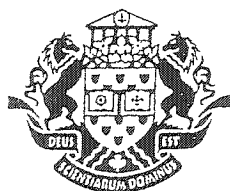


NOTE TO USERS

This reproduction is the best copy available.

UMI[®]



Université d'Ottawa • University of Ottawa



Université d'Ottawa - University of Ottawa

FACULTÉ DE ÉTUDES SUPÉRIEURES
ET POSTDOCTORALES

FACULTY OF GRADUATE AND
POSTDOCTORAL STUDIES

Kirk COLLINS

AUTEUR DE LA THÈSE - AUTHOR OF THESIS

Ph.D. (Economics)

GRADE - DEGREE

Department of Economics

FACULTÉ, ÉCOLE, DÉPARTEMENT - FACULTY, SCHOOL, DEPARTMENT

TITRE DE LA THÈSE - TITLE OF THE THESIS

Essay on Human Capital and Taxation

N. Van Quyen

DIRECTEUR DE LA THÈSE - THESIS SUPERVISOR

S. Winer

CO-DIRECTEUR DE LA THÈSE - THESIS CO-SUPERVISOR

EXAMINATEURS DE LA THÈSE - THESIS EXAMINERS

V. Barham

J. Burbidge

G. Grenier

C. Worswick

J.-M. De Koninck, Ph.D.

LE DOYEN DE LA FACULTÉ DES ÉTUDES
SUPÉRIEURES ET POSTDOCTORALES

DEAN OF THE FACULTY OF GRADUATE
AND POSTDOCTORAL STUDIES

Essays on Human Capital and Taxation

A thesis
submitted to the Faculty of Graduate and Postdoctoral Studies of the University of Ottawa
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in
Economics

by

Kirk A. Collins

The University of Ottawa
Ottawa, Ontario, Canada

© Kirk A. Collins, Ottawa, Canada, 2004



Library and
Archives Canada

Bibliothèque et
Archives Canada

Published Heritage
Branch

Direction du
Patrimoine de l'édition

395 Wellington Street
Ottawa ON K1A 0N4
Canada

395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence

ISBN: 0-494-01682-5

Our file Notre référence

ISBN: 0-494-01682-5

NOTICE:

The author has granted a non-exclusive license allowing Library and Archives Canada to reproduce, publish, archive, preserve, conserve, communicate to the public by telecommunication or on the Internet, loan, distribute and sell theses worldwide, for commercial or non-commercial purposes, in microform, paper, electronic and/or any other formats.

The author retains copyright ownership and moral rights in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

AVIS:

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque et Archives Canada de reproduire, publier, archiver, sauvegarder, conserver, transmettre au public par télécommunication ou par l'Internet, prêter, distribuer et vendre des thèses partout dans le monde, à des fins commerciales ou autres, sur support microforme, papier, électronique et/ou autres formats.

L'auteur conserve la propriété du droit d'auteur et des droits moraux qui protègent cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

In compliance with the Canadian Privacy Act some supporting forms may have been removed from this thesis.

Conformément à la loi canadienne sur la protection de la vie privée, quelques formulaires secondaires ont été enlevés de cette thèse.

While these forms may be included in the document page count, their removal does not represent any loss of content from the thesis.

Bien que ces formulaires aient inclus dans la pagination, il n'y aura aucun contenu manquant.


Canada

ACKNOWLEDGEMENTS

I have been fortunate in my studies to be surrounded by a number of caring and intelligent people. Without their tireless efforts and uncanny ability to keep me on track and not allow me to get discouraged (too much) this work would not have been possible. My brief acknowledgement of their support does not do justice to the amount of hours, days, weeks, months, years, that some have had to put up with me. They each deserve a medal.

First, I would like to thank two professors who came into my life (or more appropriately, I theirs) at a time when I was questioning my economics faith: Jim Davies and Al Slivinski. Both made economics come alive and were instrumental in my decision to go on to graduate school. Little did Jim or I know at the time that it would be the start of a journey that has taken up the better part of the past 6 years.

To say Jim Davies has been a constant figure in my academic life is an understatement. His guidance has been immeasurable in my development as an economist. For this and for the many, many other things he has found the time to help me with, I am truly grateful.

The other members of my thesis committee, Stan Winer and Nguyen Van Quyen, while arriving a little later in my academic career, have also provided me with invaluable assistance over the duration of my doctoral degree. Their tireless effort to do everything necessary to get me out “on time” has been greatly appreciated.

I would also like to thank a number of people who have, in some way or another, helped me out, more often than not in times of need (and in most cases, more than once): Vicky Barham, Gilles Grenier, Rose Anne Devlin, Luce Laviolette, and Irene Pare. I am indebted to each of you. A debt of further gratitude also goes out to two of those listed above, Vicky Barham and Gilles Grenier, as well as Chris Worswick and John Burbidge, who each took the time to read and make very valuable comments on this work.

Finally, I would like to thank the person whom I leaned on the most over the duration of my academic career. She has been my rock, my parole officer, my recess monitor, and in some cases, when mine when on extended vacation, my intelligence and ability to reason. This person

is my wife. While she claims not to be a paid member of the University of Ottawa staff, I must admit at times it felt like she was. They would do well to hire her as a motivational speaker for graduate students or for some sort of graduate student bootcamp. While no more than 105 pounds soaking wet and a sky-scraping height of 5 feet 1½ inches, she has an uncanny ability to put the fear of the Almighty into an individual. Thank the big fellow for this or I would not be writing these acknowledgements presently. She is undoubtedly the best thing that has ever happened to me.

TABLE OF CONTENTS

ACKNOWLEDGMENTS	II
TABLE OF CONTENTS	IV
ABSTRACT	VI
INTRODUCTION	VII
CHAPTER 1: Measuring Effective Tax Rates on Human Capital: Methodology and an Application to Canada	1
<i>1.1 Introduction</i>	2
<i>1.2 Conceptual Framework</i>	5
<i>1.3 Treatment of Human Capital under Canadian Tax and Student Loan Systems</i>	17
<i>1.4 Effective Tax Rates on Undergraduate University Education in Canada</i>	26
<i>1.5 Conclusion</i>	38
<i>Appendix 1A</i>	42
<i>Appendix 1B</i>	45
CHAPTER 2: Tax Impacts on the Incentive to Invest in Human Capital: A Canada - US Comparison	49
<i>2.1 Introduction</i>	50
<i>2.2 Conceptual Framework</i>	53
<i>2.3 Comparison of Canada-U.S. Tax Systems</i>	60
<i>2.4 Effective Tax Rates on First Time University Graduates</i>	67
<i>2.5 Human Capital Policy</i>	76
<i>2.6 Concluding Remarks</i>	79
<i>Appendix 2A</i>	82

CHAPTER 3: Taxation, Human Capital and Tuition Fee Deregulation: A Study of Canadian Universities	84
3.1 <i>Introduction</i>	85
3.2 <i>Methodology</i>	88
3.3 <i>Tax Impacts on Incentive to Invest</i>	93
3.4 <i>Deregulation of Fees: Intended and Unintended Consequences</i>	97
3.5 <i>Education Policy in Canada</i>	104
3.6 <i>Concluding Remarks</i>	107
<i>Appendix 3A</i>	111
CHAPTER 4: The Two-Sided Capital Levy Problem	112
4.1 <i>Introduction</i>	113
4.2 <i>Model</i>	115
4.3 <i>Nash Equilibrium: Existence and Characterization</i>	134
4.4 <i>The Reference Case</i>	143
4.5 <i>The Provision of Public Goods: The Case of Social Welfare Maximization</i>	144
4.6 <i>The Provision of Public Goods When Industry Lobbies are Active</i>	157
4.7 <i>Discussion of the Results</i>	163
4.8 <i>Concluding Remarks</i>	166
<i>Appendix 4A</i>	168
<i>Appendix 4B</i>	175
<i>Appendix 4C</i>	177
<i>Appendix 4D</i>	181
<i>Appendix 4E</i>	190
<i>Appendix 4F</i>	192
<i>Appendix 4G</i>	195
<i>Appendix 4H</i>	197
REFERENCES	199
TABLES	205
FIGURES	227

ABSTRACT

This body of work contains four essays. The first three use a novel approach to measuring the impact that taxation has on individuals' incentive to invest in human capital; specifically, a university education. The final essay uses the results from the first three to explore the capital levy problem in a new light.

Using the framework for effective marginal tax rates (EMTRs) on physical capital, a conceptual framework is developed for measuring similar rates on human capital. Unlike their physical capital counterpart, effective tax rates (ETRs) on human capital are not measured at the margin, but rather are based on the next level of education attainment (e.g. high school vs. university/college). The reason, which is explained in detail, is that the lumpiness of human capital investment matters, unlike for physical capital. Results show that the progressivity of personal income taxation plays a large role in human capital ETRs, as do non-tax policy instruments (e.g. registered education savings plans, tuition and other direct costs to education, education allowances, etc.). Human capital ETRs are nonuniform, like their EMTR cousins, but are lower in magnitude. The results also support the view that the tax structure may influence the incentive for highly educated Canadians to seek employment in the United States, mitigating the brain drain phenomenon.

The final essay looks at the capital levy problem. If capital investments are irreversible, governments can tax these items *ex post* with little (or no) deadweight loss. As a result, smart investors end up investing less in certain types of capital. In the end there is an underinvestment in capital. The problem with this view is that it only describes what happens in the case of *physical* capital investment. Given the importance of *human* capital in today's "knowledge-based" economy, it is imperative that the framework address both of these types of capital. A general equilibrium model is developed. Results support the view that it is more than wages alone that determine migration incentives; the structure of the tax system, public goods, adjustment costs, are all shown to play a role. Simulation results are also provided.

Keywords: Human Capital, Taxation, Effective Tax Rates, University, Brain Drain
JEL Classification: H20, H30, H52, I28, J24

INTRODUCTION

It is widely recognized that we live in a “knowledge based economy” and that human capital is the crucial input. Since the advent of endogenous growth theory in the 1980’s (Romer, 1986; Lucas, 1988) human capital has taken on new appeal. While the central role in the labour market has been understood since at least the early 1960’s (Schultz, 1962; Becker, 1964), today’s models suggest that the externalities arising from human capital can have important spin-off’s that we are only beginning to understand. Whether it is from education, formal training, or innovation, human capital can play a leading role in a country’s economic advancement. This body of work explores how taxation can impact the formation of human capital and the implications this has for human capital policy.

Effective marginal tax rates (*EMTRs*) have been used to study investment in all kinds of physical capital. Using these as a guide, a conceptual framework is developed for human capital. An *EMTR* can be defined as the proportional reduction in the rate of return on a marginal investment, which occurs as a result of a specified set of taxes and (perhaps) subsidies. Studies have shown that *EMTRs* on capital in many countries, including Canada, differ considerably across type and industries (see, e.g., MacKenzie et al., 1997).

In order to gauge how large the impact of taxes/subsidies is on human capital, we can replace the methods used to compute *EMTRs* for physical capital to deal with human capital instead. The problems faced when dealing with human capital are quite different than in the study of physical capital. For example, in calculating *EMTRs* for physical capital one must specify a scenario concerning the determination of market rates of

return. It might be assumed, for example, that Canada is a small player in a perfectly competitive world capital market. In order to pay the world interest rate, a corporation would have to earn a gross rate of return on a debt-financed project sufficient to pay both tax and interest at the world rate. By observing market rates and tax parameters one can infer the before-tax rate of return on a marginal investment. The after-tax return is then found by deducting all taxes. As we shall see, the procedure for human capital is quite different.

In the case of human capital, rather than asking what the tax rate is on a marginal investment, of say, another \$1,000 or \$10,000, the natural question to ask is how heavily the capital produced through an additional period of time spent in education or training will be taxed. Time spent in education or training tends to be “lumpy”. There is little point asking what rate of return an individual who just got their B.A. would earn on an additional month of schooling, or how that rate of return would be affected by taxation. The best approach is to look at how taxation affects the returns to a particular educational program, be it a college diploma, bachelor’s degree, master’s degree, or apprenticeship. The lumpiness of investments in education or training means that it is not effective *marginal* tax rates that we are interested in, but simply effective tax rates (*ETRs*) on the total human capital accumulated in specific educational or training programs. The *ETR* is defined as the gap between gross- and net-of-tax rates of return to a whole program of study. The first three chapters of this work use *ETRs* on human capital as the guiding principle in the analysis.

This first paper, done jointly with James B. Davies of The University of Western Ontario, analyzes the impacts of a wide range of tax provisions on the incentive to invest

in human capital and shows how these effects can be quantified using effective tax rates, or *ETRs*. The approach is illustrated using data for Canada. For individuals with median earnings, *ETRs* on the human capital formed in first-degree university study are sizeable, although not as large as for physical capital in Canada. When the expenditure side and its direct subsidies are also taken into account, the net effective tax rate on human capital becomes negative. The taxation of human capital is far from uniform. *ETRs* vary by income level, gender, part-time vs. full-time study, whether students have loans, number of dependants, and use of sheltered savings plans. Workers at higher percentile levels of the earnings distribution throughout life may face *ETRs* substantially higher than those for low-income workers, as a result of progressive income taxation.

The second chapter examines the impacts that the Canadian and U.S. tax systems have on the incentive to invest in human capital. Also assessed are the implications that the respective tax systems have on North American integration. To illustrate the differences in the two systems effective tax rates (*ETRs*) and subsidy rates (*ESRs*) on human capital are calculated. Findings show that Canadian university graduates face greater human capital *ETRs* than their U.S. counterparts. Results also show that students in Canada face tax side incentives to move to the U.S. after graduation, as indicated by a substantial reduction in their *ETRs*. At the same time, Canadian students who are educated in the U.S. fail to have any such incentives to return to Canada. On the bright side, both countries provide substantial encouragement to invest in human capital on the expenditure side. While the findings do not provide the full picture when it comes to migration decisions, they do provide further insight into an interesting problem for Canadian policymakers; namely, how to keep our best and brightest from leaving.

The third chapter takes the analysis of *ETRs* even further. It examines the impact that the current taxation and expenditure structure in Canada has on individuals' incentives to invest in different fields of study at the university level. Effective tax rates and effective subsidy rates by field of study are calculated. The chapter also examines the impact that deregulation of tuition fees has had on individual incentives to invest in certain programs. To this end we concentrate on three of the top business schools in Canada in an attempt to determine what deregulation has meant for business students. The incentive effect is that rates of return will be unambiguously lower. Findings also show that *ETRs* are quite uniform across the different fields. The range of female *ETRs* is lower, than males, while their rates of return higher. When the expenditure side is taken into account, there is substantial encouragement in all fields to invest in human capital at the university level. Fields with a laboratory component are treated far more favorably.

While effective tax rates have been used to study the impact of taxation on physical capital investment, little work has been done on human capital. By measuring effective tax rates on human capital as well, one can obtain a picture of the overall tax distortions affecting aggregate capital accumulation – that is in both human and physical forms. In addition, the research makes apparent whether the tax system distorts the allocation of investment between these forms of capital. The comparison between Canada and the U.S. also provides a picture of the incentives, created by the tax system, for university graduates to migrate.

Using the work on human capital *ETRs* as background, the final chapter asks what light political economy throws on the tax treatment of human capital. By examining the role political economy plays, we are able to explore the impact that human capital may

have in the analysis of the expropriation of capital when time consistency problems arise in government policy. More specifically, we revisit an issue in economics that has been studied extensively; namely, the capital levy problem.

The capital levy problem is well documented in the public finance literature. If capital investments are irreversible, governments can tax these items with little (or no) deadweight loss. As a result, smart investors end up investing less in certain types of capital. In the end there is an underinvestment in capital. The problem with this view is that it only describes what happens in the case of *physical* capital investment. Given the importance of *human* capital in today's "knowledge-based" economy, it is imperative that the framework address both of these types of capital.

The mobility of people, combined with the portability of human capital, provides a deterrent to the government when deciding how much to tax human capital and, as such, provides important implications for public policy. Likewise, the introduction of lobbying allows otherwise immobile firms to indirectly receive more favorable tax treatment by subsidizing a political party's platform. To study the interaction between these two aspects, mobility of workers and lobbying, a general equilibrium model is developed. Findings show that the introduction of public goods, along with lobbying and mobility play a large role in the determination of the tax mix. The study also bears on how tax structure is determined. The weight given by politicians to welfare maximization, and the make up of the population (capitalists vs. labor), are mitigating factors in this determination.

Chapter 1:

Measuring Effective Tax Rates on Human Capital: Methodology and an Application to Canada¹

¹¹ This paper is done jointly with James B. Davies of the University of Western Ontario. The ideas presented in this paper were collaborated on together. When it came time to write the paper, Jim's original contribution was the first half; specifically, he wrote the Introduction, Conceptual Framework and Treatment of Human Capital under Canadian Tax and Student Loan Systems. The remainder of the paper, Section 1.4, Section 1.5, Appendix 1B, and Tables, was my contribution. We have since made suggestions, additions, and changes to each others' original work. We gratefully acknowledge the support of the Institute for Research on Public Policy. We would also like to thank John Burbidge for helpful comments and for assistance with the earnings data. Responsibility for any errors or omissions is our own.

1.1 INTRODUCTION

Over the last two decades there has been a considerable amount of research on effective tax rates on physical capital. It has been found that these are generally high, and that they vary across types of firms, industries, and types of capital. (See Boadway et al., 1984; King and Fullerton, 1984; and McKenzie et al., 1998.) While the *size* of the impact on investment and its composition is an important question that cannot be addressed simply by estimating tax wedges, these findings have helped to create concern about such impacts. This has added impetus to the movement to reduce capital taxation and to make it more uniform.

While there has also been considerable interest in recent years in the tax treatment of education and training², we do not have estimates of the effective tax rates on human capital. This is a problem since some features of the tax system, e.g. progressivity, tend to discourage human capital formation, while others, e.g. deductions or credits to support education, have the opposite effect. We do not know the net impact, and therefore do not know whether the tax system encourages or discourages human capital; how it treats human capital compared with physical capital; or how effective tax rates on human capital vary across the population.

This paper provides a conceptual framework for measuring effective tax rates (*ETRs*) on human capital, analyzing how the progressivity of personal income taxes interacts with other PIT features, other taxes, and student loan plans. It then provides estimates for the *ETRs* on human capital formed in first degree university studies in

² See e.g. Boskin, 1975; Dupor et al., 1996; Kaplow, 1996; and Heckman et al., 1999.

Canada.³ We find that these are sizeable although not as large as effective tax rates on physical capital, and that they vary considerably across individuals. *ETRs* on human capital in Canada are, on average, greater for males than for females, and increase as we go up the income scale. *ETRs* are lower for individuals who take out student loans, and for those who take advantage of Registered Education Savings Plans (RESP's). There are also differences in *ETRs* created by a number of other tax features. The conclusion is thus that Canada has far from uniform tax treatment of human capital.

In assessing fiscal incentives or disincentives for human capital investment it is essential to take into account the encouragement that governments provide for such investment, on their expenditure side. For a more complete treatment one therefore needs to consider the effective subsidy rate, *ESR*, as well as the *ETR*.⁴ The "bottom line" is given by the *net* effective tax rate, $ETR - ESR$. As we show, this net tax rate is on average negative.

Care must be taken in interpreting the results of our study. This is especially so if one wishes to draw normative implications. First there are some standard considerations from the economics of education. A negative net tax on human capital can, in principle, be justified by positive externalities of education or by capital market imperfections that make it hard for students to borrow. However, while earlier literature claimed to find evidence of large externalities, recent work tends to dispute this (see e.g. Heckman and

³ It would of course be interesting to study *ETRs* on other levels of education, as discussed briefly in the conclusion. These would include the *ETR* on incomplete university education. Estimation of these other *ETRs* is beyond the scope of the present study.

⁴ Note that tax and expenditure systems may have effects on human capital investment apart from those via tax and subsidy rates. For example, if students are liquidity constrained, taxes that are incurred more after graduation - - e.g. income and payroll taxes - - will encourage human capital investment compared with e.g. consumption taxes. Future research may allow us to take these other aspects into account, and also to investigate the quantitative impact of *ETRs* e.g. on students' propensity to obtain university education.

Klenow, 1997; Acemoglu and Angrist, 2000; and the survey by Davies, 2002). Doubt has also recently been cast on the importance of borrowing problems (see e.g. Shea, 2000; Cameron and Taber, 2000). Merit good arguments are sometimes also used. On the other side, to the extent that education represents private consumption rather than an investment the strength of subsidy arguments declines. Going further, if education pays off for individuals due to screening for ability, or because of the status it confers, it is wasteful from a social viewpoint, and should be discouraged. The bottom line that should be taken from economics of education considerations is thus unclear.

Turning to the public finance literature, there are several strands. A variety of studies have endogenized human capital in dynamic models, either in a neoclassical framework (see e.g. Davies and Whalley, 1991; Trostel, 1993; Perroni, 1995; Jones et al., 1997) or with endogenous growth (see e.g. Pecorino, 1993; Jones et al., 1993; Davies et al., 2002). It is well-known that the optimal tax rate on physical capital goes to zero in the long-run in perfect foresight infinite horizon dynamic models (Judd, 1985; Chamley, 1986). A similar result extends to human capital when it is endogenized (Jones et al., 1997). However, results of recent studies suggest that this need not imply zero labor income taxes. Bovenberg and Jacobs (2002) and Davies et al. (2002) both show that education subsidies can be used to counter the disincentive effect of labor income taxes on human capital formation. An important element in our study is to see how complete this offset is in practice. Another interesting recent insight is provided by Nielsen and Sorensen (1997) who show that if the imposition of capital income taxes cannot be avoided there may be excess investment in human capital, which can be combatted by levying progressive labor income taxes. In other words, if the effective tax rate on

physical capital is unavoidably positive, then the optimal tax rate on human capital may be positive as well.

The remainder of the paper is organized as follows. Section 1.2 provides a description of the conceptual framework adopted. In Section 1.3 we examine the treatment of human capital under the Canadian tax system. Finally, Section 1.4 presents our numerical results, and Section 1.5 concludes.

1.2 CONCEPTUAL FRAMEWORK

A common approach in evaluating the impact of factor taxes is to juxtapose effective tax rates on physical capital with tax rates on labor. In this context, if labor income were taxed at a proportional rate of 30%, for example, and the EMTR for physical capital were, say, 20%, it would appear that the tax system discriminates in favor of physical capital. However, as is now well-known (see, e.g., Davies and Whalley, 1991), if the only private cost of education is forgone earnings, a proportional labor income tax is neutral with respect to human capital investment. (It implicitly subsidizes the costs at the same rate it taxes the benefits of education.) In the example given, the tax system would in fact heavily discriminate in favor of human capital. Thus, it is as important to include impacts on investment costs on the labor side as it is on the physical capital side. There is an increasing trend to do this (see, e.g., Mintz, 2001, for Canada). Our purpose here is to highlight the impact of taking these investment aspects into account.⁵

⁵ In the investment context tax burdens may be evaluated on a stock or flow basis. We do our analysis on a stock basis since this facilitates comparisons with the effective tax rate on physical capital. An alternative is to annualize the impacts and express them as a fraction of unit labor costs, that is to put the analysis on a flow basis. Mintz (2001) partially implements this latter approach.

How can one tell whether a tax system provides a net incentive or disincentive for investment? This problem has been analyzed by previous authors for the case of physical capital. Structures, equipment, and inventories are taxed in different ways, and there are also differences across industries and according to how investment is financed. In order to summarize these effects and see how they net out, it has proven fruitful to calculate hypothetical effective marginal tax rates (*EMTRs*) by type of capital, industry, and method of finance. (See, e.g., Boadway et al., 1984; King and Fullerton, 1984, and McKenzie et al. 1998.)

EMTR's on physical capital are high and non-uniform. Looking only at non-personal taxes, McKenzie et al. (1998), for example, find that EMTRs in Canada in 1997 averaged 29.0% on inventories, 19.0% on machinery, 18.9% on structures, and 15.6% on land. The overall average EMTR was 21.8%. Rates within industries ranged from 8.5% in agriculture, fishing and trapping, to 29.5% for public utilities. Largely due to their lower rate of corporate income tax, small firms on average faced an EMTR of only 13.3% while large firms paid 27.0%.

Personal taxation of capital income is also significant and highly non-uniform. Poddar and English (1999) estimate that about 75% of investment income is tax-free at the personal level in Canada - - due to various tax shelters (e.g. retirement savings plans) and other factors such as the non-taxation of imputed rent on owner-occupied housing. On the other hand, tax rates on the interest, dividends, and capital gains that are not sheltered can be quite high. There are no estimates of personal-level *EMTRs* on capital income for Canada. However, most investors would have paid tax on taxable elements of investment income at top marginal rates, which averaged about 46% in Canada in 1997,

including provincial taxes. Applying the Poddar and English result, the average personal EMTR on investment income may then have been about 10%. Added to the McKenzie et al. figure, this suggests an average total (personal plus non-personal) EMTR on physical capital of at least 30%.

While the problem of measuring effective tax rates on human capital is formally the same as that for physical capital, there are measurement issues that make a different approach necessary in practice.⁶ In the case of physical capital one can make plausible assumptions about the rate of return to a hypothetical marginal investment based on observed asset returns in capital markets. Human capital rates of return are not directly observable. For physical capital the fact that real-world investments are typically lumpy does not affect the results. Corporate taxes are levied at a flat rate, so the estimated effective tax rate does not depend on the size of the investment. For human capital the most important tax is the personal income tax, whose graduated rate structure makes the effective tax rate depend on the scale of the investment.

For human capital rates of return can be estimated using microdata on education and earnings over the lifetime. Tax treatment depends on individual circumstances and requires a comparison of the taxes that would be paid in the counterfactual, i.e. without additional education, vs. those paid if extra schooling is obtained. The most meaningful calculation compares the before- and after-tax rates of return to participation in a

⁶ The problems faced when dealing with human capital are quite different than in the study of physical capital. For example, in calculating *EMTR*'s for physical capital one must specify a scenario concerning the determination of market rates of return. It might be assumed, for example, that Canada is a small player in a perfectly competitive world capital market. In order to pay the world interest rate, a corporation would have to earn a gross rate of return on a debt-financed project sufficient to pay both tax and interest at the world rate. By observing market rates and tax parameters one can infer the before-tax rate of return on a marginal investment. The after-tax return is then found by deducting all taxes. As we shall see, the procedure for human capital is quite different.

complete education program, whether it be e.g. community college, undergraduate university study, M.A. or Ph.D. work.⁷ These tax rates are similar to the EMTR's on physical capital in that they measure the effective tax rate on the last meaningful unit of education, but since these units are not small we speak in terms of "effective tax rates" (ETR's) on human capital rather than EMTR's below.

The *ETR* for human capital is defined as the gap between gross- and net-of-tax rates of return to a whole program of study, r_g and r_n , respectively:

$$(1) \quad ETR = \frac{r_g - r_n}{r_g} = 1 - \frac{r_n}{r_g}$$

This definition, which is built on the use of internal rates of return, follows the methodology applied in computing *ETRs* on personal financial assets by Davies and Glenday (1990).⁸

Suppose that an individual aged t is planning to engage in a program of education that will take m years of study. We will assume that after this program is completed the individual will stay in the labor force until age T . Students may continue to earn while going to school. Their wage rates can vary over time, perhaps increasing while they are still in school, and likely rising in real terms over much of the lifetime after graduation.

Actual earnings before-tax are given by E_t , which is the product of the wage rate and

⁷ The situation for on-the-job training is different. (This is one of the reasons that we do not deal with OJT in this paper. It would require a separate study.) One can imagine OJT being provided in quite small units, and the sensitivity of results to the size of the investment becomes less of a problem. This is because the relevant tax on the employer's side, i.e. the corporate tax, is levied at a flat rate, and provided investments are not too large individuals' marginal tax rates will also not be strongly affected by OJT.

⁸ An alternative is to define the ETR as the ratio of the present value of net taxes on labour income over the lifetime to the present value of lifetime earnings. (See Mintz, 2001.) While the two approaches will often produce similar results, this is not always the case. We prefer the approach followed here in part because it does not require any assumption to be made about individuals' discount rates.

hours worked. Earnings before-tax in the absence of the educational program would have been E_t^* , where we assume that $E_t^* < E_t$ in the $T - m$ years after graduation. Forgone earnings costs of education, FE_t , are thus $E_t^* - E_t$ in the first m years. In addition to these costs, there are private direct costs of education, C_t . After-tax variables will be denoted E_t^a , E_t^{a*} , FE_t^a , and C_t^a . Initially we will assume that human capital investments are self-financed, that is that student loans are absent.

Rates of return on the investment described are calculated as internal rates of return. For example, we can compute the gross private rate of return, r_g , from:

$$(2) \quad \sum_{t=1}^T \frac{E_t - C_t}{(1 + r_g)^{t-1}} = \sum_{t=1}^T \frac{E_t^*}{(1 + r_g)^{t-1}}.$$

By replacing E_t , E_t^* , and C_t with the after-tax variables E_t^a , E_t^{a*} , and C_t^a , we could compute the net after-tax rate of return, r_n , using this same equation. Note that in the case of a flat tax with tuition and other direct costs of education deductible $r_n = r_g$, and $ETR = 0$. This is because with such a tax levied at the rate, say, τ , we have

$E_t^a = (1 - \tau)E_t$, $E_t^{a*} = (1 - \tau)E_t^*$, and $C_t^a = (1 - \tau)C_t$. That is, the three variables have the same relative values after- as before-tax. We shall refer to this type of tax system as *neutral* with respect to human capital.⁹ It imposes a zero ETR because the forgone earnings and direct costs of education are implicitly subsidized at the same rate, τ , at which the gains from education are taxed.

⁹ Note that "neutral" is used here in a special sense. We do not imply, e.g., that a tax system that is neutral with respect to human capital is non-distortionary in its treatment of human vs. physical capital. That depends on the effective tax rate on physical capital, and also on whether there are any relevant non-tax distortions (e.g. capital market imperfections).

Note that “neutrality” is used here in a special, and very limited, sense. It is simply a benchmark. There is no implication that a zero *ETR* on human capital is the optimal rate. Externalities of human capital, or capital market imperfections that make it difficult for students to finance their studies, could call for a negative *ETR*. Absent such factors, a non-zero *ETR* could be needed in the second-best solution if there were a positive *EMTR* on physical capital. In that case, while a low *ETR* would avoid depressing investment it would also tilt the playing field away from physical capital investment, causing a distortion in the composition of investment. Clearly, optimal design of the tax treatment of human capital is contingent on any constraints (political or otherwise) on the tax treatment of physical capital.

By replacing private costs with public costs, C_t^p , we can use (2) to compute the public rate of return, r_p . Given r_p we can define the effective subsidy rate (*ESR*) on human capital:

$$(3) \quad ESR = \frac{r_g - r_p}{r_g}.$$

Whether the tax and expenditure systems combined have an incentive or disincentive effect on human capital investment can be investigated by computing the *net* effective tax rate on human capital, $ETR - ESR$. We proceed here by first analyzing the behaviour of *ETRs*, and returning to *ESRs* at the end of the section.

The behaviour of *ETRs* can best be illuminated if we assume, for the sake of illustration, that the length of the schooling program, m , is just one year. Rearrange (2) so all the $t = 1$ terms are on one side and the remaining terms on the other:

$$(4) \quad E_1^* - E_1 + C_1 = \sum_{t=2}^T \frac{E_t - E_t^*}{(1 + r_g)^{t-1}}$$

The left-hand side of (4) represents the private costs of the education program, made up of foregone earnings, $E_1^* - E_1$, and direct costs, C_1 . The right-hand side is the present value of future earning increments due to education, $E_t - E_t^*$.

Again for the sake of illustration, suppose that the yearly benefits of additional education, $E_t - E_t^* - C_t$, are constant. Then because T is typically large we have:

$$E_s^* - E_s + C \approx \frac{E_w - E_w^*}{r_g}$$

where we use subscripts s and w to denote the schooling and working periods. We now have a simple expression for the before-tax rate of return r_g and a parallel expression for the after-tax rate of return, r_n :

$$(i) \quad r_g \approx \frac{E_w - E_w^*}{E_s^* - E_s + C} = \frac{EI}{FE + C}$$

(5)

$$(ii) \quad r_n \approx \frac{E_w^a - E_w^{a*}}{E_s^{a*} - E_s^a + C^a} = \frac{(1 - \tau_w)EI}{(1 - \tau_s)FE + C^a}$$

where FE is forgone earnings and EI is the "earnings increment" achieved due to the extra education. Both FE and EI are before-tax. The tax rates τ_s and τ_w represent the fraction of FE that *would* have been paid in tax, and the fraction of EI that *is* paid, respectively.

If we ignore direct costs for the time being and let $T \rightarrow \infty$ for simplicity we have:

$$(i) \quad r_g|_{C=0} = \frac{EI}{FE}$$

(6)

$$(ii) \quad r_n|_{C=0} = \frac{(1-\tau_w)EI}{(1-\tau_s)FE}$$

Applying (1) the effective tax rate on human capital in this case is:

$$(7) \quad ETR|_{C=0} = \frac{r_g - r_n}{r_g} = \frac{\tau_w - \tau_s}{1 - \tau_s}$$

This simple expression has some interesting implications. It indicates that, in the absence of direct costs, the effective tax rate on human capital is directly related to the gap between τ_s and τ_w . The most obvious possibility is that the graduated rates under personal income tax will make $\tau_s < \tau_w$, resulting in a positive ETR . The gap between τ_s and τ_w will tend to be largest for those education programs that have the biggest impact on earnings. This is one reason that first-degree university education is of particular interest. Not only is it a very important element in our education system, but it is well-known to increase earnings substantially. In contrast, incomplete university education, or graduate education, have smaller effects on earnings, which will result in a smaller gap between τ_s and τ_w . Equation (7) gives reason to expect smaller ETR 's in these cases.

Of course other taxes also affect the ETR . Since social security and unemployment insurance contributions are capped at maximum insurable earnings, their

schedules are regressive. To the extent that contributions represent pure taxes (i.e. not offset by expected benefits), these schemes work towards $\tau_s > \tau_w$ for workers whose *EF*s fall entirely or partly above maximum insurable earnings. It should also be borne in mind that sales taxes reduce real earnings. In the absence of any other taxes, proportional sales taxes on a comprehensive base would give $\tau_s = \tau_w$, that is neutrality. However, some necessities are widely exempt from sales tax in North America and elsewhere (food, children's clothing etc.) or taxed at a lower rate, which reinforces the tendency for $\tau_s < \tau_w$, and a positive *ETR*.

Expressions (6) and (7) also make possible a number of other insights. We note that:

Result 1: If $\tau_s < \tau_w$, equal absolute or equal proportional increases in τ_s and τ_w will reduce $r_n|_{C=0}$ and increase $ETR|_{C=0}$.

This result hinges on the fact that with $\tau_s < \tau_w$, we have $(1 - \tau_s) > (1 - \tau_w)$. Equal absolute or proportional changes in τ_s and τ_w have a greater proportional impact on $(1 - \tau_w)$ than on $(1 - \tau_s)$. The effect is of course stronger in the case of equal proportional changes in the tax rates.

Result 1 is of interest when more than one tax is levied. It points out e.g. that even if a tax would be neutral on its own, when added to an existing system that imposes a positive tax rate on human capital it will increase the size of the tax wedge. If one

perhaps thought of the federal personal income tax as the basic element in the system, then adding even uniform sales taxes or flat-rate provincial income taxes raise the ETR.

Moving to the more general case, we need to take into account tuition and other direct costs; the student loan amount, L ; student loan repayments, iL , where i is the interest rate; the rate of tax relief on student loan payments, d ; and credits for tuition and other expenses, A .¹⁰ Making the appropriate adjustments to the costs and returns we have:

$$(8) \quad ETR = 1 - \frac{r_n}{r_g} = 1 - \left[\frac{(1 - \tau_w)EI - i(1 - d)L}{(1 - \tau_s)FE + (C - L - A)} \right] \left[\frac{FE + C - L}{EI - iL} \right]$$

From (8) we have immediately:

Result 2: Increases in tuition credits, A , or in interest deductibility, d , unambiguously reduce the ETR .

Note also from (8) that the ETR is affected by several *non-tax* policy variables, e.g. tuition fees, student loan amounts, and interest rates on student loans. These interaction effects are perhaps unexpected, and therefore particularly interesting. It should be emphasized that they are independent of the impact of these non-tax variables

¹⁰ How tax relief for education and student loan aspects can be incorporated in the finite lifetime, multi-year schooling case is set out in Appendix 1A. Analytic results are not available for r_g , r_n , or the ETR in that case. The rates of return must be computed from more general versions of equation (2).

on the effective subsidy rate on education. We summarize these effects in Results 3 and 4.

Result 3: A rise in tuition and other direct costs, C , raises the ETR .

The intuition for this result is that if C rises, with education credits A constant, the implicit rate of subsidy to direct costs of education in the tax system has fallen. The result is of topical interest in Canada and other countries, like the U.S., where tuition fees have been rising rapidly in recent years. In the absence of offsetting action in the tax system, such increases raise the tax distortion affecting human capital. Rising tuition fees may also reflect a reduced rate of public subsidy to colleges and universities, meaning that the ESR has been falling. Thus the net effective tax rate on human capital, $ETR - ESR$ tends to rise *a fortiori*.

In the next section we set out the many steps that have been taken at the federal level in Canada in recent years to ease the tax treatment of human capital. These initiatives will have acted to offset the rise in $ETRs$ caused by increasing tuition fees and other direct costs.

The following result reflects the effect of student loans:

Result 4: If $d \geq \tau_w$ the ETR is strictly decreasing in L . If $d < \tau_w$ the sign of the effect of L on the ETR is ambiguous.

Thus, a sufficient condition for an increase in student loans to reduce the effective tax rate on human capital is that the fraction of student loan interest that is creditable should exceed the tax rate on the earnings increment due to education. In the calculations reported in Section 1.4 below we find that this is the direction of the effect in most cases we consider.

We should say a few words about the effective subsidy rate, ESR , which was defined in (3). Note that the ESR depends only on r_g and r_p . It is thus independent of any aspects of the tax system (in a partial equilibrium framework). It can, however, be affected by the presence of student loans, since as we saw in (8) these affect r_g . (Student loans have no effect on r_p , however.)¹¹

Let $\sigma = 1 - C/C^p$ be the rate of subsidy on the direct costs of education. Then, in the absence of student loans, the wedge between r_g and r_p , and therefore the ESR , will be greater the larger σ or C^p , as we can see from:

$$(9) \quad ESR|_{L=0} = \sigma [C^p / (FE + C^p)]$$

which is derived from (3) and 5(i), noting that 5(i) yields r_p if C is replaced by C^p .

Introducing student loans will tend to raise r_g if the student loan interest rate is less than r_g (which is plausible). This is likely to raise r_g relative to r_p and increase the ESR .

¹¹ The public rate of return is similar to the social rate of return. (The only difference is that the public rate of return omits external costs or benefits of education.) From a social viewpoint, whether students take out loans or not has no effect on the costs of, or returns to, education.

1.3 TREATMENT OF HUMAN CAPITAL UNDER CANADIAN TAX AND STUDENT LOAN SYSTEMS

The calculations in the next section incorporate the effects of both the personal income tax system (federal and provincial) and payroll taxes, as they applied after the federal budget of 1998, which made a number of important changes in the tax treatment of education.¹² Here we describe the relevant features of the PIT and payroll tax systems, noting the reforms introduced in 1998 (as well as changes leading up to those reforms) and developments since. We also describe the student loan system as it existed in 1998, and note more recent changes.

Personal Income Tax

A useful benchmark for describing how PIT impinges on human capital is a flat tax system under which direct costs of education or training are fully deductible. Interest on student loans would not be deductible. Under such a neutral system, $ETR = 0$. Canadian PIT departs from neutrality by levying graduated marginal tax rates, in its treatment of direct costs, and (since 1998) by allowing a credit for interest on student loans.

Both federal and provincial PIT are levied on individuals, unlike the U.S. where most married couples are taxed jointly. In 1998, basic federal marginal rates of 17%, 26% and 29% were levied on taxable income in the ranges 0 - \$29,590, \$29,591 - \$59,180, and \$59,181+. (These rates and brackets were in force from 1993 to 1999.) Adding in

¹² In a more comprehensive investigation some other taxes would also be taken into account. In the previous section we remarked on the impact of sales taxes. In addition, corporate income taxes have impacts on human capital formed via on-the-job training. See Collins and Davies (2002).

surtaxes and provincial income tax, the full marginal rates in the three brackets came to about 26, 40, and 46% in 1998 (Canadian Tax Foundation, 1999, Table 3.5). Important deductions made in arriving at taxable income included those for Registered Retirement Savings Plan (RRSP) and Registered Pension Plan (RPP) contributions and child care expenses. Rather than providing personal allowances or exemptions as in most other countries, a system of personal credits was applied. These gave all taxpayers the same relief as if they had received personal deductions but were in the 17% marginal tax bracket. On that basis, the credits given were equivalent to deductions of \$6,456 for the taxpayer and \$5,380 for a dependent spouse or child over 18.

Refundable tax credits for children under 18 were provided via the Canada Child Tax Benefit (CCTB) and the National Child Benefit Supplement (NCBS). The latter were clawed back on family net incomes above \$25,921 and \$20,921 respectively. These programs have little impact on costs of education, since relatively few students have children, but they increase marginal tax rates for many graduates, and will therefore drive up the *ETR* on human capital somewhat.¹³

The tax relief on tuition and other direct expenses provided by the PIT comes in the form of various credits, not as a deduction. In 1998 a credit was given for 17% of tuition and additional mandatory fees paid to approved post-secondary institutions. A further credit equal to 17% of an "education amount" was provided. The education amount was \$80 per month prior to 1996, but was raised in steps to \$200 per month by

¹³ The NCBS was clawed back at rates ranging from 12.1% for one-child families to 26.8% for a family with three or more children. This means that the credit was already clawed back completely for most families at net income of \$25,921, where the CCTB clawback kicked in at rates from 2.5% to 5.0%. The latter relatively low rates mean that the CCTB clawback range is very wide. The clawback affects families with incomes up to \$67,000 - \$75,000. However, since the CCTB clawback rates are relatively low, their impact on human capital *ETRs* would be fairly small.

1998. Since most students have low incomes, these credits would in many cases not be very valuable if they were only available to reduce the student's own tax liability. Their value is enhanced by the fact that any unused portion can be transferred to a spouse, parent or grandparent.¹⁴ Also, in 1997 a carryforward provision for unused education credits was introduced that would allow students to obtain tax relief themselves in later years. These measures ensure that the effective implicit federal subsidy on direct costs of education via PIT is close to being uniform at a 17% rate. Adding in provincial tax, the average rate of relief is about 26%.

Note that the "education amount" credits are not related to actual expenditures, but are simply paid as a lump sum. They are thus similar to a system of student grants. This form of assistance would not have a tax-side rationale under a flat tax, but with progressivity might be advocated as a rough offset to the effect of graduated marginal tax rates on human capital *ETRs*.

The PIT system also provides assistance for education and training via registered savings plans. First, Canadians are able to withdraw funds from their RRSPs without penalty two years after contributions are made. This means that, assuming contribution limits are not binding, parents could save for their children's post-secondary education via their RRSP's. While this avenue is no doubt sometimes chosen, it is not as attractive as it might be since RRSP contribution limits have been held at relatively low levels.¹⁵

¹⁴ That is, up to a limit of \$5,000 minus the part of the credit used by the student to reduce his/her tax liability to zero.

¹⁵ The current contribution limit for RRSPs plus Registered Pension Plans is the lesser of \$13,500 or 18% of earnings per year. The dollar limit is slated to rise to \$14,500 in 2004 and to \$15,500 in 2005, after which it will be indexed to the average industrial wage. These levels represent a significant retreat, however, from those promised by earlier federal budgets. The 1984 and 1985 budgets promised a limit of \$15,500 by 1990, with subsequent indexation.

Also, withdrawals are taxed. Parents will typically be in their peak earning years when their kids go to college, and will therefore face high tax rates on withdrawals. This will also make the RRSP saving route less attractive.

Parents are encouraged to save for their kids' education via Registered Education Saving Plans (RESP's). In contrast to an RRSP, contributions to an RESP are not tax deductible. However, income earned within the plan is tax free, and if the proceeds are spent on the child's education withdrawals of accrued income enter the child's income for tax purposes. Given that post-secondary students are generally in low tax brackets, the result is that the net of tax rate of return on RESP saving generally exceeds that on non-sheltered saving.¹⁶ While RESP's provide a higher rate of return than on non-sheltered saving, in the pre-1998 regime they were not sufficiently attractive to induce much use. This may have been due to the opportunities for fully sheltered saving (e.g. via RRSPPs) or because a higher rate of return could be achieved by paying down mortgages and consumer debt.¹⁷

The 1996, 1997 and (especially) 1998 federal budgets introduced a number of changes intended to reduce burdens on post-secondary students and to stimulate education and training in Canada. The following were the principal changes:

1. The 1996 and 1997 budgets announced that the education amount would be raised from its original \$80 per month to \$150 per month in 1997 and \$200 per month in 1998.

¹⁶ Since withdrawals are generally taxed at a low rate, RESP's approximate Roth IRA plans in the U.S., which have non-deductible contributions and tax-free withdrawals. Greater use of this type of sheltered saving has been urged for Canada by e.g. Kesselman and Poschmann (2001).

¹⁷ In Canada interest on mortgages and consumer debt is not tax deductible. This makes paying down these forms of debt a popular form of saving for those in the age range of about 25 – 45.

2. The education amount was extended to part-time post-secondary students in the 1998 budget, at \$60 per month. Part-time students also became eligible to claim child care expense deduction (CCED) for the first time, up to \$2,200 per year.

3. Canada Study Grants (CSG's) of up to \$3,000 per year were created in the 1998 budget for both full- and part-time students in financial need who had children or other dependants.

4. Interest on student loans became eligible for a tax credit at the 17% rate in the 1998 budget.

5. Tax-free withdrawals of up to \$10,000 per year (\$20,000 in total) from RRSPs were introduced in the 1998 budget to finance full-time training or education (or part-time for disabled people). These withdrawals must be repaid within 10 years.

6. The 1996 and 1997 budgets raised the annual contribution limits on RESPs from \$1,500 to \$4,000 per student, and also increased the lifetime limit on contributions from \$31,500 to \$42,000. The 1998 budget introduced Canada Education Saving Grants (CESGs) equal to 20% of RESP contributions up to a limit of a \$400 annual grant per student. CESG amounts become part of the RESP. The 1998 budget also made it possible to transfer an RESP balance to an RRSP if the student did not go on to qualifying study after leaving high school.

All of these provisions act to increase the net-of-tax expected return to planned or actual human capital investment for some taxpayers.¹⁸ Note, however, that the incidence of the increased returns varies greatly. Increased education amounts raise r_n for almost all

¹⁸ The RESP and RRSP provisions might be seen as raising the rate of return to financial assets. However, the benefits in question are only realized as a result of planned or actual human capital investment. They are therefore regarded here as increasing the net expected return on *human* capital.

students. On the other hand, interest credits benefit only those with student loans, and the RESP/RRSP provisions have similarly limited incidence. Note also that the value of the RESP/RRSP measures will vary substantially even among those who make use of these savings plans. CESG's are proportional to RESP contributions; the benefit of RESP saving depends on how attractive is the after-tax rate of return on the next-best saving vehicle; the value of the option to rollover unused RESP funds into an RRSP depends on how likely it is that education plans will fall through; and the benefit of being able to take money out of an RRSP temporarily to finance education depends on the size of the tax rate thereby avoided.

Since 1998 the most important PIT changes affecting human capital have been (i) a doubling of the education amounts in the 2001 tax year (to \$400 and \$120 per month for full-time and part-time students respectively), (ii) reductions in federal tax rates and changes in the rate structure, and (iii) the freeing-up of provincial PIT rate structures.¹⁹ By the 2001 tax year the federal government had moved from its sharply graduated three bracket rate structure to more gradual progressivity. Federal rates were applied at the rates of 16, 22, 26, and 29% on taxable income in the ranges 0 - \$30,754, \$30,755 - \$61,509, \$61,510 - \$100,000, and \$100,000+. All federal surtaxes had been removed. Including provincial taxes, full marginal rates in the four brackets were 24%, 33%, 40%, and 44%. The reduced progressivity should reduce human capital ETR's somewhat.

Prior to the 2001 tax year all nine provinces that were signatories to the federal-provincial tax collection agreements were bound to levy their basic PIT as a flat % of the

¹⁹ A further change that could have a significant effect on human capital ETR's in the long-run was the re-indexation of federal brackets, credits and deductions announced in the February 2000 budget. Lack of indexation erodes the progressivity of the tax system over time, as more and more taxpayers' rising nominal

basic federal tax. Quebec levied and collected its own separate PIT. Under this arrangement, federal surtaxes did not affect provincial PIT, and the provinces were free to enact their own surtaxes and credits additional to those provided by Ottawa. While in the 1970s and 80s provincial PIT payments could broadly be thought of as proportional to federal, by 1998 this approximation was becoming strained. Some provinces, notably Ontario, levied surtaxes, and a wide range of provincial credits were provided, e.g. for provincial political contributions, qualifying investments, property and sales taxes, and dependent children. Finally, the Quebec rate structure was somewhat less progressive than the federal structure, featuring marginal rates of 17%, 21.25%, and 24.5% on taxable incomes of 0 - \$26,000, \$26,001 – \$52,000, and \$52,000+ in 2001, for example.

Beginning in 2001 provinces covered by the tax collection agreements are free to levy tax as a function of federal taxable income rather than basic federal tax. This has already led to significant differences in rate structure across the provinces, and divergence from the federal structure. While six provinces kept the three-bracket structure for 2001, New Brunswick followed the federal lead to create a new \$100,000+ bracket. Alberta introduced a flat tax at a 10% rate. British Columbia introduced five brackets, with the top one beginning at \$85,000.

Payroll Taxes

In 1998 employees and employers each paid Canada Pension Plan (CPP) contributions at a rate of 3.2 % on earnings, with a cap reached at maximum pensionable earnings of \$36,900. Employment insurance (EI) contributions were paid at a rate of

incomes push them into the top tax brackets. This may create a tendency for human capital ETR's to fall over time in a non-indexed system.

2.7% by the employee and 3.78 % by the employer, on earnings up to \$39,000. For workers whose earnings did not exceed \$36,900 the payroll rate structure was mildly progressive, since the first \$3,500 of earnings were not subject to CPP contributions. However, for middle and high earners, the system was clearly regressive. This regressivity should offset the positive effect of PIT progressivity on human capital *ETRs* to some extent.

Student Loan Plans

Both the provinces and the federal government help students to finance their education by providing guaranteed student loans. The provinces are responsible for administration. Attempting to take into account variations in provincial plans is beyond the scope of this study. Here we have modelled the effects of the Canada and Ontario Student Loan Plans (CSLP and OSLP). The results should be reasonably representative for the country as a whole since the federal and provincial governments instituted reforms in 1995/96 to achieve a fairly high degree of standardization (see e.g. Finnie and Schwartz, 1996).

The CSLP/ OSLP system allows students to take out loans up to a limit which equals allowable education expenses minus the student's expected contribution. The latter is calculated taking family resources and dependants (e.g. children of a single parent) into account. Maximum loan amounts are \$165 per week from the federal government and about \$110 per week from provincial governments, for a total of \$9,350 over a 34 week school year. Importantly, interest is paid by the government sponsors of the plan until six months after graduation. Beyond that point the loans must normally be

paid back within a period of 9½ years. Finnie (2001) finds that graduates, on average, pay the loans back quite quickly. Statistics Canada's National Graduate Survey (NGS) found that for 1995 first-degree university graduates (the latest cohort for which figures are available) about 40% of debt had been repaid after two years (Finnie, 2001, Figure 4).

In recent years student loans have become controversial, for two reasons. First, the default rate has been growing, and there have been concerns that defaulters are treated too leniently. Second, there has been some alarm at reports of substantial accumulated debts. A wide range of average amounts of debt have been reported in the media, with differences depending on which students are included, whether the average is taken for just those students in debt or for all students, and so on. According to the Department of Finance (1998), for a typical graduate with student loans, debt loads following a four-year post-secondary program averaged \$13,000 in 1990-91, and could be expected to rise to \$25,000 in 1998-99. On the other hand, the NGS results show average debt of only about \$10,000 for 1990 grads with loans and \$13,600 for 1995 grads. The incidence of debt in the NGS was about 46% for both the 1990 and 1995 graduates (see Finnie, 2001, Figure 1).

In order to prevent students defaulting on their loans, prior to 1997 those who could demonstrate financial hardship received up to 18 months of interest relief. In 1997 relief was extended to 30 months. The February 1998 budget extended the maximum period of interest relief to 54 months. In order to qualify for full interest relief gross earnings had to be less than \$22,300 as of April 1998.²⁰ (Prior to this the cutoff had been

²⁰ The budget also introduced partial interest relief on a sliding scale for those whose incomes exceeded the threshold for full relief by a small amount.

\$20,460.) And in order to go from 30 to 54 months' relief individuals had to qualify as still being in financial hardship after their loans had been rescheduled to cover a 15 year period. Finally, for those individuals who still remain in financial difficulties, the government will reduce the loan principal if annual payments exceed, on average, 15 % of income. Maximum assistance is limited to the lesser of \$10,000 or 50% of the loan. To qualify, five years must have passed since the completion of study and normal interest relief must have been exhausted.²¹

Together with the tax provisions discussed earlier, the CSLP changes in the 1998 budget substantially increased support for post-secondary students. The modified CSLP can be viewed as a crude income contingent student loan plan. The expectation is that the majority of students will pay off their loans in full, but very sizeable reductions in the effective burden of student loans will be provided to a significant group with low incomes.

1.4 EFFECTIVE TAX RATES ON UNDERGRADUATE UNIVERSITY EDUCATION IN CANADA

Data and Assumptions

In order to gauge the typical size of *ETR*'s in Canada we compute representative values of the net- and gross-of-tax rates of return, r_n and r_g . To do this we use Statistics Canada's 1995 Survey of Consumer Finance (SCF) to model actual and potential earnings, E_t and E_t^* , before- and after-tax. We perform our calculations as if the 1995

²¹ The February 1998 budget also announced a billion dollar Millenium Scholarship Fund, which may reduce the need for student loans somewhat. Finally, in view of the provisions to assist repayment, it was ruled that student loans would survive bankruptcy for 10 years after the completion of studies.

cross-section was a snapshot from an economy in steady state.²² From this dataset we took median earnings (and other quantiles) of full-time male and female workers conditioned on the highest completed level of schooling being high school or a bachelor's degree, as the basis for E_t^* and E_t respectively.²³ We have used median rather than mean earnings since we wish to investigate rates of return and *ETRs* for an “average” student. Since earnings are positively skewed the mean is above the median and is not representative for the typical student.

The estimation of E_t , E_t^* , and their differential is clearly critical. This requires specification of a counterfactual scenario. How much would the university graduate have earned if he/she had stopped formal education after high school? Our counterfactual says they would have received the median amount earned by high school graduates of the same age and gender. Some authors have argued that university graduates have greater ability and that an ability differential (typically 10 or 15%) therefore needs to be applied to the earnings of high school graduates when forming the counterfactual (see, e.g., Stager, 1994). We take a comparative advantage view, in which it is not necessarily clear that the median university graduate would have earned more than the median high school grad if his/her education had been terminated after high school.²⁴

²² While this assumption is not completely innocuous, the Canadian earnings distribution was in fact very stable in the 1990's. There was little per capita earnings growth, and relative dispersion trended upward only mildly. Under these circumstances, students' forecasts of the earnings gains from education at later ages might not have been markedly different from current differentials.

²³ We also examined individuals with “some post-secondary” education. This group includes those obtaining a community college diploma, but also students who attend university for some time without graduating. Due to difficulty in estimating costs and the fact that this group is not representative of community college graduates we do not show results for this group.

²⁴ Studies have shown that skill-levels among university graduates are not equivalent and that many have ended up taking jobs which were predominantly held by high school graduates previously (see, e.g. Pryor and Schaffer, 1997). Therefore, to assume a positive ability differential could be somewhat misleading.

An alternative to our approach would be to estimate human capital earnings equations, and to form the counterfactual by reducing the value of the years of schooling variable for university graduates. This approach would allow more variables that affect earnings to be held constant than are controlled in our approach. We hold constant age, gender, and hours of work. The additional variables that could be controlled for in a regression approach could include e.g. occupation, industry, region, union membership, marital status, and fertility. While the results of such an exercise would be of interest, we believe there is reason to prefer our approach. Holding these additional variables constant would be inappropriately restrictive. High school and university graduates differ in occupation, industry, region, and so on, in part *because of* their different levels of education. The reason for obtaining a university degree is often to enter an occupation that would otherwise be inaccessible, and reaping the advantage of one's degree often means moving to a different industry or region. Thus, we do not see being able to hold constant a set of additional characteristics in comparing high school vs. university graduate earnings as an advantage. We are interested in the total, rather than the partial impact of education.

We have specified costs and tax features, as far as possible to be those prevailing in the academic year 1997-98.²⁵ In 1997-98 undergraduate Arts tuition (representative for core university programs and likely for median graduates) averaged \$3,253, and additional fees \$342, according to Statistics Canada. Other direct expenses (books,

²⁵ Using 1997-98 for this purpose allows us to capture the large increases in tuition fees, and the major tax changes that occurred over the period 1996 - 1998. When we performed this research the most recent SCF data we could obtain on earnings were for 1995. We do not regard the slight mismatch in dates as a significant problem since male earnings in Canada were changing very slowly in the mid 1990s. Our detailed assumptions, as well as references to data sources, are set out in Appendix 1B.

supplies, and return transportation to the educational institution) were assumed to be \$1,000 per year. Thus we estimate total direct expenses to have averaged \$4,595.

In addition to distinguishing between men and women, the calculations we report below consider part-time and full-time students separately. Full-time students are assumed to work the equivalent of four months per year, during which they would earn the same amount as a high school graduate. As in previous studies we reduce these earnings somewhat (by 20%) to allow for unemployment and job search.²⁶ Part-time students are assumed to earn their degrees in six years, as opposed to four for full-time students. We assume that they work year-round - - part-time during the winter months and full-time during the summer. They are assumed to earn half as much as if they were employed full-time year round.

In modelling the taxes paid by workers after graduation we have assumed that they do not claim a credit for a dependant spouse, and in the main results ignore the tax consequences of children. The incidence of dependant spouses has been declining rapidly in recent years, and we expect will be very low over the lifetimes of recent graduates. Ignoring the tax consequences of children leads to an overstatement of tax burdens over the working lifetime, but only a small error in the calculation of the taxes paid on the incremental earnings due to education, as we argued in the last section. We do take the tax treatment of children into account when considering the situation of single parents.

²⁶ Morisette (1998, p. 32) reports that the unemployment rate for all men aged 17 to 24 in 1996 was 14.8%. In addition, 5.3% had involuntary part-time employment, for a total of 20.1% who did not have full-time employment.

We make no allowance in our main results for deductions from income after graduation. (Personal credits and credits for interest on student loans where appropriate are taken into account.) The principal deduction that could potentially be modelled is that for RRSP/RPP contributions. However, this would be misleading since our calculations only consider earnings over the working lifetime. If we took the tax relief on RRSP/RPP contributions into account we would have to also model the tax paid on withdrawals. Ignoring both contributions and withdrawals should be approximately offsetting. Deductions for RESP contributions are taken into account when we model the impact of CESGs.

Results

Results from our base case are shown in Table 1.1. This case uses the 1998 tax system (i.e. as modified by the 1998 federal budget) and assumes a single student with no dependants who finances his/her education without the help of a student loan or an RESP. The estimated rates of return are lower than those found by Vaillancourt (1997) and Stager (1994) using 1991 Census data. Whereas we find the net-of-tax private rate of return was 7.9% for male full-time university students, and 12.6% for female, Vaillancourt found figures of 12.3 and 16.1%. Stager obtained private rates of return of 13.8% for men and 17.6% for women. Aside from using more recent earnings data, and incorporating the effects of higher tuition fees, our study differs from the two earlier studies by using median rather than mean earnings, and by assuming retirement after age

60 rather than 64 (in order to reflect the move to earlier retirement). These differences act to produce lower estimated rates of return.²⁷

[Table 1.1 to appear about here.]

A notable feature of these results is that, as in previous studies, the rate of return is considerably higher for females than for males. The reason is that the earnings of women with a university degree are much closer to those of their male counterparts than is the case for workers with only high school. We also find somewhat lower rates of return to part-time than to full-time study. This difference is due mainly to the delay by two years of the earnings benefits of study for the part-timers (since they remain in school that much longer).

Table 1.1 shows a relatively small difference between gross and net private rates of return for university graduates. The proportional difference is, of course, the effective tax rate. At 19.3% and 11.9% for full-time male and female students respectively, the *ETRs* indicate that, in the no-loan no-RESP case, human capital investment is not taxed as heavily as physical capital. (Recall our earlier discussion of the McKenzie et al., 1998, results.) The difference in *ETRs* for men and women reflects the impact of progressivity. Male university graduates still earn more than women, and on their earnings increments due to education are therefore taxed more heavily on average. *ETRs* for those who attend

²⁷ The use of medians tends to give lower estimated rates of return because the gap between median and mean earnings rises, both absolutely and proportionally, over the lifetime. Thus our estimates of forgone earnings are closer to those of Vaillancourt and Stager than our estimates of the earnings gain accruing over the working lifetime.

part-time are higher because they spend more time working while going to school, leading to a higher marginal tax rate on their forgone earnings.

Turning to Table 1.2 we see the effects not only of taxes, but also of subsidies to universities. The second column shows, again, the gross-of-tax private rate of return, which does not take subsidies into account. The first column figures in the direct costs of university education which are funded by government and which do not enter the private calculation.²⁸ An effective subsidy rate (*ESR*) can be calculated as the proportional difference between these rates of return. We find that the subsidy rates obtained are greater than the effective tax rates shown in Table 1.1 for all cases.²⁹ We thus find a negative net effective tax rate, $ETR - ESR$, as shown in the last column of the table. This would imply that overall the public sector *encourages* human capital investment - - a conclusion that is in line with the results of earlier studies and that will be strengthened by taking into account student loans and other forms of special assistance to post-secondary students analyzed below.

[Table 1.2 about here]

²⁸ In estimating direct costs one must keep in mind that part of universities' costs are incurred for graduate education, research, and other non-instructional purposes. No estimates are available that separate these functions from undergraduate education. Tenure-track university professors are typically expected to devote 40 - 50% of their time to teaching, including graduate teaching. We think a reasonable guess is that about 30% of operating costs are incurred for undergraduate education. Estimates are also not available for capital costs (interest, depreciation etc.) on a national basis, but Stager (1994) estimates that capital costs are about 60% of operating costs. On this basis we have a figure of 50% ($\cong 1.6 \times 30\%$) of operating costs as an estimate of total direct costs of undergraduate university education.

²⁹ The significance of the small variations in the subsidy rate across cases in Table 1.2 should not be exaggerated. We assume the same tuition fees for male and female students, and are simply pro-rating in our treatment of part-time students. There are no doubt differences in programs of study across these different groups that imply further differences in subsidy rates. Capturing these effects is beyond the scope of our study.

Next we take into account the impacts of student loan financing on private rates of return and *ETR*'s. As Table 1.3 shows, both gross and net private rates of return increase with the student loan amount. The reason for this increase lies mainly in the fact that interest is not paid until graduation, providing a subsidy that of course increases with the size of the loan.³⁰ The net rate of return is more strongly affected because the implicit subsidy is larger relative to after-tax than before-tax earnings. The result is that, even without interest deductibility, providing student loans would reduce the effective tax rate significantly. This aspect is reinforced by the provision of interest deductibility on student loans. Both effects are present in Table 1.3. For males the tax rate declines from 19.3% in the no loan case to just 17.2% with \$15,000 in loans. For females, the drop is even larger: from 11.9% to 8.3%.

[Table 1.3 about here]

Table 1.3 illustrates another interesting point. As we increase the loan amount up to \$15,000 there is a roughly linear decrease in the *ETR*. But, when the loan is raised to \$30,000 there is a larger decline in the *ETR*. In the female case, for example, the *ETR* becomes negative, falling to -3.4%. The reason is that in Ontario a student with a \$30,000 loan would qualify for loan forgiveness on \$2,000 of the principal. Once again, the effect on the estimated rates of return is higher for the net- than for the gross-of-tax

³⁰ We assume a student loan interest rate of 9%, which is at the centre of the range of rates paid in June 1998 (see Appendix 1B). Since this rate is of similar magnitude to our estimated rates of return to a university degree, the benefit of student loans does not come principally via a low interest rate after graduation.

return. In fact, the difference in these impacts is so large that we obtain a negative effective *ETR*.

The single female parent case reported in Table 1.3 shows that family status may significantly affect tax impacts on education in Canada. The gross rates of return for a single female parent are taken to be the same as those for a woman without children, but the net rates of return are lower since after-tax forgone earnings are enlarged by the child care expense deduction. The result is that the *ETR* is higher for a single parent. Also note that the *ETR* falls less rapidly as the student loan amount is increased than in the case without dependants. This is because before- and after-tax forgone earnings are more similar for the single parent, so that loan benefits do not differ greatly in relative importance between gross vs. net of tax calculations.

The second to last column of Table 1.3 shows the impact of student loans on the expenditure side. The *ESR* rises quite strongly with the loan amount, increasing from 25.1% without loans to 29.6% with a \$15,000 loan for males, and from 27.6% to 35.2% for females. Putting the impacts on the *ETRs* and *ESRs* together, a \$15,000 student loan decreases the net effective tax rate, $ETR - ESR$, from -5.8% to -12.3% for males and from -15.6% to -26.9% for females. At a rough guess, these numbers suggest that the median $ETR - ESR$ for all students may have been about -9% for males and -21% for females in 1998.³¹ For males and females together median $ETR - ESR$ may then have been around -15% . This represents fairly significant encouragement of human capital

³¹ The discussion in the last section indicated that by 1998 it would be reasonable to expect about half of graduates to have had student loans and the average amount to have been about \$15,000. We take an average of the *ETRs* for zero vs. \$15,000 debt.

investment, especially when we bear in mind our earlier conclusion that the average *EMTR* for physical capital in Canada likely totalled at least 30%.

Table 1.4 shows part-time results corresponding to the full-time case shown in Table 1.3. In the part-time case we find that the size of loan has little impact on the *ETR*. This is because part-timers pay interest on their student loans from the time they are taken out, rather than benefiting from zero interest payments until six months after graduation like full-time students.

[Table 1.4 about here]

Table 1.5 shows results for full-time university students with interest relief. In order for individuals in our calculations to qualify for 18 or 30 months of interest relief it is sufficient that their earnings should be 2/3 of median after graduation. Rates of return are accordingly lower for this group than for the median achievers studied in Tables 1.1 – 1.3. We see that providing interest relief has relatively little impact on the calculated effective tax rates. A similar outcome is found for part-time students (see Collins and Davies, 2002).

[Table 1.5 about here]

Next we study the effects of Canada Education Savings Grants (CESG's).³² As of Jan. 1, 1998, Canada Education Saving Grants (CESGs) add 20% to RESP contributions

³² We do not attempt to estimate the impact of RESP's *per se* on the *ETR*'s since the effects vary greatly across taxpayers depending on their use of RESP's vs. other saving vehicles. Also, prior to the introduction of CESG's, RESP's were not very popular. Thus we believe the most important effect to study is that of CESG's.

annually, up to a grant limit of \$400 per child. Net-of-tax rates of return rise and effective tax rates decline. In the case of full-time male university students, for example, Table 1.6 indicates that the ETR drops from 19.3% to 15.9% when parents make \$650 annual contributions over a 15 year period. If maximum contributions (\$2,000) are made, the ETRs fall much further - - to just 7.9% for full-time males and - 2.3% for full-time females. Effects for part-time students are also large. These results show that CESGs may have a very powerful effect as they accrue over the coming years.

[Table 1.6 about here]

Table 1.7 replicates the Table 1.1 case (no student loans and no RESP's), assuming alternatively that the graduate earns at the 25th or the 75th percentile of the earnings distribution, rather than at the median.³³ We see that for males there is a drop in rates of return and the *ETR* of going to the 25th percentile case from the median; and there is an increase in going to the 75th percentile. The net-of-tax rate of return varies from 5.4% for the 25th percentile earner to 9.9% at the 75th percentile, compared with 7.9% for the median male in Table 1.1. The *ETR* ranges from 10.9% to 24.1%, compared to 19.3% for the median.

[Table 1.7 about here]

For women, rates of return are also lower at the 25th percentile than at the median. The net-of-tax rate of return for full-time students is 8.5%, for example, vs. 12.6% at the

³³ Our counterfactual remains that the university graduates would have earned the median amount if they had finished their formal education after high school. It is possible that this exaggerates both rates of return

median. The *ETR* is also lower, at 7.0% vs. 11.9% in the base case. However, when we move to the 75th percentile the rates of return rise less, proportionally, than for males, reflecting a less skewed distribution of earnings (and therefore lower peak tax rates on earning gains) among female graduates. The *ETR* rises only to 18.6% at the 75th percentile, compared to 24.1% for males.

The Table 1.7 results indicate the impact of the graduated rates in the tax system. Effective tax rates on human capital investment rise with the lifetime earnings of graduates. Another way of putting this is that the net-of-tax rates of return on human capital investment are depressed more for high earners.

In order to get a complete assessment of the incentive effect on human capital formation one must of course deduct the *ESR* from the *ETR*. Looking back at Table 1.2 we see that if the graduates at the 75th percentile had the same *ESRs* as median workers, the *ETR* – *ESR* figures for males would be – 1.0% and 1.0% for full-time and part-time students respectively. Those for females would be – 9.0% and – 5.7% for full-time and part-time. However, the assumption that the *ESRs* at higher percentiles are the same as at the median may be incorrect. The highest paid graduates are those in professional programs like engineering and medicine, which in 1997-98 were still more heavily subsidized than general arts and science programs. Vaillancourt (1997) finds that the difference is sufficient that the net subsidy rates (i.e. *ESR* - *ETR*) in 1990 were highest in science, engineering and medicine and lowest in the humanities and social science.³⁴

and *ETRs* somewhat for those at the 75th percentile and has the opposite effect at the 25th percentile. For this reason the results by income level may be less reliable than those at the median.

³⁴ The net subsidy rates implied by Vaillancourt's 1990 results for males are 17.6% in medicine, 10.6% in engineering, 6.0% in natural science, 2.2% in social science and 0.6% in humanities. These figures represent the difference between private and public rates of return in Panel B of Vaillancourt's Table 3, p. 6.

Finally, we have generated results (not shown) corresponding to Tables 1.1, 1.3, and 1.4 for the tax system as it existed in 1997, that is prior to the major changes of the February 1998 federal budget. We found that the difference in 1997 vs. 1998 results for full-time students without student loans or RESPs were small. These differences come from the fact that the education amount was just \$150 per month in 1997 for full-timers compared to \$200 per month in 1998. After-tax rates of return were slightly lower, and ETRs slightly higher, in 1997 for part-timers however, since they received no education amount tax credit. A monthly credit of \$60 was introduced for part-timers in the 1998 budget.

We also found that the effects of the interest credit on student loans introduced in 1998 are quite small. For loans of up to \$10,000 net-of-tax rates of return are less than 0.1 % points lower under the 1997 system, and the difference in *ETR's* is correspondingly small. Compared to the impacts of CESGs, the credit for interest on student loans has a relatively weak effect.

1.5 CONCLUSION

We have argued that effective tax rates are a useful device for summing up the effects of the tax system on the incentive to invest in human capital, and have illustrated the approach for undergraduate university level education in Canada. Our analysis has concentrated on two broad features of effective tax rates - - how high they are for the median person, and how they vary across individuals.

We have found that there is a notable difference between the effective tax rate on human capital coming from the tax system *per se* (the *ETR*) and the net effective tax rate,

which subtracts the effective subsidy rate (the *ESR*) on the expenditure side. For median earners, *ETRs* on human capital are sizeable, although lower than effective marginal tax rates for physical capital in Canada. This is true even in the wake of the federal budgets of 1996, 1997 and 1998, which introduced a wide range of measures that reduced *ETRs*. On the other hand, $ETR - ESR$ at the median is about -9% for males and -21% for females. Thus, government provides more incentive on the expenditure side for investment in university education than disincentive on the tax side.

Whether a net effective tax rate on human capital that averages about -15% across the sexes is appropriate is an interesting question. For this to be supported on efficiency grounds it is likely that one would have to appeal to externality arguments. Students' liquidity constraints could also help to justify the negative $ETR - ESR$, although the potential importance of this factor is significantly eroded by Canada's quite generous system of student loans. In view of the substantial positive effective tax rates on physical capital, there is certainly a possibility that, from an efficiency standpoint, as of the late 1990's Canadian governments provided too much encouragement for university study. Since tuition fees have risen quite significantly in the last four or five years, one must caution, however, that if this was indeed a problem its correction may already have occurred.

We have also found that the taxation of human capital is far from uniform in Canada. This raises the possibility of distortions in the supply of human capital, with too much investment taking place in programs, or by individuals, with low *ETRs*, and too little occurring where *ETRs* are high. We have found that *ETRs* differ depending on income after graduation, full-time vs. part-time study, receipt of student loans, gender,

presence of dependants, and use of RESPs. For example, we found that *ETRs* for full-time students who go on to earn at the 75th percentile of the earnings distribution throughout their lifetimes are higher than for those earning at the 25th percentile. In view of the strong association between earnings and area of university studies this may have interesting implications for the composition of human capital investment. Other things equal, the highest *ETRs* will be felt by graduates in areas such as business, engineering, and medicine. At the opposite extreme are graduates in the humanities. We have seen that in some of the high tax areas there has in the past been an offsetting effect in the form of heavy direct subsidies. However, the tendency to allow tuition fees to rise in recent years, especially in more specialized programs, may be eroding that offset.

It is possible that the provisions of the 1998 federal budget, and the doubling of the education amount tax credit in 2001, may not only have reduced the tax-side disincentive for human capital investment, but may also have reduced non-uniformity in *ETRs*. Increases in the education amount have a broadly based impact that has lowered *ETRs* for the majority of students. The special provisions for part-time students and those with dependants reduce *ETRs* for people whose human capital investments were less-favored by the tax system. And in the future, as higher income taxpayers take increasing advantage of Canada Education Savings Grants (CESGs) they should see some reduction in their *ETRs*.

While the analytical framework we have introduced can be applied to human capital investment at any level, our numerical results have been confined to the case of first-degree university graduates. It would be interesting to extend the results in order to compute *ETRs* on completed high school, community college, incomplete college and

university studies, post-graduate work and on-the-job training (OJT). We expect that effective tax rates are lower for high school completion, community college, and incomplete post-secondary studies than for undergraduate university degrees. This result is likely in view of the importance of income level in determining *ETRs*. Results for post-graduates are harder to anticipate since rates of return to graduate study are much lower than for undergraduate programs, and *ETRs* could be very sensitive to small absolute differences in gross and net rates of return.

Attention to the *ETR* on OJT would be valuable since it is clear that a large element of human capital is formed on the job. There is good reason to expect much lower *ETRs* than for formal schooling. In general firms and workers share the costs of such training. Workers do so by receiving lower wages or salaries during training. But progressivity effects are likely to be much less serious than for formal schooling, since it is only a portion of earnings that is being given up and the tax rate on foregone earnings may not be much less than that on the earnings increments due to training. On the employer's part, at least for corporations the tax rate is constant, so that there is no progressivity effect at all. Hence *ETRs* for OJT, like effective subsidy rates, may be quite small.

APPENDIX 1A

This appendix provides the general form of the basic problem presented in Section 1.2 of the paper. In that section we illustrated the calculation of the *ETR* for the case where the length of the schooling period, m , was just one year, and the length of life, T , went to infinity. If we do not make those assumptions analytic solutions for the gross and net-of-tax rates of return r_g and r_n , and thus for the *ETR*, do not exist. The purpose of this appendix is to take the analysis up to the point where numerical solutions must be sought.

The starting point is equation (2) in Section 1.2, which can be used to compute r_g in the case where the tax system takes no account of education and there are no student loans:

$$(2) \quad \sum_{t=1}^T \frac{E_t - C_t}{(1 + r_g)^{t-1}} = \sum_{t=1}^T \frac{E_t^*}{(1 + r_g)^{t-1}}.$$

As explained in Section 1.2, this equation can also be used to compute the public rate of return, r_p , if C_t is replaced by the full direct costs of education, C_t^p . And it can be used to compute r_n if E_t and E_t^* are replaced by the after-tax earnings E_t^a and E_t^{a*} .

To bring in the tax treatment of education and student loans we need to modify (2) to take account of (i) amounts L_t borrowed in the form of student loans in the schooling period, (ii) repayment of those loans at the interest rate i , with tax relief via a credit for a fraction d of interest payments, and (iii) tax credits for

tuition and education expenses, A_t . Introducing these elements will modify both r_g and r_n , but makes no difference to the public rate of return, r_p .

As explained in Section 1.3 of the paper, the scheduling of student loan repayments is flexible in Canada, but they must normally be repaid within 10 years of graduation. Here we let annual payments during this period of ℓ years equal $i\theta(L_b, t)$, where $\theta(L_b, t)$ gives the amount on which interest must be paid each year. This amount is less than the principal in the first year of loan repayment for all student borrowers in Canada, since loans are interest free for the first 6 months after graduation. Also, as explained in Appendix 1B, in some cases there is interest relief for low-income graduates, which would also reduce the effective amount on which interest is paid below principal. In the calculations reported in our tables we assume principal is paid off on a straight-line basis, but other assumptions could clearly be made.

Finding the internal rates of return r_g and r_n requires solving the general form of (2) numerically, which can be done with a variety of computer packages, including standard spreadsheets. Note that the RHS is not altered by taking tax relief for education or student loans into account, since it shows the present value of the earnings stream without the education in question. Thus we focus on the LHS of (2), which we denote PV in the before-tax case. Taking student loans, but not tax relief on education, into account we have:

$$(A.1) \quad PV = \sum_{t=1}^m \frac{E_t - C_t + L_t}{(1+r_g)^{t-1}} + \sum_{t=m+1}^{m+\ell} \frac{E_t - i\theta(L_b, t) - R_t}{(1+r_g)^{t-1}} + \sum_{t=m+\ell+1}^T \frac{E_t}{(1+r_g)^{t-1}}.$$

where R_t is the repayment of student loan principal in year t .

Turning to after-tax values, we have:

$$(A.2) \quad PV^a = \sum_{t=1}^m \frac{E_t^a - C_t + A_t + L_t}{(1+r_n)^{t-1}} + \sum_{t=m+1}^{m+\ell} \frac{E_t^a - i(1-d)\theta(L_t, t) - R_t}{(1+r_n)^{t-1}} \\ + \sum_{t=m+\ell+1}^T \frac{E_t^a}{(1+r_n)^{t-1}}$$

Again, r_n is found numerically, by setting PV^a equal to the RHS of (2) where E_t^* is replaced by the after-tax value E_t^{a*} .

Appendix 1B details the tuition and “education amount” credits that compose A_t in the Canadian case, as well as the rules on student loans.

APPENDIX 1B

B.1 Basic Data

- 1) Our estimates of tuition and additional expenses are based on Statistics Canada data for 1997-8. See <http://www.statcan.ca/Daily/English/970825/d970825.htm#art2>. An average was taken over arts degrees across the country.
- 2) Data on “other expenses” were taken from a variety of sources- Statistics Canada databases, university web sites, and university calendars. “Other expenses” refers to items that are only required for schooling (e.g. books and supplies for schooling).
- 3) The earnings data come from Statistics Canada’s 1995 Survey of Consumer Finance microdata tape.

B.2 Assumptions on Earnings

- 1) Part-time earnings for full-time students are assumed to be summer earnings and therefore comprise a maximum of four months of earnings potential. To account for unemployment and job search the value is reduced by 20%.
- 2) We assume that part-time students work part-time during the regular school year and full-time in the summer. This motivates the further assumption that their annual earnings are half of full-time earnings. A part-time student is assumed to take, on average, 3.3 courses a year. This assumption allows for a part-time student to get a four-year degree in approximately six years. Taking more than three courses in a normal school year would qualify a person as full-time. Therefore, it is assumed that a part-time individual works, as mentioned, year round and goes to school year round. He/she takes 2.5 courses during the school year and 1 during the summer, accordingly, to finish his/her degree (requiring 20 credits in a 5 credit/year school).

B.3 Public Rates of Return

- 1) Data on government spending and enrollment for male and female, full-time and part-time students were obtained from the Statistics Canada website. The most recent data available at this site were expenditure values on education and enrollment figures for 1995-96. It is these figures that are used to calculate the public rate of return.
- 2) Current and capital expenditures on undergraduate instruction are assumed to equal one half of operating expenditures. The justification for this assumption is given in the text of the paper.

3) Public expenditures per student are calculated as in Vaillancourt (1995). Operating expenditure on universities is divided by full-time equivalent (FTE) enrollment, where a part-time student counts as one third of a full-time student.

4) Public expenditures per part-time student are assumed to be one third of those for full-time students, in line with point 3.

B.4 Tax Features

B.4.i) Tax Credits

In addition to basic personal amounts, students are eligible for non-refundable credits on tuition and certain additional fees. They may also be eligible for non-refundable credits in the form of the education amount, and on interest paid on student loans. As outlined in the paper, the education amount was \$150 per month in 1997 and \$200 per month in 1998 for full-time students. Part-time students did not receive the education amount in 1997, but could claim \$60 per month in 1998. The taxpayer earns a net credit applicable to federal tax equal to 17% of the amount claimed, and there is a further credit against provincial tax. We assume that the sum of the two equals 25%, as it did in Ontario in 1998.

B.4.ii) Child Care Expense Deduction (CCED)

1) In 1998, the government allowed taxpayers to deduct from taxable income child care expenses of up to \$7,000 for each eligible child under seven years of age. A deduction of up to \$4,000 was allowed for children aged 7 to 16.

2) For full-time students we assume that child care expenses equal \$4200 (\$350 * 12 months), and that these expenses only last until the child is seven years old. We assume that the child is one year old when the parent is 19. Therefore, child care expenses are only deducted up until the age of 25.

3) Most part-time students were not eligible to claim CCED prior to the 1998 budget. The latter allowed part-time students to deduct up to \$2200. We assume that a part-time student with a dependant would be at this maximum.

B.4.iii) Registered Education Savings Plans (RESPs) and Canada Education Savings Grants (CESG's)

1) In both 1997 and 1998 the federal government allowed taxpayers to contribute up to \$4,000 per child to an RESP.

2) Since January 1, 1998 the federal government has been providing a CESG, equal to 20% of the first \$2,000 of RESP contributions per child. We assume alternative RESP contribution values of \$650/year and \$2000+/year in calculating the amount of CESG awarded.

3) The calculation for the CESG amount is based on an example in the 1998 Budget documents, which assumed a 5% rate of return and a contribution rate of \$650/year. For a contribution rate of \$2000/year the CESG amount increases proportionally.

B.5 Canada Student Loan Plan

B.5.i) Basic CSLP Repayment Features

1) Students have a choice upon consolidating their Canada Student Loans. They can either choose a maximum fixed interest rate equal to the bank's prevailing unsecured consumer loan rate, which cannot exceed prime plus 5%, or a maximum floating interest rate of prime plus 2.5%. For Ontario Student Assistance Program (OSAP) loans students pay an interest rate of prime plus 1%.

2) Data on interest rates were taken from the Globe and Mail web site (<http://www.globeandmail.ca>) on Tuesday, June 30th, 1998. The Canadian prime interest rate on this date was equal to 6.50%. Being dependent upon the loan held, the interest rate that a student actually faces may vary significantly. For example, using a prime interest rate 6.5% would result in an interest rate of anywhere between 7.5-11.5%, which would have a dramatic effect on the type of repayment plan chosen. For the purposes of this study a middle rate of 9% is used.

3) Information on CSL and OSAP loans was taken from the following web sites: CSL - (http://www.hrdc-drhc.gc.ca/student_loans/), OSAP - (<http://osap.gov.on.ca>).

4) The regulations on loan forgiveness under OSAP were taken from the above Government of Ontario address. As of 1997-8, loan forgiveness was only available on loans that exceeded \$7,000 for two terms of study; two terms being defined as 21-40 weeks of schooling (i.e. any amount of loan exceeding \$7000 for one eight-month school year was forgiven). For our purposes loan forgiveness only figures into the \$30,000 loan case, as it is assumed that the loan is broken into four equal parts to coincide with the four years of full-time study. Thus, \$7500/year is being borrowed of which \$500 is forgiven each year. It should also be noted that part of the loan is forgiven only after the loan(s) is (are) consolidated (meaning that a payment schedule has been agreed upon and signed at a bank). For example, upon graduation \$2,000 of the \$30,000 loan will be forgiven and interest payments will be calculated therefore on the remaining \$28,000, not the entire \$30,000. Part-time students receive no loan forgiveness, as they do not

qualify for OSAP loans; one must have at least a 60% course load (i.e. 3 out of a maximum of 5 courses) to be eligible for such loans.

5) Net-of-tax and gross-of-tax private benefits/costs are calculated taking into account that accruing interest is paid for by government during full-time studies. If individuals are studying part-time they do not benefit from having the interest that accrues on their loan paid off by the government. Part-time individuals must pay the interest on their loan from the moment it is acquired.

6) A part-time student is assumed to be working (approx. 20 hrs/week). Therefore, it is assumed that he/she will not accumulate as much debt as someone who is not working. Thus a part-time person only faces loan amounts that range from \$2500-\$15000 in our calculations.

B.5.ii) Interest Relief under CSLP

1) For individuals to be able to qualify for interest relief a reduction in median earnings is necessary. For the purposes of this study we use two thirds of median earnings to ensure that individuals fit the specified criteria set forth in the 1998 Budget. As of April 1998, full-time students are able to benefit from full interest relief provided their gross earnings are less than \$22,300 (prior to this change the value was \$20,460).

2) As recently as 1996 interest relief was only available for up to 18 months, but this was changed in 1997 with an extension of the period to 30 months. Once again in 1998 this period has been extended; it is now a maximum of 54 months, although the extension only includes those who are in dire straits financially. To qualify for the extended 54-month period an individual must have exhausted the 30 months of interest relief and still be in financial hardship once the repayment period is extended to 15 years. All of this must take place during the first five years upon leaving school.

3) For those in the most difficulty, the federal government introduced debt reduction in 1998. Upon exhausting all relief and having five years pass since the completion of schooling, if an individual is still in financial hardship he/she can have his/her loan principal reduced if annual payments exceed, on average, 15% of his/her income.

Chapter 2:

Tax Impacts on the Incentive to Invest in Human Capital: A Canada - US Comparison

2.1 INTRODUCTION

It is widely recognized that we live in a “knowledge based economy” and that human capital is the crucial input. Since the advent of endogenous growth theory in the 1980’s (Romer (1986), Lucas (1988)), human capital has taken on new appeal. While the central role in the labour market has been understood since at least the early 1960’s (Schultz (1962), Becker (1964)), today’s models suggest that the externalities arising from human capital can have important spin-off’s which we are only beginning to understand. Whether it is from education, formal training, or innovation, human capital can play a leading role in a country’s economic advancement.

Motivated by this reality, the (dis)incentive effects created by the tax systems in Canada and the United States to invest in human capital for first time university graduates are examined. The work builds on Collins and Davies (2001) by extending the analysis to include a detailed discussion and quantitative assessment of the incentives for Canadian graduates to re-locate to the U.S. and vice versa. Attention is also paid to the role that North American integration can have on investment in and the stock of human capital.

Effective tax rates are used to analyze the incentive and disincentive effects created by the tax systems. Human capital ETRs are simply the proportional difference in before and after tax rates of return on investment in human capital. While ETRs have been used extensively to measure the effect of the tax system on all kinds of physical capital investment, the adoption for human capital has only recently begun to take shape. Recent estimates on the size of human capital ETRs show that Canadian graduates face substantially higher rates than their American counterparts (Collins and Davies, 2001). Similarly, results differ based on whether individuals

are male or female, full-time or part-time, single parents, have student loans, etc. (Collins and Davies, 2002).

Findings here show that those educated in Canada face strong tax-side incentives to relocate to the United States. Furthermore, the tax system provides no incentives for those Canadians educated in the U.S. to return once their tenure is complete. Both of these facts are troubling and present an interesting dilemma for policymakers. Is the brain drain phenomenon significant enough to mandate a change in policy? If so, where should the changes come from – expenditures or taxation? We attempt to shed light on these and other questions.

Results show that those educated in Canada who move to the United States after graduation face some of the lowest effective tax rates of all graduates. The ETR for males and females is – 7.1% and – 5.6%, respectively.¹ Given the tax treatment of income and the potential for higher earnings in the U.S., Canadian graduates are effectively receiving a subsidy if they migrate; the net-of-tax rate of return is actually larger than the gross-of-tax rate of return. The stark contrast between leaving and staying in Canada is even more apparent when we compare these results to the base case results of 20.0% for males and 12.1% for females.²

The results are not any more encouraging for U.S. educated Canadians. While students who stay in the U.S. after graduating face lower rates of return than Canadian educated students, they are nonetheless treated more favorably by the tax system. U.S educated Canadian males and females face roughly the same ETRs at – 9.8%, although males have slightly higher rates of return, in large part, due to the difference in earnings after graduation. If U.S. educated Canadian students return to Canada, they face ETRs which approximate the base case results.

¹ Results are reported for Case A in Table 4. See Results section for a description.

² Base Case results are based on students being educated and remaining in their home country.

Similar results are found for U.S. graduates thinking about moving to Canada.³ Whether they are educated at private or public institutions the ETRs are exceedingly high. Males at four-year public institutions face ETRs of 25.4%, while those at private universities face ETRs of 36.6%. Compared to the base case ETRs for males of 8.1% for public universities and 13.9% for private, the unfortunate reality is there does not seem to be any tax-side incentive for these students to come to Canada after graduation. For females the results are slightly better. Women at four-year public universities face ETRs of 16.2%, compared to 6.4% if they stay in the U.S. At private schools this rate jumps to 23.9%, compared to 12.0%.

While the tax treatment of human capital provides one reason for domestically educated Canadians to migrate, it obviously does not provide the full story. Similarly, even if the tax system was neutral in its treatment of human capital this would not guarantee that cross border migration would cease. Despite these points, the government still has a number of items at their disposal that can reduce the incentives for highly educated Canadians to leave, as well as increase the incentives for similar Americans to come to Canada. We address these points in the body of the paper.

In an attempt to provide a more complete analysis the impact of the expenditure system is also provided through the use of effective subsidy rates, or ESRs. Findings show both countries provide substantial incentives on the expenditure side to invest in human capital. The overall net effect of the expenditure and tax systems, as indicated by the *net* effective tax rate, $ETR - ESR$, is also largely positive.

³ The difference between U.S. students moving to Canada and Canadian students who were educated in the U.S. moving back home after graduation is primarily the result of two items: the opportunity costs of the students while in school and the earnings of high school graduates once they enter the labour force full-time. U.S. high school graduates will generally make more than similar graduates in Canada.

The rest of the paper is organized as follows. In Section 2.2 we provide a description of the conceptual framework and some illustrative calculations. Section 2.3 provides some background to the Canadian and U.S. tax systems. The empirical results are provided in Section 2.4. Section 2.5 talks about the policy implications and finally, Section 2.6 provides some concluding remarks and avenues for future research.

2.2 CONCEPTUAL FRAMEWORK

While there exists much qualitative work on human capital and taxation, surprisingly the quantitative literature is less well developed. Similarly, while marginal effective tax rates (METRs) have been used extensively to study investment decisions in all kinds of physical capital, the spillover into human capital has not taken place until quite recently (see, e.g., Collins and Davies, 2001, 2002 and Mintz, 2000). Perhaps not surprisingly the tax system in Canada treats both types of capital investments similarly. Studies have found that the tax treatment of human and physical capital in Canada is highly nonuniform and varies depending upon the nature of the investment. For physical capital the type, industry, and method of finance all have significant impacts on the magnitude of the METR (see, e.g., McKenzie et al., 1998). For human capital whether the individual is male or female, studying full-time or part-time, their field of study, use of student loans, etc. have all shown to play a role in determining the (dis)incentive effects of the tax system (see, e.g., Collins and Davies, 2002).

This paper examines the impact that taxation has on the incentive to invest in human capital for first time university graduates in Canada and the U.S. We look at the incentives for Canadian graduates to remain in Canada after graduation, their incentive to move to the United

States, and vice versa for their American counterparts. Given the nature of the American education system we assess the implications of being educated at a private or public university.

It should also be pointed out that we are not examining the *marginal* investment in human capital, per se, when calculating human capital ETRs. That is, we do not look at the change in the effective tax rate brought about by the marginal change in human capital investment. The reason is that human capital tends to come in stages. For instance, high school, college, university and post-graduate work (M.A., M.Sc., Ph.D.).⁴ Therefore, we are looking at the next stage or level of the investment as it pertains to higher education, rather than the marginal change.

The ETR is defined as the proportional difference between gross-of-tax (r_g) and net-of-tax internal rates of return (r_n),⁵

$$(1) \quad ETR = \frac{r_g - r_n}{r_g}.$$

To calculate internal rates of return (IRRs), the difference between lifetime earnings from investing in human capital and not investing is used. As well, direct costs (e.g. tuition, books, and ancillary fees) and forgone earnings are taken into account. We can therefore write,

$$(2) \quad \sum_{t=1}^T \frac{(E_t - E_t^*) - C_t}{(1 + r_i)^{t-1}} = 0 \quad i = n, g$$

⁴ This is not to downplay or ignore the relevance of on-the-job training as a means of human capital investment. Its importance is without question, but unfortunately it is beyond the scope of this study. This would be an excellent avenue for future research.

⁵ See Davies and Glenday (1990) for an explanation of the appropriateness of using internal rates of returns over other methodologies (e.g. present value calculations).

where E_t and E_t^* represent, respectively, earnings from investing in human capital and not. For the purposes of this study, E_t will refer to the earnings realized as a result of going to university and obtaining a four-year bachelors degree, while E_t^* will be the earnings from going to high school and then directly into the labor market. C_t is the direct costs to schooling.

The effective subsidy rate (ESR) can also be calculated in much the same way as the ETR. Replacing direct costs to education in (2) with public costs, the public rate of return, r_p , can be calculated. Then, by way of (1), we can write

$$(3) \quad ESR = \frac{r_g - r_p}{r_g}.$$

Through the use of the ETR and the ESR we can determine whether or not the expenditure and tax systems, when combined, provide an incentive or disincentive for human capital investment. To do this we compute the *net* effective tax rate on human capital, $ETR - ESR$. We will have more to say about the ESR and the net effective tax rate later on when we talk about policy impacts.

Following Collins and Davies (2002) we perform some illustrative calculations to help clarify the impact of certain variables. In this illustrative case individuals go to school for one year, earnings over the life cycle are constant, and there is an infinite time horizon.⁶ Making the appropriate modifications to (2) and allowing for student loans and tax credits, we can write the gross and net rates of return as,

⁶ See the appendix for a more detailed discussion of the derivations.

$$(4) \quad r_g \approx \frac{EI - iL}{FE + C - L}$$

and

$$(5) \quad r_n \approx \frac{(1 - \tau_w)EI - i(1 - \tau_w d)L}{(1 - \tau_s)FE + C - L - A}$$

where EI is the earnings increment ($E_t - E_t^*$), which is the difference between the wages you earn as a result of obtaining a four-year university education and that which you would have earned had you not gone to school. FE is the forgone earnings ($E_t^* - E_t$), A is the tax credits on direct costs, i is the interest rate, iL is the loan payments, d is the credit allowed for interest on loan repayments, τ_w and τ_s are, respectively, the tax rates on labour and in-school (forgone) income. If interest paid on student loans is fully deductible, then $d = 1$ and interest is deductible at the marginal tax rate paid on the earnings increment, EI .⁷ Similarly, if the direct costs to education are fully deductible then $A = \tau_s C$. That is, out-of-pocket expenses are deductible at the marginal tax rate on in-school earnings (FE). Substituting (4) and (5) into (1) we can write,

$$(6) \quad ETR = 1 - \frac{r_n}{r_g} = 1 - \left(\frac{(1 - \tau_w)EI - i(1 - \tau_w d)L}{(1 - \tau_s)FE + C - L - A} \right) \left(\frac{FE + C - L}{EI - iL} \right).$$

Allowing direct costs and student loans to be zero for the time being, we see from (6) that an $ETR = 0$ could result from proportional labour income taxes.⁸ The reason is that this results in a reduction in net-of-tax forgone earnings and labour market earnings after graduation by

⁷ At present, interest on student loans is creditable at a federal rate of 17%. When combined with provincial rates, this increases to about 26%. Therefore, $d < 1$ is the likely result.

equal proportions. A zero ETR illustrates the important point that it is possible to have a tax system that does not distort the incentive to invest in human capital. The current progressive income tax systems in Canada and the U.S. are somewhat different from this setting. The earnings in both countries after graduation are taxed at a higher rate than in-school earnings. Of course, regressive taxes, like payroll taxes in Canada and the U.S., have the opposite effect for certain individuals. The likelihood that these taxes will offset the progressivity of the income tax for many individuals is small.

Another option to offset the positive ETRs that result from progressivity in the income tax is through non-tax measures. Subsidization of forgone earnings and direct costs (which includes tuition) to education requires less revenue than the tax system provides, while at the same time reducing ETRs. This illustrates another important point; namely, that positive ETRs on human capital are not necessary. That is, non-tax measures can offset and can even override the disincentive effects of the tax system. Given that people relocate based on, among other things, the tax system and the benefits realized from government spending (e.g. health care, public goods, education, etc.), then how the government spends its money is as important as how it taxes its constituents (see, e.g., Mintz, 2001). The net impact of this is captured in the *ETR* – *ESR* calculation.

Another thing (6) illustrates is that certain tax measures are more efficient at lowering ETRs. For instance, deductibility for out-of-pocket expenses (i.e. direct costs to education) has a much greater impact in reducing ETRs than does interest deductibility on student loans.⁹ This finding is consistent with that of Collins and Davies (2002) who find that the advent of interest

⁸ Alternatively, we could have a proportional sales tax on a comprehensive base, which exempted inputs from human capital or uniform MTRs with no borrowing and full creditability of direct costs.

⁹ The easiest way to see this is by comparing the ETRs under full interest deductibility and full direct cost deductibility. The numerator is larger, while the denominator smaller for full deductibility of direct costs.

deductibility in the 1998 federal budget provided little impact on ETRs.¹⁰ Therefore, in the face of rising direct costs to education and greater participation in student loan programs it appears a government would do better to concentrate tax policy and subsequent relief on the direct costs to education, as opposed to interest on student loans.

Replacing direct costs with public costs in (4) and ignoring student loans we can write the ESR as,

$$(7) \quad ESR = \frac{C^P - C}{FE + C^P}$$

where C^P is public costs. Combining the ETR with the ESR, we can then calculate the *net* effective tax rate,

$$(8) \quad ETR - ESR = \frac{r_p - r_n}{r_g}.$$

Using (4), (5) and (7) in (8) we can write,

$$(9) \quad ETR - ESR = (C + FE) \left(\frac{1}{C^P + FE} - \frac{1 - \tau_w}{FE(1 - \tau_s) + C - A} \right).$$

Equation (9) allows us to examine the implications of supporting education versus changing the tax system on the net ETR. Without any change in the net ETR we can see that the expenditure and tax systems could be used to reduce the incentive to leave the country

¹⁰ The change was less than 1% in all cases.

considerably by reducing government subsidies to tuition and reducing higher tax rates on income. In (9) this would be equivalent to reducing τ_w and A . The reduction in τ_w increases $1 - \tau_w$, which in turn decreases the net ETR. Conversely, a fall in A causes the second term in the brackets to fall, which increases the net ETR. Assuming that the reduction in τ_w and A offset one another there will be no change in the overall value.

Therefore, without any change in the overall value of $ETR - ESR$, the expenditure and tax systems can be used to reduce migration incentives without impacting the overall incentives to invest in human capital. The implication is that individual incentives can be impacted positively, without any likely significant change in the budget balance of the government. Therefore, through careful planning policymakers can “tweak” taxation and spending initiatives to stem migration without sacrificing much (if any) revenue.

Through (9) we are also able to see that a move to a more flat income tax structure would have the added benefit of increasing the incentive to invest in human capital, while still reducing the incentive to migrate. If we let τ represent a flat tax where $\tau_w > \tau > \tau_s$, then $(1 - \tau_w) < (1 - \tau) < (1 - \tau_s)$. The second term in (9) has a larger numerator and smaller denominator with the flat tax τ than with the graduated income tax system. Therefore, $ETR - ESR$ is reduced to a greater extent under the flat tax regime; as a result, the incentive to invest in human capital is increased and the incentive to migrate, which is impacted largely by the tax structure after graduation, is reduced. With Mario Dumont in Quebec proposing a flat tax, on top of the Alberta initiative, the move to such a regime is becoming more of a live proposition and with the benefits surrounding such a move, policymakers would be wise to investigate.

Before moving on to discuss the Canadian and U.S. tax systems it should be mentioned that one problem critics often have with these types of studies dealing with post secondary

education is that they feel that individuals who go off to university are on average more able than high school graduates. Therefore, to use the median (or mean) high school graduate's income in the calculation of foregone earnings (or the earnings increment) could be seen as misleading and likely to bias the results. The solution they see is that there should be some sort of "ability adjustment" in estimating how much university graduates would have earned if they had stopped their education after high school. The size of the required ability adjustment remains in question though, as does how exactly it should be measured. While we do not include any ability adjustment in our calculations, the implications of such an experiment can be illustrated with the use of equations (4), (5) and (6). Taking ability into account would result in an increase in forgone earnings, FE , and a decrease in the earnings increment, EI . The reason is that high school earnings, used to calculate FE and EI , have now increased, while university earnings have remained constant. An increase in FE or a decrease in EI will result in a reduction in the net of tax rate of return by a smaller margin than the gross of tax return; as a result, ETRs would marginally decline. Since it is the magnitude of the ability adjustment that is the crux of this argument and its measurement remains in question, we choose to leave it out of our calculations.

2.3 COMPARISON OF CANADA-U.S. TAX SYSTEMS

Personal Income Tax (PIT)

In this section we briefly discuss some of the differences between the Canadian and U.S. tax systems.¹¹ Most of the major components of the two tax systems, such as the personal income tax and payroll taxes, have implications for the incentive to invest in human capital and as such are relevant for this study. Given the rising participation in student loan programs, we also

¹¹ For a more in depth discussion the reader is directed to Collins and Davies (2001).

discuss the current treatment in the two countries. We gear our discussion to the state of the tax system in 1998, the year of our data, but also discuss the relevance of recent changes.

Until the 1998 budget in Canada there was no relief for the interest paid on student loans, but the PIT system did provide relief for certain direct costs to education (e.g. tuition, fees, and an education amount). In 1998 the interest paid on student loans became creditable at the 17% federal rate.¹² Contrary to the Canadian system, the U.S. system traditionally provided relief for interest on student loans in the form of a deduction or credit, but failed to provide any support for direct costs. Recent developments in both systems have since eroded this difference.

The PIT systems on both sides of the border allow parents to oversave by means of registered savings programs, RRSPs in Canada and IRAs in the U.S., to fund their children's education. Both countries also have sheltered savings dedicated strictly to education: Canada has the Registered Education Savings Plan (RESPs) and the U.S. has Education IRAs. Canadian contribution limits are higher on sheltered savings strictly for education (\$4,000 compared to \$2,000 USD in the U.S.) and are encouraged by a subsidy in the form of the Canada Education Savings Grant, which equals 4% of annual contributions to a maximum of \$400. Annual contribution limits for RRSPs of \$13,500 or 18% of income are generally higher than IRAs; the exception to the rule is for low income individuals.¹³

It is generally believed that the Canadian PIT system is more progressive, due to its graduated rate structure, than that of the U.S. One reason is that in Canada we move more quickly into the upper tax brackets than people in the United States. This is partly because the U.S. tax brackets are wider and partly because their standard deductions and exemptions are

¹² The value of the credit is enhanced when provincial income taxes are taken into account. There is no limit on the amount of interest that may be claimed. Unused credits may be carried forward for up to five years, but are not transferable to other taxpayers.

more generous. Combine this with the fact that high-income Americans make heavy use of their more liberal itemized deductions and the U.S. system becomes substantially less progressive than the Canadian.

To put this into perspective, in 2000 a Canadian earning total income of \$60,009 would be in the third and top tax bracket of 29%, while a single taxpayer in America would have to earn \$70,750 USD (or, approximately, \$110,000 CDN) to be in the third tax-bracket in the U.S. Even with the 2 % difference (the third tax-bracket in the U.S. is 31%), it is easy to see that there is a dramatic difference between the two countries – and this is without the use of itemized deductions. If we were to take into account all itemized deductions available to American taxpayers the difference between the two countries would become even greater.

Recent developments in the PIT system in both countries should help to promote investment in human capital. In Canada, for instance, the three-bracket structure has been extended to add a fourth and the rates reduced.

**Canada Federal Marginal Tax Rates by Taxable
Income Pre- and Post-2000 Change**

Before		After	
Income	Rate	Income	Rate
0	17%	0	16%
30,004	25%	30,755	22%
60,009	29%	61,510	26%
		100,000	29%

¹³ For a Canadian taxpayer with an income below \$17,000 CDN, the RRSP contribution limits is less than that for a single U.S. taxpayer.

While the reduction in the rates is positive for Canadian taxpayers, their effect on ETRs is not as encouraging. The impact on ETRs is greatest for earners at the 75th quantile and lowest at the 25th quantile.

As if to keep pace with changes in Canada, President Bush also unveiled a new proposal for tax relief. The rate structure is summarized in the following table as it was in 2000 and as it will be once the changes proposed by Bush have been fully phased in.¹⁴

**United States Federal Marginal Tax Rates by
Taxable Income in 2000, Pre- and Post-Bush Tax Cuts**

Before			After		
Single	Couples*	Rate	Single	Couples*	Rate
0	0	15%	0	0	10%
26,250	43,850	28%	6,000	12,000	15%
63,550	105,950	31%	27,050	45,200	25%
132,600	161,450	36%	136,750	166,500	33%
288,350	288,350	39.6%			

Note: * -- Couples filing jointly

As in the Canadian case the largest reduction in MTRs is for the middle-income taxpayers. But unlike Canada, there is also a substantial reduction in the bottom bracket. How will the changes affect ETRs? Again, it appears that the overall results are positive; most people should see a reduction in their ETRs as a result of the changes. Once again it should be pointed out that we are ignoring the fact that a number of middle and, particularly, low income earners are eligible for tax relief in the U.S. either in the form of deductions or credits that would reduce their ETRs. For instance, the Earned Income Tax Credit generates a large negative marginal tax rate for the lowest earners.

¹⁴ The changes in the marginal rate structure will be fully phased in by 2006.

While tax relief in the form of credits and deductions, as well as reductions in the marginal tax rates, are positive for the economy as a whole, their impact on ETRs of university students is likely to be rather small. The reason is that most of the provisions in the tax system are designed to benefit families with children. The majority of individuals in university are without families; as a result, much of the relief doesn't apply. The relief for students comes largely in the form of government sponsored loan programs and, for a small percentage of students, grants.

Payroll Taxes

Payroll taxes have a regressive rate structure, unlike the PIT, since they are typically defined with a flat rate for contributions up to some limit, defined as "maximum insurable earnings," and fall to zero thereafter. The implications of the unemployment and pay-as-you-go social security schemes in both countries on investment in human capital would seem to be that payroll taxes decrease the incentive to invest during the "schooling years," while the impact after schooling depends upon the earnings of the individual. If earnings after education are above maximum insurable earnings, the rate structure becomes regressive. As a result, the ETR will likely decline.

Social security is relatively more important in the U.S. This fact is reflected in much larger maximum insurable earnings.¹⁵ The impact of social security on U.S. ETRs is therefore greater than it is for Canada. The higher contribution limits in the United States lead to increases in the tax rate on labor income while the individual is in school and after graduation of approximately equal magnitude; as a result, ETRs increase. For those Canadians whose earnings

¹⁵ In 2000 the Canadian limit was \$37,600 CDN while the U.S. had a limit of \$76,200 USD, respectively.

are above maximum insurable earnings the increase in τ_w is less than that in τ_s , due to CPP contributions. Therefore, ETRs are likely to decrease.

While the regressive nature of payroll taxes for middle and high income individuals in Canada offsets the progressivity of the PIT system to some extent and lowers ETRs, this is not the case for all Canadians. Low income Canadians, those that fall below the limit of maximum insurable earnings, experience a mildly *progressive* rate structure. This progressivity is due to the fact that the first \$3,500 of earnings are not subject to CPP contributions. Combined with the PIT system, the structure of the payroll tax exacerbates the disincentive effects of the tax system to invest in human capital for these individuals. Once again, this brings up the question of equitable treatment.

Student Loan Programs

Both Canada and the United States help students to finance their education by providing guaranteed student loans. Due in part to rising tuition costs the participation in such programs has been increasing. Perhaps even more unsettling than the rise in participation rates is the startling debt load some students are accumulating. In 1998 the Department of Finance estimated that the average debt of students participating in student loan programs was approximately \$14,000 upon graduation. For the same time period in the U.S., the average loan amount was about \$13,845 USD.¹⁶

In Canada, students rely on the Canada Student Loan Plan (CSLP), while in the U.S. options are somewhat more diversified. U.S. students have the option of participating in the Ford Direct Student Loan Program (FDSLPL) or the Federal Family Education Loan Program

¹⁶ This value is derived from the College Boards, “*Trends in Student Pricing*,” Table 4b by calculating the average value for Stafford Subsidised student loans over the years 1994/5 – 1997/8.

(FFELP).¹⁷ Loans from these programs may be subsidized or unsubsidized. If they are subsidized they are similar to student loans in Canada. The government pays the interest that accumulates on the loan as long as the student meets some minimum requirements (usually full-time status suffices). Both the CSLP and the subsidized portion of the FDSLPP are dispensed on a needs basis.

Unsubsidized loans were introduced during the 1992-93 school year in the U.S. and have seen their participation rates steadily rise. The reason is in part that they are not administered on a needs basis. Interest accumulates while the student is in school and gets added to the principle amount of the loan. This is similar to the case of part-time students in Canada. While participation by part-time students in the CSLP and other provincial plans is permitted, the interest that accumulates must be paid by the individual from the time the loan is taken up.

The effect of student loans on the accumulation of human capital comes largely from the fact that they are subsidized.¹⁸ The benefits provided tend to have larger impacts on net IRRs than gross and as a result ETRs fall (Collins and Davies, 2002). The unsubsidized loans have less leveraging benefit; as a result their impact on ETRs is somewhat limited. Both types of student loans help to ease the burden of paying for school by stretching the payment out over a number of years. In Canada, for instance, students have up to 9 1/2 years to repay their loans. The silver lining in these rising participation rates is that studies have shown that almost 40% of students who have loans have repaid them within two years after graduation (Finnie, 2001. Figure 4).

¹⁷ The FDSLPP allows students to borrow directly from the government through the school they are attending. FFELP loans are administered by private lending institutions and guaranteed by the government.

¹⁸ Critics may claim that this ignores the fact that student loans may fill a market that would otherwise be missing. Without such a market some students may not be able to finance their education. While no doubt relevant for the discussion of student loans in general, it is the subsidization of student loans that impacts the calculation of human capital ETRs and not the fact that a market is being filled.

2.4 EFFECTIVE TAX RATES ON FIRST TIME UNIVERSITY GRADUATES

Data and Assumptions

Using the 1998 Statistics Canada Survey of Consumer Finances (SCF) and the U.S. Census Bureau's Current Population Survey (CPS) for the same year, we construct a measure of the rates of return for first time university graduates and their effective tax rates.¹⁹ Sample sizes are 68,633 and 253,044 for the SCF and CPS, respectively. Earnings and tax information are reported for the year preceding the survey and are used to create hypothetical lifetime earnings and tax scenarios. To accomplish this the assumption is made that graduates with a certain level of education earn at the same earnings quantile throughout life. Through the smoothing procedures devised by Burbidge et al. (1988) and Magee et al. (1991) we project the life-cycle path of earnings using quantile age-profiles. Earnings include only wages and salary income.

We constrain our sample to include only full-time, full-year workers in an attempt to capture the full returns to human capital. In other words, only those individuals who have indicated that they were employed for 52 weeks during the year of the survey, and who worked full-time during this period are considered. We define university graduates as those individuals who have *completed* only a bachelor's degree.²⁰ High school graduates include only those who have completed high school, and *not* gone on to complete or attend any further schooling.

Our first step is to impute tax payments on the wage and salary component of total income. First, an average tax rate (ATR) is calculated. For those in the SCF, the ATR is

¹⁹ Each of the surveys use 1997 earnings data.

²⁰ Specific areas of study within the chosen degree are not identified in the data. For a study of rates of return to different fields see, e.g., Appleby et al. (2000).

calculated by dividing total tax paid by total income. This ratio is then multiplied by total wages and salary to compute the imputed tax burden faced by each individual on their labor earnings.²¹

For the CPS there is an important distinction between those filing as single taxpayers and those filing jointly with a spouse. For those who file separately (i.e. as a single taxpayer) the ATR is calculated in much the same way as with the SCF; the total tax paid (both federal and state) is divided by total personal income. For individuals who file jointly, we compute the ATR as total tax paid over total family income.²² The ATR is then multiplied by total wages and salary of the individual to arrive at a tax liability value. In short, we compute the couple's joint ATR and subsequently apply this to the husband's and wife's individual labour incomes to compute their respective tax liabilities.²³

Individuals are admitted to university when they are 19, earn a four-year bachelor's degree, and then enter the labor force at 23. During their tenure at university individuals forgo the income they would have earned in the labor market, less summer earnings.²⁴ Forgone earnings are based on the earnings of the median high school graduate. Sensitivity analysis around these results is also performed.

Statistics Canada data is used to compute values for tuition and additional expenses for Canadian students. The average tuition and fees reported are based on Arts programs across Canada for the 1997-8 academic year. A figure of \$3,253 was obtained for tuition, \$342 for fees, and we assume that additional direct costs were \$1,000. By way of the College Board's *Trends in*

²¹ Due to the small probability that the tax liabilities may be outliers, we use a weighted average centered around the respective income value.

²² It should be noted that due to the nature of the survey it was necessary to avoid any income that may come from other family members, who are not dependants. Therefore, families with more than two individuals who had no children under the age of 18 were dropped from the calculation, since they may in fact be contributing to the data in immeasurable ways.

²³ While some might suggest that the secondary earner's income should be treated as marginal, we are of the view that it has now become exceedingly difficult to identify whose earnings are marginal in a marriage.

College Pricing (2000), we obtain similar results for the U.S. Given that the U.S. has a large number of private, as well as public, institutions we provide results on both types of education. Tuition and fees for four-year public institutions for the 1997-8 academic year averaged \$3,111 USD and for four-year private institutions \$13,644 USD. It is also assumed that U.S. students face additional direct costs to education of \$1,000 USD.

Students in both countries are assumed to make full use of the relief provided by the tax system. In 1998 in Canada students received a \$200/month education amount creditable at a federal rate of 17%. When combined with the provincial system this rate rises to around 26%. They also claim the full amount of their tuition and fees (again creditable at around 26% when we combine federal and provincial rates). This of course ignores the possibility that some students may not need the full amount to reduce their tax liability to zero and would carry forward any unused portion (or transfer it to a spouse or parent). The impact of this assumption on ETRs is likely negligible.

For students in the U.S. there are two mutually exclusive tuition credits at their disposal: the Hope Scholarship Tax Credit and the Lifetime Learning Credit. The Hope Credit provides a 100% credit on the first \$1,000 of tuition and fees, and 50% on the next \$1,000 for the first two years of post secondary education. The Lifetime Learning Credit is levied at a 20% rate on the first \$5,000 of tuition and fees. Students are assumed to make full use of these credits.

Results

Results from the base case are shown in Table 2.1. This case uses the 1998 tax systems for Canada and the U.S., assumes that the student is single with no dependents and finances her

²⁴ Summer earnings are defined as being equivalent to 4 months of forgone earnings less 20% for search costs and uncertainty.

education through savings. For the U.S. we report results from four-year public and private institutions – the main difference being the amount of tuition and fees students face. Results show that students in the U.S. face lower ETRs than do Canadians and that female ETRs are less than males. For U.S. students at private schools high tuition costs have a significant impact on rates of return, as well as the ETRs they face. In fact, the tuition difference is so great that the rates of return of Canadian students are greater than U.S. students at private institutions. U.S. males at private universities face ETRs roughly 42% greater than their public school counterparts, whereas females face rates approximately 47% greater.

An interesting result from this analysis is that higher tuition at private universities has a stronger impact on females than on males. That is, the increase in the direct costs of education is enough to offset any advantage the females have in the public school case which allows them to realize higher rates of return than males. The reason for this turnaround may be the fact that males have higher forgone earnings and so an increase in direct costs has less of an impact on ETRs. Put another way, the gap between the gross and net of tax rates of return is smaller for males than for females as we increase tuition and as a result the male ETR is affected less by the change.

Consider the illustrative case with increasing marginal tax rates, no loans and less than full deductibility of out-of-pocket expenses, $A < \tau_s C_s$. Equation (6) becomes,

$$(10) \quad ETR = 1 - \left(\frac{(1 - \tau_w)(FE + C)}{(1 - \tau_s)FE + C - A} \right).$$

Taking the derivative with respect to costs we find,

$$(11) \quad \frac{\partial ETR}{\partial C} = \frac{(A + FE\tau_s)(1 - \tau_w)}{(FE(1 - \tau_s) + C - A)^2} > 0.$$

If C increases, the impact on males and females is determined by the magnitude of forgone earnings, FE , since A and τ_s are assumed to be roughly identical for all individuals. Therefore, taking the derivative of (11) with respect to FE will determine how forgone earnings impact ETRs as direct costs to schooling change. Doing so yields,

$$(12) \quad \frac{\partial^2 ETR}{\partial C \partial FE} = \frac{(1 - \tau_w)(\tau_s(C - (1 - \tau_s)FE) - A(2 - \tau_s))}{(FE(1 - \tau_s) + C - A)^3} < 0.$$

Providing after-tax forgone earnings are greater than the direct costs to schooling then (12) will be negative. Male FE 's are typically greater than females. Therefore the impact on ETRs will be proportionately smaller for men.²⁵ As a result, any increase in the direct costs to schooling, C , will increase the ETR by less for males than for females. Therefore, an increase in direct costs to education appears to have a greater disincentive effect on females to invest in human capital than males. This presents an interesting dilemma for policymakers.

Table 2.2 illustrates the impact of expenditure and tax systems in both countries on individual incentives to invest in human capital. For the most part, subsidy rates are enough to offset effective tax rates. The exception is for males who undertake private school education in the U.S. For these individuals the ETR is greater than the ESR, due in part to the high tuition at

private universities. Canadian students face significantly higher ESRs than U.S. students. The net ETRs (i.e. $ETR - ESR$) are more negative for females than males, which would imply a greater overall incentive to invest in human capital. This may counteract the aforementioned disincentive effect associated with direct costs to education for females. When the expenditure and tax systems are combined there appears to be an overall incentive for students to pursue higher education, a conclusion which is in line with results from earlier studies.

Table 2.3 repeats the base case analysis, but for people at the 25th and 75th quantiles of the earnings distribution. These results are based on a “clone” calculation. That is, a comparison is made between the Xth quantile high school earner and a university graduate earning at the same quantile. The results are then used to calculate forgone earnings and the earnings increment as described previously.²⁶ In all cases the ETRs at the 75th quantile are greater than those at the 25th. Canadian males at the 75th quantile face the highest ETRs of 21.2%, while males in the 25th quantile who go to four-year public universities in the United States face the lowest at 5.1%. Rates of return and ETRs are also nonuniform, making them consistent with their physical counterparts.

Treating rates of return by quantile as a proxy for the rates of return to different fields of study the results in Table 2.3 suggest interesting implications for public policy. If we consider the fact that high rates of return come from fields such as engineering or business then having the highest effective tax rates on these individuals may be somewhat troubling, particularly if we are

²⁵ This assumes that the smaller MTRs faced by females do not offset the higher forgone earnings of males.

²⁶ An alternative approach is to treat every high school student going to university as equal. Therefore, the forgone earnings of all university students would be equivalent to the median high school student's earnings. In university students differentiate themselves by field of study, which can be approximated by the rate of return, ability, etc. and as a result earn at different levels of the earnings distribution. Hence, after graduation you would compare Xth quantiles to calculate the earnings increment as in the clone case. Performing this calculation does not significantly impact the conclusions reached. For a discussion and quantitative assessment of the two approaches see Collins and Davies (2001).

concerned with things like migration. As Tables 2.4 – 2.6 show, those seeking relief from the Canadian tax system can indeed find it south of the border.

Table 2.4 shows the results for Canadian students who upon graduating decide to move to the U.S. Two different scenarios are considered. Case A illustrates the case where a university education opens doors in the United States and presents the Canadian student with more opportunities after graduation. If this student did not go to university then he/she ends up working in Canada after high school. Hence, we calculate the earnings increment as the difference between U.S. university earnings (transformed into Canadian dollars) less Canadian high school earnings.²⁷ Summer earnings are calculated as the median high school earner's income for four months, discounted by 20% for search costs and uncertainty. The results from Case A show that Canadian graduates who move to the U.S. after graduation face ETRs which are *negative*. The rates of return are also the some of highest in the study; all are over 20%.

Case B is identical to Case A, but with one significant difference. It is assumed here that the Canadian student is going to move to the U.S. after high school, unconditionally. Therefore, we compare high school earnings of students in the U.S. with university earnings in the U.S. The change has a significant impact on IRRs and ETRs, but in all cases the rates of return are still quite high, all are over 16.5%, and the ETRs marginal – with males at 4.0% and females 2.9%. The conclusion, therefore, seems to be that there are substantial tax side incentives to invest in an education in Canada and look to the U.S. labor market after graduation.

As for U.S. students thinking about moving to Canada after graduation, the results are just the opposite. For these cases earnings of U.S. high school students, converted to Canadian dollars, are compared with those of university students in Canada. U.S. students face higher

²⁷ At the time of this analysis the exchange rate was \$1.53046. An exchange rate of \$1.50 is used to convert American earnings to Canadian dollars.

ETRs and lower rates of return when compared to the base case. For instance, private school ETRs for males and females are 36.6% and 23.9%, respectively, compared with 13.9% and 12.0% from the base case.

Table 2.5 continues the Case A story from Table 2.4 for Canadians, as well as the U.S. cases, but for the 25th and 75th quantiles. Canadian males and females receive marginally lower rates of return than they did at the median. Despite this, the ETRs follow suit with Table 2.4. Canadian graduates at all levels are encouraged by the tax system to move to the United States. Perhaps most discouraging for Canadian policymakers is that it is the 75th quantile graduate who receives the largest incentive with ETRs of -7.8% for males and -5.7% for females. Conversely, U.S. graduates at the upper end of the earnings distribution face significantly higher ETRs, which provides substantial encouragement to remain in the U.S.

In Table 2.6, we examine Canadian students who are educated in the United States. The idea here is to see how the tax system treats these students if they decide to return and work in Canada after graduating. It is assumed that these students work in Canada over the summer and go to school in the United States from September to April. The biggest difference is that they pay much higher tuition (converted to Canadian dollars) than in our earlier cases. This case is also interesting since in Canada tuition fees have been rising steadily over the last number of years.

Case I looks at those Canadian students educated at four-year private universities in the U.S. For those that stay in the U.S. we compare Canadian high school earnings with U.S. university earnings. Case II examines those Canadian students who decide to move back after graduating from a U.S. private university. Here we compare Canadian high school earnings with Canadian university earnings. As is evident from the results, remaining in the U.S. after graduation is the better option in terms of tax side incentives.

Perhaps more importantly, we see that if tuition reaches that of private institutions in the U.S., rates of return are hit quite dramatically. For instance, net rates of return go from 8.76% to 4.86% for males and from 12.31% to 7.28% for females. The impact on the ETRs is not as significant. Surprisingly, the low earnings of the 25th quantile individual combined with the significant increase in tax credits actually causes ETRs to be marginally reduced.²⁸ Unfortunately the same cannot be claimed for high earners. Once again, those at the upper end of the earnings distributions are (negatively) affected the most; ETRs rise from 21.2% to 25.9% for males and 15.3% to 17.1% for females.

Table 2.7 explores a number of policy experiments that are in line with recent changes in the Canadian education system. For instance, tuition increases and expenditure reductions have been a large part of the education system over the last number of years. Recently education amounts have also been increased and progressivity in the income tax, reduced. The results from Table 2.7 allow us to examine the implications these changes may have had on the incentive to invest in human capital for Canadian students, as well as their incentive to relocate after graduation. All comparisons are made with respect to the base case results.

Results show that if tuition is increased without the requisite allowances for tuition credits that ETRs rise and rates of return fall for both males and females. Perhaps surprisingly, when credit allowances for tuition are maintained at their current levels the results approximate our base case. This shows that increases in direct costs to education can be offset by establishing the appropriate credits. The downside is that the change is still accompanied by a reduction in rates of return.

Table 2.7 also illustrates the positive aspects of increasing education amounts and decreasing progressivity of the income tax system. While doubling the education amount

²⁸ We assume no limit on the credit.

increases rates of return and lowers effective tax rates, the impact is far less than that realized as a result of implementing a flat income tax. Recall that the latter also has the added bonus of stemming migration, unlike the former as explained earlier. This lends credence to the belief that how students are treated after graduation is just as important, if not more so, than how they are treated while in school.

Finally, Table 2.7 shows the impact on the ESR and net ETR of reducing expenditures to education by 20%. Notice that while the reduction leads to a decrease in ESRs and subsequent increase in net ETRs, the net effect is still negative. The implication is that perhaps the Canadian system is still spending too much on its education system. Of course, while the reduction in expenditures would have no direct effect on rates of return it may have an indirect effect through the increased inability of Canadian schools to retain and recruit professors. It is possible that this indirect effect may be quite large. This would be a good avenue for future research to explore.

2.5 HUMAN CAPITAL POLICY

The incentives to invest in human capital can have important implications for public policy. In this section we concentrate on two issues: emigration decisions and domestic incentives. In both of these cases the tax treatment of human capital is important. The first considers the treatment of taxation as a catalyst for cross border migration (e.g. the brain drain phenomenon), while the latter considers the implications taxation can have on the incentive to invest in human capital over other alternatives, such as physical capital.

We have seen that Canadian students face disproportionately higher ETRs than their American counterparts. We have also seen that the tax incentives to move to the U.S. after graduation are significant and that higher income individuals face greater incentives. So why

isn't there a mass exodus? The obvious response is that there is more to migration than tax treatment alone. People have family considerations, ties to the community in which they live, friends, etc. There is also the fact that not all individuals, whether skilled or otherwise, have the same opportunities.²⁹

While Canadians have seen an increase in emigration from doctors, nurses and natural scientists the averages for the most part have been steady and when considered as a percentage of the total workforce, remain quite small. Therefore, the outflow of human capital to the U.S. appears to be small overall and the impact on existing stocks minimal. Although, with an aging population and the state of health care should these trends continue the flows in health related disciplines could become significant. Combine this with the fact that temporary emigration tends to make the above numbers higher and the loss of skilled labour could become even larger.

Of course, even if ETRs were zero this would not make us brain drain proof. The reason is that it is not the treatment of direct costs to education that affects the emigration decision, but rather the tax treatment of earnings after graduation. While subsidization is beneficial in reducing ETRs, we have seen that it does not have the impact on emigration decisions that, say, a reduction in marginal tax rates could have. It is the way in which policy goes about reducing ETRs (or *net* ETRs) that is of crucial importance. For instance, policy initiatives aimed at reducing human capital ETRs can play a role in the emigration decision only if they are directed at taxing returns less. Additional education credits or relief while an individual is in school are successful at reducing ETRs, but have no impact on individual decisions once the student has graduated.

It is also important to realize that higher human capital ETRs in Canada need not necessarily imply a relative lack of investment compared with the United States. While

²⁹ Helliwell (2000) provides other explanations.

investment in human capital does depend on human capital ETRs, it also depends on the tax treatment of personal savings and investment. The upper-middle class in both countries could therefore be seen as having an incentive to invest in physical rather than human capital, due to high positive ETRs on human capital. With the higher marginal tax rates in Canada, high-income earners can be expected to invest less in physical capital. So while middle to upper-middle income Canadians have an incentive effect that encourages investment in physical as opposed to human capital, this result may change when personal investment income becomes taxable.³⁰

It is also important to realize that whether or not people have an incentive to invest in human as opposed to physical capital does not necessarily determine which country will be more human capital intensive. Again, the reason is due to migration. While there may be an incentive to invest in physical capital at the individual level this result may be eroded at the economy level because physical capital can move to a more favorable tax environment. This presents an interesting dilemma for Canada in particular. For instance, it might be that Canadian policy is encouraging a physical to human capital ratio that is too low, which could be contributing to our lag in productivity growth in the economy, while at the individual level distorting investment away from human capital. Combine this with the fact that investment in Canadian businesses has been relatively low over the last decade and Canada's position becomes even less favorable.

³⁰ This has to do with the fact that roughly 70% of personal investment income in Canada has been calculated to be tax-free (Poddar and English, 1999).

2.6 CONCLUDING REMARKS

This paper has shown how the incentive to invest in human capital can be assessed using effective tax rates (ETRs) and subsidy rates (ESRs). The approach was illustrated for undergraduate university education in Canada and the United States by way of the 1998 Survey of Consumer Finances and Current Population Survey, respectively. Our results have concentrated on the relative magnitude of ETRs and ESRs in Canada and the U.S., as well as the incentives for recent graduates to migrate.

We have seen that ETRs vary considerably among individuals and can be quite large. Results show that Canadian students face much higher ETRs than their American counterparts. Canadian students also face greater incentives to migrate after graduation. Both of these facts are lessened when the expenditure system is taken into account. ESRs counteract the disincentive effect created by the tax system and promote human capital investment. Canadian males tend to face higher ETRs than females due in large part to higher earnings. This latter result may help to explain why we have seen lower male/female ratios in university and college enrolment.

While lower ETRs are beneficial from the standpoint of creating greater incentives to invest in human capital, we have shown that a reduction for its own sake is not the best policy. Policy initiatives aimed at reducing taxation of returns to education, as opposed to increasing the benefits to the student while in school (e.g. tuition credits, education amounts), are far more promising. While both policies unambiguously reduce ETRs, the latter has no effect on emigration decisions. Furthermore, policy initiatives designed to increase the benefits of the student while in school may cause more harm than good if such benefits are enacted without any subsequent relief on returns. The reason is that such policy only enhances the benefits of migration. Should the government find policies designed to lower the taxation of returns

unpalatable, cross border migration will continue at a rate equal to the elasticity of migration with respect to the tax differential.³¹ What this means for Canada's long term economic position remains to be seen.

Over the last several years Canada and the U.S. have made some significant changes to higher education. Whether these changes come on the expenditure side in the form of less funding for institutions or on the tax side their effects are complex. While tax credits have been made more generous in both countries, tuition and other direct costs to education have been rising. These changes have opposite effects on human capital ETRs and would seem to indicate a somewhat counter productive human capital policy. Perhaps the most important policy change in Canada and the U.S. is the reduction in marginal rate structures for income tax. The changes while undoubtedly leading to a reduction in observed ETRs and increasing the incentives to invest in human capital have but one problem for Canadians. The parallel reduction in MTRs by the U.S. will unlikely impact migration decisions to any great extent.

While the empirical analysis focused on the PIT, many other taxes have an effect on human capital ETRs as well. For example, payroll taxes in Canada have a much lower earnings threshold at which marginal rates go to zero, which offsets the effects of the graduated marginal rate structure for income taxes. Since rates in Canada are lower than those of the U.S. they tend to offset income taxes to a greater extent and reduce ETRs more. Sales taxes are also much more important in Canada than in the U.S. The greater reliance in items such as the broad-based goods and services tax as well as provincial taxes, all result in greater ETRs in Canada. We also talked about how student loans affect the results. Through the use of illustrative calculations we showed that the tax credit provided for interest on student loans is in fact not as valuable as the credit for

³¹ What this rate is exactly is a good question for future research.

direct out-of-pocket expenses. The credit for out-of-pocket expenses leads to a larger reduction in ETRs, than the interest credit.

While ETRs have been used to study the incentives on physical capital investment created by the tax system, the work on human capital investment is in its infancy. This study has attempted to shed some light on tax side incentives for investing in human capital in Canada and the United States by examining cross border migration and domestic investment decisions. The insights in this paper provide only a small glimpse into the research possibilities. More work is needed on the incentive effects of additional forms of taxation and different types of human capital accumulation (e.g. OJT, College, Vocational programs, etc.). Disaggregation by field of study or program would also prove useful, since it would allow a more accurate assessment of how different students are impacted by the tax system. Finally, how the earnings of private university students compare with those of public university students in the U.S. would allow a more accurate depiction of how ETRs vary among these individuals.

APPENDIX 2A

In this section we work through the derivation of the illustrative equations. The derivation follows closely that of Collins and Davies (2001). We start by assuming the length of schooling is just one year, $t = 1$. The calculations are first performed for the gross-of-tax rate of return and then repeated for the net-of-tax rate of return. Including loans in (2), the IRR equation, we find,

$$(A1) \quad \sum_{t=1}^T \frac{(E_t - E_t^*) - C_t - iL_t}{(1 + r_j)^{t-1}} = 0 .$$

Moving all the $t = 1$ terms to the LHS results in,

$$(A2) \quad E^* - E + C - L = \sum_{t=2}^T \frac{E_t - E_t^* - iL_t}{(1 + r_i)^{t-1}} .$$

Notice that since our education program lasts only one year that direct costs, C , appear only on the LHS of (A2). Forgone earnings are represented by $E_1^* - E_1$, while the RHS is the future value of the earnings increment. The interest rate i is assumed to be constant and L represents student loans. iL is loan repayments.

Assuming that the yearly benefits of additional education and cost of student loan repayments are constant and that T is large, we can write (A2) as,

$$(A3) \quad E_s^* - E_s + C_s - L_s \cong (E_w - E_w^* - iL_w) \sum_{t=2}^T \frac{1}{(1 + r_g)^{t-1}} = \frac{E_w - E_w^* - iL_w}{r_g}$$

where we adopt the subscript s and w to denote the periods for school and work. Rewriting (A3) in terms of r_g , we find

$$(A4) \quad r_g \cong \frac{E_w - E_w^* - iL_w}{E_s^* - E_s + C_s - L_s} = \frac{EI - iL}{FE + C - L}$$

where EI is the earnings increment and FE is forgone earnings. Performing the same calculations for after-tax returns and assuming that tax rates are constant with $\tau_w \geq \tau_s$, we get

$$(A5) \quad r_n \cong \frac{(E_w - E_w^*)(1 - \tau_w) - i(1 - \tau_w d)L_w}{(E_s^* - E_s)(1 - \tau_s) + C_s - A_s - L_s} = \frac{EI(1 - \tau_w) - i(1 - \tau_w d)L}{FE(1 - \tau_s) + C - L - A}$$

where τ_w and τ_s are, respectively, the marginal tax rates on labour (i.e. earnings increment) and forgone earnings, A is the credit provided for direct out-of-pocket expenses for education, and d is the deductibility of interest paid on student loans. If we have full deductibility, then $d = 1$ and interest is deductible at the marginal tax rate on labour income τ_w . We parallel this with the deductibility of direct costs for education, which we assume is $A \leq \tau_s C$. If we have full deductibility of out-of-pocket expenses then $A = \tau_s C$. Replacing (A4) and (A5) in our ETR equation we can write,

$$(A6) \quad ETR = 1 - \frac{r_n}{r_g} = 1 - \left(\frac{(1 - \tau_w)EI - i(1 - \tau_w d)L}{(1 - \tau_s)FE + C - L - A} \right) \left(\frac{FE + C - L}{EI - iL} \right).$$

It is (A6) which provides us with the illustrative capabilities presented and discussed in the paper.

Chapter 3:

Taxation, Human Capital and Tuition Fee Deregulation: A Study of Canadian Universities

3.1 INTRODUCTION

The purpose of this paper is twofold. First, it is intended to show the impact that the current tax structure in Canada has on individuals' incentives to invest in different fields of study at the university level. To do this effective tax rates (ETRs) and effective subsidy rates (ESRs) by field of study are calculated. Second, it is to examine the impact that deregulation of tuition fees in particular disciplines or programs has on individuals' incentives to invest. To this end we concentrate on three of the top business schools in Canada.¹

The issues of taxation and fee deregulation at the university level bring up a number of interesting questions. For instance, is the taxation among different disciplines uniform? If not, what impact does this have on issues like brain drain? In terms of deregulating tuition fees, has this policy had the intended impact it was designed to have? That is, has it been able to lower or maintain enrolment in order to keep class sizes down? Are people who are admitted to these disciplines "better off" in the long run than they otherwise would be? What is the impact of higher tuition on males and females? Are both impacted equally or is one sex more adversely affected than the other?

Effective tax rates are the proportional difference in before and after-tax rates of return. While they have been used to study investment behavior in all kinds of physical capital, the use of ETRs to study investment decisions in human capital has only recently begun to take shape (see Collins and Davies, 2002). This is somewhat surprising due to the overall impact that human capital investment has on the economy. Both the externalities arising from the accumulation of human capital and its impact on growth and innovation have been studied extensively (see, for

example, Davies, 2002; Barro and Sala-I-Martin, 1995). While the framework developed in this paper is used to examine the incentive effects of investing in a university education for different fields of study, there is a wide range of possible extensions. We discuss some of the more pressing issues later in the paper.

While previous studies have shown the impact of the tax structure on individuals' incentives to invest in a university education nationwide (see, e.g., Collins and Davies, 2002), none have disaggregated by field of study. By disaggregating we can get a sense of how different fields are treated. Individuals in different fields earn at different levels. Given the graduated rate structure on income this means that certain fields of study will be treated differently. Likewise, different fields charge different tuition and fees. Similarly, some fields are harder to get into than others. Therefore, students in particular disciplines may be of higher quality or ability. If people in particular fields are more able than others, then the earnings premium in different fields may be partly the result of ability; the degree may act as a signal to employers. If "higher quality" disciplines (like top ranked versus lower ranked business schools) act as better signals, then even higher earnings premiums may result. If true, then this may offset the recent trend of some schools that are charging high tuition.

Like their physical capital counterpart, ETRs on human capital are nonuniform. Findings here show that they vary depending on whether the student is male or female and what discipline they are in. As with past studies, female rates of return are found to be greater than males. This is a result of the larger earnings increment that exists between female high school and university graduates. Males face higher ETRs than females, due to higher marginal tax rates on income. Female ETRs average 11.7%, while males average 13.4%. When the expenditure side is taken

¹ The three schools are: The Richard Ivey School of Business (University of Western Ontario), The Rotmann School of Management (University of Toronto), and Queen's School of Business (Queen's University).

into account and the *net* effect of both taxation and expenditures calculated, the findings support an education system that promotes investment in all major fields of study at the university level, with the largest support going to the health related disciplines. The least support is to social science and commerce fields, which may explain why many business schools lobbied for the deregulation of fees in Ontario in the late 1990's.

In 1998 in Ontario the Tories permitted some programs at Ontario Universities to deregulate their tuition fees. As a result, certain disciplines (e.g. Engineering, Computer Science, and Business) are now charging tuition that is far higher than that faced by the average university student. Previous studies have shown the impact that increasing tuition has on rates of returns (see, for example, Vallaincourt and Bourdeau-Primeau, 2002). These studies find that despite large, hypothetical increases in tuition, investing in a university degree remains an attractive option for many students, given the high rates of return. While interesting, little of the work has taken into account the impact of the tax structure on these disciplines in conjunction with the added tuition hike. Fields that were once high return fields may not be so as a result of deregulation. The findings here support this latter view. For instance, students at one of the top three business schools in Canada would have to make an earnings premium of between 16 – 39%, depending upon whether they were male or female and what school they attended, in order to have the same rate of return as prior to deregulation. In other words, these students would have to make 16 – 39% more than the average business graduate if they wanted to get the same rate of return on their degree as they had before the rise in tuition levels. With no such increase, the rate of return to an undergraduate business degree would dominate only that of a humanities degree.

An additional dilemma for Canadian policymakers is that the profitability of obtaining a university degree in Canada increases dramatically if students choose to migrate to the United States after they graduate (see Chapter 2 of this thesis). We show that education policy, combined with tax structure, may be a contributing factor to the brain drain phenomenon witnessed in Canada.

The rest of the paper is organized as follows: Section 3.2 examines the methodology used to calculate rates of return and effective tax/subsidy rates; Section 3.3 looks at the impacts that taxation has on individual incentives to invest in different fields, while Section 3.4 looks at the field of business and assesses the impact that deregulation of fees has had on students; Finally, some concluding remarks are offered in Section 3.5.

3.2 METHODOLOGY

Background

A number of studies have looked at the returns to education and tuition policy in Canada (see, for instance, Rathje and Emery, 2002; Vallaincourt and Bourdeau-Primeau, 2002). While interesting, there has been no account of the impact of the tax and expenditure systems on individual incentives to invest in a university education. Many of these studies look solely at rates of return, public (or social) and private. The issue here is that returns tell only part of the story. It is the intent of this paper to extend the previous analyses in an attempt to provide a more comprehensive look at higher education in Canada. To this end we examine both the taxation and expenditure systems in conjunction with one another. This permits a better overall picture of education policy as it pertains to university students, since it allows us to note the impact tuition hikes have on the university education system as a whole. To accomplish this, we calculate

effective tax rates (ETRs) and effective subsidy rates (ESRs). The difference will provide an overall assessment of tax and expenditure effects on the incentives to take higher education in Canada.

While effective marginal tax rates (EMTRs) have been used to study a wide range of investment opportunities in physical capital, the study of ETRs on human capital has only recently begun to take shape (see, e.g., Chapters 1 and 2 of this thesis; and Mintz, 2001). The distinction between the calculation of EMTRs for physical capital and ETRs for human capital is that the lumpiness of human capital investments tends to matter, unlike for physical capital, as explained below. Therefore, we are not necessarily measuring the marginal investment in human capital *per se*, but rather the next level of the investment. For instance, the move from middle school to high school or from secondary schooling to post-secondary education.

While the problem of measuring effective tax rates on human capital is formally the same as that for physical capital, there are measurement issues that make a different approach necessary in practice.² In the case of physical capital one can make plausible assumptions about the rate of return to a hypothetical marginal investment based on observed asset returns in capital markets. For human capital rates of return are not directly observable. For physical capital the fact that real-world investments are typically lumpy does not affect the results. Corporate taxes are levied at a flat rate, so the estimated effective tax rate does not depend on the size of the investment. For human capital the most important tax is the personal income tax, whose graduated rate structure makes the effective tax rate depend on the scale of the investment.

² The problems faced when dealing with human capital are quite different than in the study of physical capital. For example, in calculating *EMTR*'s for physical capital one must specify a scenario concerning the determination of market rates of return. It might be assumed, for example, that Canada is a small player in a perfectly competitive world capital market. In order to pay the world interest rate, a corporation would have to earn a gross rate of return on a debt-financed project sufficient to pay both tax and interest at the world rate. By observing market rates and tax parameters one can infer the before-tax rate of return on a marginal investment. The after-tax return is then found by deducting all taxes. As we shall see, the procedure for human capital is quite different.

In the past, changes in tuition have been examined for their impact on rates of return. If the rates of return remain higher than the next best alternative, previous studies, like those mentioned above, assume that the increase can be justified. The methodology employed here allows for a more detailed interpretation of the deregulation of tuition fees. Rather than look at hypothetical increases across all disciplines, we examine the actual results post-deregulation. Our assessment of the overall impact on the education system is based on rates of return, to provide a point of comparison with past studies, ETRs and ESRs.

Regression Equation, ETR and ESR Calculation

We examine six undergraduate fields: Humanities, Social Sciences, Commerce, Natural Sciences, Engineering, and Health Sciences. A description of each field is provided in Table 3.1.

[Insert Table 3.1 Here]

Using the regression results in Vallaincourt and Bourdeau-Primeau (2002) - - henceforth **VB** - - which are based on the 1996 Census, we are able to compute lifetime earnings per field of study.³ In their study **VB** use the standard semi-logarithmic regression equation:

$$\ln(\text{earnings}) = \beta_0 + (\beta_1 \times \text{Age}) + (\beta_2 \times \text{Age}^2) + \left[\sum_i \beta_{i3} \times \text{Fields} + \sum_i \beta_{i4} \times \text{Fields} \times \text{Age} \right]$$

³ For a description of how this is done, the reader is directed to Vaillancourt and Bourdeau-Primeau (2002).

to compute earnings over the lifecycle. To calculate our counterfactual we use the relationship between age and age squared to compute high school earnings and the entire equation to compute earnings by field of study. The difference between these two is the earnings increment. We calculate this for each field and for each age. The findings are then used to compute internal rates of return and ultimately ETRs and ESRs by field of study. VB's data on tuition, fees and public expenditures are also used for the calculation of our counterfactual (i.e. before deregulation).⁴

Suppose that an individual aged t is planning to engage in a program of education that will take m years of study. We will assume that after this program is completed the individual will stay in the labor force until age T . Students may continue to earn while going to school. Their wage rates can vary over time, perhaps increasing while they are still in school, and likely rising in real terms over much of the lifetime after graduation. Actual earnings before-tax are given by E_t , which is the product of the wage rate and hours worked. Earnings before-tax in the absence of the educational program would have been E_t^* , where we assume that $E_t^* < E_t$ in the $T - m$ years after graduation. Forgone earnings costs of education, FE_t , are thus $E_t^* - E_t$ in the first m years. In addition to these costs, there are private direct costs of education, C_t .

The gross private rate of return, r_g , solves the equation:

$$(1) \quad \sum_{t=1}^T \frac{(E_t - E_t^*) - C_t}{(1 + r_g)^{t-1}} = 0.$$

⁴ For regression results and tuition values, the reader is directed to Vaillancourt and Bourdeau-Primeau (2002).

By replacing gross-of-tax variables in (1) with after-tax variables the net after-tax rate of return, r_n , may be computed.

The *ETR* for human capital is simply defined as the proportional difference between gross- and net-of-tax rates of return to a program of study:

$$(2) \quad ETR = \frac{r_g - r_n}{r_g}.$$

This definition, which is built on the use of internal rates of return, follows the methodology applied in computing *ETRs* on personal financial assets by Davies and Glenday (1990).⁵

By replacing private costs with public costs, C_t^p , we can use (1) to compute the public rate of return, r_p . Given r_p we can define the effective subsidy rate (*ESR*) on human capital:

$$(3) \quad ESR = \frac{r_g - r_p}{r_g}.$$

Whether the tax and expenditure systems combined have an incentive or disincentive effect on human capital investment can be investigated by computing the *net* effective tax rate on human capital, $ETR - ESR$. Through the use of these three equations, we are able to get an overall

⁵ An alternative is to define the *ETR* as the ratio of the present value of net taxes on labour income over the lifetime to the present value of lifetime earnings (see Mintz, 2001). While the two approaches will often produce similar results, this is not always the case. We prefer the approach followed here in part because it does not require any assumption to be made about individuals' discount rates.

picture of the incentives to invest in different fields of study, as well as the impact of deregulation.

3.3 TAX IMPACTS ON INCENTIVES TO INVEST

Tables 3.2 through 3.4 illustrate the overall impact of Canada's education system on individuals incentive to invest in a university education. In Table 3.2 we see that female rates of return are higher than male in all disciplines, except for engineering. The male/female wage gap is sufficiently large in engineering to make the rate of return lower for women. While the Female/Male ratio has been rising over the last number of years at universities, when broken down by field, men still predominantly choose engineering; historically, this has also been the case. The result is that males predominantly hold many of the high paying senior positions. Therefore, the earnings increment for men, that is the difference between high school earnings and university earnings, is greater. Large enough, in fact, to override the disincentives created by the higher marginal tax bracket male earners find themselves in.

[Insert Table 3.2 Here]

The opposite can be seen in health science. Historically, women have tended to hold these positions and, as such, are in the higher paying jobs; this results in a higher earnings increment and an increase in rates of return. Once again, the disincentives created by the progressive income tax system are not enough to offset the income differential between health professionals and high school graduates.

More importantly, table 3.2 shows that effective tax rates do not vary greatly across disciplines. This is particularly interesting since each field has different earnings potential. For instance, commerce and engineering graduates tend to have higher paying jobs, on average, then, say, humanities or social science graduates. This would tend to push individuals in these fields into higher tax brackets due to the graduated rate structure on income. Surprisingly, the higher rate of taxation, combined with the higher tuition business and engineering students face, is not enough to cause the ETRs to be exceedingly higher.⁶

Males face higher ETRs in all disciplines, than females; as a result, they face greater tax-side disincentives to invest in a university education. The disincentive is so large that it actually increases the financial incentive for men to seek alternative job opportunities in the United States. As seen in Chapter 2 of this thesis, university graduates have large tax-side incentives to extend their job search to the United States. Not only is this due to the larger earnings potential, but also the more liberal tax treatment on labor income. The U.S. system is flatter (i.e. less progressive, with more liberal itemized deductions) than the Canadian. Given this, net rates of return are depressed greater in Canada. The result is a larger gap between net and gross rates of return and higher ETRs. How this contributes to the brain drain in Canada is something that deserves further exploration.

Of course, the tax system is only half of the education puzzle; there is also the expenditure side. The education system in Canada is heavily funded and this is illustrated in Table 3.3. Public rates of return, which are those that take into account public funding per full time equivalent student, are remarkably lower than gross or net private rates. This leads to exceptionally high effective subsidy rates (ESRs) for all fields.

⁶ We will see that this is not the case when we consider deregulated tuition values.

[Insert Table 3.3 Here]

An interesting result is that unlike the ETRs, the ESRs are highly nonuniform. Those disciplines which require labs and research facilities, such as engineering and health programs, receive disproportionate funding, compared to those that do not, such as the social sciences and commerce. This imbalance is one element in the argument that deregulation of tuition fees in certain fields, such as commerce, is needed. Deregulation counteracts the funding formula of the government, in terms of the amount that can be spent per student, by replacing the missing public contribution in under funded areas by private contributions. Another reason for deregulation, which we will have more to say about later, is the higher expenditure on professors' salaries in certain fields, like business administration. Higher salaries are required, in part, to compensate for higher market value of professors. Without deregulation, universities argue that students suffer due to retention and recruiting problems of high quality professors.

Another interesting result in Table 3.3 is the greater subsidy rate for females as opposed to males. Combined with lower ETRs and higher rates of return, this may account, in part, for female/male ratios rising over the past number of years. The largest difference between male and female subsidies is in the engineering field – a field that is predominantly male. The higher subsidy per full time equivalent female counteracts this latter fact by increasing the incentives for females to choose engineering. Whether by design or by accident, this policy seems to have positive repercussions.

To get a full picture of the education system in Canada we calculate the *net* ETR, which takes both the subsidy rate and rate of taxation into account. These results are presented in Table 3.4. Not surprisingly, given our previous findings, the net ETRs are nonuniform. The ESR

overrides the ETR, leading to negative net ETRs. The result is that the Canadian education system tends to promote investment in university for all fields. The fields that face the highest overall incentives are the ones that receive the highest funding from the government (engineering, pure sciences, and health).

[Insert Table 3.4 Here]

The results bring up some interesting policy issues. While it is true that some disciplines require more money to conduct labs and run research facilities, these fields are often the higher return fields. Witness the fact that both males and females have their highest returns from the engineering and health related fields, respectively. Without commerce, the three fields with high costs for labs and research facilities would rank 1-2-3 for both males and females. Given the return on their investment, it would seem that these students are in a position to incur additional direct costs to education and still receive a rate of return above and beyond many other disciplines. Does this justify deregulation?

One problem with the above argument is that, as mentioned, these fields already receive a disproportionate amount of government funding. Allowing them to deregulate fees, without changing the funding formula, would seem to be benefiting the “rich” programs (highly funded fields) at the expense of the “poor” programs. Then there is the issue of enrolment and job opportunities.

Engineering graduates, for instance, typically earn more than, humanities graduates. Does that make them more valuable? In terms of market value, the response would seem to be yes. But, is market value the appropriate unit of measurement here? Do humanities graduates bring

something to the economic table that graduates in other disciplines do not? Studies would seem to indicate that degrees like humanities and fine arts have large external benefits (Rathje and Emery, 2002). The tricky part comes when deciding how to incorporate these findings into the funding formula of the government. Few would argue that a world full of engineers, devoid of artists, would be a good thing.

One dilemma is that health related disciplines also have high rates of external benefits. From Table 3.3, we see that the health field also receives the highest amount of subsidization. Few would argue that this latter fact isn't justified by the former. Engineering, on the other hand, while contributing to growth and innovation, does not have the same external benefits (Rathje and Emery, 2002).⁷ Of course, we are talking about the undergraduate level. At the graduate level, external benefits of engineering, like many other disciplines, rise. Does this justify the increased funding? Unfortunately, an answer to this question is beyond the scope of this analysis, but nonetheless, would prove fruitful for further study.

3.4 DEREGULATION OF FEES: INTENDED AND UNINTENDED CONSEQUENCES

The Case for Ontario

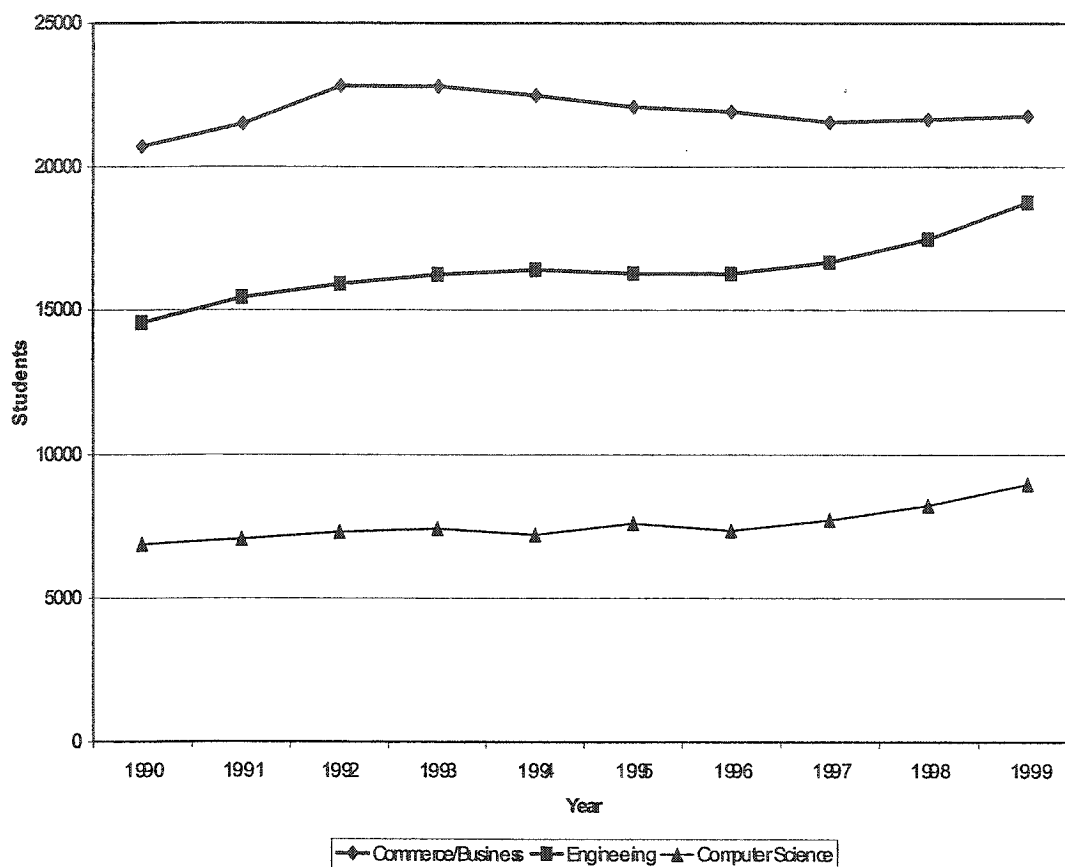
In 1998 in Ontario the provincial government permitted some programs (e.g. engineering, computer science, commerce, etc.) at Ontario Universities to deregulate their tuition fees; as a result, certain disciplines are now charging tuition that is far higher than that faced by the average university student. Studies have shown that increasing tuition, while having a negative impact on returns, would still not make other means of investing more attractive (see, for

⁷ This is not to say that engineering is without external benefits. According to endogenous growth literature, or at least one strand of it, emphasis is placed on the spillover effects of human capital, technology adoption, etc. Often the percentage of engineers in a country's population is one of the most important determinants of the rate of technological adoption.

instance, Stager, 1994; Rathje and Emery, 2002). These previous studies have not taken into account the impact of the tax structure on these disciplines, let alone in conjunction with the added tuition hike. More to the point, fields that were once high return fields may not be so as a result of deregulation, which raises the question of why so many students continue to enroll in these programs.

Proponents of deregulation argue that increasing tuition fees in certain disciplines is necessary to maintain class size and quality of education. Provincial funding cuts in the 1990's also made finding other sources of revenue a priority for certain fields; namely, the fields where market value of professors is high. In this section we address deregulation five years after its inauguration in an attempt to determine if it has had its intended effects.

Figure 3.1
Full-Time Enrolment Figures, 1990-1999



Source: Council of Ontario Universities

Figure 3.1 shows full-time enrollment figures in three of the main deregulated fields: Business, Engineering, and Computer Science. As we see all three fields see an increase in enrollment numbers after 1997. The threat of larger tuition fees seemed to have little effect on the graduating classes of 1997 and 1998.

The increase in enrollment comes even as tuition and fees in these programs continue to rise. Of course, the rise in enrollment may not spell the end of manageable classroom sizes. It could be that more sections of the same course are now offered. Higher tuition fees may also

permit the hiring of more professors. Therefore, to draw any conclusion about deregulation based on enrollment numbers alone would be unjustified.

Unfortunately, the data do not support the latter view. Table 3.5 shows that during the 1990's the student teacher ratio rose. This means that per full-time equivalent student there were less teachers to go around or, put differently, the hiring did not keep up with the increase in enrollment.

Table 3.5
Student/Teacher Ratios, 1990-1999

Year	Ratio
1990	18.0
1991	19.1
1992	19.6
1993	19.7
1994	20.1
1995	20.1
1996	21.2
1997	21.4
1998	21.4
1999	22.1

Source: Council of Ontario Universities

An Examination of Three Top Canadian Business Schools

We now turn our attention to the case of Canada's top three business schools: Queen's School of Business (Queen's University), The Richard Ivey Business School (University of Western Ontario), and The Rotman School of Management (University of Toronto). Tuition in the deregulated fields is roughly 200% greater for students admitted to a 4-year honors program in business, than the tuition fees that the majority of students are facing. This can mean tuition in excess of \$15,000 for one year of education. Does the selective nature of these programs ensure a return high enough to offset these high tuition fees? To this end, what type of "income premium"

is required to return the rate of return to its pre-deregulation value? Finally, given deregulation, does it pay for students to invest in a business degree over other fields? We address these questions below.

Our selection of these three business schools is based on rankings in magazines such as *Business Week* and the *Financial Times*. As Table 3.6 shows, these universities are in the top echelon in Canada. On the international front, a recent survey by *Business Week* places Queen's 2nd among international business schools (i.e. business schools outside of the U.S.), while Western ranked 6th and Toronto 5th. It should be pointed out that while researchers are currently studying the importance of such rankings in the selection process of students, we make no such claim. Our selection is simply based on the fact that these three schools rank the highest for the field of business in Canada in recent surveys. Whether or not students are of better quality, or the rankings lead more able students to choose these schools is left for future research.

Table 3.6
Ranking of Top Three Business Schools

School	Business Week	Financial Times		
	Int Bus Schools	MBA		
	2001	2003	2002	2001
Western	6	22	18	19
Toronto	5	21	31	46
Queen's	2	40	46	87

Using the latest information on tuition and fees, table 3.7 shows estimated net rates of return for students in these business schools. The high tuition fees result in a drastic reduction in rates of return for all students. The drop is so large that all other fields, except humanities, strictly dominate a business degree from these three schools. That is, all fields of study, besides

humanities, yield higher rates of return than does a business degrees from any of the three top business schools.

[Insert Table 3.7 Here]

The rates of return are calculated using mean earnings of all 4-year business degree graduates. Some would argue that this logic is flawed, since higher quality business schools typically have better students; as a result, this may lead to greater possibilities after graduation and higher salaries. With this in mind, we calculate a quality premium, which is the loss in rates of return as a result of going to these schools, as well as an income premium. The income premium is based on a required increase in mean earnings of top business school graduates, such that their rates of return are returned to their original levels (i.e. pre-deregulation numbers).

The quality premium is calculated by taking the difference between the pre- and post-deregulation rates of return for business school students. The quality premium for females is higher than it is for males. Higher tuition and fees have a greater impact on female rates of return, than on males (see Chapter 2 of this thesis). While the quality premium has a negative impact, one cannot discount the possibility of increased earnings as a result of attending one of these three schools. Therefore, students may in fact be better off, even in the face of exceedingly high tuition.

Of the three schools in our study students at the University of Western Ontario, the school with the highest tuition and arguably the school with the best reputation among business schools, must have the highest income premium if they are to realize an overall monetary benefit. The income premium for these students is 39% for females and 23% for males. Students

at business schools at Queen's and Toronto face roughly the same income premium of 28% for females and 16% for males. Are these increases in income likely? If students at these schools are the "cream of the crop" then their income after graduation may indeed be higher. The question then arises, how much of this increase is due to ability and/or how much of it is the "signal" provided by their place of study? If it is simply ability, then these students would be better off studying business at a different school. If it is the signal, then, providing the income premium is large enough, deregulation would appear to be justified from an equity standpoint. Whether or not deregulation can be justified from an efficiency standpoint would be an interesting question for further research.

While it is interesting to discuss income premiums and examine changes in rates of return due to increased tuition, the real benefit of the methodology laid out in the beginning of this paper is the fact that we can study the taxation and expenditure implications of such an increase. In Table 3.8 we see a reduction in gross rates of return, as well as net rates of return for all students at these three business schools. The proportional difference between gross and net rates of return is also increased due to the impact that an increase in tuition has on net rates of return (see Chapter 1 of this thesis). The result is a larger effective tax rate for males and females, compared to our base case. Therefore, not only are these students facing much higher tuition than that of the average student, they are also subjected to greater disincentives on the tax side to invest in the education in the first place.

[Insert Table 3.8 Here]

On the expenditure side, the increase in tuition has resulted in a reduction in the subsidy rate per full time equivalent student. The rise in ETR and fall in ESR, increases the disincentives for students to invest in a business degree; this is seen through an increase in net ETRs. The changes also lead to greater incentives for students to seek employment elsewhere upon graduation.

With a more progressive income tax system in Canada than the U.S., graduates are somewhat at a disadvantage when compared with their American counterparts. Often higher paying jobs in the United States are to blame for graduates leaving the country, but as we see here the tax system may also be to blame. Even in the face of purchasing power parity, students in Canada would still find it worthwhile to move to the U.S. (see Chapter 2 of this thesis). Not only is there a more mildly progressive income tax, but many other tax breaks also exist, making the U.S. a very attractive destination for many graduates.

3.5 EDUCATION POLICY IN CANADA

In the face of rising costs to education, tuition deregulation, double cohorts, rising participation rates, recruiting and retention problems of quality professors, the post secondary education system in Canada seems to be in a state of perpetual flux these days. In this section we address some of the issues in more detail and offer some guidelines for dealing with them.

With rising costs to higher education in Canada more people have started to take advantage of registered education savings plans (RESPs). RESPs allow people to save for their children's education by earmarking money that is to be spent on education alone. This plan works in much the same way as RRSPs, with a few fundamental differences. The first, is that money being put into the plan is not tax deductible, but withdrawals are tax free. Therefore, these

are much the same as Roth IRA's in the United States. To encourage the use of RESPs as a means of saving for education, the government in Canada initiated a subsidy scheme called the Canada Education Savings Grant (CESGs). This program provides people with a grant of 2% a year on the money they place in the RESP, up to a maximum of \$400.

While the use of RESPs has increased in recent years due to this initiative, the participation rates have been somewhat skewed. The problem is that those in the upper income brackets have had the greatest participation (see, e.g., Milligan, 2002). Those that can afford to pay for their kids to go to school are the ones being subsidized. If the system was designed to help alleviate the burden of paying for higher education on all families, then it would appear to be a success for the wealthy. But, if it was designed to make education more attainable to the less well off, then it would seem that the program needs to be reevaluated.

In any event, the use of RESPs, with the help of CESGs, does indeed increase the incentives for investing in higher education (Collins and Davies, 2002). Ignoring any sort of equity argument, results show that the program can indeed combat rising education costs. If costs continue to rise, an increase in the CESG, either in absolute terms (i.e. increasing the \$400 limit) or in percentage terms (i.e. increase the 2% grant) would be a wise consideration.

It should be mentioned that families are also capable of withdrawing from their RRSPs to pay for education. The tax free withdrawal can be made to pay for the education of a child, but must be repaid within 10 years. If so, then no tax will be charged on the withdrawn funds. The benefit of using a RESP to pay for a child's education over an RRSP is clear; the CESG is only applicable to the RESP, not the RRSP. Even if the child chooses not to go to school, money put into the RESP is not lost, since it can be transferred to an RRSP, with the appropriate deductions made for the grant and any interest accumulating on the grant.

Previous studies have attempted to justify increases in tuition from that of potential earnings. The higher the potential earnings in certain disciplines, the higher the tuition. Likewise, if there are any capacity constraints, then these disciplines should also be considered for increases in tuition. If we ignore migration effects and substitutability, then fields with a limited number of spots will tend to realize an increase the overall rate of return to the discipline simply because labour market supply is now limited.

This argument for increasing tuition is a slippery slope. While proponents of deregulation in Ontario used capacity constraints, or something quite similar, in their arguments enrollment numbers continue to rise. The problem is a lack of incentives for universities to commit to the limited enrollment numbers. That is, there is a time consistency problem. The reason, is money.

If they commit to their limited enrollment number, in an attempt to keep class sizes down, universities forgo tuition revenues. Providing they have the space, universities would like to have as many students as possible in these programs to increase their revenues. This is what appears to be happening. Figure 3.1 shows a rise in enrollment numbers in computer science, engineering and business programs in Ontario, since deregulation. Table 3.2 shows that class sizes have also been getting larger in general. The funding cuts of the government may be driving universities to seek extra funding from deregulated fees, but the fact remains that one intention of deregulation was to limit class size and this appears to be taking a back seat to the possibility of increased revenues. Therefore, arguments based on capacity constraints, while theoretically sound, do not appear practical in the current market context.

Finally, with increased costs to education, student loans have become increasingly important. Participation rates in student loan programs in Canada have been rising in recent years, as has the amount of student debt upon graduation. In the current education system,

deregulation of tuition fees will only exacerbate these facts. Many people look at the rising participation rates and increased debt loads as a potential problem for graduates, but is this necessarily so?

Using the same methodology, Collins and Davies (2002) compute ETRs of males and females with Ontario student loans and Canada student loans. They find that student loans decrease the disincentive effects created by the tax system to invest in a university education, while increasing rates of return. The reason is that student loans spread out the repayment period and, more important, are interest free while the student is in school.⁸ With the recent addition of interest repayment of student loans being made tax deductible, students are even better off.⁹

3.6 CONCLUDING REMARKS

We have gone beyond previous studies on university education in Canada, which simply look at rates of returns, to illustrate the impact that rising costs have on individuals from a taxation and expenditure perspective. While there is the inevitable reduction in rates of return, there is also the increase in effective tax rates and fall in effective subsidy rates, which lead to a reduction in incentives for Canadian students to invest in a university education. There is also the increased possibility that these students will look for work elsewhere after graduation to realize a higher payoff on their investment. This type of behavior is consistent with the brain drain phenomenon.

We have also shown that deregulation of tuition fees has caused previously high return fields to be surpassed by all other fields in this study, except for humanities degrees. While we concentrated on 4-year business degrees, the same conclusion would likely apply to other

⁸ The student must maintain full time status.

⁹ Collins and Davies (2002) found the effect of this to be rather small, but nonetheless positive.

disciplines where tuition fees have been deregulated, e.g., engineering and computer science. Unless these fields have a high earnings premium, that is earnings over and above the mean university student, then these students will find it worthwhile to pursue education in an alternative field. Results showed that the earnings premium would have to be approximately 32% for females and 18% for males (on average) for 4-year business degrees to be as profitable as they were prior to deregulation. The lack of a sufficient earnings premium also makes migration a more attractive option.

The use of effective tax and subsidy rates to measure the incentives for university students to invest in alternative fields of study has shed new light on policies surrounding Canada's universities. With rising tuition fees for the average student, combined with deregulation in certain fields, many fear that Canadian universities are moving towards a system more like the United States. This has led to a number of critiques about higher education in Canada, but as we have shown, these arguments are sometimes without merit.

Critics claim that, as a result of the current system, students are taking out more and bigger loans in order to take part in higher education. While the participation and loan numbers have been increasing in recent years, studies have shown that this isn't necessarily a bad thing (see Chapter 1 of this thesis). Students, who are participating in student loan plans, tend to have higher rates of return and lower net ETRs. The reason for this result is primarily due to the interest free status enjoyed by students participating in student loan plans. The unfortunately reality is that if students are ineligible for student loans, which they may be as a result of their parents' income, then this result falls apart. Fortunately, research has shown that credit constraints do not appear to be as big a problem as previously thought (Cameron and Heckman, 1998). Recently there has also been talk about revamping student loan plans in Canada. It would

be interesting to see if proposed plans, like income contingent student loans, would yield similar or, perhaps, more favorable results.

Capacity constraints have also been argued as a reason for increasing tuition (Smith, 2002). Proponents argue that spots in certain programs are best kept limited. Students get more individualized attention, due to smaller student teacher ratios, they feel less intimidated to ask questions, and are able to become acquainted with their fellow classmates more easily. If capacity constrained programs are to maintain the high quality that students have come to expect then increasing tuition is a necessary evil. But, as we have shown and as economic theory predicts there can be a commitment failure among these so called capacity constrained programs. Once they are able to charge higher tuition fees, the lure of higher revenues from increasing enrollment numbers is often too great. In the end, they end up increasing their enrollment by offering larger classes, if possible, or more sections of the same class.

This study has attempted to show how the incentive effects of different fields of study are affected by the tax and expenditure systems in Canada. We have also attempted to explain the role of deregulation, by way of reference to top business schools, in a much more comprehensive manner than previously done, but more work is needed. It would be interesting to see the general equilibrium effects of policy changes. While this study has been able to capture more effects than its predecessors, much remains unanswered and which can only be answered with a general equilibrium model. The role of externalities in the different fields of study would also be interesting to explore. If “higher return” fields contribute more to things like economic growth, do we really want to make these students pay exorbitant amounts of tuition making migration to the United States after graduation more profitable? Finally, it would be interesting to see what moving to a system like that of the United States, one in which we have private and public

universities, would mean for Canada. Would Canada be able to sustain such a system? Would it mean or allow the development of a “Harvard of Canada,” as some authors have proposed?

These are interesting questions and, given the state of the education system in Canada, deserve our attention.

APPENDIX 3A

In this section we provide the data used to compute the rates of return and subsequent ETRs and ESRs for business school graduates at Western, Queen's and Toronto. The tuition and fee values are expressed in Table 3A and are derived from the websites of the respective business schools.

Table 3A
The Ontario "Quality" Education Premium for 4 Year University Business Degree

	Tuition	Ancillary Fees	Additional Expenses	Total/Yr
Western				
Yr 1	5000	900	1000	6900
Yr 2	5000	900	1000	6900
Yr 3	16000	900	3750	20650
Yr 4	15800	900	3750	20450
Toronto				
Yr 1	4107	794.86	1500	6402
Yr 2	8000	1062.04	4500	13562
Yr 3	8000	1062.04	1500	10562
Yr 4	8000	1062.04	1500	10562
Queens				
Yr 1	4522.1	792.12	1500	6814
Yr 2	8712	792.12	4500	14004
Yr 3	7920	792.12	1500	10212
Yr 4	7920	792.12	1500	10212

Source: University Websites

Western is the most expensive of the three schools in our study, with tuition and additional fees and expenses totaling \$54,900. Queen's is second with \$41,243 and Toronto third with \$41,088. Note the drastic change in either the second or third year of study. This is when the student officially becomes a member of the business school. The first year tuition values (and in Western's case the second year also) are the ones faced by the majority of undergraduates. When they become members of the business school, rates jump remarkably.

Chapter 4:

The Two-Sided Capital Levy Problem

4.1 INTRODUCTION

This paper asks what light political economy throws on the tax treatment of human capital. In particular, it looks at the role that human capital may play in analysis of the expropriation of capital when time consistency problems arise in government policy. The interesting implication here is that the consistency problem has no clear answer *a priori* with the introduction of human capital, as we shall see.

The capital levy problem is well documented in the public finance literature. If capital investments are irreversible, governments can tax these items *ex post* with little (or no) deadweight loss. As a result, smart investors end up investing less in certain types of capital. In the end there is an underinvestment in capital. The problem with this view is that it only describes what happens in the case of *physical* capital investment. Given the importance of *human* capital in today's "knowledge-based" economy, it is imperative that the framework address both of these types of capital.

The intuition here is that we have an immobile factor, *physical* capital, and a mobile factor, labor. It is, of course, optimal to tax the immobile factor 100% (lump-sum tax), but the allowance of lobbying by the owners of physical capital modifies this. Similarly, the mobility of people, combined with the portability of human capital, provides a deterrent to the government when deciding how much to tax human capital. This presents some interesting implications for public policy.

Does the existence of both human and physical capital in the model alter the expropriation of capital, since individuals can now escape into leisure (or migrate) if income is taxed too heavily? As example of this, consider the baby boom generation. Individuals in this era accumulated human capital with the expectation of being

prosperous, but ex post, tax rates increased markedly. Come the late 80's and early 90's the burdens faced by these individuals were quite large compared with earlier generations. Early retirement (i.e. baby boomers escaping into leisure) may, at least partially, be the ultimate result of time consistency problems.

Having a tax on capital and labour also bears on the issue of how tax structure is determined. If the link is strong enough between certain types of human and physical capital and/or individuals are sufficiently mobile, then taxing one type of capital in favor of another may lead to (more) harmful disincentive effects and may even reduce the overall tax revenue of the government. We can also not rule out the possibility that a change in the tax rate on physical or human capital may lead to spillover effects that can have positive or negative repercussions.

The rest of the paper is organized as follows. Section 4.2 introduces the model, while Section 4.3 lays out the criteria for a Nash Equilibrium. Section 4.4 discusses the reference case and, Section 4.5, the different tax mix scenarios. The implications of lobbying are explained in Section 4.6. Section 4.7 examines the results of the model in greater detail. Finally, Section 4.8 provides some concluding remarks and avenues for future research.

4.2 THE MODEL

Preferences and Payoffs

Consider a small open economy in which one public good – labeled good 0 – and N private consumption goods – labeled $1, 2, \dots, N$ – are produced. We shall assume that the public good is non-traded, while the N private goods are freely traded. The world price of good i , $i = 1, \dots, N$, is denoted by $\bar{p}_i$. The industry that produces good i is called industry i . Each private good is produced by a single industry, using labor and capital. As for the public good, it is produced by the government, also with inputs of labor and capital.

There exists a continuum of consumers in this economy and, to simplify, we shall normalize the population size to 1. The population is divided into two major groups: capitalists and workers. Workers earn their living by supplying part of their time endowment – normalized to 1 – on the labor market. Capitalists do not work. They are the owners of capital stocks in the private sector, which constitute the sources of their income. Let $\gamma_i > 0$, $i = 1, \dots, N$, denote the fraction of the population who are the owners of the capital stock in industry i . We suppose that the group that consists of the owners of the capital stock in industry i and the group that consists of the owners of the capital stock in industry j , $j \neq i$, are disjoint. As a group, the capitalists thus make up a fraction of the population equal to $(\gamma_1 + \gamma_2 + \dots + \gamma_N)$, while the proportion of the population who are workers is given by $(1 - \gamma_1 - \gamma_2 - \dots - \gamma_N)$.

We shall assume that for each i the owners of the capital stock in industry i are equal residual claimants of the profits made by the industry. Workers, however, are assumed to differ in their earning capacity. A worker's earning capacity is identified by

her *human capital level*. The human capital level of a worker is denoted by θ . To avoid corner solutions we impose the following condition on the distribution of θ :

ASSUMPTION 1: The distribution of types among workers is assumed to be represented by a continuous density function $h: \theta \rightarrow h(\theta)$, with $h(\theta) > 0$ for all $\theta \geq 0$, where

$$\int_0^{\infty} h(\theta) d\theta = 1 - \sum_{i=1}^N \gamma_i .$$

Now for two workers with human capital levels θ and θ' , $\theta' > \theta$, we expect the one with the human capital level θ' to earn more per hour worked than the one with human capital level θ . To model the difference in earnings due to variation in human capital levels, we shall assume that labor inputs are measured in *effective labor units* and that for each hour that a worker of type θ spends in the production of a good, she provides θ units of effective labor input. If we let ω denote the wage rate paid to one unit of effective labour input, then the labor income earned by a worker of type θ , when she works one hour, is $\omega \theta$.

A worker's preferences are assumed to be represented by the following utility function:

$$(1) \quad u_0(x_0) + u(x_1, x_2, \dots, x_N) - u_{N+1}(\ell) .$$

In (1), x_0 is consumption of the public good; x_i , $i = 1, \dots, N$, is consumption of the i^{th} private good; and ℓ is labor supply in hours. Also, u_0 is the subutility function associated

with consumption of the public good; u is the subutility function associated with the consumption of the private goods; and u_{N+1} is the subutility function associated with the disutility of working. We impose the following conditions on the preferences represented by (1).

ASSUMPTION 2: (i) $u_0(0) = 0$, $u'_0(x_0) > 0$ and $u''_0(x_0) < 0$ for all $x_0 \geq 0$. Furthermore,

$$\lim_{x_0 \rightarrow 1} u'_0(x_0) = \infty.$$

$$(ii) \ u_{N+1}(0) = 0, \ u'_{N+1}(0) = 0, \ u'_{N+1}(\ell) > 0 \text{ and } u''_{N+1}(\ell) < 0 \text{ for all } \ell > 0.$$

$$\text{Also, } \lim_{\ell \rightarrow 1} u'_{N+1}(\ell) = \infty.$$

(iii) The subutility function u is linear homogeneous and increasing in all its arguments.

As for a capitalist, who does not work and thus does not suffer from the disutility of working, her utility depends only on her consumption bundle. Her utility function is obtained from (1) by setting labor equal to 0; that is, the preferences of a capitalist are represented by the following utility function:

$$(2) \quad u_0(x_0) + u(x_1, x_2, \dots, x_N).$$

Observe that the subutility functions associated with the consumption of the public and private goods are the same for all individuals – workers and capitalists – in this small open economy.

To finance the production of the public good, the government levies a capital income tax and a labor income tax. Let τ_i be the tax rate on profits made by firms in industry i and t the tax rate on wages. There is no double taxation of physical capital. A *tax policy* is therefore represented by a list $((\tau_i)_{i=1}^N, t)$.

We want to explore the impact that taxation has on workers' incentives to migrate, therefore we allow them to be perfectly mobile within the boundaries of the small open economy – at no cost. They could also choose to leave the home country and work in the outside world if they are willing to pay some cost of adjustment. We make the following assumption about the adjustment cost:

ASSUMPTION 3: The cost of adjustment of a worker of type θ , denoted by $a(\theta)$, is continuously differentiable, strictly positive, and strictly decreasing in θ .

Let $\bar{w}$ denote the wage rate earned by one unit of effective labor abroad. For a worker of type θ , leaving the country to work in a foreign country will yield a net labor income – net of adjustment costs – equal to $\bar{w}\theta\ell - a(\theta)$, if she chooses to work ℓ hours.

To influence the tax policy implemented by the government, the owners of the capital stock in each industry get together and form a special-interest group to lobby for favorable tax treatments. We shall not explain how the owners of the capital stock in an industry become organized, but simply assume that their efforts are successful and that they manage to behave like a cohesive unit in their attempts to further their collective interests. In what follows, the owners of the capital stock in industry i will be referred to as industry lobby i .

Let $((\tau_i)_{i=1}^N, t)$ be the tax policy implemented by the government. Under this tax policy, the representative firm in industry i , solves the following profit maximization problem:

$$(3) \quad \max_{L_i} (1 - \tau_i)(\bar{p}_i F_i(K_i, L_i) - \omega L_i) = (1 - \tau_i)\Pi_i(\omega).$$

In (3), $F_i(K_i, L_i)$ is the technology used in the production of good i ; K_i is the capital stock in this industry; and L_i is the labor inputs – measured in effective labor units. It is assumed that $F_i(K_i, L_i)$ is continuously differentiable and strictly increasing in each of its arguments. Furthermore, there are diminishing returns in each factor and the following Inada conditions are satisfied $\lim_{L_i \rightarrow 0} \frac{\partial F_i}{\partial L_i}(K_i, L_i) = +\infty$ and $\lim_{L_i \rightarrow +\infty} \frac{\partial F_i}{\partial L_i}(K_i, L_i) = 0$. As defined, $\Pi_i(\omega)$ represents the before-tax profits made by industry i , given that it faces the effective labor wage rate ω . Note that the capital income tax does not influence the production plan of the industry. We shall denote by $L_i(\omega)$ the demand for effective labor by industry i .

As a group, the owners of the capital stock in industry i receive an income equal to $(1 - \tau_i)\Pi_i(\omega)$, which gives each capitalist in this group a capital income of

$\frac{(1 - \tau_i)\Pi_i(\omega)}{\gamma_i}$. Thus, a member of the group that owns capital stock in industry i solves

the following utility maximization problem:

$$(4) \quad \max_{(x_1, \dots, x_N)} (u_0(x_0) + u(x_1, \dots, x_N)) = u_0(x_0) + v\left(\frac{(1 - \tau_i)\Pi_i(\omega)}{\gamma_i}\right)$$

subject to the budget constraint,

$$(5) \quad \sum_{i=1}^N \bar{p}_i x_i - \frac{(1 - \tau_i) \Pi_i(\omega)}{\gamma_i} = 0.$$

Note that in solving the above utility maximization problem, the capitalist takes as given x_0 , the level of the public good provided by the government. Also, in (4), we have let

$v\left(\frac{(1 - \tau_i) \Pi_i(\omega)}{\gamma_i}\right)$ denote the indirect utility function associated with the consumption of

the N private goods, as a function of the after-tax capital income $\frac{(1 - \tau_i) \Pi_i(\omega)}{\gamma_i}$. Since

the subutility function associated with the consumption of the private goods is linear homogenous, we must have

$$(6) \quad v\left(\frac{(1 - \tau_i) \Pi_i(\omega)}{\gamma_i}\right) = \left(\frac{(1 - \tau_i) \Pi_i(\omega)}{\gamma_i}\right) v(1),$$

Without any loss of generality, we set $v(1) = 1$. This assumption allows us to rewrite (6) as follows:

$$(7) \quad v\left(\frac{(1 - \tau_i) \Pi_i(\omega)}{\gamma_i}\right) = \frac{(1 - \tau_i) \Pi_i(\omega)}{\gamma_i}$$

which asserts that the utility of a capitalist is the same as her net income.

Consider a worker of type θ , who chooses not to emigrate. Let ℓ be her labor supply. Her disposable income is then $(1 - t)\omega\theta\ell$, which will be spent on private goods. According to (7), the utility obtained from the consumption of the private goods is $v((1 - t)\omega\theta\ell) = (1 - t)\omega\theta\ell$. Also the disutility from working is $u_{N+1}(\ell)$. Thus she solves the following utility maximization problem:

$$(8) \quad \max_{0 \leq \ell \leq 1} \left(u_0(x_0) + (1 - t)\omega\theta\ell - u_{N+1}(\ell) \right) = u_0(x_0) + \phi(\omega, t, \theta).$$

Again, note that in solving the above utility maximization problem, the worker takes as given x_0 , the level of the public good. Also, in (8) we have let $\phi(\omega, t, \theta)$ denote the indirect utility function associated with the consumption of the N private goods and the disutility of working for a worker of type θ , who chooses not to emigrate. Using (ii) of Assumption 2, we can assert that (8) has a unique interior solution, which is characterized by the following first-order condition:

$$(9) \quad (1 - t)\omega\theta - u'_{N+1}(\ell) = 0.$$

The optimal labor supply of a worker of type θ who chooses not to leave the country is then given by

$$(10) \quad \ell((1 - t)\omega\theta) = \left(u'_{N+1} \right)^{-1}((1 - t)\omega\theta),$$

where we have let $(u'_{N+1})^{-1}$ denote the inverse of u'_{N+1} . Because the marginal disutility of working is strictly increasing in ℓ , it is clear that the optimal labor supply of a worker of type θ who does not emigrate is strictly increasing in $(1-t)\omega\theta$.

For a worker who chooses to leave the country, her labor income abroad is $\bar{\omega}\theta\ell$. Because she has to pay the cost of adjustment $a(\theta)$, her net income is then given by $\bar{\omega}\theta\ell - a(\theta)$. Assuming $\bar{\omega}$ is net of income taxes, she will obtain a utility level equal to her disposable income, namely $\bar{\omega}\theta\ell - a(\theta)$. Note that the last statement has been obtained by invoking the assumption that the subutility function associated with the consumption of the private goods is linear homogenous. Thus a worker who chooses to leave the country will solve the following utility maximization problem:

$$(11) \quad \max_{0 \leq \ell \leq 1} (\bar{\omega}\theta\ell - a(\theta) - u_{N+1}(\ell)) = \bar{\phi}(\theta)$$

Note that in the objective function (11) there is no public good. The following first-order condition characterizes the worker's optimal labor supply

$$(12) \quad \bar{\omega}\theta - u'_{N+1}(\ell) = 0.$$

The optimal labor supply of a worker of type θ who chooses to leave the country is then given by

$$(13) \quad \bar{\ell}(\theta) = (u'_{N+1})^{-1}(\bar{\omega}\theta).$$

Now consider a worker with human capital level θ . If she emigrates and decides to work ℓ hours, then after paying for the adjustment cost, she is left with a net income of $\bar{w}\theta\ell - a(\theta)$. On the other hand, if she decides to stay, then her disposable income is $(1-t)\omega\theta\ell$. It is clear that if $\bar{w}\theta - a(\theta) \leq (1-t)\omega\theta$, then $\bar{w}\theta\ell - a(\theta) < (1-t)\omega\theta\ell$ for all $0 < \ell < 1$, which in turn implies that it is not optimal for her to leave the country. Hence only a worker with a human capital level θ that satisfies the strict inequality

$$(14) \quad \bar{w}\theta - a(\theta) > (1-t)\omega\theta,$$

or equivalently,

$$(15) \quad \bar{w} > \frac{a(\theta)}{\theta} + (1-t)\omega,$$

could entertain the idea of leaving the country. Thus if $\bar{w} \leq (1-t)\omega$, then no worker, regardless of her human capital level, will choose to leave the country. The phenomenon of brain drain could only occur if $\bar{w} > (1-t)\omega$, i.e., if the net wage rate in the home country is below that abroad. If migration costs are positive then the wage abroad must reflect this, otherwise no emigration will occur. Furthermore, when the utility of the public good is also taken into consideration, only a worker with a sufficiently high level of human capital would think of leaving the country.

To see why, first note that according to Assumption 3, $\frac{a(\theta)}{\theta}$ is strictly decreasing in $\theta > 0$ and tends to infinity when θ tends to 0. Hence when $\bar{\omega} > (1-t)\omega$, there exists a unique value of θ , say $\underline{\theta}((1-t)\omega)$, such that $\bar{\omega} = \frac{a(\theta)}{\theta} + (1-t)\omega$. It follows directly from the definition of $\underline{\theta}((1-t)\omega)$ that

$$(16) \quad \bar{\omega} \underline{\theta}((1-t)\omega) \ell - a(\underline{\theta}((1-t)\omega)) < (1-t)\omega \underline{\theta}((1-t)\omega) \ell$$

for all $0 < \ell < 1$, which in turn implies

$$(17) \quad \bar{\phi}(\underline{\theta}((1-t)\omega)) - \phi(\omega, t, \underline{\theta}((1-t)\omega)) < 0.$$

When the impact of the public good is taken into consideration, the loss in utility suffered by a worker of type $\underline{\theta}((1-t)\omega)$, if she decides to leave the country will be

$$(18) \quad \bar{\phi}(\underline{\theta}((1-t)\omega)) - \phi(\omega, t, \underline{\theta}((1-t)\omega)) - u_0(x_0),$$

which is even more pronounced.

To continue, let

$$(19) \quad q(\theta) = \bar{\phi}(\theta) - (u_0(x_0) + \phi(\omega, t, \theta))$$

for all $\theta \geq \underline{\theta}((1-t)\omega)$. Then

$$(20) \quad q(\underline{\theta}((1-t)\omega)) < 0.$$

Now,

$$\begin{aligned}
 (21) \quad q'(\theta) &= \bar{\phi}'(\theta) - \frac{\partial \phi(\omega, t, \theta)}{\partial \theta} \\
 &= \bar{\omega} \bar{\ell}(\theta) - \alpha'(\theta) - (1-t)\omega \ell((1-t)\omega \theta) \\
 &= \bar{\omega} \left((u'_{N+1})^{-1}(\bar{\omega} \theta) \right) - \alpha'(\theta) - (1-t)\omega \left((u'_{N+1})^{-1}((1-t)\omega \theta) \right) \\
 &> (\bar{\omega} - (1-t)\omega) \left((u'_{N+1})^{-1}((1-t)\omega \theta) \right) > 0
 \end{aligned}$$

Note that in (21) the second equality is obtained with the help of the envelope theorem; the third equality is obtained with the help of (10) and (13). To obtain the first inequality in (21), observe that when $\theta \geq \underline{\theta}((1-t)\omega)$, we have $\bar{\omega} \theta - \alpha(\theta) \geq (1-t)\omega \theta$, which together with the increasing marginal disutility of working, imply that

$$(22) \quad \left((u'_{N+1})^{-1}(\bar{\omega} \theta) \right) > \left((u'_{N+1})^{-1}(\bar{\omega} \theta - \alpha(\theta)) \right) \geq \left((u'_{N+1})^{-1}((1-t)\omega \theta) \right).$$

According to Assumption 3, $\alpha'(\theta) < 0$. This fact, together with inequality (22) and the strict inequality $\bar{\omega} - (1-t)\omega > 0$, then yield the two inequalities in (21). Also, observe that when $\theta \rightarrow \infty$, we have $\left((u'_{N+1})^{-1}((1-t)\omega \theta) \right) \rightarrow 1$. This last result together with the inequality $\bar{\omega} - (1-t)\omega > 0$ imply that $q'(\theta)$ is positive and bounded below by $\bar{\omega} - (1-t)\omega$ when $\theta \rightarrow \infty$. Therefore, $q(\theta)$ is strictly increasing to infinity as θ tends to

infinity. Furthermore, $q(\theta)$ is strictly negative at $\bar{\theta}((1-t)\omega)$. Hence there exists a unique value of θ , say $\theta = \bar{\theta}((1-t)\omega)$, such that $q(\bar{\theta}((1-t)\omega)) = 0$. We summarize the preceding results in the following lemma:

LEMMA 1: Let $((\tau_i)_{i=1}^N, t)$ be a tax policy implemented by the home government and x_0 be the level of the public good it provides. Suppose that ω is the wage rate paid to one unit of effective labor in the home country. If $\bar{\omega}$, the wage rate paid to one unit of effective labor abroad, is less than or equal to $(1-t)\omega$, then no worker will choose to leave the home country. On the other hand, if $\bar{\omega} > (1-t)\omega$, then there exists a critical level of human capital, say $\bar{\theta}((1-t)\omega, x_0)$, which depends on the net wage rate as well as the level of the public good provided, such that a worker will choose to leave the country if and only if her human capital level exceeds $\bar{\theta}((1-t)\omega, x_0)$. This critical level of human capital is the unique value of θ that solves the following equation:

$$(23) \quad \bar{\phi}(\theta) - (u_0(x_0) + \phi(\omega, t, \theta)) = 0.$$

Furthermore, the critical human capital level $\bar{\theta}((1-t)\omega, x_0)$ is strictly increasing in ω and x_0 , but strictly decreasing in t .

The Wage Rate, the Level of the Public Good, and the Payoffs Induced by the Tax System

Let $((\tau_i)_{i=1}^N, t)$ be the tax policy implemented by the government and suppose that x_0 is the level of the public good it provides. If ω is the wage rate paid to one unit of effective labor, then the aggregate supply of effective labor in the small open economy is

$$(24) \quad \int_0^{\bar{\theta}((1-t)\omega, x_0)} \theta \ell((1-t)\omega \theta) h(\theta) d\theta$$

while the aggregate demand for effective labor by the private sector is $\sum_{j=1}^N L_j(\omega)$.

Furthermore, the total tax revenues collected by the state are given by

$$(25) \quad t\omega \int_0^{\bar{\theta}((1-t)\omega, x_0)} \theta \ell((1-t)\omega \theta) h(\theta) d\theta + \sum_{j=1}^N \tau_j \Pi_j(\omega).$$

These tax revenues are used to pay for the effective labor inputs used in the production of the public good. The following amount of effective labor can be purchased:

$$(26) \quad t \int_0^{\bar{\theta}((1-t)\omega, x_0)} \theta \ell((1-t)\omega \theta) h(\theta) d\theta + \frac{1}{\omega} \sum_{j=1}^N \tau_j \Pi_j(\omega).$$

The wage rate for effective labor that clears the labor market in the small open economy satisfies the following market-clearing condition:

$$(27) \quad \int_0^{\bar{\theta}((1-t)\omega, x_0)} \theta \ell((1-t)\omega \theta) h(\theta) d\theta = \sum_{j=1}^N L_j(\omega) + t \int_0^{\bar{\theta}((1-t)\omega, x_0)} \theta \ell((1-t)\omega \theta) h(\theta) d\theta$$

$$+ \frac{1}{\omega} \sum_{j=1}^N \tau_j \Pi_j(\omega)$$

In order for the labor input, given by (26), to be sufficient for producing the amount of public good x_0 , the following condition must also be satisfied:

$$(28) \quad F_0\left(K_0, t \int_0^{\bar{\theta}((1-t)\omega, x_0)} \theta \ell((1-t)\omega \theta) h(\theta) d\theta + \frac{1}{\omega} \sum_{j=1}^N \tau_j \Pi_j(\omega)\right) = x_0.$$

In (28), $F_0(K_0, L_0)$ is the production function used in the production of the public good, where K_0 is the stock of public capital and L_0 is the input of effective labor used in the production of the public good. It is assumed that $F_0(K_0, L_0)$ is continuously differentiable and strictly increasing in each of its variables. Furthermore, the marginal product of labor is strictly decreasing when L_0 increases and the Inada conditions are satisfied.

Together, (27) and (28) constitute a system of two equations in two unknowns – ω and x_0 . For any given tax system $((\tau_i)_{i=1}^N, t)$, we shall let $\omega((\tau_i)_{i=1}^N, t)$ and $x_0((\tau_i)_{i=1}^N, t)$ be the values of ω and x_0 that solve the system. As defined, $\omega((\tau_i)_{i=1}^N, t)$ is the equilibrium wage paid to one unit of effective labor and $x_0((\tau_i)_{i=1}^N, t)$ the equilibrium amount of public good produced when the tax system $((\tau_i)_{i=1}^N, t)$ is imposed.

Under the tax policy $((\tau_i)_{i=1}^N, t)$, the critical level of human capital that separates the workers who stay from those who leave the country is $\bar{\theta}((1-t)\omega((\tau_i)_{i=1}^N, t), x_0((\tau_i)_{i=1}^N, t))$. To keep the notation from becoming too burdensome, we shall write $\theta((\tau_i)_{i=1}^N, t)$, instead of $\bar{\theta}((1-t)\omega((\tau_i)_{i=1}^N, t), x_0((\tau_i)_{i=1}^N, t))$, to denote the critical human capital level. A worker will stay if and only if her type is less than or equal to $\theta((\tau_i)_{i=1}^N, t)$. For a worker who stays, her utility under the tax policy $((\tau_i)_{i=1}^N, t)$ is given by

$$(29) \quad u_0(x_0((\tau_i)_{i=1}^N, t)) + \phi(\omega((\tau_i)_{i=1}^N, t), t, \theta).$$

As a group, the welfare of the workers who stay is given by

$$(30) \quad \int_0^{\theta((\tau_i)_{i=1}^N, t)} \left(u_0(x_0((\tau_i)_{i=1}^N, t)) + \phi(\omega((\tau_i)_{i=1}^N, t), t, \tilde{\theta}) \right) h(\tilde{\theta}) d\tilde{\theta} \\ = u_0(x_0((\tau_i)_{i=1}^N, t)) H(\theta((\tau_i)_{i=1}^N, t)) + \Phi((\tau_i)_{i=1}^N, t)$$

In (30), we have let $H(\theta)$ denote the cumulative distribution of θ . Also note that on the right-hand side of (30) the product expression, gives the utility from the consumption of the public good, while $\Phi((\tau_i)_{i=1}^N, t)$ represents the utility from the consumption of the private goods and the disutility of working, for all workers who stay.

As for the owners of the capital stock in industry $j, j = 1, \dots, N$, each of them has a capital income equal to

$$(31) \quad \frac{(1 - \tau_j) \Pi_j \left(\omega \left((\tau_i)_{i=1}^N, t \right) \right)}{\gamma_j},$$

which according to (7), is also the capitalist's utility from the consumption of private goods. Her utility under the tax policy $((\tau_i)_{i=1}^N, t)$ is thus given by,

$$(32) \quad u_0(x_0((\tau_i)_{i=1}^N, t)) + \frac{1}{\gamma_j} (1 - \tau_j) \Pi_j \left(\omega \left((\tau_i)_{i=1}^N, t \right) \right).$$

Thus as a group, the owners of the capital stock in industry j obtain the following utility under the tax policy $((\tau_i)_{i=1}^N, t)$

$$(33) \quad \gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + (1 - \tau_j) \Pi_j \left(\omega \left((\tau_i)_{i=1}^N, t \right) \right) = \gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j \left((\tau_i)_{i=1}^N, t \right)$$

In (33), we have let $\Psi_j \left((\tau_i)_{i=1}^N, t \right)$ denote the utility that this group obtains from the consumption of the private goods under the tax policy $((\tau_i)_{i=1}^N, t)$.

Without political contributions, the social welfare obtained under the tax policy $((\tau_i)_{i=1}^N, t)$, is given by

$$(34) \quad W((\tau_i)_{i=1}^N, t) = u_0(x_0((\tau_i)_{i=1}^N, t)) \left(H(\theta((\tau_i)_{i=1}^N, t)) + \gamma_1 + \dots + \gamma_N \right) \\ + \Phi \left((\tau_i)_{i=1}^N, t \right) + \sum_{j=1}^N \Psi_j \left((\tau_i)_{i=1}^N, t \right).$$

The Extensive Form of the Game

The extensive form of the game is as follows. First, for each $j = 1, \dots, N$, industry lobby j announces a contingent political contribution schedule

$$(35) \quad C_j : ((\tau_i)_{i=1}^N, t) \rightarrow C_j((\tau_i)_{i=1}^N, t),$$

which expresses the political contribution it is willing to make to the government if the latter player implements the tax policy $((\tau_i)_{i=1}^N, t)$. The contingent political contribution C_j is required (i) to be continuous, which is a technical requirement; (ii) nonnegative, which reflects the desire of an industry lobby to buy influence; and (iii) less than or equal to $\Psi_j((\tau_i)_{i=1}^N, t)$, which captures the idea that it is not rational for any industry lobby to contribute more than its potential profits. Next, the government, taking as given the list of political contribution schedules $(C_j)_{j=1}^N$ implements a tax policy $((\tau_i)_{i=1}^N, t)$. Under the tax policy $((\tau_i)_{i=1}^N, t)$, the equilibrium wage rate and the equilibrium level of the public good are given by $\omega((\tau_i)_{i=1}^N, t)$ and $x_0((\tau_i)_{i=1}^N, t)$, respectively. Once a tax policy has been implemented and the level of the public good is known, all the workers with a human capital level higher than $\theta((\tau_i)_{i=1}^N, t)$ will leave the country. Production activities take place, with firms hiring the workers who remain; profits are made and workers receive their wages. After paying capital income taxes from its gross profits, each industry lobby then pays the political contributions it promised to the government according to the contingent political schedule it announced. What remains of the profits is next distributed equally to all the owners of the capital stock in that industry. These dividends constitute

the incomes of the capitalists and are spent on private goods. The total tax revenues collected by the state are then used to hire the necessary effective labor inputs needed to produce the public good.

Now as a group, after paying the capital income tax and the political contributions it promised, the owners of the capital stock in industry j are left with a total income of

$$(36) \quad \Psi_j((\tau_i)_{i=1}^N, t) - C_j((\tau_i)_{i=1}^N, t)$$

to spend on the private goods. The total welfare obtained by this group is then given by

$$(37) \quad \gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) - C_j((\tau_i)_{i=1}^N, t).$$

We shall assume that the payoff for the government is a linear function of the total political contributions it receives and the net social welfare, with ε , $0 < \varepsilon < 1$, as the weight assigned to net social welfare and 1 as the weight assigned to the total political contributions it receives. Here net social welfare is obtained by summing the welfare of all the workers who stay and the welfare of the capitalists. More precisely, the government payoff is assumed to have the following form:

$$(38) \quad \sum_{j=1}^N C_j((\tau_i)_{i=1}^N, t) + \varepsilon \left(\sum_{j=1}^N \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) - C_j((\tau_i)_{i=1}^N, t) \right) \right) \\ + u_0(x_0((\tau_i)_{i=1}^N, t)) H(\theta((\tau_i)_{i=1}^N, t)) + \Phi((\tau_i)_{i=1}^N, t) \\ = (1 - \varepsilon) \left(\sum_{j=1}^N C_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1 - \varepsilon} W((\tau_i)_{i=1}^N, t) \right)$$

Because a positive monotonic transformation of a utility function is a utility function that represents the same preferences, we shall assume that the payoff for the government, as a function of the contingent political contribution schedules and the tax policy it implements, is given by

$$(39) \quad G\left(\left((\tau_i)_{i=1}^N, t\right), \left(C_j\right)_{j=1}^N\right) = \left(\sum_{j=1}^N C_j\left((\tau_i)_{i=1}^N, t\right) + \frac{\varepsilon}{1-\varepsilon} W\left((\tau_i)_{i=1}^N, t\right)\right).$$

In what follows, we shall let

$$(40) \quad \mathfrak{R}\left(\left(C_j\right)_{j=1}^N\right) = \arg \max_{\left((\tau_i)_{i=1}^N, t\right)} G\left(\left((\tau_i)_{i=1}^N, t\right), \left(C_j\right)_{j=1}^N\right)$$

denote the set of best responses to $\left(C_j\right)_{j=1}^N$ for the government.

The Nash Equilibrium

Let $\hat{C}_j$ be a contingent political contribution schedule announced by industry j , and $\left((\hat{\tau}_i)_{i=1}^N, \hat{t}\right)$ be the tax policy implemented by the government in response to $\hat{C}_j$. The combination of strategies $\left(\hat{C}_j, \left((\hat{\tau}_i)_{i=1}^N, \hat{t}\right)\right)$ is said to constitute a Nash equilibrium for the two-sided capital levy problem if the following conditions are satisfied:

$$(a) \quad \left((\hat{\tau}_i)_{i=1}^N, \hat{t}\right) \in \mathfrak{R}\left(\left(\hat{C}_j\right)_{j=1}^N\right).$$

- (b) For each $j = 1, \dots, N$, and any contingent political contribution schedule C_j ,
the following inequality must hold:

$$\begin{aligned} & \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) - \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\ & \geq \sup_{((\tau_i)_{i=1}^N, t) \in \mathfrak{R}(\hat{C}_j, C_j)} \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) \right) - C_j((\tau_i)_{i=1}^N, t) \end{aligned}$$

4.3 NASH EQUILIBRIUM: EXISTENCE AND CHARACTERIZATION

The following proposition is our restatement – in the current context – of Lemma 2 in Bernheim and Whinston (1986); it gives a set of necessary and sufficient conditions for a combination of strategies chosen by the N industry lobbies and the government to be a Nash equilibrium.

PROPOSITION 1: *Let $\hat{C}_j$ be a contingent political contribution schedule announced by industry j , $j = 1, \dots, N$, and $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ be a tax policy implemented by the government in response to $(C_j)_{j=1}^N$. The combination of strategies $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ constitutes a Nash equilibrium for the two-sided capital levy problem if and only if the following conditions are satisfied:*

$$(a) \ ((\hat{\tau}_i)_{i=1}^N, \hat{t}) \in \mathfrak{R}\left((\hat{C}_j)_{j=1}^N\right)$$

(b) For each $j' = 1, \dots, N$, we have

$$\begin{aligned} ((\hat{\tau}_i)_{i=1}^N, \hat{t}) \in \arg \max_{((\tau_i)_{i=1}^N, t)} & \left(\gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) \right) \\ & + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1 - \varepsilon} W((\tau_i)_{i=1}^N, t) \end{aligned}$$

(c) For each $j' = 1, \dots, N$, there exists a tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t}) \in \mathfrak{R} \left(\left(\hat{C}_j \right)_{j=1}^N \right)$ such

$$\text{that } \hat{C}_{j'}((\tau_i)_{i=1}^N, t) = 0$$

PROOF: See Appendix 4A.

The following proposition provides a characterization of the Nash equilibrium under the assumption that the tax policy implemented by the government is an interior solution and that all the contingent political contribution schedules are differentiable at this best response of the government. The proposition can be used to compute the equilibrium tax policy.

PROPOSITION 2: Let $\hat{C}_j$ be a contingent political contribution schedule announced by industry lobby $j, j = 1, \dots, N$, and $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ be a tax policy implemented by the government in response to $(C_j)_{j=1}^N$. Suppose that the combination of strategies

$\left((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right)$ constitutes a Nash equilibrium for the two-sided capital levy problem and that $\hat{\tau}_i, i = 1, \dots, N$, and t are all positive and less than 1. Suppose also that each of the contingent political contributions is differentiable at $((\hat{\tau}_i)_{i=1}^N, \hat{t})$. Then the tax system $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ satisfies the following first-order conditions:

$$(41) \quad \frac{\partial \left(\sum_{j=1}^N \gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t})}{\partial \tau_i} = 0, \text{ for } i = 1, \dots, N,$$

$$\frac{\partial \left(\sum_{j=1}^N \gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t})}{\partial t} = 0$$

PROOF: See Appendix 4B.

In what follows, we often refer to the government as player 0; that is, a variable with 0 in one of the subscripts refers to the government. Now let

$$(42) \quad \mu_0^{\max} = \max_{((\tau_i)_{i=1}^N, t)} \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t).$$

As defined, $\mu_0^{\max}$ represents the payoff for the government, given that it does not receive any political contributions. The government can always obtain this level of payoff by refusing to accept political contributions and then implementing the tax policy that maximizes social welfare. Next, let I be a subset of $\{1, \dots, N\}$, i.e., a group of industry lobbies, then define

$$(43) \quad \mu_{\{0\} \cup I}^{\max} = \max_{((\tau_i)_{i=1}^N, t)} \sum_{j \in I} \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) \right) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t)$$

As defined, $\mu_{\{0\} \cup I}^{\max}$ represents the maximum joint payoff for the government and the industry lobbies in I , given that no industry lobby outside I makes any political contributions.

Let M denote the set of vectors $(\mu_j)_{j=1}^N$ that satisfy the following conditions:

$$(44) \quad \mu_j \geq 0, j = 1, \dots, N,$$

$$(45) \quad \sum_{j=1}^N \mu_j \leq \mu_{\{0,1,\dots,N\}}^{\max} - \mu_0^{\max}$$

$$(46) \quad \sum_{j=1}^N \mu_j \leq \mu_{\{0,1,\dots,N\}}^{\max} - \mu_{\{0\} \cup \bar{I}}^{\max}$$

In (46), $\bar{I}$ denotes the complement of I in $\{1, 2, \dots, N\}$. An element of M can be interpreted as a vector of net payoffs for the N industry lobbies. The conditions imposed on $(\mu_j)_{j=1}^N$ can be rationalized as follows. First, observe that (44) is evident: the net payoff for each lobby is nonnegative. Second, note that the government can always obtain at least the payoff $\mu_0^{\max}$ by implementing the tax policy that maximizes social welfare. Furthermore, $\mu_{\{0,1,\dots,N\}}^{\max}$ is the maximum global payoff for all the players – the government and the N industry lobbies – in the game. Hence the N industry lobbies – as a group – can never hope to obtain more than the value on the right-hand side of (45). The condition (46) has a similar interpretation. The left-hand side of (46) is the sum of payoffs for the industry lobbies in I . This sum can never exceed the expression on the right-hand side. Indeed, if this were the case, then all the industry lobbies outside I and

the government together would obtain a payoff strictly less than $\mu_{\{0\} \cup \bar{I}}^{\max}$, which will induce these players to form a coalition to raise their joint payoff back to $\mu_{\{0\} \cup \bar{I}}^{\max}$.

An element of M , say $(\mu_j)_{j=1}^N$, is said to be *inefficient* if there exists another element in M , say $(\mu'_j)_{j=1}^N$, such that $\mu'_j \geq \mu_j$ for $j = 1, \dots, N$, with at least one strict inequality holding. An element of M is said to be *efficient* otherwise. The set of efficient vectors in M is called the Pareto frontier of M and is denoted by $\hat{M}$. Because M is a closed and bounded set in R^N , it contains its Pareto frontier, i.e., $\hat{M} \subset M$.

The following proposition is our restatement – in the current context – of Theorem 2 in Bernheim and Whinston, op.cit.. It gives a constructive proof of the existence of a Nash equilibrium for the capital levy problem.

PROPOSITION 3: Let $(\hat{\mu}_j)_{j=1}^N$ be an element on the Pareto frontier of M and $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ be a tax policy that maximizes the global payoff of the home government and the N industry lobbies, i.e.,

$$(47) \quad ((\hat{\tau}_i)_{i=1}^N, \hat{t}) \in \arg \max_{((\tau_i)_{i=1}^N, t)} \sum_{j=1}^N \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) \right) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t)$$

Suppose that for each $j = 1, \dots, N$, the j^{th} industry lobby announces the following contingent political schedule

$$(48) \quad \hat{C}_j((\tau_i)_{i=1}^N, t) = \max \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) - \hat{\mu}_j, 0 \right)$$

Then the combination of strategies $\left((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t})\right)$ constitutes a Nash equilibrium for the two-sided capital levy problem.

PROOF: See Appendix 4C.

Bernheim and Whinston, op. cit., called the contingent political contribution schedules defined in Proposition 3 *truthful strategies* and the Nash equilibrium under which the lobbies use truthful strategies a *truthful Nash equilibrium*. A truthful strategy, say for industry lobby j , is a contingent political contribution schedule of the following form:

$$(49) \quad C_j((\tau_i)_{i=1}^N, t) = \max\left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) - \mu_j, 0\right)$$

where μ_j is a nonnegative number. In announcing such a contingent political contribution schedule, this industry lobby informs the government that it only aims for a payoff, net of political contributions, equal to μ_j . If the gross payoff it obtains under the tax policy implemented is less than or equal to μ_j , it will make no political contribution. On the other hand, if its gross payoff is higher than μ_j , then all the profits in excess of μ_j will be given away as political contributions. Truthful strategies and truthful Nash equilibria have two attractive properties: (i) they are coalition-proof, and (ii) for any coalition-proof Nash equilibrium, there is a truthful Nash equilibrium that gives each

player exactly the same net payoff. Thus in searching for a solution to the capital levy problem we can restrict ourselves to truthful Nash equilibria.

To explain the concept of a *coalition-proof Nash equilibrium*, let us consider a Nash equilibrium, say $\left((\tilde{C}_j)_{j=1}^N, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t})\right)$, for the capital levy problem. For each subset $J \subset \{1, 2, \dots, N\}$, let $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$ be the game defined as follows. In $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$, the government and the industry lobbies in J are the *active players*, while the industry lobbies outside J are *passive*. More precisely, each of the industry lobbies in J are allowed to choose any contingent political contribution schedule it deems fit in its aggressive efforts to buy political influence, while all the industry lobbies outside J are passive in the sense that they always use the strategies $(\tilde{C}_j)_{j \in \bar{J}}$, regardless of the actions chosen by the lobbies in J . Thus if $(C_j)_{j \in J}$ is the combination of strategies chosen by the players in J and $((\tau_i)_{i=1}^N, t)$ is the tax policy implemented by the government, then the payoffs, net of political contributions, of the players in J are given by

$$(50) \quad \gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) - C_j((\tau_i)_{i=1}^N, t), \quad j \in J,$$

while the payoff for the government is given by

$$(51) \quad \sum_{j \in J} C_j((\tau_i)_{i=1}^N, t) + \sum_{j \in \bar{J}} \tilde{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1 - \varepsilon} W((\tau_i)_{i=1}^N, t).$$

The game $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$ is called *the J-subgroup component game* and is associated with the combination of strategies $(\tilde{C}_j)_{j=1}^N$.

In what follows, we shall denote the number of industry lobbies in J by $|J|$. First, let us consider the case of a single industry lobby, say $J = \{j1\}$. Clearly,

$(\tilde{C}_{j1}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}))$ is a Nash equilibrium for the subgroup- J component game $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$ because $((\tilde{C}_j)_{j=1}^N, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}))$ is a Nash equilibrium for the principal game. According to (b) of Proposition 1,

$$(52) \quad ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \in \arg \max_{((\tau_i)_{i=1}^N, t)} \left(\gamma_{j1} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j1}((\tau_i)_{i=1}^N, t) \right) \\ + \sum_{j \neq j1, j=1}^N \tilde{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1 - \varepsilon} W((\tau_i)_{i=1}^N, t)$$

Furthermore, according to (iii) of the same proposition, industry lobby $j1$ extracts all the surplus that comes from the cooperation of the government. Hence the contingent political contribution schedule $\tilde{C}_{j1}$ is *coalition-proof* in the obvious manner that no other contingent political contribution schedule gives lobby $j1$ a strictly higher net payoff.

Next, consider the case J contains two lobbies, say $J = \{j1, j2\}$. Clearly,

$(\tilde{C}_{j1}, \tilde{C}_{j2}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}))$ is a Nash equilibrium for the component game $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$ because $(\tilde{C}_{j1}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}))$ is a Nash equilibrium of the component game $\Gamma\left((\tilde{C}_j)_{j \in (\bar{J} \cup \{j2\})}\right)$ and $(\tilde{C}_{j2}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}))$ is a Nash equilibrium of the component game $\Gamma\left((\tilde{C}_j)_{j \in (\bar{J} \cup \{j1\})}\right)$. Each

of the small component games contains exactly one industry lobby. Hence each of the Nash equilibria $\left(\tilde{C}_{j1}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ and $\left(\tilde{C}_{j2}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ is coalition-proof. However, the J -subgroup component game $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$ might have another Nash equilibrium, say $\left(\hat{C}_{j1}, \hat{C}_{j2}, ((\hat{\tau}_i)_{i=1}^N, \hat{\tau})\right)$, under which the net payoffs for the two lobbies $j1$ and $j2$ are strictly higher. Under such a scenario, we expect that lobby $j1$ and lobby $j2$ will communicate with each other to arrange a joint deviation away from the Nash equilibrium $\left(\tilde{C}_{j1}, \tilde{C}_{j2}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ in favor of $\left(\hat{C}_{j1}, \hat{C}_{j2}, ((\hat{\tau}_i)_{i=1}^N, \hat{\tau})\right)$. If no such deviation is possible, we say that the Nash equilibrium $\left(\tilde{C}_{j1}, \tilde{C}_{j2}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ is a *coalition-proof Nash equilibrium* for the J -subgroup component game $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$.

For the case J contains more than two industry lobbies, say $|J| > 2$, we can also assert that $\left((\tilde{C}_j)_{j \in J}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ is a Nash equilibrium for the J -subgroup component game $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$ because $\left((\tilde{C}_j)_{j=1}^N, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ is a Nash equilibrium for the principal game. We say that the Nash equilibrium $\left((\tilde{C}_j)_{j=1}^N, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ is *self-enforcing* if for each proper subset $I \subset J$, the Nash equilibrium $\left((\tilde{C}_j)_{j=1}^N, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ of the component game $\Gamma\left((\tilde{C}_j)_{j \in (\bar{J} \cup (J-I))}\right)$ is a coalition-proof Nash equilibrium. The Nash equilibrium $\left((\tilde{C}_j)_{j \in J}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{\tau})\right)$ for the J -subgroup component game $\Gamma\left((\tilde{C}_j)_{j \in \bar{J}}\right)$ is coalition-proof if this component game has no other self-enforcing Nash equilibrium that gives each of the industry lobbies in J a strictly higher net payoff.

PROPOSITION 4: *All truthful Nash equilibria are coalition-proof. Under a coalition-proof Nash equilibrium, the list of the net payoffs for the N industry lobbies are in $\hat{M}$, the Pareto frontier of M .*

PROOF: See Appendix 4D.

4.4 THE REFERENCE CASE

In the reference case, it is assumed that there are no taxes. Without any tax revenues to finance the production of public goods, these goods will not be provided to the population. It is also assumed that emigration is forbidden, although private goods are allowed to flow freely across international borders.

As a function of the prevailing wage rate ω , the aggregate demand for effective labor is $\sum_{j=1}^N L_j(\omega)$, while the aggregate supply of effective labor is $\int_0^\infty \tilde{\theta} \ell(\omega \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}$.

The market-clearing condition for labor is

$$(53) \quad \sum_{j=1}^N L_j(\omega) = \int_0^\infty \tilde{\theta} \ell(\omega \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}.$$

The equilibrium wage rate is the value of ω that solves (53). It is assumed that the equilibrium wage rate in the reference case is equal to $\bar{\omega}$, the wage rate abroad. This assumption means that there will be no brain drain in the reference case even if workers

are free to emigrate (i.e. adjustment costs are zero). The equilibrium in the reference case is depicted in Figure 4.1.

[Insert Figure 4.1 Here]

4.5 THE PROVISION OF PUBLIC GOODS: THE CASE OF SOCIAL WELFARE MAXIMIZATION

Suppose that the home government behaves like a benevolent dictator in its efforts to raise the revenues needed for the provision of public goods. Then it solves the following social welfare maximization problem:

$$(54) \quad \max_{((\tau_i)_{i=1}^N, t)} W((\tau_i)_{i=1}^N, t).$$

Let $((\tau_i^*)_{i=1}^N, t^*)$ be a solution of (54). The equilibrium wage rate and the level of public goods provided under the tax policy $((\tau_i^*)_{i=1}^N, t^*)$ are given, respectively, by $\omega((\tau_i^*)_{i=1}^N, t^*)$ and $x_0((\tau_i^*)_{i=1}^N, t^*)$. Now define,

$$\tau^* = \frac{\sum_{j=1}^N \tau_j^* \Pi_j(\omega((\tau_i^*)_{i=1}^N, t^*))}{\sum_{j=1}^N \Pi_j(\omega((\tau_i^*)_{i=1}^N, t^*))},$$

then denote by the ordered pair (τ^*, t^*) the tax policy under which capital is taxed uniformly at rate τ^* across industries and wages are taxed at rate t^* . We claim that (τ^*, t^*) is also a tax policy that maximizes social welfare. Indeed, when the wage rate $\omega((\tau_i^*)_{i=1}^N, t^*)$ prevails, the representative firm in industry j will use the same level of effective labor input whether its profits are taxed at rate τ_j^* or at rate τ^* . As for a worker, if the level of public goods provided remains at $x_0((\tau_i^*)_{i=1}^N, t^*)$ and if the wage rate $\omega((\tau_i^*)_{i=1}^N, t^*)$ still prevails, then her labor supply is still the same when the home government switches from the tax policy $((\tau_i^*)_{i=1}^N, t^*)$ to (τ^*, t^*) . Given the behavior of the firms and the workers just described, the home government collects the same amount of taxes under the tax policy (τ^*, t^*) as under the tax policy $((\tau_i^*)_{i=1}^N, t^*)$, i.e., the same level of public goods is provided when the home government switches from $((\tau_i^*)_{i=1}^N, t^*)$ to (τ^*, t^*) . We state formally this result in the following lemma:

LEMMA 2: In finding the tax policy to generate the revenues needed for the provision of the public goods, the home government can restrict itself to a uniform tax on capital.

In what follows, the ordered pair (τ, t) represents the tax policy under which capital is uniformly taxed at rate τ across industries and wages are taxed at rate t . When the tax policy (τ, t) is implemented, the social welfare obtained will be written under the following form:

$$(55) \quad W(\tau, t) = u_o(x_o(\tau, t)) \left(H(\theta(\tau, t)) + \sum_{j=1}^N \gamma_j \right) + \Phi(\tau, t) + \sum_{j=1}^N \Psi_j(\tau, t).$$

The Provision of Public Goods When Only Capital is Taxed

In this subsection, we consider the case where capital is uniformly taxed at rate τ , $0 \leq \tau \leq 1$, across industries, but wages are not taxed. Under this scenario, the home government solves the following social welfare maximization problem:

$$(56) \quad \max_{\tau} W(\tau, 0) = \max_{\tau} \left[u_o(x_o(\tau, 0)) \left(H(\theta(\tau, 0)) + \sum_{j=1}^N \gamma_j \right) + \Phi(\tau, 0) + (1 - \tau) \sum_{j=1}^N \Pi_j(\omega(\tau, 0)) \right]$$

The equilibrium induced by the tax policy $(\tau, 0)$ is depicted as point E in Figure 4.2. Observe that the aggregate demand for effective labor input is obtained by shifting horizontally the demand for effective labor input of the private sector. It is clear from Figure 4.2 that the equilibrium wage rate $\omega(\tau, 0)$ is strictly increasing from $\bar{\omega}$, the wage rate abroad, when τ rises from 0. Because $\omega(\tau, 0) > \bar{\omega}$, there is no brain drain when only capital is taxed.

[Insert Figure 4.2 Here]

Observe that the horizontal distance $E'E$ represents the equilibrium level of effective labor input in the public sector, when the tax policy $(\tau, 0)$ is implemented. It is clear that $E'E$, and a fortiori $x_o(\tau, 0)$, is strictly increasing when τ rises from 0 to 1.

Because the equilibrium wage rate $\omega(\tau, 0)$ and the equilibrium level of public goods provided $x_0(\tau, 0)$ both rise with τ , the utility enjoyed by a worker under the tax policy $(\tau, 0)$ unambiguously rises with τ . As for the owners of the capital stock in each industry, a rise in τ , which induces a rise in the equilibrium wage rate $\omega(\tau, 0)$, reduces the gross profits of the industry. Their net incomes are even lower. Hence the utility these owners of capital derive from the consumption of the private goods will decline as τ rises. On the other hand, the level of public goods rises with τ . The net impact of a rise in τ -- on the welfare of the owners of capital -- depends on which effect will dominate: the increase in welfare due to a higher level of public goods or the decrease in welfare due to a lower level of consumption of private goods. Using the Inada condition $\lim_{x_0 \rightarrow 0} u'_0(x_0) = +\infty$, and the continuity result $\lim_{\tau \rightarrow 0} x_0(\tau, 0) = 0$, we can assert that the former effect dominates the latter effect when τ rises slightly above 0. Therefore, when only capital is taxed to provide the revenues needed in the production of the public goods the optimal tax rate on capital will be positive. To learn more about the optimal tax rate on capital under this scenario, we now study (56) in detail.

Because there is no brain drain, i.e. $H(\theta(\tau, 0)) + \sum_{j=1}^N \gamma_j = 1$, under the tax policy $(\tau, 0)$, we have

$$(57) \quad \Phi(\tau, 0) = \int_0^\infty \phi(\omega(\tau, 0), 0, \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}.$$

Using (57), we obtain the following more explicit expression for the social welfare obtained under tax policy $(\tau, 0)$:

$$(58) \quad W(\tau, 0) = u_0(x_0(\tau, 0)) + \int_0^\infty \phi(\omega(\tau, 0), 0, \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} + (1 - \tau) \sum_{j=1}^N \Pi_j(\omega(\tau, 0))$$

Differentiating (58) with respect to τ , we obtain

$$(59) \quad \frac{\partial W(\tau, 0)}{\partial \tau} = u'_0(x_0(\tau, 0)) \frac{\partial x_0}{\partial \tau}(\tau, 0) + \frac{\partial \omega}{\partial \tau}(\tau, 0) \int_0^\infty \tilde{\theta} \ell(\omega(\tau, 0) \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} \\ - \sum_{j=1}^N \Pi_j(\omega(\tau, 0)) - (1 - \tau) \frac{\partial \omega}{\partial \tau}(\tau, 0) \sum_{j=1}^N L_j(\omega(\tau, 0))$$

To evaluate the right-hand side of (59), we need to compute the partial derivatives

$\frac{\partial x_0}{\partial \tau}(\tau, 0)$ and $\frac{\partial \omega}{\partial \tau}(\tau, 0)$. Doing so transforms expression (59) into the following

expression, which is more conducive to an economic interpretation of the optimal tax rate on capital,

$$\left(\frac{\partial W(\tau, 0)}{\partial \tau} \right) \left(\frac{\partial \omega}{\partial \tau}(\tau, 0) \right)^{-1} = \left(u'_0(x_0(\tau, 0)) \frac{\partial F_0}{\partial L_0}(K_0, L_0(\tau, 0)) - \omega(\tau, 0) \right) \\ \times \left(\int_0^\infty \tilde{\theta}^2 \ell'(\omega(\tau, 0) \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} - \sum_{j=1}^N L'_j(\omega(\tau, 0)) \right)$$

where we have let

$$(60) \quad L_0(\tau, 0) = \frac{\tau}{\omega(\tau, 0)} \sum_{j=1}^N \Pi_j(\omega(\tau, 0))$$

denote the equilibrium level of effective labor input in the public sector under the chosen

tax policy. Because $\frac{\partial \omega}{\partial \tau}(\tau, 0) > 0$, $\ell'(\omega(\tau, 0)\tilde{\theta}) > 0$ for $\tilde{\theta} > 0$, and $L'_j(\omega) < 0$, we can

assert that the sign of $\frac{\partial W}{\partial \tau}(\tau, 0)$ is the same as the sign of

$$(61) \quad u'_0(x_0(\tau, 0)) \frac{\partial F_0}{\partial L_0}(K_0, L_0(\tau, 0)) - \omega(\tau, 0).$$

Observe that $u'_0(x_0(\tau, 0)) \frac{\partial F_0}{\partial L_0}(K_0, L_0(\tau, 0))$ represents the marginal social welfare

of effective labor in the public sector. It is strictly decreasing as τ rises. Using the Inada

conditions $\lim_{x_0 \rightarrow 0} u'_0(x_0) = +\infty$ and $\lim_{L_0 \rightarrow 0} \frac{\partial F_0}{\partial L_0}(K_0, L_0) = +\infty$, we can assert that

$u'_0(x_0(\tau, 0)) \frac{\partial F_0}{\partial L_0}(K_0, L_0(\tau, 0)) \rightarrow +\infty$, when $\tau \rightarrow 0$. On the other hand, as τ rises from

0, the equilibrium wage rate $\omega(\tau, 0)$ rises with τ from the initial level $\bar{\omega}$. Hence (61) is

strictly decreasing from $+\infty$ as τ rises from 0. Depending on the endowments and

parameters of the home economy the curve

$$(62) \quad \tau \rightarrow u'_0(x_0(\tau, 0)) \frac{\partial F_0}{\partial L_0}(K_0, L_0(\tau, 0)) - \omega(\tau, 0)$$

might or might not cross the horizontal axis. The latter scenario will occur if the marginal

utility of the public good is extremely high. When the marginal utility of the public good

is not too high, after a small amount of this good is provided, the curve represented by (62) will cross the horizontal axis at a unique point, τ° , $0 < \tau^\circ < 1$. The social welfare maximization problem has an interior solution in this scenario.

We summarize the preceding discussion in the following lemma:

LEMMA 3: For each τ , $0 < \tau \leq 1$, let

$$(63) \quad Q(\tau) = u'_0\left(F_0(K_0, L_0(\tau, 0))\right) \frac{\partial F_0}{\partial L_0}(K_0, L_0(\tau, 0)) - \omega(\tau, 0)$$

As defined, $Q(\tau)$ represents the excess of the marginal utility of the public goods over the equilibrium wage rate. The curve $Q: \tau \rightarrow Q(\tau)$, thus defined, is downward sloping and $\lim_{\tau \rightarrow 0} Q(\tau) = +\infty$. Because $\omega(\tau, 0)$ represents the marginal product of labor in the private sector as well as the marginal disutility of working, $Q(\tau)$ represents the inefficiency of resource allocation that is induced by the tax policy $(\tau, 0)$. Next let

$$(64) \quad \tau^\circ = \arg \max_{\tau} W(\tau, 0)$$

denote the optimal tax rate on capital, given that only this factor of production is taxed to raise the revenues needed for the provision of the public goods. Then $\tau^\circ > 0$.

Furthermore, if $Q(1) < 0$, then $\tau^\circ < 1$ and $Q(\tau^\circ) = 0$. Also, if $q(1) \geq 0$, then $\tau^\circ = 1$.

Now $\omega(\tau, 0)$ is the equilibrium wage rate under the tax policy $(\tau, 0)$. Profit maximization ensures that $\omega(\tau, 0)$ is equal to the marginal revenue product of effective labor in each industry. Expression (63) thus represents the net gain in social welfare when one unit of effective labor is transferred from the private sector to the public sector. As long as (63) is still positive, social welfare can be raised by diverting labor from the private sector to the public sector. On the other hand, if (63) is negative, the tax rate on capital is too high and the amount of the public goods provided is excessive.

The Provision of Public Goods When Only Labor is Taxed

Suppose that the home government chooses to tax labor, not capital, in its effort to raise the revenues needed for the provision of public goods. Then it solves the following social welfare maximization problem:

$$(65) \quad \max_{0 \leq t < 1} W(0, t).$$

Let t , $0 < t < 1$, be the tax rate imposed on wages. When the tax policy $(0, t)$ is implemented, the gross equilibrium wage rate is $\omega(0, t)$ and the net equilibrium wage rate is $(1 - t)\omega(0, t)$. Using this, we write the following lemma:

LEMMA 4: *Suppose that the home government chooses to tax labor, but not capital, at rate t , $0 < t < 1$. Then*

$$(66) \quad (1 - t)\omega(0, t) < \bar{\omega} < \omega(0, t),$$

i.e., under the tax policy $(0, t)$ the gross equilibrium wage rate rises above, but the net equilibrium wage rate falls below, $\bar{\omega}$. The ensuing consequence of the drop in the net equilibrium wage rate below $\bar{\omega}$ is an outflow of workers at the higher end of the human capital ladder.

According to Lemma 4, the critical human capital level $\theta(0, t)$ is finite when $t > 0$. The social welfare obtained under the tax policy $(0, t)$ is

$$(67) \quad W(0, t) = u_0(x_0(0, t)) \left(H(\theta(0, t)) + \sum_{j=1}^N \gamma_j \right) + \int_0^{\theta(0, t)} \phi(\omega(0, t), t, \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} \\ + \sum_{j=1}^N \Pi_j(\omega(0, t))$$

Differentiating (67) with respect to t , we obtain

$$(68) \quad \frac{\partial W}{\partial t}(0, t) = \left(u'_0(x_0(0, t)) \frac{\partial x_0}{\partial t}(0, t) \right) \left(H(\theta(0, t)) + \sum_{j=1}^N \gamma_j \right) + \\ + \left(u_0(x_0(0, t)) + \phi(\omega(0, t), t, \theta(0, t)) \right) h(\theta(0, t)) \frac{\partial \theta}{\partial t}(0, t) \\ - \omega(0, t) \int_0^{\theta(0, t)} \tilde{\theta} \ell((1-t)\omega(0, t)\tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}$$

where the result has been obtained with the help of the market-clearing condition for labor. Note that on the right-hand side of this equality the expression on the first line

represents the rate of gain in the public good component of social welfare enjoyed by the workers who choose to stay and by the owners of capital when the tax policy $(0, t)$ is implemented. Using the Inada conditions $u'_0(x_0) \rightarrow +\infty$ when $x_0 \rightarrow 0$ as well as

$$\frac{\partial F_0}{\partial L_0}(K_0, L_0) \rightarrow +\infty \text{ when } L_0 \rightarrow 0, \text{ both } u'_0(x_0(0, t)) \rightarrow +\infty \text{ and } \frac{\partial x_0}{\partial t}(0, t) \rightarrow +\infty \text{ when}$$

$t \rightarrow 0$. The expression on the second line of the equality represents the loss in social welfare due to the emigration of the workers at the margin when the tax policy $(0, t)$ is implemented. This expression converges to a finite value when $t \rightarrow 0$. The expression on the last line of the equality is the rate of income loss suffered by the group of workers who stay when the tax policy $(0, t)$ is implemented. The right-hand side of the equality thus represents the rate of change in social welfare at the margin when the tax policy $(0, t)$ is implemented. Finally, observe that the rise in the gross equilibrium wage rate $\omega(0, t)$ associated with a rise in t exerts a negative impact of the second order on the profits of the firms and a fortiori on the welfare of the capital owners. The rise in $\omega(0, t)$ offsets somewhat the rise in the tax rate on labor incomes of workers. At the aggregate level, these impacts cancel each other.

The preceding discussion allows us to assert that $\frac{\partial W}{\partial t}(0, t) \rightarrow +\infty$ when $t \rightarrow 0$,

i.e., when only labor is taxed to raise the revenues needed for the provision of the public goods, the optimal tax rate on wages is strictly positive. However, unlike the case where only capital is taxed, the home government cannot tax wages at a confiscatory rate without inducing a massive brain drain, as asserted by the following lemma:

LEMMA 5: *Suppose that the home government chooses to tax only labor, not capital, and at rate $t > 0$. Then we have*

$$(69) \quad \lim_{t \rightarrow 1} \int_0^{\theta(0,t)} \tilde{\theta} \ell((1-t)\omega(0,t)\tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} = 0$$

that is, when the tax rate on wages tend to 1, the equilibrium aggregate supply of effective labor will tend to 0.

Lemma 5 is proved in Appendix 4E. It follows in a straightforward manner from (69) that either $\lim_{t \rightarrow 1} \theta(0,t) = 0$ or $\lim_{t \rightarrow 1} (1-t)\omega(0,t) = 0$. Under the former scenario, brain drain takes place on a massive scale. Under the latter scenario, any worker who elects to stay will choose not to work because the net wage rate goes to 0; all the time endowment will be spent on leisure. Under both scenarios, there are no public goods. The income of capital owners are also zero. Hence compared to the reference case, capital owners are unambiguously worse off when $t \rightarrow 1$. As for a worker who stays, she is also unambiguously worse off. Indeed, in the reference case she can choose not to work and obtains the same utility as under the scenario $t \rightarrow 1$. We summarize the results just obtained in the following lemma:

LEMMA 6: *Let*

$$(70) \quad t^{\circ} = \arg \max_t W(0, t)$$

denote the optimal tax rate on wages, given that only labor is taxed to raise the revenues needed in the provision of public goods. Then $0 < t^{\circ} < 1$; that is, in its efforts to provide public goods, the home government – if it has decided to tax only labor – is willing to tolerate a certain level of brain drain.

The Provision of Public Goods When Both Labor and Capital are Taxed

Having analyzed the cases where only one factor of production is taxed to raise the revenues needed for the provision of the public goods, we now allow the home government the flexibility of being able to tax both labor and capital. Under this scenario, the home government solves the following social welfare maximization problem:

$$(71) \quad \max_{(\tau, t)} W(\tau, t)$$

While a tax on profits is neutral, a tax on wages distorts the labor-leisure choice of workers and might induce emigration. Therefore, we expect that the home government will favor taxing capital over taxing labor in its efforts to raise the revenues needed in the provision of the public goods. Proposition 5 confirms this intuition. In proving the second half of Proposition 5 and in some arguments to come, we appeal to the following lemma, which is proved in Appendix 4E.

LEMMA 7: Let τ , $0 < \tau \leq 1$, be a uniform tax rate on capital. If

$$u'_0\left(F_0(K_0, L_0(\tau, 0))\right) \frac{\partial F_0}{\partial L_0}(K_0, L_0(\tau, 0)) - \omega(\tau, 0) > 0$$

then $\frac{\partial W}{\partial t}(\tau, 0) > 0$. That is, if capital has been taxed at rate τ and the marginal utility of the public good is still higher than the equilibrium wage rate $\omega(\tau, 0)$, then social welfare can be raised by also taxing wages.

PROPOSITION 5: If $\tau^* < 1$, i.e., if the optimal tax rate on capital, given that only this factor of production is taxed, is strictly less than one, then it is not socially optimal to tax labor. On the other hand, if $\tau^* = 1$, then optimal tax policy dictates that all profits be taxed away while wages be taxed at the rate which solves the following maximization problem:

$$(72) \quad \max_t W(1, t).$$

Furthermore, the optimal tax rate on wages in this case is strictly positive if and only if

$$(73) \quad u'_0\left(F_0(K_0, L_0(1, 0))\right) \frac{\partial F_0}{\partial L_0}(K_0, L_0(1, 0)) - \omega(1, 0) > 0$$

PROOF: See Appendix 4F.

4.6 THE PROVISION OF PUBLIC GOODS WHEN INDUSTRY LOBBIES ARE ACTIVE

Let $((\tau_i)_{i=1}^N, t)$ be a tax policy implemented by the home government. When the industry lobbies are active, the global payoff of the home government and the N industry lobbies is given by

$$(74) \quad Z((\tau_i)_{i=1}^N, t) = \sum_{j=1}^N \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) \right) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t)$$

According to Proposition 3, the tax policy implemented by the home government is a solution of the following maximization problem:

$$(75) \quad \max_{((\tau_i)_{i=1}^N, t)} Z((\tau_i)_{i=1}^N, t)$$

Let $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ be a solution of (75). Under this tax policy, the equilibrium wage rate is $\omega((\hat{\tau}_i)_{i=1}^N, \hat{t})$ and the total capital income tax revenues collected are given by

$$\sum_{j=1}^N \tau_j \Pi_j(\omega((\hat{\tau}_i)_{i=1}^N, \hat{t})). \text{ Let } (\hat{\tau}_i)_{i=1}^N \text{ be a capital income tax policy that satisfies the}$$

following condition:

$$(76) \quad \sum_{j=1}^N \tau_j \Pi_j(\omega((\tau_i)_{i=1}^N, \hat{t})) = \sum_{j=1}^N \hat{\tau}_j \Pi_j(\omega((\hat{\tau}_i)_{i=1}^N, \hat{t}))$$

It is clear that the tax policy $((\tau_i)_{i=1}^N, \hat{t})$ induces the same equilibrium as the tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t})$. That is, the equilibrium wage rate and the equilibrium level of public goods provided are the same under both tax policies. Hence the critical human capital levels are also the same under both tax policies, and the utility of a worker who stays under these tax policies remains the same when the home government switches from $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ to $((\tau_i)_{i=1}^N, \hat{t})$. Furthermore, because the equilibrium wage rates are the same under both tax policies, the (before-tax) profits earned by each industry are also the same under both tax policies. According to (76), the total capital tax revenues collected under both tax policies are also the same. Hence the welfare of the owners of capital, as a group, does not change when the home government switches from $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ to $((\tau_i)_{i=1}^N, \hat{t})$, although the welfare of the owners of capital in a particular industry, say i , will rise (fall) if τ_i is less than (greater than) $\hat{\tau}_i$.

At the global level, the joint payoff of the home government and the N industry lobbies thus does not change when the home government switches from $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ to $((\tau_i)_{i=1}^N, \hat{t})$. In particular, if the home government taxes capital uniformly across industries at the following rate

$$\tau = \frac{\sum_{j=1}^N \hat{\tau}_j \Pi_j(\omega((\hat{\tau}_i)_{i=1}^N, \hat{t}))}{\sum_{j=1}^N \Pi_j(\omega((\hat{\tau}_i)_{i=1}^N, \hat{t}))}$$

and labor at rate $\hat{t}$, then the joint payoff of the government and the N industries under this tax policy is the same as that under the tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t})$. Therefore, in solving (75), the home government can restrict itself to the case $\tau_1 = \tau_2 = \dots = \tau_i = \dots = \tau_N = \tau$, i.e., the case where capital is taxed at the same rate across industries. A tax policy can now be represented by an ordered pair, say (τ, t) , where τ is the uniform tax rate on capital and t is the tax rate on wages. The gross equilibrium wage rate and the equilibrium level of public goods provided will be denoted, respectively, by $\omega(\tau, t)$ and $x_0(\tau, t)$.

PROPOSITION 6: *Let*

$$(77) \quad \tau^1 = \arg \max_{\tau} Z(\tau, 0)$$

denote the tax rate on capital imposed by the home government when the N industry lobbies are active, given that it chooses to tax only this factor of production in its efforts to raise the revenues needed for the provision of public goods. Then we have $\tau^1 \leq \tau^\circ$, with strict inequality holding if $\tau^\circ < 1$. That is, if the home government chooses not to tax wages, then the tax rate it imposes on capital is lower when the N industry lobbies are active than when they are inactive: lobbying activities, under this scenario, reduce the capital income tax rate and a fortiori the level of public goods provided.

PROOF: See Appendix 4G.

Consider a tax policy (τ, t) , with $\tau > 0$, $t \geq 0$ and t is sufficiently small. Because t is sufficiently small and $\tau > 0$, there will be no brain drain when the tax policy (τ, t) is implemented. For the workers, as a group, their total welfare is given by,

$$(78) \quad u_0(x_0(\tau, t)) \left(1 - \sum_{j=1}^N \gamma_j \right) + \int_0^{\infty} \phi(\omega(\tau, t), t, \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}.$$

As for the owners of capital in the home country, as a group, their total welfare is given by

$$(79) \quad \sum_{j=1}^N \left(\gamma_j u_0(x_0(\tau, t)) + (1 - \tau) \Pi_j(\omega(\tau, t)) \right).$$

Differentiating (78) with respect to t , then evaluating the result at $t = 0$, we obtain

$$(80) \quad u'_0(x_0(\tau, 0)) \frac{\partial x_0}{\partial t}(\tau, 0) \left(1 - \sum_{j=1}^N \gamma_j \right) + \frac{\partial \omega}{\partial t}(\tau, 0) \int_0^{\infty} \tilde{\theta} \ell(\omega(\tau, 0), \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} \\ - \omega(\tau, 0) \int_0^{\infty} \tilde{\theta} \ell'(\omega(\tau, 0), \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}$$

Now we have shown that $\frac{\partial \omega}{\partial t}(\tau, 0) > 0$. Also, $\frac{\partial x_0}{\partial t}(\tau, 0) > 0$. Using these results,

we can interpret (80) as follows. The first expression in (80) represents the rate of change in the welfare of the workers due to a higher level of public goods, which is financed by raising the wage rate slightly above 0. The second expression in (80) represents the rate

of change in the wage bill received by the workers due to the rise in the gross equilibrium wage rate $\left(\frac{\partial \omega}{\partial t}(\tau, 0) > 0 \right)$ when the tax rate on wages rises slightly above zero. Both the first and second expressions are positive. The last expression represents the rate of income loss suffered by the workers as t rises in a right neighborhood of 0. The Inada condition $\lim_{x_0 \rightarrow 0} u'_0(x_0) = +\infty$ ensures that the first expression dominates the last expression where $\tau \rightarrow 0$. Therefore, (80) will be positive when τ is not too high. However, (80) might be negative if τ is substantial.

Differentiating (79) with respect to t , then evaluating the result at $t = 0$, we obtain,

$$(81) \quad \sum_{j=1}^N \left(\gamma_j u'_0(x_0(\tau, 0)) \frac{\partial x_0}{\partial t}(\tau, 0) - (1 - \tau) L_j(\omega(\tau, 0)) \frac{\partial \omega}{\partial t}(\tau, 0) \right)$$

Observe that for each $j = 1, \dots, N$, the expression $\gamma_j u'_0(x_0(\tau, 0)) \frac{\partial x_0}{\partial t}(\tau, 0)$ represents the rate of change in the welfare of the owners of capital in industry j due to a higher level of public goods provided, while the expression $(1 - \tau) L_j(\omega(\tau, 0)) \frac{\partial \omega}{\partial t}(\tau, 0)$ represents the loss of capital incomes suffered by this group due to a higher wage bill that the industry pays to its workers. As in the case of workers, the first expression dominates the second expression when τ is small. However, when τ is substantial, the summation in (81) might be negative. Under such a scenario, raising the tax rate on wages above zero might make the owners of capital in the home economy worse off as a group. Because the impact, on the owners of capital, of a rise in the wage rate operates indirectly through the

rise in the gross equilibrium wage rate and the rise in the level of public goods provided, while the impact on workers operates both directly – through the reductions in labor income – and indirectly – through the rise in the level of public goods provided and the rise in the gross equilibrium wage rate – we expect that the impacts, when they are negative, to be more adverse to the workers. In particular, it is difficult to imagine that a slight increase in the wage rate above zero will improve the situation of the workers, but make the situation of the owners of capital worse off. Therefore, we make the following assumption:

ASSUMPTION 4: For any $0 < \tau \leq 1$, if the home government has already taxed capital at rate τ and can raise the welfare of the workers by also taxing wages slightly, then this action also raises the welfare of the owners of capital.

When Assumption 4 holds, we can make the following claim,

PROPOSITION 7: *The tax rate on wages will be positive, $t > 0$, if industry lobbies are active.*

PROOF: See Appendix 4H.

4.7 DISCUSSION OF THE RESULTS

The first result worth noting is the fact that it is more than just wages alone that determine whether or not emigration will take place. Lemma 1 shows that only those workers whose human capital level is above a critical level, which is dependent upon income taxes, wages, the level of public goods, and adjustment costs, will choose to leave. Therefore, even if countries offer more competitive wages, it may not be enough to entice workers from abroad. Emigration depends on which country is able to offer a “better quality of life.”

In arriving at Lemma 1, we saw that as migration (or adjustment) costs change, there is an indirect effect on the stock of human capital. If the cost of migration rises in relation to the cost of capital, then more workers of higher skill are hired. Given that more workers are remaining, the relative wage being offered to skilled labor decreases. The economy is now more human capital intensive and according to endogenous growth theory, the economic outlook more sound.

Restricting ourselves to coalition-proof Nash equilibria we see that a government concerned with maximizing social welfare will elect to tax physical capital over human capital, since workers are mobile. The first best solution is to tax physical capital only. Table 4.1 represents simulation results based on the first best scenario with and without lobbying. We see that as the government becomes more concerned with social welfare maximization, that is as ϵ increases from the base case to case 3, capital income taxation in the face of lobbying rises. In the absence of lobbying the CIT is somewhat stable. Even a reduction in the fraction of capitalists in the economy by 80% only mildly impacts the optimal CIT – a reduction of 1% from the base case results.

[Insert Table 4.1 Here]

Not surprisingly, when the tax rate on labor income rises, all else being equal, the greater the decline in labor supply. This brings up the notion of how tax structure is determined. A government concerned with raising the necessary revenue to provide public goods would prefer a tax mix more heavily favored to physical, as opposed to human, capital. Of course, with the allowance of lobbying the capital income tax can fall dramatically when both capital and labor are free to be taxed (i.e. we are no longer at a first best scenario).

In the presence of lobbying firms can alleviate some of their tax burden by providing financial support for a political party's platform. The resulting loss in tax revenues used to fund the provision of the public goods must either be recouped by increasing the taxation on labor income or by reducing the level of public goods (Proposition 6). As we saw, any reduction in public goods will lower the welfare of the government's constituents by a larger amount, than a small increase in income taxes. Therefore, taxes on labor income rise in the presence of lobbying (Proposition 7) and the government has to concede the resulting migration by some skilled labor.

If restrictions are place on a firm's ability to make political contributions, the capital levy problem is mitigated. If firms could make unlimited contributions to politicians then taxes would be passed along to workers. Given that only skilled workers are mobile, the brunt of the increase in taxes would be born by unskilled workers. With only unskilled workers left, productivity suffers and future growth is compromised; this

is represented by a decrease in total welfare. By placing a restriction on the contribution limits of firms, governments achieve a more equitable tax treatment and, as a result, higher welfare. That is, the more restriction on political contributions, the closer the tax policy is to the one that maximizes social welfare, (i.e. the tax shifts from labor to capital, hence there is less distortion). Note that in the case that lobbying is forbidden, the tax policy implemented is the one that maximizes social welfare, i.e., τ^o , $t = 0$. By the continuity argument, when the restriction on lobbying is weakened, τ will be reduced and t will rise.

Table 4.2 provides simulation results based on a number of different tax mix and lobbying scenarios. In each of the scenarios brain drain occurs, due to the allowance of lobbying. The tax mix that results depends on the weight given to political contributions (ε) in the government's problem and the fraction of the population who own capital.

The base case gives equal weight to contributions and social welfare ($\varepsilon = 1/2$). The population consists of 25% capitalists. Under this scenario physical capital is not taxed and labor is taxed at 12%. The critical human capital level, the level that determines who stays, is 7.55, while the equilibrium wage rate is 3.29.

[Insert Table 4.2 Here]

If political contributions carry more weight in the government's welfare function, then this affects the tax mix, which in turn affects the composition of labor. This is illustrated in Cases 1 through 3. The higher ε the more weight the home government gives to social welfare. Hence, the tax policy implemented is closer to the one that

maximizes social welfare. Therefore, the tax rate on capital is higher and more skilled labor remains, as is illustrated by the critical human capital level rising with ε .

In Case 4, there is a smaller fraction of capitalists in the economy (5%). The critical human capital level rises in comparison with the base case, but the equilibrium wage rate falls. Therefore, while more skilled workers remain, they are paid less due to labor supply being greater. Labor income taxation falls (to 10%) compared with the base case (12%), while capital income taxation remains at zero. Labor ends up funding the entire public good, but with a larger workforce the burden faced by each worker is reduced.

4.8 CONCLUDING REMARKS

Considering human without physical capital, or vice versa, can lead to incorrect or inaccurate conclusions being reached about certain policy initiatives. We have attempted to shed light on some of these inaccuracies by putting a new spin on an old problem. The capital levy problem has been examined in the literature, but only from the *physical* capital perspective. If one accepts the link between human and physical capital, then the problem must be extended to include human capital as well.

The two-sided capital levy problem shows that not only do contribution limits and capital taxation play a role in the expropriations problem, but that the tax rate on labor and the mobility of workers is also important. Indirect effects that have gone largely unrecognized in previous literature are shown to play a significant role in a country's economic outlook. For instance, whether or not a country is human capital intensive will

depend directly on the taxation of skilled labor and its mobility, as well as indirectly on policies guiding political contributions and capital income taxes.

While the coalition-proof Nash equilibrium under social welfare maximization calls for a high capital income tax, this result falls apart with the allowance of lobbying. Fortunately, the mobility of skilled labor provides a larger deterrent to the government when determining the structure of taxation. Hence, labor income taxation remains low even in the face of lobbying. If workers have no alternatives other than to work in their home country (i.e. wages abroad are not competitive), then labor income taxation rises quite dramatically in the face of intense lobbying.

We conclude by offering avenues for future research. It would be interesting to calibrate the model and examine the impact of large policy changes. Also, extending the analysis to include endogenous growth may provide some interesting implications. Allowing firms to be mobile would also be a useful extension. This would provide some insight into the benefits of political contributions versus migration incentives. The erection of new barriers to migration on a global scale could also have interesting implications for the current analysis. The rise in adjustment costs could make many skilled workers far less mobile; as a result, labor income taxation could rise as per the traditional capital levy problem. Although, the introduction of a graduate rate structure on income may counteract this. The fact that workers of higher skill, which is often synonymous with higher income, are more plentiful could actually mean a drop in the tax rates, assuming an equal yield comparison. This would be similar to what was found in Case 4 of Table 4.2.

APPENDIX 4A

PROOF: Suppose that $\left(\left(\hat{C}_j\right)_{j=1}^N, \left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right)\right)$ is a Nash equilibrium. Then (a) is clearly satisfied. To establish (b), pick a lobby, say j' . Let $\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right)$ be a tax policy that solves the following maximization problem:

$$(1a) \quad \max_{\left(\left(\tau_i\right)_{i=1}^N, t\right)} \left[\gamma_{j'} u_0\left(x_0\left(\left(\tau_i\right)_{i=1}^N, t\right)\right) + \Psi_{j'}\left(\left(\tau_i\right)_{i=1}^N, t\right) + \sum_{j \neq j', j=1}^N \hat{C}_j\left(\left(\tau_i\right)_{i=1}^N, t\right) + \frac{\varepsilon}{1-\varepsilon} W\left(\left(\tau_i\right)_{i=1}^N, t\right) \right]$$

If (b) does not hold for lobby j' , then we have

$$(2a) \quad \gamma_{j'} u_0\left(x_0\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right)\right) + \Psi_{j'}\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) + \sum_{j \neq j', j=1}^N \hat{C}_j\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) + \frac{\varepsilon}{1-\varepsilon} W\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) \\ > \gamma_{j'} u_0\left(x_0\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right)\right) + \Psi_{j'}\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right) + \sum_{j \neq j', j=1}^N \hat{C}_j\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right) + \frac{\varepsilon}{1-\varepsilon} W\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right)$$

Now let $\varepsilon > 0$ be the number that must be added to the right-hand side of the preceding inequality to turn it into an equality, i.e., ε is such that

$$(3a) \quad \gamma_{j'} u_0\left(x_0\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right)\right) + \Psi_{j'}\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) + \sum_{j \neq j', j=1}^N \hat{C}_j\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) + \frac{\varepsilon}{1-\varepsilon} W\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) \\ = \varepsilon + \gamma_{j'} u_0\left(x_0\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right)\right) + \Psi_{j'}\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right) + \sum_{j \neq j', j=1}^N \hat{C}_j\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right) + \frac{\varepsilon}{1-\varepsilon} W\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right)$$

Equation (3a) can be rewritten as follows:

$$(4a) \quad \gamma_{j'} u_0\left(x_0\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right)\right) + \Psi_{j'}\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) - \left[\gamma_{j'} u_0\left(x_0\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right)\right) + \Psi_{j'}\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right) - \hat{C}_{j'}\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right) + \frac{1}{2} \varepsilon \right] \\ = \left[\sum_{j=1}^N \hat{C}_j\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right) + \frac{\varepsilon}{1-\varepsilon} W\left(\left(\hat{\tau}_i\right)_{i=1}^N, \hat{t}\right) \right] \\ - \left[\sum_{j=1}^N \hat{C}_j\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) + \frac{\varepsilon}{1-\varepsilon} W\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) \right] + \hat{C}_{j'}\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) + \frac{1}{2} \varepsilon \\ \geq \hat{C}_{j'}\left(\left(\tilde{\tau}_i\right)_{i=1}^N, \tilde{t}\right) + \frac{1}{2} \varepsilon$$

Suppose that lobby j' adopts the following contingent political contribution schedule

$$(5a) C_{j'}((\tau_i)_{i=1}^N, t) \\ = \max \left[\gamma_{j'} u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_{j'}((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) - \left[\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{1}{2} \varepsilon \right], 0 \right]$$

If the government implements the tax policy $((\tilde{\tau}_i)_{i=1}^N, \tilde{t})$, then using (5a), we can assert that

$$(6a) C_{j'}((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \\ = \gamma_{j'} u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_{j'}((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) - \left[\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{1}{2} \varepsilon \right] > 0$$

The total payoff for the government is then given by

$$(7a) \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{1}{2} \varepsilon$$

Now any tax policy $((\tau_i)_{i=1}^N, t)$ with

$$\gamma_{j'} u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_{j'}((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) - \left[\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{1}{2} \varepsilon \right] \leq 0$$

will elicit no political contribution from lobby j' . Under this scenario, the payoff for the government is given by the left-hand side of the first inequality of the following chain of inequalities.

$$(8a) \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \\ \leq \sum_{j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \\ \leq \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\ < \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{1}{2} \varepsilon$$

In (8a), the first inequality is due to the fact that $\hat{C}_{j'}((\tau_i)_{i=1}^N, t) \geq 0$; the second inequality is due to the fact that $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is the government's best response to $(C_{j'})_{i=1}^N$; the last inequality is evident. Also, according to (7a), the expression on the right-hand side of the last inequality in (8a) is the government's payoff if it implements the tax policy $((\tilde{\tau}_i)_{i=1}^N, \tilde{t})$. Hence a tax policy that elicits zero political contributions from industry lobby

j' is strictly inferior to $((\tilde{\tau}_i)_{i=1}^N, \tilde{t})$; that is, a best response to $(C_{j'}, \hat{C}_{-j'})$ must lobby j' to offer a positive political contribution and will result in the following net payoff for industry lobby j' :

$$\gamma_{j'} u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_{j'}((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) - \left[\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{1}{2} \varepsilon \right] \leq 0$$

which is strictly higher than the net payoff it obtains under the Nash equilibrium $((C_{j'})_{i=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$. The contingent political contribution schedule defined by (5a) is better than $\hat{C}_{j'}$, contradicting the hypothesis that $((C_{j'})_{i=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ is a Nash equilibrium. Part (b) of the proposition is now established.

To prove (c), pick a lobby, say j' . If $\hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) = 0$, then lobby j' satisfies (c) under the tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t})$; there is nothing to prove this case. Let us consider the case $\hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) > 0$. First, define

$$(9a) \quad m_0 = \max_{((\hat{\tau}_i)_{i=1}^N, \hat{t})} \left(\sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \right)$$

Next, define

$$(10a) \quad m_{j'} = \max_{((\hat{\tau}_i)_{i=1}^N, \hat{t})} \left(\gamma_{j'} u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_{j'}((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \right) - m_0$$

It is clear that $m_{j'} \geq 0$. Now use (b), which has just been proved, to rewrite (10a) as follows

$$(11a) \quad m_{j'} = \left(\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) - m_0$$

Because $\sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is the payoff obtained by the government under its best response to $(\hat{C}_{j'})_{i=1}^N$, we must have

$$(12a) \quad \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \geq 0.$$

Using (12a) in (11a), we can assert that

$$(13a) \quad m_{j'} \geq \gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}).$$

Furthermore, we claim that (13a) is actually an equality. Indeed, if it is not true, then we can find a positive number, say $\hat{\varepsilon}$, such that

$$(14a) \quad m_{j'} - \hat{\varepsilon} = \gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}).$$

Now pick ε in the neighborhood of $\hat{\varepsilon}$, then define the following contingent political contribution schedule for industry lobby j' :

$$(15a) \quad C_{j'}((\tau_i)_{i=1}^N, t) = \max(\gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) - (m_{j'} - \varepsilon), 0).$$

Consider a tax policy $((\tau_i)_{i=1}^N, t)$. If

$$\gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) - (m_{j'} - \varepsilon) \leq 0$$

then $C_{j'}((\tau_i)_{i=1}^N, t) = 0$, and the payoff for the government is then given by

$$(16a) \quad \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \leq m_0.$$

On the other hand, if

$$\gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) - (m_{j'} - \varepsilon) > 0,$$

then $C_{j'}((\tau_i)_{i=1}^N, t) = \gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) - (m_{j'} - \varepsilon)$, and the payoff for the government is

$$\begin{aligned} (17a) \quad & \gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) - (m_{j'} - \varepsilon) + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \\ & \leq -(m_{j'} - \varepsilon) \max_{((\tilde{\tau}_i)_{i=1}^N, \tilde{t})} \left(\gamma_{j'} u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_{j'}((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \right) \\ & = m_0 + \varepsilon. \end{aligned}$$

It follows from (16a) and (17a) that a tax policy – chosen in response to $\hat{C}_{-j'}$ and (15a) – that does not induce a positive political contribution from industry lobby j' will not be a best response for the government. Furthermore, a tax policy that induces a positive political contribution from industry lobby j' gives the government exactly the payoff of $(m_0 + \varepsilon)$.

Now in the case we are considering, $\hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) > 0$. It follows directly from (14a) that the following strict inequality holds within ε in the neighborhood of $\hat{\varepsilon}$,

$$(18a) \quad \gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - (m_{j'} - \varepsilon) > 0.$$

If the government implements the tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t})$, then it obtains the following payoff:

$$(19a) \quad \gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) - (m_{j'} - \varepsilon) + \sum_{j \neq j', j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1 - \varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\ = m_0 + \varepsilon$$

Hence the tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is a best response against the contingent political contribution schedule $\hat{C}_{-j'}$ and (15a). This tax policy gives the government the payoff $(m_0 + \varepsilon)$ and the industry lobby j' the payoff $(m_{j'} - \varepsilon)$, which is strictly greater than

$$m_{j'} - \hat{\varepsilon} = \gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}),$$

the payoff it obtains under the Nash equilibrium $((C_{j'})_{i=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$: a contradiction! The claim that (13a) is an equality is now established.

It follows directly from (13a) – as an equality – and (11a) that

$$(20a) \quad m_{j'} = \gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\ + \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1 - \varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) - m_0 \\ = m_{j'} + \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1 - \varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) - m_0$$

It follows directly from (20a) that the payoff for the government under the Nash equilibrium $((C_{j'})_{i=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ is given by

$$(21a) \quad \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1 - \varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) = m_0.$$

Now let $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ be a tax policy that solves the maximization problem in (9a). Then we have

$$\begin{aligned}
(22a) \quad m_0 &= \sum_{j \neq j', j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\
&\leq \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\
&\leq \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) = m_0.
\end{aligned}$$

Hence,

$$(23a) \quad \hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) = 0,$$

and (c) is now proved.

Having proved the necessary part of the proposition, we now prove the sufficiency part. Suppose then that the combination of strategies $((C_{j'})_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ satisfies (a), (b), and (c) of Proposition 1. We shall now prove that it is a Nash equilibrium.

It follows directly from (a) that $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is a best response for the government against $(\hat{C}_j)_{j=1}^N$. We now use reduction ad absurdum to show that for every lobby j' , the contingent political contribution schedule $\hat{C}_{j'}$ is best against $\hat{C}_{-j'}$. Suppose then that there exists a contingent political contribution schedule $C_{j'}$ and a tax policy $((\tau_i)_{i=1}^N, t)$ that is best against $(\hat{C}_{j'}, \hat{C}_{-j'})$ such that

$$\begin{aligned}
(24a) \quad \gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) - C_{j'}((\tau_i)_{i=1}^N, t) \\
> \gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}).
\end{aligned}$$

Using (b), we can write

$$\begin{aligned}
(25a) \quad \gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j \neq j', j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\
\geq \gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t).
\end{aligned}$$

Adding (24a) and (25a), we obtain

$$(26a) \quad \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) > C_{j'}((\tau_i)_{i=1}^N, t) + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t)$$

Now use (c) to find a tax policy, say $((\hat{\tau}_i)_{i=1}^N, \hat{t})$, which is a best response to $(\hat{C}_j)_{j=1}^N$ and under which $\hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) = 0$. Then we have

$$(27a) \sum_{j \neq j', j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) = \sum_{j \neq j', j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) = m_0$$

It follows from (26a) and (27a) that

$$(28a) C_{j'}((\tau_i)_{i=1}^N, t) + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \\ > C_{j'}((\tau_i)_{i=1}^N, t) + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t)$$

The left-hand side of (28a) is the payoff for the government under $((\tau_i)_{i=1}^N, t)$, if this is the tax policy chosen in response to $(\hat{C}_{j'}, \hat{C}_{-j'})$; the right-hand side of (28a) is the payoff under the best response, also to $(\hat{C}_{j'}, \hat{C}_{-j'})$. The strict inequality (28a) asserts that the payoff is higher under $((\tau_i)_{i=1}^N, t)$, than under the best response, which is absurd. The proof of the sufficiency part is now complete.

APPENDIX 4B

PROOF: Because $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is a best response of the government to $(\hat{C}_j)_{j=1}^N$, it must maximize this player's payoff, given $(\hat{C}_j)_{j=1}^N$. The following set of first order conditions must hold for an interior solution:

$$(29a) \quad \frac{\partial \left[\sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right]}{\partial \tau_i} = 0, \quad \text{for } i = 1, \dots, N,$$

$$\frac{\partial \left[\sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right]}{\partial t} = 0.$$

The following set of first-order conditions characterize the tax policy that maximizes the joint payoff of industry lobby j and the government, given the contingent political contribution schedules of the other industry lobbies:

$$(30a) \quad \frac{\partial \left[\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right]}{\partial \tau_i} = 0, \quad \text{for } i = 1, \dots, N,$$

$$\frac{\partial \left[\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right]}{\partial t} = 0.$$

Using (29a) and (30a), we obtain the following set of first-order conditions for each industry lobby $j = 1, \dots, N$,

$$(31a) \quad \frac{\partial [\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t})]}{\partial \tau_i} = 0, \quad \text{for } i = 1, \dots, N,$$

$$\frac{\partial [\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t})]}{\partial t} = 0.$$

The set of first-order conditions (31a) assert that under the Nash equilibrium, the marginal gain in welfare of an industry lobby, due to a small variation – from its equilibrium level – of the corporate tax rate imposed on an industry or due to a small variation – from its equilibrium level – of the personal income tax rate, will be given away completely as political contributions. Summing (31a) over $j = 1, \dots, N$, and using

(29a), we obtain the following set of first-order conditions that characterize the maximization of the global payoff under the Nash equilibrium:

$$(32a) \quad \frac{\partial \left[\sum_{j=1}^N \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right]}{\partial \tau_i} = 0, \quad \text{for } i = 1, \dots, N,$$

$$\frac{\partial \left[\sum_{j=1}^N \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right]}{\partial t} = 0.$$

APPENDIX 4C

PROOF: To show that $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ is a Nash equilibrium, we apply Proposition 1. To this end, we need to establish some preliminary results.

First, pick a lobby j . For the group consisting only of lobby j , we have the following:

$$(33a) \quad \hat{\mu}_j \leq \mu_{\{0,1,\dots,N\}}^{\max} - \mu_{\{0,1,\dots,j-1,j+1,N\}}^{\max} \\ = \left(\sum_{j'=1}^N \left(\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) - \mu_{\{0,1,\dots,j-1,j+1,N\}}^{\max},$$

which can be arranged as follows

$$(34a) \quad \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) \right) - \hat{\mu}_j \\ \geq \mu_{\{0,1,\dots,j-1,j+1,N\}}^{\max} - \left(\sum_{j' \neq j, j'=1}^N \left(\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) \geq 0$$

Using (34a), we can now assert that

$$(35a) \quad \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) = \gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{\mu}_j, \quad j = 1, \dots, N.$$

We shall now use (35a) to show that the tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is best against $(\hat{C}_j)_{j=1}^N$. Indeed if this is not true, then there exists a tax policy $((\tau_i)_{i=1}^N, t)$ such that

$$(36a) \quad \sum_{j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) > \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}).$$

Let J be the group of lobbies that make a positive political contribution under $((\tau_i)_{i=1}^N, t)$. There are two possibilities to consider: $J = \{1, \dots, N\}$ and J is a proper subset of $\{1, \dots, N\}$. Under the former possibility, (36a) takes on the following form:

$$(37a) \quad \sum_{j=1}^N \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) - \hat{\mu}_j \right) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \\ > \sum_{j=1}^N \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{\mu}_j \right) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t})$$

In obtaining (37a), we have used (35a). Clearly (37a) is a contradiction. Under the latter possibility, (36a) takes on the following, simplified, form:

$$\begin{aligned}
(38a) \quad \sum_{j \in J} \hat{\mu}_j &> \sum_{j=1}^N \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right. \\
&\quad \left. - \sum_{j \in J} \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t) + \Psi_j((\tau_i)_{i=1}^N, t)) - \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \right) \right. \\
&\quad \left. \geq \mu_{\{0,1,\dots,N\}}^{\max} - \mu_{\{0\} \cup J}^{\max} .
\end{aligned}$$

The strict inequality between the first expression and the last expression in the chain of inequalities (38a) is a violation. The claim that $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is best against $(\hat{C}_j)_{j=1}^N$ is now proved. Having shown that $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ satisfies (a) of Proposition 1, we next show that it also satisfies (b) of that proposition. Now for any tax policy $((\tau_i)_{i=1}^N, t)$, we have

$$(39a) \quad \hat{C}_j((\tau_i)_{i=1}^N, t) = \gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) - \hat{\mu}_j, \quad j = 1, \dots, N.$$

It follows directly from (35a) and (39a) that for $j' = 1, \dots, N$, we have

$$\begin{aligned}
(40a) \quad &\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) - (\gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t)) \\
&\geq \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_j((\tau_i)_{i=1}^N, t)
\end{aligned}$$

Because $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is a best response for the government against $(\hat{C}_j)_{j=1}^N$, we must have

$$(41a) \quad \sum_{j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \geq \sum_{j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t)$$

Adding (40a) and (41a) and rearranging, we obtain for each $j' = 1, \dots, N$,

$$\begin{aligned}
(42a) \quad &\gamma_{j'} u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_{j'}((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j \neq j', j=1}^N \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\
&\geq \gamma_{j'} u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_{j'}((\tau_i)_{i=1}^N, t) + \sum_{j \neq j', j=1}^N \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t),
\end{aligned}$$

which shows that the combination of strategies $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ also satisfies (b) of Proposition 1.

To prove that $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ also satisfies (c) of Proposition 1, pick a lobby j' . We claim that there is a subset $J \subset \{1, 2, \dots, N\}$, $j' \in J$, such that

$$(43a) \sum_{j \in J} \hat{\mu}_j = \mu_{\{0,1,\dots,N\}}^{\max} - \mu_{\{0\} \cup J}^{\max}.$$

Now let

$$(44a) \xi = \min_{J, J \ni j'} \left(\mu_{\{0,1,\dots,N\}}^{\max} - \mu_{\{0\} \cup J}^{\max} - \sum_{j \in J} \hat{\mu}_j \right)$$

then for $j = 1, \dots, N$, define

$$(45a) \mu_j = \begin{cases} \hat{\mu}_j + \xi & \text{if } j = j' \\ \hat{\mu}_j & \text{if } j \neq j' \end{cases}$$

In this case, the list $(\mu_j)_{j=1}^N$ Pareto dominates $(\hat{\mu}_j)_{j=1}^N$, which is not possible since $(\hat{\mu}_j)_{j=1}^N$ is on the Pareto frontier. Now let J be a group of lobbies such that (42a) holds. We can rewrite (42a) as follows:

$$(46a) \sum_{j \in J} \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) = \sum_{j \in J} \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) - \mu_{\{0,1,\dots,N\}}^{\max} + \mu_{\{0\} \cup J}^{\max} \\ \leq - \left(\sum_{j \in J} \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) - \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) \\ + \left(\sum_{j \in J} \left(\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \right) - \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \right) \\ + \sum_{j \in J} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}).$$

Note that in (46a), we have denoted by $((\tilde{\tau}_i)_{i=1}^N, \tilde{t})$ the tax policy that maximizes the joint payoff of the government and all the lobbies outside J . Also the inequality is obtained by adding $\sum_{j \in J} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t})$, a sum of nonnegative terms, to the right hand side of the fourth equation. If one of these terms is positive, the inequality in (46a) will be strict. In fact, each of these terms is zero, as we not try to show.

Now it follows immediately from the definition of $\hat{C}_j((\tau_i)_{i=1}^N, t)$ that

$$(47a) \sum_{j \in J} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \geq \sum_{j \in J} \left(\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) - \hat{\mu}_j \right) \\ = \sum_{j \in J} \left(\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \right) \\ - \sum_{j \in J} \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right)$$

Rearranging (47a), adding in (46a), and simplifying the result, we obtain the following inequality:

$$(48a) \quad \sum_{j \in J} \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j \in J} \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\ \leq \sum_{j \in J} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) + \sum_{j \in J} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^N, \tilde{t})$$

Observe that the left-hand side of (48a) is the payoff obtained by the government under the tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t})$, a best response to the combination of contingent political contribution schedules $(\hat{C}_j)_{j=1}^N$, while the right-hand side is the payoff it obtains by playing $((\tilde{\tau}_i)_{i=1}^N, \tilde{t})$ against the same combination of contingent political contribution schedules. Hence (48a) must be an equality, which means that $\sum_{j \in J} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) = 0$; that is, $\hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) = 0$ for all j , including j' , in J . Therefore, $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ also satisfies (c) of Proposition 1. We have just shown that the combination of strategies $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ constitutes a Nash equilibrium for the two-sided capital levy problem.

APPENDIX 4D

PROOF: The proof of Proposition 4 is accomplished by carrying out an induction on N , the number of industry lobbies which try to buy influence; it is long and thus broken into several steps.

First of all, we need to set up the needed machinery used in the proof. To this end, let $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ be a truthful Nash equilibrium, the contingent political schedule of industry lobby j , $j = 1, \dots, N$, is given by

$$(49a) \quad \hat{C}_j((\tau_i)_{i=1}^N, t) = \max \left[\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) - \hat{\mu}_j, 0 \right]$$

Also, under the tax policy $((\hat{\tau}_i)_{i=1}^N, \hat{t})$, the political contribution of each lobby is given by

$$(50a) \quad \hat{C}_j((\tau_i)_{i=1}^N, t) = \gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{\mu}_j \geq 0,$$

which yields lobby j a net payoff of $\hat{\mu}_j$.

Next, let J be a subset of $\{1, 2, \dots, N\}$, then consider the J -subgroup component game $\Gamma(\hat{C}_j((\tau_i)_{i=1}^N, t)_{j \in J})$. Let

$$(51a) \quad \nu_0^{\max} = \max_{((\tau_i)_{i=1}^N, t)} \left[\sum_{j \in J} \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1 - \varepsilon} W((\tau_i)_{i=1}^N, t) \right].$$

As defined, $\nu_0^{\max}$ represents the payoff for the government in the J -subgroup component game $\Gamma(\hat{C}_j((\tau_i)_{i=1}^N, t)_{j \in J})$, given that it does not receive any political contributions from the active industry lobbies in this game. Next, for any subset I of J , let

$$(52a) \quad \nu_{\{0\} \cup I}^{\max} = \max_{((\tau_i)_{i=1}^N, t)} \left[\sum_{j \in I} (\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t)) + \sum_{j \in J} \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1 - \varepsilon} W((\tau_i)_{i=1}^N, t) \right]$$

As defined, $\nu_{\{0\} \cup I}^{\max}$ represents the maximum joint payoff – in the J -subgroup component game $\Gamma(\hat{C}_j((\tau_i)_{i=1}^N, t)_{j \in J})$ – for the government and the industry lobbies in I , given that no industry lobby inside J but outside I makes any political contributions. To continue, let $M((\hat{C}_j)_{j \in J})$ as the set of vectors $(\nu_j)_{j \in J}$ that satisfy the following conditions:

$$(53a) \quad \nu_j \geq 0, j \in J,$$

$$(54a) \sum_{j \in J} v_j \leq v_{\{0\} \cup J}^{\max} - v_0^{\max},$$

$$(55a) \sum_{j \in I} v_j \leq v_{\{0\} \cup J}^{\max} - v_{\{0\} \cup (J-I)}^{\max}.$$

In (55a), $(J-I)$ denotes the complement of I in J . We now make several claims. First, we claim that

$$(56a) \left((\hat{\tau}_i)_{i=1}^N, \hat{t} \right) \in \arg \max_{((\tau_i)_{i=1}^N, t)} \left(\sum_{j \in J} \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) \right) + \sum_{j \in J} \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \right)$$

Second, we claim that $(\hat{\mu}_j)_{j \in J}$ belongs to $M((\hat{C}_j)_{j \in J})$. To this end, let I be a subset of J and

$$(57a) \left((\tilde{\tau}_i)_{i=1}^N, \tilde{t} \right) \in \arg \max_{((\tau_i)_{i=1}^N, t)} \left(\sum_{j \in (J-I)} \left(\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) \right) + \sum_{j \in J} \hat{C}_j((\tau_i)_{i=1}^N, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \right)$$

Using (49a) and (50a), we can write

$$(58a) \begin{aligned} & \gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\ &= \hat{\mu}_j \geq \gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) - \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \end{aligned}$$

Furthermore, because $((\hat{\tau}_i)_{i=1}^N, \hat{t})$ is a best response for the government against $((\hat{C}_j)_{j=1}^N)$, the following inequality must hold:

$$(59a) \sum_{j \in J} \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \geq \sum_{j \in J} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^N, \tilde{t}).$$

Summing (58a) over $j \in (J-I)$, then adding the result (59a) and rearranging, we obtain

$$\begin{aligned}
(60a) \quad & \sum_{j \in J} \gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j \in \bar{J}} \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \\
& - \left(\sum_{j \in (J-I)} (\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \sum_{j \in \bar{J}} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \right) \\
& \geq \sum_{j \in I} (\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) - \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t})) \\
& = \sum_{j \in I} \hat{\mu}_j.
\end{aligned}$$

Now using the definition of $\nu_{\{0\} \cup J}^{\max}$, we can assert

$$(61a) \quad \nu_{\{0\} \cup J}^{\max} \geq \sum_{j \in J} \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j \in \bar{J}} \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right)$$

Furthermore, by definition

$$(62a) \quad \nu_{\{0\} \cup (J-I)}^{\max} \geq \sum_{j \in (J-I)} \left(\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) + \sum_{j \in \bar{J}} \hat{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \right)$$

Using (61a), (60a) and (59a), we can write

$$(63a) \quad \sum_{j \in I} \hat{\mu}_j \leq \nu_{\{0\} \cup J}^{\max} - \nu_{\{0\} \cup (J-I)}^{\max}.$$

Inequality (63a) assert that $(\hat{\mu}_j)_{j \in J}$ belongs to $M((\hat{C}_j)_{j \in \bar{J}})$. Third, we claim that $(\hat{\mu}_j)_{j \in J}$ actually belongs to the Pareto frontier of $M((\hat{C}_j)_{j \in \bar{J}})$ such that

$$\begin{aligned}
(64a) \quad & \mu_j \geq \hat{\mu}_j, \text{ for all } j \in J, \\
& \mu_{j_1} \geq \hat{\mu}_{j_1}, \text{ for one } j_1 \in J,
\end{aligned}$$

Applying (b) of Proposition 1, to the Nash equilibrium $((\hat{C}_j)_{j=1}^N, ((\hat{\tau}_i)_{i=1}^N, \hat{t}))$ of the J -subgroup component game $\Gamma((\hat{C}_j)_{j \in \bar{J}})$, we can assert the existence of a tax policy $((\tau_i^1)_{i=1}^N, t^1)$ such that $\hat{C}_{j_1}((\tau_i^1)_{i=1}^N, t^1) = 0$. Next, let

$$(65a) \quad I^1 = \{j \in J \mid \hat{C}_j((\tau_i^1)_{i=1}^N, t^1) = 0\}.$$

Note that both $\hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t})$ and $((\tau_i^1)_{i=1}^N, t^1)$ are best responses against $(\hat{C}_j)_{j \in \bar{J}}$, therefore they must give the government the same payoff. Using (49a) and (50a), we can write

$$(66a) \sum_{j \in I^1} \hat{\mu}_j = \sum_{j \in J} \left(\gamma_j u_0(x_0((\hat{\tau}_i)_{i=1}^N, \hat{t})) + \Psi_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \sum_{j \in J} \hat{C}_j((\hat{\tau}_i)_{i=1}^N, \hat{t}) + \frac{\varepsilon}{1-\varepsilon} W((\hat{\tau}_i)_{i=1}^N, \hat{t}) \right) \\ - \sum_{j \in (J-I^1)} \left(\gamma_j u_0(x_0((\tau_i^1)_{i=1}^N, t^1)) + \Psi_j((\tau_i^1)_{i=1}^N, t^1) + \sum_{j \in J} \hat{C}_j((\tau_i^1)_{i=1}^N, t^1) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i^1)_{i=1}^N, t^1) \right)$$

On the right-hand side of (66a), the expression inside the first pair of brackets, according to the first claim, is equal to $\nu_{\{0\} \cup J}^{\max}$, while the expression inside the second pair of square brackets is less than or equal to $\nu_{\{0\} \cup (J-I^1)}^{\max}$. Hence

$$(67a) \sum_{j \in I^1} \hat{\mu}_j \leq \nu_{\{0\} \cup J}^{\max} - \nu_{\{0\} \cup (J-I^1)}^{\max}.$$

Together, (64a) and (67a) imply that

$$(68a) \sum_{j \in I^1} \mu_j \leq \nu_{\{0\} \cup J}^{\max} - \nu_{\{0\} \cup (J-I^1)}^{\max};$$

that is, $(\mu_j)_{j \in J}$ does not belong to $M((\hat{C}_j)_{j \in J})$: a contradiction. The third claim is now proved. We now have assembled enough machinery to prove Proposition 4. First, let us consider the case $N = 1$, i.e., there is only one industry lobby in the capital levy problem. In this case, we have

$$(69a) \mu_0^{\max} = \max_{(\tau_1, t)} \frac{\varepsilon}{1-\varepsilon} W(\tau_1, t), \\ \mu_{\{0,1\}}^{\max} = \max_{(\tau_1, t)} \left(\gamma_1 u_0(x_0(\tau_1, t)) + \Psi_1(\tau_1, t) + \frac{\varepsilon}{1-\varepsilon} W(\tau_1, t) \right), \\ \hat{\mu}_1 = \mu_{\{0,1\}}^{\max} - \mu_0^{\max}.$$

Furthermore, $M = [0, \hat{\mu}_1]$ and $\hat{M} = \{\hat{\mu}_1\}$. Let $(\hat{C}_1, (\hat{\tau}_1, \hat{t}))$ be a Nash equilibrium for the capital levy problem when $N = 1$. Under such an equilibrium, the only industry lobby will design a contingent political contribution schedule that induces the government to maximize the global payoff but extracts all the surplus that results from the latter's cooperation. That is,

$$(70a) (\hat{\tau}_1, \hat{t}) \in \arg \max_{(\tau_1, t)} \left(\gamma_1 u_0(x_0(\tau_1, t)) + \Psi_1(\tau_1, t) + \frac{\varepsilon}{1-\varepsilon} W(\tau_1, t) \right)$$

The net payoff for the singly lobby is

$$(71a) \hat{\mu}_1 = \mu_{\{0,1\}}^{\max} - \mu_0^{\max}$$

and the equilibrium political contribution is

$$(72a) \hat{C}_1(\hat{\tau}_1, \hat{t}) = \gamma_1 u_0(x_0(\hat{\tau}_1, \hat{t})) + \Psi_1(\hat{\tau}_1, \hat{t}) - \hat{\mu}_1,$$

which gives the government $\mu_0^{\max}$, the exact payoff it obtains by ignoring completely the industry lobby and by choosing the tax policy that maximizes social welfare. For the case $N = 1$, all the Nash equilibria thus give the single industry lobby the payoff $\hat{\mu}_1$, which is the highest that the single lobby can obtain. Thus all the Nash equilibria, in particular the truthful Nash equilibrium $(\hat{C}_1, (\hat{\tau}_1, \hat{t}))$, where

$$(73a) \hat{C}_1(\hat{\tau}_1, \hat{t}) = \max (\gamma_1 u_0(x_0(\tau_1, t)) + \Psi_1(\tau_1, t) - \hat{\mu}_1, 0),$$

are coalition-proof. We have just shown that when $N = 1$, the truthful Nash equilibrium is a coalition-proof Nash equilibria give the single lobby the same net payoff $\hat{\mu}_1$, which is the only element of $\hat{M}$.

We are now ready to start the induction of N . Suppose then that Proposition 4 has been proved for $N \geq 1$ and that for any coalition-proof Nash equilibrium $((\hat{C}_j)_{j=1}^N, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}))$, we have

$$(74a) ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \in \arg \max_{((\tau_i)_{i=1}^N, t)} \left(\sum_{j=1}^N (\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t)) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^N, t) \right).$$

Next, let $((\hat{C}_j)_{j=1}^{N+1}, ((\hat{\tau}_i)_{i=1}^{N+1}, \hat{t}))$ be a truthful Nash equilibrium for the case $N + 1$. We want to show that this truthful equilibrium is coalition-proof. First, we claim that it is self-enforcing. To establish this claim, pick a proper subset J of $\{1, 2, \dots, N, N + 1\}$. Because J has at most N industry lobbies, we can invoke the induction hypothesis to assert that in the J -subgroup component game $\Gamma((\hat{C}_j)_{j \in J})$ the Nash equilibrium $((\hat{C}_j)_{j=1}^{N+1}, ((\hat{\tau}_i)_{i=1}^{N+1}, \hat{t}))$ is self-enforcing.

Next, we show that this truthful Nash equilibrium cannot be Pareto dominated by any other self-enforcing Nash equilibrium. To show this suppose the contrary, i.e., suppose that there exists a self-enforcing Nash equilibrium, say $((\tilde{C}_j)_{j=1}^N, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}))$, for which the following inequalities are true:

$$(75a) \tilde{\mu}_j = \gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) - \tilde{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \geq \hat{\mu}_j \geq 0 \text{ for } j = 1, \dots, N + 1$$

with at least one strict inequality holding. In (75a), $\tilde{\mu}_j, j = 1, \dots, N$, is the net payoff for industry lobby j under the Nash equilibrium $\left((\tilde{C}_j)_{j=1}^N, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t})\right)$. Because the vector of net payoffs under the truthful Nash equilibrium $\left((\hat{C}_j)_{j=1}^{N+1}, ((\hat{\tau}_i)_{i=1}^{N+1}, \hat{t})\right)$ belongs to the Pareto frontier of M , the inequalities in (75a) imply that the vector of net payoffs $(\tilde{\mu}_j)_{j=1}^{N+1}$ is above the Pareto frontier of M , a result, which we now show is not possible.

First note that

$$(76a) \quad \sum_{j=1}^{N+1} \tilde{\mu}_j = \sum_{j=1}^N \left(\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^N, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) - \tilde{C}_j((\tilde{\tau}_i)_{i=1}^N, \tilde{t}) \right) \\ = \sum_{j=1}^N \left[\left(\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right] \\ - \left[\sum_{j=1}^{N+1} \left(\tilde{C}_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right].$$

Observe that on the right-hand side of the second equality in (76a), the expression inside the first pair of brackets is less than or equal to $\mu_{\{0,1,\dots,N+1\}}^{\max}$, while the expression inside the first pair of square brackets gives the payoff of the government under the truthful Nash equilibrium $\left((\hat{C}_j)_{j=1}^{N+1}, ((\hat{\tau}_i)_{i=1}^{N+1}, \hat{t})\right)$. Because the government can always ignore the $(N+1)$ industry lobbies and choose a tax policy that maximizes social welfare, its payoff under its best response to $(\tilde{C}_j)_{j=1}^{N+1}$ must be at least $\mu_0^{\max}$. Hence using (76a), we can assert that

$$(77a) \quad \sum_{j=1}^{N+1} \tilde{\mu}_j \leq \mu_{\{0,1,\dots,N+1\}}^{\max} - \mu_0^{\max}.$$

Next, pick a nonempty subset J of $\{1, \dots, N+1\}$. Then $\bar{J}$, the complement of J in $\{1, \dots, N+1\}$, contains at most N industry lobbies. We have

$$(78a) \quad \sum_{j \in J} \tilde{\mu}_j = \sum_{j=1}^{N+1} \left(\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right) \\ - \left(\sum_{j \in \bar{J}} \left(\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right) \right. \\ \left. + \sum_{j \in \bar{J}} \left(\tilde{C}_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right).$$

Now in the $\bar{J}$ – subgroup component game $\Gamma((\tilde{C}_j)_{j \in \bar{J}})$, the Nash equilibrium $((\tilde{C}_j)_{j \in \bar{J}}, ((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}))$ is coalition-proof because $((\tilde{C}_j)_{j=-1}^{N+1}, ((\tilde{\tau}_i)_{i=1}^N, \tilde{t}))$ is assume to be self-enforcing. Hence using the induction hypothesis (74a), we can assert that

$$(79a) \sum_{j \in \bar{J}} (\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})) + \sum_{j \in J} (\tilde{C}_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})$$

$$= \max_{((\tau_i)_{i=1}^{N+1}, t)} \left(\sum_{j \in \bar{J}} (\gamma_j u_0(x_0((\tau_i)_{i=1}^{N+1}, t)) + \Psi_j((\tau_i)_{i=1}^{N+1}, t)) \right.$$

$$\left. + \sum_{j \in J} \tilde{C}_j((\tau_i)_{i=1}^{N+1}, t) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^{N+1}, t) \right).$$

Observe that the right-hand side of (79a) is greater than or equal to $\mu_{\{0\} \cup \bar{J}}^{\max}$. Also the right-hand side of (78a) is less than or equal to $\mu_{\{0,1,\dots,N+1\}}^{\max} - \mu_{\{0\} \cup \bar{J}}^{\max}$, i.e.,

$$(80a) \sum_{j \in \bar{J}} \tilde{\mu}_j \geq \mu_{\{0,1,\dots,N+1\}}^{\max} - \mu_{\{0\} \cup \bar{J}}^{\max}.$$

It follows from (75a), (77a), and (80a) that the vector of net payoffs $(\tilde{\mu}_j)_{j=1}^{N+1}$ belongs to M . This last result contradicts (75a), which asserts that $(\tilde{\mu}_j)_{j=1}^{N+1}$ is above the Pareto frontier of M . We have just shown that the truthful Nash equilibrium $((\hat{C}_j)_{j=1}^{N+1}, ((\hat{\tau}_i)_{i=1}^{N+1}, \hat{t}))$ is coalition-proof. Half of Proposition 4 is now proved.

To prove the other half of Proposition 4, we shall now show that $(\tilde{\mu}_j)_{j=1}^{N+1}$, the vector of net payoffs associated with a coalition-proof Nash equilibrium, say $((\tilde{C}_j)_{j=-1}^{N+1}, ((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}))$, is on the Pareto frontier of M . Indeed, if this were not true, then we would be able to find a vector of net payoffs, say $(\mu_j)_{j=1}^{N+1}$, on the Pareto frontier of M that Pareto dominates $(\tilde{\mu}_j)_{j=1}^{N+1}$. If we let industry lobby j use the following truthful strategy:

$$(81a) C_j((\tau_i)_{i=1}^N, t) = \max[\gamma_j u_0(x_0((\tau_i)_{i=1}^N, t)) + \Psi_j((\tau_i)_{i=1}^N, t) - \mu_j, 0], j = 1, \dots, N+1,$$

then we will obtain a truthful Nash equilibrium, which is coalition-proof and under which the vector of net payoffs $(\mu_j)_{j=1}^{N+1}$ Pareto dominates the vector of net payoffs under the coalition-proof Nash equilibrium $((\tilde{C}_j)_{j=-1}^{N+1}, ((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}))$, and this is absurd.

Finally, we need to prove that (74a) also holds for $(N+1)$. To this end, let $((\tilde{C}_j)_{j=-1}^{N+1}, ((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}))$ be a coalition-proof Nash equilibrium. $(\tilde{\mu}_j)_{j=1}^{N+1}$ is the vector of net

payoffs for the $(N+1)$ industry lobbies under this Nash equilibrium. We have just shown that $(\tilde{\mu}_j)_{j=1}^{N+1}$ is on the Pareto frontier of M . We shall now show that

$$(82a) \quad ((\tau_i)_{i=1}^{N+1}, \tilde{t}) = \arg \max_{((\tau_i)_{i=1}^{N+1}, t)} \left[\sum_{j=1}^{N+1} (\gamma_j u_0(x_0((\tau_i)_{i=1}^{N+1}, t)) + \Psi_j((\tau_i)_{i=1}^{N+1}, t)) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^{N+1}, t) \right].$$

Suppose that (82a) is not true. Then we can find a tax policy $((\tau_i)_{i=1}^{N+1}, t)$ such that

$$(83a) \quad \sum_{j=1}^{N+1} (\gamma_j u_0(x_0((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})) + \Psi_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \\ < \sum_{j=1}^{N+1} (\gamma_j u_0(x_0((\tau_i)_{i=1}^{N+1}, t)) + \Psi_j((\tau_i)_{i=1}^{N+1}, t)) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^{N+1}, t).$$

Let us rewrite (83a) as follows

$$(84a) \quad \sum_{j=1}^{N+1} \tilde{\mu}_j < \left[\sum_{j=1}^{N+1} (\gamma_j u_0(x_0((\tau_i)_{i=1}^{N+1}, t)) + \Psi_j((\tau_i)_{i=1}^{N+1}, t)) + \frac{\varepsilon}{1-\varepsilon} W((\tau_i)_{i=1}^{N+1}, t) \right] \\ - \left[\sum_{j=1}^{N+1} \tilde{C}_j((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) + \frac{\varepsilon}{1-\varepsilon} W((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right]$$

Now on the right-hand side of (84a), the expression inside the first pair of grand square brackets gives the global payoff – under the tax policy $((\tau_i)_{i=1}^{N+1}, t)$ – for the government and all the industry lobbies; this global payoff is less than or equal to $\mu_{\{0,1,\dots,N+1\}}^{\max}$. As for the expression inside the second pair of grand square brackets, it is the government's payoff under the tax policy $((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t})$, which is a best response to the combination of contingent political contribution schedules $(\tilde{C}_j)_{j=1}^{N+1}$. Because the government can always ignore the lobbies and choose to maximize social welfare, this payoff is at least $\mu_0^{\max}$. It follows from these two observations and (84a) that

$$(85a) \quad \sum_{j=1}^{N+1} \tilde{\mu}_j < \mu_{\{0,1,\dots,N+1\}}^{\max} - \mu_0^{\max}.$$

Finally, let J be a proper subset of $\{1, 2, \dots, N+1\}$, then rewrite (84a) as follows:

$$(86a) \sum_{j \in J} \tilde{\mu}_j < \mu_{\{0,1,\dots,N+1\}}^{\max} - \left[\sum_{j \in J} \left(\gamma_j u_0 \left(x_0 \left((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t} \right) \right) + \Psi_j \left((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t} \right) \right) \right. \\ \left. + \sum_{j \in J} \tilde{C}_j \left((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t} \right) + \frac{\varepsilon}{1-\varepsilon} W \left((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t} \right) \right]$$

Because $\left((\tilde{C}_j)_{j \in J}, ((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t}) \right)$ is a coalition-proof Nash equilibrium in the $\bar{J}$ – subgroup component game $\Gamma \left((\tilde{C}_j)_{j \in J} \right)$, we can invoke the induction hypothesis to assert that

$$(87a) \left((\tilde{\tau}_i)_{i=1}^{N+1}, \tilde{t} \right) = \arg \max_{((\tau_i)_{i=1}^N, t)} \left[\sum_{j \in \bar{J}} \left(\gamma_j u_0 \left(x_0 \left((\tau_i)_{i=1}^{N+1}, t \right) \right) + \Psi_j \left((\tau_i)_{i=1}^{N+1}, t \right) \right) \right. \\ \left. + \sum_{j \in J} \tilde{C}_j \left((\tau_i)_{i=1}^{N+1}, t \right) + \frac{\varepsilon}{1-\varepsilon} W \left((\tau_i)_{i=1}^{N+1}, t \right) \right].$$

Using (87a) and (86a), we obtain

$$(88a) \sum_{j \in J} \tilde{\mu}_j < \mu_{\{0,1,\dots,N+1\}}^{\max} - \mu_{\{0\} \cup \bar{J}}^{\max}.$$

Together (85a) and (88a) imply that for the case $(N+1)$, the vector of net payoffs $(\tilde{\mu}_j)_{j=1}^{N+1}$ does not belong to the Pareto frontier of M . This is absurd because we have already shown that $(\tilde{\mu}_j)_{j=1}^{N+1}$ is on the Pareto frontier M . Hence (82a) must hold. The proof of the second half of Proposition 4 is now complete.

APPENDIX 4E

PROOF: We now conduct the proof of Lemma 5. Although brain drain does not occur when wages are taxed at a low rate, it might take place on a massive scale when wages are heavily taxed, as we now show. To this end, we first establish the following result:

$$(89a) \lim_{t \rightarrow 1} \int_0^{\theta(0,t)} \tilde{\theta} \ell((1-t)\omega(0,t)\tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} = 0.$$

To show (89a), suppose that it is not true. Then we can find a sequence $(t_n)_{n=0}^\infty$, $0 < t_n < 1$, $\lim_{n \rightarrow \infty} t_n = 1$, such that

$$(90a) \lim_{n \rightarrow \infty} \int_0^{\theta(0,t_n)} \tilde{\theta} \ell((1-t_n)\omega(0,t_n)\tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} > 0.$$

Now in order for (90a) to hold we must not have $(1-t_n)\omega(0,t_n)$ converging to zero when $n \rightarrow \infty$; that is, we must have $(1-t_n)\omega(0,t_n)$ bounded below by a positive number when $n \rightarrow \infty$. Furthermore, recall that

$$(91a) L_j(\omega(0,t_n)) = \left[\frac{\bar{p}_j}{\omega(0,t_n)} (1-\alpha_j) A_j \right]^{\frac{1}{\alpha_j}} K_j$$

if the technology used in producing good j , $j = 1, \dots, N$, is of the Cobb-Douglas type, say $F_j(K_j, L_j) = A_j K_j^{\alpha_j} L_j^{1-\alpha_j}$, $0 < \alpha_j < 1$. Thus

$$(92a) \frac{1}{1-t_n} L_j(\omega(0,t_n)) = \left[\frac{\bar{p}_j (1-\alpha_j) A_j}{(1-t_n)\omega(0,t_n)} \right]^{\frac{1}{\alpha_j}} (1-t_n)^{\frac{1}{\alpha_j}-1} K_j.$$

Because $(1-t_n)\omega(0,t_n)$ is bounded below by a positive number, the expression inside the square brackets of (92a) must also be bounded below by a positive number when $n \rightarrow \infty$. Hence

$$(93a) \lim_{n \rightarrow \infty} \frac{1}{1-t_n} L_j(\omega(0,t_n)) = 0, \quad (j = 1, \dots, N).$$

Next, note that under the tax policy $(0, t_n)$ the market-clearing condition for labor takes on the following form

$$(94a) \frac{1}{1-t_n} L_j(\omega(0,t_n)) = \int_0^{\theta(0,t_n)} \tilde{\theta} \ell((1-t_n)\omega(0,t_n)\tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}.$$

When $n \rightarrow \infty$, the expression on the left-hand side of (94a) tends to zero according to (93a), but the integral on the right-hand side of this expression is bounded below by a positive number. This is absurd. Hence, (89a) must hold, as claimed.

APPENDIX 4F

PROOF: In proving Proposition 5, we let $((\tau)^*, t^*)$ be a tax policy that maximizes social welfare. We have

$$\begin{aligned}
 (95a) \quad W((\tau)^*, t^*) &= \left[u_0 \left(F_0(K_0, L_0((\tau)^*, t^*)) \right) \right] \left[H(\theta((\tau)^*, t^*)) - \sum_{j=1}^N \gamma_j \right] \\
 &\quad + \sum_{j=1}^N \bar{p}_j \left(F_0(K_0, L_0((\tau)^*, t^*)) \right) - \int_0^{\theta((\tau)^*, t^*)} \left(\ell((1-t^*)\omega((\tau)^*, t^*)\tilde{\theta}) \right) h(\tilde{\theta}) d\tilde{\theta} \\
 &\leq u_0 \left(F_0(K_0, L_0((\tau)^*, t^*)) \right) + \sum_{j=1}^N \bar{p}_j \left(F_0(K_0, L_0((\tau)^*, t^*)) \right) \\
 &\quad - \int_0^{\theta((\tau)^*, t^*)} u_{N+1} \left(\ell((1-t^*)\omega((\tau)^*, t^*)\tilde{\theta}) \right) h(\tilde{\theta}) d\tilde{\theta}.
 \end{aligned}$$

Where we have denoted by

$$(96a) \quad L_0(\tau, t) = \frac{\tau}{\omega(\tau, t)} \sum_{j=1}^N \Pi_j(\omega(\tau, t)) + t \int_0^{\theta(\tau, t)} \tilde{\theta} \ell((1-t)\omega(\tau, t)\tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}$$

the equilibrium level of effective labor input in the public sector under the tax policy (τ, t) .

Next, let $\bar{\omega}$ be the value of ω that solves the following equation

$$\int_0^{\infty} \tilde{\theta} \ell(\bar{\omega} \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} = \int_0^{\theta((\tau)^*, t^*)} \tilde{\theta} \ell((1-t^*)\omega((\tau)^*, t^*)\tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta}.$$

As defined, $\bar{\omega}$ is the wage rate that must prevail to elicit the same aggregate supply of effective labor as the tax policy $((\tau)^*, t^*)$, given that wages are not taxed and that emigration is forbidden. We claim that

$$(97a) \quad \int_0^{\infty} u_{N+1}(\ell(\bar{\omega} \tilde{\theta})) h(\tilde{\theta}) d\tilde{\theta} \leq \int_0^{\theta((\tau)^*, t^*)} u_{N+1}(\ell((1-t^*)\omega((\tau)^*, t^*)\tilde{\theta})) h(\tilde{\theta}) d\tilde{\theta}.$$

To establish the claim, let $\omega(\theta)$, $\theta \geq \theta((\tau)^*, t^*)$, be the wage rate that satisfies the following condition:

$$(98a) \int_0^\theta \ell(\omega(\theta)\tilde{\theta})h(\tilde{\theta})d\tilde{\theta} \leq \int_0^{\theta(\tau^*, t^*)} \tilde{\theta}(\ell((1-t^*)\omega(\tau^*, t^*)\tilde{\theta})h(\tilde{\theta}))d\tilde{\theta},$$

and for all $\theta \geq \theta(\tau^*, t^*)$, let

$$(99a) \beta(\theta) = \int_0^\theta u_{N+1}(\ell(\omega(\theta)\tilde{\theta}))h(\tilde{\theta})d\tilde{\theta}.$$

Differentiating the expression on the left-hand side of (98a), with respect to θ , we obtain

$$(100a) \theta \ell(\omega(\theta)\tilde{\theta})h(\tilde{\theta}) + \int_0^\theta \tilde{\theta}^2 \ell'(\omega(\theta)\tilde{\theta})\omega'(\theta)h(\tilde{\theta})d\tilde{\theta} = 0.$$

Differentiating (99a) with respect to θ , we find that $\beta'(\theta) \leq 0$, where the right-hand side is obtained from (100a). Hence, $\beta(\theta)$, $\theta \geq \theta(\tau^*, t^*)$, is non-increasing. Furthermore, when $\theta = \theta(\tau^*, t^*)$, we have $\omega(\theta(\tau^*, t^*)) = (1-t^*)\omega(\tau^*, t^*)$, which, in turn, implies

$$\beta(\theta(\tau^*, t^*)) = \int_0^{\theta(\tau^*, t^*)} u_{N+1}(\ell((1-t^*)\omega(\tau^*, t^*)\tilde{\theta}))h(\tilde{\theta})d\tilde{\theta}.$$

Hence the claim is proved. According to Lemma 3, when $\tau < 1$, we have

$$(101a) u'_0 \left(F_0 \left(K_0, L_0 \left(\tau, 0 \right) \right) \right) \frac{\partial F_0}{\partial L_0} \left(K_0, L_0 \left(\tau, 0 \right) \right) - \omega \left(\tau, 0 \right) = 0$$

Furthermore, according to profit maximization,

$$(102a) \bar{p}_j \frac{\partial F_j}{\partial L_j} \left(K_j, L_j \left(\omega \left(\tau, 0 \right) \right) \right) - \omega \left(\tau, 0 \right) = 0 \quad (j = 1, \dots, N).$$

Also,

$$(103a) L_0 \left(\tau, 0 \right) + \sum_{j=1}^N L_j \left(\omega \left(\tau, 0 \right) \right) = \int_0^\infty \tilde{\theta} \ell \left(\omega \left(\tau, 0 \right) \tilde{\theta} \right) h(\tilde{\theta}) d\tilde{\theta}$$

is the form assumed by the market-clearing condition for labor under the tax policy $\left(\tau, 0 \right)$. Hence $L_0 \left(\tau, 0 \right), L_1 \left(\tau, 0 \right), \dots, L_N \left(\tau, 0 \right)$, and $\lambda = \omega \left(\tau, 0 \right)$ constitute the solution of

the maximization problem for the case where $\omega = \omega(\dot{\tau}, 0)$. If we let ω^1 be the wage rate at which $\lambda(\omega)$ crosses the forty-five degree line, then because $\lambda\left(\omega(\dot{\tau}, 0)\right) = \omega(\dot{\tau}, 0)$, we must have $\omega(\dot{\tau}, 0) = \omega^1$. We have just shown that when $\dot{\tau} < 1$, the socially optimal tax to policy dictates that wages should not be taxed, but capital should be taxed at rate $\dot{\tau}$.

Let us next consider the scenario $\dot{\tau} = 1$. This scenario occurs when

$$(104a) \quad u'_0(F_0(K_0, L_0(1,0))) \frac{\partial F_0}{\partial L_0}(K_0, L_0(1,0)) - \omega(1,0) \geq 0$$

If inequality holds in (104a), then the argument just presented for the case $\dot{\tau} < 1$ can be repeated verbatim obtain the same conclusion: capital should be taxed at rate $\dot{\tau} = 1$, but wages should not be taxed.

We now claim that if (104a) is a strict inequality, then the optimal tax rate on wages is positive. Indeed, if it is not optimal to tax wages, then capital will be taxed at rate $\dot{\tau}$ and the optimal social welfare will be given by $W(\dot{\tau}, 0) = W(1, 0)$. However, when (104a) is a strict inequality, we must have $\frac{\partial W}{\partial t}(1, 0) > 0$, i.e., social welfare can be raised by also taxing wages after having taxed away all profits.

APPENDIX 4G

PROOF: If $\dot{\tau} = 1$, then obviously $\dot{\tau} \geq \tau^1$, as claimed by the proposition. We now show that if $\dot{\tau} < 1$, then $\dot{\tau} > \tau^1$. To this end, suppose that the home government chooses to tax only capital and at rate $\tau > 0$. Recall that in the discussion leading to the statement of Lemma 3, we have shown that $\omega(\tau, 0) > \bar{\omega}$ and that both the equilibrium wage rate $\omega(\tau, 0)$ and the equilibrium level of the public good $x_0(\tau, 0)$ provided rise with τ . That is, as τ rises the tax policy induces no brain drain and raises the welfare of the workers as a group. The social welfare obtained under this tax policy is given by

$$(105a) \quad W(\tau, 0) = \sum_{j=1}^N [\gamma_j u_0(x_0(\tau, 0)) + \Psi(\tau, 0)] + (u_0(x_0(\tau, 0))) u_0(x_0(\tau, 0)) \left[1 - \sum_{j=1}^N \gamma_j \right] + \Phi(\tau, 0).$$

Differentiating (105a) with respect to τ , we obtain

$$(106a) \quad \frac{\partial W(\tau, 0)}{\partial \tau} = \frac{\partial}{\partial \tau} \left(\sum_{j=1}^N [\gamma_j u_0(x_0(\tau, 0)) + \Psi(\tau, 0)] \right) + \frac{\partial}{\partial \tau} \left((u_0(x_0(\tau, 0))) u_0(x_0(\tau, 0)) \left[1 - \sum_{j=1}^N \gamma_j \right] + \Phi(\tau, 0) \right).$$

In the discussion leading to Lemma 3, we have shown that if $\dot{\tau} < 1$, then $\frac{\partial W(\tau, 0)}{\partial \tau} < 0$ for all $\dot{\tau} \leq \tau \leq 1$. Using this result and the fact that

$$\frac{\partial}{\partial \tau} \left((u_0(x_0(\tau, 0))) u_0(x_0(\tau, 0)) \left[1 - \sum_{j=1}^N \gamma_j \right] + \Phi(\tau, 0) \right) > 0$$

we can assert that if $\tau \geq \dot{\tau}$, then

$$(107a) \quad \frac{\partial}{\partial \tau} \left(\sum_{j=1}^N [\gamma_j u_0(x_0(\tau, 0)) + \Psi(\tau, 0)] \right) < 0.$$

Now the joint payoff for the home government and the N industry lobbies under the tax policy $(\tau, 0)$ is given by

$$(108a) \quad \Gamma(\tau, 0) = \sum_{j=1}^N [\gamma_j u_0(x_0(\tau, 0)) + \Psi(\tau, 0)] + \frac{\varepsilon}{1 - \varepsilon} W(\tau, 0).$$

For any $\tau \geq \tau^*$, we have

$$(109a) \quad \frac{\partial \Gamma(\tau, 0)}{\partial \tau} = \frac{\partial}{\partial \tau} \left(\sum_{j=1}^N [\gamma_j u_0(x_0(\tau, 0)) + \Psi(\tau, 0)] \right) + \frac{\varepsilon}{1-\varepsilon} \frac{\partial W(\tau, 0)}{\partial \tau} < 0,$$

which has been obtained with the help of (107a) and the fact that $\frac{\partial W(\tau, 0)}{\partial \tau} < 0$ when

$\tau^* \leq \tau \leq 1$. We have just shown that the joint payoff for the home government, given that only capital is taxed, is strictly decreasing in the interval $\tau^* \leq \tau \leq 1$. Hence, when $\tau^* < 1$, the value of τ , namely τ^1 , that solves the maximization problem in Proposition 6 must be strictly less than τ^* . Proposition 6 is now proved.

APPENDIX 4H

PROOF: There are two cases to consider in the proof of Proposition 7: $\dot{\tau} < 1$ and $\dot{\tau} = 1$.

When $\dot{\tau} < 1$, we have $\tau^1 < \dot{\tau}$ according to Proposition 6. Because $\tau^1 < \dot{\tau}$, we must have

$$(110a) \quad u'_0(F_0(K_0, L_0(\tau^1, 0))) \frac{\partial F_0}{\partial L_0}(K_0, L_0(\tau^1, 0)) - \omega(\tau^1, 0) > 0,$$

according to Lemma 3. According to Lemma 7, (110a) also implies that $\frac{\partial W}{\partial t}(\tau^1, 0) > 0$.

We claim that

$$(111a) \quad \sum_{j=1}^N \left[\gamma_j u'_0(x_0(\tau^1, 0)) \frac{\partial x_0}{\partial t}(\tau^1, 0) - (1 - \tau^1) L_j(\omega(\tau^1, 0)) \frac{\partial \omega}{\partial t}(\tau^1, 0) \right] > 0,$$

Indeed, if this is not the case, then according to Assumption 4, we must have

$$(112a) \quad \left[u'_0(x_0(\tau^1, 0)) \frac{\partial x_0}{\partial t}(\tau^1, 0) \right] \left[1 - \sum_{j=1}^N \gamma_j \right] + \frac{\partial \omega}{\partial t}(\tau^1, 0) \int_0^{\infty} \tilde{\theta} \ell(\omega(\tau^1, 0) \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} \\ - \omega(\tau^1, 0) \int_0^{\infty} \tilde{\theta} \ell(\omega(\tau^1, 0) \tilde{\theta}) h(\tilde{\theta}) d\tilde{\theta} < 0$$

Because the sum of the expression on the left-hand side of (111a) and the expression on the right hand side of (112a) is equal to $\frac{\partial W}{\partial t}(\tau^1, 0)$, we will be led to the conclusion that

$\frac{\partial W}{\partial t}(\tau^1, 0) < 0$ if (111a) does not hold, a conclusion that is opposite to the result $\frac{\partial W}{\partial t}(\tau^1, 0) > 0$, already established.

Using (111a) and the result $\frac{\partial W}{\partial t}(\tau^1, 0) > 0$, we obtain

$$(113a) \quad \frac{\partial \Gamma}{\partial t}(\tau^1, 0) = \sum_{j=1}^N \left[\gamma_j u'_0(x_0(\tau^1, 0)) \frac{\partial x_0}{\partial t}(\tau^1, 0) - (1 - \tau^1) L_j(\omega(\tau^1, 0)) \frac{\partial \omega}{\partial t}(\tau^1, 0) \right] \\ + \frac{\varepsilon}{1 - \varepsilon} \frac{\partial W}{\partial t}(\tau^1, 0) > 0.$$

It follows directly from (113a) that $\Gamma(\tau^1, t) > \Gamma(\tau^1, 0)$, i.e., taxing capital at rate τ^1 and wages at a low rate $t > 0$ will yield a higher joint payoff for the home government and

the N industry lobbies than taxing only capital. Thus when the industry lobbies are active, their lobbying activities will induce the home government to tax wages at a positive rate.

Having considered the case $\dot{\tau} < 1$, we next consider the case $\dot{\tau} = 1$. The case $\dot{\tau} = 1$ arises when (109a), of Appendix G, holds. If (109a) holds with equality, then $\tau^1 < \dot{\tau}$ and the preceding argument can be repeated verbatim to show that the tax rate on wages is positive. If (109a) holds with strict inequality, then $\frac{\partial W}{\partial t}(1,0) > 0$ by Lemma 7. The preceding argument can be repeated verbatim with τ^1 replaced by 1 to show that $\frac{\partial \Gamma}{\partial t}(1,0) > 0$, i.e., $\frac{\partial \Gamma}{\partial t}(1,t) > \frac{\partial \Gamma}{\partial t}(1,0)$ for small values of t . The tax rate on wages is thus also positive in this case. The proof of Proposition 7 is now complete.

REFERENCES

- ACEMOGLU, DARON J. AND JOSHUA ANGRIST (2001) "How Large are Human Capital Externalities? Evidence from Compulsory Schooling Laws," *NBER Macroeconomics Annual* 2000, 15, pp. 9-59.
- APPLEBY, JOHN AND MANON ROULEAU (2000) "Distribution by Rate of Return by Field of Study and Level of Education in Canada," *Human Resources Development Canada*, Ottawa.
- ASHENFELTER, O. AND A. KRUEGER (1994) "Estimates of the Economic Return to Schooling From a New Sample of Twins," *American Economics Review*, 84, pp. 1157-73.
- BAR-OR, YUVAL, JOHN BURBIDGE, LONNIE MAGEE AND A. LESLIE ROBB (1995) "The Wage Premium to a University Education in Canada, 1971-1991," *Journal of Labor Economics*, 13(4), pp. 762-94.
- BARRO, ROBERT J. AND XAVIER SALA-I-MARTIN (1995) "Economic Growth," New York; McGraw-Hill Inc.
- BEAUDRY, PAUL AND DAVID A. GREEN (2001) "Canada-U.S. Integration and Labour Market Outcomes: A Perspective within the General Context of Globalization," North American Linkages: Opportunities and Challenges for Canada, Industry Canada, Working Paper, 2001.
- BECKER, GARY (1964) "Human Capital." (1st ed.) *National Bureau of Economic Research*. New York: Columbia University Press.
- BERNHEIM, B. DOUGLAS AND MICHAEL D. WHINSTON (1986) "Menu Auctions, Resource Allocation, and Economic Influence," *Quarterly Journal of Economics*, 101, pp. 1-31.
- BOADWAY, ROBIN, NEIL BRUCE AND JACK MINTZ (1984) "Taxation, Inflation and the Effective Marginal Tax Rate on Capital in Canada," *Canadian Journal of Economics*, 17, pp. 62-79.
- BOSKIN, M.J. (1975) "Notes on the Tax Treatment of Human Capital," in *Conference on Tax Research*, Office of Tax Analysis, Department of the Treasury, Washington, D.C.
- BOVENBERG, A. LANS AND BAS JACOBS (2001) "Redistribution and Education Subsidies are Siamese Twins," CentER Discussion Paper 2001-82, Tilburg University.
- BURBIDGE, JOHN AND JAMES DAVIES (1994) "Household Data on Saving Behavior in Canada" in *International Comparisons of Household Saving*, ed. James Poterba, Chicago: University of Chicago Press for the NBER, pp. 11-56.

BURBIDGE, JOHN, LONNIE MAGEE AND LESLIE ROBB (1988) "Alternative Transformations to Handle Extreme Values of the Dependent Variable," *Journal of the American Statistical Association*, 83, pp. 123-27.

CAMERON, STEPHEN AND JAMES HECKMAN (1998) "Life Cycle Schooling and Dynamic Selection Bias: Models and Evidence for Five Cohorts of American Males," *Journal of Political Economy*, 106(2), pp.262-333.

CAMERON, STEPHEN AND CHRISTOPHER TABER (2000) "Borrowing Constraints and the Returns to Schooling," NBER Working Paper 7761.

CANADIAN TAX FOUNDATION (1999), *Finances of the Nation 1998*, Toronto.

CANADIAN TAX FOUNDATION (2000, *Finances of the Nation 2000*, Toronto.

CARD, D. (1995) "Using Geographic Variation in College Proximity to Estimate the Return to Schooling," in *Aspects of Labour Market Behaviour: Essays in Honour of John Vanderkamp*, eds. L. Christofides, E.K. Grant, and R. Swidinsky. Toronto: University of Toronto Press.

CD HOWE INSTITUTE (2002) *Renovating the Ivory Tower: Canadian Universities and the Knowledge Economy*, ed. David Laidler, Toronto.

CHAMLEY, CHRISTOPHE (1986) "Optimal Taxation of Capital Income in General Equilibrium With Infinite Lives," *Econometrica* 54 (3), pp. 607-622.

COLLINS, KIRK A. AND JAMES B. DAVIES (2001) "Tax Treatment of Human Capital in Canada and the United States: An Overview and Examination of the Case of University Graduates," manuscript, September.

_____ (2002) "Measuring Effective Tax Rates on Human Capital: The Canadian Case," The University of Western Ontario, Economic Policy Research Institute, Working Paper #2002-05.

_____ (2002) "Taxing Investments in Higher Education," University of Western Ontario, mimeo.

DAVIES, JAMES B. AND JOHN WHALLEY (1991) "Taxes and Capital Formation: How Important is Human Capital?" in *National Saving and Economic Performance* edited by D.Bernheim and J.Shoven, Chicago, University of Chicago Press, pp.169-197.

DAVIES, JAMES B. AND FRANCE ST-HILAIRE (1987) *Reforming Capital Income Taxation in Canada: Efficiency and Distributional Effects of Alternative Options*, Economic Council of Canada.

DAVIES, JAMES B. AND GRAHAM GLENDAY (1990) "Accrual Equivalent Marginal Tax Rates for Personal Financial Assets," *Canadian Journal of Economics* 23, pp. 189-209.

DAVIES, JAMES B. (2002) "Empirical Evidence on Human Capital Externalities," University of Western Ontario, mimeo.

DAVIES, JAMES B., JIE ZHANG AND JINLI ZENG (2002) "Optimal Fiscal Policy in a Two-Sector Growth Model With Transitional Dynamics," University of Western Ontario, mimeo.

DEPARTMENT OF FINANCE (1997), *Report of the Technical Committee on Business Taxation*, Ottawa, December.

DEPARTMENT OF FINANCE (1998) *The Canadian Opportunities Strategy*, Ottawa, February budget paper.

DUPOR, BILL, LANCE LOCHNER, CHRISTOPHER TABER AND MARY BETH WITTEKIND (1996) "Some Effects of Taxes on Schooling and Training," *American Economic Review* 86, pp. 340-46.

FINNIE, ROSS (2001) "Measuring the Load, Easing the Burden: Canada's Student Loan Programs and the Revitalization of Canadian Postsecondary Education," C.D. Howe Commentary 155, November.

FINNIE, ROSS AND SAUL SCHWARTZ (1996) *Student Loans in Canada*, C.D. Howe Institute, Toronto.

HARDING, ANN (1995) "Financing Higher Education: An Assessment of Income-Contingent Loan Options and Repayment Patterns over the Life Cycle," *Education Economics*, Vol. 3(2), pp. 173-203.

HECKMAN JAMES J. AND PETER J. KLENOW (1997) "Human Capital Policy," University of Chicago, forthcoming in M. Boskin (ed.), *Understanding Economic Growth*, Hoover Institution Press, Stanford.

HECKMAN, JAMES J., LANCE LOCHNER AND CHRISTOPHER TABER (1999) "General Equilibrium Cost-Benefit Analysis of Education and Tax Policies," in Gustav Ranis and Lakshmi K. Raut (eds.), *Trade, growth and development: Essays in honor of Prof. T.N. Srinivasan*, Contributions to Economic Analysis, Vol. 242. Amsterdam; New York and Oxford: Elsevier Science, North-Holland, pp. 291-349.

HELLIWELL, JOHN (2000) "Globalization: Myths, Facts, and Consequences," C.D. Howe Institute, Benefactor's Lecture, October, pp.64.

JONES, LARRY E., RODOLFO E. MANUELLI, AND PETER E. ROSSI (1997) "On the Optimal Taxation of Capital Income," *Journal of Economic Theory* 73, pp. 93-117.

JONES, LARRY E., RODOLFO E. MANUELLI AND PETER E. ROSSI (1993) "Optimal Taxation in Models of Endogenous Technological Change," *Journal of Political Economy* 101 (3), pp. 485-517.

JUDD, KENNETH L. (1985) "Redistributive Taxation in a Simple Perfect Foresight Model," *Journal of Public Economics* 28, pp. 59-83.

KAPLOW, LOUIS (1996) "On the Divergence Between 'Ideal' and Conventional Income-Tax Treatment of Human Capital," *American Economic Review* 86, pp. 347-52.

KESSELMAN, JONATHAN AND FINN POSCHMANN (2001) "A New Option for Retirement Saving - Tax-Prepaid Savings Plans," C.D.Howe Institute, Toronto, Commentary No. 149.

KING, M.A. AND D. FULLERTON (1984) *The Taxation of Income From Capital: A Comparative Study of the United States, United Kingdom, Sweden and West Germany*, Chicago: University of Chicago Press.

LAROCHE, MIREILLE AND MARCEL MERETTE (1999) "On the Concept and Dimensions of Human Capital in a Knowledge-Based Economy Context," *Canadian Public Policy* XXV (1), pp. 87-100.

LUCAS, ROBERT E. (1988) "On the Mechanics of Economic Development," *Journal of Monetary Economics* 22(1), pp. 3-42.

MAGEE, LONNIE, JOHN BURBIDGE AND LESLIE ROBB (1991) "Computing Kernel-smoothed Quantiles From Many Observations", *Journal of the American Statistical Association*, 86, pp. 673-77.

MARCEAU, NICOLAS AND MICHAEL SMART (2003) "Corporate Lobbying and Commitment Failure in Capital Taxation," *American Economic Review*, 93(1), pp.241-51.

MCKENZIE, KENNETH J., MARIO MANSOUR AND ARIANE BRULE (1998) "The Calculation of Marginal Effective Tax Rates," Working Paper 97-15, Technical Committee on Business Taxation, Department of Finance, Ottawa.

MERETTE, MARCEL (1997) "Income Taxes, Life-Cycles and Growth," Working Paper No. 97-06, Department of Finance, Ottawa.

MILLIGAN, KEVIN (2002) "Tax Preferences for Education Savings: Are RESPs effective?" *Commentary* 174, CD Howe Institute, November.

MINTZ, JACK M. (2001) *Most Favored Nation: Building a Framework for Smart Economic Policy*, C.D. Howe Institute, Toronto, Policy Studies 36.

MORISSETTE, RENE (1998) "The Declining Labour Market Status of Young Men," in Statistics Canada, *Labour Markets, Social Institutions, and the Future of Canada's Children*, Publication No. 89-553-XPB, Ottawa, Chapter 3, pp. 31-50.

MURPHY, KEVIN, W. CRAIG RIDDELL AND PAUL ROMER (1998) "Wages, Skills and Technologies in the United States and Canada," in Elhanan Helpman (ed.), *General Purpose Technologies and Economic Growth*, Cambridge, Mass.: MIT Press, pp. 283-309.

NIELSEN, SOREN B. AND PETER B. SORENSEN (1997) "On the Optimality of the Nordic System of Dual Income Taxation," *Journal of Public Economics*, 63, pp. 311-329.

PECORINO, PAUL (1993) "Tax Structure and Growth in a Model with Human Capital," *Journal of Public Economics*, 52, pp. 251-271.

PERRONI, CARLO (1995) "Assessing the Dynamic Efficiency Gains of Tax Reform When Human Capital is Endogenous," *International Economic Review*, 36, pp. 907-925.

PODDAR, SATYA AND MORLEY D. ENGLISH (1999) "Canadian Taxation of Personal Investment Income," *Canadian Tax Journal*, 47 (5), pp. 1270-1304.

PRYOR, FREDERIC L. AND DAVID SCHAFFER (1997) "Wages and the University Educated: A Paradox Resolved," *Monthly Labor Review*, 120 (7), pp. 3-14.

ROMER, PAUL M. (1986) "Increasing Returns and Long Run Growth," *Journal of Political Economy*, 94 (5), pp. 1002-1037.

ROWLEY, ROBIN (1993) "Income Contingency and the Repayment of Student Loans," *Journal of Income Distribution*, Vol. 3 (2), pp. 263-99.

SCHULTZ, THEODORE W. (1962) "Reflections on Investment in Man," *Journal of Political Economy* LXX (No. 5, Part 2), Supplement: October, pp. 1-8.

SHEA, JOHN (2000) "Does Parents' Money Matter?" *Journal of Public Economics*, 77, pp. 155-184.

STAGER, A.A. DAVID (1994) "Returns to Investment in Ontario University Education, 1960-1990, and Implications for Tuition Fee Policy," *Council of Ontario Universities*, December.

VAILLANCOURT, FRANCOIS (1997) "The Private and Total Returns to Education in Canada, 1990: A Note," Centre de recherche et developpement en economique, Universite de Montreal, September (mimeo).

VAILLANCOURT, FRANCOIS (1995) "The Private and Total Returns to Education in Canada, 1985," *Canadian Journal of Economics*, 28(3), pages 532-54.

VALLAINCOURT, FRANCOIS AND SANDRINE BOURDEAU-PRIMEAU (2002) "The Returns to University Education in Canada, 1990 and 1995," *Renovating the Ivory Tower: Canadian Universities and the Knowledge Economy*, ed. David Laidler, CD Howe Institute, pp. 215-240.

TABLES

Table 1.1

**Rates of Return and Effective Tax Rates for First University Degree Graduates:
1998 Tax System, No Student Loans, No Dependants (Base Case)**

	IRR (%) Net-of-Tax (1)	IRR (%) Gross-of-Tax (2)	ETR [(2) - (1)] / (2)
Males			
Full-Time	7.94	9.84	0.193
Part-Time	7.06	9.00	0.215
Females			
Full-Time	12.63	14.34	0.119
Part-Time	11.52	13.29	0.133

Notes: IRR = internal rate of return
ETR = effective tax rate

Source: Authors' calculations using 1995 Statistics Canada Survey of Consumer Finance data.

Table 1.2

Base Case Rates of Return, Effective Subsidy Rates, and Tax Minus Subsidy Rate

	IRR (%) Public (1)	IRR (%) Gross-of-Tax Private (2)	ESR [(2) - (1)]/(2)	ETR - ESR
Males				
Full-Time	7.37	9.84	0.251	-0.058
Part-Time	6.86	9.00	0.238	-0.023
Females				
Full-Time	10.39	14.34	0.276	-0.157
Part-Time	9.85	13.29	0.259	-0.126

Notes: Definition of base case is as in Table 1.1.
ESR = effective subsidy rate
ETR, IRR – see Table 1.1.

Source: See Table 1.1.

Table 1.3

**Rates of Return and Effective Tax Rates for Full-Time Students, 1998 Tax System
With Student Loans**

Sex and Dependants	Value of Loan (\$)	IRR (%) Net-of-Tax (1)	IRR (%) Gross-of-Tax (2)	ETR [(2) - (1)] / (2)	ESR*	ETR - ESR
Male, No Dependants	0 (base case)	7.94	9.84	0.193	0.251	-0.058
	5000	8.15	10.03	0.187	0.265	-0.078
	10000	8.39	10.24	0.180	0.280	-0.100
	15000	8.66	10.46	0.172	0.296	-0.124
	30000	10.31	11.77	0.124	0.374	-0.250
Female, No Dependants	0	12.63	14.34	0.119	0.276	-0.157
	5000	13.20	14.83	0.110	0.299	-0.189
	10000	13.88	15.38	0.098	0.324	-0.226
	15000	14.70	16.03	0.083	0.352	-0.269
	30000	20.49	19.81	-0.034	0.475	-0.509
Female, Single Parent With one child	0	11.59	14.34	0.192	0.276	-0.084
	5000	12.04	14.83	0.188	0.299	-0.111
	10000	12.56	15.38	0.184	0.324	-0.140
	15000	13.16	16.03	0.179	0.352	-0.173
	30000	16.99	19.81	0.142	0.475	-0.333

Notes: 1) The zero loan case without dependants is the same as the base case considered in Tables 1 and 2.

2) The female single parent is assumed to have had a child at age 18. This child will generate a child care expense deduction until the parent is aged 25. Canada Study Grants, which were offered starting in 1999, are not included.

3) For the \$30,000 loan, \$2,000 of the principal qualifies for loan forgiveness. See Appendix 1B.

4) * ESR = [(2) - (appropriate entry from col. 1 of Table 1.2)]/(2)

Source: See Table 1.1.

Table 1.4

Rates of Return and Effective Tax Rates for Part-Time Students, 1998 Tax System

With Student Loans

Sex and Dependants	Value of Loan (\$)	IRR (%) Net-of-Tax (1)	IRR (%) Gross-of-Tax (2)	ETR [(2) - (1)] / (2)	ESR*	ETR - ESR
Male, No Dependants	0	7.06	9.00	0.215	0.238	-0.023
	5000	7.02	8.98	0.218	0.236	-0.018
	10000	6.97	8.95	0.221	0.233	-0.012
	15000	6.92	8.92	0.224	0.231	-0.007
Female, No Dependants	0	11.52	13.29	0.133	0.259	-0.126
	5000	11.58	13.35	0.133	0.262	-0.129
	10000	11.63	13.42	0.133	0.266	-0.133
	15000	11.70	13.49	0.133	0.270	-0.137
Female, Single Parent With one child	0	11.17	13.29	0.159	0.259	-0.100
	5000	11.21	13.35	0.160	0.262	-0.102
	10000	11.25	13.42	0.161	0.266	-0.105
	15000	11.30	13.49	0.162	0.270	-0.108

Notes: 1) The zero loan case without dependants is the same as the base case considered in Tables 1 and 2.

2) The female single parent is assumed to have had a child at age 18. This child will generate a child care expense deduction until the parent is aged 25. The amount claimed during study is subject to the restrictions imposed in the 1998 federal budget. (See Appendix 1B.) Canada Study Grants, which will be offered starting in 1999, are not included.

3) * ESR = [(2) - Appropriate entry from col. 1 of Table 1.2]/(2)

Source: See Table 1.1.

Table 1.5

**Rates of Return and Effective Tax Rates for Full-Time Students, 1998 Tax System
With \$10,000 Student Loan and Interest Relief**

Sex and Dependants	Interest Relief (months)	IRR (%) Net-of-Tax (1)	IRR (%) Gross-of-Tax (2)	ETR [(2) - (1)] / (2)
Male, No Dependants	0	6.54	7.45	0.122
	18	6.66	7.55	0.118
	30	6.72	7.60	0.116
Female, No Dependants	0	10.86	11.37	0.045
	18	11.04	11.51	0.041
	30	11.14	11.59	0.039
Female, Single Parent With one child	0	10.06	11.37	0.115
	18	10.18	11.51	0.116
	30	10.24	11.59	0.116

Notes: 1) Assumptions on the female single parent are as in Table 1.3.
2) Earnings equal 2/3 of median.

Source: See Table 1.1.

Table 1.6

**Rates of Return and Effective Tax Rates with CESGs,
1998 Tax System, No Student Loans, No Dependants**

Sex	Yearly Contribution (\$)	IRR (%) Net-of-Tax (1)	IRR (%) Gross-of-Tax (2)	ETR [(2) - (1)] / (2)	ESR*	ETR - ESR
Male						
Full-Time	650	8.27	9.84	0.159	0.251	-0.092
Part-Time	650	7.34	9.00	0.184	0.238	-0.054
Female						
Full-Time	650	13.22	14.34	0.078	0.276	-0.198
Part-Time	650	12.01	13.29	0.096	0.259	-0.163
Male						
Full-Time	2000	9.06	9.84	0.079	0.251	-0.172
Part-Time	2000	7.98	9.00	0.114	0.238	-0.124
Female						
Full-Time	2000	14.67	14.34	-0.023	0.276	-0.299
Part-Time	2000	13.18	13.29	0.008	0.259	-0.251

Notes: 1) CESG = Canada Educational Study Grant. CESG benefits incorporated here are based on an example provided by Department of Finance (1998, p. 35). Contributions are made over a 15 year period and earn a 5 % rate of return.

2) * ESR = [(2) - Appropriate entry from col. 1 of Table 1.2]/(2)

Source: See Table 1.1.

Table 1.7

**Rates of Return and Effective Tax Rates for 25th and 75th Quantiles:
1998 Tax System, No Student Loans, No Dependents**

Sex	Quantile	IRR (%) Net-of-Tax (1)	IRR (%) Gross-of-Tax (2)	ETR [(2) - (1)] / (2)
Male				
Full-Time	25th	5.35	6.00	0.109
Part-Time	25th	4.29	4.92	0.129
Female				
Full-Time	25th	8.46	9.09	0.070
Part-Time	25th	8.69	9.49	0.081
Male				
Full-Time	75th	9.88	13.02	0.241
Part-Time	75th	9.16	12.19	0.248
Female				
Full-Time	75th	12.42	15.25	0.186
Part-Time	75th	12.95	16.22	0.202

Source: See Table 1.1.

Table 2.1
Rates of Return and Effective Tax Rates for First
University Degree Graduates (Base Case)

	Net-of-Tax IRR	Gross-of-tax IRR	ETR
Canada			
Male	8.76	10.94	0.200
Female	12.31	14.01	0.121
U.S.			
Public			
Male	13.03	14.17	0.081
Female	14.06	15.03	0.064
Private			
Male	8.48	9.85	0.139
Female	8.54	9.71	0.120

Source: Authors calculations using 1998 Statistics Canada Survey of Consumer Finances and 1998 Current Population Survey data

Table 2.2
Base Case Rates of Return, Effective Subsidy Rates
and Net Effective Tax Rates

	Gross-of-tax IRR	Public IRR	ESR	ETR-ESR
Canada				
Males	10.94	8.28	0.243	-0.043
Females	14.01	10.71	0.235	-0.114
U.S.				
Public				
Male	14.17	12.28	0.133	-0.052
Female	15.03	12.65	0.159	-0.095
Private				
Male	9.85	8.61	0.126	0.013
Female	9.71	8.27	0.149	-0.029

Source: See Table 2.1

Table 2.3
Rates of Return and Effective Tax Rates for First University Degree Graduates
at the 25th and 75th Quantiles

	Quantile	Net-of-Tax IRR	Gross-of-tax IRR	ETR
Canada				
Male	25th	10.14	11.71	0.134
Female	25th	14.06	15.81	0.111
U.S.				
Public				
Male	25th	13.13	13.81	0.051
Female	25th	13.21	14.12	0.065
Private				
Male	25th	7.68	8.58	0.106
Female	25th	7.13	8.24	0.135
Canada				
Male	75th	6.69	8.49	0.212
Female	75th	10.16	11.99	0.153
U.S.				
Public				
Male	75th	13.88	15.35	0.096
Female	75th	14.09	15.59	0.096
Private				
Male	75th	10.03	11.62	0.137
Female	75th	9.30	10.97	0.152

Source: See Table 2.1

Table 2.4
Rates of Return and Effective Tax Rates for Cross Border Migration
by Domestically Educated Individuals

	Net-of-Tax IRR	Gross-of-tax IRR	ETR
Canada - U.S.			
Case A			
Male	23.22	21.69	-0.071
Female	24.05	22.78	-0.056
Case B			
Male	16.53	17.21	0.040
Female	17.70	18.23	0.029
U.S. - Canada			
Public			
Male	6.51	8.72	0.254
Female	9.75	11.63	0.162
Private			
Male	3.51	5.54	0.366
Female	5.80	7.62	0.239

Source: See Table 2.1

Note: Case A – student stays in Canada after high school graduation, but moves to the U.S. after university.
Case B – student moves to the U.S. after high school or university graduation in Canada.

Table 2.5
Rates of Return and Effective Tax Rates for Cross Border Migration of
Domestically Educated Individuals for the 25th and 75th Quantiles

	Quantile	Net-of-Tax IRR	Gross-of-tax IRR	ETR
Canada				
Male	25th	21.61	20.69	-0.044
Female	25th	23.77	23.18	-0.026
U.S.				
Public				
Male	25th	8.15	9.72	0.162
Female	25th	10.83	12.55	0.137
Private				
Male	25th	4.26	5.84	0.269
Female	25th	5.82	7.50	0.223
Canada				
Male	75th	22.83	21.17	-0.078
Female	75th	22.74	21.51	-0.057
U.S.				
Public				
Male	75th	5.14	7.21	0.287
Female	75th	8.28	10.55	0.215
Private				
Male	75th	3.02	5.06	0.403
Female	75th	5.17	7.32	0.295

Source: See Table 2.1

Table 2.6
Rates of Return and Effective Tax Rates for Canadians, Educated
at Private Universities in the U.S.

	Quantile	Net-of-Tax IRR	Gross-of-tax IRR	ETR
Case I- Stay in U.S.				
	Male			
	25th	13.08	11.86	-0.103
	Median	15.15	13.80	-0.098
	75th	16.50	15.14	-0.089
Female	25th	13.13	12.08	-0.087
	Median	14.71	13.40	-0.098
	75th	15.44	14.38	-0.073
Case II - Move Back				
	Male			
	25th	5.44	6.28	0.134
	Median	4.86	6.23	0.220
	75th	4.12	5.57	0.259
Female	25th	7.43	8.20	0.093
	Median	7.28	8.26	0.119
	75th	6.43	7.76	0.171

Source: See Table 2.1

Table 2.7
Canadian Education System Experiments

	Net-of-Tax IRR	Gross-of-tax IRR	ETR	ETR - ESR
Male				
100% increase in tuition, no change in credit	7.42	9.63	0.230	-0.013
100% increase in tuition, credit changes	7.72	9.63	0.199	-0.044
Double education amount	8.95	10.94	0.181	-0.062
Flat Income Tax	11.12	10.94	-0.016	-0.259
Female				
100% increase in tuition, no change in credit	10.53	12.37	0.148	-0.087
100% increase in tuition, credit changes	10.93	12.37	0.117	-0.118
Double education amount	12.58	14.01	0.102	-0.133
Flat Income Tax	14.23	14.01	-0.016	-0.251

	Public IRR	Gross-of-Tax IRR	ESR	ETR - ESR
Male				
Cut Expenditures by 20%	8.71	10.94	0.204	-0.004
Female				
Cut Expenditures by 20%	11.24	14.01	0.198	-0.077

Source: See Table 2.1.

Table 3.1

Field of Study	Description
Humanities	Fine and applied arts, music, drama, classics, languages, philosophy, communications, history, library services
Social Sciences	geography, anthropology, sociology, economics, political science, psychology, social work, law
Commerce	Management, Business
Pure Sciences	Agriculture, biological, pure and mathematical sciences
Engineering	Engineering and applied sciences
Health Sciences	Nursing, health professions (speech therapy, physiotherapy, etc.)

*Source: Vallaincourt and Bourdeau-Primeau (2002)

Table 3.2
Gross and Net Rates of Return and Effective Tax Rates (ETRs)
for Full-time University Students

Females	Humanities	Social Sciences	Commerce	Pure Sciences	Engineering	Health Sciences
Net IRR	10.6%	15.0%	19.7%	17.5%	18.5%	21.3%
Gross IRR	12.3%	16.9%	22.1%	19.8%	21.1%	23.9%
ETR Female	0.134	0.111	0.109	0.114	0.124	0.108
Males						
Net IRR	-2.4%	12.8%	16.1%	15.2%	19.1%	14.8%
Gross IRR	-1.8%	14.8%	18.6%	17.7%	21.9%	17.0%
ETR Males	-0.324	0.136	0.132	0.141	0.128	0.132

Source: Author's calculation

Table 3.3
Grosss and Public Rates of Return and Effective Subsidy Rates (ESRs)
for Full-time University Students

Females	Humanities	Social Sciences	Commerce	Pure Sciences	Engineering	Health Sciences
Public IRR	5.1%	8.6%	11.4%	7.6%	4.6%	3.8%
Gross IRR	12.3%	16.9%	22.1%	19.8%	21.1%	23.9%
ESR Females	0.585	0.490	0.484	0.616	0.782	0.842
Males						
Public IRR	-3.8%	9.1%	11.1%	7.7%	9.3%	3.3%
Gross IRR	-1.8%	14.8%	18.6%	17.7%	21.9%	17.0%
ESR Males	-1.136	0.383	0.400	0.566	0.573	0.808

Source: See Table 3.2

Table 3.4
ESRs, ETRs and Net ETRs (ETR - ESR) for Full-time University Students

	Humanities	Social Sciences	Commerce	Pure Sciences	Engineering	Health Sciences
Females						
ETR	0.134	0.111	0.109	0.114	0.124	0.108
ESR	0.585	0.490	0.484	0.616	0.782	0.842
Net ETR	-0.451	-0.379	-0.376	-0.502	-0.658	-0.734
Males						
ETR	-0.324	0.136	0.132	0.141	0.128	0.132
ESR	-1.136	0.383	0.400	0.566	0.573	0.808
Net ETR	0.813	-0.247	-0.268	-0.426	-0.444	-0.677

Source: See Table 3.2

Table 3.7
Net Rate of Return Comparison for 4-Year University Business Degree

	Net IRR	Average IRR	Quality Premium	*Income Premium
Females				
Western	12.2%	19.7%	-7.5%	39%
Toronto	13.9%	19.7%	-5.8%	28%
Queens	13.8%	19.7%	-5.9%	28.5%
Males				
Western	10.8%	16.1%	-5.3%	23%
Toronto	12.1%	16.1%	-4.0%	16%
Queens	12.0%	16.1%	-4.1%	16.3%

* - Income required to return rate of return to pre-deregulation value

Source: See Table 3.2

Table 3.8
ETRs, ESRs and Net ETRs for Business School Graduates

	Net IRR	Gross IRR	ETR	ESR	Net ETR
Females					
Western	10.8%	13.0%	0.170	0.371	-0.202
Toronto	12.7%	15.0%	0.152	0.395	-0.243
Queens	12.7%	14.9%	0.152	0.393	-0.241
Males					
Western	9.8%	12.3%	0.204	0.303	-0.099
Toronto	11.3%	13.8%	0.182	0.324	-0.142
Queens	11.2%	13.7%	0.183	0.323	-0.141

Source: See Table 3.2

Table 4.1
Simulation Results for the Optimal Corporate Income Tax
With and Without Lobbying

Political Weight	Fraction of Pop'n who own Capital	Optimal Tax Rate on Capital	Optimal Tax Rate on Capital with Lobbying
0.50	0.25	0.22	0.09
0.80	0.25	0.22	0.15
0.90	0.25	0.22	0.19
0.95	0.25	0.22	0.20
0.50	0.05	0.21	0.06

Source: Author's calculation

Table 4.2
Simulation Results Based on the Allowance of Lobbying
and the Ability of the Government to Tax Capital and Labor

Political Weight	Fraction of Pop'n who own Capital	Equilibrium Tax Mix		Critical Human Capital Level	Equilibrium Wage
		Capital	Labor		
0.50	0.25	0.00	0.12	7.55	3.29
0.80	0.25	0.03	0.13	8.89	3.36
0.90	0.25	0.05	0.13	10.65	3.38
0.95	0.25	0.07	0.12	15.44	3.38
0.50	0.05	0.00	0.10	9.67	2.93

Source: See Table 4.1

FIGURES

Figure 4.1

Reference Case Equilibrium

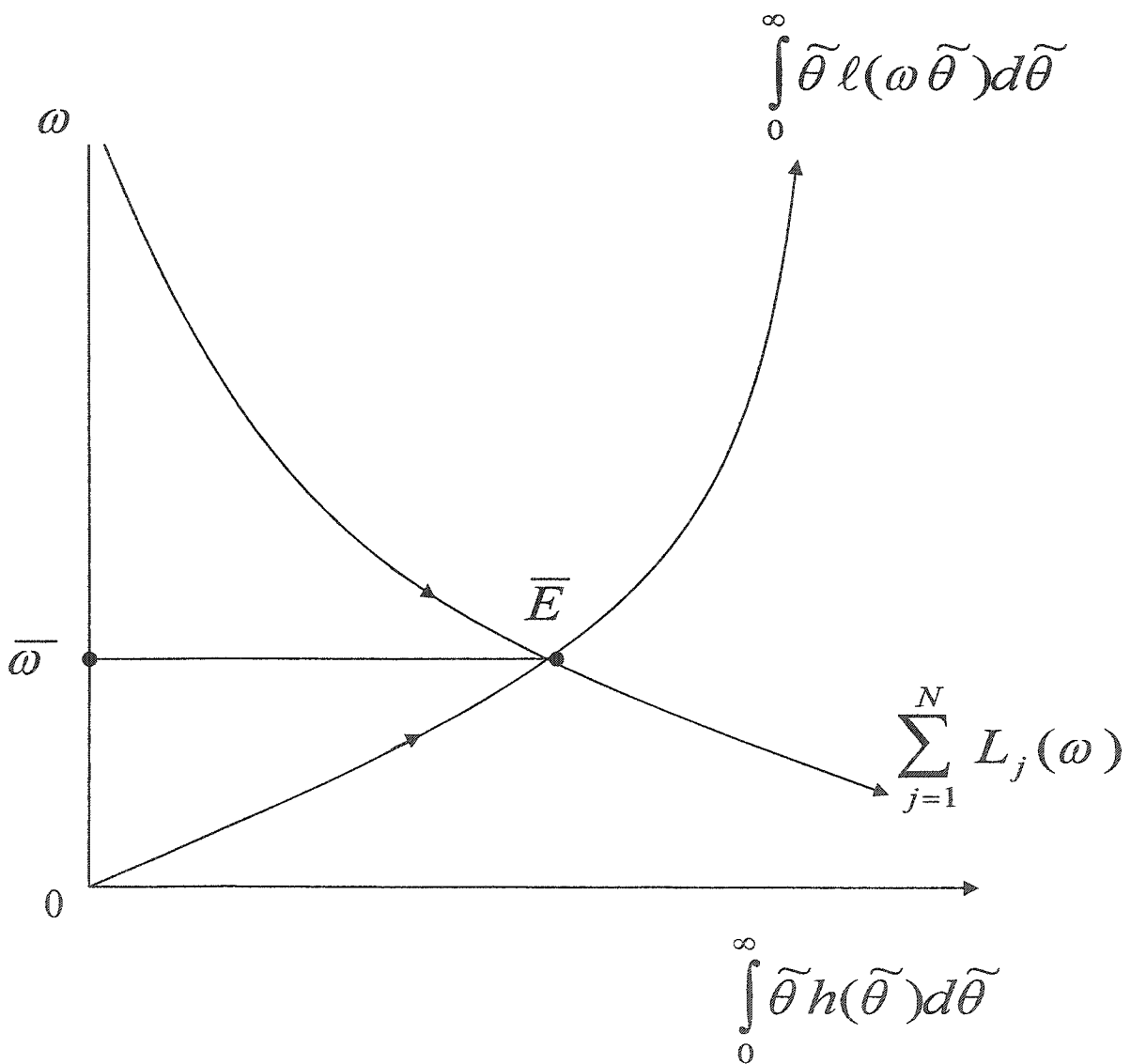


Figure 4.2

The Provision of Public Goods When Only Capital is Taxed

