow	1995/1	1995/6

Org. code	Full organization name
9121109	University of Cambridge

Department/Division name: Isaac Newton Institute for Mathematical Sciences

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Postdoctoral fellow or associate	1993/8	1994/12

Org. code	Full organization name
1350911	University of Toronto

Department/Division name: Management

Position	Start date (yyyy/mm)	End date (yyyy/mm)
Postdoctoral fellow or associate	1992/8	1993/7

Org. code	Full organization name
1590111	The University of British Columbia

Department/Division name: Mathematics

Position	Start date (yyyy/mm)	End date (yyyy/mm)

Org. code	Full organization name

Department/Division name:

Family name, Given name
Cadenillas, Abel

Academic Background

List up to 5 degrees, beginning with the highest degree first and all others in reverse chronological order, based on the start date.

Degree type	Degree name	Start date (yyyy/mm)	Expected date (yyyy/mm)	Awarded date (yyyy/mm)
Doctorate	Doctor of Philosophy	1988/09		1992/10

Disc. code	Discipline	Did SSHRC support enable you to get this degree?
99999	Statistics	◯ Yes ◉ No

Org. code	Organization
9931101	Columbia University

Country: UNITED STATES

Degree type	Degree name	Start date (yyyy/mm)	Expected date (yyyy/mm)	Awarded date (yyyy/mm)
Master's	Master of Philosophy	1988/09		1991/02

Disc. code	Discipline	Did SSHRC support enable you to get this degree?
99999	Statistics	◯ Yes ◉ No

Org. code	Organization
9931101	Columbia University

Country: UNITED STATES

Degree type	Degree name	Start date (yyyy/mm)	Expected date (yyyy/mm)	Awarded date (yyyy/mm)
BA Gen.	Bachiller en Ciencias	1979/04		1983/09

Disc. code	Discipline	Did SSHRC support enable you to get this degree?
80100	Mathematics	◯ Yes ◉ No

Org. code	Organization
9725101	Pontificia Universidad Católica del Peru

Country: PERU

Degree type	Degree name	Start date (yyyy/mm)	Expected date (yyyy/mm)	Awarded date (yyyy/mm)

Disc. code	Discipline	Did SSHRC support enable you to get this degree?
		◯ Yes ◯ No

Org. code	Organization

Country:

Degree type	Degree name	Start date (yyyy/mm)	Expected date (yyyy/mm)	Awarded date (yyyy/mm)

Disc. code	Discipline	Did SSHRC support enable you to get this degree?
		◯ Yes ◯ No

Org. code	Organization

Country:

Family name, Given name
Cadenillas, Abel

Credentials

List up to 6 licences, professional designations, awards and distinctions you have received and feel would be the most pertinent to the adjudication of your application. List them in reverse chronological order, based on the year awarded.

Category	Name	Source or Country	Duration (Months)	Value / Year awarded
Academic Prize	Visiting Professorship, Dept Finance, Boston Univ	University UNITED STATES	4	$50,000 2015
Academic Prize	World Class University Distinguished Professorship	Federal Government KOREA, SOUTH	12	$460,300 2010
Academic Prize	J.M. Mitchell Mentorship Award	University CANADA	12	$0 2009
Academic Prize	Visiting Professorship, Stern School of Business	University UNITED STATES	12	$80,000 2008
Fellowship	Humboldt Research Fellowship	GERMANY	12	2001
Fellowship	Rosenbaum Visiting Fellowship, Cambridge	UNITED KINGDOM	6	1995

Research Expertise

The information provided in this section refers to your own research expertise, not to a research proposal.

Keywords

List keywords that best describe your areas of research expertise. Separate keywords with a semicolon.

Mathematical Finance; Financial Engineering; Risk Management; Insurance; Mathematical Economics; Operations Research; Finance; Economics; Management Science; Optimal Contracts; Optimal Dividend Policy; Monetary Policy; Regime Switching; Stochastic Control

Disciplines

Indicate and rank up to 5 disciplines that best correspond to your research interests. Duplicate entries are not permitted.

Rank	Code	Discipline	If Other, specify
1	62600	Management, Business, Administrative Studies	
2	62612	Finance, Banking, Insurance	
3	61023	Mathematical and Quantitative Methods	
4	62632	Quantitative Methods	
5	61011	Macroeconomics and Monetary Economics	

Family name, Given name
Cadenillas, Abel

Funded Research

List up to 8 grants or contracts you have received from SSHRC or other sources. List them in reverse chronological order, based on the year awarded. If you are not the applicant (principal investigator), specify that persons' name.

Org. code	Full name of funding organization	Year awarded (yyyy)	Total amount (CAN$)
3010316	Natural Sciences and Engineering Research Council of Canada	2015	$55,000

Role: Applicant — Completion status: ☐ Complete

Project title: Stochastic Control

Applicant's family name	Applicant's given name	Initials

Org. code	Full name of funding organization	Year awarded (yyyy)	Total amount (CAN$)
3010325	Social Sciences and Humanities Research Council of Canada	2010	$48,000

Role: Applicant — Completion status: ☒ Complete

Project title: Financial Crises and Business Cycles

Applicant's family name	Applicant's given name	Initials

Org. code	Full name of funding organization	Year awarded (yyyy)	Total amount (CAN$)
3010316	Natural Sciences and Engineering Research Council of Canada	2010	$60,000

Role: Applicant — Completion status: ☒ Complete

Project title: Stochastic Control

Applicant's family name	Applicant's given name	Initials

Org. code	Full name of funding organization	Year awarded (yyyy)	Total amount (CAN$)
3010325	Social Sciences and Humanities Research Council of Canada	2006	$86,655

Role: Applicant — Completion status: ☒ Complete

Project title: Optimal Contracts

Applicant's family name	Applicant's given name	Initials

Family name, Given name
Cadenillas, Abel

Funded Research (cont'd)

Org. code	Full name of funding organization	Year awarded (yyyy)	Total amount (CAN$)
3010316	Natural Sciences and Engineering Research Council of Canada	2005	$85,000

Role: Applicant — Completion status: [X] Complete

Project title: Stochastic Control

Applicant's family name	Applicant's given name	Initials

Org. code	Full name of funding organization	Year awarded (yyyy)	Total amount (CAN$)
3010325	Social Sciences and Humanities Research Council of Canada	2003	$66,033

Role: Applicant — Completion status: [X] Complete

Project title: Risk Management and Optimal Dividend Policies

Applicant's family name	Applicant's given name	Initials

Org. code	Full name of funding organization	Year awarded (yyyy)	Total amount (CAN$)
3010325	Social Sciences and Humanities Research Council of Canada	2000	$45,000

Role: Applicant — Completion status: [X] Complete

Project title: Option Pricing & Consumption-Investment Problems

Applicant's family name	Applicant's given name	Initials

Org. code	Full name of funding organization	Year awarded (yyyy)	Total amount (CAN$)
3010325	Social Sciences and Humanities Research Council of Canada	1997	$22,000

Role: Applicant — Completion status: [X] Complete

Project title: Mathematical Finance

Applicant's family name	Applicant's given name	Initials

RESEARCH CONTRIBUTIONS

1. Relevant Research Contributions Over the Last Six Years

1. Refereed Contributions

Book Chapters

* [1] A. Cadenillas (2015): Cash Management, in Tariq Samad and John Baillieul (editors): *Encyclopedia of Systems and Control*, Springer - Verlag, London, appeared online, 4 pages.

* [2] A. Cadenillas (2011): Stochastic Control Methods for the Joint Optimization of the Risk and Dividend Policies of a Firm, in H.K. Koo (editor): *New Trends in Financial Engineering*, IOS Press, Amsterdam.

Articles in Scholarly Refereed Journals

* [1] A. Cadenillas and R. Huaman-Aguilar (2015b): Explicit Formula for the Optimal Government Debt Ceiling, *Annals of Operations Research*, published online in November 2015.

* [2] R. Huaman-Aguilar and A. Cadenillas (2015a): Government Debt Control: Optimal Currency Portfolio and Payments, *Operations Research*, vol 63, number 5, pp. 1044–1057.

[3] A. Bensoussan, A. Cadenillas and H.K. Koo (2015): Entrepreneurial Decisions on Effort and Project with a Nonconcave Objective Function, *Mathematics of Operations Research*, vol 40(4), pp. 902–914.

[4] B. Zou and A. Cadenillas (2014b): Explicit Solutions of Optimal Consumption, Investment and Insurance Problems with Regime Switching, *Insurance: Mathematics and Economics*, vol 58, pp. 159-167.

[5] B. Zou and A. Cadenillas (2014a): Optimal Investment and Risk Control Policies for an Insurer: Expected Utility Maximization, *Insurance: Mathematics and Economics*, vol 58, pp. 57–67.

* [6] A. Cadenillas, P. Lakner and M. Pinedo (2013): Optimal Production Management When Demand Depends on the Business Cycle, *Operations Research*, vol 61, number 4, pp. 1046–1062.

[7] L.R. Sotomayor and A. Cadenillas (2013): Stochastic Impulse Control with Regime Switching for the Optimal Dividend Policy When There Business Cycles, Taxes and Fixed Costs, *Stochastics: An International Journal of Probability and Stochastic Processes* [formerly *Stochastics and Stochastics Reports*], vol 85, number 4, pp. 707–722.

[8] L.R. Sotomayor and A. Cadenillas (2011): Classical and Singular Stochastic Control for the Optimal Dividend Policy When There Is Regime Switching, *Insurance: Mathematics and Economics*, vol 48, issue 3, pp. 344–354.

[9] A. Cadenillas, P. Lakner and M. Pinedo (2010): Optimal Control of a Mean-Reverting Inventory, *Operations Research*, vol 58, number 6, pp. 1697–1710.

2. Other Refereed Contributions

[10] A. Cadenillas (2016): Optimal Investment and Liability Ratio Policies in a Multidimensional Regime Switching Model (joint work with B. Zou), *9th World Congress of the Bachelier Finance Society*, New York City, USA.

* [11] A. Cadenillas (2014): Explicit formula for the optimal government debt ceiling (joint work with R. Huaman-Aguilar), *8th World Congress of the Bachelier Finance Society*, Brussels, Belgium.

* [12] A. Cadenillas (2013): On the Optimal Debt Ceiling (joint work with R. Huaman-Aguilar), *International Conference "Advanced Finance and Stochastics"*, Moscow, Russia.

* [13] A. Cadenillas (2012): Credit Risk with Selection of Effort and Volatility (joint work with A. Bensoussan, H.K. Koo and J. Sung), *7th World Congress of the Bachelier Finance Society*, Sydney, Australia.
* [14] A. Cadenillas (2010): Optimal Production When the Demand is Stochastic (joint work with P. Lakner and M. Pinedo), *INFORMS Annual Meeting 2010*, Austin, Texas, USA.

3. Non-Refereed Contributions

3.A. Invited Conference Presentations:

• Sixth International Institute of Mathematical Statistics - Finance, Insurance, Probability, Statistics Workshop, Edmonton, Canada, July 7 - 9, 2016.
• INFORMS Annual Meeting, Philadelphia, Pennsylvania, November 1 - 4, 2015.
• CORS-INFORMS Joint International Meeting, Montreal, Canada, June 14 - 17, 2015.
• Annual Meeting of the Korean Association of Financial Engineering, Busan, South Korea, August 22 - 23, 2014.
* • 20th Conference of the International Federation of Operational Research Societies (IFORS), Barcelona, Spain, July 13 - 18, 2014.
* • 3rd Rutgers Applied Probability Conference, Piscataway, New Jersey, June 6 - 7, 2014.
* • INFORMS Annual Meeting, Minneapolis, Minnesota, October 6 - 9, 2013.
* • INFORMS Applied Probability Society 17th Conference, Costa Rica, July 15 - 17, 2013.
* • 26th European Conference on Operational Research, Rome, Italy, July 1 - 4, 2013.
* • INFORMS Annual Meeting, Phoenix, Arizona, October 14 - 17, 2012.
* • Conference on Financial Engineering Trends, Suwon, South Korea, August 16 - 17, 2012.
* • 2012 Financial Engineering Research Forum, Seoul, South Korea, July 20, 2012.
* • Ajou International Workshop in Financial Economics and Mathematics, Suwon, South Korea, July 13 - 15, 2012.
* • *Segunda Jornada Internacional de Probabilidad y Estadística, Pontificia Universidad Católica del Perú*, Lima, Perú, February 1 - 3, 2012.
* • INFORMS Annual Meeting, Charlotte, North Carolina, November 13 - 16, 2011.
* • The 8th Conference of Asia-Pacific Association of Derivatives, Busan, South Korea, August 25 - 26, 2011.
* • The 4th POSTECH-Ajou-KAIST Conference in Finance and Mathematics, Pohang, Korea, July 21 - 22, 2011.

3.B. Invited Seminars at Universities or Institutes:

* • Université de Lausanne, Faculté des Hautes Etudes Commerciales (2016).
* • Swiss Federal Institute of Technology (Zurich), ETH Risk Center (2016).
* • Humboldt Universität zu Berlin, Institut für Mathematik (2016).
• Boston University, Questrom School of Business, Department of Finance (2015).
* • New York University, Stern School of Business (2013).
* • The Fields Institute for Research in Mathematical Sciences (2012).
* • National University of Singapore, Department of Mathematics (2012).
• University of Alberta, Department of Computing Science (2011).
* • Vienna University of Economics and Business, Department of Finance, Accounting and Statistics (2010).

4. Forthcoming Contributions

* [1] A. Cadenillas, J. Cvitanić and F. Zapatero (2013): Executive Stock Options as a Screening Mechanism (previous versions were titled "Executive Stock Options with Unknown Executive Type"), *Operations Research*, submitted, 30 pages.

[2] B. Zou and A. Cadenillas (2016): Optimal Investment and Liability Ratio Policies in a Multidimensional Regime Switching Model, *Risks*, submitted, 32 pages.

Note: For all co-authored publications, I have contributed to the modeling and solution of the problems studied in these papers, and well as in the interpretation of the results.

5. Creative Outputs

The South Korean government awarded me a "World Class University Distinguished Professorship in Financial Engineering" in 2010. There are less than 340 scholars in the world who have received a World Class University award (in many different fields). The group of World Class University scholars/researchers includes Nobel laureates (at least 9 of them), Fellows of the Royal Society (UK), members of the Academia Europeae, Humboldt Prize winners, Guggenheim Fellows, members of the National Academy of Sciences (USA), members of the National Academy of Engineering (USA), Fellows of the American Academy of Arts and Sciences (USA), and members of the French Academy of Sciences. As part of this distinction, I visited Ajou University in the summers of 2010, 2011, 2012 and 2013.

2. Other Research Contributions

I was a member of the editorial board of "Mathematics and Financial Economics" until December 2014. The board of "Mathematics and Financial Economics" included famous researchers like Xavier Gabaix (Martin J. Gruber Professor of Finance at Stern School of Business, NYU), Darrell Duffie (Dean Witter Distinguished Professor of Finance at Stanford University), Ivar Ekeland (former Canada Research Chair in Mathematical Economics), George Constantinides (Leo Melamed Professor of Finance at the University of Chicago), José Scheinkman (Theodore A. Wells Professor of Economics at Princeton University), Hans Föllmer (2006 Georg Cantor Medal of the German Mathematical Society), Costis Skiadas (Harold L. Stuart Professor of Finance at Northwestern University), and Leonid Kogan (Nippon Telephone and Telegraph Professor of Management at MIT).

I have been actively involved in the organization of the PhD program in Mathematical Finance, the MSc program in Mathematical Finance, and the BSc Specialization program in Mathematics and Finance at the University of Alberta. Our graduates have been very successful in the job market.

I was a member of the 2011 and 2016 SSHRC Insight Development Grants Selection Committees. I was also a member of the Pre-Selection Committee for the 2016 SSHRC Doctoral Awards Competition.

3. Most Significant Career Research Contributions

* [1] A. Cadenillas, P. Lakner and M. Pinedo (2013): Optimal Production Management When Demand Depends on the Business Cycle, *Operations Research*, vol 61, number 4, pp. 1046–1062.

* [2] A. Cadenillas, J. Cvitanić and F. Zapatero (2007): Optimal Risk-Sharing with Effort and Project Choice, *Journal of Economic Theory*, vol 133, issue 1, pp. 403–440.

* [3] A. Cadenillas, S. Sarkar and F. Zapatero (2007): Optimal Dividend Policy with Mean-Reverting Cash Reservoir, *Mathematical Finance*, vol 17, issue 1, pp. 81–110.

* [4] A. Cadenillas, J. Cvitanić and F. Zapatero (2004): Leverage decision and manager compensation with choice of effort and volatility, *Journal of Financial Economics*, vol 73, pp. 71–92.

* [5] A. Cadenillas and F. Zapatero (1999): Optimal Central Bank intervention in the foreign exchange market, *Journal of Economic Theory*, vol 87, pp. 218–242.

We obtained in [1] the optimal production policy when the demand depends on the business cycle. We developed in [2] a very general model in continuous time for the optimal contract that a principal should offer an agent. In [3] we obtained some surprising results about taxes on dividends. We studied in [4] the incentive effects of granting levered or unlevered stock to a risk-averse manager. We considered a dynamic setting and found that levered stock is optimal for high-type managers, firms with high momentum, large firms, and firms for which additional volatility only implies a modest increase in expected return. We developed in [5] a model in continuous time for the optimal interventions of a Central Bank. My research in all the above five papers was supported by SSHRC.

4. Career Interruptions and Special Circumstances

There were no career interruptions.

5. Contributions to Training

Within the last six years, I have been the only supervisor of three PhD students and one Master student at the University of Alberta. My former PhD student Ricardo Huaman-Aguilar graduated in the Fall of 2015. He is currently a Visiting Scholar (Postdoctoral Fellow) at the Department of Finance, Questrom School of Business, Boston University. My former PhD student Bin Zou graduated in the Spring of 2015. He accepted a tenure-track position at the Assistant Professor level at the Department of Mathematics of the University of Connecticut. This is a position in Mathematical Finance and Actuarial Sciences. Bin asked the University of Connecticut to start his appointment in 2017 instead of 2016, because he wanted some postdoctoral experience. Thus, Bin has been a Postdoctoral Research Fellow at the Chair of Mathematical Finance, Faculty of Mathematics of the Technical University of Munich, and is currently an Acting Assistant Professor at the Department of Applied Mathematics at the University of Washington (Seattle). In September 2014, my MSc student Kevin Wai successfully defended his MSc thesis "Optimal Regulation of Systemic Risk by Tax". After graduation, he became Quantitative Risk Analyst at Canadian Western Bank (Edmonton). I am currently the only supervisor of Wenyue Liu, who is a PhD student in Mathematical Finance at the University of Alberta.

Within the last six years, I have been a member of the doctoral final examination committees of five students at the University of Alberta: R. Huaman-Aguilar, B. Zou, A. Nosrati, J. Deng, and I. Smirnov; and one student at Humboldt Universität zu Berlin: Felix Naujokat. I have also been a member of the examination committees of many Master theses and projects.