Trade, Fiscal Transfers, Diversity and the Resource Curse:

Evidence from Canada and the US

By

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Declaration

I declare that this thesis is my own work and has not been submitted in any form for any other academic award.

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Abstract

This thesis examines various issues related to intranational and international trade, fiscal decentralization, trade openness, economic diversity, resource curse and economic growth – all within a Canada-US sub-national framework. Chapter 1 provides the motivation for the study and sets the stage for the various empirical-based policy trade-offs and insights arrived at in the subsequent chapters. In chapter 2, we examine the extent to which trade costs, modeled by distance and contiguity, influence the magnitude and direction of both east-west and north-south trade in Canada and the US .We provide an alternative framework which pays special attention to estimation issues related to unobserved heterogeneity, log-linearization in the presence of heteroscedasticity, and logarithmic transformation of zero bilateral trade flows. In all, this thesis provides updated results and garners further evidence in support of the home bias argument of McCallum (1995) and Obstfeld and Rogoff (2000b). Equally, our results uphold the Linder-hypothesis, but refute the Heckscher-Ohlin factor endowment proposition.

Chapter 3 focuses on the relative importance of fiscal redistribution and trade openness in the economic growth analysis of Canada and the US. Using a dynamic panel of Canada-US data, we estimate the importance of redistributive flows based on personal income after federal taxes and transfers, and pretax personal income. We conclude that there is a clear incidence of "immiserising growth". The coefficient of the interaction variable gives no evidence of fiscal transfer-induced growth across all four major estimators. Chapter 4 explores the diversity-resource-growth nexus. The first major conclusion is that the diversity measures employed are arbitrary because both the absolute and relative specialization measures, on which they are based, are arbitrary. We find evidence for a positive direct relationship for the diversity-growth nexus. Due to statistically insignificant coefficients, the GMM framework does not provide us with predictive power to test the resource curse proposition. However, through the fixed effects technique, we provide evidence for the role of economic diversity as a transmission channel of the resource curse.

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List of Abbreviations

ACS:	American Community Survey
AGV:	Absolute Ogive Index
AIT:	Agreement on Internal Trade
CFS:	Commodity Flow Survey
DiD:	Difference-in-Differences
DIFF GMM:	Two-Step Difference GMM
DPD:	Dynamic Panel Data
ENT:	Entropy Index
FEM:	Fixed Effects Model
FGLS:	Feasible Generalized Least Square
FMAP:	Federal Medicaid Assistance Percentages
GDP:	Gross Domestic Product
GFK:	Gross Fixed Capital Formation
GMM:	Generalized Methods of Moments
HHI:	Herfindahl-Hirschman Index
ICT:	Information and Communications Technology
KSI:	Krugman Specialization Index
LFS:	Labour Force Survey
NAFTA:	North American Free Trade Agreement
NAICS:	North American Industry Classification System
NFT:	Net Fiscal Transfers
OLS:	Ordinary Least Squares
PCTR:	Personal Current Transfer Receipts
PIM:	Perpetual Inventory Method
PPML:	Pseudo Poisson Maximum Likelihood
QGV:	Quadratic Ogive Index
RNFT:	Relative Net Fiscal Transfers
RPI:	Real Personal Income Per Capita
RRPI:	Relative Real Personal Income Per Capita
REM:	Random Effects Model
SYST GMM:	Two-Step System GMM
TDO:	Trade Data Online
US:	United States

Chapter 1 Introduction and Overview

1.1 Motivation and Objectives of the Study

Intranational trade, international trade, fiscal decentralization, income disparity, trade openness, resource curse, economic diversity and growth are fundamental issues of significant interest among economists, researchers and policy makers across industry, government and academia. Many a times, these issues generate a host of all-or-nothing propositions that involve policy trade-offs on fairness, efficiency, macroeconomic stabilization and growth, among others. Regardless of the differences in geography, economics, institutions and political systems, policy makers everywhere ponder, identify and use common tools to analyze various policy scenarios in order to realize the fundamental objectives of fairness, efficiency, macroeconomic stabilization and growth.

Apart from being each other's largest trading partner and sharing the world's longest border, Canada and the US share a great deal of common cultural, historical and institutional framework. This thesis, therefore, provides a veritable opportunity to examine these issues empirically. We do so in three substantive chapters; within the gravity framework for the first chapter, and the broad framework of the Solow growth model, in a dynamic panel data (DPD) environment, for the other two.

The first issue relates to intranational and international trade. Talking about trade, global trade flows over the last several decades have grown exponentially due to increased globalization and the gradual disappearance of trade "walls" among nations of the world. This continues to leave many wondering about when the notion of a "borderless" world would be achieved. About 90% of the Canadian population lives within 100 miles of the United States (US) border (Wall, 2000). Despite the huge trade flows between both countries, provinces trade with themselves far more than adjacent US states, a phenomenon often explained by the presence of international borders, and termed 'home bias'.

We apply the gravity model to assess bilateral trade flows between provinces and states in Canada and the US, respectively. Specifically, we estimate a gravity model focusing on the border effects and subsequent tests of the Heckscher-Ohlin and Linder hypotheses, while paying particular attention to the estimation issues. We adopt a data-driven approach and in the interest of keeping the model and robustness tests as simple as possible, we perform the tests for the baseline model first and then compare our results with those obtained from other models. We then offer possible interpretations of the results in light of the estimation strategies employed

The second issue examined is the relative importance of intergovernmental fiscal redistribution and economic openness in the economic growth process of Canada and the US – two federations with different divisions of powers between national and sub-national governments. No doubt, Canada and the US are two affluent countries. However, the various provinces and states that make up both countries are characterized by huge income gaps, growth differentials and differences in fiscal capacities. This leads to a major motivation to empirically test the redistributive consequences of fiscal transfers, even when it is not a policy objective ex-ante, in some instances.

Using a dynamic panel of Canada-US data, selected over short-term periods to overcome cyclical factors, we estimate the importance of redistributive flows by regressions which estimate the relationship between personal income after federal taxes and transfers, and pretax personal income. This gives a direct measure of the degree to which fiscal transfers reduce inequalities in regional incomes. Using the difference-in-differences (DiD) methodology, we also empirically evaluate the impact of the Agreement on Internal Trade (AIT) policy on income convergence in Canada, while controlling for fiscal federalism.

In order to increase the reliability of our econometric estimates, we also introduce a number of refinements in the estimation methods. In particular, we pay special attention to the difference and system Generalized Method of Moments (GMM) estimator in a Canada-US sub-national panel data environment. Most of the latest literature examining the fiscal decentralization-growth question tends to rely on cross-country ordinary least square (OLS) empirical methodology; a few others incorporate the fixed effects model (FEM).

Last but not least, this thesis contributes to the debate on economic diversity, resource curse and economic growth across Canadian and US jurisdictions by using the most recent techniques of DPD models. Canadian and US jurisdictions have a variety of policies in place to diversify their economies, but the degree to which the "ideal diversity" has been achieved varies. While some states and provinces have a concentration of goods-producing sectors making up a substantial part of their economies, others have economic structures with heavier weights on the services-producing sectors. We estimate a conditional growth model in a Canada-US regional growth context to (i) investigate the relationship between economic diversification and growth (ii) examine real per capita income as a function of natural resources and a set of variables drawn from the existing literature and (iii) take a closer look at the transmission channel of the resource curse, with diversity as focus.

1.2 The Importance of Sub-National Focus

The academic and policy literature increasingly recognizes that globalization and advances in technology have made it important that sub-national regions respond flexibly to global economic dynamics – in order to create wealth. For instance, while sub-national jurisdictions with good locational access to international markets may benefit substantially from national export promotion policies, a high natural resource royalty regime may impact resource-rich jurisdictions more disproportionately. In a way, this shows that successful policy coordination across regional levels of government depends, to a large extent, on how national governments adopt different institutional responses. To the extent that regional economic diversity allows global integration and technological progress to shift economic landscapes, national economic policies continue to have differential sub-national impacts.

The three central topics analyzed in this thesis are crosscutting issues; successfully integrating them into the policy cycle requires interaction between both national and sub-national levels of government. This explains how our approach complements a better understanding of trade, intergovernmental fiscal relations, economic diversity and the resource curse. We attempt to bridge the gap with a sub-national analysis of three topical issues that are traditionally addressed with cross-country frameworks. By so doing, we indirectly identify and strengthen the determinants of the effectiveness of regional economic analysis. Our approach provides an opportunity to review best practices and successful policies of various regional jurisdictions in Canada and the US, with a view to helping to improve performance at the national levels. Using a sub-national framework creates a robust platform which, among other things, incorporates an institutional setting with regional trade and economic development policies, administrative systems, and the nuances of intergovernmental relations.

This thesis focuses on the sub-national level because for Canada and the US, many important social and economic characteristics at the sub-national level are expected to vary sharply from what is observed at the national levels. This becomes even more important because a sub-national framework also serves as a laboratory for testing direct policy interventions that enable poorer jurisdictions to benefit from national economic growth. That is in addition to ensuring that fairness, equity and efficiency are balanced, while the issue of spatial disparity is addressed.

1.3 The Gravity Model of Trade

1.3.1 Background

The gravity equation, which relates trade between two jurisdictions positively to both of their sizes and negatively to the distance between them, is one of the most popular and successful empirical models in international economics. Pioneered by Tinbergen (1962), the model has been widely used because it provides a good fit to intranational and international trade flows data. Among other things, the gravity model of trade explains why international borders constitute an impediment to trade flows. We apply the gravity model to assess bilateral trade flows between provinces and states in Canada and the US, respectively.

About 90% of the Canadian population lives within 100 miles of the US border (Wall, 2000). Despite the huge trade flows between both countries, provinces trade with themselves far more than adjacent US states, a phenomenon often explained by the presence of international borders, and termed ‘home bias’. The choice of this country-pair provides a robust jurisdictional framework that allows us to seamlessly model various policy issues and scenarios related to trade costs, while paying serious attention to estimation issues that have qualified an array of studies in this field. Much of our analysis on the border effects build upon two seminal papers in the gravity literature: Anderson and van Wincoop (2003) and McCallum (1995). They both directly and indirectly make a useful suggestion to policy makers and academic economists interested in examining the impact of the border on trade flows: to consider a general equilibrium comparative statics exercise of removing the border in order to produce unbiased estimates of the border effects. This is especially important considering the fact that the past 30 years have seen regionalism re-emerge as a major issue in the policy agenda.

We exploit a large annual panel data set spanning three five-year intervals from 1997 to 2007 and covering all 10 provinces and 50 states. We follow a more standard formulation of the gravity model developed by Anderson and van Wincoop (2003), albeit we augment it with a contiguity dummy, differences in relative factor endowments and per capita income. That way, we estimate a gravity model focusing on the border effects and subsequent tests of the Heckscher-Ohlin and Linder hypotheses, while paying particular attention to the estimation issues. We provide an alternative framework which pays special attention to unobserved heterogeneity, log-linearization in the presence of heteroscedasticity, and logarithmic transformation of zero bilateral trade flows. Our methodology recognizes that in the presence of these issues, the biases that are present in the various strategies employed to estimate the gravity model often produce misleading estimates of bilateral trade flows determinants.

1.3.2 Research Hypotheses

Following the literature framework and theoretical issues, we advance the following six hypotheses in order to answer the research questions posed in this chapter:

H_1: There is a positive effect of economic size on bilateral trade flows between trading partners.

H_2: There is a negative effect of geographical distance on bilateral trade flows between trading partners.

H_3: There is a stronger negative effect of the border on state-province trade, compared to interstate and interprovincial trade.

H_4: There is a stronger negative effect of the border on interprovincial trade, compared to interstate trade

H_5: There is a positive relationship between factor endowment differentials and bilateral trade flows.

H_6: There is a negative relationship between per capita income differentials and bilateral trade flows.

1.3.3 Findings and Contribution

For the full sample, we find across all specifications that the coefficients of exporter's GDP, importer's GDP and bilateral distance are economically significant with meaningful interpretations. Estimated elasticities of trade to size and distance are close to unity. With a statistically and economically contiguity dummy, we also conclude that the presence of a border affects the intensities of economic exchange between a jurisdiction-pair, after controlling for bilateral distance. The border effect is more pronounced under the Pseudo Poisson Maximum Likelihood (PPML) than when OLS is used.

For the sub-samples, statistically and economically significant coefficients of 0.299 (Canada-US) and 0.362 (US-US) uphold the hypothesis that there is a stronger negative effect of the border on international trade, compared to within-country trade. Notwithstanding a statistically insignificant border effect for the Canada-Canada sub-sample, we find with the aid of the Feasible Generalized Least Square (FGLS) method, after controlling for scale and distance, that interprovincial trade is about 17 times more important than state-province trade. This upholds the hypothesis that there is a stronger negative effect of the border on interprovincial trade, compared to interstate trade. This finding is consistent with major findings on the border effect; e.g. McCallum (1995), Wall (2000) and Anderson van Wincoop (2003).

We also compute how wide the border is, based on both the distance and border effects. Our conclusion is that the unrealistically high distance elasticities in our regressions do not help the predictive powers of the methods deployed. Results in this chapter provide mixed evidence for the Heckscher-Ohlin proposition and the Linder hypothesis; the former is refuted, while the latter is supported. We find that a 100% increase in per capita income differential will dampen trade by 7.5% and 19.4% for the low and high estimates, respectively. In stark comparison, negative signs on the coefficients of human capital differential and physical capital stock differential refute the Heckscher-Ohlin hypothesis that jurisdictions should trade more, the more different their factor endowments. Similar to the Linder scenario, the Heckscher-Ohlin coefficients are economically and statistically significant, ranging from a high absolute value of 0.305 to a low value of 0.198.

Overall, the findings in this chapter confirm that the Canada-US border remains a major factor that influences the patterns of trade flows between both countries. Our statistically and economically significant state-province and within-country border effects show a decline in the home bias syndrome for Canadian provinces, reflecting, in a way, the effects of NAFTA's full implementation and AIT's progress. Our results reject the notion that trade is driven by differences in relative factor endowments between regions. To the extent that gains from specialization arise because of differences between regions, the results fail to pick any sharp contrasts in the resource endowments of both countries.

This chapter contributes to the debate on whether or not there is a stronger negative effect of the border on interprovincial trade, compared to interstate trade, with implications for policy. Among other things, we note that any further reductions in US-Canada trade barriers will benefit Canada more disproportionately. The attention of policy makers is therefore drawn to the need to continue to favour policies focused on reducing Canada-US border thickening. In particular, we identify the joint declaration issued by the Canadian and US governments in 2011 tagged, "Beyond the Border: A Shared Vision for Perimeter Security and Economic Competitiveness". To the extent that this policy is geared towards addressing the trade-off involving border security and trade relations, the findings in our study will be a useful empirical guide for future negotiations.

1.4 Fiscal Transfers, Trade Openness and Economic Growth

1.4.1 Background

The theory of public finance recognizes the importance of fairness and efficiency in resource allocation. An important function of fiscal policy in a federal system is the capacity to make continuing income transfers from richer to poorer regions; and for a fact, such transfers play different roles. This chapter examines the relative importance of intergovernmental fiscal redistribution and economic openness in the income growth process of Canada and the US – two federations with different divisions of powers between national and sub-national governments. The decentralization-growth question remains open, as most cross-country econometric studies provide weak evidence chiefly because results change depending on the countries examined.

Two major pieces of literature are central to the discussion in this chapter. First, Bayoumi and Masson (1993) use fiscal transfers at the sub-national level within the US and Canada to analyze long-term fiscal flows (the redistributive element) and short-term responses to regional business cycles (the stabilization element). While long-run flows amount to 22 cents of every dollar spent while the stabilization effect is 31 cents in the dollar for the US, Canada produces a larger redistributive effect (39 cents) and smaller stabilization effect (17 cents). They conclude that federal flows depend on the institutional structure of the country concerned, in addition to providing evidence that a federal fiscal system tends to support the relative income of poor regions and reduce that of rich regions.

Checherita *et al.* (2009) use a large sample of European regions covering 19 European Union (EU) member states for the 1995-2005 period to analyze the aggregate impact of taxation and transfers on income and output convergence. They find evidence in support of a convergence process across the member states in terms of both per-capita output and income. Their results show that output growth rates in less prosperous receiving regions decline by less, compared to contributing more prosperous regions, in reaction to the fiscal transfers: a condition termed immiserising convergence.

In this chapter, we look at sub-national regions in both countries that share many common characteristics typical of a fiscal union, we control for many jurisdiction-specific features that might obscure the dynamics of the decentralization-growth nexus. Using a dynamic panel of Canada-US data, selected over short-term periods to overcome short-term cyclical factors, we estimate the importance of redistributive flows by regressions which estimate the relationship between personal income after federal taxes and transfers and pretax personal income. This gives a direct measure of the degree to which fiscal transfers reduce inequalities in regional incomes. As expected, differences in the economic structures and performances among different regions are likely to have an impact on the way fiscal redistribution affects income convergence.

In the past, many restrictions on interprovincial trade were prevalent in Canada. Over the years, specifically starting in 1995, some efforts to ease trade were made – the result of which was the AIT negotiated in 1994 and executed in 1995. While this is not the first paper to study the implications of Canada-US interregional fiscal transfers for income convergence, it definitely is the first to look at this issue from a pre- and post-AIT perspective. Even so, we extend the analysis by applying the DiD methodology to better capture the effect of the AIT policy. This is a major contribution of this chapter.

We also introduce a number of refinements in the estimation methods in order to increase the reliability of our econometric estimates. Special attention is paid to the difference and system GMM estimators. Most of the latest literature examining the fiscal decentralization-income convergence question tends to rely on cross-country OLS empirical methodology; a few others incorporate the FEM. Applying both system and difference GMM estimation techniques is a major advance.

1.4.2 Research Hypotheses

Summarized, the following seven hypotheses are advanced in this chapter:

H_1: There is a positive relationship between net fiscal transfers and GDP per capita.

H_2: There is a different impact of fiscal flows on GDP per capita for prosperous and poor regions.

H_3: There is a stronger effect of fiscal transfers and lagged income on GDP per capita, compared to the lone effect of fiscal transfers

H_4: There is a positive relationship between trade openness and GDP per capita

H_5: The combined effect of lagged income and trade openness on GDP per capita is much stronger than the individual effect of trade openness on GDP per capita.

H_6: There is a positive relationship between the AIT policy and GDP per capita

H_7: The combined effect of lagged income and the AIT policy on GDP per capita is much stronger than the individual effect of the policy on GDP per capita.

1.4.3 Findings and Contribution

Our analysis in this chapter finds evidence for the negative effect of fiscal transfers on per capita income; no evidence to comment on the degree to which past income distribution is linked to economic growth through fiscal transfers in Canada and the US. Based on the reported standard errors, the Windmeijer's (2005) finite sample correction clearly suggests that the system GMM performs much better than the difference GMM model.

The DPD-based method produces a coefficient of 0.875 on the relative net fiscal transfers variable, while the non-DPD FEM estimator produces coefficients that range from -2.272 to -2.381. We conclude that while the FEM results clearly agree with Checherita *et al.* that net fiscal transfers impede output growth, the system GMM technique suggests the opposite. The exact opposite is the case when we model relative transfers simply as the ratio of disposable income to personal income. We draw a fundamental conclusion: the DPD estimators are highly sensitive to the particular specification of the model and its instruments. This cautious note guides all recommendations in this chapter.

On the policy front, we divide the full sample into below-average, above-average, net receiving and net contributing jurisdictions. With estimated coefficient values of -2.467, -2.051, -1.205 and -2.354 for the fiscal transfers coefficients, we establish a two-way negative impact of net fiscal transfers on real GDP per capita. Our conclusion is novel: while higher taxes have a negative impact on economic growth in the donor jurisdictions, higher net fiscal receipts equally have a negative effect in the receiving regions. This is a clear incidence of "immiserising growth". The coefficient of the interaction variable is further used to test for the impact of past income on economic growth and redistribution through fiscal transfers. With statistically insignificant results, we conclude that there is no evidence that lagged income distribution has affected the intensity of the impact of fiscal transfers on growth.

Furthermore, we find evidence in support of the plethora of studies on the inconclusive trade-growth link. As well, the hypothesis that the AIT policy has any growth or income distributional impacts on Canadian jurisdictions is refuted. Given coefficient values of 0.290 and -0.183 for the interaction between lagged income and the AIT under the FEM and the system GMM, respectively, we conclude that there is evidence for lagged income impact on economic growth through the AIT policy, while the same policy inhibits growth in the latter environment. Before making any policy statements, we point out the caveat that the coincidence in the timing of the signing of AIT and the execution of NAFTA may obscure key issues. Addressing this concern through Mexico-US and Canada-Mexico sub-national export and import data is difficult and qualifies the results.

Any intergovernmental transfers, whether or not explicitly designed to help equalize the fiscal capacities of sub-national governments, will have redistributional implications. This is because one thing is common to all transfer programs: they involve a flow of resources from the center to regional governments. Therefore, appropriate designs of transfer systems should recognize that transfer programs may have conflicting objectives or unintended consequences which may affect their potency.

The two major policy contributions of this chapter are: (i) while regional fiscal disparity may be bad for growth, policy designs that focus on taxes and transfers may even cause more harm than good; policy makers are therefore advised to be cautious in drawing specific conclusions on the negative effect of redistributive policies (ii) fiscal authorities in the US could consider an Equalization policy that guides and determines the appropriate level of fiscal capacity and fiscal need – as an alternative to the complex and highly politicized Grants-in-Aid model.

Both recommendations above are in addition to the need for policy makers to first unbundle the different components of a redistributive fiscal policy and weigh carefully the pros and cons of each specific component, before making a decision on the optimal redistributive policy for a regional economy.

1.5 Economic Diversity, Growth and the Resource Curse

1.5.1 Background

The notion of spreading economic activity across a relatively wide range of industry sectors as a strategy to address regional income disparities and asymmetric macroeconomic shocks continues to gain popularity among practitioners and academic researchers. Economic diversification remains a popular topic in policy circles; it is popularly believed to be the cure to the "resource curse" challenge. Maliza and Ke (1993), for instance, see the wisdom behind economic diversity because a variety of economic activities that reflect differences in economic structure can help a region handle the disruptive effects of business cycles. While there still is no consensus on which diversity measures best capture specialization, capturing the dynamics of continually evolving economic structures will go a long way in helping policy makers to identify optimal diversification strategies. This chapter makes a major contribution in this regard.

Economic diversification remains a recurring theme in public policy debates; it is popularly believed to be the cure to the "resource curse" challenge. The economic explanation of the curse is that the crowding out effect of a resource boom leads to a diminished importance of the manufacturing sector. This is the Dutch disease proposition that on average, resource-abundant regions lag behind countries with less resources. The benefits of diversification, as well as the importance of key economic, demographic, geographic and institutional factors that explain it, remain widely acknowledged. However, explaining the specific reasons why diversification helps some economies to succeed where others fail remains a mirage. To further complicate things, most empirical investigations of the relationship between economic growth and diversity provide inconclusive evidence. This chapter provides empirical evidence in an attempt to fill this void.

Among other influential contributions, Corden and Neary (1982), Sachs and Warner (1995), Auty and Mikesell (1998), Bulte *et al.* (2005), Mehlum *et al.* (2006), Robinson *et al.* (2006) and Torres *et al*. (2013) provide extensive analysis on the resource curse and its transmission channel. Macaspac (2007), Palan (2010), Ahmadov (2012) and Pede (2013) offer robust and contemporary perspectives on the economic diversity-growth nexus.

We go a step further by proposing that economic diversity is a possible transmission channel of the curse; this is then modeled using five different indices with varying characteristics. By looking at the twin issues of diversification and the resource curse, our chapter contributes to this debate from a Canada-US regional perspective. This becomes even more significant considering our use of the GMM estimator, one of the most recent DPD techniques used in empirical regional growth analyses.

1.5.2 Hypotheses

At a high level, the following hypotheses are presented to test the research questions in this chapter:

> H_1: There is a positive relationship between economic diversification and economic growth
>
> H_2: There is a negative relationship between resource abundance and economic growth
>
> H_3: The outcome of the interactions between resource abundance and economic diversity is the key determinant of the existence, or otherwise, of the resource curse.

1.5.3 Findings and Contribution

Partly blamed on the notion of equiproportionality of employment share and economic activity, we find that the economic diversity measures used are arbitrary because both the absolute and relative specialization measures, on which they are based, are also arbitrary. Next to that, the Quadratic Ogive Diversity Index supports the growth-promoting stance of economic diversity. By implication, this supports the hypothesis that economic diversity is associated with increased levels of economic growth. The use of dynamic panel techniques also helps resolve the uncertainty related to the so called diversification effects. We join other empirical researchers who find evidence for a positive direct relationship for the diversity-growth nexus (e.g. Hackbart and Anderson, 1975; Dissart, 2003; and Pede, 2013).

The GMM framework does not provide us with predictive power to test the resource curse proposition; same goes for the interactive effect of diversity on resources. On the other hand, the FEM with statistically and economically significant coefficients capture the partial impact of an increase in natural resources on growth through the diversity transmission channel. The required diversity threshold for not having the resource curse is given as 0.209. Above this threshold, the marginal contribution of natural resources to economic growth is higher for a relatively more diversified regional economy than a less diversified one. The reverse is true when such diversity measure based on the Krugman Index is below 0.209.

In all, our results show that the two-step system GMM estimator handles well the endogenous regressors by generating internal instruments from their lagged values for them. This strategy also augurs well for our static-dynamic and diversity-diversification debates. A major policy conclusion is noted from the finding in the preceding paragraph: jurisdictions with Krugman Index value less than 0.209 are bound to suffer from the curse of natural resources, while those above will not.

We conclude that in practical terms, this implies that it is only when regional economies are not diversified up to a certain degree that resource abundance is harmful to growth. Unlike its counterparts without natural resources, governments of resource-endowed regions may be indirectly faced with incentives to pursue growth-deterring policies. This is because resource endowments mean citizens expect much more from their leaders, and these leaders are in turn under a lot of pressure. They may end up pursuing policies that crowd out investment and allocate productive resources away from more profitable sectors, with diminishing marginal returns that impact inefficiently on the economy.

1.6 Organization of Chapters

The thesis is structured as follows. In chapter 2, we examine the extent to which trade costs, modeled by distance and contiguity, influence the magnitude and direction of both east-west and north-south trade in Canada and the US .Using a variety of linear and non-linear estimation techniques, we provide an alternative framework which pays special attention to issues related to unobserved heterogeneity, log-linearization in the presence of heteroscedasticity, and logarithmic transformation of zero bilateral trade flows. We equally examine both the intranational and international home bias arguments of McCallum (1995), Obstfeld and Rogoff (2000b) and those after them, in addition to the Linder-hypothesis and the Heckscher - Ohlin factor endowment proposition.

Chapter 3 builds on the US-Canada sub-national framework, but differs in that it focuses on fiscal transfers. In addition to the fixed effects techniques, this chapter incorporates dynamic panel methods in examining the relative importance of fiscal redistribution and trade openness in the economic growth analysis of Canada and the US. We estimate the importance of redistributive flows based on personal income after federal taxes and transfers, and pretax personal income using various econometric strategies. Important policy lessons are drawn.

In Chapter 4, economic diversity is proposed as the main channel through which the effects of natural resources on growth are gauged. This chapter explores the diversity-resource-growth nexus. Five diversity indices are examined through the OLS, FEM and DPD strategies. Chapter 5 concludes the thesis with key findings, policy implications and limitations. As an extension of the current research, we provide directions for future research in the same chapter.

Chapter 2 The Gravity Model of Trade: A Canada-US Sub-National Framework

2.1 Introduction

According to Obstfeld and Rogoff (2000b), the border effect on trade flows remains one of the "six major puzzles in international macroeconomics". The gravity equation, which relates trade between two jurisdictions positively to both of their sizes and negatively to the distance between them, is one of the most popular and successful empirical models in international economics. Pioneered by Tinbergen (1962), the model has been widely used because it provides a good fit to intranational and international trade flows data.

This chapter applies the gravity model of trade to assess bilateral trade flows between provinces and states in Canada and the US, respectively. The volume of trade between both countries is the largest between any two countries in the world (Government of Canada, 2014), and both countries are each other's biggest trading partners. This should not come as a surprise; both economies, by many measures and along many dimensions, are highly integrated and share many economic, geographic, historical and cultural similarities. Even so, huge differences exist between them. In particular, fundamental differences exist in the structure of each country's population, geography, market size, productivity, taxation, prices and social policy. These result in different economies, especially in terms of the relative importance of industries producing specific goods and services.

We focus on regional Canadian and US jurisdictions because many important social and economic characteristics at the sub-national level are expected to vary sharply from what is observed at the national levels. The academic and policy literature increasingly recognizes that globalization and advances in technology have made it important that sub-national regions respond flexibly to global economic dynamics – in order to create wealth. For instance, while sub-national jurisdictions with good locational access to international markets may benefit substantially from national export promotion policies, a high natural resource royalty regime may impact resource-rich jurisdictions more disproportionately. In a way, this shows that successful policy coordination across regional levels of government depends, to a large extent, on how national governments adopt different institutional responses.

Using a sub-national framework creates a robust platform which, among other things, incorporates an institutional setting with regional trade policies and administrative systems. This becomes even more important because a sub-national framework also serves as a laboratory for testing direct policy interventions that enable poorer jurisdictions to benefit from trade-induced national economic growth.

About 90% of the Canadian population lives within 100 miles of the US border (Wall, 2000). Despite the huge trade flows between both countries, provinces trade with themselves far more than adjacent US states, a phenomenon often explained by the presence of international borders, and termed 'home bias'. Closely related to this is the presence of within-country border effects; the so-called intranational home bias. At the aggregate level, the gravity model is the most common tool used to control for the most important determinants of trade between a bilateral pair (e.g., GDP, distance, contiguity e.t.c). We exploit a large annual panel data set spanning three five-year intervals from 1997 to 2007 and covering all 10 provinces and 50 states.

Frankly speaking, this chapter follows a more standard formulation of the gravity model developed by Anderson and van Wincoop (2003), albeit we augment it with a contiguity dummy, differences in relative factor endowments and per capita income. Summarized, our goal is to estimate the gravity model focusing on the border effects and subsequent tests of the Heckscher–Ohlin and Linder hypotheses, while paying particular attention to the estimation issues. We adopt a data-driven approach in the analyses that follow. In the interest of keeping the model and robustness tests as simple as possible, we perform the tests for the baseline model first and then compare our results with those obtained from other models. We then offer possible interpretations of the results in light of the estimation strategies employed.

There are three novelties in our approach. First, to our knowledge we are the first to use a Canada-US regional panel data framework to jointly test an extended gravity model, incorporating factor endowments and per capita income differentials. These additional variables allow us to test the Heckscher–Ohlin proposition-type factor endowment differences and Linder hypothesis-style taste differences, respectively.

The second novelty is the attention given, again in a Canada-US panel data environment, to the following three econometric problems: unobserved heterogeneity, log-linearization of the gravity equation in the presence of heteroscedasticity, and logarithmic estimation of zero trade flows. Most previous studies that jointly addressed these three issues did so using a cross-country framework. The other few that considered them with regional data did so either individually for Canada or the US, but not for regions in both countries together. Also, this chapter provides updated results and garners further evidence in support of the home bias argument – both international and intranational. Our goal is to use the extended model to justify examining the above issues jointly. We hope to show that such a model performs well empirically, when particular attention is paid to the estimation procedures.

This chapter proceeds as follows. In section 2.2, we review some related literature. Section 2.3 discusses a number of theoretical issues related to the gravity model, and introduces our data sources and the variables considered as potential determinants of bilateral trade. Estimation methods and empirical results are presented in section 2.4, while section 2.5 presents conclusions and policy implications.

2.2 Literature Review

2.2.1 Theoretical Foundations of the Gravity Model

Proposed by Tinbergen (1962), to explain international bilateral trade, the gravity model of trade is inspired by Newton's law of universal gravitation in physics. Newton's law states that the gravitational force with which two bodies attract each other is directly proportional to the product of their masses, and inversely proportional to the square of their distance. The intuition for the gravity model of trade therefore comes from here; with economic sizes serving as proxies for masses and distance measuring how far apart both jurisdictions are from each other. Tinbergen (1962) and Poyhonen (1963) were the first to apply the gravity model to international trade flows.

In their highly influential work, “Gravity with Gravitas: A Solution to the Border Puzzle”, Anderson and van Wincoop (2003) present a theoretical framework for understanding the determinants of bilateral trade flows. They manipulate the constant elasticity of substitution expenditure system to estimate a theoretical gravity equation and calculate the comparative statics of trade frictions. Anderson and van Wincoop assume that countries are representative agents that export and import goods, and goods are differentiated by place of origin such that each country is specialized in the production of only one good.

2.2.2 Border Effects and the Gravity Model

2.2.2.1 The Border Effects

Simply put, the border effects exist when after controlling for important factors, there is a tendency for the volume of domestic trade to exceed the volume of international trade (Evans, 2003). The country-to-country comparison is known as the international border effect. However, another version of the border effect also exists: the domestic border effect or intranational home bias. This helps explain why, for instance, trade within individual provinces (or states) is significantly larger than trade between provinces (or states), after controlling for economic size, distance and other important determinants of bilateral trade flows.

Understanding the nature of trade barriers is important since they serve as deterrents to market integration, with negative welfare consequences. In order to effectively measure their economic impacts, it is important to accurately estimate the magnitudes of both domestic and international border effects. After controlling for economic size, distance and other determinants, Wolf (2000) concludes that trade flows within individual US states are much higher than trade between US states. Nitsch (2000) carries out a similar exercise for the European Union (EU), with the conclusion that within-country trade is roughly ten times larger trade among countries.

In order to solve the border effects puzzle, Anderson and van Wincoop maintain that two important criteria must be met. First, that the estimation of the gravity model must be based on theory as done by McCallum (1995). Their second argument is that since most policy makers and macroeconomic analysts are more interested in examining the impact of trade barriers, especially borders, on international trade, it is essential that a general equilibrium comparative statics exercise of removing the US- Canada border barrier be carried out in order to determine the effect of the border on trade flows. This is especially important considering the fact that the past 30 years have seen regionalism re-emerge as a major issue in the policy agenda. For instance, with the creation of the North American Free Trade Agreement (NAFTA) in 1992, various empirical studies have come up with different estimates of the border effect.

2.2.2.2 McCallum vs. Anderson and van Wincoop

McCallum (1995), in his seminal paper, assuming a borderless situation, compares trade among Canadian provinces relative to corresponding flows with US states in a gravity framework based on aggregate trade volumes. McCallum equation predicts a radically different distribution of Canada-US trade, compared to what was documented prior to his estimation. With the aid of an “economic map of North America”, he intuitively provides a justification for the predicted north-south flow of Canadian trade. McCallum’s conclusion: interprovincial trade is 22 times larger than state-province trade.

His point of view is simple: Canadian provinces are small and distant from each other, compared to larger, more numerous, and less distant US states. This finding points to the relatively skewed spatial distribution of economic activity between both countries. Also, a higher population density of 30.71 sq. km in the US, compared to Canada’s 3.0 sq. km., is highly instructive. Most other studies after McCallum have estimated similar border effects for North American and European jurisdictions, albeit with much smaller magnitudes.

McCallum concludes that contrary to what some believe, national borders actually matter. He draws empirical evidence from how the border continues to influence continental trade patterns. One of the major predictions by McCallum was that the newly formed NAFTA (in 1992) would cause a radical shift in Canadian trade patterns in the future[1]. Considering some of the economic asymmetries between the US and Canada, e.g. GDP, population, factor endowments, and technology, the relative impact of the agreement on the economy of Canada and the US remains an attractive area to gravity researchers.

[1] In all fairness, that is one prediction that has come to pass.

Anderson and van Wincoop, in a bid to prove that the border effects were exaggerated by McCallum and others after him, concluded that the estimated border effects were high due to two reasons. First, the omission of the multilateral resistance term in McCallum's specification could not account for the decomposition of trade resistance into bilateral partners' resistance and the multilateral resistances of each trading partner. Anderson and van Wincoop derive a decomposition of trade resistance into three parts: (i) the bilateral trade barrier between region *i* and region *j*, (ii) *i*'s resistance to trade with all regions, and (iii) *j*'s resistance to trade with all regions.

One of the major novelties of Anderson and van Wincoop's work is the inclusion and estimation of a multilateral resistance term in order to conduct comparative statics exercises of the effect of trade barriers on trade flows. They estimate a theoretical gravity equation and establish that while the effect of national borders among other industrialized countries is a reduction of about 30% in trade, Canada-US trade is reduced by about 44% due to the border effects. Essentially, their important contribution is to highlight that bilateral trade is determined by relative trade costs.

The second reason is that compared to the US, a small trade barrier between Canada (a small open economy that trades a lot with the rest of the world, with the US being the dominant trade partner) and its other trading partners has a large effect on multilateral resistance of the provinces. This, they conclude, explains the increase in province-state trade by a mere factor of six, compared to McCallum's 22.

Brown (2003) summarizes the logic behind this as follows:

> Canadian regions experience a potentially higher multilateral resistance to trade because there are substantial transaction costs associated with trading across the border and because of the relative remoteness of Canada's regions, its spatial structure. Effectively, the Canadian economy functions over a thin, dispersed market that stretches east-west along the U.S. border; hemmed in by largely uninhabited land to the north and the U.S. border to the south. In contrast, the U.S. economy has no comparable economic or geographic limitations. Its market is larger, denser and more evenly spread over space. Therefore, because of barriers to trade associated with the border and Canada's spatial structure, Canadian regions encounter a higher level of multilateral resistance than their U.S. counter parts. Consequently, any measure of the border effect that uses interprovincial trade as a benchmark may be substantially biased upwards.

According to Anderson and van Wincoop, McCallum's conclusion that the removal of the US- Canada border will raise province-state trade 22 times is wrong; they find a much lower ratio when they estimate McCallum's model using 1993 data. Anderson and van Wincoop maintain that the regression by McCallum and the subsequent literature following him are not adequate to document such huge border effects. In their words, "McCallum cautiously did not claim that his estimated factor 22 implied that removal of the border would raise Canada-US trade relative to within-Canada trade by 2200%". Anderson and van Wincoop claim their theoretically grounded approach does a better job in estimating the border effect.

In comparative terms, the seminal work of McCallum (1995) pioneered the empirical debate on border effects. Known as the international border effect, McCallum shows that provinces in Canada trade 22 times more with each other than with US states – the so-called home bias. However, it was Anderson and van Wincoop that introduced a theoretical foundation robust enough to allow for a consistent and efficient estimation of a theoretical gravity model.

2.2.3 The Heckscher–Ohlin Model and the Linder Hypothesis

The Heckscher–Ohlin theorem states that under a set of assumptions, a country will export the good that relatively intensively uses its relatively abundant good, while it imports the good that relatively intensively uses its relatively scarce factor. The model assumes that factors of production are immobile across countries, while goods are not, so trade in goods is enough to lead to factor price equalization. Central to the Heckscher–Ohlin model is the equilibrium relations between goods prices, factor prices and factor inputs. The model argues that trade occurs due to differences in labour, labour skills, physical capital, natural capital, or other factors of production across countries.

Of the several implications of the model, the following three are particularly important in a Canada-US setting and are worth looking at closely: (i) factor prices equalize when endowments are similar between two countries (ii) countries specialize based on factor abundance and factor intensity (iii) countries always gain from trade while industries and factors may lose. Compared to developing countries, both economies are developed, with a relatively high proportion of their skilled labour force engaged in capital intensive goods production; at least compared to most primary production-based economies in the developing world. A very intuitive way to restate implication (i) above is that the ‘death’ of the US-Canada border will ultimately wipe out differences in wage or rental rates between both countries. While this may not be the exact case, we know it is close to reality when we focus on some specific industry sectors.

Leontief (1953) conducts the first major econometric test of the Heckscher–Ohlin theorem using 1947 US trade data. With the aid of input-output tables of US exports and import substitutes, Leontief concludes that contrary to the predictions of the model, the US – which was the most capital-abundant country in the world – actually exported labour-intensive commodities and imported capital-intensive commodities. This has since been labeled the Leontief Paradox. Over the years, several tests have shown that the Leontief Paradox became less pronounced, but has not completely disappeared.

Testing and estimating the Heckscher–Ohlin model is a complex and rigorous exercise. Krugman *et al.* (2012) conclude that except for when high-income countries trade with low or middle income countries (or when technology differences are included), empirical support of the Heckscher–Ohlin model is weak. A review in 2008 by the World Trade Organization (World Trade Report, 2008) concludes that most empirical attempts at testing the model are irrelevant because of the use of inappropriate methods. The review states further that when the right estimation strategy is adopted, there appears to be robust evidence on the effect of relative factor abundance on trade; albeit the trio of an integrated world, same technology, and absence of home bias assumptions need to be relaxed.

Again, the above underscores the importance of using a gravity approach in a Canada-US data environment. The following three reasons explain why. First, the model incorporates a distance variable which addresses the relaxation of an integrated world assumption. Second, the home bias argument advocated by McCallum, which focuses on the effect of formal and informal trade barriers as a result of national borders, is revisited. Regarding McCallum’s 22-to-1 factor conclusion, more recent studies (e.g.

Helliwell and Schembri, 2005) have shown that this bias is actually less. Apparently, the fact that McCallum's paper is based on a single year data (i.e. 1988) and 30 US states presents some challenges. Our work fills this lacuna by using all 50 states, with more detailed and current datasets.

The third issue of technological differences above is also important in our analysis because Canada has historically had a large gap in the level of technology per capita relative to the US. In a way, this partly explains the productivity gap between both countries. A study by Sharpe and Andrews (2012) concludes that nominal information and communications technology (ICT) investment growth in Canada in 2010 was 3.1 per cent, while the US had 7.1 per cent. In addition to that, all the three ICT investment components experienced slower growth in Canada.

Rao *et al.* (2008) use 31 industries to estimate Canada-US productivity, capital intensity and multifactor productivity gaps. Their results show that the labour productivity levels in Canada are much lower in the primary, manufacturing and services sectors, albeit Canada does well predominantly in the resource-based and transportation equipment industries. They reveal further that wide productivity gap exists in the machinery and computer, and electronics and electrical equipment industries, to the advantage of the US. Lee and Tang (2000) and Baldwin *et al.* (2008) also estimate and conclude that Canada's labour productivity level is considerably lower than that in the US; they conclude that the gap continues to widen. This result is always directly linked to multifactor productivity gap for the most part.

Both countries have remarkable supplies of skilled labour, physical capital stock, and natural resources; albeit Canada's natural resources are more abundant when compared to the US on a per capita basis. Many of both countries' important industries are based on the exploitation of these resources. With both exporting a significant chunk of their GDPs, the US relies on Canada's natural resources for products like timber and minerals, while Canada relies on the US for a variety of manufactured goods.

In a way, Rao *et al.*'s results above, just like many others in the literature (e.g. Leamer, 1995), remind us of the important implications of the Heckscher–Ohlin model for a similar country-pair like Canada and the US with notable differences in technology and resource endowments. This further justifies using our current panel framework to test the likely outcome of the Heckscher–Ohlin model. Though adequate natural resources data for all 50 US states and 10 Canadian provinces are difficult to come by for the years considered, nonetheless human and physical capital endowments data are incorporated in our study. This provides a more than enough robust setting to re-examine the Heckscher–Ohlin model.

Simply stated, the Linder hypothesis predicts that countries of similar income per capita would trade more intensely with one another. Unlike many others, the Linder hypothesis departs significantly from the neoclassical theories of trade by assuming trade is largely determined by supply conditions. This hypothesis emphasizes the structure of preferences as what determines bilateral trade flows; in order words, the presence of a large domestic market is a key factor in the choice of countries' export of goods (Bohman and Nilsson, 2006).

Helpman and Krugman (1985) push this further by incorporating the importance of specialization; according to them, "in the presence of increasing returns to scale, specialization is promoted and excess production is exported". Linder concludes that inequality, or the so-called negative correlation between per capita incomes and bilateral trade flows is caused by differences in taste; Helpman and Krugman attribute this to capital-labour ratio differential. The implication of this is that the higher the level of a country on the economic development ladder, the higher is the willingness to pay for product differentiation by its high income consumers.

The results in Bergstrand (1990) provide further evidence for the Linder hypothesis with the conclusion that the hypothesis holds due to the Heckscher-Ohlin-Samuelson supply induced reason, and Linder-type demand reason. We can relate to this in a Canada-US context. Per capita income is the most frequent measure of economic development across countries. According to the Conference Board of Canada (2014), Canada's income per capita trails that of the US and is about 84 per cent of the US level. This gap tripled between 1980 and 2012, to nearly $7,000. This provides enough justification to apply our robust panel data framework to test the Linder hypothesis.

Based on the analysis so far, it is hard to think of a more important pair of countries that are more economically, geographically, politically and culturally linked than Canada and the US. Thus, we conduct tests of the Heckscher–Ohlin theorem and Linder hypothesis on trade between both countries in order to determine whether their trade patterns conform to the predictions of these models, and if not, explain the likely reasons behind the divergence.

This chapter fits into the various discussions so far because it is an extension of the various issues bothering on the gravity model in general: the US-Canada border effect, the three empirical issues mentioned earlier, and a review of the Heckscher–Ohlin theorem and Linder hypothesis. This is interesting because previous studies on these issues have been largely done at the cross-country level, especially the Heckscher–Ohlin theorem and Linder hypothesis tests. This is notably because the necessary data and information at the sub-national level are often hard to come by.

From the foregoing review, it is apparent that our four different panel data sets provide a robust framework to examine the identified issues. By looking at jurisdictions that share many common characteristics in both countries, we empirically model bilateral trade flows making sure to control for many country-specific features that might obscure the key role of our key gravity variables.

2.3 Theoretical Setup, Variables and Data Sources

2.3.1 Gravity Model of Bilateral Trade

Newton's law of universal gravitation states that the gravitational attraction between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Tinbergen (1962) interprets the bodies as exporting and importing countries, while their masses represent their economic sizes. In other words, he describes the patterns of bilateral trade flows between two countries i and j to be proportional to their gross national products and inversely proportional to the square of the distance between them. Newton's law of universal gravitation between two bodies i and j is stated below:

$$F_{ij} = \frac{GM_iM_j}{D_{ij}^2} \quad (2.1)$$

where;

F = attractive force;

M = mass;

D = distance;

G = gravitational constant

Similar to the above, the gravity model of trade in its basic form assumes that only size and distance are important for bilateral trade in the following way:

$$X_{ij} = \frac{KY_i^{\alpha}Y_j^{\beta}}{T_{ij}^{\theta}} \quad (2.2)$$

where,

X_{ij}= exports from *i* to *j*; or total trade (i.e. $X_{ij} + X_{ji}$)

Y= economic size (GDP or population)

T = trade costs (given by distance)

K = constant of proportionality

2.3.2 Evolution of the Gravity Model

Theoretical support of the gravity model was limited initially, but since 1979 several theoretical developments have sprung up in support of it. After its specification by Tinbergen, the first theoretical foundation of the model was provided seventeen years later by Anderson (1979). By focusing on the properties of expenditure systems, with identical homothetic preferences across regions as a major assumption, Anderson provides a micro foundation for the model.

With the advent of the new trade theory a few years later, Armington's (1969) assumption of product differentiation by country of origin was replaced by the assumption of product differentiation among producing firms. In particular, Deardoff (1998) concludes that the gravity model can be derived from standard trade theories, thereby integrating views from both the traditional and new trade theories.

Over time, there has been a convergence[2] of opinions in the international trade literature that the gravity model can be derived from a host of other trade theories like: Ricardian comparative advantage model, Heckscher–Ohlin factor endowment theory, and Helpman-Krugman new trade theory, based on the exploitation of scale economies in imperfectly competitive markets. Evenett and Keller (2002) argue that perfect specialization is a common attribute of these models, and opine that along with the Heckscher-Ohlin-Vanek factor service trade model, the gravity model is one of the most important models of trade flows. The differences in these theories, in a way, serve as an added advantage for multiple specifications and availability of varieties in empirical results.

2.3.3 The Anderson and van Wincoop Framework

Based on Anderson and van Wincoop (2003), their gravity equation (i.e. Equation 13 in their paper) is given below as:

$$x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{t_{ij}}{P_i P_j}\right)^{1-\sigma} \qquad (2.3)$$

subject to Equation 2.4 below (i.e. Equation 12 in their paper):

$$P_j^{1-\sigma} = \sum_i P_i^{\sigma-1}\theta_i t_{ij}^{1-\sigma} \ \ \forall j \quad (2.4)$$

where x_{ij} represents exports from region *i* to region *j*, y_i and y_j are the GDP in regions *i* and *j*, y^W is world's GDP, t_{ij} represents bilateral trade barriers, P_i and P_j are price indexes for regions *i* and *j*, θ_i represents income share and σ is the constant elasticity of substitution between all goods.

Anderson and van Wincoop call the price indices multilateral resistance variables, and explain that after controlling for size, bilateral trade depends on the trade barrier

[2] Krugman (1980), Helpman and Krugman (1985), Bergstrand (1990), Markusen and Wigle (1990), Deardorff (1998), Anderson and van Wincoop (2003), Evenett and Keller (2002), Melitz (2003), and Helpman et al. (2007)

between i and j, relative to the product of their multilateral resistance indices. They also add that the model in (3) suggests that bilateral trade is homogenous of degree zero in trade costs, since the equilibrium multilateral resistances P_i are homogenous of degree ½ in trade costs.

The economic implication of this, according to Anderson and van Wincoop, is simple: despite higher trade costs, the constant vector of real products must be distributed. This delivers one of the most important insights from the theoretical gravity model of Anderson and van Wincoop; the proposition that trade between regions is determined by relative trade barriers. The next issue to which we turn is the comparative statics of this model.

Below is the linear gravity equation estimated by Anderson and van Wincoop:

$$\ln x_{ij} = k + \ln y_i + \ln y_j + (1-\sigma)\rho \ln d_{ij} + (1-\sigma)\ln b_{ij} - (1-\sigma)\ln P_i - (1-\sigma)\ln P_j \quad (2.5)$$

Our objective in this chapter is to analyze intranational and international bilateral trade flows using the Anderson van Wincoop model as a general framework. At this juncture, it is important to point to two caveats regarding both the theoretical model derived by Anderson and van Wincoop and the empirical model estimated in (2.5) above. First, in estimating a gravity model, it is important to take a closer look at the multilateral trade resistance – the barriers to trade that each region faces with all its trading partners. P_i and P_j are the multilateral trade resistances derived by Anderson and van Wincoop and are not observed. Even though they conclude that this method is more efficient than others in estimating multilateral resistances, data limitations preclude us from fully employing such a structural model.

Also, Anderson and van Wincoop's assumption of symmetric trade flows in the gravity model can potentially bias the estimates since this may not be consistent with the data. Even though the Anderson and van Wincoop model cannot be estimated fully, we nonetheless use it as a framework as best as we can. We employ an estimation strategy that effectively corrects the identified biases under section 2.4.

2.3.4 Methodological Issues and the Gravity Model

2.3.4.1 A Multiplicative Constant Elasticity Model

As discussed under our introductory remarks, recent empirical literature on the gravity model now focuses on the issue of estimation strategies, with emphasis on the following three: the existence of heteroscedasticity in trade data, zero trade flows, and unobserved heterogeneity. The gravity model is a multiplicative[3] constant elasticity model; thus likening the properties and accuracy of a physical model with an economic one creates many estimation problems. One of the important implications of Jensen's inequality, often ignored in many econometric estimations, is that in the presence of heteroscedasticity, the estimated elasticities of a log-linearized model will be biased when the ordinary least squares (OLS) method is used. This is because to log-linearize a constant elasticity model, some restrictions have to be placed on the error term. The two estimation strategies we adopt to resolve this are the Feasible Generalized Least Square (FGLS) and the Pseudo Poisson Maximum Likelihood (PPML) estimators. These are further explained below.

2.3.4.2 Feasible Generalized Least Square

The FGLS estimator is an alternative technique, applied to the linearized model to correct for heteroscedasticity. This estimator is a member of the least squares estimators' family and is an efficient estimator in the presence of heteroscedastic errors. It is computed using weighted least squares, whereby the squared OLS residuals are computed (z^2) and regressed on the explanatory variables and a constant. An analytical weight, computed as $1/ z^2$, is then used in the second step weighted least squares regression. Since it uses the square root of the variance of each observation as a weight, even when the weight is biased, the FGLS still results in consistent estimates provided the right method is used to retransform the model (Martinez-Zarzoro et al.,

[3] A type of nonlinear relationship that has firm grounding in economic theory. By implication, the effect of a change on any explanatory variable X_i on Y depends on the levels of the other X's in the equation.

2007). Martinez-Zarzoro *et al*. suggest the FGLS as the solution if we ignore the exact form of heteroscedasticity[4].

2.3.4.3 Pseudo Poisson Maximum Likelihood

As stated under equation 2.3 above, the nonlinear form of the Anderson and Van Wincoop gravity model comes with a multiplicative error term. Taking logarithms helps achieve linearization of the standard gravity model; however, we face an unintended consequence – the error term is in logarithms as well. A situation in which errors are heteroskedastic, which is the case in most cases, means we rely on one or more of the explanatory variables to determine the expected value of the error term . This therefore makes the OLS an inconsistent and biased estimator.

Santos Silva and Tenreyro (2006) examine the performance of the PPML and conclude that it is a heteroscedasticity-consistent estimator, albeit it assigns the same weight to all observations. They, however, conclude that in the absence of any further information on the pattern of heteroscedasticity, the PPML is the most appropriate procedure and would provide consistent estimates provided that the conditional mean is correctly specified.

Santos Silva and Tenreyro estimate the Anderson and Van Wincoop model and find that there are significant differences between estimates obtained using traditional OLS methods and the PPML estimation technique. Santos Silva and Tenreyro suggest that the PPML method aids in the estimation of constant-elasticity models in their multiplicative forms, and this effectively takes care of the issue of heteroscedasticity, in addition to the zero trade flows problem for the dependent variable in trade data. The literature generally agrees that the PPML method is capable of resolving both issues, albeit some authors qualify such generalization.

For instance, while Martinez-Zarzoro *et al.* and Martin and Pham (2008) agree that the PPML is effective in dealing with heteroscedasticity, they are of the opinion that it does a better job when used to resolve zero trade issues in data sets with relatively few zero observations. For us, this is good news. With only 51 zero trade flows data in our

[4] The is because the FGLS is robust to any form of heteroscedasticity, in addition to being able to weigh the observations in our data sets based on the square root of their variances.

13,781 observations, the PPML should provide very robust estimates. Another advantage is that many econometric packages have programs designed to implement the PPML.

2.3.4.4 The Fixed Effects Model and Unobserved Heterogeneity

The effects of size and trade costs on trade flows patterns can suffer from misinterpretation if the issue of unobserved heterogeneity is not adequately resolved. We therefore use the fixed effects model (FEM) to control for heterogeneous trading relationships. Using Canada-US trade data, Wall (2000) claims that those trying to explain the sources of the border effects using the standard gravity model need to be aware of its tendency to provide biased estimates. As an alternative, he uses a heterogeneous gravity model in place of the standard gravity model to correct for heterogeneity bias. The results show that the home bias is 40 per cent larger, the asymmetry of the border is reversed, and all provincial differences are altered significantly. The FEM is discussed in detail under section 2.4.1 on model specification.

2.3.5 Data and Variables

Our data are compiled from seven main sources: Statistics Canada (Input-Output Division, National Economic Accounts, and Provincial Economic Accounts), Industry Canada (Trade Data Online(TDO), US Bureau of Economic Analysis (Regional Economic Accounts), US Census Bureau, the Commodity Flow Survey (CFS), Bank of Canada (Rates and Statistics – Annual Average Exchange Rates) and the distance data website: http://www.worldatlas.com/aatlas/infopage/howfar.htm.

We discuss the data sources and construction of our variables below:

2.3.5.1 Bilateral Trade Flows

Our preferred measure of bilateral trade is the log of bilateral exports or imports in current dollars from jurisdiction i to j. We exploit a large annual panel data set covering all 10 Canadian provinces and 50 US states for 1997, 2002 and 2007. We do not average the trade flows data, but instead use unidirectional bilateral exports or imports, leaving five years between our observations to avoid the problem of biased fixed effects estimators: this occurs when dependent and independent variables do not fully adjust over a single year for data pooled over consecutive years.

There are at least two ways in which estimated fixed effects are important in this chapter. First, we are interested in estimates of the relative magnitude of the fixed effects for the jurisdictions; at least to the extent that such cardinal ranking is important for the interpretation of the results and resulting policy implications. Also, fixed effects are known to soak up a significant portion of the explanatory power of explanatory variables that are relatively time-invariant. One consequence of this is that even when such variables are economically significant, they may appear to be statistically insignificant. The five-year intervals in 1997, 2002 and 2007 help overcome these issues.

Since the gravity model is an expenditure equation which explains the value of spending by one jurisdiction on the goods produced by another jurisdiction, using averages will lead to difficulty in interpreting the coefficients of the regressions (Baldwin and Taglioni, 2006). In all, data on the 60 jurisdictions are pooled for 1997, 2002 and 2007.

Our interprovincial trade data are compiled from the matrix of interprovincial trade produced by the Input-Output Division of Statistics Canada. These data sets are available (in current and producer prices) under CANSIM Tables 386-002 and 386-003. For our three specific years, estimates of trade flows from each province to the other nine provinces are provided. Interprovincial trade flows data are in Canadian dollars, and these are converted back to US dollars by adjusting with the average annual US-CDN exchange rate for each year. This amounts to nine bilateral trade relationships for each province, and when computed for all 10 provinces, this results in 90 relationships each year. We then multiply this with three years for a total of 270 observations on interprovincial trade.

The Commodity Flow Survey (CFS), undertaken through a partnership between the US Census Bureau and the Bureau of Transportation Statistics is conducted every 5 years as part of the Economic Census. The CFS produces data on the movement of goods in the US. It provides information on commodities shipped, their value, weight, and mode of transportation, as well as the origin and destination of shipments of commodities from manufacturing, mining, wholesale, and selected retail and services establishments. Estimates of trade flows in US dollars from each state to the other 49 states are provided. This amounts to 49 bilateral trade relationships for each state, and when computed for all 50 states, this results in 2,450 relationships each year. We then multiply 2,450 with the five years for which data are available (1997, 2002 and 2007 for exports, and 1997 and 2002 for imports) for a total of 12,250 observations on interstate trade.

To generate the dependent variable, our interprovincial and interstate trade flows are supplemented with a third data source which provides estimates of exports from each Canadian province to each US state and imports from a US state to each of the 10 Canadian provinces. Collected on a province of origin basis, Statistics on Canadian domestic exports indicate the province (or territory) in which the goods were grown, extracted or manufactured. This may not always coincide with the province where the goods were cleared by Customs. According to Trade Data Online (TDO), Canadian import statistics are collected by the province of clearance; that is, the province (or territory) in which goods were cleared by Customs either for immediate consumption in Canada or for entry into a bonded Customs warehouse. This may also not always coincide with the province in which they are consumed. These data are sourced from Industry Canada: TDO; a database which provides the ability to generate customized reports on Canada's trade in goods with over 200 countries.

Only data on trade in goods are available in TDO, data on trade in services are not included. For consistency, our interprovincial trade flows comprise of trade in goods only, trade in services is excluded. There are 50 bilateral relationships for each province-state pair (or state-province), resulting in 500 observations for all 10 provinces. With both exports and imports data included for the three years considered, this amounts to a total of 3,000 observations.

All bilateral trade relationships therefore result in 15,520 observations, out of which there are 1,739 outright incidences of missing data; with the US-US subsample accounting for 1,738 and one for the Canada-US subsample. This leaves us with a total number of 13,781 observations, out of which there are 51 zero trade flows[5]. All 51 zero trade flows are contained in the US- US subsample; none in the US-Canada and Canada-Canada subsamples. We do not delete these zeros in order to test the robustness of our estimation techniques, which aim at using standard econometric techniques to deal with the issue of zero trade flows.

A variety of reasons can be responsible for missing data. For instance, there are proprietary concerns when a single firm dominates a particular industry and this often leads to data suppression for confidentiality reasons. Also, since the CFS data are derived from a sample survey and may differ from the actual, unknown values for the entire population of businesses they represent, data users are often cautioned to take into account both the measures of sampling error and the potential effects of non-sampling error when using the CFS estimates (US Department of Transportation, 2014). When such errors significantly affect the reliability of the CFS estimates, the corresponding data are reported as missing.

2.3.5.2 Economic Size

Since larger economies produce more goods and services in order to have more to sell in the export market, the size of an economy will be positively related to the volume of trade flows. Also, larger economies generate more income from the goods and services sold, so people are able to buy more imports. This explains why GDP is an important proxy for economic size in the empirical gravity model. GDP in current[6] (Canadian) dollars data for all 10 Canadian provinces are obtained from Statistics Canada (National Economic Accounts – CANSIM Table 384-0002).

Like the interprovincial trade data, we convert back to US dollars by adjusting with the average annual US-CDN exchange rate for each year. Bilateral US-Canada real exchange rates data come from the Bank of Canada (Rates and Statistics – Annual Average Exchange Rates). US data on GDP in current (US) dollars for all 50 states are

[5] Zero trade flows are completely different from missing data. While missing data do not show up at all in our datasets, absence of trade between a jurisdiction-pair is reported under our bilateral trade flows variable as zeros.

[6] Neither the GDP nor trade data are deflated. The reason for this is simple: the gravity model is an expenditure function which merely allocates nominal GDP into nominal imports. As explained by Baldwin and Taglioni (2006), the problem of spurious correlation might occur when the price deflators are correlated as a result of international inflation.

obtained from the US Bureau of Economic Analysis (Regional Economic Accounts). As done for their Canadian counterparts, we obtain data on population for all 50 states from the US Census Bureau and apply these on GDP to get per capita GDP data.

2.3.5.3 Distance

Based on the gravity model, the bilateral trade between two regions is inversely proportional to the geographic distance between them. Despite the large number of papers that have controlled for distance while examining the determinants of bilateral trade flows, the distance effect is not definitive till date. Following Glick and Rose (2002), we model distance as the logarithm of the distance between two cities *i* and *j*. Data on road distances are measured in kilometers based on the capital city of each jurisdiction, and are obtained from the distance data website which uses Google Maps: http: www.worldatlas.com/aatlas/infopage/howfar.htm. In addition to Google Maps, this site incorporates a supplementary list of cities from around the world to find the latitude and longitude of the two jurisdictions[7].

2.3.5.4 Per Capita Income Differential

In order to explain the trade flow patterns observed between a particular region pairs, we include the per capita income for each region. In particular, this variable will enable us to re-examine the Linder hypothesis. As discussed in section 2, the Linder hypothesis maintains that the structure of preferences is the major determinant of trade flows between regions. Therefore, closer levels of per capita income will translate into similar preferences; similar but differentiated products, and therefore, more intensive trade for regions. Linder therefore suggests that per capita income is a reasonable proxy for preferences.

To test this hypothesis, we include the log of the absolute value of the difference in per capita incomes between a bilateral trading pair. We obtain data on population for all 10 provinces from Statistics Canada (CANSIM Table 051-0001) and then apply these to the GDP data discussed above to generate data on per capita GDP.

[7] The appendix section contains the full list of cities used for the 60 jurisdictions.

2.3.5.5 Factor Endowment Differences

Factor endowments remain an important determinant of the trade patterns of nations. The Heckscher–Ohlin model of international trade underscores the importance of factor endowments in influencing the intensity of trade between any two countries, as previously explained. In order to justify the choice of each factor endowment proxy included in this chapter, we quickly cite two important papers below.

Ghosh and Yamarik (2004) use differences in per capita land, educational attainment and capital-labour ratios as proxies for factor endowments. They find in their regressions that these variables are positively related to bilateral trade flows and are robust to the inclusion of other variables in their dataset. Likewise, Romalis (2004) uses detailed trade data to establish a strong support for two predictions: (i) countries capture larger shares of world production and trade of commodities that use their abundant factors more intensively (ii) when countries rapidly accumulate a production factor, they see their production and export structures systematically shift towards industries that intensively use that factor.

To get at the Heckscher–Ohlin theory appropriately, we follow Ghosh and Yamarik by measuring the endowments of two factors of production: human capital and physical capital. Comparable per capita land data for our 60 jurisdictions are difficult to come by, so we leave this component of factor endowment. Measurement details of the two factor endowment proxies are summarized below:

2.3.5.6 Human Capital Stock

Estimates of educational attainment provide a reasonable proxy for the stock of human capital and should be useful for a variety of empirical work (Barro and Lee, 2012). Blundell et al. (1999) categorize human capital into three main components — early ability (whether acquired or innate); qualifications and knowledge acquired through formal education; and skills, competencies and expertise acquired through training on the job. We use educational attainment as a proxy for human capital. In a broad sense, the US Census Bureau defines educational attainment as the highest level of education that an individual has completed, and distinguishes this from the level of schooling that an individual is attending.

In this chapter, educational attainment is defined as the percent of persons 25 years and over who have completed at least a Bachelor's degree. The use of the 25+ population is plausible since it focuses on adults age 25 years and over, when education has been completed for most people. Educational attainment is closely related to the skills and competencies of a country's population, and could be seen as a proxy of both the quantitative and qualitative aspects of the stock of human capital. EDU_{itj}, our measure of the difference in the educational attainment between jurisdictions *i* and *j* at time *t*, is constructed as follows:

$$EDU \ = \frac{(persons\ 25 + with\ a\ Bachelor's\ degree\ or\ more)}{population\ of\ 25 +} \quad (2.6)$$

Data on educational attainment for all Canadian provinces come from Statistics Canada’s Labour Force Survey (LFS), CANSIM Table 282-0004. Corresponding educational attainment data for all 50 US states are obtained from the US Census Bureau, American Community Survey (ACS). ACS is an ongoing statistical survey sent to approximately 250,000 addresses monthly. It provides estimates of educational attainment for US states on an annual basis from 2000 onwards; prior to this time, only 1990 data are available.

As stated in chapter 1, while our analysis in this chapter is based on 1997, 2002 and 2007 for all 10 Canadian provinces and 50 US states, chapters 3 and 4 cover the 1987-2010 period. We therefore deploy a simple and consistent methodology to derive data for the missing 1987-1989 and 1991-1999 periods. First we calculate the average annual growth rate based on the available 2000-2010 educational attainment data for all 60 jurisdictions. This gives us 0.44 percentage points per annum. Generally speaking, we expect all 60 jurisdictions to record higher gains in the percent of persons 25 years and over who have completed at least a Bachelor's degree in the 1991 – 1999 period, compared to the 1987-1989 period. The reason is simple: universities in most countries have witnessed increased enrolments in the last three decades (Conference Board of Canada, 2014; and National Center for Education Statistics, 2014).

Following this logic, we assume 0.15 and 0.3 percentage points gains in yearly educational attainment for the 1987-1989 and 1991-1999 periods, respectively. This empirical strategy does not constitute a limitation because, as defined above, the "percent of persons 25 years and over who have completed at least a Bachelor's degree" is a proportion and does not change significantly – year over year.

2.3.5.7 Physical Capital Stock

The variable of interest here is CAP_{it} , our measure of the capital stock endowments in jurisdiction *i* at time *t*. CAP_{it} is the ratio of capital stock to real GDP[8]. First, we use gross private capital as a percentage of GDP for US states and gross business fixed capital formation as a percentage of GDP for Canadian provinces. Next, and following Yamarik (2011) and Hall and Jones (1999), we construct our capital stock series using the perpetual inventory method (PIM)[9] below:

$$K_t = K_{t-1} - \partial K_{t-1} + GFK_t = (1-\partial)K_{t-1} + GFK_t \quad (2.7)$$

where K_t is capital stock level at time *t*, GFK_t is gross fixed capital formation at time *t* and δ is the rate of depreciation (which is assumed constant over time). The PIM assumes a geometric declining pattern (Baldwin *et al*., 2008). In order to implement the PIM, the size and time profile of depreciation rates, gross investment time series and an initial level of capital stock are required. After creating our capital stock from gross fixed capital formation using equation 7, we then construct the initial capital stock series using Hall and Jones' formula below:

$$K_0 = \frac{GFK_0}{\partial + g_{GFK}} \quad (2.8)$$

[8] The real GDP data used are from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA). For 1997 forward, BEA reports real GDP by state based on the North American Industry Classification System (NAICS). From 1977 through 1997, BEA reports real GDP by state based on the Standard Industrial Classification (SIC). A set of quantity indexes for real GDP by state (1997=100) is available for 1977 through 1997. Given the differences in NAICS and SIC, BEA has cautioned against appending the two data series in an attempt to construct a single time series. However, this caveat does not impact our results since our measure is the ratio of capital stock to real GDP, in addition to the fact that the discontinuity in the methodology affects all 60 jurisdictions in our sample.

[9] This method is popular because it provides a seamless means of calculating the stock of fixed assets whenever direct information is missing.

where K_0 is the initial capital stock, GFK_0 is the level of gross fixed capital formation in the initial period, g_{GFK} is the average annual geometric growth rate of GFK, and δ is as previously defined. We assume in this study that capital stocks depreciate at a constant rate of 6%, in line with Hall and Jones.

Canadian provincial capital stock data are calculated using the PIM discussed above. We use GFK data for estimating the initial capital stock. Our g_{GFK} value[10] is taken as 3.6% – based on the average of Statistics Canada's old and new capital stock annual growth rates. Equivalent capital stock data for US states are based on Yamarik's net private capital stock data[11] constructed for the 50 states.

Considering that Yamarik's data are available only up to 2007, we assume that capital stock and GDP grew at the same rate for the 2008 - 2010 period. We therefore use the growth rates of real GDP to derive the capital stock figures for 2008, 2009 and 2010. Corresponding Canadian provincial capital stock data are calculated using the PIM discussed above. In order to generate a series comparable to Yamarik's net private capital stock, at least as much as possible, we use business gross fixed capital formation – the private sector portion of total GFK.

According to the Organization for Economic Cooperation and Development, this is measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non- produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realized by the productive activity of institutional units. To a large extent, this captures the private sector share of total capital formation. As a check, we compare the capital stock and real GDP series for all 60 jurisdictions and find that jurisdictions with the highest real GDPs (e.g. California and Ontario) have corresponding highest capital stock values, while those with the lowest GDPs (e.g. Prince Edward Island and Vermont) have corresponding lowest capital stock figures.

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[10] Statistics Canada uses 3.58% and 3.65% as the old and new capital stock annual growth rates, respectively.

[11] https://web.csulb.edu/~syamarik/

2.3.5.8 Border Effects

In addition to sharing the world's longest border, Canada and the US have the world's longest undefended border – with a length of 8,893 kilometers. While it may not be correct to conclude that borders constitute significant barriers to trade that should be removed, research shows that the intensities of economic exchange within and across borders are remarkably dissimilar for one simple reason: economic linkages are much tighter within, than among nation-states. This refers to the home bias argument.

This chapter uses the indicator variable of common borders attributed to Glick and Rose (2002), which is unity if a jurisdiction-pair shares a border and zero for lack of common border. As discussed in the preceding section, both international and within-country border effects exist. Therefore, the border effects here refer to both national and state/provincial borders. We expect to gain valuable insights on the border effect for province-province pairs like Alberta-British Columbia and Quebec-Ontario in Canada, state-state pairs like Texas-New Mexico and Oregon-Washington, and province-state pairs like Ontario-Michigan and Saskatchewan-North Dakota.

2.3.6 Research Hypotheses

Following the literature framework and theoretical issues discussed so far, we advance the following hypotheses to help address the research questions posed:

Hypothesis 1

> H_0: There is no relationship between economic size and bilateral trade flows between trading partners.
>
> H_1: There is a positive effect of economic size on bilateral trade flows between trading partners.

Intuitively, this hypothesis emphasizes the role of income level as a determinant of trade; it asserts that after controlling for other important factors, countries with higher income levels will trade more.

Hypothesis 2

H_0: There is no relationship between geographical distance and bilateral trade flows between trading partners.

H_1: There is a negative effect of geographical distance on bilateral trade flows between trading partners.

Indeed, the inverse relationship between distance and trade is one of the most robust findings in international economics. Among other things, this helps us understand the nature of distance as a trade barrier which not only inhibits trade flows, but also creates negative welfare consequences.

Hypothesis 3

There is a negative effect of the border on bilateral trade flows. We exploit the variation across state-state, province-province and state-province trade flows to estimate the border effects, while controlling for other factors. To examine this within the context of the discussion so far, we advance two lower-level versions for Hypothesis 3 below:

Hypothesis 3a

H_0: There is no distinction in the effect of the border on state-province trade, compared to interstate and interprovincial trade between trading partners.

H_1: There is a stronger negative effect of the border on state-province trade, compared to interstate and interprovincial trade.

International borders represent large barriers to trade. Can we say the same about within-country borders? For instance, it is expected that if the border is truly a deterrent to trade, Canadian provinces should trade more with each other than U.S. states. We investigate international and within-country bother effects in a unified framework.

Hypothesis 3b

H_0: There is no distinction in the effect of the border on interprovincial trade, compared to interstate trade

H_1: There is a stronger negative effect of the border on interprovincial trade, compared to interstate trade

Hypothesis 3a implies that the influence of the border on trade is substantially less for interstate trade, compared to interprovincial trade.

Hypothesis 4

H_0: There is no relationship between factor endowment differentials and bilateral trade flows.

H_1: There is a positive relationship between factor endowment differentials and bilateral trade flows.

In other words, jurisdictions should trade more, the more different their factor endowments. A positive sign supports the Heckscher-Ohlin factor endowment proposition, while a negative sign refutes it. The Heckscher-Ohlin theory predicts that country pairs should trade more, the more different are their factor endowments. Again, Canada and the US have similar human and physical capital endowments, so we expect a positive sign on the Heckscher-Ohlin variables to support the proposition.

To the extent that differences in per capita income are correlated with differences in factor endowments, it is possible for smaller differences to produce lower bilateral trade – especially intra-industry trade that depends on existing comparative advantages. It is therefore possible to also test the Heckscher-Ohlin proposition through the sign on the per capita income differential variable. A positive sign will support the Heckscher-Ohlin hypothesis; a negative sign, as discussed below, would support the Linder hypothesis.

Hypothesis 5

H_0: There is no relationship between per capita income differentials and bilateral trade flow.

H_1: There is a negative relationship between per capita income differentials and bilateral trade flows.

The Linder hypothesis explains the effects of quality differences on the direction of trade flows – a stark contrast to the standard Heckscher-Ohlin proposition. Linder's approach provides an alternative explanation of trade flows, consistent with Leontief's findings. Similar levels of per capita income produce similar tastes, which lead to the production of similar but differentiated products that result in higher bilateral trade flows between jurisdiction-pairs. A negative sign on the Linder coefficient term will support the Linder-hypothesis, while a positive sign will refute it. Canada and the US have similar economies because they are both developed countries and are each other's largest trading partners. This further leads to closer levels of per capita income and similar preferences, similar but differentiated products, and therefore more intensive trade for regions. We expect a negative sign to support the Linder-hypothesis.

2.3.7 Descriptive Statistics

As stated under the introductory section, the volume of trade between Canada and the US is the largest between any two countries in the world, and both countries are each other's biggest trading partners. Figure 2.1 depicts this succinctly, with other countries included for context and better comprehension. Table 2.1 shows total exports and imports between each of the four Canadian regions and the US for 1997, 2002 and 2007. The resulting percentages are interesting. For example, exports from each Canadian region to the US (as a percentage of total exports) increased between 1997 and 2002, generally speaking. Beyond 2002, these percentages trended downward for each of the four regions.

It is evident from Table 2.1 below that Canada's manufacturing heartland, Central Canada, had the largest export shares for each of 1997, 2002 and 2007. British Columbia (B.C.) and the territories had the lowest export shares for the three periods considered. This may be partly explained by B.C.'s strategic location as Canada's western continental coastline on the Pacific Ocean, leading to significant trade with other Asia Pacific countries. Unlike export shares, Table 2.1 shows fluctuations in import shares of the US for each region's total imports.

Table 2.1: Canadian Regional Trade with the US

Panel A: Exports to the US as a Percentage of Total Exports

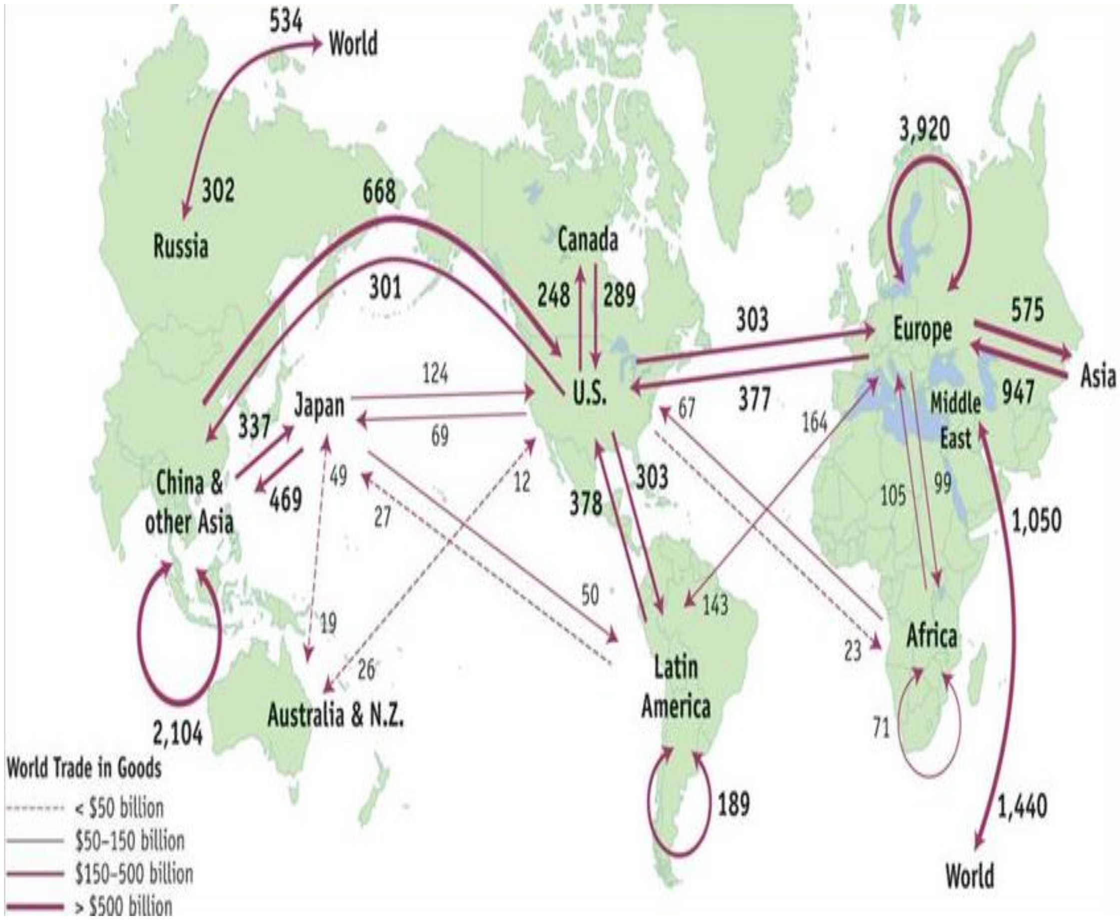
	1997	2002	2007
Atlantic Canada	73.2%	82.9%	81.0%
Central Canada	88.1%	90.9%	81.3%
Prairies	73.3%	82.6%	79.6%
British Columbia & Territories	55.2%	66.6%	56.5%

Panel B: Imports from the US as a Percentage of Total Exports

	1997	2002	2007
Atlantic Canada	20.5%	22.8%	14.8%
Central Canada	70.5%	66.0%	55.5%
Prairies	79.8%	75.6%	75.8%
British Columbia & Territories	49.9%	37.6%	41.2%

Note: Canada comprises of five regions. Newfoundland, New Brunswick, Prince Edward Island and Nova Scotia are collectively referred to as Atlantic Canada. Central Canada is made up of Quebec and Ontario. Manitoba, Saskatchewan and Alberta are all together called the Prairies. B.C. (which borders the Pacific Ocean) is called the West Coast, while Canada's northern region, called the Territories, comprises of Nunavut, the Yukon and the Northwest Territories. For reasons related to data, B.C. is often combined with Nunavut, the Yukon and the Northwest Territories, as one entity.

Figure 2.1: Global Trade in Merchandise Goods, 2010 ($Billions)



Source: Essentials of International Economics, 3e. Feenstra/Taylor

In general, imports from the US trended downward, with the Prairies recording the highest shares, while the Atlantic provinces had the lowest import shares from the US The economic structure of the Atlantic provinces – which traditionally rely on the resource sector, including fishing, farming, forestry and mining – may be attributed to the low import shares.

Summary statistics for the full sample, Canada-US subsample, Canada-Canada subsample and US-US subsample are displayed in levels in Tables 2.2 and 2.3 below. The data in levels show some interesting trends. While the average trade flow in the full sample is about $1.8 billion, average trade flow differs significantly across the other subsamples: $401 million for Canada-US trade, $1.1 billion for Canada-Canada trade

Table 2.2: Summary Statistics of Gravity Variables (Full and International Samples)

Panel A: Full Sample

Measure	EXP_{ijt} (\$M)	GDP_{it} (\$M)	GDP_{jt} (\$M)	DST_{ij} (KM)	PCD_{ijt} (\$)	EDU_{ijt} (p.p.)	CAP_{ijt} (p.p.)
Mean	1,814	197,119	217,767	2,292	6,827	6	26
Median	419	124,391	137,145	1,922	5,364	5	12
St. Dev.	3,893	241,531	258,425	1,580	5,868	4	31
Minimum	0	2,800	2,800	30	0	0	0
Maximum	64,156	1,870,916	1,870,916	11,727	41,809	26	165

Panel B: Canada-US Sample

Measure	EXP_{ijt} (\$M)	GDP_{it} (\$M)	GDP_{jt} (\$M)	DST_{ij} (KM)	PCD_{ijt} (\$)	EDU_{ijt} (p.p.)	CAP_{ijt} (p.p.)
Mean	401	119,791	219,412	2,961	7,972	10	76
Median	40	36,559	134,053	2,745	6,143	9	70
St. Dev.	1,847	146,898	267,938	1,618	7,044	5	29
Minimum	0	2,800	14,556	233	15	0	8
Maximum	46,411	583,946	1,870,916	11,727	41,809	26	165

Notes: The full sample and US-US subsample (which both contain 51 zero trade flows) have 13,781 and 10,553 observations, respectively. The Canada-Canada and Canada-US subsamples contain 270 and 2,958 observations, respectively. EXP_{ijt}, GDP_{it}, GDP_{jt}, DST_{ij}, PCD_{ijt}, EDU_{ijt} and CAP_{ijt} stand for bilateral trade flows, Gross Domestic Product, bilateral distance, per capita income differential, educational attainment differential and capital stock differential. The unit of measurement for educational attainment differential and capital stock differential is percentage point (p.p.). The two bilateral partners are represented by *i* and *j*, and *t* represents the time period.

Table 2.3: Summary Statistics of Gravity Variables (Intranational Samples)

Panel A: Canada-Canada Sample

Measure	EXP_{ijt} (\$M)	GDP_{it} (\$M)	GDP_{jt} (\$M)	DST_{ij} (KM)	PCD_{ijt} (\$)	EDU_{ijt} (p.p.)	CAP_{ijt} (p.p.)
Mean	1,140	118,247	118,247	2,888	9,044	4	32
Median	300	35,451	35,451	2,582	6,583	3	26
St. Dev.	2,496	146,691	146,691	1,800	8,118	2	24
Minimum	2	2,800	2,800	326	68	0	0
Maximum	19,321	583,946	583,946	7,095	39,927	12	93

Panel B: US-US Sample

Measure	EXP_{ijt} (\$M)	GDP_{it} (\$M)	GDP_{jt} (\$M)	DST_{ij} (KM)	PCD_{ijt} (\$)	EDU_{ijt} (p.p.)	CAP_{ijt} (p.p.)
Mean	2,228	220,812	219,853	2,090	6,449	5	11
Median	676	140,378	139,202	1,748	5,137	4	9
St. Dev.	4,235	259,211	257,465	1,506	5,362	4	9
Minimum	0	14,556	14,556	30	0	0	0
Maximum	64,156	1,870,916	1,870,916	9,656	37,355	22	67

Notes: The full sample and US-US subsample (which both contain 51 zero trade flows) have 13,781 and 10,553 observations, respectively. The Canada- Canada and Canada-US subsamples contain 270 and 2,958 observations, respectively. EXP_{ijt}, GDP_{it}, GDP_{jt}, DST_{ij}, PCD_{ijt}, EDU_{ijt} and CAP_{ijt} stand for bilateral trade flows, Gross Domestic Product, bilateral distance, per capita income differential, educational attainment differential and capital stock differential. The unit of measurement for educational attainment differential and capital stock differential is percentage point (p.p.). The two bilateral partners are represented by *i* and *j*, and *t* represents the time period.

and $2.2 billion for US-US trade. This shows that the average bilateral sub-national trade for each of Canada and the US is much higher than the average bilateral trade between jurisdictions within both countries.

Also, the average bilateral distance between a trading pair in Canada (2,888 km) is higher than in the US (2,090 km). This may be partly explained by the higher population density in the US (30.71 sq. km), compared to Canada's 3.0 sq. km. The average bilateral distance of 2,961 km for the Canada-US sample also shows that trade between both countries involves a larger distance than sub-national trade, on average.

2.4. Estimation Methods

2.4.1 Model Specification

Following Equation 2.2, below is the basic gravity model:

$$X_{ij} = \frac{KY_i^{\alpha}Y_j^{\beta}}{D_{ij}^{\theta}} \quad (2.9)$$

where X_{ij} is exports and imports from *i* to *j*, Y= GDP and D is bilateral distance. The basic intuition in the above is that the larger and closer to each other, the more likely it is that two jurisdictions are likely to trade.

Log-linearizing and employing our standard notations, we have:

$$\ln(EXP_{ijt}) = \alpha_0 + \alpha_1 \ln(GDP_{it}) + \alpha_2 \ln(GDP_{jt}) + \alpha_3 \ln(DST_{ij}) + \varepsilon_{ijt} \quad (2.10)$$

The basic version of the model above takes into account only the standard factors, as suggested by the literature. However, we know that there are other factors stimulating or hindering bilateral trade flows, beyond economic size and distance. Aside from distance, which is often the major proxy for trade costs, other spatial exogenous barriers that drive up transport costs are also expected to affect bilateral trade. For instance, sharing a common border and language or even the removal of non-spatial trade barriers – e.g. trade liberalization – will significantly affect bilateral trade flows.

As discussed under the variables section, it is also common to include factor endowment controls, as the availability of skilled labour or abundant natural resources and capital stock can directly and indirectly affect trade relations. The Heckscher–Ohlin model explains the reasoning behind this. Equally, the stage of economic development can determine the patterns of bilateral trade flows, and this is often proxied by per capita income in most tests of the Linder hypothesis. We therefore use the extended version of equation 10 above to control for three additional factors including: contiguity, factor endowment and per capita income differential.

Our model could be further augmented to incorporate cultural and linguistic proximity, institutional quality, and historical links, but considering the many similarities between Canada and the US in these areas, we decide to leave these out.

Our extended gravity model is presented below:

$$\ln(EXP_{ijt}) = \alpha_0 + \alpha_1 \ln(GDP_{it}) + \alpha_2 \ln(GDP_{jt}) + \alpha_3 \ln(DST_{ij}) + \alpha_4 \ln(PCD_{ijt}) + \alpha_5 \ln(CAP_{ijt}) + \alpha_6 \ln(EDU_{ijt}) + \alpha_7 BDR_{ij} + \varepsilon_{ijt} \qquad (2.11)$$

In order to effectively deal with the issue of zero trade flows, the PPML method estimates bilateral trade flows in three functional forms: X_{ij}, $\ln(X_{ij})$ and $\ln(1 + X_{ij})$. A detailed explanation is provided under the estimation strategy in the next section.

In the presence of unobserved heterogeneity, different amounts would be exported by the same region to two different regions with the same GDPs and same bilateral distance. This may be due to some common factors which affect bilateral trade flows, and are also correlated with the two standard gravity variables – i.e. GDP and distance. The intercept for each jurisdiction-pair includes the effects of all omitted variables that are specific for each year but remains constant over time; such include distance, border effect, culture, and language (Cheng and Wall, 2005). With the omission of individual effects, OLS estimates will be biased when individual effects are correlated with the independent variables. As an alternative, we use the FEM in our panel data environment to account for such heterogeneity bias. With a FEM though, all time-invariant variables drop out as the inherent transformation wipes out such variables. We therefore do not include the DST_{ij} and BDR_{ij} variables since they are time invariant[12].

With this in mind, our extended FEM is specified below:

$$\ln\left(EXP_{ijt}\right) = \alpha_1 \ln(GDP_{it}) + \alpha_2 \ln\left(GDP_{jt}\right) + \alpha_4 \ln\left(PCD_{ijt}\right) + \alpha_5 \ln\left(CAP_{ijt}\right) + \alpha_6 \ln\left(EDU_{ijt}\right) + \alpha_7 \text{JUR}_{it} + \alpha_8 \text{TIM}_{it} + \varepsilon_{ijt} \qquad (2.12)$$

All variables and notations are defined below:

i = exporting jurisdiction; j = importing jurisdiction; and t = time period

α_{ij} = specific jurisdiction-pair effect between the bilateral trading partners

EXP_{ijt} = export flows from jurisdiction i to jurisdiction j at time t.

GDP_{it} = gross domestic product of jurisdiction i and in period t

GDP_{jt} = gross domestic product of jurisdiction j in period t

DST_{ij}, = distance between the exporting and importing jurisdiction

PCD_{ijt} = per capita income differential between jurisdictions i and j in period t

CAP_{ijt} = capital stock endowment differential between jurisdictions i and j in period t

EDU_{ijt} = educational attainment differential between jurisdictions i and j in period t

BDR_{ij} = contiguity dummy; unity if i and j share a land border and zero otherwise

JUR_{ijt} = specific jurisdiction-pair effect between the bilateral trading partners

TIM_{ijt} = specific time effect between the bilateral trading partners

ε_{ijt} = a normally distributed idiosyncratic error term, with mean 0 and variance σ_ε^2. The error term captures all other omitted effects on trade and is assumed to be well-behaved.

Based on Equation 2.11 and the explanations from section 2.3.5 above, our hypotheses are based, a priori, on the signs of the following parameters: we expect positive signs for

[12] The fixed effects model is discussed in details under estimation strategy below.

$\alpha_1, \alpha_2, \alpha_5, \alpha_6$ and α_7, and a negative sign for α_3 and α_4. A negative sign on α_4 will support the Linder-hypothesis, while a positive sign will refute it. For α_5 and α_6, a positive sign supports the Heckscher-Ohlin factor endowment proposition, while a negative sign refutes it.

In Tables 2.4 and 2.5 below, we present the summary statistics and correlation matrix for all the variables included in the estimated models. A cursory look at the correlation matrix shows that multicollinearity is not a problem because all the regressors have relatively small correlation coefficients.

2.4.2 Estimation Strategy

Now that we have agreed on the specification framework to be employed, the next issue to which we turn is the performance of the different estimation techniques. This has become necessary because recent literature in this field now focuses on all three[13]: unobserved heterogeneity, log- linearization in the presence of heteroscedasticity, and the problem of estimating the logarithm of zero trade flows. All of these problems are prevalent in our case. The first empirical issue is log-linearization in the presence of heteroscedasticity. Since the gravity model is nothing but a multiplicative model, log-linearization is a form of transformation that can alter the properties of the error term and produce inefficient estimates.

By Jensen's inequality, a log-linear model cannot be expected to provide unbiased estimates of mean effects when the errors are heteroscedastic; this may lead to a huge difference between the estimates of the log-linearized model and those of a gravity model estimated in levels (Silva and Tenreyro, 2006). Yet, log-linearization is exactly what the Anderson van Wincoop framework proposes.

[13] See Herrera (2012), Cheng and Wall (2005), and Silva and Tenreyro (2006)

Table 2.4: Summary Statistics for Key Model Variables

Measure	$\ln(EXP_{ijt})$	$\ln(GDP_{it})$	$\ln(GDP_{jt})$	$\ln(DST)$	$\ln(PCD_{ijt})$	$\ln(EDU_{ijt})$	$\ln(CAP_{ijt})$
Mean	8.46	11.03	11.11	3.25	3.64	0.12	1.07
Median	8.63	11.10	11.14	3.28	3.73	0.10	1.09
St. Dev.	1.11	0.52	0.46	0.33	0.49	0.09	0.62
Min	2.57	9.45	9.45	1.48	-0.63	0.00	-3.19
Max	10.81	12.27	12.27	4.07	4.62	0.55	2.22

Notes: Based on 13,730 observations; zero trade flows not included

Table 2.5: Correlation Matrix for Key Model Variables

Variable	$\ln(EXP_{ijt})$	$\ln(GDP_{it})$	$\ln(GDP_{jt})$	$\ln(DST)$	$\ln(PCD_{ijt})$	$\ln(EDU_{ijt})$	$\ln(CAP_{ijt})$
$\ln(EXP_{ijt})$	1.00						
$\ln(GDP_{it})$	0.65	1.00					
$\ln(GDP_{jt})$	0.39	-0.01	1.00				
$\ln(DST)$	-0.49	-0.14	-0.02	1.00			
$\ln(PCD_{ijt})$	-0.10	-0.04	0.01	0.05	1.00		
$\ln(EDU_{ijt})$	-0.45	-0.37	0.00	0.16	0.22	1.00	
$\ln(CAP_{ijt})$	-0.44	-0.26	-0.08	0.22	0.08	0.38	1.00
BDR	0.28	0.04	-0.03	-0.52	-0.03	-0.09	-0.09

Notes: Based on 13,730 observations; zero trade flows not included

A basic assumption with OLS estimation is homoscedasticity, thereby resulting in a constant variance and expected value for the error term. If this assumption breaks down, which is often the case for trade flows, the expected value of the error term becomes statistically dependent on the regressors[14]. With panel data in our case, it is taken that the error term in our specified model is constant across jurisdictions or jurisdiction-pairs[15]. If not, we run into this problem. Note that the parameter estimates are still unbiased, hence unaffected by heteroscedasticity; but the variance of the estimates are biased and this has huge implications on the *t*-values.

Martinez-Zarzoro et al. suggest the FGLS as the solution if we ignore the exact form of heteroscedasticity[16]. The FGLS estimator is computed using weighted least squares, whereby the squared OLS residuals are computed (z^2) and regressed on the explanatory variables and a constant. An analytical weight, computed as $1/ z^2$, is then used in the second step weighted least squares regression.

Santos Silva and Tenreyro examine the performance of the PPML and conclude that it is a heteroscedasticity-consistent estimator, albeit it assigns the same weight to all observations. They, however, conclude that in the absence of any further information on the pattern of heteroscedasticity, the PPML is the most appropriate procedure and would provide consistent estimates provided that the conditional mean is correctly specified. We use the FGLS for samples with truncated zero flows only, and the PPML for all three categories: truncated zero flows, retained zero trade flows and zero trade flows replaced with one. The FGLS, if one is happy with ignoring the exact nature of heteroscedasticity, is a consistent estimator. The PPML, if one is happy with the lesser accuracy associated with this estimator in the presence of zero trade flows, is also robust. We employ both estimators and consider the results for the different subsamples.

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[14] This is because the logarithm of a random variable has an expected value that depends on the mean and higher-order moments of the distribution of the random variable. This violates the condition for the consistency of OLS.

[15]Silva and Tenreyro suggest that in the presence of heteroscedasticity, nonlinear estimators should be used.

[16] The is because the FGLS is robust to any form of heteroscedasticity, in addition to being able to weigh the observations in our data sets based on the square root of their variances.

The presence of zero trade flows in our data is the second estimation issue we are confronted with. While the Newtonian gravitational force between two masses can be very small, but never zero, it is the case that bilateral trade flows between many jurisdiction-pairs for a particular time period is actually zero. In the presence of such zeros, the use of logarithmic transformation for the dependent variable poses a problem since the logarithm of zero is undefined.

Most authors recommend truncating the sample by deleting the observations with zero trade flows. However, this method is problematic because it leads to loss of information. It can also create the problem of sample selection bias, Heckman (1979). In other words, dropping zeros from the sample implies that the dependent variable is no longer really bilateral trade, but bilateral trade contingent on a trading relationship existing. This can bias our OLS estimates, to the extent that the probability of selection is correlated with the regressors. We estimate the model under the zero truncation scenario using both the standard OLS and the FGLS methods.

Some other authors estimate in levels so that the estimation can proceed with the zero trade values. Again, the PPML estimator recommended by Santos Silva and Tenreyro solves this problem, especially when the incidences of zero trade values are infrequent. We use the PPML, believing this to yield unbiased estimates since both the full sample and the US-US subsample only contain 51 zero trade flows apiece. The third strategy for the zero trade issue is to simply replace the value of bilateral trade flows by the value of trade flows plus one: i.e. instead of using $\ln(X_{ij})$ as the dependent variable, we use $\ln(1 + X_{ij})$ instead. We also employ this method and estimate with OLS and PPML, albeit we make the model with the truncated trade flows our baseline model in order to compare the results with the former.

The last but not least is the issue of unobserved heterogeneity. We use a panel data set to disentangle the time invariant region-specific effects and to capture the relationships between the relevant variables over time. Also, if individual effects are to be included, then we must decide whether to treat them as fixed or random effects, and provide a justification for our decision. The issue of using either a FEM or random effects model (REM) has received a lot of attention in the literature[17]. Egger (2000) summarizes these views and concludes that the FEM is more appropriate than the REM when dealing with trade flows between an ex ante predetermined selection of regions. Egger's reason is simple: most of the factors that drive trade flows between regions are not random but deterministically associated with certain historical, political, geographical and other factors.

In our case, our sample comprises of bilateral trade flows for 60 jurisdictions that share a great deal of common cultural, historical and institutional framework. We therefore concur with Egger's point of view on the FEM above. Any estimation carried out without properly accounting for these factors will suffer from heterogeneous bias. We control for these factors by allowing each jurisdiction-pair to have its own dummy variable.

The analysis proceeds as follows. First, we present a simple summary of the possible relationships between bilateral trade flows, GDP and distance using simple scatter plots and other descriptive tools. Second, we look more formally at the relationship using standard OLS regression methods for panel data. We use the FEM in addition to the pooled estimator. Using the Chi square test, the null hypothesis which states that unobserved heterogeneity does not exist is either rejected or not. Other hypotheses which consider the interaction effect between economic sizes and specific trade costs proxies (e.g. distance and contiguity), as well as the individual and combined effect of these variables on bilateral trade flows in the selected jurisdictions are considered. The robustness of both the baseline specification and the other models is tested for all four samples using the traditional OLS estimators and other advanced techniques discussed above.

[17] For detailed explanation, see Baldwin (1994) and Cheng and Wall (2005)

2.4.3 Gravity Variables: Correlation vs. Causation

We now take a quick look at the data with respect to discussions so far on the gravity model. To achieve this, we plot the log of bilateral trade flows against the log of GDP for the exporting jurisdiction, log of GDP for the importing jurisdiction, and the log of bilateral distance. Figures 2.2-2.5 below show the results for our four data sets.

Figure 2.2: Full Sample

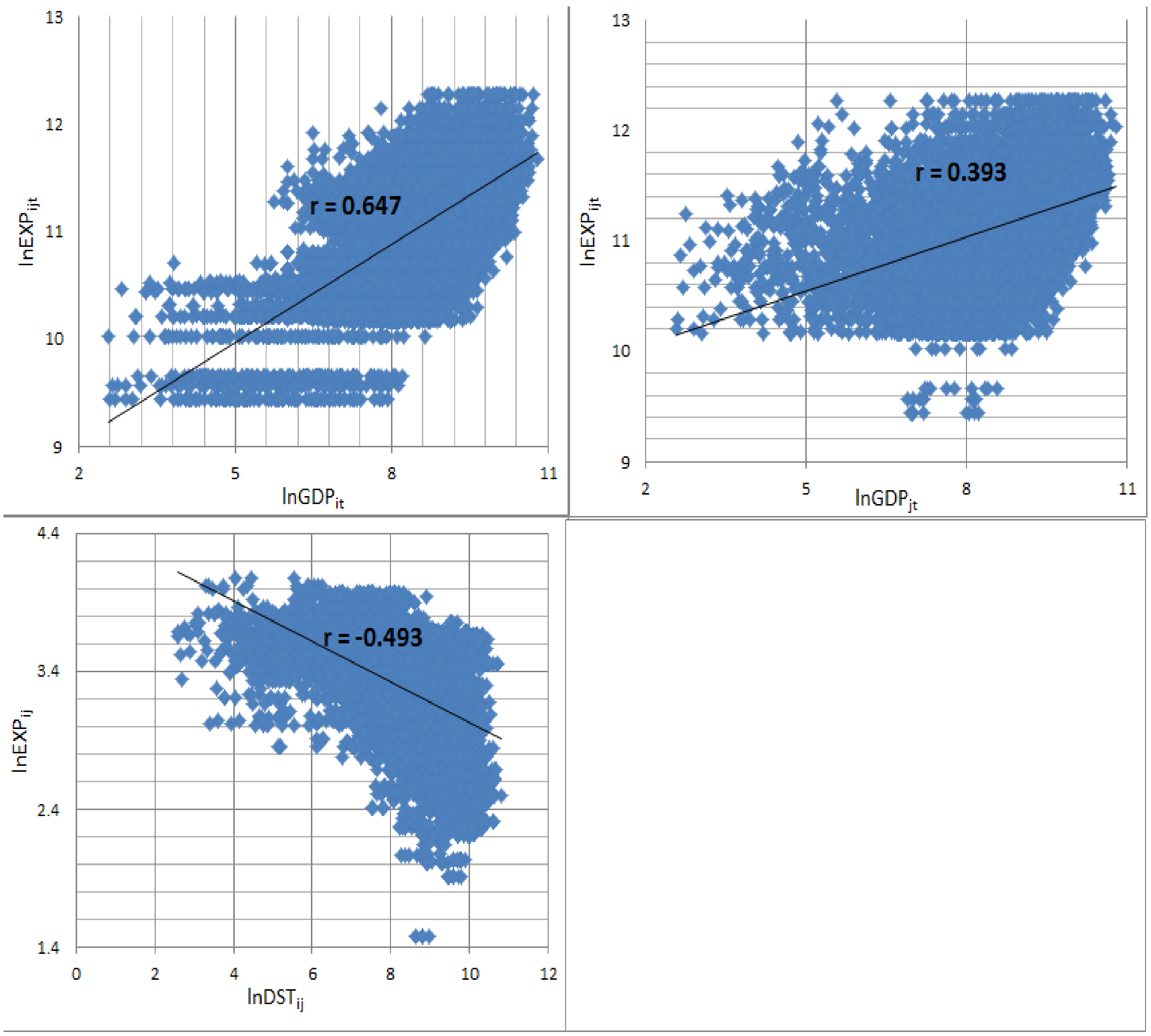
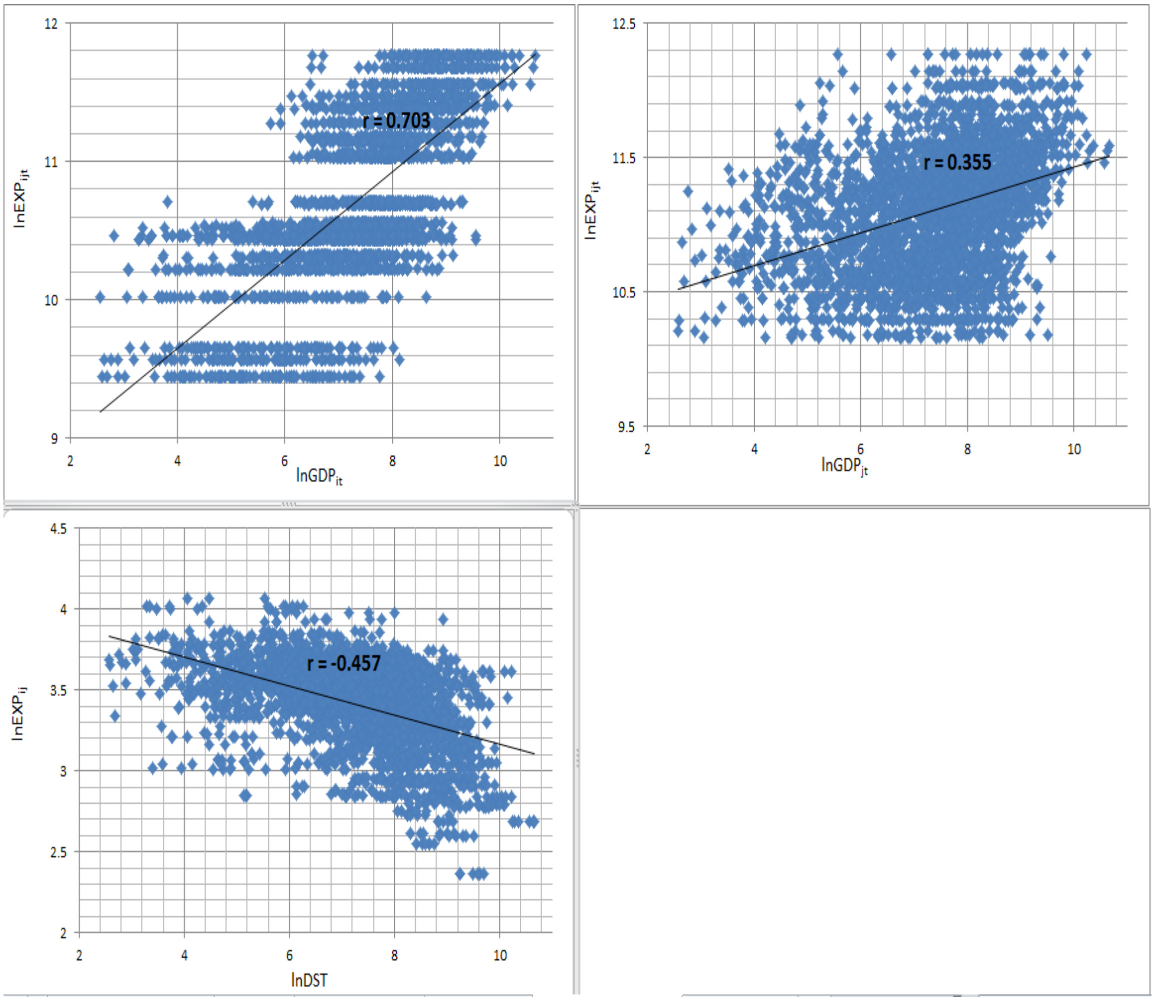


Figure 2.3: Canada-US Subsample



The plots provide evidence of a positive relationship between bilateral trade flows and economic sizes, and a negative one with distance. In addition to that, we see that the strength of the relationship between $\ln EXP_{ijt}$ and $\ln GDP_{it}$ differs significantly from that of $\ln EXP_{ijt}$ and $\ln GDP_{jt}$ for the different data sets. While the correlation coefficient r between $\ln EXP_{ijt}$ and $\ln GDP_{it}$ is 0.647, the relationship between $\ln EXP_{ijt}$ and $\ln GDP_{jt}$ is much weaker, with an r value of 0.393. A variety of factors can be adduced for this, but we are unable to disentangle them since we are using the full sample.

We observe that while the Canada-US subsample has a stronger relationship for the $\ln EXP_{ijt}$-$\ln GDP_{it}$ nexus, the US.-US. subsample shows the strongest relationship for both the $\ln EXP_{ijt}$ and $\ln GDP_{jt}$ and the $\ln EXP_{ijt}$ and lnDST relationships.

The relatively higher correlation between $\ln EXP_{ijt}$ and lnDST for the US subsample may be interpreted to mean that when we control for other things, bilateral trade responds more to distance among US states, compared to interprovincial trade in Canada and US.-Canada trade. This seems plausible because of the relative homogeneity across US states, compared to Canada.

Figure 2.4: Canada-Canada Subsample

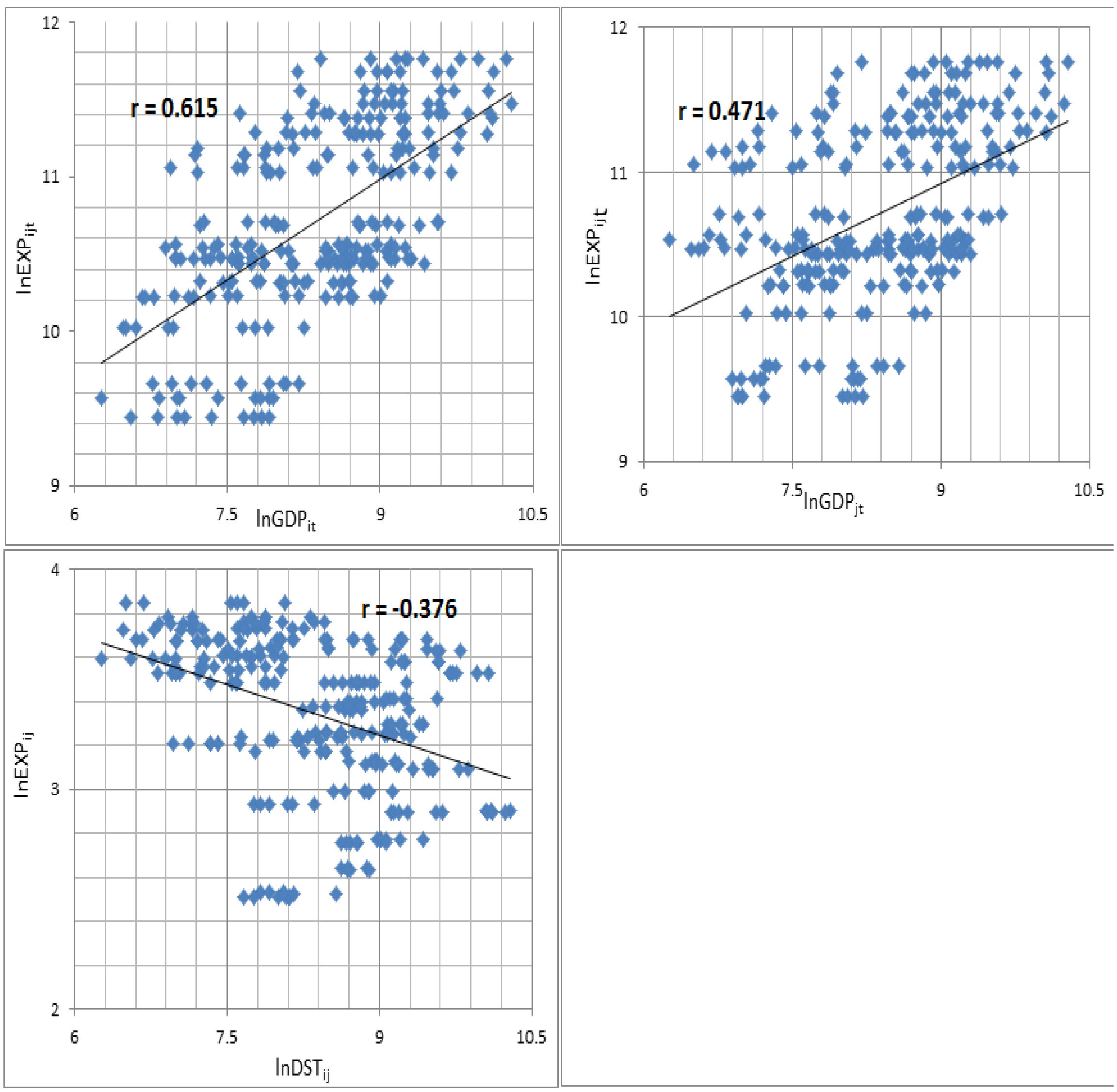
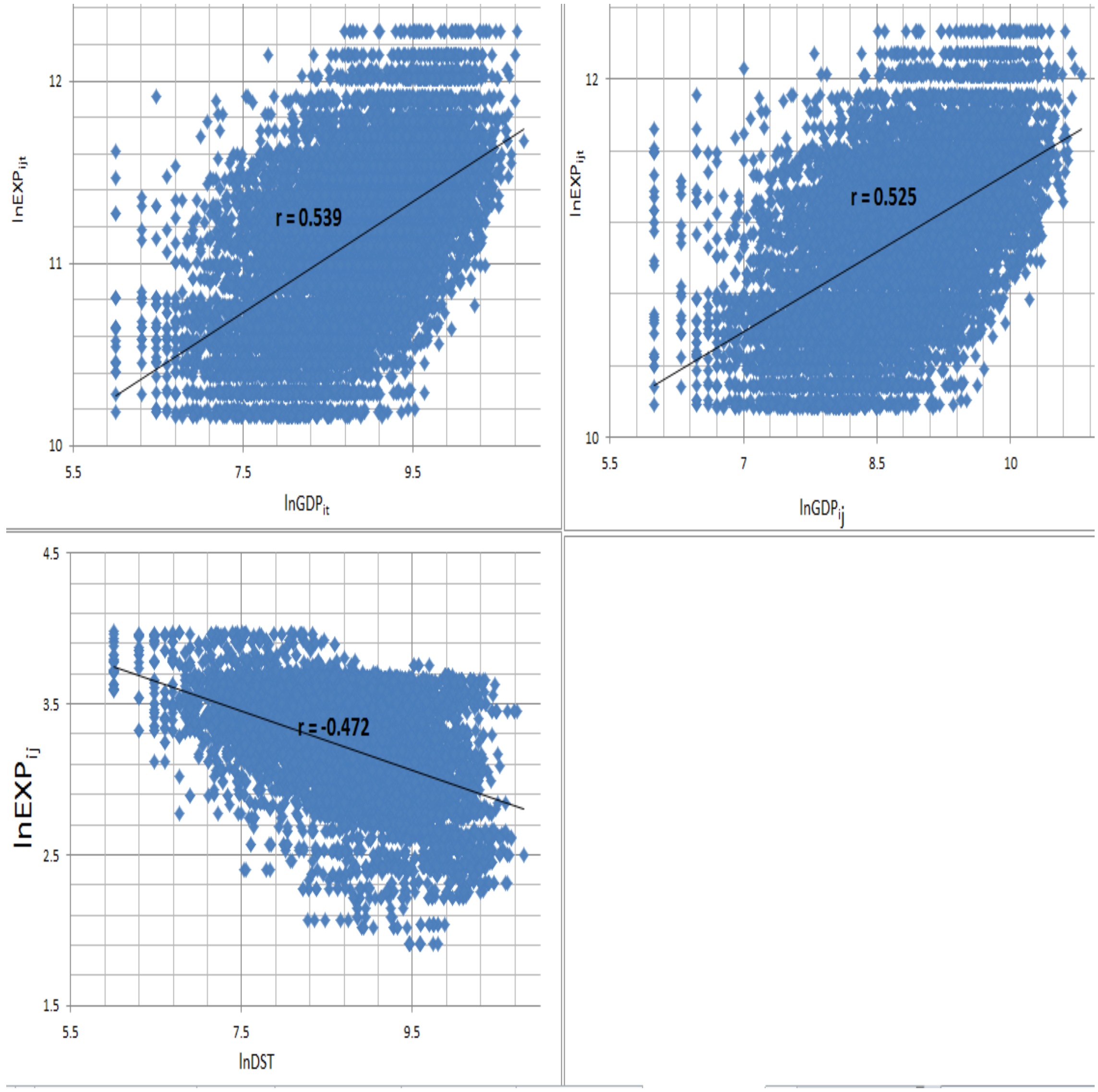


Figure 2.5: US-US Subsample



It is clear in the data, prior to any sophisticated use of controls, that there is some preliminary evidence for the economic size and trade cost effects predicted by the gravity model. While these correlations are consistent with our priors as well as the literature reviewed earlier on the gravity model, one has to be careful interpreting these, especially the economic size effect, as causal. It is perfectly plausible that the causation runs in the opposite direction: a higher level of trade flows increases total output. Many authors have done extensive research in this area, e.g. Ahmad (2001) and Gurgul and Lach (2010).

The concerns of reverse causality raised above can be addressed by using instrumental variable estimation, conditional on finding appropriate instruments. Another alternative is to use a DPD framework where the lags of variables are used as instruments; the Arellano-Bond or Blundell-Bond GMM estimators are suitable candidates here. The challenge with this method though is that PPML or related methods cannot then be used; this is always a trade-off. Unfortunately, a more thorough treatment of reverse causality is beyond the scope of the chapter in order to focus on the three estimation issues outlined.

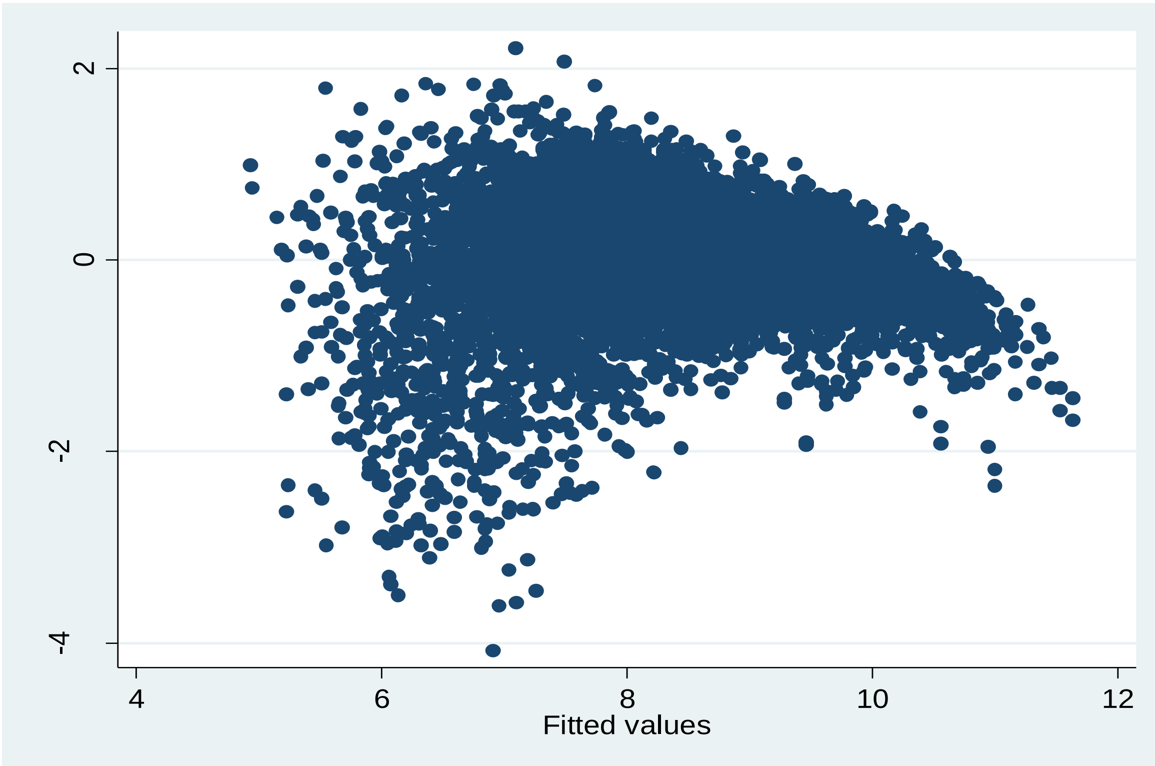
2.5 Estimation Results

2.5.1 Full Sample Results

In this section, two tables are presented to summarize our estimation results. Tables 2.5 and 2.6 show the estimation results based on the full sample, with the former based on the standard gravity model and the latter for the extended model. All the different estimators are presented in both cases. Each table shows the results of using both the traditional OLS method and other advanced techniques, including a FEM, in order to check the robustness of the model. As discussed earlier, we use the FEM in addition to the other estimators because the former allows for variation among the observations in the sample data in response to jurisdiction-pair fixed effects and, as a result, it takes into account within jurisdiction-pair variations.

In order to validate the specification and estimation of a FEM, we carry out a Hausman test which basically tests whether the unique errors (ε_{ijt}) are correlated with the regressors or not. We specify the null hypothesis that the preferred model is random effects, while the alternative specifies a FEM (Green, 2008). We therefore reject the null hypothesis of no fixed effects. Likewise, we carry out the standard F-test for the joint significance of jurisdiction-pair dummies and conclude that unobserved heterogeneity is present and OLS estimation yields biased and inconsistent estimates. Also, a quick check for heteroscedasticity is necessary at this point. Figure 2.6 below shows the relationships between the residuals and the fitted values. This graph confirms the presence of heteroscedasticity in the regression; hence the need for nonlinear estimation methods is upheld.

Figure 2.6: Residuals vs. Fitted Values Plot



We estimate different versions of Equations 2.10 and 2.11 using four classes of estimators: OLS for models with logged dependent variables, PPML for bilateral trade flows in levels, FGLS for purging our dataset of heteroscedasticity from the disturbance process, and panel methods for unobserved heterogeneity.

The first column in each of Tables 2.6 and 2.7 below shows the results of the model estimated with OLS using the logarithm of bilateral trade flows after truncating jurisdiction-pairs with zero trade flows. As explained earlier, the second column reports the OLS estimates adding a constant which equals one; the assumption here is that zero trade flows take a value of one. This is not a theoretically consistent assumption and may lead to OLS estimators with higher standard errors compared to the other estimators (Herrera, 2012). This is exactly the case here, all standard errors of the estimated

Table 2.6: Standard Gravity Model (Full Sample)

Estimator	OLS	OLS	PPML	PPML	PPML	FGLS	Panel FE
Dependent Variable	**$ln(X_{ij})$**	**$ln(1 + X_{ij})$**	**$X_{ij} > 0$**	**$1 + ln(X_{ij})$**	**X_{ij}**	**$ln(X_{ij})$**	**$ln(X_{ij})$**
Log of exporter's GDP	1.265***	1.292***	1.972***	1.973***	1.973***	1.102***	0.387***
	[0.013]	[0.014]	[0.027]	[0.027]	[0.027]	[0.003]	[0.116]
Log of importer's GDP	0.934***	0.986***	1.919***	1.920***	1.920***	0.946***	0.551***
	[0.011]	[0.014]	[0.027]	[0.027]	[0.027]	[0.002]	[0.106]
Log of bilateral distance	-1.356***	-1.473***	-1.821***	-1.821***	-1.821***	-0.966***	
	[0.018]	[0.025]	[0.042]	[0.042]	[0.042]	[0.006]	
Constant	-11.457***	-11.969***	-16.885***	-16.896***	-16.896***	-10.970***	-1.926***
	[0.205]	[0.227]	[0.475]	[0.475]	[0.475]	[0.048]	[0.291]
Observations	13,730	13,781	13,730	13,781	13,781	13,730	13,730
R - squared	0.737	0.671	0.789	0.790	0.790	0.986	0.179

Notes: Figures in parentheses are robust standard errors. The dependent variable is the logarithm of Xij in all cases except for Poisson regressions, where bilateral trade flows X_{ij} are expressed in levels. * significant at 10%; ** significant at 5%; *** significant at 1%; no sign means not significant at 1%, 5% and 10%. Contiguity dummy could not be estimated with Poisson regressions.

Table 2.7: Extended Gravity Model (Full Sample)

Estimator	OLS	OLS	PPML	PPML	PPML	FGLS	Panel FE
Dependent Variable	**ln(X_{ij})**	**ln (1 +X_{ij})**	**X_{ij} > 0**	**1 + ln(X_{ij})**	**X_{ij}**	**ln(X_{ij})**	**ln(X_{ij})**
Log of exporter's GDP	1.158***	1.194***	1.896***	1.897***	1.938***	1.158***	0.395***
	[0.012]	[0.013]	[0.027]	[0.027]	[0.028]	[0.000]	[0.116]
Log of importer's GDP	0.921***	0.976***	1.846***	1.846***	1.908***	0.921***	0.545***
	[0.010]	[0.014]	[0.027]	[0.027]	[0.028]	[0.000]	[0.106]
Log of bilateral distance	-1.077***	-1.237***	-1.193***	-1.194***	-1.761***	-1.077***	
	[0.020]	[0.031]	[0.036]	[0.036]	[0.039]	[0.000]	
Log of per capita income differential	-0.075***	-0.099***	-0.176***	-0.176***	-0.194***	-0.075***	0.002
	[0.009]	[0.012]	[0.021]	[0.021]	[0.022]	[0.000]	[0.010]
Log of human capital differential	-0.218***	-0.198***	-0.255***	-0.255***	-0.240***	-0.218***	-0.019***
	[0.009]	[0.012]	[0.020]	[0.020]	[0.022]	[0.000]	[0.008]
Log of physical capital differential	-0.305***	-0.273***	-0.212***	-0.212***	-0.221***	-0.305***	-0.012***
	[0.008]	[0.010]	[0.021]	[0.021]	[0.019]	[0.000]	[0.007]
Contiguity dummy	0.319***	0.256***	0.748***	0.747***	n/a	0.319***	
	[0.018]	[0.021]	[0.032]	[0.032]	n/a	[0.000]	
Constant	-10.323***	-10.794***	-16.318***	-16.331***	-15.541***	-10.323***	-1.959***
	[0.193]	[0.220]	[0.478]	[0.478]	[0.475]	[0.003]	[0.301]
Observations	13,730	13,781	13,730	13,781	13,781	13,730	13,730
R - squared	0.783	0.701	0.836	0.837	0.81	1.000	0.180

Notes: Figures in parentheses are robust standard errors. The dependent variable is the logarithm of Xij in all cases except for Poisson regressions, where bilateral trade flows X_{ij} are expressed in levels. * significant at 10%; ** significant at 5%; *** significant at 1%; no sign means not significant at 1%, 5% and 10%. Contiguity dummy could not be estimated with Poisson regressions.

coefficients in column two are higher than those in column one for both tables. The third, fourth and fifth columns present the results of Poisson estimates using truncated, replaced, and retained zero flows, respectively. Results based on FGLS estimation procedure are presented in column six, while the last column shows the fixed effects estimates.

In general terms, the results of the standard gravity model are very similar to those of the extended model, with little differences. To keep things simple, I first compare the results of the former with the latter, and report any stark contrasts. Thereafter, our full sample analysis proceeds with the extended model only, which is our baseline model. First, the coefficient estimate of exporter's GDP in the standard model is higher than that of the extended model across all estimation strategies, with the exception of the FGLS and FEM. This is even more pronounced in the case of importer's GDP: the standard model has higher estimated coefficients in all cases.

The same trend is observed for bilateral distance: the absolute value of estimated coefficient is higher in all cases for the standard model, compared to the baseline model; the only exception here being the FGLS estimator. As discussed earlier, the effects trade costs on trade flows patterns can suffer from misinterpretation if the issue of unobserved heterogeneity is not adequately resolved. The baseline model has a better explanatory power than the standard gravity model across all the seven estimators. Obviously, the use of more control variables seems to significantly improve the goodness of fit in all cases.

We now analyze the results from the extended model in Table 2.7 based on our full sample. In general, differences in estimation techniques seem to affect only the magnitudes of the estimated parameters, but not their signs. The only exception though is the coefficient of per capita income differential. This comes out with a positive sign when estimated with the fixed effects method, compared with the other six cases where the sign is negative. All variables are found to be statistically significant at the 1% level, and the goodness of fit ranges from 0.701 to 0.837. The estimated coefficients are also significant economically, given the right signs and plausible magnitudes that enable us conclude that size, distance and other variables indeed determine bilateral trade flows. We notice that the within R-squared for the fixed effect estimator is considerably low, but this is normal considering that we are using the within estimator here. Also, the FGLS estimator has a 100% goodness of fit. This looks bizarre at first; but when we consider the fact that the FGLS estimator itself is computed using weighted least squares based on an analytical weight of $1/z^2$, this result becomes plausible.

Using datasets with truncated, replaced, and retained zero trade flows, it turns out that both the PPML and OLS-estimated coefficients show remarkable similarities, albeit the OLS estimates are much smaller than for PPML. Santos Silva and Tenreyro attribute this to the fact that residuals for zero trade flows are also very close to zero since the estimated value of trade is close to zero. This does not pose much problem in our case since there are only 51 zero trade flows in the full sample. Another general observation is that the standard errors for OLS and FGLS estimates are much lower than those under PPML, an indication of a more accurate estimation with the least square method. For the FGLS, the estimated standard errors are extremely small and close to zero in most cases.

Except for the PPML where we introduce bilateral trade flows in levels, the dependent variable is the log of exports in all cases. In line with our a priori expectations, the coefficients of the standard gravity variables come out with the hypothesized signs and are statistically significant at the 1% level. The duo of exporter's GDP and importer's GDP both affect bilateral trade flows positively regardless of the estimation method used, while the inverse relationship between trade and bilateral distance is upheld in all cases. These coefficients are economically significant.

Also, the results show that the estimated income elasticity of trade is closer to the theoretical value of 1 when the model is estimated using the log of bilateral trade flows, compared with trade flows in levels. Therefore, it is not surprising that the coefficients of exporter's GDP and importer's GDP are approximately equal to 1 with OLS and FGLS, and about 2 for PPML. The fixed effects results show significantly lower estimates. In all cases, the coefficients of exporter's GDP are much higher than for importer's GDP; in partial agreement with the OLS results of Santos Silva and Tenreyro, but not their PPML's – where the reverse is the case. Santos Silva and Tenreyro's observation is worthy of note here: the assumption of unit income elasticities in the simple gravity framework contradicts the observation of a decreasing trade-to-GDP ratio with increasing total GDP. The income elasticities of trade for the PPML estimates show strikingly close values for both exporters and importers, but the FEM is an exception.

Our results confirm the role of bilateral distance as a barrier to trade flows between a jurisdiction-pair, although the effects are generally comparable among the different estimators. For the truncated zeros sample, the estimated effect of distance on trade flows is the same for OLS and FGLS at -1.077. This implies that bilateral distance reduces trade by 1.1% for every percentage increase in the distance itself. Compared to other international studies, e.g. Tinbergen (1962), Frankel (1993), Cheng and Wall (2005), Santos Silva and Tenreyro (2006) Martinez-Zarzoso et al. (2007) and Herrera (2012), the point estimate of the distance variable is somewhat large. One reason for this, according to McCallum (1995), maybe because most North American trade goes by air and land, compared to most global trade which is transported by water. Also, water transport is much cheaper than other modes of transport.

The same value of 1.077 for OLS and FGLS is plausible since bilateral distance is time-invariant, and FGLS is used to estimate the variance structure of an unknown disturbance process. The standard errors show further that the FGLS is consistent and asymptotically more efficient than OLS; hence FGLS is a good alternative to OLS in large samples (Baltagi 2008; Baum 2006). Across the board, PPML (under retained zero trade flows) has the highest effect at -1.761, followed by OLS (under replaced zero trade flows) at -1.237.

Accurately identifying the magnitudes of coefficients is a necessary step for assessing their economic significance. After the pioneering research of Tinbergen (1962) and Poynohen (1963) applied the gravity model to international trade, most gravity regressions have typically yielded high R-squared in the 0.65-0.95 range (Sohn, 2005).

Our results agree with this; the model fits the data well, explaining over three quarters of the variation in bilateral trade flows, in most cases.

Based on the preceding literature framework and theoretical issues, and following the hypotheses advanced in section 2.3.5, a positive effect of economic size, and a negative effect of distance are expected on bilateral trade flows, respectively. Across all specifications, the three baseline variables (exporter's GDP, importer's GDP and bilateral distance) are economically significant with meaningful interpretations.

In all cases, the income elasticity of trade is close to the theoretical value of 1, with the coefficients of exporter's GDP much higher than for importer's GDP. The notable exception is the FEM with much lower values and reasons have been adduced. For instance, a 1% increase in exporter's GDP is associated with an increase in bilateral trade flows of 0.4%; a 1% increase in importer's GDP will increase trade by 0.6%. As well, with distance elasticity of trade coefficient values generally stable and hovering around unity, results confirm that trade costs increase with distance in a log-linear way. In all, elasticities of trade to size and distance close to unity are plausible and economically meaningful. Therefore, Hypothesis 1 on the positive effect of economic size on bilateral trade, and Hypothesis 2 on the negative effect of distance on bilateral trade, are strongly supported. We conclude that the bilateral trade between two regions is proportional to their respective sizes, measured by their GDP, and inversely proportional to the geographic distance between them.

We also conclude that jurisdictions that share a common border tend to trade more, as the contiguity dummy has highly statistically significant coefficients which are positive in all cases. The extent to which the presence of a border affects the intensities of economic exchange between a jurisdiction-pair, after controlling for bilateral distance, turns out to be more pronounced under the PPML than when OLS is used. The border effect is calculated here as $(e^{vi} - 1) \times 100$, where v_i is the estimated coefficient from Table 2.7. Our results show that the presence of a border between two jurisdictions in the sample increases bilateral trade flows by about 38%, 111% and 38% for the OLS, PPML, and

FGLS techniques, respectively. Similar to the marginal effect for the distance variable, the estimated border effect is exactly the same under OLS and FGLS.

Again, the explanation under the bilateral distance variable will suffice for the contiguity dummy here. In the words of Wall (2000), "what is surprising about Canada-US trade is not how large it is compared to trade between other international trading partners, but how small it is compared with the level of trade within the two countries". Our results uphold the border effect. In terms of economic significance, the values of 38%, 111% and 38% for the OLS, PPML and FGLS techniques show that borders – international or domestic – represent large barriers to trade. In other words, after controlling for distance and size, borders inhibit trade flows since they impede the integration of markets, with negative welfare consequences. It is therefore important to accurately estimate the economic significance of the border effects at the domestic and international levels. We discuss the economic significance of both domestic and international border effects under section 2.5.2 below.

Table 2.7 provides mixed evidence regarding the Linder hypothesis and Heckscher–Ohlin factor endowment proposition. Our research hypothesis expects a negative sign for the coefficient of per capita income differential to support the Linder-hypothesis, and this is upheld in the empirical results, albeit the effects are stretched over a wide range of 0.075 and 0.194 for the various estimators. Thus, a 100% increase in per capita income differential decreases trade by 7.5% and 19.4% for the low and high estimates, respectively. The Linder coefficients are economically and statistically significant with sensible interpretations: similar levels of per capita income produce similar tastes, which lead to the production of similar but differentiated products, which result in higher bilateral trade flows between jurisdiction-pairs.

In stark comparison, however, the coefficients of both human capital differential and physical capital stock differential appear with negative signs, refuting the Heckscher–Ohlin hypothesis: a conjecture that jurisdictions should trade more, the more different their factor endowments. As stated under Hypothesis 4, a positive relationship between factor endowment differentials and bilateral trade flows will support the Heckscher–Ohlin proposition. In other words, jurisdictions should trade more, the more different their factor endowments. Canada and the US have similar human and physical capital endowments, so we expected a positive sign on the Heckscher–Ohlin variables to support the Heckscher–Ohlin proposition. Similar to the Linder scenario above, the Heckscher–Ohlin coefficients are economically and statistically significant, ranging from a high absolute value of 0.305 to a low value of 0.198.

According to Leamer (1995), commodities exchange among regions amounts to indirect factor arbitrage since services of otherwise immobile production factors are transferred from regions with surplus to regions with deficit. A fundamental insight from the Heckscher–Ohlin model is that traded commodities are nothing more than bundles of production factors – land, labour and capital. Large differences in regions' factor endowments generate specialization in production. The empirical result here merits a more detailed investigation, but we will not pursue it further. It turns out that the major differences among the seven estimators are reflected in the relative magnitudes of coefficients.

The FEM finds modest effects on trade from economic sizes and distances, like the other estimators. Compared to the baseline estimation technique (i.e. OLS with truncated zero data in this case), the economic size effect based on the FEM is much weaker – a 1% increase in exporter's GDP is associated with an increase in bilateral trade flows of 0.4%. Likewise, a 1% increase in importer's GDP will increase trade by 0.6%, compared to 1.2% for exporter's GDP and importer's GDP using the baseline technique. The lower estimates of the FEM, compared to other estimators shows a tradeoff: fixed effects account for multilateral resistance.

The significantly lower coefficient estimates for the FEM shows that unobserved heterogeneity does have a huge impact on the results of gravity model estimates. With jurisdiction-pair heterogeneity accounted for, certain deterministic factors (e.g. historical, political, and geographical factors) driving trade flows explain why the fixed effects-estimated log of exporter's GDP and log of importer's GDP for the full sample are significantly lower than what we have for other estimators. The economic size effect here implies that there are pair-specific effects that maybe correlated with the trade flows between a jurisdiction-pair. Suffice it to say though that the FEM seems to not fit the model well, compared with the other estimators. For instance, while the coefficient estimate of the log of per capita income differential turns out to be statistically insignificant, that of log of physical capital stock differential is barely significant only at the 10% level.

2.5.2 Estimation Results for Subsamples

In this section, Tables 2.8, 2.9 and 2.10 summarize our regression results for the Canada-US, US-US and Canada-Canada subsamples. Looking at the standard gravity variables, the results indicate that the effect of each of exporter's GDP, importer's GDP and bilateral distance on trade flows varies sharply across the different samples. Based on our baseline estimation method, the Canada-US subsample has a more pronounced economic size and distance effects, compared with the US-US and Canada-Canada samples. Subsamples results are generally comparable with those based on the full sample, in terms of statistical and economic significance of coefficients.

The log of exporter's GDP, log of importer's GDP and log of bilateral distance each has a coefficient estimate of 1.330, 1.067 and -1.657 in the baseline model, compared with 0.962, 0.938, and -0.875 for US-US trade and 1.010, 0.823 and -1.249 for Canada-Canada trade. Most notably, the point estimate of importer's GDP for the Canada-Canada sample turns out to be negative when estimated with the FEM, though it is not statistically significantly different from zero.

It is also not surprising that the distance effect is higher for interprovincial trade than interstate trade – our descriptive statistics show that the average bilateral distance between a trading pair in Canada (2,888km) is much higher than in the US (2,068 km). The higher population density in the US (30.71 sq. km), compared to Canada's 3.0 sq. km

Table 2.8: Extended Gravity Model (Canada – US Sample)

Estimator	OLS	PPML	FGLS	Panel FE
Dependent Variable	**$ln(X_{ij})$**	**X_{ij}**	**$ln(X_{ij})$**	**$ln(X_{ij})$**
Log of exporter's GDP	1.330***	1.911***	1.329***	0.578***
	[0.027]	[1.107]	[0.001]	[0.217]
Log of importer's GDP	1.067***	1.948***	1.068***	0.467**
	[0.029]	[0.097]	[0.001]	[0.227]
Log of bilateral distance	-1.657***	-2.002***	-1.653***	
	[0.064]	[0.164]	[0.002]	
Log of per capita income differential	-0.184***	-0.262***	-0.183***	-0.027
	[0.026]	[0.087]	[0.000]	[0.027]
Log of human capital differential	-0.117***	-0.628***	-0.118***	-0.060***
	[0.034]	[0.096]	[0.001]	[0.023]
Log of physical capital differential	-0.239***	0.148	-0.238***	0.192
	[0.090]	[0.346]	[0.002]	[0.165]
Contiguity dummy	0.299***	0.732***	0.290***	
	[0.076]	[0.171]	[0.011]	
Constant	-12.790***	-15.342***	-12.801***	-4.233***
	[0.512]	[2.761]	[0.022]	[0.755]
Observations	2,958	2,958	2,958	2,958
R - squared	0.730	0.812	1.000	0.124

Notes: Figures in parentheses are robust standard errors. The dependent variable is the logarithm of Xij in all cases except for Poisson regressions, where bilateral trade flows X_{ij} are expressed in levels. * significant at 10%; ** significant at 5%; *** significant at 1%; no sign means not significant at 1%, 5% and 10%. Contiguity dummy could not be estimated with Poisson regressions.

Table 2.9: Extended Gravity Model (US – US Sample)

Estimator	OLS	PPML	FGLS	Panel FE
Dependent Variable	ln(X_{ij})	X_{ij}	ln(X_{ij})	ln(X_{ij})
Log of exporter's GDP	0.962***	1.855*	0.963***	0.236***
	[0.008]	[0.027]	[0.001]	[0.075]
Log of importer's GDP	0.938***	1.863*	0.938***	0.622***
	[0.008]	[0.027]	[0.002]	[0.075]
Log of bilateral distance	-0.875***	-1.124***	-0.876***	
	[0.018]	[0.037]	[0.003]	
Log of per capita income differential	-0.083***	-0.185***	-0.0838**	0.009
	[0.008]	[0.021]	[0.002]	[0.008]
Log of human capital differential	-0.067***	-0.164***	-0.067***	-0.011
	[0.008]	[0.020]	[0.000]	[0.008]
Log of physical capital differential	-0.087***	-0.065***	-0.087***	0.016***
	[0.007]	[0.022]	[0.000]	[0.006]
Contiguity dummy	0.362***	0.767***	0.361*	
	[0.015]	[0.031]	[0.000]	
Constant	-9.169***	-16.325***	-9.170***	-0.803***
	[0.140]	[0.447]	[0.003]	[0.245]
Observations	10,467	10,467	10,467	10,467
R - squared	0.805	0.842	1.000	0.233

Notes: Figures in parentheses are robust standard errors. The dependent variable is the logarithm of Xij in all cases except for Poisson regressions, where bilateral trade flows X_{ij} are expressed in levels. * significant at 10%; ** significant at 5%; *** significant at 1%; no sign means not significant at 1%, 5% and 10%. Contiguity dummy could not be estimated with Poisson regressions.

Table 2.10: Extended Gravity Model (Canada – Canada Sample)

Estimator	OLS	PPML	FGLS	Panel FE
Dependent Variable	$ln(X_{ij})$	X_{ij}	$ln(X_{ij})$	$ln(X_{ij})$
Log of exporter's GDP	1.010***	2.023***	1.010***	1.815***
	[0.030]	[0.079]	[0.003]	[0.316]
Log of importer's GDP	0.823***	1.876***	0.833***	-0.284
	[0.026]	[0.075]	[0.005]	[0.312]
Log of bilateral distance	-1.249***	-1.829***	-1.247***	
	[0.064]	[0.148]	[0.007]	
Log of per capita income differential	0.021	0.014	0.021***	0.119**
	[0.044]	[0.100]	[0.003]	[0.058]
Log of human capital differential	-0.045	0.028	-0.056***	-0.043
	[0.029]	[0.055]	[0.007]	[0.029]
Log of physical capital differential	-0.102**	0.481	0.107***	-0.134**
	[0.041]	[0.100]	[0.006]	[0.059]
Contiguity dummy	0.012	0.186**	0.019***	
	[0.046]	[0.092]	[0.006]	
Constant	-7.280***	-16.800***	7.407***	-8.275***
	[0.425]	[1.288]	[0.072]	[1.111]
Observations	270	270	270	270
R - squared	0.897	0.936	0.999	0.707

Notes: Figures in parentheses are robust standard errors. The dependent variable is the logarithm of Xij in all cases except for Poisson regressions, where bilateral trade flows X_{ij} are expressed in levels. * significant at 10%; ** significant at 5%; *** significant at 1%; no sign means not significant at 1%, 5% and 10%. Contiguity dummy could not be estimated with Poisson regressions.

may partly explain this. The average bilateral distance of 2,961 km for the Canada-US sample also shows that trade between both countries involves a larger distance than sub-national trade, on average; so our point estimate for Canada-US trade is consistent with the descriptive statistics.

Next, we look at the border effect. Focusing on the parameter of interest – contiguity dummy – the estimated coefficients of 0.299 (Canada-US) and 0.362 (US-US) are highly significant, statistically and economically. These coefficients are comparable to estimates from some of the seminal papers cited under the literature review – e.g. McCallum. As stated under Hypothesis 3, there is a negative effect of the border on bilateral trade flows, with a stronger negative effect expected on state-province trade, compared to interstate and interprovincial trade. In addition, our hypothesis expects a stronger negative effect of the border on interprovincial trade, compared to interstate trade. This means we expect the influence of the border on trade to be substantially less for interstate trade, compared to interprovincial trade. Tables 2.8 and 2.9 show that the US-US subsample (0.362) has a more pronounced border effect than Canada-US trade (0.299). This upholds Hypothesis 3a: there is a stronger negative effect of the border on state-province trade, compared to interstate trade. The fact that sharing a common border has a greater influence on US-US trade than Canada-US trade does not come as a surprise. After controlling for distance, we expect Texas and New Mexico, for instance, to trade more than Montana and Saskatchewan, on average.

The point estimate for Canada-Canada trade turns out to be statistically insignificant. However, the FGLS estimates allow us to compare Canada-Canada border effect with the other two samples, since the point estimates of the contiguity dummies are all statistically significant under the FGLS scenario. Point estimates of 0.361, 0.290 and 0.019 for interstate, Canada-US and interprovincial trades, respectively, imply that trade between two contiguous jurisdictions is 43.5%, 33.6% and 1.92% higher than trade between jurisdictions that do not share a border. These estimates are economically significant as well. Comparing only Canada-US and interprovincial trades like McCallum, this is a factor of 17-to-1 (i.e. 33.6%-to-1.92%). In other words, after controlling for scale and distance, interprovincial trade is about 17 times more important than state-province trade. This agrees with Hypothesis 3b on a stronger negative effect of the border on interprovincial trade, compared to interstate trade. This finding is consistent with major findings on the border effect; e.g. McCallum (1995), Wall (2000) and Anderson van Wincoop (2003). This finding confirms the well-known home bias in trade, which Obstfeld and Rogoff (2000b) refer to as one of the six major puzzles in international macroeconomics. Our results uphold the home bias argument; thus, we present new estimates for the Canada-US border effect.

Furthermore, using the same McCallum-type gravity equation with the same 1993 data, Anderson van Wincoop estimate a McCallum-type border effect of 1.6 for interstate trade. In our case, we find a border effect of one – with a factor of roughly 1-to-1 (i.e. 33.6%-to-43.5%). Again, our result is comparable to Anderson van Wincoop's 1.6. Anderson van Wincoop explain the relatively small interstate border effect (and the seemingly large discrepancy between Anderson van Wincoop and McCallum's interprovincial border effect) away by the smallness in size of the Canadian economy, compared to the US. As discussed under the review of literature in section 2.2.2, Anderson van Wincoop derive a decomposition of trade resistance into three parts: (i) the bilateral trade barrier between region *i* and region *j*, (ii) *i*'s resistance to trade with all regions, and (iii) *j*'s resistance to trade with all regions. They reason that compared to the US, a small trade barrier between Canada (a small open economy that trades a lot with the rest of the world, with the US being the dominant trade partner) and its other trading partners has a large effect on multilateral resistance of the provinces. They see the inclusion of the multilateral resistance variable as a way of modeling the effect of trade barriers on trade flows, while controlling for omitted variable bias.

International trade volumes remain small compared to intranational trade. Again, the seminal work by McCallum compares trade among the provinces with the states for 1988 using a gravity framework; McCallum concludes that interprovincial trade is about twenty times larger than province-state trade. McCallum says national borders matter, since "even the relatively innocuous Canada-US border continues to have a decisive effect on continental trade patterns". After McCallum, other studies have estimated smaller, but comparable border effects (e.g. Helliwell, 1998 and Anderson van Wincoop, 2003). The study by Anderson van Wincoop, in particular, estimates a border effect that lies in the 14-16 range. Again, we join the list of researchers in this field.

Combined with the distance effect discussed earlier, we take this discussion a step further by computing how wide the border is – based on both the distance and border effects. In addition to a variety of cultural, historical, linguistic, institutional and political obstacles, distance and borders constitute a major impediment to both intranational and international trade. Given the rapid rate of globalization and disappearance of trade walls, many wonder when the notion of a borderless world will become reality. Among other things, the law of one price establishes the lack of perfect market integration as the reason why the prices of similar goods will not equalize. Friedman (2005) in his popular book, "The World is Flat", talks about the notion of a 'flat earth' with perfect market integration. The Commission on Growth and Development (2008), for instance, recommends a rapid integration into the global economy as a major ingredient needed for economic growth.

Based on the specified gravity equation, the border effect parameter is simply the ratio of interprovincial weighted trade to US-Canada weighted trade. Using the McCallum-type border effect [i.e. parameter exp (e)], we estimate the width of the US-Canada border in this thesis. As discussed under sections 2.3.4.3 and 2.3.4.8, distance is modeled as the logarithm of the distance between two cities i and j, while border is proxied by an indicator variable of common borders with unity if a jurisdiction-pair shares a border and zero for lack of common border. Data on road distances are measured in kilometers based on the capital city of each jurisdiction. Engel and Rogers (1996) [18] estimate a distance effect of 75,000 miles (based on their central estimate) and 1,780 miles (using the 95% upper confidence estimate for the coefficient on bilateral distance). Parsley and Wei (1999) estimate 32 billion miles[19].

Equation 2.13 below shows the simple framework needed to achieve our objective:

$$\ln(EXP_{ijt}) = \alpha_0 + \alpha_1 \ln(DST_{ij}) + \alpha_2 BDR_{ij} + \varepsilon_{ijt} \qquad (2.13)$$

[18] Engel and Rogers[18] (1996) use the covariability of prices between Canadian and US domestic and international city pairs.

[19] Parsley and Wei (1999) focus on the US and Japan.

We follow the Engel and Rogers (1996) and Parsley and Wei (1999) analyses; the border effect is stated in terms of an equivalent distance, using our estimated gravity coefficients. From Equation 2.13, the distance effect of the border is given as $exp\ (\frac{\alpha_4}{\alpha_3})$. Again, based on the FGLS estimator the coefficients on the log of distance (contiguity dummy) for the interstate, Canada-US and interprovincial samples are -0.876 (0.361), -1.653 (0.290) and -1.247(0.019), respectively.

Using the US-Canada sample, we estimate a distance effect of *exp* (0.290/-1.653) = 1.19 kilometers. The PPML and OLS estimates produce distance effects of 1.44 and 1.20 kilometers, respectively. Obviously this estimate is small, considering that the average bilateral distance in our Canada-US sample is 2,961 km. More so, Engel and Rogers estimate 75,000 miles and 1,780 miles using two different coefficients above. Our candidate explanation for this observation is that the estimated distance elasticities in our regressions are unrealistically high. Such high distance coefficients apparently affect the ability of the Engel and Rogers equation to deliver reasonable estimates of the distance effect. In addition to that, the fact that the distance variable is modeled in its logarithmic form may be a contributory factor.

We next consider an alternative strategy to estimate the distance equivalent of the border. Helliwell (2002) suggests that a comparison between the distance and border effects should provide an adequate measure of the border effect in terms of an equivalent increase in distance, if truly both distance and borders determine the strength of economic linkages between two jurisdictions. Following Parsley and Wei (1999) and Helliwell[20] (2002), we determine the increase in distance that is needed to exactly offset the border effects, using the average distance between both jurisdictions as the baseline. While Helliwell (2002) is based on an equality method, Parsley and Wei's (1999) strategy uses only the estimated intercept, but not the coefficient on the border dummy.

Suppose *Y* represents the observed average bilateral trade flows between Canadian and US jurisdictions, we compute the distance equivalent of the border effect as the value of *Z* that solves Equation 2.14 below (see Parsley and Wei, 1999):

[20] Helliwell suggests that the supposed distance effect with and without taking account of the intervening border should be estimated.

$$\ln(Y) = \alpha + \beta \ln(\text{distance} + Z) \qquad 2.14$$

Based on the summary statistics from Table 2.3, the mean bilateral trade volume *Y* and mean distance for the Canada-US sample are $401million and 2,961 km, respectively. From the regression results in Table 2.9 and following Equation 2.14 above, α and β values for OLS (-12.790 and -1.657), PPML (-15.342 and -2.002) and FGLS (-12.801 and -1.653) are as provided in the brackets, respectively. The value of Z for each of the three models is not significantly different from the average bilateral distance value of 2,961 km. Again, the excessively high distance elasticities in our regressions do not help the predictive powers of the Parsley and Wei (1999) and Helliwell (2002) methods.

Many of the other regressors, included to test the Linder hypothesis and Heckscher-Ohlin proposition, are also quite different across the various subsamples – both for the baseline model and others, albeit not significantly. The log of per capita income differential has a negative coefficient estimate for both Canada-US trade and US-US trade, just like the full sample. In a stark comparison, however, this coefficient turns out to be positive for all five estimators in our interprovincial sample, albeit it is statistically insignificant for our benchmark estimator and PPML. This coefficient is insignificant under the FEM for both interstate and Canada-US trade. Focusing on the baseline model, again, we conclude that the Linder hypothesis holds for Canada-US trade and US-US trade, while the Heckscher-Ohlin proposition is not supported; we do not take a position on interprovincial trade because of statistically insignificant variables. Interestingly, the parameter estimates on the per capita income differential variable are markedly lower for interstate trade, in comparison to the Canada-US sample. Rather curiously, coefficient estimates of human capital differential and physical capital differential are also relatively lower in the US-US sample, compared to the Canada-US sample.

2.6 Summary and Conclusions

This chapter examines the extent to which trade costs, modeled by distance and contiguity, influence intranational and international trade. In an attempt to estimate the magnitude and direction of both east-west and north-south trade in Canada and the US, we provide an alternative framework which pays special attention to estimation issues related to unobserved heterogeneity, log-linearization in the presence of heteroscedasticity, and logarithmic transformation of zero bilateral trade flows. Our methodology recognizes that in the presence of these issues, the biases that are present in the various strategies employed to estimate the gravity model often produce misleading estimates of bilateral trade flows determinants.

Faced with a multiplicative gravity model, log-linearization in the presence of heteroscedasticity produces a form of transformation that can alter the properties of the error term and produce inefficient estimates, as a result of the huge difference between the estimates of the log-linearized model and those of a gravity model estimated in levels. We go with Martinez-Zarzoro *et al*.'s suggestion on the ability of the FGLS method to solve this problem, by ignoring the exact form of heteroscedasticity. The other strategy is the reliance on Santos Silva and Tenreyro's PPML, a heteroscedasticity-consistent estimator which assigns the same weight to all observations. The use of the PPML estimator comes with a cost – lesser accuracy in the presence of zero trade flows.

The presence of zero bilateral trade flows are a common occurrence in international trade. Choosing to completely ignore or replace zeros with a small positive number creates sample selection bias that renders parameter estimates inefficient for predictive purposes, and for trade policy analysis, by extension. Under a zero truncation scenario, we use the FGLS method, while the PPML estimator is the preferred alternative when the incidences of zero trade values are infrequent. Our third strategy for the zero trade issue is to simply replace the value of bilateral trade flows by the value of trade flows plus one: i.e. instead of using $\ln(X_{ij})$ as the dependent variable, we use $\ln(1 + X_{ij})$ instead. The final methodological issue is the problem of unobserved heterogeneity. This issue is addressed by using a panel data set which incorporates the FEM to disentangle the time invariant region-specific effects and to capture the relationships between the relevant variables over time.

To achieve our objectives, a number of hypotheses are advanced. We pay special attention to the issue of within-country and international borders, leading to the hypothesis that there is a stronger negative effect of the border on state-province trade, compared to interstate and interprovincial trade. This is based on the notion that if the border is truly a deterrent to trade, Canadian provinces should trade more with each other than U.S. states. The other equally important hypothesis is that there is a stronger negative effect of the border on interprovincial trade, compared to interstate trade. In other words, we expect the influence of the border on trade to be substantially less for interstate trade, compared to interprovincial trade.

For the full sample, we find across all specifications that the coefficients of exporter's GDP, importer's GDP and bilateral distance are economically significant with meaningful interpretations. Estimated elasticities of trade to size and distance close to unity. With a statistically and economically contiguity dummy, we also conclude that the presence of a border affects the intensities of economic exchange between a jurisdiction-pair, after controlling for bilateral distance. The border effect is more pronounced under the PPML than when OLS is used.

For the sub-samples, statistically and economically significant coefficients of 0.299 (Canada-US) and 0.362 (US-US) are comparable to estimates from some of the seminal papers cited under the literature review – e.g. McCallum. This upholds the hypothesis that there is a stronger negative effect of the border on international trade, compared to within-country trade. Notwithstanding a statistically insignificant border effect for the Canada-Canada sub-sample, we find with the aid of the FGLS method, after controlling for scale and distance, that interprovincial trade is about 17 times more important than state-province trade. This upholds the hypothesis that there is a stronger negative effect of the border on interprovincial trade, compared to interstate trade. This finding is consistent with major findings on the border effect; e.g. McCallum (1995), Wall (2000) and Anderson van Wincoop (2003).

We also compute how wide the border is – based on both the distance and border effects. Our estimated distance equivalent of the border effect is not significantly different from the average bilateral distance value of 2,961 km. We conclude that the unrealistically high distance elasticities in our regressions do not help the predictive powers of the methods deployed.

Results in this chapter provide mixed evidence for the Heckscher-Ohlin proposition and the Linder hypothesis; the former is refuted, while the latter is supported. We find that a 100% increase in per capita income differential will dampen trade by 7.5% and 19.4% for the low and high estimates, respectively. In stark comparison, negative signs on the coefficients of both the human capital differential and physical capital stock differential refute the Heckscher-Ohlin hypothesis that jurisdictions should trade more, the more different their factor endowments. Similar to the Linder scenario, the Heckscher-Ohlin coefficients are economically and statistically significant, ranging from a high absolute value of 0.305 to a low value of 0.198.

Overall, the findings in this chapter are reassuring, considering that not only are bilateral trade flows from all provinces and states used, the three methodological challenges that qualify the results of most gravity studies are equally addressed. There are practical implications for the results. Despite the seemingly large similarities in geography, culture, institutional framework, climate, history and economy, the Canada - US border remains a major factor that influences the patterns of trade flows between both countries. An estimated within-country border effect of 43.5% for interstate trade, compared to 1.92% for interprovincial trade, shows that the border effect is more pronounced in Canada than in the US. Compared to McCallum and Anderson and van Wincoop estimates, this also shows a decline, over time, in the home bias syndrome for Canadian provinces, reflecting, in a way, the effects of NAFTA's full implementation and AIT's progress.

Our results reject the notion that trade is driven by differences in relative factor endowments between regions. Historically and relatively speaking, the economies of Canada and the US both have labour and capital in abundance. To the extent that gains from specialization arise because of differences between regions, the results that we see may be due to the lack of sharp contrast in their resource endowments.

That said, more research is needed to explore what impact a reduction in aggregation bias may have on estimated parameters. The reasoning behind this is simple: disaggregated industry-level trade data will better capture trade costs heterogeneity and border effects across sectors.

Chapter 3 Fiscal Federalism and Trade Openness: A Canada-US Dynamic Panel Specification

3.1 Introduction

This chapter examines the relative importance of intergovernmental fiscal redistribution and trade openness as determinants of economic growth in Canada and the US – two federations with different divisions of powers between national and sub-national governments. The central economic argument for most countries organized along federalist grounds is that economic integration helps maximize efficiency gains from common markets as a result of free trade and factor mobility; at the same time, decentralized decision making ensures welfare maximization by ensuring that local policies are customized to the needs of often heterogeneous populations with different regional tastes (Kessler and Lessmann, 2008).

Fiscal transfers have redistributive consequences, even when it is not a policy objective, ex-ante. Canada and the US share many commonalities in their intergovernmental fiscal regimes, albeit significant differences abound. For instance, both federations have two or more orders of government acting directly, rather than through another level of government, on the citizens; and in particular, there is a constitutionally defined distribution of expenditure responsibilities and revenue sources (Boadway and Watts, 2000). Unlike the US, however, where there is no harmonization in the various state and federal taxing programs, Canada's fiscal regime is relatively more integrated.

For instance, the provinces have more flexibility and discretion in the delivery of health, education and social services, compared to US states. Also, while Canada's Equalization program is explicitly intended to redistribute resources among provinces, this program has no direct counterpart in the US; the US federal government transfers resources to the states through the Grants-in-Aid system, a much more complex system.

Clearly, the decentralization-growth question remains open, as most cross-country econometric studies provide weak evidence chiefly because results change depending on the countries examined. Canada and the US are two of the most sophisticated and decentralized fiscal unions in the world. Both federal-provincial and federal-state relations provide for sovereign powers in many areas, including taxing power and the ability to tap all significant sources of revenue, including natural resources.

By looking at sub-national regions in both countries that share many common characteristics typical of a fiscal union, we control for many jurisdiction-specific features that might obscure the dynamics of the decentralization-growth nexus. As expected, differences in the economic structures and performances among different regions are likely to have an impact on the way fiscal redistribution affects income levels. Using a dynamic panel of Canada-US data, we estimate the importance of redistributive flows by regressions which estimate the relationship between personal income after federal taxes and transfers, and pretax personal income. This gives a direct measure of the degree to which fiscal transfers impact inequalities in regional incomes. This is the first major objective of this chapter.

In the past, many restrictions on interprovincial trade were prevalent in Canada. Over the years, specifically starting in 1995, some efforts to ease trade were made – the result of which was the Agreement on Internal Trade (AIT) negotiated in 1994 and executed in 1995. The AIT is a policy initiative focused on negotiations and adjustments to further liberalize trade throughout the Canadian economy. Surprisingly, no known study has attempted to empirically evaluate the impact of this policy on income growth, while controlling for fiscal federalism. While this is not the first paper to study the implications of Canada-US interregional fiscal transfers for income convergence, it definitely is the first to look at this issue from a pre- and post-AIT perspective. Even so, we extend the analysis by applying the difference-in-differences (DiD) methodology to better capture the effect of the AIT policy. This is another major contribution of this thesis.

We also introduce a number of refinements in the estimation methods in order to increase the reliability of our econometric estimates. In particular, the attention given to the difference and system generalized method of moments (GMM) estimator in a Canada-US sub-national panel data environment is worth emphasizing. Most of the latest literature examining the fiscal decentralization-economic growth question tends to rely on cross-country ordinary least squares (OLS) empirical methodology; a few others incorporate the fixed effects model (FEM).

Certainly, net fiscal transfers, trade openness and our other control measures are going to be endogenous in the model. Applying both system and difference GMM estimation techniques that eliminate biases associated with omitted variables, endogeneity and unobserved heterogeneity (within a regional income convergence framework that also examines trade liberalization effect), no doubt, is a major advance. Other by-products of this chapter include: (i) updated results with Canada-US sub-national data on the fiscal transfers-growth discussion; and (ii) estimates of the impacts of trade openness, educational attainment and physical capital stock on economic growth.

Our control measures are among the popular variables identified in the literature as potential determinants of economic growth (Mankiw *et al*, 1992; Sala-i- Martin *et al*, 2004). In the interest of keeping the model and robustness tests as simple as possible, we perform the tests for the baseline model first and compare our results with those obtained from other models. We then offer possible interpretations of the results in light of the estimation strategies employed.

The chapter proceeds as follows. In section 3.2, we review related literature. Section 3.3 discusses some theoretical issues relating to the growth empirics model, and introduces our data sources and variables considered as potential determinants of growth under a fiscal decentralization framework. Estimation methods and empirical results are presented in section 3.4, while section 3.5 concludes, with policy implications.

3.2 Literature Review

3.2.1 Fiscal Transfers and Implications

The theoretical literature is still unclear about the precise role of fiscal policy in the growth process, especially fiscal transfers and taxation (see McCracken, 2006). In particular, public finance theorists have long cited the fairness and efficiency concerns associated with regional fiscal disparities as something policy makers should worry about. The lack of reliable and consistent regional fiscal data further compounds this problem. Nonetheless, the importance of fiscal policy in achieving redistribution and stabilization for policy makers remains undisputed. Fundamentally, all transfer programs involve a flow of resources from central to sub-national governments. Whether intended or not, this has redistributive consequences.

Ma (1997), for instance, believes that the need to correct vertical fiscal imbalances, horizontal fiscal imbalances and inter-jurisdictional spill-over effects are some of the economic rationales for intergovernmental transfers. Fiscal transfer programs in many federal systems try to equalize differences in the tax capacities of regional jurisdictions. While equity considerations have a way of making regional redistribution appear as a pro-growth policy, economic efficiency arguments clearly reject such arguments based on the deadweight loss generated when equilibrium for a good or service is not Pareto optimal. Policy makers therefore constantly face the dilemma of balancing equity arguments against the distortionary effects of fiscal transfers on net payers and net recipients.

Arguments for and against decentralization abound in the literature. Public finance theory posits that fiscal decentralization helps to increase the degree of efficiency in the allocation of resources: lower levels of governments are closer to the people and are believed to have an informational advantage on the needs and preferences of residents, compared to central governments (Ezcurra and Rodríguez-Pose, 2009). When factor mobility advantages accrue as a result of fiscal decentralization, such efficiency gains will generate further benefits through the domino effect. As a pre-condition for economic convergence, for instance, fiscal transfers to poorer regions will be needed to help finance the investment needed to raise the productivity levels of residents of these regions in order to allow them compete nationally.

In the contrary, some sub-national governments may not have the capacity and sophistication required to make optimal decisions on resource allocation, compared to the central government (Gill and Rodríguez-Pose, 2004). Also, fiscal transfers to poorer regions may just be enough to supplement the income of regions with low productivity due to adverse climatic conditions or other geographic disadvantages.

On Equalization transfers for instance, Canadian territories receive more on per capita basis than the provinces due to the harsher climatic conditions and remoteness of the territories, which make them sparsely populated and with high costs for public services. In this case, we can expect such transfers to create a disincentive for labour mobility, and as such, the much expected convergence in productivity may not happen; this can be justified based on equity considerations (Boadway and Flatters, 1982). Likewise, employment Insurance plays a significant role in transferring income to regions with high unemployment; rules are designed to make qualification easier in high employment regions.

An important function of fiscal policy in a federal system is the capacity to make continuing income transfers from richer to poorer regions; we agree though that such transfers play different roles. Many countries around the world continually restructure the roles of various levels of government. For those organized along federalist grounds – e.g. Canada, Australia, Belgium, Germany and the US – pressures continue to mount regarding the balance of power between the central and sub-national levels of governments (Fraser Institute, 2013). The US, again, unlike Canada, has no formal framework – like Equalization –to transfer resources from prosperous states to less prosperous ones. Instead, the federal government uses the Grants-in-Aid, a subsidy-type program that is accompanied by federal regulations, to extend its power into state and local affairs (Fraser Institute, 2013).

While the nature of the relationship between fiscal decentralization and economic growth continues to attract considerable attention in the literature, the direction of this relationship remains an open question till date. Some empirical tests show a negative or no relationship at all [e.g. Davoodi and Zou (1998), Zhang and Zou (1998), Woller and Phillips (1998), and Xie et al. (1999)]; others such as Lin and Liu (2000), Akai and Sakata (2002) and Stansel (2005) establish a positive association. One important consensus in the literature remains though: the degree of fiscal decentralization is important in the growth accounting process of any nation.

Among others, the literature on fiscal federalism suggests three economic rationales for fiscal transfers (Ma, 1997). First, in countries where national governments have control over the major tax bases, leaving sub-national governments with insufficient fiscal resources to cover their expenditure needs, vertical fiscal imbalances result. Fiscal transfer is therefore required to meet the resulting shortfall. Fiscal transfers may also be needed to bridge differences in fiscal capacities as a result of horizontal fiscal imbalances.

For instance, while a resource-endowed jurisdiction may have more than enough to provide public goods for its residents and care less about fiscal inflows from other levels of government, another region with a relatively higher proportion of poor, old and young population may be unable to cope without such transfers. In this case, Equalization payments will be required to close the gap between the fiscal capacity and fiscal need of the jurisdiction in question. In other words, a minimum standard of public service is required in all the federating units. In order not to increase the tax burden of residents, subsidies will be required from the central government by regions without sufficient resources to reach such minimum level.

In Canada, for instance, provinces that are deemed to be eligible for Equalization receive monies while those designated as contributors do not receive any payments. For the most part, the intensity with which conditional grants are used is more pronounced in the US, compared to other federalist developed countries.

Under the assumption of perfect factor mobility, it may not be necessary for government to play the role of equalization as the market itself will reallocate resources to achieve this end. The reality, however, is that perfect factor mobility is unattainable due to information issues, relocation costs and employment constraints, among other things. Last but not least is the need to internalize inter-jurisdictional spill-over effects. Due to concerns relating to free-ridership by mobile residents and neighbouring jurisdictions, a sub-national government may underinvest in important public goods with positive externalities such as education, health and inter-regional highway. In this case, the central government will have to address such sub-optimal provision by providing subsidies or other incentives.

Bayoumi and Masson (1993) explain some of the reasons why a federal system may tend to support a redistributive fiscal regime. First, they claim that to the extent that taxes are higher in regions with high incomes, redistribution will help achieve regional after-tax income equalization. The fact that corporate taxes are, to a large extent, related to income is their second premise. Political considerations and the fact that poor regions are often in more social need (necessitating their residents to receive personal transfer payments to help in poverty alleviation) are other grounds cited by Bayoumi and Masson.

3.2.2 Fiscal Transfers and Growth Empirics

One of the main predictions of the neoclassical growth model is that less affluent regions will grow faster than more affluent ones, provided the different regions are at different points relative to their steady state growth paths (Solow 1956; Swan 1956). This has become known as β-beta convergence; for instance, Barro (1991), Barro and Sala-i-Martin (1991 and 1992), Mankiw et al. (1992) and Sala-i-Martin (1996) provide empirical evidence of income convergence of approximately 2% per annum for regions of the US, Japan and Europe.

By the way, Romer (1986), among others, argues through the endogenous growth theory that there may be constant or increasing returns to capital – suggesting that the notion of convergence in per capita income may not be true. They suggest factoring in the positive externalities of a knowledge-based economy in the growth accounting process rather than some exogenous technological factors.

In the subsequent paragraphs of this section, we organize the reviewed papers along regional and methodological themes. For the former, we look at regional studies, while recent panel techniques are examined for the latter.

Bayoumi and Masson (1993) use fiscal transfers at the sub-national level within the US and Canada to analyze long-term fiscal flows (the redistributive element) and short-term responses to regional business cycles (the stabilization element). While long-run flows amount to 22 cents of every dollar spent while the stabilization effect is 31 cents in the dollar for the US, Canada produces a larger redistributive effect (39 cents) and smaller stabilization effect (17 cents). They conclude that federal flows appear to depend on the institutional structure of the country concerned, in addition to providing evidence that a federal fiscal system tends to support the relative income of poor regions and reduce that of rich regions.

Akai and Sakata (2002) provide evidence that fiscal decentralization contributes to economic growth, using carefully selected state-level data drawn from an economic survey of the US that leaves out a period of high economic growth. Though consistent with theoretical results on the subject matter, their finding contradicts the empirical results of many papers before theirs. Akai and Sakata (2002) allude the trajectory of their finding to the nature of the data set used in the regression analysis. Among other things, this data set is characterized by small differences in history, culture, and the stage of economic development. They conclude that such distortion-free data set did indeed reveal the true positive effect of fiscal decentralization. Akai and Sakata conclude that in measuring the impact of fiscal decentralization on economic growth, it is important to get the definition of fiscal decentralization right.

Using a system of simultaneous equations, Checherita *et al.* (2009) use a large sample of European regions covering 19 European Union (EU) member states for the 1995-2005 period to analyze the aggregate impact of taxation and transfers on income and output convergence. They find evidence in support of a convergence process across the member states in terms of both per-capita output and income. Their results show that, on average, net fiscal transfers impede output growth, and when the sample is split further to show the nature and intensity of fiscal transfers, they find varying degrees of negative impact of net transfers on growth. Output growth rates in less prosperous receiving regions decline by less, compared to contributing more prosperous regions, in reaction to the fiscal transfers: a condition termed immiserising convergence.

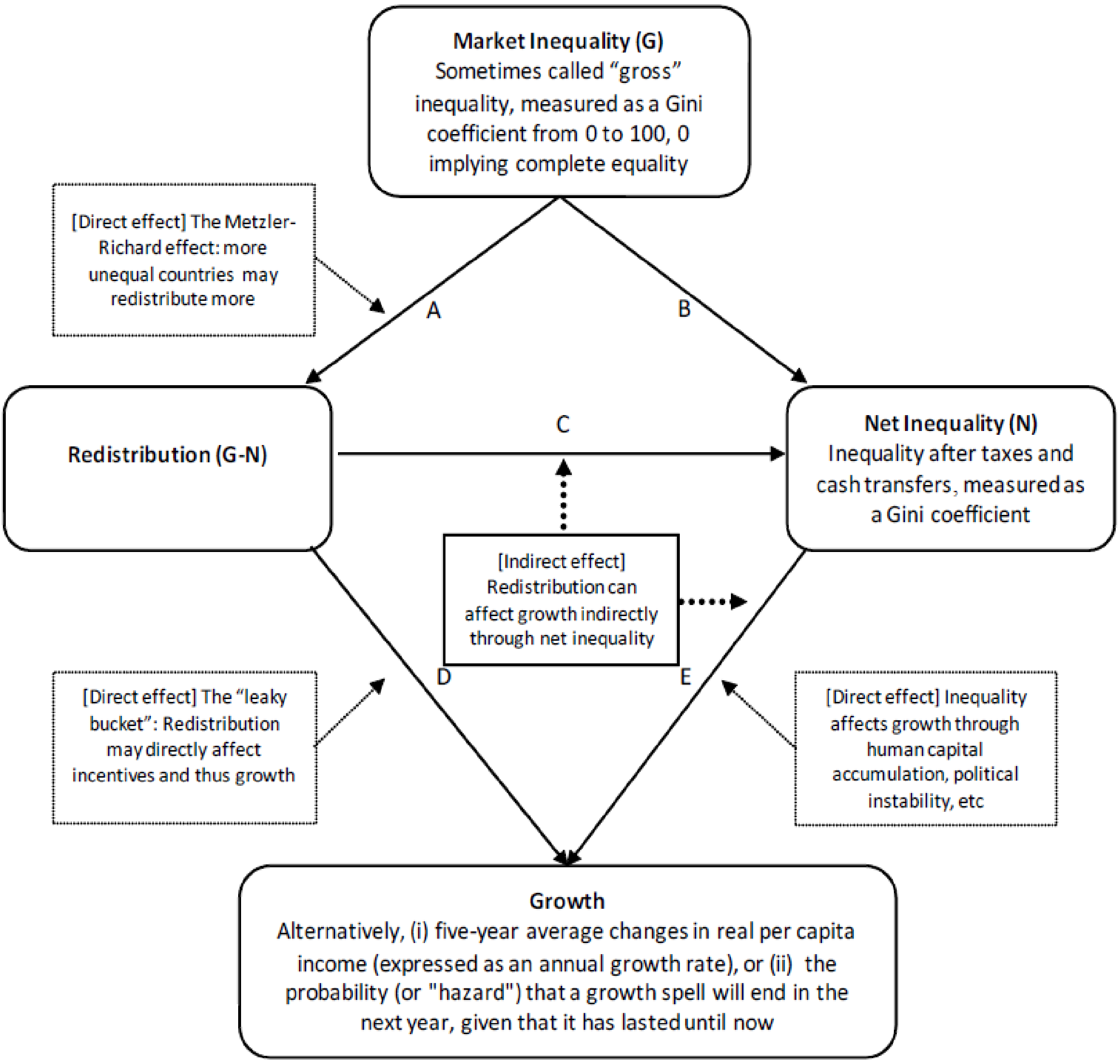
Bargain *et al.* (2013) study the redistributive and stabilizing effects of a fiscal equalization scheme in the Euro area. Precisely, they study the economic effects of introducing the following two elements of a fiscal union using representative household micro data from 11 Eurozone countries: (i) an EU-wide tax and transfer system and (ii) an EU-wide system of fiscal equalization. Their study reveals huge redistributive consequences – both within and across countries – when one third of the national tax and transfer systems are replaced by a European system. While they conclude that the EU system will benefit credit constrained countries in particular, through improved fiscal stabilization, their study also suggests that a fiscal equalization regime based on taxing capacity will lead to income redistribution from high to low income countries – with ambiguous stabilization properties.

Using dynamic panel data (DPD) techniques, Potrafke and Reischmann (2014) ask whether fiscal policy conducted by sub-national governments in Germany and the US is based on fiscal transfers. Employing a Bohn-type (1998) fiscal reaction function, and based on the assumption that the debt-to-GDP ratio in the preceding period has a positive influence on the primary surplus-to-GDP ratio in the current period, they find that sustainable fiscal policy in the US and Germany is only achievable through fiscal transfers.

McInnis (1968), the pioneer of studies on regional disparities in Canada, uses per capita income levels for the provinces (relative to the Canadian average) in both weighted and non-weighted terms to show that the income gap from 1926 to 1962 stayed the same. On the US side, Barro and Sala-i-Martin (1990) use a neoclassical growth framework to establish the presence of β convergence across the states of the US They find a rate of about 2-2.5 per cent per annum between 1940 and 1988 for per capita personal income and between 1963 and 1988 for per capita gross state product. Six years after, Sala-i-Martin (1996) included Japanese prefectures, regions in Western Europe and Canadian provinces; he finds income convergence rates for Canada (2.4 per cent from 1961 to 1991), Western Europe (1.5-1.8 per cent from 1950 to 1990), Japan (1.9 - 3.1 per cent from 1955 to 1990) and the US (1.7-2.2 per cent from 1880 to 1990).

We close this section with a brief discussion on the interrelationships between the three key variables discussed so far: income, redistribution and growth. Ostry et *al.* (2014) maintain that the link between all three is a complex one. While they agree that theory provides only a partial guide on these issues, they equally caution that care should be taken before drawing conclusions from available empirical evidence. Ostry et *al.* use the framework in Figure 3.1 below to drive home their points.

Figure 3.1: Interrelationships between Inequality, Redistribution, and Growth



Source: Ostry et *al.* (2014)

The chart shows the direct effects of redistribution (line D) and net inequality (line E), while in each case, the value of the other variable is held constant. Ostry et *al.* calculate the "total effect" of redistribution on growth based on the assumption that "redistribution does not affect market inequality, so redistribution affects net inequality one-for-one". They add that the total effect is the sum of the estimated direct effect (line D) and the indirect effect, which is a combination of the effect of redistribution on net inequality (line C) and the estimated direct effect of net inequality on growth (line E). Ostry et *al.* conclude that many other directions of causality abound, in addition to possible channels for the income-inequality-redistribution nexus.

3.2.3 Trade Openness and Convergence

The role of international trade in the determination of the long-run pattern of growth and welfare has always been under the searchlight of economic research. Major studies on the trade-convergence debate (e.g. Sachs and Warner, 1995; Ben-David, 1996; Ben-David and Bohara, 1997; Ranjan, 2003; and Sohn and Lee, 2006) conclude that trade aids the β-beta convergence process. Among others, these studies cite the factor price equalization theorem, factor proportions model and the role of international technology transfer in the determination of the long-run pattern of trade, growth and welfare (Grossman and Helpman, 1991).

In support of trade openness as a potent control measure, Gramlich (1987) argues that exposure of open economies to international competition leads to disproportionate outcomes for the regions involved. He posits that regional stabilization policies can be used to address the resulting asymmetric shocks. By allowing for interaction effects with lagged per capita income levels, we hope to garner evidence for the impact of openness on economic performance. That way, we get insights on how policies directed toward more trade openness may help address widening regional income gaps. By examining relative jurisdictional trade openness among regions in the US and Canada, our thesis makes a novel contribution to the literature.

Thie*β*en (2003) posits that there exists an inverted U-shaped relationship between fiscal decentralization and economic growth in the OECD countries. This means a quadratic specification[21] is required to estimate the optimal level of fiscal transfers required to maximize economic growth; a positively sloped curve arises when fiscal decentralization increases from low levels, while any additional transfers beyond the optimum result in a negatively sloped curve.

From an econometric perspective, the use of panel fixed effects in cross-country regressions allows for the control of unobserved factors like institutional quality, language, geography and other cultural characteristics. However, using Canada-US sub-national data provides a more robust platform to look at these issues in detail since such individual differences are not expected to be very pronounced in a regional data setting. Compared to a cross-country setting, Canadian provinces and US states are more homogeneous; we therefore expect to arrive at more precise estimates.

The conundrum on the precise role of fiscal transfers on income growth provides a major motivation for this chapter; we will examine the role of federal fiscal flows in reducing income differentials under a dynamic panel framework for all 60 jurisdictions. This thesis uses the GMM estimation method to separately explain the conditionality of income growth on fiscal transfers and economic openness. In so doing, we overcome the biases associated with unobserved heterogeneity, omitted variables, and endogeneity which often render the results of most cross-sectional OLS growth studies in the current literature less potent.

3.3 Theoretical Setup and Model Specification

3.3.1 The Mankiw-Romer-Weil Framework

We base our panel analysis on the empirics of economic growth, which has now moved from the "Barro cross-sectional regression" to the static and DPD techniques. The Solow growth model presents a theoretical framework for understanding the sources of economic growth, and the consequences for long-run growth of changes in the economic environment.

A framework available to directly test the Solow growth model is the growth empirics method of Mankiw, Romer and Weil (1992) where they argue that the Cobb-Douglas

[21] This is tested empirically under our sensitivity analysis in order to confirm or refute this hypothesis for Canada and the US

formulation of Solow's growth model should be extended to include human capital as well as physical capital. This would imply an underlying aggregate production function of the form:

$$\mathrm{Y_{jt}} = \mathrm{K_{jt}^{\alpha}\,H_{jt}^{\beta}(A_{jt}L_{jt})^{1-\alpha-\beta}} \quad (3.1)$$

Where *Y* is total income, *L* is labour supply and *A* is a technology parameter, with *L* growing at an annual rate *n* and *A* growing at rate *g*.

In line with Solow, Mankiw *et al*. (2003) rewrite income, physical and human capital in (3.1) in terms of quantities per unit of effective labour:

$$y_t = \frac{Y_t}{A_t L_t} \qquad (3.2)$$

$$k_t = \frac{K_t}{A_t L_t} \qquad (3.3)$$

$$h_t = \frac{H_t}{A_t L_t} \qquad (3.4)$$

The changes over time in physical and human capital per unit effective labour are:

$$k'_t = s_k y_t - (n + g + \delta)\, k_t \quad (3.5)$$

where δ is the proportionate depreciation for both physical and human capital, and S_k and S_h are the respective savings rates for physical and human capital which are assumed to be constant over time, though not across countries.

Solving for steady-state solutions $k*$ and $h*$, Mankiw *et al*. derive an equation for steady-state income growth as follows:

$$\ln \mathrm{Y_t} = \ln A_0 + g_t - \left(\frac{(\alpha+\beta)}{(1-\alpha-\beta)}\right)\ln(n+g+d) + \left(\frac{\alpha}{(1-\alpha-\beta)}\right)\ln s_k + \left(\frac{\beta}{(1-\alpha-\beta)}\right)\ln s_h \qquad (3.6)$$

The physical capital savings rate, S_k, was approximated by the investment share in GDP, while the human capital savings rate S_h was measured by the proportion of the working age population at any one time enrolled in secondary school. Mankiw *et al*. conclude that augmenting the Solow model with measures of human capital leads to an improvement in its predictive power of explaining cross-country per capita output growth and levels. The objective in this chapter is to assess the impact of fiscal transfers on economic growth, using the Mankiw *et al*. model as a general framework.

3.3.2 Research Hypotheses

The preceding discussion strongly suggests that the dynamics of intergovernmental transfers in federalist democracies are complex. It remains an open question what impact fiscal transfers have on GDP per capita. Doing this within a regional income framework that also examines trade openness and the AIT policy makes this chapter more encompassing.

Following the literature review and theoretical framework presented above, we generate the following hypotheses to examine in detail the central issues discussed so far:

Hypothesis 6

> H_0: There is no relationship between net fiscal transfers and GDP per capita.
> H_1: There is a positive relationship between net fiscal transfers and GDP per capita.

Fiscal transfers based on personal income after taxes and transfers, and pretax personal income, are a potent fiscal tool used to analyze the effects of redistribution. Economic theory provides a partial guide on these issues; we need empirical evidence on the precise nature of the tradeoff between redistribution and growth. While inequality may provide an incentive to redistribute, we need to establish the magnitude and direction of the impact of redistribution on growth. In light of this, the following lower-level hypotheses are advanced:

Hypothesis 6a

H_0: There is no distinction in the nature and intensity of fiscal flows impact on GDP per capita in prosperous and poor regions.

H_1: There is a different impact of fiscal flows on GDP per capita for prosperous and poor regions.

Hypothesis 6b

H_0: There is no distinction in the combined effect of fiscal transfers and lagged income on GDP per capita, compared to the lone effect of fiscal transfers.

H_1: There is a stronger effect of fiscal transfers and lagged income on GDP per capita, compared to the lone effect of fiscal transfers

Hypothesis 7a

H_0: There is no relationship between trade openness and GDP per capita

H_1: There is a positive relationship between trade openness and GDP per capita

Hypothesis 7b

H_0: There is no distinction in the combined effect of trade openness and lagged income on GDP per capita, compared to the lone effect of trade openness.

H_1: The combined effect of lagged income and trade openness on GDP per capita is much stronger than the individual effect of trade openness on GDP per capita.

Hypothesis 8a

H_0: There is no relationship between the AIT policy and GDP per capita

H_1: There is a positive relationship between the AIT policy and GDP per capita

Hypothesis 8b

H_0: There is no distinction in the combined effect of the AIT policy and lagged income on GDP per capita, compared to the lone effect of policy.

H_1: The combined effect of lagged income and the AIT policy on GDP per capita is much stronger than the individual effect of the policy on GDP per capita.

3.3.3 Model Specification

As discussed above, the theoretical underpinnings of a number of work on income convergence rely largely on the Solow growth model; for instance, Mankiw *et al*., Barro and Sala-i-Martin (1992), Coulombe and Lee (1995) and Islam (1995). Even so, many other studies relating fiscal transfers specifically to regional income growth are also largely based on Solow; as is the case in Coulombe and Lee (1995), Darku (2011) and Checherita *et al*. (2009), among others.

Following section 3.3.1 above, we conclude that:

$$\ln \mathrm{Y_t} = \ln A_0 + g_t - \left(\frac{(\alpha+\beta)}{(1-\alpha-\beta)}\right)\ln(n+g+d) + \left(\frac{\alpha}{(1-\alpha-\beta)}\right)\ln s_k + \left(\frac{\beta}{(1-\alpha-\beta)}\right)\ln s_h \qquad (3.7)$$

Many studies on conditional convergence (e.g. Barro and Sala-i-Martin 1990, 1991 and 1992) pay little or no attention to the initial state of technology, denoted by the technology parameter A (0) and the technological growth rate g. Rather than accept that A (0) and g differ across regions and therefore correlated with the S and $(n + g + \delta)$ variables, they are often considered part of the residuals or the constant terms. While it may be plausible that g is homogeneous across regions, especially considering externalities and spillover effects of technology and innovation, to assume that A (0) does not differ across Canadian and US jurisdictions in our own case is understating the obvious.

In particular, given these two countries' vast geographic area, regional resource diversities, institutional, climate and technology differences, our strategy in this study is to implement a panel data framework that recognizes these differences in the initial endowments across jurisdictions. One of our major objectives here is to test the extent to which the various policy interventions over the years – e.g. fiscal flows, AIT and trade liberalization – have reduced the huge regional disparities in capabilities. Of course, this may not be the case for time-invariant factors like climatic differences.

For instance, while Eaton and Kortum (1999) and Keller (2001) both agree that trade liberalization helps international technology diffusion when technical knowledge is a component of the goods and services traded, Parente and Prescott (2000) believe in the contrary; they argue that income convergence might instead not occur as a result of certain constraints on technological adoption.

With differences in jurisdictional initial technological state and with a homogenous technological growth rate assumed, our focus shifts to how best to estimate a dynamic panel framework. This is important, given our interest in regional convergence among regions with transitional growth dynamics towards a steady state income path; Weeks and Yao (2003) implement an autoregressive form of the Solow growth model, resulting in a DPD model with a distinct time-invariant individual regional effect term and a time-specific term.

To assess the impact of fiscal transfers and openness on economic growth, we estimate an autoregressive model with structural change in the autoregressive coefficient and with jurisdictional fixed effects and year effects.

Following this, Equation 3.7 above is written in a general form as:

$$\mathrm{Y_{it}} = \gamma \mathrm{Y_{it-1}} + \sum \beta_{\mathrm{j}} \mathrm{X_{itj}} + \mu_{\mathrm{it}} + \nu_{\mathrm{it}} \qquad (3.8)$$

where γ measures the rate of convergence, ν_{it} is the transitory disturbance term with a mean of zero which varies across regions and time periods.

One of the objectives of this chapter is to estimate a measure of the impact of the AIT policy on economic growth in Canada. We hope to do so by taking advantage of the fact that US states were not party to this policy. In fact, the timing of the signing of AIT may be correlated with other economically significant developments in Canada – for instance, the North American Free Trade Agreement (NAFTA) and the Mexican peso crisis of 1995 which put the Canadian dollar under strong downward pressure and led to sharply rising interest rates across all maturities.

The DiD approach, by including all 50 US states in the analysis, could help us single out the effect of AIT more precisely. The central tenet of the DiD approach is, according to Slaughter (2000), in order to study the impact of a treatment, the performance of the treatment group is compared, before and after the treatment, relative to the performance of some control group pre- and post-treatment. That way, the impact of the treatment on the control group reveals what otherwise would have happened had the treatment group not been exposed to such treatment. In other words, we observe both the US and Canadian samples at two different time periods: pre-AIT and post-AIT.

With the Canadian sample exposed to the AIT policy treatment post-1995 but not in the pre-1995 period, the US sample therefore qualifies as not having been exposed to any treatment pre- or post-1995. Under our panel data framework, this methodology delivers an estimate of the required causal effect. However, underlying validity of DiD estimates is the fundamental assumption that trends in outcome variables would remain the same for treatment and control groups, even when we do not have the privilege to observe the counterfactual.

While acknowledging the many interesting advantages of the DiD estimation strategy, including being able to help overcome issues relating to endogeneity as a result of heterogeneous comparisons, Bertrand *et al*. (2003) identify major issues with this methodology; they also proffer solution to these problems. Essentially, their strategy is to "assume away biases in estimating the intervention's effect and instead focus on issues relating to the standard error of the estimate".

Following Slaughter (2000), we represent the treatment effect to be estimated with the below equation:

$$y_{it} = \alpha + \beta d_t + e_{it} \quad (3.9)$$

where y_{it} represents the outcome for agent *i* at time *t*, d_t is a dichotomous variable with value of one if t = 1 and zero if $t = 0$. The variance of the error term e_{it} varies by

t. With the aid of β, we determine the causal effect of the treatment, by considering what otherwise would have happened had the treatment group not been exposed to such treatment.

Employing our standard notations, we use two basic econometric specifications to capture the dependence of real GDP per capita on fiscal transfers, trade openness, AIT policy and other control variables.

$$\ln \mathrm{RGDP}_{it} = \beta_0 + \beta_1 (lnRGDP_{it-1}) + \beta_2 (NFT_{it}) + \beta_3 (NFT.lnRGDP_{it-1}) + \beta_4 (\mathrm{EDU_{it}}) + \beta_5 (CAP_{it}) + \beta_6 (\mathrm{AIT}) + \mathrm{JU}R_i + TIM_t + \mu_{\mathrm{it}} \quad (3.10)$$

$$ln\mathrm{RGDP}_{it} = \alpha_0 + \alpha_1 (lnRGDP_{it-1}) + \alpha_2 (OPN_{it}) + \alpha_3 (OPN.lnRGDP_{it-1}) + \alpha_4 (\mathrm{EDU_{it}}) + \alpha_5 (CAP_{it}) + \mathrm{JU}R_i + TIM_t + \mu_{\mathrm{it}} \quad (3.11)$$

All variables and notations are defined below:

$RGDP_{it}$	Real GDP per capita in levels for jurisdiction *i* at time *t*
$RGDP_{it-1}$	Lagged real GDP per capita for jurisdiction *i* at time *t*
NFT_{it}	Net fiscal transfers for jurisdiction *i* at time *t*
OPN_{it}	Trade openness measure for jurisdiction *i* at time *t*
EDU_{it}	Human capital stock for jurisdiction *i* at time *t*
CAP_{it}	Physical capital stock for jurisdiction *i* at time *t*
AIT	Agreement on Internal Trade dummy[22]
JUR_i	Jurisdiction-specific effects
TIM_t	Year-specific effects
μ_{it}	Random error term for jurisdiction *i* at time *t*.

The random error is a normally distributed idiosyncratic error term, with mean 0 and variance σ_ε^2, that captures all other omitted effects on relative real GDP per capita and is assumed to be well-behaved.

[22] Basis for period discussed later in this chapter

Based on the hypotheses advanced earlier in the chapter, a priori, we expect positive signs for $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and β_6 ; and $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ and α_6. A positive sign on the coefficient of each variable will support the notion that higher fiscal transfers, higher degree of trade openness or existence of the AIT policy – or their interaction term – is associated with higher GDP per capita.

3.4 Data, Variables and Econometric Strategy

3.4.1 Data Sources

Our data are compiled from the following sources: US Bureau of Economic Analysis (Regional Economic Accounts), Statistics Canada (Provincial Economic Accounts), World Bank (National Accounts Data), OECD (National Accounts Data Files), Industry Canada (TDO), Office of Trade and Economic Analysis, US Department of Commerce (TradeStats Express) and the Bank of Canada (Rates and Statistics – Annual Average Exchange Rates.

We exploit a large annual panel data set spanning eight three-year intervals from 1987[23] to 2010 and covering all 10 Canadian provinces and 50 states of the US GDP data for the 1981-1997 period for all 60 jurisdictions are based on the Standard Industrial Classification (SIC) system, while 1998-2010 data are based on the North American Industry Classification System (NAICS). Ordinarily, we would expect some caveat is necessary as a result of appending the two data series to construct a single time series. However, such differences do not have any major impact on our analysis since the switch in the NAICS and SIC methodology occurred across all jurisdictions at the same point in time.

We use the following specific three-year averages: 1987 – 1989; 1990 -1992; 1993 – 1995; 1996 – 1998; 1999-2001; 2002 -2004; 2005-2007 and 2008 - 2010. This gives rise to N = 60; T = 8. In the regression itself, T becomes 7 because we lose one complete data set to lagged per capita real GDP calculation. This amounts to 60 observations for each period, and when multiplied by 7, we have 420 observations.

We use three-year averages in order to abstract from short-term cyclical factors. This way, the regression coefficients obtained give a direct measure of the degree to which

[23] Real GDP data for US states are only available from 1987

the federal tax system reduces inequalities in incomes (Bayoumi and Mason, 1993). Following Loayza (1994) and Islam (1995), the use of three-year averages helps to revisit Mankiw *et al.*'s assumption that the error term is exogenous. Eberhardt and Teal (2009) maintain that "the crucial innovation over Mankiw *et al.* is the introduction of country fixed effects (operationalized using the `within-groups' transformation), which allow for differential total factor productivity levels across countries".

We therefore go with Islam's (1995) generally accepted method of short period-averaged panels, which, again, according to Eberhardt and Teal, has become a standard alternative to the single convergence regression framework. More importantly, such estimation occurs without the need to qualify our results due to the influence of undesirable properties – such as the non-stationarity of the time series. Using three-year averages also helps to avoid the problem of biased FEMs: which occurs when dependent and independent variables do not fully adjust over a single year for data pooled over consecutive years.

Since we are restricted by data availability from all sources for the three issues to be examined (i.e. fiscal transfers, trade openness and AIT policy), we focus on two different data regimes. The fiscal transfer-AIT-growth component focuses on the 1987-2010 period, while our analysis on trade openness examines the 1999-2010 period. We focus on the 1999-2010 period for the latter because while Canadian provincial exports and imports data are available from 1990-2013, state-level data for the US are only available from 1999 to 2013 for exports. Even so, imports data are available from 2010 to 2013. Further details on this are provided under the variables section below.

3.4.2 Variables

We discuss data sources and construction of our variables below:

3.4.2.1 Per Capita Real GDP

Real GDP per capita data are obtained from the US Bureau of Economic Analysis (Regional Economic Accounts) and Statistics Canada (Provincial Economic

Accounts). Canadian data are converted into US dollars using annual Canada-US average nominal exchange rates.

3.4.2.2 Relative per Capita Real GDP

Most government fiscal transfer programs are based on the relative fiscal capacities of the participating jurisdictions. In Canada, for instance, the Equalization program is executed based on a formula-driven measure of provincial fiscal disparities. Provinces with relatively low fiscal capacities receive the most transfers on a per capita basis, while provinces with higher fiscal capacities receive less. Not just that, the program is set up such that as a province's relative fiscal capacity grows, the new program automatically reduces fiscal transfers and vice versa (Department of Finance, Canada).

As previously discussed, the US is one of the few federations in the world without a formal system of equalization among its sub-national governments to reduce fiscal disparities. Regardless, this country uses its other federal grants programs in such a way that the relative fiscal capacities of states are taken into consideration. For instance, Medicaid, the largest states' federal grants program is implemented on the basis of the formula based "Federal Medicaid Assistance Percentages" or FMAP (Stark, 2010).

The FMAP formula uses relative per capita income as a measure of fiscal capacity. In other words, this percentage is calculated by reference to the relative per capita income of states – thereby guaranteeing higher FMAP for low-income states and lower FMAP for high-income states FMAP (Stark, 2010). Similarly, under the Canadian Equalization program, once a province is deemed to have adequate fiscal capacity to provide essential public services, it stops being a beneficiary of the program.

To effectively control for different fiscal capacities in all 60 jurisdictions, the above analysis provides a major motivation for the inclusion of relative per capita GDP. This is constructed as the ratio of the per capita GDP of a province (state), relative to the Canadian (US) average. As explained above, Canadian real GDP per capita data are converted into US dollars using annual Canada-US average nominal exchange rates.

3.4.2.3 Net Fiscal Transfers

One of the major goals of fiscal transfers from central governments is to promote equalization of basic public services through narrowing of fiscal disparities across the various sub-national regions. In the fiscal transfers literature, the macroeconomic approach to measuring sub-national fiscal capacity is based largely on the notion that the level of economic activity within a region ultimately constitutes the measuring rod for the ability of sub-national governments to raise revenues (Schroeder and Smoke, 2003).

Working with county datasets on fiscal transfers from 1993 to 2003, Heng (2008) investigates impacts of fiscal disparities and equalization in China. Heng defines fiscal ability as the per capita revenue collected by local government plus per capita transfers from upper governments, with different definitions in use for net fiscal transfers during the 1993-2003 period.

Cottarelli and Guerguil (2014) define net fiscal transfers as the net fiscal flows between central and sub-national governments. They explain this term to be the difference between gross transfers from the centre to sub-national governments and taxes paid by sub-national government residents to the central government. In constructing net fiscal transfers, Cottarelli and Guerguil do not include government levels below states/provinces. They also do not consider transfers for the purposes of offsetting structural vertical imbalances that are the same across regions. Lastly, fiscal transfers channeled to help regions during crisis episodes are also excluded in their definition.

Bayoumi and Masson (1993), working with sub-national US and Canada data, show the importance of fiscal transfers in redistributing income across regions by estimating cross-section regressions based on the relationship between personal income before and after the influence of federal fiscal flows. Likewise, Checherita *et al*. (2009) investigate the effect of fiscal transfers on economic convergence across 19 European regions by measuring fiscal transfers in a similar fashion to Bayoumi and Masson. In Checherita *et al*.'s words, "we construct the variable net transfers as the ratio between household disposable income and primary income, thus capturing the aggregate impact of taxation and other distributional policy measures" (p.7)

By the way, personal income is defined as the sum of all incomes received by residents, including returns for labour and investments, and transfers from the government and other sectors (including old age security payments and employment insurance). And of course, personal disposable income is what is left from personal income after deducting direct taxes and other mandatory insurance premiums to government.

The Bureau of Economic Analysis defines personal income as the income received by residents from participation in production, from government and business transfer payments, and from government interest. Statistics Canada uses a slightly different definition (which though conveys the same meaning); personal income is defined as the sum of all incomes received by residents, including returns for labour and investments, and transfers from the government and other sectors (including old age security payments and employment insurance). In essence, personal income[24] includes both earnings and transfers such as wages and salaries, supplementary labour income, dividends, interest and miscellaneous investment income and all transfer payments.

Following Bayoumi and Masson (1993), Obstfeld and Peri (1998) and Checherita *et al. (*2009), our net fiscal transfers variable is constructed as net transfers (i.e. the difference between personal income and disposable income) as a percentage of personal income. This is captured below:

$$\mathrm{NFT}_{it} = \left(\frac{\mathrm{RPI}_{it} - \mathrm{RPDI}_{it}}{\mathrm{RPI}_{it}}\right) \qquad 3.12$$

Here, RPI_{it} is real personal income per capita and RPDI_{it} is real personal disposable income per capita. NFT_{it} therefore represents the percentage of income that constitutes the transfers. This ratio reflects the distributional outcomes of net taxes and transfers paid and received by households in a region, respectively (Obstfeld and Peri, 1998). The difference between the two gives a fair approximation of the income

[24] Personal income does not include capital gains from the sale of assets; the taxes paid for such capital gains are captured in the calculation of personal income taxes.

redistribution regime in a federal system. Real personal income and real personal disposable income data for Canada are converted into US dollars using annual Canada-US average nominal exchange rates.

3.4.2.4 Relative Net Fiscal Transfers

As part of our robustness checks, we also use relative fiscal transfers as an alternative measure of fiscal transfers. In this case, both RPI $_{it}$ and RPDI $_{it}$ are constructed as the ratio between each province (state), relative to the Canadian (US) average – as discussed above. Canadian data are converted into US dollars using annual Canada-US average nominal exchange rates.

3.4.2.5 Personal Current Transfer Receipts

As part of our robustness checks, we also use personal current transfer receipts as an alternative fiscal transfers measure. The US Bureau of Economic Analysis defines this variable as the benefits received by persons for which no current services are performed. In other words, payments by governments and businesses to individuals and nonprofit institutions serving individuals. Data are converted into US dollars using annual Canada-US average nominal exchange rates.

3.4.2.6 Human Capital Stock

Apart from fiscal transfers, governments deploy other policy tools, from time to time, to encourage regional income convergence. Typical tools include human capital investment, physical capital investment, social programs and others. Human capital stock is one of the two control variables employed in the model. Blundell *et al*. (1999) categorize human capital into three main components — early ability (whether acquired or innate); qualifications and knowledge acquired through formal education; and skills, competencies and expertise acquired through training on the job. We use educational attainment as a proxy for human capital; educational attainment is defined as the percent of persons 25 years and over who have completed at least a Bachelor's degree. This variable has been discussed extensively under data and variables in section 2.3.4.

3.4.2.7 Physical Capital Stock

Physical capital stock is our proxy for investment in infrastructure. The variable of interest here is CAP_{it} , our measure of the capital stock endowments in jurisdiction *i* at time *t*. This variable has been discussed extensively under data and variables in section 2.3.4.

3.4.2.8 Trade Openness

Sachs and Warner (1995), Ranjan (2003) and Sohn and Lee (2006), among others, show that international trade has an important role in regional and national income convergence. Most cross-country analyses measure trade openness as the sum of exports and imports divided by GDP. To test the impact of trade openness on the reduction of income disparities, we follow suit, except that our measure is narrowed down to the ratio of exports to GDP as discussed under data constraints above.

Merchandise exports are used; our focus is on international and not interprovincial or interstate trade – i.e. the trade flows between a Canadian province – or a US state – and the rest of the world. The US is Canada's largest trade partner; we therefore expect north-south trade to have a significant influence on the degree of jurisdictional economic openness. Trade data for all provinces are compiled from Industry Canada (TDO), while corresponding data for US states are sourced from the Office of Trade and Economic Analysis, US Department of Commerce (TradeStats Express).

3.4.2.9 AIT Policy

We are interested in looking at the possible impact of the AIT policy on regional economic growth. The AIT came into force on July 1, 1995 for all Canadian provinces; it was aimed at reducing trade costs by eliminating barriers to trade, investment and mobility within Canada. Considering that US states were not party to the AIT, we use the DiD approach to single out the effect of the AIT.

3.4.3 Econometric Strategy

Now that we have agreed on the specification framework to be employed, the next issue to which we turn is the performance of the different estimation techniques. This has become necessary because our estimation work is based on this. The theoretical framework presented in the previous section offers interesting insights that require empirical testing. One of the major objectives of this research is to examine the extent to which fiscal redistributive systems reduce inequalities in regional incomes. To eliminate the influence of business cycle (Islam, 1995) on our results, and more importantly, to facilitate comparison of our results with other studies on regional income redistribution, we calibrate our variables relative to the national average.

From the analysis so far, it is hard to think of a more important federation-pair with regions that are similar in many respects, yet distinct in other areas. Thus, we conduct tests of the fiscal transfer-growth nexus in Canada and the US in order to determine the impacts of governmental transfers. This chapter fits into the various discussions so far because it is an extension of the various issues related to fiscal decentralization and economic growth: income disparities, fiscal federalism, and estimation techniques. This is interesting because previous studies on these issues have been largely done at the cross-country level with OLS and other static linear panel techniques, notably because the necessary data and information at the sub-national level are often hard to come by.

Given the inclusion of the lagged value of relative real GDP per capita in our growth empirics framework, traditional panel data estimators such as fixed and random effects will not be consistent in the present context. In other words, the FEM is inconsistent because it often eliminates the error term by a de-meaning transformation that induces a negative correlation between the transformed error and the lagged dependent variables of order $1\backslash T$, which in short panels remains substantial (Cavalcanti *et. al*, 2012). We also can no longer impose the restriction that there is no correlation between the error term and the explanatory variables required for random effects consistency. Any traces of heteroscedasticity or serial correlation in the errors will render the estimators inconsistent.

The Arellano-Bond (1991) and Arellano-Bover (1995)/Blundell-Bond (1998) GMM estimators are general estimators designed for situations with "small T, large N" panels, with independent variables that are not strictly exogenous, meaning correlated with past and possibly current realizations of the error; with fixed effects; and with heteroscedasticity and autocorrelation within individuals. According to Bond (2002), a generally acceptable consistent estimator will lie between the OLS and "within-group" estimates, and the GMM provides a convenient framework for obtaining it. In the words of Roodman (2009), the Arellano–Bover/Blundell–Bond estimator augments Arellano–Bond by assuming that first differences of instrument variables are uncorrelated with the fixed effects. This provides flexibility in introducing more instruments, leading to improved efficiency. This is the way Roodman explicitly puts it, "It builds a system of two equations—the original equation and the transformed one—and is known as system GMM".

Large finite sample biases occur when instrumental variables are weak; this leads to poorly behaved first-differenced GMM estimators because "under these conditions, lagged levels of the variables are only weak instruments for subsequent first-differences" (Bond *et al.* 2000). The system estimator, on the other hand, leverages initial conditions assumptions to obtain moment conditions that provide useful information for persistent series, leading to efficient coefficient estimates. Roodman posits that using too many instruments can lead to biased results in GMM estimation; using the xtabond2 command in a panel data environment helps in implementing these. In order to correct for the biases created by lagged endogenous variables and the simultaneity of growth determinants, we use the GMM estimators developed for DPD models.[25]

A number of specifications are used to test our three central and lower level hypotheses, using the Solow Growth model as the benchmark. Among other things, we compare our results with those of pioneers [e.g. Bayoumi and Masson (1993) and Coulombe and Lee, 1995] and subsequent researchers (e.g. Checherita *et al.* 2009 and others) in this area. By looking at jurisdictions that share many common characteristics, we empirically model various scenarios – including recent trade policy issues from the Canadian Internal Trade Secretariat – while making sure to leverage the GMM methodology to control for endogeneity and many country-specific features that might obscure the key role of our key variables. In all specifications, we apply both least squares and panel estimation techniques, in addition to difference GMM

[25] This will be discussed in details.

and system GMM estimators. Different scenarios on instruments exogeneity and functional forms are modeled separately as part of our robustness checks.

To summarize and conclude our thoughts in this section, we employ and compare four econometric methods for estimating the specified models using two separate datasets with a variety of known characteristics. While the OLS strategy is expected to generate upward-biased estimates, due to its inability to incorporate the panel structure of our datasets, the FEM does handle the panel framework well – albeit it produces downward-biased estimates because it is unable to handle the dynamic component, which involves the lagged dependent variable and regression residuals. The difference GMM methodology seamlessly captures the lagged endogenous variable as an explanatory variable by first-differentiating the regression each period in order to eliminate individual specific effects. The system GMM on the other hand incorporates both lagged levels and lagged differences. This estimator is obtained at a cost involving a set of additional restrictions on the initial conditions of the process generating y (Baum, 2013).

3.5 Descriptive and Exploratory Analysis

3.5.1 Descriptive Statistics

No doubt, Canada and the US are two affluent countries. However, the various provinces and states that make up both countries are characterized by huge income gaps, growth differentials and differences in fiscal capacities. We provide descriptive analysis below on the three central issues in this chapter: income distribution, intergovernmental transfers and trade openness.

3.5.1.1 Income Distribution

Figures 3.2 puts into context the respective locations of all 60 Canadian and US jurisdictions, while Figure 3.3 shows the income distribution in both countries, including their neighbour to the south, Mexico, for better comprehension.

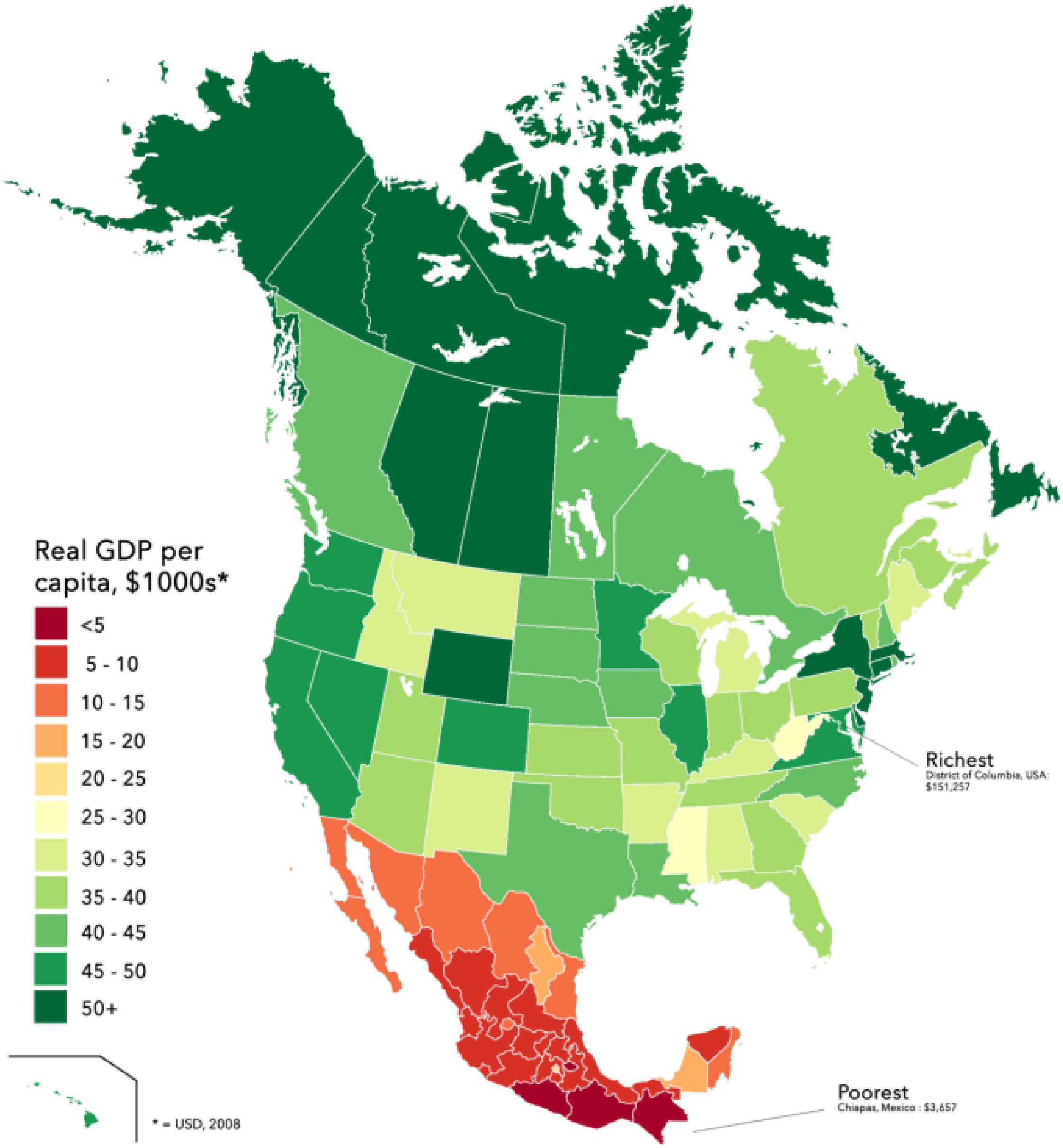
The relatively affluent nature of the US and Canada (compared to Mexico) is amplified by Figure 3.3's varying colour shades – almost entirely red and orange for Mexico; different shades of green for Canada and the US. Table 3.1 corroborates the income distribution pattern displayed in Figure 3.3. As depicted, all US and Canadian jurisdictions have real GDP per capita greater than $25,000[26]. At $68,847 and $ 66,080, Alaska and Alberta in the US and Canada, respectively, come first on our per capital income scale (Table 3.1 Panel A).

Figure 3.2: Map of Canada and the US

[26] Based on methodology and year used by chart provider; figures in Table 3.1 may not necessarily match those in Figure 3.3. In addition, our data are averaged over the 2007-2010 period, while chart uses 2008 figures.

Source: http://www.newthinktank.com/2011/08/blank-usa-map

Figure 3.3: Income Distribution in Canada, US and Mexico (2008)



Source: Statistics Canada, US Census and Reddit.com

Prince Edward Island and Mississippi rank as the poorest jurisdictions in their respective countries, with $31,277 and $31,744 in average incomes over the 2007-2010 period. We see from Table 3.1 that the richest and poorest US states are richer than their Canadian counterparts. The table reveals further that over the 2008-2010 period, the regional income gaps between the richest and poorest jurisdictions in the

US and Canada are $37,103 and $34,803, respectively. This has huge policy implications. We expatiate below.

As discussed earlier, fiscal decentralization is at the heart of the discussion on whether poor regions eventually catch-up with affluent ones and how long this might take. The observed distribution in average income above can be attributed, at least partly, to fiscal federalism. As explained in the preceding section, sub-national governments in fiscal unions receive significant transfers from the central government, in different forms, to assist them in the provision of essential programs and services. The Canadian Constitution specifically makes provision for Equalization to ensure the regions have the fiscal capacity to provide reasonably comparable levels of public service at reasonably comparable levels of taxation. The US does not have such a system; its closest intergovernmental fiscal transfer mechanism is the Grants-in-Aid system which the US federal government uses to extend aid to the states and local governments to finance certain areas of domestic public spending. To continue to qualify for federal funds for projects, recipients have to abide by certain rules from the federal government. The Grants-in-Aid system has grown steadily for more than a century, with more than 1,100 aid programs at present for the states[27].

Stark (2009) suggests the adoption of a Canada-type Equalization as a strategy to address the huge fiscal disparities among the states of the US. In addition, fiscal decentralization means resource-endowed jurisdictions have sole access to natural resource revenues; these greatly enhance their fiscal capacities. This is the case of resource-endowed jurisdictions like Alaska, Alberta, Wyoming, Saskatchewan, Newfoundland and North Dakota, all with above average incomes (Table 3.1).

[27] Appendix 3.7 depicts the exponential growth in federal aid to the states, increasing from four in 1905 to 1,122 in 2010.

Table 3.1: Per Capita Income Levels for US and Canadian Jurisdictions (2008-2010)

Panel A: Top Five Jurisdictions

Jurisdiction	Per Capita Income ($)	Jurisdiction	Per Capita Income ($)
Alaska	68,847	Alberta	66,080
Wyoming	67,929	Newfoundland	50,438
Connecticut	64,997	Saskatchewan	48,789
Delaware	62,587	Ontario	42,348
Massachusetts	59,756	British Columbia	41,846

Panel B: Bottom Five Jurisdictions

Jurisdiction	Per Capita Income ($)	Jurisdiction	Per Capita Income ($)
Mississippi	31,744	Prince Edward Island	31,277
West Virginia	34,496	Nova Scotia	34,787
Idaho	35,567	New Brunswick	34,903
Arkansas	35,612	Quebec	37,126
South Carolina	35,880	Manitoba	39,689

Notes: Figures in Panel A are in descending order; figures in Panel B are in ascending order. Data are averaged over the 2007-2010 period. Per capita income is based on real GDP as explained under the data section.

Natural resources continue to play an increasingly important role in these countries' overall economic picture. Bernard (2012) observes this and concludes that the large differences in revenues obtained by the resource-endowed jurisdictions, coupled with the instability of resource prices, have been and remain at the origin of the greatest difficulties encountered in the implementation of the Canadian Equalization program. We will explore the natural resource-economic growth link further in chapter 4.

3.5.1.2 Intergovernmental Transfers and Fiscal Capacities

As discussed in section 3.4.2, net fiscal transfers (NFT) and relative net fiscal transfers (RNFT) are both expressed in terms of net transfers as a percentage of primary income. Table 3.2 below, sorted on the basis of both NFT and RNFT, shows that the US state of Connecticut (with -14.2% NFT and -4.5% RNFT) and the Canadian province of Alberta (-17.3% NFT and -5.7% RNFT) emerge as the highest contributors (Panel B). Negative transfers from these jurisdictions imply that they are net contributors to the fiscal redistributive regimes in their respective countries.

Tennessee (-6.9% NFT and 3.7% RNFT) and Newfoundland (-2.4% NFT and 11.3% RNFT) both settle for the top net fiscal recipient positions in their respective countries (Panel A). The picture that emerges in Table 3.2 does not come as a surprise, especially when reconciled with our earlier discussion on sub-national income distribution in Table 3.1. The league of poor and rich jurisdictions each features the states/provinces that we see in Panel A and Panel B, respectively[28]. Another interesting observation from Table 3.2 is the fact that Newfoundland received more than Tennessee, both in absolute and relative terms. The converse is true for Alberta and Connecticut: the former contributed more than the latter both in absolute and relative terms. Again, such Gumbel-type distribution, with extreme values in both directions, underscores the relative pointedness of the intergovernmental fiscal policy in Canada, compared to the US. To fully understand the importance of constructing our regional fiscal transfers measures relative to their respective national averages, we take a closer look at Table 3.2.

[28] With mixed evidence for Newfoundland and Tennessee; this is due largely to the dynamics of the resource economy for the former and by the relatively arbitrary nature of federal spending in the US for the latter.

Table 3.2: Net Fiscal Transfers for US and Canadian Jurisdictions (2008-2010)

Panel A: Top Five Jurisdictions

Jurisdiction	NFT (%)	RNFT (%)	Jurisdiction	NFT (%)	RNFT (%)
Tennessee	-6.9	3.7	Newfoundland	-2.4	11.3
South Dakota	-7.0	3.6	Prince Edward Island	-2.5	11.2
Mississippi	-7.4	3.1	New Brunswick	- 4.6	8.8
New Mexico	-8.1	2.4	Nova Scotia	-7.4	5.6
Texas	-8.2	2.2	Manitoba	-10.5	2.1

Panel B: Bottom Five Jurisdictions

Jurisdiction	NFT (%)	RNFT (%)	Jurisdiction	NFT (%)	RNFT (%)
Connecticut	-14.2	-4.5	Alberta	-17.3	-5.7
New York	-13.9	-4.1	Ontario	-12.9	-0.7
Massachusetts	-12.7	-2.8	British Columbia	-11.1	1.4
New Jersey	-11.9	-1.9	Quebec	-11.0	1.5
Maryland	-11.7	-1.6	Saskatchewan	-10.5	2.1

Notes: Figures in Panel A are in descending order; figures in Panel B are in ascending order. Data are averaged over the 2007-2010 period. NFT stands for net fiscal transfers; RNFT for relative net fiscal transfers.

While we see negative NFT values for all top five jurisdictions in both countries, their corresponding RNFT values remain positive. Not just that, three out of the bottom five Canadian provinces come out with positive relative transfers, while the net transfers to all bottom five US states, both in absolute and relative percentages, are negative[29]. These findings are consistent with previous research as discussed under the review of literature.

In particular, we garner support for two of the basic tenets of this chapter: (i) relative net fiscal transfers as an alternative measure of fiscal transfers and (ii) the relative importance of fiscal capacity in both countries' intergovernmental fiscal policy. The results in (i) above have serious econometric implications; this will be looked at more formally under sensitivity analysis under the estimation section. We provide further insights on (ii) below.

As reiterated, the US is about the only federation in the developed world without a formal federal Equalization policy in place to address regional fiscal disparities. Stark (2009) says it is important to prove the existence of interstate fiscal disparities in the US prior to implementing an Equalization program similar to Canada's. Not just that, he emphasizes the need to take a closer look at how "fiscal capacity" is defined; with preference for per capita income or its other variants. Clearly, Table 3.2 is in agreement with Stark; the table shows net fiscal transfers (benefits) accruing largely to U.S states based on fiscal capacity. This is not the case for Canada. As proof, when we reconcile sub-national income distribution in Table 3.1 with fiscal transfers in Table 3.2, we find that most of the wealthy US states appear in both tables with similar rankings[30]. This is not true for Canadian provinces; for instance, Newfoundland and Saskatchewan which rank second and third in Table 3.1 lose those rankings in Table 3.2.

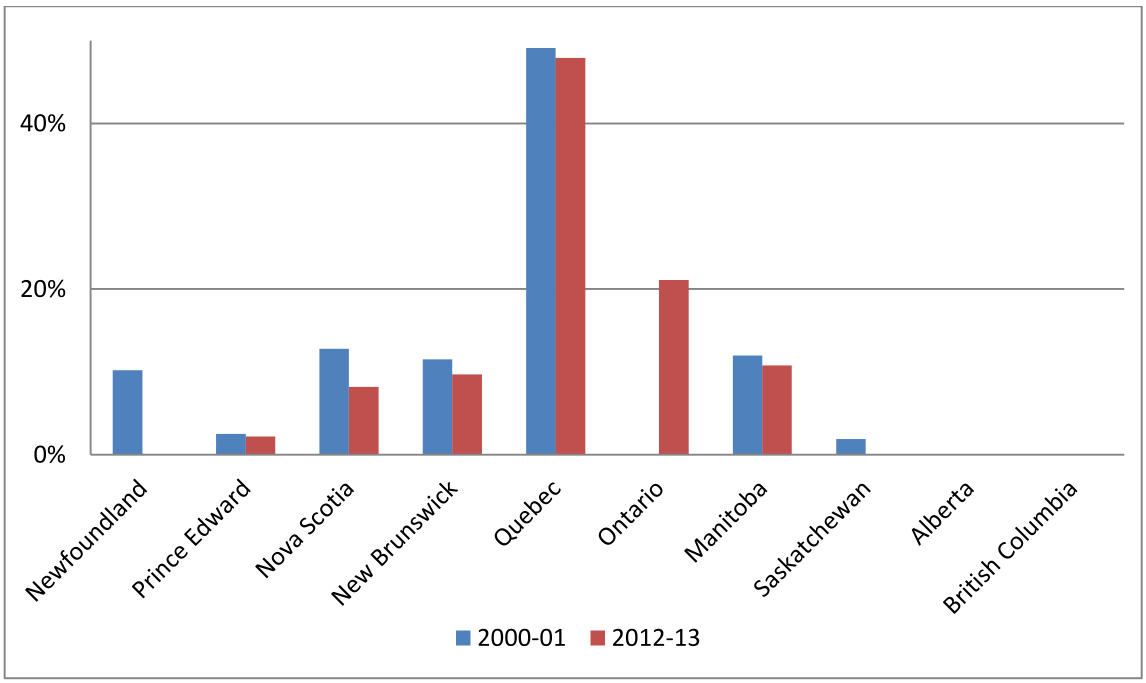
[29] A total of 36 US states turn out with positive RNFT values. The following nine states have negative RNFT values, in addition to the five reported in Table 3.3: California, Minnesota, Virginia, Oregon, Colorado, Illinois, Delaware, Pennsylvania and Wisconsin.

[30] The Appendix section contains per capita income, relative per capita income, net fiscal transfers and relative net fiscal transfers (for the 1990-1992 and 2007-2010 periods) for all US and Canadian jurisdictions ranked on the basis of relative per capita income.

3.5.1.3 Equalization System

Figure 3.4 below shows Canadian provincial Equalization receipts for the 2001-2002 and 2012-2013 fiscal years. Quebec stands out as the largest beneficiary for both years under consideration. As pointed out under the review of literature, politics sometimes overrides fairness-equity considerations in intergovernmental fiscal permutations. Figure 3.4 vividly confirms this with Quebec being the conspicuous highest recipient. This confirms that Quebec is "home to a longstanding separatist movement, being the chief beneficiary of Canada's Equalization program" (Stark, 2009).

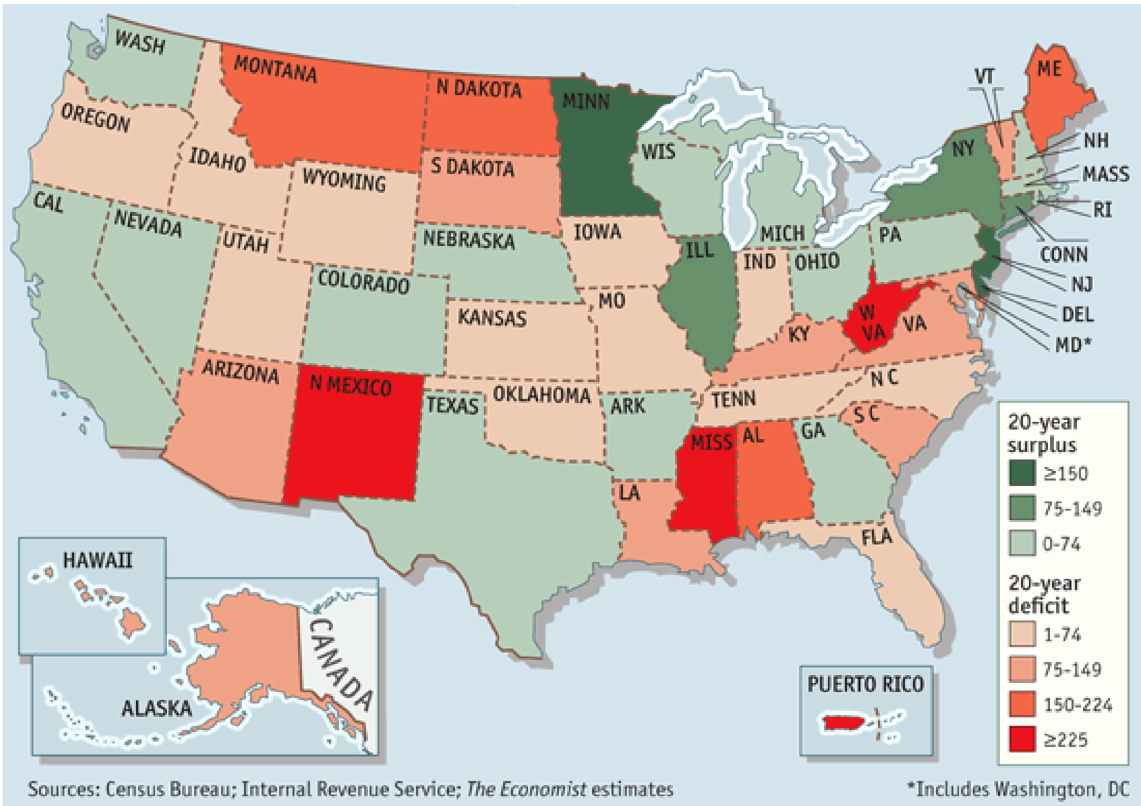
Figure 3.4: Equalization Rights as a Percentage of Total



Source: Author (based on data from the Department of Finance Canada).

In comparison to Figure 3.4 for Canadian provinces, Figure 3.5 provides a listing of US federal taxes minus spending between 1990 and 2009 as a % of 2009 GDP. Clearly, the poor states in red shades (e.g. Mississippi, New Mexico and West Virginia) resurface as the largest recipient, while affluent ones like Delaware and New Jersey (in deep green colour) are again two of the least recipients. Again, this lends some support to this chapter's central hypothesis that there is a different impact of fiscal flows on GDP per capita for prosperous and poor regions. Intuitively, this implies that there is a differential impact of intergovernmental fiscal transfers in the US, compared to Canada.

Figure 3.5: Federal Taxes minus Spending (% of 2009 GDP, 1990 -2009)



Source: The Economist Online

3.5.1.4 Trade Openness

Table 3.3 below shows trade openness expressed as total exports as a percentage of GDP for the 2008-2010 period. The US state of Louisiana and the Canadian province of New Brunswick each emerges the top candidate in each jurisdiction in terms of regional economic openness at 17.5% and 40.5%, respectively. Hawaii and Nova Scotia, at 1.1% and 13.3%, are the least open economies.

These statistics reveal that Canada is far more dependent on international trade than the US. This finding is consistent with a large body of literature on both the determinants of country size and trade openness. Generally speaking, smaller countries tend to have more

Table 3.3: Trade Openness for US and Canadian Jurisdictions (2008-2010)

Panel A: Top Five Jurisdictions

Jurisdiction	Trade Openness (%)	Jurisdiction	Trade Openness (%)
Louisiana	17.5	New Brunswick	40.5
Texas	15.3	Saskatchewan	39.1
Washington	15.0	Newfoundland and Labrador	38.1
Vermont	14.5	Alberta	31.9
South Carolina	11.7	Ontario	27.6

Panel B: Bottom Five Jurisdictions

Jurisdiction	Trade Openness (%)	Jurisdiction	Trade Openness (%)
Hawaii	1.1	Nova Scotia	13.3
New Mexico	2.2	British Columbia	14.6
Wyoming	2.5	Prince Edward Island	15.6
Colorado	2.7	Quebec	19.6
Oklahoma	3.2	Manitoba	21.9

Notes: Figures in Panel A are in descending order; figures in Panel B are in ascending order. Data are averaged over the 2007-2010 period. Trade openness is exports as a percentage of GDP.

open trade policies. For example, Alesina and Wacziarg (1997) provide empirical evidence that country size is negatively related to trade openness. Their regression results show that when other determinants of openness are held constant, doubling population is associated with a 9 percentage points reduction in the trade to GDP ratio. They conclude that "to the extent that market size influences productivity, large countries can 'afford' to be closed, while small countries face stronger incentives to remain open"

Other reasons have also been adduced for this. For instance, Doern and Stoney (2010) summarize a contemporary school of thought based on the notion of (i) a large and rising trade and current account deficits and (ii) a stagnant or declining standard of living in the past decade which has made domestic protectionist policy popular in the US.

Regardless, we point to a quick caveat. As discussed under the data section in 3.4.1, while Canadian provincial exports and imports data are available for the period considered in this thesis, state-level imports data are only available from 2010 to 2013. Our trade openness measure is therefore based on exports only; imports are not included. With imports included, we expect a different picture; this may not be dramatically different though.

3.5.2 Summary Statistics

In this section, we present summary statistics for the key variables. Panel A of Table 3.4 is based on the 1999-2010 sample (with trade openness included); Panel B is based on the 1987-2010 sample (without trade openness). From Panel A, the upper and lower boundaries of real GDP per capita in levels (and relative real GDP per capita) are $68, 847 and $18, 976 (and 157% and 65%) respectively. Absolute and relative per capita incomes do not differ significantly with $68, 847 and $17,816 for the former, and 178% and 64% for the latter (see both panels). The mean and median per capita incomes are $43,305 and $42,498, respectively (Panel A). Panel B, based on the full sample, shows lower mean and median incomes at $36,791 and $36,048, respectively. Again, we see the impact of lower per capita incomes in the earlier periods on average income over the entire study period. As well, the presence of outliers in the sample explains the mean-median income differentials in both panels. Precisely, resource-driven increases in per capita income for jurisdictions like Alberta and Alaska. The observed differentials are not significant though and should not adversely impact our estimation and inferences.

As discussed earlier, our net fiscal transfers measure shows a minimum of -18.7% in both panels, and -1.8% and 6.7% in the upper and lower panels, respectively. This implies that with the study sample enlarged, net fiscal transfers to the least recipient increased. The same is applicable to the alternative measure of transfers – relative net fiscal transfers. We expect our dynamic panel estimation procedure to provide more insights on this. The other two measures of fiscal transfers in this chapter – personal current transfer receipts and relative personal current transfer receipts – do not behave differently from the two principal measures discussed above. A standard deviation of 9.3% for the trade openness agrees with our initial analysis in section 3.5.1 above**.**

Last but not least, our two control variables reveal some interesting trends. At 318% and 60%, the difference in capital stock (as a share of output) for the largest and least capital intensive regional economies, respectively, is quite revealing. Similarly, educational attainment at 38.5% and 7.3% for the highest- and lowest-achieving jurisdictions seems to corroborate the finding on capital stock, albeit to a lesser degree. Higher educational attainment for the population is generally considered to be growth-promoting.

The Solow growth model, interpreted through the lens of the convergence hypothesis, predicts that during the adjustment to steady state, economies with a lower capital stock will grow faster than those with higher capital stocks. As discussed under the literature review section, recent endogenous growth propositions do not agree with the notion of convergence. To get a better understanding of these issues, we present a formal econometric framework in the next section. Detailed analysis on the observed patterns for capital stock and educational attainment is available under sections 2.3.4 in chapter 2.

Table 3.4: Summary Statistics for Key Variables

Panel A:

Measure	RGDP ($)	RRGDP (%)	PCT ($)	RPCT (%)	NFT (%)	RNFT (%)	CAP (%)	EDU (%)	OPN (%)
Mean	43,305	96	4,866	101	-10.8	1.5	104	24.5	9.9
Median	42,498	93	4,765	100	-10.7	1.3	91	24.7	6.4
Std. Deviation	9,511	18	1,423	14	2.8	3.2	37	5.7	9.3
Minimum	18,976	65	1,842	63	-18.7	-5.7	60	10.2	0.8
Maximum	68,847	157	8,684	138	-1.8	15.9	318	38.5	45.5

Panel B:

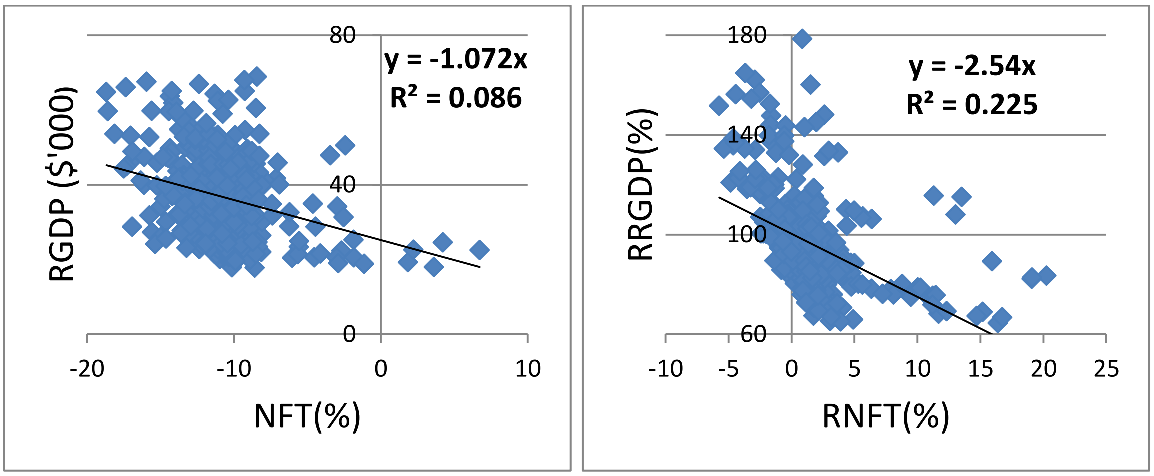
Measure	RGDP ($)	RRGDP (%)	PCT ($)	RPCT (%)	NFT (%)	RNFT (%)	CAP (%)	EDU (%)
Mean	36,791	96	4,026	100	-10.8	1.5	103	22.3
Median	36,048	93	3,645	97	-11.0	1.1	93	22.5
Std. Deviation	11,215	19	1,495	15	3.1	3.5	32	6.0
Minimum	17,816	64	1,753	63	-18.7	-5.7	60	7.3
Maximum	68,847	178	8,684	139	6.7	20.3	318	38.5

Notes: Panel A based on 1999-2010 sample (with trade openness included); 60 observations for each year for a total of 720 observations. Panel B based on 1987-2010 sample (without trade openness); 60 observations for each year for a total of 1,260 observations. RGDP stands for real GDP per capita levels; RRGDP is relative real GDP per capita; NFT is net fiscal transfers; RNFT is relative net fiscal transfers; PCT is per capita personal current transfer receipts; RPCT is relative personal current transfer receipts; CAP is capital stock as a percentage of GDP; EDU is educational attainment; and OPN is trade openness.

3.5.3 Absolute and Relative Income Analysis

In this section, two different variants of the per capita income-fiscal transfers nexus are presented. Figures 3.6 shows both variables expressed in their original units on the left side and in relative terms on the right, respectively.

Figure 3.6: Absolute and Relative Income Analysis



Both charts reveal upfront that fiscal transfers and income are negatively correlated. A higher marginal impact for the relative income-relative transfer relationship (as captured by a steeper slope of 2.54, compared to 1.07 for the comparator) signals that the relative measures may provide our estimation work with better predictive abilities. More so, R-squared value of 22.5% for the relative measures (compared to 8.6% for the absolute ones) clearly provides a stronger justification for the use of relative fiscal transfers and relative per capita income in this chapter.

3.5.4 Correlation Matrix

Table 3.5 shows the correlation matrix for all key variables. A cursory look at the matrix shows that multicollinearity is not a problem, with the notable exception of the NFT-RNFT nexus – with 90% in correlation coefficient value. Even so, we worry less because both variables do not enter any of the specified models simultaneously; we only use one at a time to perform sensitivity analysis, with results compared with the alternative measure.

Table 3.5: Correlation Matrix for Key Variables

Panel A

Variable	RGDP	RRGDP	NFT	RNFT	PCT	RPCT	CAP	EDU	OPN
RGDP	100%								
RRGDP	86%	100%							
NFT	-38%	-47%	100%						
RNFT	-59%	-49%	82%	100%					
PCT	31%	-2%	25%	-19%	100%				
RPCT	-20%	-14%	25%	33%	35%	100%			
CAP	-21%	13%	7%	22%	-40%	11%	100%		
EDU	66%	41%	-37%	-68%	35%	-34%	-51%	100%	
OPN	-30%	6%	-8%	-37%	-34%	25%	78%	-56%	100%

Panel B

Variable	RGDP	RRGDP	NFT	RNFT	PCT	RPCT	CAP	EDU
RGDP	100%							
RRGDP	62%	100%						
NFT	-29%	-47%	100%					
RNFT	-38%	-47%	90%	100%				
PCT	60%	-2%	12%	-10%	100%			
RPCT	-8%	-15%	31%	35%	34%	100%		
CAP	-11%	8%	3%	23%	-27%	12%	100%	
EDU	69%	37%	-42%	-58%	49%	-26%	-45%	100%

Notes: Panel A based on 1999-2010 sample (with trade openness included); 60 observations for each year for a total of 720 observations. Panel B based on 1987-2010 sample (without trade openness); 60 observations for each year for a total of 1,260 observations. RGDP stands for real GDP per capita levels; RRGDP is relative real GDP per capita; NFT is net fiscal transfers; RNFT is relative net fiscal transfers; PCT is per capita personal current transfer receipts; RPCT is relative personal current transfer receipts; CAP is capital stock as a percentage of GDP; EDU is educational attainment; and OPN is trade openness.

To conclude our discussion on descriptive statistics and preliminary exploratory analysis, we see that prior to any sophisticated use of controls, the data clearly show some preliminary evidence for the important issues discussed so far in this chapter. Again, while such correlation (or lack thereof) may be consistent (or inconsistent) with our priors as well as the literature reviewed earlier, one has to be careful interpreting this, especially in light of the issue of endogeneity, which is one the issues we are hoping to resolve in the next session through the use of the system and difference GMM estimation techniques. We discuss the GMM strategy a little further below.

3.5.5 The GMM Strategy

The Arellano-Bond strategy implements a GMM equation; in this case, the model is set up as a system of equations, one for each time period. That way, different instruments relate to a different equation. Arellano and Bond recommend dynamic panel models estimation using a first-differentiated GMM estimator; they state that this will help capture the lagged endogenous variable as an explanatory variable. In other words, the regression equation is first-differentiated in each period in order to eliminate individual specific effects. Arellano and Bover (1995) and Blundell and Bond (1998) point out the deficiency in the Arellano-Bond strategy; they say if the variables are close to a random walk, the lagged levels would constitute rather poor instruments for first differenced variables. Arellano and Bover, and Blundell and Bond, therefore modify the difference GMM estimator to incorporate lagged levels and lagged differences – called system GMM. The System GMM estimator is obtained at a cost involving a set of additional restrictions on the initial conditions of the process generating *y* (Baum, 2013).

Blundell and Bond's argument above essentially points to the fact that with a finite sample size, the first-differentiated GMM estimator could lead to biased results since the reliability of Y_{it-1} and Y_{it-2} as instruments cannot be guaranteed under a scenario where real GDP per capita, net fiscal transfers and openness are continuous. Arellano and Bover and Blundell, and Bond (1998), show that the system GMM estimator generates good instruments by combining both the standard set of equations with additional set of equations, all in first-differences, with lagged levels deemed as suitable.

3.6 Estimation Results

3.6.1 Growth-Fiscal Transfers Nexus

We present the results of the various estimators for the baseline and alternative specifications. We briefly look at the classical OLS estimator applied to the baseline model, followed by the alternative specifications. In light of the results obtained, and in order to refine such, we modify our estimator step by step, moving first to the FEM before the two-step difference GMM technique. We then end with the system GMM. Table 3.6 shows the estimation results for our baseline and alternative specifications using the FEM; Tables 3.7 and 3.8 report the two-step difference GMM (DIFF-GMM) and the two-step system GMM (SYST-GMM) estimators; Table 3.9 reports the restricted SYST-GMM and instrument proliferation control. We focus first on the growth-fiscal transfers nexus, and later examine the trade openness and AIT debates.

3.6.1.1 OLS Results

One quick caveat: our model cannot be estimated consistently using simple OLS due to endogeneity between real GDP per capita and net fiscal transfers; as well as between real GDP per capita and trade openness. Prior to the use of the FEM and GMM models, our OLS[31] estimator provides evidence for the negative effect of fiscal transfers on per capita income, with estimated coefficient of -1.341 on NFT in specification 3. This is the only model where either of the two variants of fiscal transfers will be statistically significant out of all six specifications. It turns out that the coefficients on the interaction term in all six specifications are not statistically significant.

Given the central objective of this chapter, we rely on the more advanced Arellano-Bond (1991) and Blundell-Bond (1998) linear GMM estimators which, as discussed earlier, generate internal instruments based on their lag values. That is in addition to providing more efficient estimates over least square methods in the presence of heteroscedastcity in error variance. Nonetheless our OLS and FEM help in providing an upper and lower benchmark, with which the finite sample performance of the GMM estimators is

[31] Appendix 3.12 presents the OLS results.

evaluated. This is based on the notion that a good estimate of the true parameter should lie somewhere between the two extremes established by both estimators. This provides a way to seamlessly evaluate the unbiasedness of the GMM estimators.

3.6.1.2 FEM Results

The lagged dependent variable under our OLS approach is endogenous to the fixed effects, causing dynamic panel bias. The omitted variables end up biasing upward the estimated relationship between lagged GDP and current GDP. This in turn biases downward the estimated speed of convergence; OLS erroneously attributes predictive power that belongs to the fixed effects to the lagged dependent variable. The need to account for jurisdictional fixed effects to capture unobserved and persistent regional variations that influence long-run per capita income (and at the same time are correlated with observed per capita income) is well established in the growth empirics literature (e.g. Islam, 1995; Caselli, Esquivel and Lefort, 1996; Acemoglu, Johnson, Robinson and Yared; 2005 and 2008; and Shibamoto and Tsutsui (2011).

Our FEM regressions are based on a panel data model with a distinct time-invariant jurisdictional effect term and a time-specific term. We estimate an autoregressive model with structural change in the autoregressive coefficient, with jurisdictional fixed effects and year effects. We use the FEM and not the random effects estimator because clearly, based on the specified model, there are omitted variables that are correlated with model variables. The FEM helps control for such omitted variable bias. In addition, it allows for variation among the observations in the sample data in response to jurisdiction-specific fixed effects and as a result, it takes into account within-jurisdiction variations.

As a quick check, we conduct a formal Hausman test to validate the specification and estimation of a FEM; this basically tests whether the unique errors (ε_{ijt}) are correlated with the regressors or not. We specify the null hypothesis that the preferred model is random effects, while the alternative specifies a FEM (Green, 2008). The null hypothesis of no fixed effects is rejected. Likewise, the standard F-test for the joint significance of jurisdiction dummies is conducted and we conclude that unobserved heterogeneity is present and OLS estimation yields biased and inconsistent estimates.

Based on Equation 3.8 from section 3.3.2, our panel framework is based on a FEM presented in Equation 3.13 below:

$$Y_{it} = \alpha + \beta X_{it} + \sigma_i + \nu_t + \varepsilon_{it} \qquad (3.13)$$

where the value of Y_{it} is determined by a group of explanatory variables (X_{it}) and two unobservable characteristics which account for time-invariant jurisdiction-specific effect (σ_i) and jurisdiction-invariant time-specific effect (ν_t).

In the presence of unobserved heterogeneity, different real GDP per capita levels may be attributed to two different jurisdictions with the same net fiscal transfers. This may be due to some common factors which affect income per capita, and are also correlated with net fiscal transfers. The intercept for each jurisdiction includes the effects of all omitted variables that are specific for each year but remains constant over time; such include certain deterministic factors (e.g. historical, political, geographical, cultural, climatic and linguistic factors. With the omission of individual effects, OLS estimates will be biased when individual effects are correlated with the independent variables.

As an alternative, we use the FEM in our panel data environment to account for such heterogeneity bias. With a FEM though, all time-invariant variables drop out as the inherent transformation wipes out such variables. We therefore do not include the jurisdiction dummy since it is time invariant. The panel data framework therefore helps to disentangle the time invariant jurisdiction-specific effects and to capture the relationships between the relevant variables over time.

Our FEM is based on the OLS deviations from the means of each jurisdiction in the sample. Biased coefficients may be produced if T is small and Y_{it-1} is correlated with σ_i; this is the first major problem with the OLS technique above. Omitted variables and other shocks, which for some reason are not modeled, may appear in the error term. In that case, the regressor and the error are positively correlated, resulting in the violation of the assumption that the OLS estimator is consistent when the regressors are exogenous (Roodman, 2009).

Table 3.6 below presents the FEM results. While the OLS baseline specification reports 0.952 in estimated coefficient for Y_{it-1}, the FEM returns a coefficient value of 0.515; this is statistically significant at the 1% level. It becomes immediately noticeable that the OLS estimator produces a higher absolute coefficient value for Y_{it-1}, compared to the FEM. This is not surprising given our one-way FEM under a DPD framework in a small *T*, large *N* environment. Nickel (1981) explains this by the fact that the demeaning process whereby the individual mean value of *y* and that of *x* are subtracted from the respective variable leads to the regressor being correlated with the error.

The lower estimate from the FEM is in line with the conclusion of Roodman (2009) and Bond (2002). Roodman believes that a credible estimate of the lagged value of the dependent variable should lie below 1:00 because greater values may signify an unstable dynamic, which tends to show divergence away from equilibrium values with increasing speed. Bond says a candidate consensus estimator will lie between the OLS and FEM estimates or at least will not be significantly higher than the former or significant lower than the latter. He reinforces this based on the notion that it constitutes useful checks on results from theoretically superior estimators.

Under OLS, a higher coefficient value confirms that Y_{it-1} and the error are positively correlated, resulting in an upwardly biased estimate – a penalty for the violation of a fundamental OLS assumption.

Table 3.6: FEM Estimation Results

	[1]	[2]	[3]	[4]	[5]	[6]
Dependent Variable	**lnRRGDP**	**lnRRGDP**	**lnRGDP**	**lnRGDP**	**lnRRGDP**	**lnRGDP**
Log of lagged RGDP			0.807***	0.717***		0.712***
			[0.057]	[0.077]		[0.080]
Log of lagged RRGDP	0.515***	0.532***			0.524***	
	[0.051]	[0.066]			[0.083]	
NFT			-5.465***	4.763		-4.471
			[0.548]	[7.130]		[5.955]
RNFT	-2.272***	-2.381***			-2.263***	
	[0.308]	[0.377]			[0.384]	
Log of lagged RGDP x NFT				-0.998		0.138
				[0.678]		[0.572]
Log of lagged RRGDP x RNFT		-0.484			-0.292	
		[0.948]			[0.990]	
Capital stock	0.036*	-0.038*	0.050	0.052	-0.035*	0.095**
	[0.019]	[0.020]	[0.045]	[0.049]	[0.019]	[0.045]
Educational attainment	0.045	0.051	1.508***	1.407	0.318	0.874**
	[0.083]	[0.082]	[0.502]	[0.526]	[0.303]	[0.435]
Constant	0.038	0.039	1.111**	2.057	-0.033	2.474***
	[0.028]	[0.030]	[0.514]	[0.761]	[0.087]	[0.812]
Year dummies	No	No	No	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of jurisdictions	60	60	60	60	60	60
Observations	360	360	360	360	360	360
R-Squared	0.544	0.545	0.930	0.931	0.556	0.946

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. RGDP stands for relative GDP per capita; RRGDP stands for relative real GDP per capita; NFT stands for net fiscal transfers; RNFT stands for relative net fiscal transfers.

This will lead to an inflated estimate for the coefficient of Y_{it-1} because predictive power is wrongly attributed to Y_{it-1}, when this actually belongs to v_i; this is the chief cause of endogeneity (Roodman, 2009). This will constitute a major setback given our objective of examining the conditional convergence hypothesis.

The FEM, also called the within group estimator, helps to apply a mean deviation to each variable in order to partial the cross-sectional fixed effects from the data. No doubt, the FEM strategy is a major achievement over OLS. However, this strategy still does not get rid of the dynamic panel bias mentioned earlier. We could address this problem by (i) using the difference GMM to remove the fixed effects by transforming the data or (ii) by directly instrumenting Y_{it-1} and other endogenous variables like fiscal transfers and trade openness. More than anything, this is one major concern that motivates a GMM strategy.

3.6.1.3 GMM Estimators

Before we begin our DPD analysis, we restate Equations 3.8 and 3.9 again below:

$$\mathrm{lnRGDP}_{it} = \beta_0 + \beta_1 (lnRGDP_{it-1}) + \beta_2 (NFT_{it}) + \beta_3 (NFT.lnRGDP_{it-1}) + \beta_4 (\mathrm{EDU_{it}}) + \beta_5 (CAP_{it}) + \beta_6 (\mathrm{AIT}) + \mathrm{JU}R_i + TIM_t + \mu_{\mathrm{it}} \quad (3.14)$$

$$ln\mathrm{RGDP}_{it} = \alpha_0 + \alpha_1 (lnRGDP_{it-1}) + \alpha_2 (OPN_{it}) + \alpha_3 (OPN.lnRGDP_{it-1}) + \alpha_4 (\mathrm{EDU_{it}}) + \alpha_5 (CAP_{it}) + \mathrm{JU}R_i + TIM_t + \mu_{\mathrm{it}} \quad (3.15)$$

We have identified in the preceding section that the following major econometric issues are associated with estimating these equations: (i) the net fiscal transfers, trade openness and the two control variables are assumed to be endogenous (since causality may run in both directions for each variable, these regressors may be correlated with the error term) (ii) the time-invariant jurisdiction specific fixed effects may be correlated with the explanatory variables (iii) our panel dataset has a short time dimension (T =*6*) relative to a larger jurisdictional dimension (N =*60*) and (iv) the presence of Y_{it-1} in the model is ground for autocorrelation.

The FEM could help address problem (ii) above, but not (i) and (iii). The GMM estimator provides a one-stop shop strategy that addresses all these issues. The GMM developed by Hansen (1982) uses a set of moment conditions to produce an asymptotically efficient GMM estimator. There are two versions: the difference and system GMM estimators. They basically use fewer assumptions about the underlying data-generating process and more complex techniques to isolate useful information (Roodman, 2009). Usually attributed to Arellano and Bond (1991), the DPD approach was actually pioneered by Holtz-Eakin, Newey and Rosen (1988), based on the notion that the 2SLS method described in the preceding section does not take full advantage of all of the sample information – especially the potential orthogonality conditions (Baum, 2013).

3.6.1.4 GMM Results and Diagnostic Tests

Table 3.7 displays the results of both the two-step difference GMM (DIFF-GMM) and the two-step system GMM (SYST-GMM) estimations. The first three columns present results for the former; the last three columns for the latter. As noted under the notes to the table, relative real GDP per capita and RNFT are used in all six specifications. The first specification under each technique does not include the interactive term; the other four do.

As indicated earlier, an appropriate dynamic model specification must include a lagged dependent variable to control for the prior period's income level. These coefficients are used to check for the validity of our estimates. Bond (2002) argues that a candidate consensus estimator will lie between the OLS and FE estimates or at least will not be significantly higher than the former or significant lower than the latter. The coefficient values of 0.447 (DIFF-GMM) and 0.963 (SYST-GMM) both agree with Bond’s claim, albeit they both marginally fall out of the expected range. This does not constitute a problem.

Table 3.7: Difference and System GMM Results

	Two-Step Diff GMM			Two-Step Sys GMM		
	[1]	[2]	[3]	[1]	[2]	[3]
Dependent Variable	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**
Log of lagged RRGDP	0.447***	0.532***	0.547***	0.962***	0.963***	0.958***
	[0.065]	[0.084]	[0.100]	[0.028]	[0.023]	[0.031]
		-	-			
RNFT	-2.219	2.286***	2.286***	-0.033	-0.099	-0.037
	0.343	[0.469]	[0.444]	[0.202]	[0.205]	[0.193]
Log of lagged RRGDP x RNFT		-0.242	-0.302		-0.365	-0.195
		[1.061]	[1.072]		[0.335]	[0.412]
Capital stock	-0.058**	-0.055**	-0.042**	0.018*	0.016	0.017
	[0.027]	[0.021]	[0.020]	[0.010]	[0.010]	[0.014]
Educational attainment	0.056	0.041	0.087	0.051	0.043	0.073
	[0.094]	[0.110]	[0.365]	[0.063]	[0.054]	[0.108]
Constant				-0.029	-0.025	-0.030
				[0.024]	[0.221]	[0.045]
Year dummies	No	No	Yes	No	No	Yes
Year fixed effects	No	No	No	No	No	No
Number of observations	300	300	300	360	360	360
Number of jurisdictions	60	60	60	60	60	60
Number of instruments	56	76	91	74	100	119
Specification Tests						
Sargan Test (p value)	0.000	0.000	0.000	0.000	0.000	0.000
Hansen Test (p value)	0.375	0.855	0.995	0.894	1.000	1.000
Arellano-Bond AR(1) (p-value)	0.044	0.024	0.019	0.003	0.004	0.003
Arellano-Bond AR(2) (p-value)	0.685	0.705	0.659	0.344	0.362	0.502

Notes: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. All estimations based on the Windmeijer's (2005) finite sample correction to the standard errors.

The other four specifications (i.e. 2 and 3 under DIFF GMM and 2 and 3 under SYST GMM) do not produce significantly different results, compared to the baseline models. The coefficients on the lagged dependent variables are very close to what we see under the two specifications discussed earlier (0.532 and 0.547 for DIFF GMM and 0.963 and 0.958 for SYST GMM). These are equally statistically significant at the 1% level. We notice also that the coefficients on RNFT are statistically significant at the 1% level and also come out with negative signs under the DIFF GMM models; they are not significant statistically under SYST GMM.

Again, this provides evidence for the negative effect of fiscal transfers on per capita output. The interaction terms between lagged per capita GDP and fiscal transfers are not statistically significant under the four scenarios modeled; they are economically significant though within the context of the discussion in this chapter. We therefore do not have evidence to comment on the degree to which lagged income is linked to economic growth through fiscal transfers in Canada and the US. The first result supports the hypothesis that there is a relationship between net fiscal transfers and GDP per capita, albeit a negative one. By implication, the latter result means we have no evidence on the combined effect of fiscal transfers and lagged income on GDP per capita.

These results clearly help to establish one thing: the major concern that motivated a GMM strategy in the first place is addressed. In all, results from our four alternative specifications complement one another. It would amount to a difficult task choosing one specification over the other prior to dealing with the issue of instrument proliferation, which we discuss in detail later in this section. Prior to that, we discuss the results of the various specification tests below.

We report the p-values for the following four diagnostic tests in the lower panel of the table: Hansen test, Sargan test, Arellano – Bond test for first order autocorrelation AR(1) and second order autocorrelation AR(2) tests. We conduct the Sargan/Hansen test for joint validity of the instruments; the validity of GMM is based on the assumption that the instruments are exogenous. If the model is exactly identified, it will be impossible to detect invalid instruments, but when it is over-identified, a test statistic for the joint validity of the moment conditions falls naturally out of the GMM framework (Roodman, 2009). A higher p-value on the Sargan/Hansen test is indicative of a better fitted model.

The AR test is specified as a null hypothesis of no autocorrelation; this is applied to the differenced residuals. The presence of significant AR(2) is a diagnostic test of the validity of the instruments. In a way, this compliments the standard Sargan–Hansen test of overidentifying restrictions. We expect the residuals of the differenced equation to be serially correlated, but if the assumption of serial independence in the original errors is upheld, then the differenced residuals should not exhibit significant AR(2) behaviour (Baum, 2013). Usually, the test for AR (1) process in first differences leads to a rejection of the null hypothesis; this is not surprising given that the term $e_{i,t-1}$ is common to these two equations: $\Delta e_{it} = e_{it} - e_{i,t-1}$ and $\Delta e_{i,t-1} = e_{i,t-1} - e_{i,t-2} = e_{i,t-1}$. Because it is able to detect autocorrelation in levels, we conclude that the test for AR (2) in first differences is more important (Mileva, 2007).

The DIFF-GMM estimation process uses 56, 76 and 91 instruments for specification 1, 2 and 3, respectively; the SYST-GMM on the other hand uses 74, 100 and 119 instruments in the same order. Our first comment is that the number of instruments used in each case was lower than the number of observations; this provides the first cursory evidence that we may not have run into any issues related to identification. Obviously, the difference GMM produces fewer instruments for the same specification, compared to the system GMM. This explains why the number of observations is less by a complete set for the difference GMM. For simplicity in our reporting, we discuss the performance of the various diagnostic tests for the baseline specification, and only include the others when it is necessary to point out something worth mentioning.

The Sargan tests return p-values of 0.000 for both estimators; the Hansen tests produce p-values of 0.375 and 0.894. The Hansen test p-values are fairly large and are in no way close to 1:00. As noted by Roodman, in reference to Anderson and Sorenson (1996) and Bowsher (2002), the GMM estimators often generate moment conditions prolifically, leading to several problems in finite samples – meaning that the Hansen test may then be weakened so much that it generates "implausibly good p-values of 1.00".

As initially stated, a higher p-value on the Sargan test is indicative of a better fitted model. The value of 0.00 here does seem to lend us any support. Roodman, however, warns that if non-sphericity is suspected in the errors, the Sargan statistic can be expected to be inconsistent. In that case, he suggests a theoretically superior over-identification test to be based on the Hansen statistic from a two-step estimate. Based on this recommendation, we conclude that the Hansen test fails to detect any problem with the validity of the instruments used in our baseline estimation; less so for the Sargan test. Also, the issue of instrument proliferation remains a concern and will be addressed in the next section.

Next on the list of our battery of tests is the AR(2) in disturbances. Based on 0.044 (AR1) and 0.685 (AR2) and 0.003 (AR1) and 0.344 (AR2) values for the DIFF-GMM and SYST-GMM, respectively, the tests of disturbances fail to reject the respective nulls. These tests therefore support the validity of the instruments used in our model.

In all, we conclude that the various diagnostic tests fail to detect any problem with the validity of the instruments used in our baseline estimation; the major concern that motivated a GMM strategy is now addressed. Also, we realize that in addition to the validation provided for the DIFF-GMM and SYST-GMM, we certainly need to carry out further robustness checks before concluding that the specified models are correctly instrumented and estimated coefficients are reliable for inference. This especially becomes necessary given the degree of instrument proliferation under all six specifications.

3.6.1.5 Under-identification, Instrument Proliferation and Weak Instruments

Looking at Table 3.7 again, the coefficients on the lagged dependent variable for all three specifications under both the DIFF-GMM and the SYST-GMM are statistically significant at the 1% level. Based on the reported standard errors, we see the efficacy of the Windmeijer's (2005) finite sample correction in action for SYST-GMM, compared to the DIFF-GMM models. Clearly, this provides some justification for the SYST-GMM, over the DIFF-GMM. However, we are careful to not base our preference of one estimator over the other solely on the basis of the results they give.

Roodman (2009) advises that before using System GMM, the required assumptions should be pondered. Roodman states thus, "The validity of the additional instruments in System GMM depends on the assumption that changes in the instrumenting variables are uncorrelated with the fixed effects". System GMM avoids dynamic panel bias by instrumenting endogenous explanatory variables with their lagged values; this turns the endogenous regressors to exogenous ones and by so doing helps to satisfy the required identifying moment conditions.

Roodman hints that instrument proliferation can overfit endogenous variables, and as such, fail to expunge their endogenous components. The downside, when this happens, is that it weakens the power of the Hansen test in detecting this issue. As advised by Roodman, a perfect Hansen statistic of 1:00 is a telltale sign: a way out here is to test for robustness to severely reducing the instrument count, including a reduction in the lags used in GMM-style instruments, and collapsing instruments in the xtabond2 environment.

We therefore perform a battery of tests on the key issues of under-identification, instrument proliferation and weak instruments. Instrument proliferation in the system GMM, according to Roodman (2009), leads to biased estimates as a result of model over-fitting – since the endogenous components of endogenous explanatory variables remain unexpunged. Bazzi & Clemens (2013) establish that the results of most growth regressions that use the dynamic panel approach are qualified due to the problem of underidentification and weak instrumentation. They state further that even after reducing the number of instruments, both problems may persist. Roodman (2009) warns that "instrument proliferation in system GMM may generate results that are invalid, yet appear valid because of a silently weakened Hansen over-identification test". He offers three strategies to reduce the instrument set: (i) restrict the number of lags for the GMM-style instruments (ii) collapse the instrument set into a smaller dimension matrix and (iii) combine (i) and (ii). We pursue the first option of restricting the number of lags; all six models in Table 3.7 are then re-estimated.

We start the modeling exercise with lower order lags as instruments and gradually increase the order. In each scenario, we notice that the various specification tests improve significantly with higher order lags. It is worth mentioning that results for the fifth lag show remarkable overall model performance, with convincing signs that the issue of instrument proliferation has been addressed. Table 3.8 below reports the outcome for the SYST-GMM model – with results from the third to the seventh lags included for clarity.

As clearly displayed in Table 3.8, all six specifications are the same in that they all include the interaction term between the lagged dependent variable and fiscal transfers. The only two differences are: (i) year dummies are included in three specifications and excluded from three in an alternate fashion and (ii) columns 1 and 2 are based on third and fourth order lags; columns 3 and 4 are based on fifth and sixth order lags; and columns 5 and 6 are based on sixth and seventh order lags, respectively. The table shows that the number of instrument reduces significantly as a result of the restriction in the number of instruments. For instance, when we compare results under columns 2 and 3 of the SYST-GMM under Table 3.7 with Table 3.8, we observe that the instrument count has reduced from 100 and 119 for the former to 43 and 54 for the third and fourth lags, respectively, for the latter table. When compared even further with the fifth and sixth lags only, our instrument count falls to 19 and 25. For the sixth and seven lags, the number of instruments falls to eight and 13; in this case though, we exercise great care

Table 3.8: Two-Step System GMM (Restricted Lags)

	[1]	[2]	[3]	[4]	[5]	[6]
Dependent Variable	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**
Log of lagged RRGDP	0.973***	1.041***	1.020***	0.964***	0.905***	1.078**
	[0.035]	[0.064]	[0.057]	[0.070]	[0.128]	[0.504]
RNFT	0.243	0.121	0.575***	0.875***	0.292	-1.408
	[0.149]	[0.211]	[0.185]	[0.254]	[0.596]	[3.853]
Log of lagged RRGDP x RNFT	0.649	0.203	2.387	3.148	0.978	-0.862
	[0.521]	[0.691]	[2.141]	[2.014]	[3.000]	[3.518]
Capital stock	0.017	-0.013	0.022	0.059**	0.114	-0.063
	[0.011]	[0.026]	[0.028]	[0.026]	[0.116]	[0.381]
Educational attainment	0.113	-0.171	0.034	0.439	0.465	-2.082
	[0.076]	[0.223]	[0.157]	[0.305]	[0.471]	[5.286]
Constant	-0.043	0.072	-0.027	-0.172*	-0.227	0.639
	[0.027]	[0.088]	[0.051]	[0.093]	[0.212]	[1.827]
Year dummies	No	Yes	No	Yes	No	Yes
Year fixed effects	No	No	No	No	No	No
Number of observations	360	360	360	360	360	360
Number of jurisdictions	60	60	60	60	60	60
Number of lags used	3&4	3&4	5&6	5&6	6&7	6&7
Number of instruments	43	54	19	25	8	13
Specification Tests						
Sargan Test (p value)	0.000	0.002	0.000	0.000	0.730	0.681
Hansen Test (p value)	0.008	0.234	0.171	0.204	0.513	0.587
Arellano-Bond AR(1) (p-value)	0.003	0.002	0.004	0.004	0.027	0.131
Arellano-Bond AR(2) (p-value)	0.296	0.334	0.174	0.283	0.613	0.392

Notes: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. All estimations based on the Windmeijer's (2005) finite sample correction to the standard errors.

to guide against instrument over-pruning. We discuss below the changes observed across the various specification tests.

First, the p-values of the Sargan tests improved significantly across three specifications, compared to the all-zero values in Table 3.7. This ranges between 0.002 and 0.730. Roodman (2009) amplifies this by concurring that instrument proliferation causes model over-fitting, which in turn generates biased estimates because it fails to rid the concerned explanatory variables of their endogenous components. He adds that this usually manifests through high p-values for the Hansen tests –often close to 1. After our re-estimation, the Hansen test p-values all decrease in value across the board; from minimum and maximum values of 0.894 and 1.000 under the SYST-GMM group of specifications in Table 3.8 to 0.008 and 0.587 in Table 3.9, respectively. This is novel, and indeed validates Roodman's proposition above. Both AR (1) and AR (2) tests also improve under all specifications in Table 3.8.

The estimated lagged real per capita GDP coefficient is quite sensitive to the choice of lag length. For instance, going from the fifth and sixth to the sixth and seventh lags leads to a fall in the values of the lagged dependent variable from 1.020 to 0.905 – for specifications 3 and 5. Similar to the lagged dependent variable, the coefficient on net fiscal transfers also becomes statistically significant at the 1% level under specifications 3 and 4; it is not statistically significant under the other four specifications. Across all specifications, the coefficient on the interactive term is not significant.

The other explanatory variables also appear highly sensitive to lag length with changes in magnitudes and directions of impact common across both groups. Our capital stock control variable turns out to be statistically and economically significant under the fifth and sixth lags with the year dummies included; educational attainment is not statistically significant across all specifications. In all, our results show that the SYST-GMM handles well the endogenous regressors by generating instruments from their lagged values.

To conclude this section, the diagnostics in Table 3.8 are not radically different from those presented in Table 3.7. However, results in the former show significant improvements in the various specifications, in addition to lending support to the validity of instruments in our SYT-GMM specifications. In all, our results suggest that the main results remain consistent, with marginal changes in the predictive abilities of the coefficient estimates.

3.6.2 Summary of Results and Policy Implications

In this section, we discuss the implications of the various estimation results so far.

3.6.2.1 Further Analysis

From the analysis so far, the SYST-GMM estimator seems to behave well. This is based on at least four facts: (i) precision of coefficient estimates (ii) instrument validity (iii) heteroscedasticity and autocorrelation robust covariance matrix and (iv) dynamic stability. This does not come as a surprise. As severally discussed, the two-step GMM provides a covariance matrix that is robust to heteroscedasticity and autocorrelation, and unlike the one-step system GMM, provides a robust Hansen J-test for over-identification (Mileva, 2007). Bond *et al.* (2001) also lend their voice; they say though both estimators become asymptotically equivalent when the disturbances are spherical, the two-step system GMM produces more efficient estimators, compared to one-step system GMM.

Based on Table 3.8 above, the two most preferred models are specifications 4 and 5. We choose both because the coefficient on lagged per capita income is under unity and the problem of instrument proliferation is taken care of. Depending on what it is we want to achieve, models 4 and 5 have some unique properties that give them both an edge, in some way, over the other. For instance, specification 4 includes the year dummies in addition to having a statistically significant coefficient on the RNFT variable. On the other hand, with only the sixth and seventh lags used, resulting in only eight instruments, the specification tests on model 5 perform much stronger than what we see in model 4. We see a major trade-off in action here; dealing with the econometric problem of endogeneity results in statistical insignificance for some key variables. The coefficients on lagged GDP per capita in models 4 and 5 are 0.964 and 0.905, respectively; they are both economically and statistically significant at the 1% level. Surely, we will find the two uniquely desirable properties in model 4 above quite useful under the policy analysis section below.

3.6.2.2 Implications for Policy

The central objective of our chapter is to investigate the impact of fiscal transfers on economic growth and redistribution. At the same time, we hope to address the problems that arise as a result of the endogenous nature of net fiscal transfers in the specified model. Clearly, our results on the fiscal transfers-growth question are in two parts. Based on the selected models, our DPD-method produces a coefficient of 0.875 on the RNFT variable in specification 4; specification 5 produces a statistically insignificant coefficient. In contrast, the non-DPD FEM estimators produce statistically significant coefficients ranging from -2.272 to -2.381 for the RNFT-based specifications. All listed coefficients are economically and statistically significant at the 1% level.

While the above FEM results clearly agree with Checherita *et al.* – that on average, net fiscal transfers impede output growth – the statistically significant SYST-GMM technique suggests the opposite. Furthermore, we find the exact opposite (for both FEM and SYST-GMM) when we model relative transfers simply as the ratio of disposable income to personal income – like Checherita *et al.* This does not come as a surprise. Our analysis and Checherita *et al.*'s are similar in two fundamental ways: (i) like Checherita *et al*., the fiscal transfers variable in our analysis is constructed relative to the national average and (ii) fiscal transfer is the ratio between household disposable income and household primary income; the only difference though is that we measure fiscal transfers as percentage change; not just as a ratio of two incomes like Checherita *et al.* Like them, our GMM technique takes into account the endogenous nature of net fiscal transfers.

Notwithstanding the many similarities between our analysis and Checherita *et al.*'s, ours focuses on Canada and the US, while theirs look at Europe. This is one factor that could explain the seeming divergence. Also, the range of period for data and a host of idiosyncratic issues may have played a role in what we see. As noted by Baum (2013), "Although the DPD estimators are linear estimators, they are highly sensitive to the particular specification of the model and its instruments: more so in my experience than any other regression-based estimation approach".

We equally compare our results with Bayoumi and Masson – a US-Canada regional study discussed under the review of literature. They employ OLS on 48 US states and 10 Canadian provinces; they find the coefficient on pretax income to be 0.781 (with a standard error of 0.028) and 0.608 (with a standard error of 0.025) for the US and Canada, respectively. In other words, fiscal transfers reduce income inequalities by 22 cents in the dollar and 33 cents in the dollar, on average, for these countries, in the stated order. Even though we are not able to directly compare our results with Bayoumi and Masson's due to the different models, data, periods considered and the fact that our focus is on real GDP per capita (while theirs is income inequalities), our both results are highly instructive.

To further aid policy analysis, we take a closer look at net fiscal transfers to the regions. To achieve this, we divide the full sample into two, on the basis of the RNFT variable. Based on the summary statistics presented earlier in this chapter, relative net transfer ranges from -5.7% to 20.3%, with mean and median values of 1.5% and 1.1%, respectively. This suggests that the highest contributor pays about 5.7% of its primary income, while the highest recipient gets over 20% of its income. We therefore split the sample on the basis of the median[32] value of 1.1%. In light of this, jurisdictions with median values above 1.1% are named below-average jurisdictions, while those below are tagged above-average jurisdictions.

We go a step further and use another yardstick to achieve this dichotomy: jurisdictions with positive RNFTs are called net recipients while those with negative values are called net contributors. We then conduct our formal econometric test using the OLS, FEM and SYST-GMM estimators. Regression results across all estimators show that the estimated

[32] Using the median, instead of the mean, helps address the issue of outliers like Alaska and Alberta in the full sample.

coefficients on the lagged dependent variable are very significant. In addition, the coefficients fall within the upper-lower bounds established by the OLS and FEM estimators.

The GMM technique produces similar results to what we have in Table 3.8, albeit the RNFT variable and interaction term are statistically insignificant in all cases. The non-DPD based estimators however yield statistically significant coefficients, thus aiding in definitive policy analysis. Considering the persistence and consistency in the FEM outcomes, in particular, we base our policy analysis for the most part on this technique; of course, we tangentially discuss the DPD outcome to get the complete picture. Another reason we focus on the fixed effects strategy is because in all of the four specifications, the subsamples become so truncated that estimation based on the GMM technique is inefficient.

The FEM produces -2.467, -2.051, -1.205 and -2.354 for the lagged per capita output coefficients for our below-average, above-average, net receiving and net contributing jurisdictions, respectively. This clearly establishes a two-way negative impact of net fiscal transfers on real GDP per capita: i.e. while higher taxes have a negative impact on economic growth in the donor jurisdictions, higher net fiscal receipts equally have a negative effect in the receiving regions. Apart from the signs, the values of -1.205 and -2.354 for the receiving and donor jurisdictions, respectively, also show that the impact of net fiscal transfers on growth is greater for the latter group than the former. Clearly, this result is profound and merits further discussion.

This is a clear incidence of “immiserising growth” (Bhagwati, 1958). In other words, not only does fiscal transfer have a detrimental effect on growth in general, economic growth in receiving jurisdictions decline by less than in contributing regions. This is similar to Checherita *et al*.’s finding on “immiserising convergence”. According to Checherita *et al.*, “fiscal transfers impede output growth in both samples, they have a stronger growth-reducing effect on richer regions”.

Hypothesis 6 is based on the precise nature of the tradeoff between redistribution and growth. As stated earlier, while inequality may provide an incentive to redistribute, we need to establish the magnitude and direction of the impact of redistribution on growth. A priori, we expect a positive correlation between fiscal transfers and growth, based on the notion that intergovernmental transfers rely principally on per capita income as an indicator of fiscal capacity. Not just that, fiscal flows are also expected to impact growth and redistribution in prosperous and poor regions differently. We should be cognizant of the inherent limitations in this conclusion however, considering that our GMM estimation technique which explicitly models the endogenous nature of net fiscal transfers does not produce definitive results. Regardless, we are comfortable concluding that fiscal transfers have a significant and direct negative impact on income per capita growth. This conclusion is in agreement with the preliminary exploratory analysis (section 3.5.3) that higher net benefits are associated with lower regional income levels and vice versa (see Figure 3.6). Even so, we expect this finding to be more amplified for Canadian provinces, compared to US states, for reasons related to the specifics of each country's fiscal union, as discussed earlier.

We reiterate here again that Canada has a relatively stronger arrangement of using federal fiscal flows to redistribute income across regions, compared to the US with no formal framework in place to transfer resources from prosperous states to less prosperous ones. While Canada uses both Equalization payments and other transfer payments to equalize fiscal capacities from province to province, the US federal government uses the Grants-in-Aid, a subsidy-type program that is accompanied by federal regulations, to extend its power into state and local affairs (Fraser Institute, 2013). We will look at this in detail under the analysis on the Canada-only and US-only samples in section 3.6.3.

We now use the coefficient of the interaction variable to test for the impact of lagged income on economic growth, through the fiscal transfer channel. The two specifications carrying an interactive term produce statistically insignificant results in all cases in Table 3.9. We conclude that there is no evidence that lagged income distribution has affected the intensity of the impact fiscal transfers have on growth. The same conclusion applies even under the OLS, FEM and DIFF-GMM.

One major policy implication of the above result is that while regional fiscal disparity may be bad for growth, policy designs that focus on taxes and transfers may even cause more harm than good. Drawing specific conclusions on the negative effect of redistributive policies is indeed a dilemma. As pointed out by Okun (1975) in his popular book, Equality and Efficiency: The Big Tradeoff, economic efficiency is achieved at a cost: inequalities in income and wealth. Okun underscores, yet again, the trade-off facing policy makers: a clear choice between an efficient economy or an egalitarian society. This implies that certain economic policies designed to reduce regional fiscal disparities may end up producing weakened economic efficiency as unintended consequence – due to negative production incentives.

Bleaney *et al.* (2001) provide a benign solution to Okun's dilemma by suggesting that investments in public goods could produce pro-growth and pro-equality effects, simultaneously. Checherita *et al.* also caution that governments can use a range of tools, in addition to fiscal transfers, to foster regional convergence (e.g. investment in infrastructure and human capital formation, and corporate subsidies differentiated by region). The equivalents of these variables in our chapter are physical capital stock, educational attainment and trade openness.

A major policy lesson from our results is that care should be taken before drawing a line on the pro-growth or anti-growth stance of fiscal redistributive policies. As discussed under the Ostry *et al.* framework under the review of literature, the dynamics of the inequality-redistribution-growth nexus can often assume varying degrees of complexity. By way of policy recommendation, we suggest that policy makers first unbundle the different components of a redistributive fiscal policy and weigh carefully the pros and cons of each specific component, before making a decision on the optimal redistributive policy for a regional economy. It is also important to note that whatever conclusion we reach here is inherently qualified due to the issue of endogeneity between fiscal transfers and per capita GDP, which is beyond the control of the fixed effects technique. Taken together, the evidence provides mixed support with respect to the DPD and FEM techniques.

In many ways, our conclusion in this section is related to the discussion on economic diversity in the next chapter. First, to the extent that government budget revenues in many jurisdictions are determined by changing economic structures, sectoral composition and changes in the economic structure will be relevant for fiscal policy because sectoral specialization can be expected to have consequences for the transmission of fiscal policy and other macroeconomic shocks. Given the volatile nature of commodity prices, sectoral specialization in resource-dependent economies will also likely drive potential growth and business cycle dynamics, at least to the extent that different commodity price regimes persist. Societies are heterogeneous, both in their income-earning abilities and preferences; economies are equally different in their structures and productive capacities. We therefore examine these links between economic growth and natural resources, in an environment where economic diversity plays a major role.

3.6.3 Trade Openness and AIT Policy

In this section, we shift our attention to the trade openness- growth and AIT-income links. Table 3.9 reports our trade openness regressions; Table 3.10 reports the results of AIT regressions.

3.6.3.1 Trade Regressions

As stated earlier, our analysis on trade openness focuses on the 1999-2010 period because we are constrained by the availability of state-level data for the US. Again, below is the estimated model:

$$ln\text{RGDP}_{it} = \alpha_0 + \alpha_1\,(lnRGDP_{it-1}) + \alpha_2\,(OPN_{it}) + \alpha_3\,(OPN.lnRGDP_{it-1}) + \alpha_4\,(\text{EDU}_{\text{it}}) + \alpha_5\,(CAP_{it}) + \text{JUR}_i + TIM_t + \mu_{\text{it}} \qquad (3.16)$$

Table 3.9 presents the OLS, FEM and SYST-GMM results. Under the SYST-GMM, we see clearly that the number of instruments drops from 23 to 6, and from 31 to 8, when the lag length is raised from 0 to 3, respectively. As discussed in the previous section, the various diagnostics also improve drastically once the issue of instrument proliferation is addressed. The Sargan, Hansen and difference-in-Hansen tests all validate our results once we move from 0 to 3 for instrument lags. Our AR (2) p-value, unfortunately, is unavailable due to the smallness of *T*; so is the difference-in-Hansen p-value for one of the restricted models.

All coefficient estimates on trade openness turn out to be statistically insignificant. The same goes for the interaction term between the lagged dependent variable and our trade openness measure. Under Hypothesis 7, on average, we expect a higher degree of trade openness to be associated with higher GDP per capita. As well, the interaction term between trade openness and lagged income should have a higher marginal impact, compared to the impact of trade openness alone. These results refute our hypotheses, but support the battery of studies on the inconclusive evidence regarding the trade-growth debate.

For instance, Eaton and Kortum (1999) and Keller (2001) support the conditional income convergence notion on the basis that trade liberalization helps international technology diffusion when technical knowledge is a component of the goods and services traded. Parente and Prescott (2000) on the other hand argue that income convergence might not occur as a result of certain constraints on technological adoption. A quick caveat will suffice. Our measure is narrowed down to the ratio of exports to GDP as discussed under data constraints; this might have played a role in what we see here.

Table 3.9: Regression Results for Trade Openness

Dependent Variable	OLS1 lnRRGDP	OLS2 lnRRGDP	FEM1 lnRRGDP	FEM2 lnRRGDP	SGMM1 lnRRGDP	SGMM2 lnRRGDP	SGMM3 lnRRGDP	SGMM4 lnRRGDP
Log of lagged RRGDP	0.977***	1.007***	0.538***	0.728***	0.960***	1.088***	0.818	0.456
	[0.030]	[0.045]	[0.151]	[0.184]	[0.077]	[0.095]	[0.753]	[0.871]
Openness	-0.014	-0.047	-0.107	-0.123	0.064	-0.077	0.097	0.556
	[0.082]	[0.094]	[0.165]	[0.164]	[0.081]	[0.091]	[0.739]	[0.829]
Log of lagged RRGDP x Openness		-0.246		-1.208**		-0.701		3.779
		[0.174]		[0.515]		[0.606]		[5.763]
Capital stock	0.015	0.022	0.024	0.035*	0.005	0.02	-0.001	-0.028
	[0.015]	[0.016]	[0.020]	[0.019]	[0.017]	[0.019]	[0.026]	[0.168]
Educational attainment	0.027	0.014	0.502*	0.514**	0.115	-0.048	0.301	0.591
	[0.112]	[0.121]	[0.252]	[0.248]	[0.190]	[1.445]	[0.612]	[0.690]
Constant	-0.014	-0.015	-0.160***	-0.168***	-0.036	0.007	-0.088	-0.178
	[0.040]	[0.040]	[0.059]	[0.059]	[0.068]	[0.054]	[0.164]	[0.286]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	Yes	No	No	No	No
Number of observations	180	180	180	180	180	180	180	180
Number of jurisdictions			60	60	60	60	60	60
Number of instruments					23	31	6	8
Number of lags used					0	0	3	3
Specification Tests								
R-squared	0.959	0.960	0.302					
Sargan Test (p value)					0.000	0.000	0.207	0.433
Hansen Test (p value)					0.187	0.160	0.248	0.509
Arellano-Bond AR(1) (p-value)					0.042	0.024	0.254	0.787
Arellano-Bond AR(2) (p-value)					n/a	n/a	n/a	n/a

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. A-B stands for Arellano-Bond; OPN for trade openness; RRGDP for relative real GDP per capita; and SGMM for two-step system GMM estimator. All GMM estimations based on the Windmeijer's (2005) finite sample correction to the standard errors.

3.6.3.2 AIT Policy

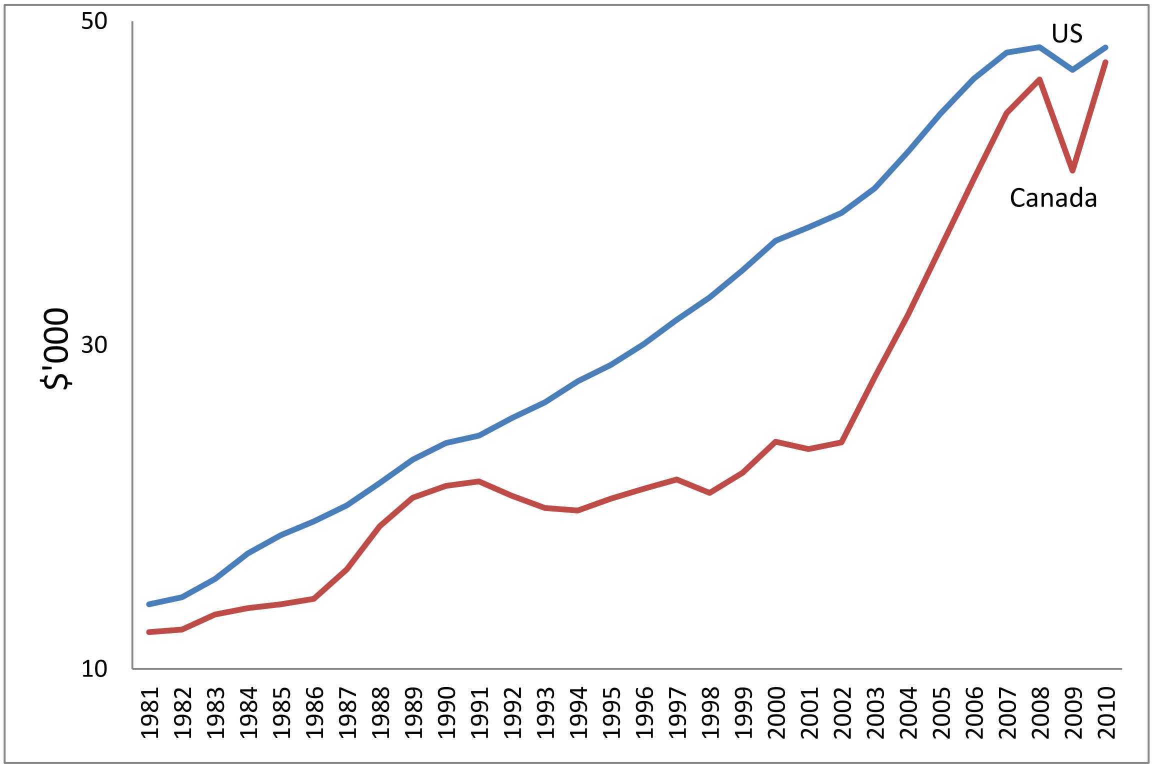
As discussed under model specification, one of the objectives of our chapter is to estimate a measure of the impact of the AIT policy on regional economic growth in Canada; we hope to do so by taking advantage of the fact that the US states were not party to this policy. With the Canadian sample exposed to the AIT policy treatment post-1995 but not in the pre-1995 period, the US sample therefore qualifies as not having been exposed to any treatment pre- or post-1995.

The timing of the signing of AIT, we agreed, may be correlated with other economically relevant milestones in Canada. The DiD approach, by including the US states in the analysis, is helpful in singling out the effect of AIT more precisely. As discussed under model specification, AIT is a year dummy with 1 for post-AIT period and 0 for pre-AIT period. As additional control variables, we add a Canada dummy (which applies to the whole sample for Canada), a Canada slope dummy (which is the interaction of the Canada dummy with the lagged dependent variable) and the AIT slope dummy (the interaction of the AIT dummy with the lagged dependent variable).

Prior to any formal analysis by regressions, we show in Figure 3.7 below the evolution of real GDP per capita (pre-AIT and post-AIT) for Canada and the US. The figure[33] confirms, anecdotally, the tendency for Canada to catch up with the US. Table 3.10 (displayed after Figure 3.7) corroborates the observation in the figure. The table shows the results of the DiD strategy under OLS, FEM and various specifications for the SYST-GMM. As already discussed under the diagnostic tests and estimation issues for fiscal transfers and trade openness above, the same trend is observed for the specification tests. After crossing from 3 to 5 for the number of instruments, the various tests improve drastically.

[33]Among other factors, Canada-US exchange rate dynamics may have some influence on what is seen in Figure 3.7. However, considering that the chart is based on real per capita income, and not current per capita income, such impact is expected to be negligible, if at all existent.

Figure 3.7: Per Capita Income for Canada and the US (1981-2010)



Hypothesis 8 states that the combined effect of the AIT policy and lagged income on GDP per capita is much stronger than the individual effect of the AIT policy on GDP per capita. Therefore, we expect that while the AIT policy is associated with higher GDP per capita, on average, the interaction term between the AIT policy and lagged income will have a higher marginal impact, compared to the impact of the AIT policy alone. It turns out that the AIT dummy is not statistically significant across all specifications. Hypothesis 8a is not confirmed; we need further evidence to prove that the AIT policy has any growth and distributional impacts on Canadian jurisdictions.

On the other hand, our AIT slope dummy, i.e. the interaction between the lagged dependent variable and the AIT dummy, is significant under the FEM and SYST-GMM with a lag length of five. It comes out with a positive sign for the former and a negative sign for the latter. Coefficient values are 0.290 and -0.183 with 5% and 1% statistical significance, respectively. This implies that under FEM, there is evidence of the linkage of lagged income distribution to future economic growth through the AIT policy, while the same

Table 3.10: AIT Policy Estimation Results with the DiD Approach

Estimator	OLS	FEM	SGMM1	SGMM2	SGMM3	SGMM4
Dependent Variable	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**
Log of lagged RRGDP	0.952***	0.541***	0.949***	0.972***	1.111***	1.131
	[0.021]	[0.070]	[0.035]	[0.060]	[0.046]	[0.049]
AIT dummy	0.001		0.009	0.013	0.029	-0.023
	[0.018]		[0.021]	[0.037]	[0.058]	[0.045]
Log of lagged RRGDP x AIT dummy	0.002	0.290**	0.015	-0.040	-0.092	-0.183*
	[0.031]	[0.120]	[0.041]	[0.081]	[0.122]	[0.104]
Capital stock	0.017	0.001	0.008	-0.0004	-0.022	0.007
	[0.016]	[0.020]	[0.019]	[0.028]	[0.054]	[0.050]
Educational attainment	0.080	0.060	0.079	0.083	-0.110	-0.202**
	[0.052]	[0.087]	[0.075]	[0.109]	[0.104]	[0.088]
Constant	-0.036**	-0.031	-0.027	-0.020	0.050	0.049
	[0.018]	[0.024]	[0.027]	[0.029]	[0.050]	[0.053]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	No	No	No
Number of observations	360	360	360	360	360	360
Number of jurisdictions		60	60	60	60	60
Number of instruments			75	27	13	12
Number of lags used			0	3	5	5
Specification Tests						
R-squared	0.960	0.365				
Sargan Test (p value)			0.000	0.001	0.425	0.295
Hansen Test (p value)			0.857	0.062	0.427	0.291
Arellano-Bond AR(1) (p-value)			0.004	0.003	0.002	0.002
Arellano-Bond AR(2) (p-value)			0.353	0.354	0.244	0.245

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. SGMM1, SGMM2 and SGMM3 treat educational attainment as the only strictly exogenous variable; SGMM4 assumes both educational attainment and AIT dummy are strictly exogenous. All estimations based on the Windmeijer's (2005) finite sample correction to the standard errors policy has inhibited growth in a SYST-GMM environment. This result is profound and this makes it necessary to provide some further comments below.

It remains a fact that the early 1980s in North America was marked by a more aggressive international trade policy, especially with respect to free trade agreements. Among others, negotiations toward a free trade agreement between Canada and the US began in 1986, and culminated in the signing of the Canada-United States Free Trade Agreement (CUSFTA) in 1988. Shortly after that, precisely in 1995, Mexico was incorporated and the three countries jointly executed the NAFTA. The AIT agreement also took effect in 1995. Cox (1995), Wall (2003) and Romalis (2007) provide evidence to support the fact that CUSFTA and NAFTA are both trade-promoting and welfare-improving among member countries.

Hiroshi (2013) investigates the welfare effect of forming free trade agreements in an international oligopoly model with cost heterogeneity and concludes that the inherent complexities complicate the welfare effect of FTAs and could decrease consumer surplus in member countries. Krueger (1999, 2000) advises that there is no evidence to show that NAFTA has had any impact on intra-North American trade; Darku (2011) concludes that the distributional impact of the benefits of free trade agreements may either help reduce or further widen the income gaps of member countries.

All of these findings and conclusions make it necessary to point to one quick caveat at this point. Agreed, we leverage an important capability of the DiD strategy in estimating the coefficient of our AIT dummy: the fact that US states were not party to the AIT policy. As argued under the section on model specification, the timing of the signing of AIT may be correlated with other economically significant developments in Canada. Indeed, NAFTA and AIT came into effect in 1995. No doubt, this coincidence will obscure our measure of the extent to which the AIT policy has influenced income growth in Canada. We definitely need to control for this in some way before we can draw any meaningful conclusions from the estimates.

A good empirical strategy to deal with the above concern will be to get both Mexico-US and Canada-Mexico sub-national export and import data. While the Canada-Mexico portion of the data is available, albeit from 1999 onwards, the Mexico-US part is not available. This concern is therefore difficult to address in our empirical work and qualifies the results. A more thorough treatment of this issue is beyond the scope of this thesis.

3.6.4 Sensitivity Analysis and Discussion

In this section, we conduct detailed sensitivity analysis of our central results, in order to confirm how robust the different patterns of relationships are to permutations of the original sample and model. Amplifying Baum, yet again, the DPD estimators are linear estimators, but highly sensitive to the particular specification of the model and its instruments. We explain below alternative regressions designed to deal with potential problems of functional specifications, econometrics and short panel bias.

3.6.4.1 Alternative Fiscal Transfers Measures

As discussed under data/variables, a concern with this work is that variable definitions could affect results. We therefore examine the robustness of our results to alternative measures of net fiscal transfers. To do this, we define fiscal transfers as personal current transfer receipts – as previously explained. To maximize space and further explore other issues yet unaddressed, we treat educational attainment as a strictly exogenous variable. Based on the composition of personal current transfer receipts, compared to the conventional fiscal transfers used so far in this chapter, we model this variable in both ways – endogenously as a GMM-style variable and as a strictly exogenous IV-style variable.

Results are robust to the alternative measure of fiscal transfers. Using personal current transfer receipts as a measure of net transfers produces a somewhat complicated outcome. First, only one out of all three SYST-GMM specifications produces a statistically significant coefficient on the lagged dependent variable. Second, the other two coefficients come out with negative signs, a rarity so far in this chapter, albeit not statistically significant. Only the FEM produces a statistically significant coefficient on the RNFT variable. At -0.312, this is probably the smallest marginal impact of fiscal transfers on output that we have seen so far in the analysis. See Table 3.11 below.

The result above is probably an indication of the significant difference between personal current transfer receipts and other conventional measures of fiscal transfers so far employed in the study. For instance, the Bureau of Economic Analysis maintains that estimates of personal current transfer receipts are prepared for approximately 50 subcomponents of transfer receipts. In addition, approximately 95 percent of the estimates of transfer receipts are derived from direct measures of the receipts at the state level; this proportion is even said to be lower for current estimates and rises as more complete source data become available.

3.6.4.2 Logarithmic and Quadratic Functional Forms

As a final sensitivity test, we estimate a variety of different functional specifications. We realize that it is also quite possible that the fiscal transfer-growth nexus is non-linear. Sala-i-Martin, Doppelhoffer and Miller (2004) deal with this issue extensively. To test for this plausibility, we model two different functional forms: logarithmic and quadratic. For the former, we use the log form for all non-binary variables in the model, while we square net fiscal transfers for the latter. The notion of modeling the impact of fiscal transfers on per capita income in a quadratic fashion is based on two things. First, it allows for greater flexibility in modeling the possible direct relationship. Second it allows us to postulate that there are diminishing returns to government fiscal transfers. In other words, the incremental gain in per capita income falls for higher levels of fiscal transfers. In each case, we use the different estimation techniques.

In turn, we offer some explanation for the two functional specifications. The coefficient on the lagged dependent variable is significant for the FEM and SYST-GMM with 95 instruments.

Table 3.11: Fiscal Transfers as Personal Current Transfer Receipts

Estimator	OLS	FEM	SGMM1	SGMM2	SGMM3
Dependent Variable	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**
Log of lagged RRGDP	0.866***	0.166	0.726***	-0.591	-0.327
	[0.080]	[0.230]	[0.175]	[0.969]	[1.632]
RPCT	-0.002	-0.312***	0.006	0.166	0.038
	[0.017]	[0.071]	[0.038]	[0.107]	[0.062]
Log of lagged RRGDP x RPCT	0.084	0.427*	0.209	1.509	1.259
	[0.073]	[0.245]	[0.168]	[0.947]	[1.533]
Capital stock	0.020***	-0.004	0.022***	0.066***	0.041
	[0.007]	[0.021]	[0.008]	[0.018]	[0.055]
Educational attainment	0.068	0.185	0.065	0.050	-0.114
	[0.048]	[0.092]	[0.66]	[0.171]	[0.126]
Constant	-0.033	0.257***	-0.043	-0.239*	-0.074
	[0.022]	[0.070]	[0.040]	[0.137]	[0.122]
Year dummies	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	No	No
Number of observations	360	360	360	360	360
Number of jurisdictions		60	60	60	60
Number of instruments			100	16	16
Number of lags used			0	5	5
Specification Tests					
R-squared	0.960	0.421			
Sargan Test (p value)			0.000	0.003	0.004
Hansen Test (p value)			0.999	0.055	0.021
Diff-in-Hansen Test (p-value)			0.866	0.810	0.658
Arellano-Bond Test for AR(1) (p-value)			0.003	0.002	0.010
Arellano-Bond Test for AR(2) (p-value)			0.368	0.284	0.258

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. RPCT stands for relative personal current transfer receipts. SGMM 1 and SGMM2 treat educational attainment as the only strictly exogenous variable; System GMM 3 assumes both RPCT and educational attainment are strictly exogenous. All estimations based on the Windmeijer's (2005) finite sample correction to the standard errors.

As always, increasing the lag length from 0 to 5 results in improved diagnostic tests, but loss in statistical significance for some of the variables. The dynamic panel results are quite robust to a variety of sensitivity analyses. When we use the estimates from the FEM estimators to judge the unbiasedness of the SYST-GMM estimator in Tables 3.12 and 3.13 (below), the parameter estimate of the lagged dependent variable, though significant, falls out of the upper and lower bound established by the OLS and fixed effects estimators.

These estimates range between 1.061 and 1.025 for the logarithmic model and 0.979-1.059 for the quadratic version. Corresponding FEM estimates are 0.932 and 0.530. The *p*-values of the Sargan test and the Hansen test do not suggest that the instruments used are not valid; we could not conclude that the estimator suffers from the weak instrument problem. This weak performance of the SYST-GMM estimator certainly does indicate that perhaps these functional forms do not depict the true nature of the relationship between these variables. This notion may be supported, in particular, by the fact that a large part of the reviewed empirical literature does not consider quadratic forms at all, while logarithmic versions are always limited to the dependent variable and the lagged dependent variable.

The FEM coefficient estimates for the RNFT variables are negative, and statistically and economically significant under both functional specifications, with -2.376 for the quadratic form and -2.167 for its logarithmic equivalent. Yet again, the results provide evidence that net fiscal transfers impede output growth in the receiving regions.

Table 3.12: Logarithmic Version

Estimator	OLS	FEM	SGMM1	SGMM2	SGMM3
Dependent Variable	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**
Log of lagged RRGDP	0.961***	0.547***	1.061***	1.025***	1.025***
	[0.018]	[0.076]	[0.063]	[0.170]	[1.170]
RNFT	-0.016	-2.167***	-0.029	-0.731	-0.731
	[0.146]	[0.396]	[0.270]	[2.036]	[2.036]
Log of lagged RRGDP x RNFT	-0.136	-0.129	-0.025	1.763	1.763
	[0.262]	[0.837]	[0.641]	[2.829]	[2.829]
Log of capital stock	0.022***	-0.025	-0.024	-0.132	-0.132
	[0.008]	[0.035]	[0.038]	[0.232]	[0.232]
Log of educational attainment	0.011	-0.040	-0.053	-0.256	-0.256
	[0.011]	[0.069]	[0.065]	[0.508]	[0.507]
Constant	0.023	-0.042	-0.058	-0.323	-0.323
	[0.015]	[0.091]	[0.083]	[0.652]	[0.652]
Year dummies	Year	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	No	No
Number of observations	360	360	360	360	360
Number of jurisdictions		60	60	60	60
Number of instruments			44	14	14
Number of lags used			3	6	6 &7
Specification Tests					
R-squared	0.962	0.549			
Sargan Test (p value)			0.002	0.087	0.087
Hansen Test (p value)			0.128	0.291	0.291
A-B Test for AR(1) (p-value)			0.002	0.025	0.025
A-B Test for AR(2) (p-value)			0.351	0.400	0.400

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. All estimations based on the Windmeijer's (2005) finite sample correction to the standard errors

Table 3.13: Quadratic Version

Estimator	OLS	FEM	SGMM1	SGMM2	SGMM3
Dependent Variable	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**	**lnRRGDP**
Lagged lnRRGDP	0.932***	0.530***	0.979***	1.059***	0.982
	[0.020]	[0.080]	[0.032]	[0.129]	[0.690]
RNFT	-0.302**	-2.376***	-0.009	0.037	-5.751
	[0.150]	[0.427]	[0.233]	[0.598]	[9.546]
Lagged lnRRGDP x RNFT	0.428	0.981	-0.057	1.007	5.813
	[0.262]	[1.147]	[0.718]	[1.163]	[9.233]
RNFT squared	-18.931	102**	-20.963	91.726	-2.593
	[19.812]	[39.95]	[22.026]	[98.625]	[225.52]
Lagged lnRRGDP x RNFT squared	2.194	-10.137**	2.233	-8.422	2.980
	[1.945]	[3.877]	[2.171]	[9.508]	[24.139]
Capital stock	0.014**	-0.030*	-0.002	-0.009	-0.303
	[0.007]	[0.018]	[0.016]	[0.039]	[0.829]
Educational attainment	0.061	0.368	-0.011	0.039	-3.195
	[0.056]	[0.300]	[0.155]	[0.404]	[9.111]
Constant	-0.022	-0.040	0.015	0.011	1.410
	[0.022]	[0.085]	[0.056]	[0.146]	[3.310]
Year dummies	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	No	No
Number of observations	360	360	360	360	360
Number of jurisdictions		60	60	60	60
Number of instruments			58	30	17
Number of lags used			3	5	6
Specification Tests					
R-squared	0.964	0.570			
Sargan Test (p value)			0.000	0.001	0.268
Hansen Test (p value)			0.455	0.079	0.238
Arellano-Bond AR(1) (p-value)			0.003	0.007	0.460
Arellano-Bond AR(2) (p-value)			0.440	0.452	0.403

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. All estimations based on the Windmeijer's (2005) finite sample correction to the standard errors.

3.6.5 Canada-Only and US-Only Samples

Knowing beforehand that the assumptions meriting the use of the system GMM are not likely to be met under a relatively small *N*, we re-estimate models 1-6 in Table 3.8 using our Canada sample only; followed by the US-only sample. This is in order to take advantage of our DPD environment, and especially to facilitate direct comparison of our estimates with similar studies in Canada. The outcome does not surprise us. With the fifth and sixth lags used, the coefficient on the lagged dependent variable turns out to be insignificant. Apart from personal current transfer receipts in Table 3.10 above, this is the first time this would happen in the entire modeling process. The Sargan (0.005) and Hansen (1.000) tests also perform poorly showing clear signs of a large number of instruments (25) relative to number of observations. Lower lags do not fare better.

Only when instruments between the sixth and seventh lags are used do we have a statistically significant lagged per capita income; expectedly, the Hansen p-value stands at 1.000 under this scenario. Obviously, combining a lagged dependent variable and fixed effects under a sample as a small as our Canadian example here provides enough justification that we have invariably introduced a short panel bias. Without any doubt, the appropriate remedy here lies in using a static panel method to model this part of the study or as already done, focus on the more robust combined sample which allows for the proper DPD operations.

We repeat the above exercise for the US[34] only sample. Again, no surprises; the model performance across all six specification improves drastically – given the increase in N from 10 to 50. The reported coefficients on lagged per capita income are largely comparable to what we have under the combined sample in Table 3.8, with the US ones fairly large compared to the combined sample: 1.194 and 1.868 for the former and 0.964 and 1.078 for the latter, respectively. The estimated models perform well on all specification tests.

[34] We do not report estimation results for the Canada-only and US-only samples because while the former is largely inconsistent for the reasons mentioned, the latter compares reasonably well with the combined sample which is already discussed in detail.

3.7 Summary and Conclusions

This chapter investigates the role of fiscal transfers in explaining regional per capita income level in Canada and the US. Using a dynamic panel of Canada-US data, we estimate the importance of redistributive flows by regressions which estimate the relationship between personal income after federal taxes and transfers, and pretax personal income. This gives a direct measure of the degree to which fiscal transfers impact on average regional incomes. Furthermore, we leverage the DiD methodology to capture the effect of the AIT policy, pre- and post-1995. Other by-products include estimates of the impacts of trade openness, educational attainment and physical capital stock on economic growth.

In particular, we introduce a number of refinements in the estimation methods in order to increase the reliability of our econometric estimates. Given the endogenous nature of fiscal transfers and trade openness in the specified model, traditional panel data estimators such as the FEM is inconsistent because it often eliminates the error term by a de-meaning transformation that renders the estimators inconsistent. Our only option is the instrumental variable strategy; in order to correct for the biases created by lagged endogenous variables and the simultaneity of growth determinants, we take maximum advantage of the estimators developed for DPD models – the difference and system GMM.

Using the Solow Growth model as the benchmark, a number of central and lower level hypotheses are specified to guide the outcomes of the empirically modeled scenarios. It is hypothesized that fiscal transfers based on personal income after taxes and transfers and pretax personal income are a potent fiscal tool used to analyze the effects of redistribution. Needing to establish the magnitude and direction of the impact of redistribution on growth, on average, higher net fiscal transfers are proposed to be associated with higher GDP per capita. Not only that, it is also expected that fiscal flows would impact growth and redistribution in prosperous and poor regions differently, with higher net fiscal transfers leading to higher GDP per capita for net contributing jurisdictions, and lower GDP per capita for net receiving jurisdictions. Apriori, trade openness and the AIT policy are expected to be associated with higher GDP per capita.

Among other things, the results help address the major concern that motivated a GMM strategy in the first place. Results from all alternative specifications complement one another. We find evidence for the negative effect of fiscal transfers on per capita income; no evidence to comment on the degree to which lagged income distribution is linked to future economic growth through fiscal transfers in Canada and the US – the interaction terms between lagged per capita GDP and fiscal transfers are not statistically significant under the four scenarios modeled.

Based on the reported standard errors, the Windmeijer's (2005) finite sample correction clearly suggests the SYST-GMM performs better than the DIFF-GMM models. After conducting a battery of tests on the key issues of under-identification, instrument proliferation and weak instruments, we settle for the two most preferred DPD models. These are chosen because the coefficient on lagged per capita income is under unity in each case, thereby solving the problem of instrument proliferation. Lagged GDP per capita coefficients of 0.964 and 0.905 are estimated, respectively.

Back to the central objective of the study, the DPD-based method produces a coefficient of 0.875 on the RNFT variable, while the non-DPD FEM estimator produces coefficients that range from -2.272 to -2.381. We conclude that while the FEM results clearly agree with Checherita *et al.* that net fiscal transfers impede output growth, the SYST-GMM technique suggests the opposite. The exact opposite is the case when we model relative transfers simply as the ratio of disposable income to personal income. We draw a fundamental conclusion: the DPD estimators are highly sensitive to the particular specification of the model and its instruments. This cautious note guides all policy recommendations in this chapter.

To further aid policy analysis, we divide the full sample into below-average, above-average, net receiving and net contributing jurisdictions. With estimated coefficient values of -2.467, -2.051, -1.205 and -2.354 for the fiscal transfers coefficients, we establish a two-way negative impact of net fiscal transfers on real GDP per capita. We conclude that while higher taxes have a negative impact on economic growth in the donor jurisdictions, higher net fiscal receipts equally have a negative effect in the receiving regions: a clear incidence of "immiserising growth". The coefficient of the interaction variable is further used to test for the impact of lagged income on economic growth and redistribution through fiscal transfers. With statistically insignificant results, we conclude that there is no evidence that lagged income distribution has affected the intensity of the impact of fiscal transfers on growth.

The hypothesis that on average, a higher degree of trade openness is associated with higher GDP per capita is refuted. Likewise, the hypothesis that the interaction term between trade openness and lagged income should have a higher marginal impact on growth, compared to the impact of trade openness alone, is also refuted. These support the battery of studies on the inconclusive evidence regarding the trade-growth debate. With the AIT dummy not statistically significant across all specifications, the hypothesis that the AIT policy has any growth or income distributional impacts on Canadian jurisdictions is refuted. The interaction between the lagged dependent variable and the AIT comes out with coefficient values are 0.290 and -0.183 for the FEM and the SYST-GMM, respectively.

We conclude that under the FEM, there is evidence of the linkage of lagged income distribution to future economic growth through the AIT policy, while the same policy inhibits growth in a SYST-GMM environment. We quickly point to the caveat that the coincidence in the timing of the signing of AIT in Canada and the execution of NAFTA may obscure our measure of the extent to which the AIT policy has influenced income growth in Canada. It is recognized that addressing this concern through Mexico-US and Canada-Mexico sub-national export and import data is important.

The results under sensitivity analysis do not produce radically different outcomes. With the notable exception of where personal current transfer receipt – an alternative measure of fiscal transfers – produces a somewhat small coefficient estimate, results from other robustness tests are fairly consistent with what is reported under estimation results. Regardless, this has a practical implication. Any intergovernmental transfers, whether or not explicitly designed to help equalize the fiscal capacities of sub-national governments, will have redistributional implications. This is because one thing is common to all transfer programs: they involve a flow of resources from the center to regional governments. Therefore, appropriate designs of transfer systems should recognize that transfer programs may have conflicting objectives or unintended consequences which may affect their potency.

A major policy lesson from this chapter is that while regional fiscal disparity may be bad for growth, policy designs that focus on taxes and transfers may even cause more harm than good. Drawing specific conclusions on the negative effect of redistributive policies is therefore a dilemma. Policy makers are advised to first unbundle the different components of a redistributive fiscal policy and weigh carefully the pros and cons of each specific component, before making a decision on the optimal redistributive policy for a regional economy.

Chapter 4 Economic Diversity and the Resource Curse: A Dynamic Panel Model

4.1 Introduction

Economic diversification remains a recurring theme in public policy debates; it is popularly believed to be the cure to the "resource curse" challenge. The benefits of diversification, as well as the importance of key economic, demographic, geographic and institutional factors that explain it, remain widely acknowledged. However, explaining the specific reasons why diversification helps some economies to succeed where others fail remain a mirage. To further complicate things, most empirical investigations of the relationship between economic growth and diversity provide inconclusive evidence.

For instance, concerns continue to be raised on the far-reaching effects of commodity price shocks on resource-dependent economies across the world. To the extent that volatile prices have affected government revenues, output and capital investment, the popular policy debate on whether or not economic diversification can help in escaping the resource curse is back in many resource-rich and resource-dependent jurisdictions.

The diversification-growth question in regional economic analysis remains open, as most econometric studies provide weak evidence – mainly because results depend largely on the parameters of interest. While some see economic diversification as a long-term economic growth strategy that can help mitigate unforeseen problems in the event of structural economic changes, such as the decline of a region's resource base, others argue that diversification is a costly and unnecessary form of government intervention (Macaspac, 2007).

While the importance of a jurisdiction's economic structure – e.g. resource-abundance and regional comparative advantage – cannot be overemphasized in light of the above, many regional economic development policy experts believe economic diversity is a potent tool that can help achieve the twin goals of economic growth and stability. Unsurprisingly, others disagree (e.g. Akpadock, 1996); they argue that diversification does not always bring about economic stability and growth. According to Smith and

Gibson (1998), indiscriminate diversification does not necessarily deliver economic stability.

Sub-national level studies are important in complementing the understanding of regional economic development. To the extent that regional economic diversity allows global integration and technological progress to shift economic landscapes, national economic policies continue to have differential sub-national impacts. Our approach provides an opportunity to review best practices and successful policies of various regional jurisdictions in Canada and the US, with a view to helping to improve performance at the national levels. Using a sub-national framework creates a robust platform which, among other things, incorporates an institutional setting with regional economic development policies, administrative systems, and the nuances of intergovernmental relations.

This thesis focuses on the sub-national level because for Canada and the US, many important spatial and economic characteristics at the sub-national level are expected to vary sharply from what is observed at the national levels. This becomes even more important because a sub-national framework also serves as a laboratory for testing direct policy interventions that enable poorer jurisdictions to benefit from national economic growth. That is in addition to ensuring that fairness, equity and efficiency are balanced, while the issue of spatial disparity is addressed.

This chapter aims at contributing to the debate on economic diversity, resource curse and economic growth across Canadian and US jurisdictions by using the most recent techniques of dynamic panel data (DPD) models. The objectives are three-fold and we achieve them by estimating a conditional growth model in a regional context. First, we closely examine the relationship between economic diversification and growth for Canadian and US jurisdictions over the 1987-2010 period.

Humphreys *et al.* (2007), Collier and Venables (2007), Gelb (2010) and Gelb and Grasmann (2010), among others, postulate that economic diversification is a potent long-term strategy that can help resource-endowed and resource-dependent jurisdictions escape the curse. Ample facts show (e.g. Ahmadov, 2012) based on empirical studies, that many of the jurisdictions that follow this trajectory have little or nothing to show for diversification, as a policy option. This study therefore examines the effect of diversification on growth. This becomes important considering the different conclusions, both on empirical and theoretical grounds, from old and extant research studies (e.g. Attaran, 1986; Baldwin and Brown, 2004; and Essletzbichler, 2007).

Our second objective is to employ an empirical growth model to explain growth in real per capita income at the US state and Canadian provincial level as a function of natural resources and a set of variables drawn from the existing literature. Sachs and Warner (1995) argue that an indirect consequence of natural wealth is the resource curse. Contemporary evidence on the curse yields a conundrum (Collier and Goderis, 2007); most recent studies conclude that the transmission mechanism of the curse is more important. We will take a closer look at the transmission channel.

By looking at the twin issues of diversification and the resource curse, our chapter contributes to this debate, albeit from a Canada-US regional perspective. This becomes even more significant considering our use of the generalized method of moments (GMM) estimator, one of the most recent DPD techniques used in empirical regional growth analyses.

In summary, our chapter contributes to the conditional theories of economic diversification and the resource curse. Given that these regions share many common characteristics and also exhibit huge differences in economic structures and performances, we take advantage of our DPD methodology to control for the jurisdiction-specific features that might obscure our key research questions. This provides the additional advantage of providing a means to test the robustness of our different specifications.

4.2 Literature Review

4.2.1 Resource Curse Analysis

The resource curse has two common explanations in the literature: (i) economic and (ii) political-institutional. The pioneering research of Corden and Neary (1982) forms the basis of the theory of Dutch disease. The "Dutch disease" – a situation that leads to a diminished importance of the manufacturing sector due to the crowding out effect of natural resources – is the major economic explanation of the curse.

Corden and Neary (1982) use a two-factor, two-good model to explain what can cause a decrease in the competitiveness of the trade-exposed manufacturing sector. They assume a small open economy with three sectors: a non-tradable sector (service sector), an import-competing manufacturing sector and a resource sector . Corden and Neary conclude that the resource boom will affect the rest of the economy through two channels: the effect of movement of manufacturing resources and the expenditure effect. This leads to a lagging export sector which suffers through what they call de-industrialization.

Starting with the famous work of Sachs and Warner (1995), which formally established the resource curse; their results support a dynamic version of the Dutch disease model by showing that on average, resource-abundant countries lag behind countries with less resources. Using the ratio of natural resource exports to GDP as a proxy for natural resource endowment, and 1971 as the base year, they control for other determinants of economic growth such as initial per capita income, trade policy, government efficiency, and investment rates. This has become the most commonly cited work in the resource curse literature.

Auty and Mikesell (1998) in the book, "Sustainable Development in Mineral Economies", examine the problems faced by mineral-rich countries in achieving sustainable development – compared to their mineral-deficient neighbours. Focusing on nine countries – Botswana, Chile, Colombia, Indonesia, Jamaica, Namibia, Papua New Guinea, Peru and Trinidad and Tobago – Auty and Mikesell offer a compelling argument on why nurturing the economic and social conditions that sustain economic growth is more important than the sustainability of mineral production itself.

The second popular explanation is the political-institutional explanation. This model blames the existence of the curse on rent-seeking behaviour. Robinson *et al.* (2006) present a formal political-economy framework of the resource curse by arguing that in order to understand whether or not natural resources are a blessing or a curse, it is imperative to analyze the political incentives that resource endowments generate – through a careful analysis of the interaction between institutions and resources. In order to fully analyze the effects of temporary and permanent resource booms, they use a two-period probabilistic model to consider some stock of natural resources with an intertemporal path of prices subject to exogenous price variation – capturing the environment faced by small developing economies subject to international commodity price variations.

Robinson *et al.* (2006)'s analysis reveals a complex relationship between resource extraction and the political environment. Where there are weak political institutions, resource booms will lead, through the political process, to inefficient resource allocations. They conclude that the extent to which the predictions in their model generate the curse is determined by the quality of institutions since countries with strong institutions benefit from resource booms, while those without suffer from the curse. Lane and Tornell (1999) and Torvik (2002) explain this further using theoretical models of rent seeking. Isham *et al.* (2005) look at this issue from the perspective that resource rents may create a wealthy class of elites who may be opposed to welfare-improving economic and political reforms.

While corruption and rent seeking, for obvious reasons, are less prevalent in developed countries (compared to their developing counterparts), Ross (2001) cautions that resource-dependent jurisdictions may tax their residents less heavily, and in turn, tax payers may be indifferent to politicians' accountability and representation. In our case, Ross' note becomes important when we consider Alberta and Alaska, two important oil and gas jurisdictions in Canada and the US, respectively, that do not levy sales tax – an important component of consumption tax. Béland and Tiagi (2009) conclude that for any given revenue target, the incentive to tax residents decreases when natural resource rents are easily accessible. Putnam (1993) and Inglehart (1997) amplify this sentiment; they argue that this produces a bunch of citizens who care less about how accountable politicians are.

In an attempt to improve on the influential work of Sachs and Warner, Mehlum *et al.* (2006) contrast the findings of Sachs and Warner that institutions are not decisive for the resource curse by using the latter's data and methodology to test their (Mehlum *et al.*'s) hypothesis that institutions are actually decisive for the resource curse. Using the average growth rate of real GDP per capita from 1965 to 1990 as the dependent variable, and an unweighted average of five indexes which ranges from zero to unity (rule of law index, bureaucratic quality index, corruption in government index, risk of expropriation index and government repudiation of contract index) as a proxy for institutional quality, they demonstrate that countries with good institutional quality will not experience any resource curse as natural resources only inhibit economic growth in countries with 'grabber friendly' institutions and not in countries with 'producer friendly' institutions.

Mehlum *et al.* (2006) go beyond the regressions of Sachs and Warner by providing an alternative explanation for the understanding of the resource curse through the inclusion of an interaction term: [resource abundance] x [institutional quality], that captures their model prediction which states that it is only when institutions are weak that resource abundance is harmful to growth. In addition to finding a positive coefficient for the interaction term as stated in their apriori expectations, the empirical results equally show that countries with institutional quality index higher than the threshold value of 0.93 do not experience the resource curse. As such, 15 out of the 87 countries included in the regression have institutional quality strong enough to neutralize the resource curse – which is manifested through a negative growth impact of a marginal increase in resources.

To the extent that good institutions reinforce the adoption of robust measures which result in a policy mix that reflects differences in economic structure that can mitigate the disruptive effects of business cycles, we model diversity in a similar way institutional quality is modeled in the literature.

4.2.2 The Case for Economic Diversification

Gelb (2010) asks two important questions? Why diversify in the first place? Why try to move away from a sector of very strong comparative advantage? He, in turn, answers:

> The motive may simply reflect the proposition that export diversification is associated with higher long-run growth. However, resource exporters are different in many dimensions, including population, labor force and skills, location, levels of income, reserves, and the potential for other resource-based activities. These will shape diversification priorities and policies.

Regional economic diversification has been shown as a potent tool for advancing technological progress, innovation, positive technology externalities and other sources of agglomeration economies (Jacobs, 1969; Feldman and Audretsch, 1999). It prompts firms to compete for scarce resources, and in the process, promotes innovation (Porter, 1990).

As stated earlier, evidence on the diversity-growth debate is inconclusive. While Attaran (1986), for instance, fails to find any relationship between diversity and per capita income growth at the state level, Attaran and Zwick (1987) conclude that such relationship does, in fact, exist at the county level for the State of Oregon. Frenken *et al.* (2007) and Bishop and Gripaios (2010) use employment growth in place of per capita income growth, and conclude with divergent views.

Hackbart and Anderson (1975) look at the diversity-growth argument from the point of view of stability. They suggest that economic diversity makes regions less susceptible to the volatility inherent in business cycles. Dissart (2003) shares the same view. The central argument of these researchers is that stability is conducive for regional economic growth to the extent that displaced workers from other sectors of the economy can be easily absorbed by a diverse economy, compared to a highly specialized one. Bishop and Gripaios (2010) say specialization has a negative impact on growth, while the economic diversity effect is heterogeneous across sectors; Frenken *et al.* (2007) summarize their results thus: related variety enhances employment growth, while other types of agglomeration economies do not matter.

From the foregoing, the importance of the resource-diversity-growth debate in helping shape the direction of policy in resource-based economies cannot be overemphasized. This chapter fits into the various discussions so far because it is an extension of many of the studies cited above. Gelb (2010) makes an important contribution to the resource-diversity debate by pointing out the following “three main complications” in the debate: (i) how to deal with the endogeneity of measures of resource abundance and resource dependence (ii) how to measure outcomes (income levels, growth rates or broader development indicators) and (iii) how to allow for country heterogeneity. Thankfully, our sub-national focus and GMM estimation strategy enable us to deal with all three issues seamlessly, in addition to providing updated results.

4.3 Theoretical Setup

4.3.1 Measuring Economic Diversification

There is no single explicit framework that constitutes a base for empirical or theoretical work on economic diversification. Depending on the theoretical foundation explored, different measures and concepts can be used as economic diversity indicators (Macaspac, 2007; Ahmadov, 2012; and Pede, 2013). Popular models that help explain economic diversity measures in the literature include: industrial organization, economic development theory, portfolio theory, regional business cycle theory, trade models, location theory, economic base theory and input-output analysis. For instance, Hoover and Giarratani (1985) postulate that industrial clusters benefit from agglomeration economies due to specialization and regional competitive advantages; giving rise to the popular location theory, based on spatial economics and clusters.

The Herfindahl-Hirschman Index (HHI) is popularly used to measure market structure or concentration in industrial organization – a field in economics that focuses on the strategic behaviour of firms, and their interaction to determine the structure of markets. Named after the economists who derived it, HHI is constructed based on the individual share of each firm in a market. The robustness of the index depends on the number of firms and the market share of each. The HHI lower bound approaches zero for competitive industries with a large number of firms; the index value is 1 for a pure monopoly scenario. In our case, a lower value of the HHI represents higher economic diversity, while a value close to 1 depicts the absence of diversity.

Originally developed by Markowitz (1959), but later refined by Conroy (1974, 1975), this financial assets-based portfolio theory likens every economic sector in a region to individual regional investment, thereby allowing a combination of sectors to be treated as a portfolio of investments. This allows the mean return to be used as a proxy for expected returns, while risk is denoted by the variance, resulting in the set of mean-variance efficient portfolios. This provides a simple portfolio-theoretic framework to examine economic diversification.

Following Pede (2013), we test the impact of economic diversity on growth by using five popular formulations of diversity indices, which are based on the sectoral distribution of employment in a regional economy. More on these measures later.

4.3.2 The Resource Curse Paradigm

For a very long time, natural resources were considered beneficial to economic growth. The resource-growth nexus attracted a lot of attention after Sachs and Warner (1995) showed that an increase of one standard deviation in natural resource intensity (on average 16% of GNP) leads to a reduction of about 1 percent per year in economic growth. This has come to be known as the “resource curse”.

The controversy generated by Sachs and Warner’s results is understandable on a major premise: economic theory predicts that capital (of which natural resources is a component) has a positive effect on growth. However, the central question in the modern resource curse literature has gone beyond whether or not natural resources negatively impact economic growth as earlier argued ; it is now largely about the conditionality of the curse on some other factors. The approach in this thesis will closely follow Mehlum *et al.* (2006); we investigate the transmission mechanism of the curse by including a variable which serves as the interaction term that captures the precise effect of economic diversity, thereby answering the question of whether or not the curse can be avoided by diversified economic structures.

In addition to interacting diversity with the natural resource variable, we also include a number of control variables in our empirical growth model. This seamlessly fits into the discussion so far because institutional quality is among the popular variables identified in the literature as potential determinants of economic growth. For the most part, studies on the resource curse have focused largely on resource-endowed developing countries; more recent ones continue to look at both developed countries and their sub-national jurisdictions. Given the status of the US and Canada as two wealthy and highly advanced countries, we expect that differences in regional economic structures will lead to variations in the resource effect; this will depend on the extent to which our interaction term helps confirm or refute this claim.

4.3.3 The Resource-Diversity-Growth Link

As discussed under sections 4.3.1 and 4.3.2 above, we do not have a single explicit theoretical framework that constitutes a base for empirical and theoretical work on the resource-diversity-growth nexus. The Solow growth model presents a theoretical framework for understanding the sources of economic growth, and the consequences for long-run growth of changes in the economic environment.

In line with the practice in the growth empirics literature, we implement an informal growth regression which allows us to include a larger set of explanatory variables which capture not only the main explanatory variables, but controls and interaction term. Our panel analysis of the empirics of economic growth is a major advance, compared to Barro-type cross-sectional and static panel regression techniques. Based on the growth empirics method of Mankiw *et al*. (1992) which makes the Solow model directly testable, the following growth equation will be estimated:

$$y_{i,t} = \beta \ln Y_{i,0} + \lambda X_{i,t} + \sigma Z_{i,t} + \mu_{i,t} \quad (4.1)$$

where *y* is the growth rate of real GDP per capita, *X* comprises of the usual traditional economic variables that account for growth, while *Z* captures the additional growth determinants based on endogenous growth propositions (Romer, 1986; Mankiw *et al*., 1992; and Barro, 1991).

As previously discussed under the conditional convergence hypothesis, we expect $Y_{i,0}$ to play a major role in determining regional growth differentials across jurisdictions.

In line with Solow (1956), jurisdictions with higher $Y_{i,0}$ values are expected to have slower growth rates, compared with those with lower income per capita levels. These issues will be discussed in detail later in this chapter.

4.3.4 Research Hypotheses

This chapter aims at contributing to the debate on economic diversity, resource curse and economic growth by using the most recent techniques of DPD models. The theory of economic growth identifies a number of critical determinants of growth. Our empirical growth model explains growth in real per capita income at the Canada-US regional level as a function of natural resources, economic diversity and a set of variables drawn from the existing literature. Our hypotheses on the impact of economic diversity on growth are based on five popular formulations of diversity indices, which are based on the sectoral distribution of employment in a regional economy. The resource curse component is based on the hypothesis that an indirect consequence of natural wealth is the resource curse. Contemporary evidence on the curse yields a conundrum; we therefore take advantage of our DPD framework to test the hypothesis that economic diversity is a cure for the natural resource curse.

Following the literature review and theoretical framework above, we advance the following hypotheses to test the research questions in this chapter:

Hypothesis 9

> H_0: There is no relationship between economic diversification and economic growth
>
> H_1: There is a positive relationship between economic diversification and economic growth

As previously discussed, the intuition here is that economic diversification is an economic growth strategy that can help mitigate unforeseen problems in the event of structural changes in a regional economy. Higher degree of economic diversity is therefore expected to be associated with higher GDP per capita.

Hypothesis 10

H_0: There is no relationship between resource abundance and economic growth

H_1: There is a negative relationship between resource abundance and economic growth

Hypothesis 11

H_0: There is no relationship between the outcome of the interactions between resource abundance and economic diversity, and economic growth.

H_1: The outcome of the interactions between resource abundance and economic diversity is the key determinant of the existence, or otherwise, of the resource curse.

In a way, this hypothesis will help us to uphold or refute the conjecture that economic diversification is a potent strategy that can help resource-endowed jurisdictions escape the curse. Our empirical analysis should shed more light and allow us whether or not it is only when regional economies are diversified that resource abundance is not harmful to growth. The coefficient on the interaction term between natural resources and economic diversity is a key factor.

4.4 Data and Descriptive Analysis

4.4.1 Data Sources

Our data are compiled from the following sources: US Bureau of Economic Analysis (Regional Economic Accounts), Statistics Canada (Provincial Economic Accounts and Labour Force Survey), World Bank (National Accounts Data), OECD (National Accounts Data Files), Economic Freedom of North America (Fraser Institute) and the Bank of Canada (Rates and Statistics – Annual Average Exchange Rates.

As previously discussed, the Entropy index is based on the industrial organization theory, which means that we do not benchmark its calculation on any particular economy. Statistics Canada compiles annual employment data by industry from its monthly Labour Force Survey (LFS), while the Current Population Survey (CPS) is a monthly survey of households conducted by the Bureau of Census for the Bureau of Labour Statistics in the US. Both surveys provide a comprehensive body of data on the labour force, employment, unemployment, persons not in the labor force, hours of work, earnings, and other demographic and labour force characteristics.

The surveys cover a detailed group of industries: the goods-producing industries and the services-producing industries. Within each category are major sectors. The employment in these major sectors is broken down even further, using the North American Industry Classification System (NAICS). The NAICS provides a consistent industry classification system for economic analysis across the three NAFTA partners – Canada, Mexico and the US Prior to the NAICS, the Standard Industrial Classification (SIC) system had been in use for 60 years in the US NAICS has twice the number of aggregate industry groupings as SIC. The highest level of NAICS classification is called the sector, and corresponds roughly to the division in SIC. There are 20 broad sectors in NAICS, compared to only 10 divisions in SIC. Through the NAICS-SIC concordances, the conversion from SIC to NAICS has increased detail in the services-producing industries, with new sectors such as Information; Professional, Scientific, and Technical Services; and Administrative and Support and Waste Management and Remediation Services, and established a new sector, Accommodation and Food Services.

We exploit a large annual panel data set spanning eight three-year intervals from 1987 to 2010 and covering all 10 Canadian provinces and 50 states of the US GDP data for the 1987-1997 period for all 60 jurisdictions are based on the SIC system, while 1998-2010 data are based on the NAICS.

4.4.2 Data Issues

Prior to rolling up the sub-sectors to reflect the number of sectors needed for our analysis, we do have some cases of missing data in the initial dataset. A variety of reasons are responsible for missing data. It should be kept in mind that the employment levels in some industries are fairly small, and therefore subject to a greater risk of sampling errors. As a result, these figures are not as reliable as more aggregated numbers. In fact, where the employment level is less than 500, Statistics Canada reports the number as zero. Less than 10 jobs for US states is reported as (L), but the estimates for this item are included in the total. Data labelled as (D) are not shown to avoid disclosure of confidential information, but the estimates for this item are included in the total. (NA) represents completely unavailable data for the year in question.

We use the following specific 3-year averages: 1987 – 1989; 1990 -1992; 1993 – 1995; 1996 -1998; 1999 – 2001; 2002 – 2004; 2005-2007; 2008 -2010. This gives rise to N = 60; T = 8. In the regression itself, T becomes 7 because we lose one complete data set to per capita real GDP growth rate calculation. This amounts to 60 observations for each period, and when multiplied by 7, we have 420 observations. Even though some of the aforementioned categories come up in many of the sub-sectors, we are fortunate to have final figures available at a more aggregated industry level. The only exception in our dataset is the US state of Delaware with a (D) value for the mining share of employment in 2010. One is surprised that an important and relatively highly aggregated sector like mining (which comprises of activities related to oil and gas, in addition to traditional exploration for minerals, development of mineral properties and mining operations) would still show up with a confidentiality caveat.

For the 2010 missing mining share of employment data for Delaware, we weigh the option of deleting the entire row (i.e. the 2008 - 2010 average for Delaware) against using some estimation procedure to arrive at a 'fair" value for this data point. Since we are conscious of the need to maximize sample size given our relatively short panel size, we purse the latter strategy. We use the average of the six preceding data points (i.e.1990 -1992; 1993 – 1995; 1996 -1998; 1999 – 2001; 2002 – 2004 and 2005-2007) to arrive at the 2008 -2010 average. The additional one observation gained here (in addition to the very robust balanced panel status of our data), we believe, is worth the trade-off. As discussed in the preceding chapter, we go with Islam's (1995) generally accepted method of short period-averaged panels.

4.4.3 Construction of Variables

4.4.3.1 Per Capita Real GDP

We exploit a large annual panel data set covering all 50 US states and 10 Canadian provinces. The analysis is based on real GDP per capita obtained from the US Bureau of Economic Analysis (Regional Economic Accounts) and Statistics Canada

(Provincial Economic Accounts and Labour Force Survey). Canada's per capita GDP data are converted into US dollars using annual Canada-US average nominal exchange rates.

4.4.3.2 Natural Resources

Another issue equally important in the resource curse literature is the debate about which resource proxies to use. Among other things, the notion exists that abundant natural resources in a region may not necessarily translate to a large share of exports, employment or income. In the words of Pendergast *et al.* (2010), "as a country develops other sectors of its economy, the share of natural resources in exports, employment and wealth should fall".

Since the pioneer work of Sachs & Warner in 1995, the share of primary production in exports (or in GDP) has been the most widely used measure. For instance, Mehlum *et al.* (2006) follow Sachs and Warner. This measure is not without shortcomings. Bulte *et al.* (2005) point out that as a flow, this proxy will be inadequate as a measure of a jurisdiction's real stock of natural resources. The problem inherent in choosing more precise resource abundance stock measures, however, is the difficulty in measuring them, in addition to the fact that the "possible effects through which the curse takes place cannot be expected to happen until the resources are extracted" (Torres *et al.*, 2013).

A number of papers have assessed the robustness of resource curse correlation to alternative measures of resource abundance and dependence, as well as the estimation methods employed (e.g. Gylfason, 2001; Ding and Field, 2005; Papyrakis and Gerlagh, 2007; Pendergast *et al.*, 2010; Boyce and Emery, 2011 and James and Aadland, 2011). Gylfason proposes three proxies: (1) the share of primary exports in total exports (or in GDP); (2) the share of employment in primary production in total employment; and (3) the share of natural capital in national wealth.

Ding and Field (2005) use World Bank's estimation of natural capital (i.e. natural-resource capital as a percentage of total capital or as a percentage of the population) as a measure of a country's resource endowment. For their cross-country study, Pendergast *et al.* use fuel exports per capita, ores/metals exports per capita and forestry production per capita. Using data for US states over the 1970-2001 period, Boyce and Emery derive the share of employment in the exhaustible resource sector as mining employment divided by total employment for each state.

In light of the above, we follow Gylfason, Boyce and Emery and Sachs and Warner and use the following two alternative measures of natural resources: (1) mining as a share of GDP and (2) mining as a share of total employment. Data on mining as a share of GDP are sourced from Statistics Canada (Labour Force Survey) and the Bureau of Economic Analysis ((Regional Economic Accounts) based on the NAICS estimates of GDP by industry for the provinces and the states. Industry definitions follow the NAICS codes.

GDP by industry measures the output of an industry minus the value of intermediate inputs required in the production process. It is an output-based measure of industrial activities and is also referred to as the value-added of an industry. GDP by industry represents the value that a sector adds to the raw inputs it uses in the production process, which is an important aspect of the sector's contribution to the reference economy. The NAICS identifies 20 major economic sectors (at the two-digit NAICS level): five goods-producing industries and 15 services-producing industries.

Some explanation of the mining sector is instructive here. According to Statistics Canada, this sector comprises establishments primarily engaged in extracting naturally occurring minerals. These can be solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. The term mining is used in the broad sense to include quarrying, well operations, milling (for example, crushing, screening, washing, or flotation) and other preparation customarily done at the mine site, or as a part of mining activity. Establishments engaged in exploration for minerals, development of mineral properties and mining operations are included in this sector. Establishments performing similar activities, on a contract or fee basis, are also included. The mining sector, therefore, provides a benchmark for the economic impact of what is expected of the exhaustible resource sector.

In the end, we assess the robustness of the resource curse correlation to our alternative measures of natural resources and estimation methods.

4.4.3.3 Human Capital Stock

Our first control variable (which also serves as the alternative institutional quality measure), educational attainment, is defined as the percent of persons 25 years and over who have completed at least a Bachelor's degree. The use of the 25+ population is plausible since it focuses on adults age 25 years and over, when education has been completed for most people. Educational attainment is closely related to the skills and competencies of a country's population, and could be seen as a proxy of both the quantitative and qualitative aspects of the stock of human capital. Estimates of educational attainment provide a reasonable proxy for the stock of human capital and should be useful for a variety of empirical work (Barro and Lee, 2012). This variable is already discussed extensively under chapters 2 and 3, respectively.

4.4.3.4 Physical Capital Stock

Mankiw *et al*. (1992) show that physical capital accumulation is an important determinant of economic growth. The variable of interest here is CAP_{it} , our measure of the capital stock endowments in jurisdiction *i* at time *t*. CAP_{it} is the ratio of capital stock to real GDP. In line with Yamarik and Hall and Jones, we construct our capital stock series using the PIM. This variable is already discussed extensively under chapters 2 and 3, respectively.

4.4.3.5 Economic Diversity

While economic diversity continues to be promoted as a major tool for policy makers in achieving stability, low unemployment and economic growth, Wagner (2000) posits that the diversity-diversification-growth link depends on the conceptual and empirical differences between diversity and diversification. Malizia and Ke (1993) and Siegel *et al.* (1993a, 1993b, 1995a and 1995b) see the difference between diversity and diversification from a static-dynamic perspective. Attaran (1986) defines diversity as "the presence in an area of a great number of different types of industries". For Siegel *et al.*, economic diversification, as a process, should lead to an increase in the state of diversity over time. In Wagner's words, "Examining and testing the link between diversity and growth and stability, and diversification and growth and stability depend on the definitions of diversity and diversification".

Among others, empirical analysis of trade and specialization patterns uses simple statistical tools and complex econometric methods; although there is no consensus on which index is the best proxy for diversity or specialization (Palan, 2010). Of the many possible approaches available to examine a regional economy's degree of relative industrial specialization, comparing the distribution of employment across industries in the region with that of the nation is one popular strategy. Under this arrangement, the sectoral composition of the nation's employment is dynamic, and therefore defines the limits of diversification. It is thus expected that a region's employment will be more specialized (and by implication less diversified) than that of the "parent" nation. In a way, this framework essentially reflects the degree of similarity between regional and national industrial structures – and is based on the notion that the national economy is fully diversified.

In regional economic analysis, it is common practice to model diversity using employment distribution across industry sectors. We use employment data covering 10 industry sectors from the Bureau of Economic Analysis (Regional Economic Accounts) and Statistics Canada (Labour Force Survey). Our employment variable is the annual employment in full-time equivalents, a common indicator for industry structure. Some authors (e.g. Palan, 2010) suggest the use of an alternative variable (which is less prone to productivity biases) as a way of testing the robustness of both indices. A top candidate here is GDP. However, we offer two arguments for why employment does better than GDP: (i) GDP itself is likely susceptible to measurement errors and exchange rate biases (ii) the choice of variables should not significantly impact our inferences since our focus is specifically on measurement methods and not specialization per se (Palan 2010). Nonetheless, we construct these indices based on GDP in order to assess robustness. Results are presented along with the main measure later in the chapter.

Different variations and constructions of these indices abound; we consider five diversity measures in all. In order to assess the robustness of our results to the different varieties, we use five leading indices – two versions of the Ogive Index, Entropy Index, Hirschman-Herfindahl Index and the Krugman Index – to help measure the distribution of employment across 10 industry sectors. [35]. We do recognize also that our diversity measures are sensitive to the number of industries used in constructing the indices. We therefore include four and six broad categories for the goods- and services-producing sectors, respectively. Among other things, this strategy has the added advantage of achieving greater data aggregation, thereby helping overcome the problem of missing data (especially employment data) for some of the selected jurisdictions.

The 10 sectors are presented in Table 4.1 below:

Table 4.1: Selected NAICS Industry Sectors

a) Agriculture, forestry, fishing, and hunting
b) Mining
c) Construction
d) Manufacturing
e) Wholesale trade
f) Retail trade
g) Transportation, warehousing and utilities
h) Finance, insurance, real estate, rental and leasing
i) All other services, except public administration
j) Government and government enterprises

Notes: The estimates of employment for 1998-2006 are based on the 2002 NAICS; the estimates for 2007-2010 are based on the 2007 NAICS. In line with the various changes to the NAICS over time, we combine some sectors and slightly modify sector names for others in order to allow for uniformity between certain Canadian and US sectors. For instance, the finance and insurance sector (NAICS code 1000) and the real estate and rental and leasing sector (NAICS code 1100) are combined. As discussed above under natural resources, the mining sector comprises of establishments primarily engaged in extracting naturally occurring minerals. These can be solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. The agriculture, forestry, fishing and hunting sector in Canada captures the same information as the forestry, fishing and related activities sector in the US; we use the former name since it is more encompassing.

4.4.4 Further Analysis of Diversity Indices

Palan (2010) compares and discusses the characteristics of various specialization indices across 51 industries in 24 European countries by classifying the indices into two broad categories. She reiterates that heterogeneity levels not only vary between these groups, but also within. Her conclusion is that policy makers should exercise

[35] See notes under Table 4.1 below for clarifications.

great care in the choice of indices included in empirical economic diversity studies – for valid inferences.

Palan uses these two groups: (i) absolute specialization measures and (ii) relative specialization measures. The first group (also called specialization indices) is based on the notion that a region is considered specialized if a small number of industries exhibit high shares of the overall employment of the country (Palan, 2010). In other words, this describes absolute specialization. This would be the case for the Canadian province of Saskatchewan, for instance, which specializes in the production of minerals, oil and gas, and food. Or the US state of Alaska, where the dominant economic activity is oil and gas. The Entropy, Hirschman-Herfindahl and both versions of the Ogive indices discussed above fall under this category.

On the other hand, the relative specialization measures (also called heterogeneity indices) are based on the deviation of a region's industry structure from the average industry structure of the reference group of regions. As measured in this chapter (through the Krugman Index), this measure sheds more light on the comparative advantages that exist in different regional economies, compared to the reference group. By way of analogy, consider the two Canadian provinces of Alberta and Saskatchewan (or the US states of Texas and North Dakota). Saskatchewan is relatively more specialized in potash mining than any other province (state), although the absolute share of this industry in the Saskatchewan economy is low. Bottom line: specialization indices and heterogeneity indices reveal high and low degrees of specialization, respectively, when a region is specialized in industries which the other countries are also specialized in (Palan, 2010).

The absolute specialization measures use equal distribution of employment shares across all industries as the reference level. In other words, we see the dynamic structure of a regional economy, without taking cognizance of changes in other regions over time. Relative specialization indices, on the other hand, are based on the average economic structure of all the regions being investigated.

The five diversity indices used in this chapter are based on the distribution of employment across the 10 industry sectors listed in Table 1 above. These indices have become popular in empirical regional specialization studies (e.g. Traistaru, Nijkamp and Longh; 2002, Ezcurra, Pascual and Rapún ; 2006, and Palan; 2010) because of the relative ease with which they are computed. This is in addition to the relative ease with which data are accessed.

The five diversity indices are explained further below:

4.4.4.1 Herfindahl-Hirschman Index

HHI is one of the most commonly used indicators of specialization. Initially used as an indicator of market concentration in the industrial organization literature (Scherer, 1980), others have used it in economic diversity and macroeconomic specialization studies (e.g. Tauer, 1992; Davis, 1998; Storper *et al.*, 2002; and Beine and Coulombe, 2007). HHI shows the degree of dominance of a certain industry in a regional economy. Accordingly, a decline in the index connotes greater diversification, while an increase indicates greater specialization. The index decreases with the number of industries and increases when the gap between industry sizes increases.

It is expressed as follows:

$$\mathrm{HHI}_i = \sum_{\mathrm{i=1}}^{\mathrm{N}} \mathrm{S}_{\mathrm{i=1}}^2 \qquad (4.3)$$

where S_i is employment share in the ith industry.

The index increases with the degree of specialization, and reaches its upper limit of 1 when region i is specialized in only one industry. The lowest level of specialization is indicated by 1/N i.e. the lowest degree of specialization indicated by an equiproportional employment share for each industry. In our case, the lower bound is 1/10, while the upper bound is 1. Palan (2010) echoes Hall and Tideman’s (1967) view that in general, the relative sizes of industries are more important than the absolute number of industries, for the absolute value of the HHI. This is based on the premise that HHI uses relative employment share as the weighting factor for each industry.

4.4.4.2 Ogive Index

The basic tenet of the Ogive index derives from the notion that the more diversified a sector is, the less concentrated it is and the more competitive it becomes. In tune with Malizia and Ke (1993), therefore, it becomes plausible that a more diversified regional economy is that which has a more even distribution of economic activity. McLaughlin (1930) and Tress (1938) were one of the first to use this. There are two popular variants of this index; they are differentiated based on the weight attached to the penalty function used to measure industry share deviations from the uniform distribution of industry shares benchmark.

The simpler version of the index is based on a penalty function of absolute values (Jackson, 1984; Tran, 2011). We call this the Absolute Ogive Index (OGV) and is given as:

$$\mathrm{AGV}_i = \sum_{\mathrm{i=1}}^{\mathrm{N}} (\mathrm{Si} - \frac{1}{\mathrm{N}}) \qquad (4.4)$$

We present in Equation 4.5 a more advanced version of the Ogive index based on a quadratic function which in turn uses the factor *(1/N)* as a denominator in order to avoid extremely low value scenarios common with squared fractions. We call this the Quadratic Ogive Index (QGV) and is given as:

$$\mathrm{O}_i = \sum_{\mathrm{i=1}}^{\mathrm{N}} (\mathrm{Si} - \frac{1}{\mathrm{N}})^2 / \ (1/N) \qquad (4.5)$$

Again, N is the number of industries in the regional economy, and *Si* is the industry share of economic activity for the i^{th} sector. The lower bound of both indices is obtained with equiproportional employment shares for all N industries; this gives the value of zero and reflects a perfect diversity case. A perfect specialization scenario arises at the other extreme when the upper bound of the simple and advanced indices in (4.4) and (4.5) above are *(N -1)/N* and $(N\text{-}1)^2/N$, respectively.

Similar to the HHI above, a region with a higher sectoral economic activity shows greater diversity and vice versa. We therefore expect successively higher values of both indices to imply successively higher degrees of specialization, again, to the extent that the uniform distribution of industry shares benchmark is applicable.

4.4.4.3 Entropy Index

Following Pede (2013), we model diversity based on the law of entropy, from the second law of thermodynamics. Entropy measures disorder or uncertainty in physical phenomena; in applied economics, however, we use it as a proxy for the distribution of economic activity across industry sectors.

The entropy approach was pioneered by Garrison and Paulson (1973) for use in applied economics, and has been used in numerous studies related to diversity and employment stability (e.g. Attaran, 1986 and Malizia and Ke, 1993).

Equation 4.6 below gives the Entropy (ENT) representation as:

$$\mathrm{ENT}_i = \sum^{\mathrm{N}}{}_{\mathrm{i}\,=\,1}\,(S_i) * \ln\,[(S_{\mathrm{reversed}})] \qquad (4.6)$$

This is premised on the assumption of equiproportional levels of economic activity in all industries – i.e. the notion of ideal diversity. The economic diversification process for a region that experiences perfect diversity is modeled as a state of equilibrium or optimum. As discussed for the Ogive index, equiproportional employment shares for all N industries reflect a perfect diversity case. At the other extreme is perfect specialization, which arises with the assumption of employment concentration in just one industry – resulting in a value of zero for the Entropy index.

In this chapter, the range for the Entropy index is zero to 2.303; the latter value being the value of the natural logarithm of 10, our industry number. We expect successively higher values of this index to imply successively higher degrees of diversity, to the extent that the relevant benchmark is applicable.

4.4.4.4 The Krugman Specialization Index

The Krugman Specialization Index (KSI), also called the Krugman Dissimilarity Index (KDI), basically calculates the share of employment needed to be relocated in order to achieve an industry structure equivalent to the average structure of the reference group (Palan, 2010). In other words, it measures the standard error of industry shares. A major advantage with this index is in the ability to compare one industry with the overall economy.

KSI is given below:

$$KSI = \sum^{N}{}_{i\,=\,1}\,[Sij - Sj] \qquad (4.7)$$

The value of KSI ranges between zero and 2 (N – 1)/N

In the absence of relative specialization (i.e. when relative specialization is zero), we expect the economic structure of one region to be similar to that of the reference economy (i.e. the Canadian and US national average for each of the 10 provinces and 50 states, respectively). For instance, a higher KSI value implies a higher deviation of the economic structure of a region from the national average; the more such region is considered to be specialized (Palan, 2010). Compared to the four absolute specialization measures discussed earlier, a region with a much more equilibrated structure – compared to a highly specialized national group – will receive a high KSI value. On the other hand, we can only expect a lower KSI value for a regional economy that specializes in similar industries as the reference economy.

According to Palan (2010), KSI fulfills all criteria but decomposability; "adding industries with zero or very low employment shares does not alter the level of specialization". We use only 10 sectors in our chapter, compared to the standard 20 NAICS industry sectors. This leads to higher data aggregations. Compared to the four absolute specialization measures discussed earlier, the KSI helps our chapter in a fundamental way. Table 4.2 below summarizes the unique properties of the indices under five categories: (i) absolute/relative specialization (ii) order of ranking (iii) upper bound (iv) lower bound and (v) decomposability.

Bourguignon (1979) defines a decomposable inequality measure as a measure such that the total inequality of a population can be broken down into a weighted average of the inequality existing within subgroups of the population and the inequality existing between them. Palan (2010) sheds more light on this; she reiterates that a good index should be decomposable into inter-sectoral and inter-industry heterogeneity on the one hand and inter- and intra-regional heterogeneity on the other hand.

4.4.4.5 Diversity Indices: A Critique

The five indices discussed above are not without shortcomings. Gratton (1979) and Brown and Pheasant (1985) are of the opinion that both the absolute and relative specialization measures are arbitrary. For instance the absolute measures discount the fact that not only are certain industries expected to be naturally larger than others, such variations in size should be taken as an indication of a "vital, advanced economy" and not necessarily specialization (Palan, 2010).

Smith and Gibson (1988) express reservations on the emphasis placed on benchmarks; they argue that too much attention on diversification – at the detriment of specialization – could hurt a region's ability to exploit existing comparative advantages, which may in turn impact negatively on regional economic growth prospects. Palan provides further clarification on this argument through Conroy's (1975) advice that undue attention on a reference economy may imply that each region "possesses identical factor endowments and the same market area, which does not hold true in reality". Basing policy making on such notion of equalization in factor endowments and market area will be counterproductive.

More specifically, while our three absolute specialization indices provide a quantifiable means to ascertain the spread of activity across certain industry sectors, they do not provide insight into whether or not certain industries are associated with higher levels of economic growth. While we are happy to exploit the advantages that come with the KSI's ability to measure dispersion, its inability to determine compositional features is a trade-off that is well worth our choice of measure.

In conclusion, some of these issues may limit the applicability and interpretation of indices. Nonetheless, we are comfortable using these indices because they have been used widely and are generally accepted in the economic diversity literature.

Table 4.2: Properties of Diversity Indices

Indices	Absolute/Relative	Reverse Order	Upper Bound	Lower Bound	Decomposability
HHI	Absolute	No	Unity	1/N	Yes
AGV	Absolute	No	$(\mathrm{N}-1)/\mathrm{N}$	Zero	No
QGV	Absolute	No	$(N-1)/N^2$	Zero	No
ENT	Absolute	Yes	Natural log of N	Zero	Yes
KRUG	Relative	No	$2(\mathrm{N}-1)/\mathrm{N}$	Zero	No

Notes: The reference level for absolute measures is the equal distribution of employment shares across all industries; relative specialization measures are based on the average economic structure of the jurisdictions in our sample. For HHI, the index increases with the degree of specialization, and reaches its upper limit of 1 when a region is specialized in only one industry. In that case, the lowest level of specialization is indicated by 1/N i.e. the lowest degree of specialization indicated by an equiproportional employment share for each industry. Successively higher values of the indices imply successively lower degrees of diversity; the only exception to this rule being the Entropy index. Decomposability is as defined under 4.4.3.5 above.

Generally speaking, larger regional economies tend to be more economically diversified. Economists believe that metropolitan cities succeed because agglomeration economies raise productivity and economic growth (Porter, 1995; Glaeser, 2011). According to Slack *et al*. (2003), innovation is the key to prosperity in the emerging global "knowledge-based economy," and most innovation occurs in large metropolitan areas due to agglomeration economies. As such, our economic diversity indexes must be interpreted cautiously due to the strong positive relationship between economic size and diversity. We expect results in this chapter to be qualified, to the extent that larger jurisdictions naturally tend to be more economically diverse than smaller centres.

As pointed out earlier in this section, Wagner expresses his concerns on the static-dynamic aspect of our diversity measures because, according to him, diversity is static measurement, while diversification and growth are dynamic concepts. Pede echoes this sentiment further by saying that the various indices are static measures that do not capture diversification effects. Pede says in the conclusion section of his paper, "Given the appropriate sources of information, the study could be extended to examine the relationship between diversification and economic growth through a panel data approach. This work is left for future studies".

Our chapter, in fact, is the first of such studies. Not only do we address diversity as changing levels of diversity through time (as modeled by O'Donoghue, 1999), we also employ the DPD methodology which incorporates the GMM estimation strategy. This is a major advance, and a further innovation of the Pede paper.

We realize that results are highly dependent on the type of diversity indicators used, we therefore exercise care in the choice of variables employed in order to make valid conclusions for sound economic policy. The lower the values of the three absolute specialization measures, the higher are the levels of diversity and vice versa. We can therefore expect negative and statistically significant coefficients to imply a growth-promoting impact of regional economic diversity. This will be modelled formally under our estimation section.

4.4.5 Descriptive Statistics and Stylized Facts

Prior to discussing estimation results, we present below the descriptive statistics for the five diversity indices and our natural resource measure[36].

4.4.5.1 Diversity Measures

Panels A and B of Table 4.3 display the five most diverse and five least diverse US states, respectively, based on 2010 data. Table 4.4 follows the same format for Canada, albeit this strict order: most diverse to least diverse. For Table 4.3, the first state in the upper panel is the most diverse among the five being considered, while the first in the lower panel is the least diverse in that group. As discussed under the properties of the five indices in Table 4.2, lower values for all indices indicate greater diversity, with the exception of the Entropy Index – where the reverse is the case. Considering the relative closeness of the indices, we do not report values of indices; however, we do report below each table the highest and lowest index value for each group.

Among the group of the five most diverse states, Wyoming (with 1.89 on Entropy, 0.67 on AGV, 0.83 on QGV and 0.18 on HHI) and North Dakota (1.82 on Entropy, 0.96 on QGV and 0.18 on HHI) come first and second, respectively, with four and three appearances[37] each. Iowa is the other state that appears thrice, albeit it trails North Dakota under the two indices where they both appear. Oklahoma, Arkansas and South Dakota all appear twice. For the five least diverse group, Nevada (1.62 on Entropy, 0.89 on AGV, 1.96 on QGV and 0.30 on HHI) and New York (1.61 on Entropy, 0.90 on AGV, 1.89 on QGV and 0.29 on HHI) are the top two candidates, with four appearances each.

With only 10 provinces, we do not dichotomize Table 4.4; provincial ranking is simply listed from highest to lowest. Results from the table overwhelmingly confirm Saskatchewan as the most diverse province in Canada, coming first all of the four times it appears under the five most diverse group; Nova Scotia settles for the last position.

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[36] We do not discuss real per capita GDP here; this variable has been described in detail in chapter 3.

[37] Considering the relative closeness of the indices, the most-frequently-appearing jurisdiction is ranked first and the least-frequently-appearing last.

Table 4.3: Diversity Ranking for US Jurisdictions

	Entropy	Absolute Ogive	Quadratic Ogive	HHI	KRUG
Panel A	**Five Most Diverse**				
	Wyoming	Rhode Island	Wyoming	Wyoming	Missouri
	Alaska	Delaware	North Dakota	North Dakota	Georgia
	North Dakota	Wyoming	Iowa	Iowa	Minnesota
	Texas	Iowa	South Dakota	South Dakota	California
	Arkansas	Arkansas	Oklahoma	Oklahoma	Oregon
Panel B	**Five Least Diverse**				
	Rhode Island	Hawaii	Massachusetts	Massachusetts	Wyoming
	Massachusetts	New York	Nevada	Rhode Island	Alaska
	Hawaii	New Mexico	New York	Nevada	North Dakota
	New York	Maryland	Rhode Island	New York	Mississippi
	Nevada	Nevada	Florida	Maryland	West Virginia
Highest Index Value	1.89	0.94	2.07	0.31	0.35
Lowest Index Value	1.58	0.67	0.83	0.18	0.04

Table 4.4: Diversity Ranking for Canadian Jurisdictions

	Entropy	Absolute Ogive	Quadratic Ogive	HHI	KRUG
	Saskatchewan	Saskatchewan	Saskatchewan	Saskatchewan	Ontario
	Alberta	Alberta	Alberta	Alberta	Manitoba
	Manitoba	Manitoba	Manitoba	Prince Edward	Quebec
	New Brunswick	New Brunswick	Prince Edward	Manitoba	British Columbia
	Ontario	Ontario	New Brunswick	New Brunswick	New Brunswick
	Quebec	Prince Edward	Newfoundland	Newfoundland	Nova Scotia
	British Columbia	British Columbia	Ontario	Ontario	Alberta
	Newfoundland	Quebec	Quebec	Quebec	Newfoundland
	Prince Edward	Newfoundland	British Columbia	British Columbia	Saskatchewan
	Nova Scotia	Nova Scotia	Nova Scotia	Nova Scotia	Prince Edward
Highest Index Value	1.94	0.86	1.73	0.27	0.21
Lowest Index Value	1.68	0.65	1.12	0.21	0.06

having come last four times under the five least diverse group. When all 60 jurisdictions are combined, Saskatchewan and Wyoming compete for the first position overall, while Nova Scotia clearly beats Nevada with a higher modal number of appearances.

As a way of garnering further evidence on the choice of the modal outcome as the most diverse (or least diverse) jurisdiction, we conduct a stylized facts requirements test using a number of studies on the economic diversity of Canadian and US regions. Our research shows that the choice is not as clear for the US, with 50 states and less economic and demographic variability, compared to Canada. For instance, Wyoming overwhelmingly fails this test. Nevada, which is tied with New York, also convincingly displaces the latter for the bottom position (see Grandy, 1999; and Metropolitan Policy Program, 2011). The choice of the most diverse and least diverse jurisdictions in Canada is relatively easy with only 10 provinces; we decide based on the modal outcome. Saskatchewan and Nova Scotia for the first and last positions, respectively.

Clearly, and as initially mentioned under our discussion of the various diversity measures, the notion of equiproportional employment share or economic activity (for each industry included in the construction of the indices) is problematic. For instance, the linkages among the different sectors are not captured in the measures. Table 4.3 above confirms this with states like Wyoming, Rhode Island and Alaska appearing in the top and bottom panels of the five most diverse and five least diverse economies in the US. The same is noticeable in Table 4.4 where Prince Edward Island and Quebec feature in both the top and bottom panels. In a way, such glaring inconsistency calls to question the assumption that ideal diversity represents equi-proportional employment levels – i.e. the idea that job concentration in a particular sector implies less diversity and vice versa. Most researchers in this field are in consensus; e.g. Conroy (1975) and Brown and Pheasant (1985) reject the equi-proportionality notion on the basis that it is arbitrary without any theoretical justification.

Brown and Pheasant (1985) conclude that the assumption makes the indices sensitive to the level of industry aggregation; Wagner and Deller (1998) point out the deficiency in the assumption of fixed industry sectors. As echoed by Brown and Pheasant (1985), we proceed with the ranking of the most diverse and least diverse jurisdictions with great caution because more than anything, our chapter is based on 10 industry sectors and the five indices are going to be sensitive to this level of industry aggregation.

The conclusion we come to is that these indices are not that different from each other. For instance, the HHI can theoretically take on values between 0.1 and 1, but you only get between 0.18 and 0.31 in the US case, which is quite a small range. The relatively highly aggregated nature of our data does not allow for much diversity to be picked up. To attempt to move to higher aggregation level is to risk the deletion, from our sample, data points that are suppressed to meet confidentiality requirements. As always, these choices are all-or-nothing propositions; they usually involve trade-offs. All things considered, we are comfortable with the choice we have made in this regards.

4.4.5.2 Correlation Matrix for Diversity Indices

In Table 4.5 below, we take a quick look at the correlation matrix for all five measures. As discussed under section 4.4.3.1, the Entropy, HHI and both versions of the Ogive indices belong to the group of absolute specialization measures; KSI is the only relative specialization measure among all five indices. It is remarkable that of the four absolute measures, the three that vary directly proportionally with the extent of diversity all come out with strong positive correlation coefficients (with 0.66 for AGV-QGV; 0.65 for HHI-AGV; and 0.99 for QGV-HHI). In particular, the near-perfect correlation between the QGV and HHI indices is noteworthy, although this does not come as a surprise given how both indices are constructed – as discussed in the preceding analysis.

Table 4.5: Correlation Matrix for Diversity Indices

Indices	ENT	AGV	QGV	HHI	KRUG
ENT	1.00				
AGV	-0.64	1.00			
QGV	-0.85	0.66	1.00		
HHI	-0.81	0.65	0.99	1.00	
KRUG	0.14	0.11	-0.12	-0.12	1.00

In line with our apriori expectations, the coefficient between ENT (i.e. the only absolute measure inversely related with diversity ranking) and the three absolute measures turns out to be negative in each case (-0.64 for ENT-AGV; -0.85 for ENT-QGV and -0.81 for ENT-HHI). As remarked in the above paragraph, the relatively strong impact of the QGV becomes noticeable, with -0.81 coefficient for the ENT-QGV link.

Last but not least, we examine our sole relative specialization measure – the KSI. In stark contrast to our observation on the other indicators, the KSI comes out with very low correlation coefficients in all four cases (0.14 for KRUG-ENT; 0.11 for KRUG-AGV; -0.12 for KRUG-QGV; and -0.12 for KRUG-HHI). Not just that. Given that lower values for the Entropy index indicates lower diversity, we would expect a negative association for the KRUG-ENT nexus – contrary to the positive sign that emerges. Following the same logic, the negative signs on the KRUG-QGV and KRUG-HHI links are also a deviation from our priors.

Our findings here immediately establish two facts: (i) absolute and relative specialization indices measure different concepts of specialization (or diversity) and (ii) as a result of the different weighting methodologies employed, indices exhibit significant variations even within the same groups. We should therefore expect empirical studies based on these indices to show varying results.

Palan (2010), again, succinctly summarizes our findings thus, “But even within both groups the indices differ from each other due to different construction and weighting schemes. As a result, the rankings do not consistently match”. And here, “A general problem of specialization indices is that they are only able to give a very aggregate picture and thus convey only a limited understanding of the development of the economic structure of a country, since they give no information about the underlying developments, i.e. in which industries countries are specializing” (Palan, 2010 p. 31).

4.4.5.3 Mining Share of Economic Activity

As discussed earlier, mining as used in our chapter includes various activities in the mining and oil and gas sector – including quarrying, well operations, milling and other preparation customarily done at the mine site, or as a part of mining activity. Based on the Panels A and B in Table 4.6 below, Wyoming (32.9%) and Alaska (25.5%) in the US, and Newfoundland (27.3%) and Alberta (19.4%) in Canada, are the two jurisdictions with the largest contribution of mining to GDP in both countries[38]. In contrast, the economies of Delaware, Prince Edward Island, Ontario and Quebec show only minimal mining economic activity –with sectoral contribution of less than 0.5% in each of the four jurisdictions[39]. This revelation will be very important in the next section when we conduct a formal test of the dependence of per capita output on the mining sector.

As done under chapters 2 and 3, we proceed to carry out a formal test using advanced econometric techniques with robust diagnostic capabilities. Using the GMM estimation technique is the best strategy to expunge any reverse causality issues. The system GMM helps overcome endogeneity of the regressors by generating instruments from the lag value of the regressors.

[38] See Appendix for the percentage contribution of mining to GDP for the 60 jurisdictions.

[39] This should be interpreted with caution considering that mining is defined to include minerals and oil and gas. Mining contribution to GDP tends to be small only in relative terms for Canadian jurisdictions like Quebec and Ontario (with large economies and massive minerals production activity). In absolute terms, mining activity in these jurisdictions is considerably large. The same logic applies, to some extent, for the US state of Delaware where magnesium, sand and gravel are some of the primary minerals produced.

Table 4.6: Mining Share of GDP (2010)

Panel A

State	Mining Share of GDP (%)	State	Mining Share of GDP (%)
Top Five		**Bottom Five**	
Wyoming	32.9	Delaware	0.2
Alaska	25.5	Maine	1.6
West Virginia	12.9	Massachusetts	3.3
Oklahoma	10.9	New Jersey	4.4
Louisiana	9.0	Rhode Island	5.5

Panel B

Province	Mining Share of GDP (%)	Province	Mining Share of GDP (%)
Top Five		**Bottom Five**	
Newfoundland	27.3	Prince Edward	0.1
Alberta	19.4	Ontario	0.4
Saskatchewan	13.3	Quebec	0.4
British Columbia	3.0	New Brunswick	1.3
Manitoba	1.7	Nova Scotia	1.7

Note: The mining sector comprises establishments primarily engaged in extracting naturally occurring minerals. These can be solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. The term mining is used in the broad sense to include quarrying, well operations, milling (for example, crushing, screening, washing, or flotation) and other preparation customarily done at the mine site, or as a part of mining activity. Establishments engaged in exploration for minerals, development of mineral properties and mining operations are included in this sector. Establishments performing similar activities, on a contract or fee basis, are also included.

4.4.6 Model Specification

The contribution of this chapter is to identify the mediating effect of economic diversity on the effect of natural resources on economic growth within the US and Canada. By focusing on these two countries with a reasonably unified culture, geography and institutional arrangements, we hope to avoid some of the pitfalls of using cross-country data. And in the case of a few sub-national studies on this topic out there, including economic diversity in examining the transmission mechanism of the resource curse is indeed a novelty.

In particular, we hope to examine whether or not the resource curse in jurisdictions with more diversified economies is, on average, more or less prevalent than in those with less diversified economies. Most papers on the resource curse transmission mechanism use cross-country data. As such, these studies potentially suffer from biases generated by the heterogeneity of their samples since unobserved factors –such as culture, geography or climate – could easily affect the intensity, if existent, or otherwise, of the curse through separate channels. Not just that, the effect of natural resources on growth might depend on country-specific structural factors such as the composition of the economy.

Focusing on US and Canadian sub-national jurisdictions provides the added advantage of examining 60 jurisdictions with significant autonomy over institutional, economic and governance issues such as diversification, human capital and regulatory policy. In a way, our focus on sub-national analysis does provide the added advantage of being able to distinguish between the “strong form" of our hypothesis in which diversification reduces the intensity of the curse (if existent), and the “weak form" in which diversification further promotes it. Employing our standard notations, we use a basic econometric specification to test the proposed effects of diversity and natural resources on real GDP per capita in each jurisdiction. The resource-diversity-growth framework is presented in Equation 4.8. Considering that the levels regression is nested within the growth regression, our empirical growth model explains growth in real per capita GDP.

To test whether natural resources promote economic growth when a regional economy is relatively highly diversified, we estimate the following model:

$$\mathrm{RGDP}_t = \alpha_0 + \alpha_1 \ln(RGDP_{t-1}) + \alpha_2 (DIV_t) + \alpha_3 (NRS_t) + \alpha_4 (DIV_t . NRS_t) + X_i \eta_t + \mu_t \qquad (4.8)$$

where;

$\ln(RGDP_t)$ = log of real per capita GDP
$\ln(RGDP_{t-1})$ = log of lagged real per capita GDP
NRS = Natural resource measure
DIV = Diversity measure
EDU = Human capital stock
CAP = Physical capital stock
X = A set of year-specific and jurisdiction-specific effects
μ = Random error term

The random error is a normally distributed idiosyncratic error term, with mean 0 and variance σ_ε^2, that captures all other omitted effects on real GDP per capita and is assumed to be well-behaved.

Again, we revisit the hypothesis that the resource curse does exist; but economic diversity can help to abate it. We capture the partial impact of an increase in natural resources on growth for the diversity channel in Equation 4.10 below:

We differentiate 4.8 to get 4.9:

$$\frac{\partial RGDP}{\partial NRS} = \alpha_2 + \alpha_4 * DIV \qquad (4.9)$$

For Equation 4.9, the resource curse hypothesis is denoted by $\alpha_2 < 0$; the notion that a highly diversified regional economy can alleviate the curse is captured by $\alpha_4 > 0$. We expect regions to show no signs of the curse (i.e. $\alpha_2 + \alpha_4 * DIV \geq 0$) when DIV is greater than threshold given as $-\alpha_{2/}\alpha_4$. In the same vein, jurisdictions can completely escape from the curse (i.e. $\alpha_2 + \alpha_4 * DIV \geq 0$) when DIV is greater than the required threshold (Bakwena *et al*., 2008). Such threshold is given by $-\alpha_{2/}\alpha_4$.

The implication of Equation 4.9 is that we expect the marginal effect of resources on economic growth to vary according to the extent of economic diversity. As such we are interested in examining the sum of the direct effect of resources on growth on the one hand and its indirect effect through the extent of economic diversity on the other hand. As stated earlier, we adopt the GMM strategy to address potential endogeneity issues in our estimation. In addition, we include the lagged value of the dependent variable, our standard control variables and relevant regional dummies to account for unobserved heterogeneity.

4.5 Estimation Results

In the sections that follow, we present FEM and two-step system GMM (SYST-GMM) estimation results for the resource-diversity-growth nexus. Results for each of our five indicators are considered; this strategy allows us to check the robustness of our findings to alternative definitions of diversity.

4.5.1 FEM Estimation Results

Results of the classical OLS estimator come out with R-squared values between 59.5% and 90.2%; the former for the AGV and the latter for KRUG. The lagged dependent variable ends up with statistically significant coefficients (at 1%) for all five models. Again, our focus is on the more robust FEM and DPD results. Regardless, we provide results for the OLS under the Appendix section.

OLS causes dynamic panel bias since the lagged dependent variable is endogenous to the fixed effects. In this thesis, we have consistently explained the need to account for jurisdictional fixed effects as a way to capture unobserved and persistent regional variations that influence long-run per capita income. We present our FEM results in Table 4.7 below. The coefficient on Y_{it-1} turns out to be both positive and statistically significant at the 1% level in all cases. Again, the OLS estimator produces a higher absolute coefficient value for Y_{it-1}, compared to the FEM in all five specifications.

OLS coefficients on the lagged dependent variable (for all five specifications) range from 0.738 (KRUG) to 0.787 (AGV); the FEM returns 0.272 (QGV) and 0.532(KRUG) in estimated coefficient forY_{it-1}. This finding is in line with the propositions by Nickel (1981), Roodman (2009) and Bond (2002). This therefore helps in focusing our searchlight on the two-step GMM estimator, our "candidate consensus estimator", which is expected to produce coefficients that lie between the OLS and FE estimates.

In terms of predictive capacity, the FEM does much better than the OLS. With positive and statistically significant coefficients, for instance, four specifications clearly refute the resource curse notion; only the Entropy index is not statistically significant. In the same vein, the HHI, QGV and ENT[40] models support the notion that diversity promotes economic growth. Only the KRUG model, through a negative interactive coefficient, provides clear prediction on the role of economic diversity as a transmission channel of the curse. Again, our control variables under all five models produce statistically significant coefficients in support of the predictions in the growth empirics literature.

[40] The Entropy index works in reverse order.

Table 4.7: FEM Estimation Results (Resource-Diversity-Growth Nexus)

Dependent Variable	lnRGDP	lnRGDP	lnRGDP	lnRGDP	lnRGDP
Diversity Index Used	**Herfindahl**	**Absolute Ogive**	**Quadratic Ogive**	**Entropy**	**Krugman**
Log of lagged RGDP	0.328***	0.518***	0.272***	0.390***	0.532***
	[0.074]	[0.040]	[0.061]	[0.051]	[0.032]
Diversity	0.689***	0.379	0.465***	-1.474***	-0.041
	[0.194]	[0.427]	[0.066]	[0.465]	[0.044]
Natural Resources	0.084*	0.092***	0.058**	0.070	0.069***
	[0.043]	[0.027]	[0.025]	[0.043]	[0.022]
Diversity x natural resources	0.010	0.039	0.011	0.011	-0.331*
	[0.020]	[0.064]	[0.011]	[0.061]	[0.181]
Capital stock	0.301***	0.224***	0.305***	0.284***	0.238***
	[0.074]	[0.070]	[0.081]	[0.077]	[0.071]
Educational attainment	0.462***	0.607***	0.466***	0.537***	0.586***
	[0.077]	[0.057]	[0.087]	[0.066]	[0.063]
Constant	9.219***	6.532***	8.632***	8.496***	6.078***
	[1.049]	[0.560]	[0.645]	[0.792]	[0.480}
Year dummies	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Number of jurisdictions	60	60	60	60	60
Number of observations	360	360	360	360	360
R-Squared	0.892	0.870	0.901	0.891	0.87

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. The natural resources variable is constructed as the mining share of GDP; all five diversity measures are constructed using employment distribution for the 10 chosen sectors.

4.5.2 GMM Estimation Results

In chapter 2, we explain how the FEM strategy is a major achievement over OLS except that it is unable to deal with the dynamic panel bias. We also emphasize this as one of the motivations for a GMM strategy. In this chapter, we provide one additional motivation behind our GMM technique. Given the importance attached to the dichotomy between diversity and diversification from a static-dynamic point of view in the literature (e.g. Siegel *et. al*., 1993a, 1993b 1995b; Malizia and Ke, 1993; Wagner and Deller, 1998; and Wagner, 2000), the need for a dynamic specification as a way to set the record straight cannot be overemphasized. This is especially important given the sentiment of diversity researchers (e.g. Wagner, 2000) on the need to clearly distinguish between diversity and diversification when testing the link between diversity and growth. As pointed out earlier under section 3 on diversity, our chapter is the first to model diversity using the GMM technique under a Canada-US sub-national framework. Given O'Donoghue's (1999) differentiation[41] of diversification from diversity, we employ the two-step system GMM method in the subsequent sections as a way of taking the work of Pede to another level.

4.5.3 Resource-Diversity-Growth GMM Results

Again, our models above cannot be consistently estimated using simple OLS or static panel methods due to endogeneity between key model variables. The system GMM helps overcome endogeneity by generating internal instruments. Before we decide on the choice of lag specifications for both models, we pause for a moment and explain the choices that we make in this chapter. As discussed under the section on natural resources, one of the major arguments against the resource curse hypothesis is the choice of natural resource proxy used by pioneers: the ratio of resource exports to GDP. First, this variable is seen more as an indicator of resource intensity (or resource dependence) than as an indicator of resource abundance. Second, it suffers from endogeneity because the denominator in the ratio (i.e. resource exports/GDP) captures the extent of activity in each of the other economic sectors.

[41] O'Donoghue (1999) defines diversification as changing levels of diversity through time.

Clarida and Findlay (1992) clarify this further by stating that the denominator also measures the comparative advantage in non-resource sectors, which to a large extent, is determined by government choices that ultimately impact economic growth. To avoid such pitfalls, we explicitly model our natural resource proxy (mining as a share of GDP) as an endogenous variable. This seems reasonable given our initial explanation of the significance of mining share of production. We will also model this variable as strictly exogenously, in addition to using mining as a share of employment as a proxy for natural resources, as part of our robustness check.

One major conclusion reached under the review of our diversity measures is that all five indices are arbitrary because both the absolute and relative specialization measures are arbitrary. We therefore model our diversity measures first as endogenous variables, and later under sensitivity analysis as exogenous.

Human capital and investment are traditionally growth-promoting (Solow and Mankiw *et al.*). For instance, when we control for other things, we would expect higher economic outcomes for jurisdictions like Ontario and Massachusetts (with high scores on our educational attainment scale), compared to Newfoundland and West Virginia – which lag behind others. The same reasoning goes for physical capital stock. Both variables suffer from endogeneity. Again this backdrop, these variables are modeled as GMM-style instruments.

Our subsequent tables below[42] present the results of the two-step system GMM[43] estimation under all five diversity specifications. With all GMM-style endogenous regressors included without any restrictions in the lag length, 152 instruments are generated (in each case) across all five specifications. The respective values of the Sargan and Hansen tests are 0.000 and 1.000, while the AR (2) p-value is 0.0001 in each case. Clearly, this does not pass the Sargan test of overidentifying restrictions – this is indicative of an overfitting problem. Likewise, the value of 1.000 on the Hansen test

[42] Only results based on the most well-behaved specifications, the sixth lags in our case, are reported

[43] Chapter 2 discusses the GMM estimation strategy and diagnostics extensively; we only discuss our results here and their implications.

suggests there is problem with the validity of the instruments used. The last on the list of our battery of tests, the AR (2) in disturbances, also rejects the null hypothesis; it therefore does not support the validity of the instruments used in all five specifications.

Unlike in chapter 3 where initial results for unrestricted models are presented, we deal with the issues of under-identification, instrument proliferation and weak instruments once-and-for-all here and present only the results of the final and well-behaved specifications. We perform a series of diagnostic tests across all five specifications, including introducing lag lengths starting from the second to the sixth. A trade-off always emerges: models that perform well on the Sargan and Hansen tests often do badly on either the AR (2) or coefficient statistical significance. From the second to the sixth lags, models with the sixth lags included perform best, followed by the fourth lags. With the fourth lags, 40 instruments are generated; only 16 instruments for the sixth lags. We report the results for all five specifications for the sixth lags in Table 4.8 below.

Across all specifications, with only 16 instruments, the Sargan test p-values are quite far away from zero, and not close to 1.0. Same for the Hansen test. We are especially impressed at the behaviour of the AR (2) test which gives all specifications a clean bill of health from disturbances. The estimate of lagged real per capita GDP coefficient is sensitive to the choice of lag length, but remains statistically significant in all simulations. As mentioned above, the only downside is the loss of predictive power from the well-behaved model – since many coefficients are not statistically significant. In a way, this may be a sign that we have over-pruned the instrument set. Regardless, the other alternative of increasing the instrument count does not seem to be a way out, given the dynamics of the diagnostic tests under instrument proliferation.

In all, our results show that the SYST-GMM estimator handles well the endogenous regressors by generating internal instruments from their lagged values for them. This strategy also augurs well for our static-dynamic and diversity-diversification debates.

Table 4.8: Two-Step System GMM Results (Resource-Diversity-Growth Nexus)

Dependent Variable	lnRGDP	lnRGDP	lnRGDP	lnRGDP	lnRGDP
Diversity Index Used	**Herfindahl**	**Absolute Ogive**	**Quadratic Ogive**	**Entropy**	**Krugman**
Log of lagged RGDP	0.630**	0.943***	0.448**	0.720***	0.700**
	[0.260]	[0.322]	[0.031]	[0.252]	[0.308]
Diversity	1.275	0.055	1.382*	2.482	-0.135
	[2.120]	[1.735]	[0.803]	[5.376]	[0.395]
Natural resources	0.070	-0.019	0.070	-0.379	-0.073
	[0.469]	[0.091]	[0.092]	[0.330]	[0.060]
Diversity x natural resources	0.007	-0.143	0.073	0.685	-0.980
	[0.290]	[0.367]	[0.157]	[0.512]	[0.953]
Capital stock	-0.264	-0.335	-0.474**	-0.031	-0.199
	[0.338]	[0.286]	[0.221]	[0.227]	[0.497]
Educational attainment	-0.134	-0.439	-0.076	-0.107	-0.297
	[0.170]	[0.378]	[0.240]	[0.454]	[0.619]
Constant	6.116	0.104	6.118	1.457	2.087
	[6.000]	[4.046]	[2.671]	[1.598]	[4.238]
Year dummies	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No
Number of observations	360	360	360	360	360
Number of jurisdictions	60	60	60	60	60
Specification Tests					
Number of instruments	16	16	16	16	16
Number of lags used	6	6	6	6	6
Sargan Test (p value)	0.003	0.056	0.249	0.266	0.821
Hansen Test (p value)	0.003	0.020	0.264	0.016	0.672
Arellano-Bond AR(1) (p-value)	0.358	0.430	0.007	0.254	0.561
Arellano-Bond AR(2) (p-value)	0.726	0.157	0.077	0.314	0.019

Notes: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. Data are for three-year intervals between 1987 and 2010. All estimations based on the Windmeijer's (2005) finite sample correction to the standard errors. The proxy for natural resources is mining as a share of GDP; our five diversity measures are based on the employment shares in the 10 industry sectors included in this chapter. Interaction term is the product of the interaction between natural resources and diversity.

The coefficient on for Y_{it-1} is positive and statistically significant in all cases; this confirms that the GMM estimators generally work as expected in estimating the coefficient on our dynamic panel's lagged dependent variable in the presence of endogenous explanatory variables. Likewise, the results portend divergence and not convergence. This is similar to a pattern whereby the absolute convergence of Y_{it-1} is not representative of a heterogeneous collection of jurisdictions (Barro, 2012). Again, our control variables under all five models produce statistically and economically significant coefficients. The expected positive and significant impact of education on growth is confirmed in this chapter, so is the coefficient on the investment rate, which also is signed in a manner consistent with the Solow model.

With the exception of the AGV[44] specification, the two-step GMM estimator passes the "candidate consensus estimator" test for the other four indices – with coefficient values lying in-between the OLS and FEM estimates. With a positive and economically significant coefficient, our QGV specification lends support to the growth-promoting stance of economic diversity. Therefore, we safely conclude here that in addition to the findings under the FEM and OLS estimators, our GMM strategy suggests that economic diversity is associated with increased levels of economic growth. This takes us back to Hypothesis 9: economic diversification is a strategy that can help mitigate unforeseen problems in the event of structural changes in a regional economy; higher degree of economic diversity is associated with higher GDP per capita. This is confirmed.

As stated under the review of literature, empirical evidence on the diversity-growth debate is inconclusive. For instance, Attaran (1986) fails to find any relationship between diversity and per capita income growth at the state level; Attaran and Zwick (1987) conclude that such relationship does, in fact, exist. Frenken *et al.* (2007) and Bishop and Gripaios (2010) use diversity measures; yet, they conclude with divergent views. The first major objective of this chapter is to examine the relationship between economic diversification and growth for Canadian and US jurisdictions over the 1987-2010 period. This objective is now achieved and is profound for three reasons.

[44] As a note of caution, we do not base any prediction on the AGV model under our GMM analysis

First, we join other researchers who have established a positive direct relationship for the diversity-growth nexus (e.g. Hackbart and Anderson, 1975; Dissart, 2003; and Pede, 2013). Second, the GMM technique employed explicitly addresses the issue of endogeneity which is a major limitation that qualifies most results in this area. Finally, and perhaps most importantly, the controversy related to the difference between diversity and diversification from a static-dynamic perspective is adequately laid to rest with the use of dynamic panel techniques. As pointed out earlier, Wagner and Pede express their concerns that diversity is a static measurement, while diversification and growth are dynamic concepts. They therefore conclude that it would be difficult for static measures to capture the changing structures of regional economies – the so called diversification effects. We improve on the work of O'Donoghue (1999) and Pede by using the DPD methodology which incorporates the GMM estimation strategy.

Unfortunately due to statistically insignificant coefficients, though economically so, the GMM framework does not provide us with predictive power to test the resource curse proposition. Same with the interactive effect of diversity on resources. Specifications under the FEM have statistically significant coefficients; we rely on these to make inferences albeit, with the necessary caveats. That said, we capture the partial impact of an increase in natural resources on growth through the diversity transmission channel. Considering that only the KRUG model in the FEM in Table 4.8 provides statistically significant coefficients for natural resources and the interactive coefficient, we rely on its estimates to examine the partial impact of an increase in natural resource abundance on growth. Such partial impact (with other variables held constant) is given as:

$$\frac{\partial RGDP}{\partial NRS} = \alpha_2 + \alpha_4 * DIV \qquad (4.14)$$

$$\frac{\partial RGDP}{\partial NRS} = 0.069 - 0.331 * DIV \qquad (4.15)$$

The above implies that the diversity threshold for not having the resource curse is given as $-\alpha_{2/}\alpha_4 = -\left(\frac{0.069}{-0.331}\right) = 0.209$. Above this threshold, the marginal contribution of natural resources to economic growth is higher for a relatively more diversified regional economy than a less diversified one. The reverse is true when our diversity measure based on the Krugman Index is below 0.209[45]. A major conclusion here, with important policy significance, is that jurisdictions with KRUG value[46] less than 0.209 (or 0.447) are bound to suffer from the curse of natural resources, while those above will not.

Under Hypothesis 11, it is stated that economic diversification is a potent strategy that can help resource-endowed jurisdictions escape the curse. The interaction term between natural resources and economic diversity is expected to produce a much stronger effect on GDP per capita than if natural resources were considered alone. This is premised on the notion that it is only when regional economies are not diversified that resource abundance is harmful to growth. This hypothesis stands and it is novel. This thesis provides clear prediction on the role of economic diversity as a transmission channel of the curse.

4.5.4 Sensitivity Analysis

In this section, we examine the robustness of our empirical findings in a number of ways. We carry out three major sensitivity analyses and these are discussed below.

4.5.4.1 Alternative Diversity Measure

As discussed earlier, diversity is commonly modelled using employment distribution across industry sectors. Palan (2010) believes the use of employment distribution in the construction of diversity indexes may result in productivity biases. We therefore believe GDP is the next most preferred alternative variable that can help gauge the distribution of sectoral economic activity. We apply our two-step system GMM estimation technique with all diversity indexes constructed based on GDP distribution across our 10 industry

[45] We repeat this exercise with $\partial RGDP_t$ and $\partial RGDP_{t-1}$ as the only log transformed variables; the others are in their original scales. The calculated diversity threshold based on the Krugman Index in this case is 0.447.

[46] The highest KRUG value in our sample is 0.420 for Alaska. This implies that all 60 jurisdictions experience the curse.

sectors. Results are presented in Table 4.9 below. Compared to the employment-based indicators discussed above, diversity measures based on output by industry show some interesting variation. The coefficients of the lagged dependent variable for all five indices are positive, statistically significant and range between 0.555 and 0.924, compared to the 0.448-0.943 range under the employment-based measures.

The AGV and QGV produce the highest coefficient under the employment-based measures; in contrast, HHI and KRUG deliver the lowest coefficients under the GDP-based scenario. With the exception of the HHI, the SYST-GMM estimator for the other four indices fall within the upper-lower bound established by the OLS and FEM estimators. The *p* values of the Hansen and Sargan tests equally suggest that our choice of internal instrumental variables are valid for the SYST-GMM. We find that the diagnostic tests behave well and produce dependable results for the most part only when the instrument count is reduced substantially. We therefore end up with seemingly too few instruments in some cases. This is a trade-off we do not have any control over. As a check though, we compare the results under our FEM and OLS models before making any definitive conclusion.

Similar to our finding under the employment-based measures, we conclude that economic diversity has a growth-promoting effect. Again, this conclusion is a weighty one because it does come without any qualification related to endogeneity or static-dynamic caveat. Again, unfortunately, the coefficients on the natural resource measure are not statistically significant; so are those on the interaction of diversity on resources. We therefore do not have evidence on the harmful effect of resources on growth. Neither are we able to establish diversity as medium of transmission of the effect of natural resources on growth.

Table 4.9: Alternative Measures of Diversity

Dependent Variable	lnRGDP	lnRGDP	lnRGDP	lnRGDP	lnRGDP
Diversity Index Used	**Herfindahl**	**Absolute Ogive**	**Quadratic Ogive**	**Entropy**	**Krugman**
Lagged log GDP	0.924***	0.633**	0.718***	0.755***	0.555**
	[0.257]	[0.259]	[0.266]	[0.128]	[0.241]
Diversity	-1.567	1.200*	-0.011	-2.703**	0.549
	[1.229]	[0.615]	[0.717]	[1.334]	[0.348]
Natural resources	-0.097	0.036	-0.014	0.068	0.072
	[0.384]	[0.050]	[0.070]	[0.109]	[0.113]
Diversity x natural resources	-0.004	-0.026	-0.056	-0.047	0.072
	[0.218]	[0.069]	[0.075]	[0.157]	[0.071]
Capital stock	-1.040**	0.256	-0.130	-0.075	-0.016
	[0.431]	[0.276]	[0.412]	[0.272]	[0.222]
Educational attainment	-1.236**	0.028	-0.355	-0.328	0.153
	[0.527]	[0.475]	[0.559]	[0.216]	[0.491]
Constant	-4.727	4.693	2.512	4.137**	5.621
	[5.155]	[3.610]	[3.862]	[1.850]	[3.544]
Year dummies	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No
Number of observations	360	360	360	360	360
Number of jurisdictions	60	60	60	60	60
Specification Tests					
Number of instruments	16	16	16	16	16
Number of lags used	6	6	6	6	6
Sargan Test (p value)	0.244	0.188	0.013	0.196	0.426
Hansen Test (p value)	0.270	0.479	0.029	0.058	0.245
Arellano-Bond Test for AR(1) (p-value)	0.074	0.155	0.132	0.172	0.416
Arellano-Bond Test for AR(2) (p-value)	0.886	0.082	0.098	0.011	0.000

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. Data are for three-year intervals between 1987 and 2010. All estimations based on the Windmeijer's (2005) finite sample correction to the standard errors. The proxy for natural resources is mining as a share of GDP; our five diversity measures are based on the GDP shares in the 10 industry sectors included in this chapter. Interaction term is the product of the interaction between natural resources and diversity.

4.5.4.2 Strict Exogeneity Assumption for Diversity Indices

We also reach the conclusion that the five diversity indices are arbitrary and sensitive to the level of industry aggregation used because the assumption of equi-proportionality lacks any theoretical justification. We therefore model all five diversity indices as strictly exogenous, IV-style, regressors through a one-way deterministic link. Results are similar in all respects to what we have in Table 4.9 above[47].

The coefficients of the lagged dependent variable for all five indices are positive and statistically significant. The SYST-GMM estimator produces lagged dependent variable coefficients that fall within the upper-lower bound established by the OLS and FEM estimators. The *p* value of the Hansen and Sargan tests equally behave in line with expectation. Diversity is positively related to growth under the statistically significant coefficients, with the coefficients on the Entropy index carrying a negative sign in each case, based on reasons discussed earlier. The coefficients on natural resources and interaction of diversity on resources all turn out to be statistically insignificant. We conclude that the differentiation of our diversity measures into IV-style or GMM-style variables do not significantly change the overall results.

4.6 Summary and Conclusions

Economic diversity is widely believed to be a potent tool policymakers use to achieve their stability and economic growth objectives. As well, the benefits of diversification, as well as the importance of key economic, demographic, geographic and institutional factors that affect explain it, remain widely acknowledged. However, explaining the specific reasons why diversification helps some economies to succeed where others fail remain a mirage. To further complicate things, most empirical investigations of the relationship between economic growth and diversity provide inconclusive evidence.

Closely related to this is the inability of the empirical literature to agree on the precise nature of the relationship between diversity and growth– as well as how diversity is measured. Most measures of economic diversity are arbitrary; this often leads to

[47] We therefore do not bother to present results here.

inconclusive growth-diversity analysis. Based on preliminary analysis and prior to formal econometric procedure, we see that all five indices are quite arbitrary because both the absolute and relative specialization measures are arbitrary.

In this chapter, we propose a dynamic panel method of regressions as a panacea to the diversification-growth question. We estimate a conditional growth model, in a regional growth context, to explain real per capita income at the US state and Canadian provincial level as a function of five diversity indexes. Resource curse pioneers argue that an indirect consequence of natural wealth is the resource curse; however, contemporary evidence on the curse yields a conundrum as most recent studies conclude that the transmission mechanism of the curse is more important. This provides the motivation for us to take a closer look at the transmission channel. We achieve this objective through an empirical growth model that explains growth in real per capita income as a function of natural resources and a set of variables drawn from the existing literature. Not just that; the model is specified in a way that such relationship is conditional on the degree of economic diversity in all the 60 jurisdictions examined.

Within the context of the specified model, two central hypotheses are advanced using five formulations of diversity indices which are based on the sectoral distribution of employment in a regional economy. Our second hypothesis is based on the notion that an indirect consequence of natural wealth is the resource curse. Premised on contemporary evidence that the resource curse analysis yields a conundrum, we take advantage of the DPD framework to test the hypothesis that economic diversity is a cure for the natural resource curse. Our analysis is centred on the fact that the interaction term between natural resources and economic diversity should produce a much stronger beneficial effect on GDP per capita, compared to either natural resource or diversity apiece. This helps in discerning that when regional economies are not diversified, resource abundance is harmful to growth.

The QGV specification supports the growth-promoting stance of economic diversity; this supports Hypothesis 1 and we conclude that economic diversity is associated with increased levels of economic growth. The use of dynamic panel techniques also helps resolve the uncertainty related to the so called diversification effects. We join other empirical researchers who find evidence for a positive direct relationship for the diversity-growth nexus (e.g. Hackbart and Anderson, 1975; Dissart, 2003; and Pede, 2013). Due to statistically insignificant coefficients, the GMM framework does not provide us with predictive power to test the resource curse proposition. Same with the interactive effect of diversity on resources. The FEM with statistically and economically significant coefficients capture the partial impact of an increase in natural resources on growth through the diversity transmission channel. The required diversity threshold for not having the resource curse is given as 0.209. Above this threshold, the marginal contribution of natural resources to economic growth is higher for a relatively more diversified regional economy than a less diversified one. The reverse is true when such diversity measure based on the Krugman Index is below 0.209. We draw a major policy conclusion: jurisdictions with KRUG value less than 0.209 are bound to suffer from the curse of natural resources, while those above will not. The practical implication here is that it is only when regional economies are not diversified up to a certain degree that resource abundance is harmful to growth.

In place of employment, we use GDP under sensitivity tests to construct our diversity indices. Results show interesting variation, with the lagged dependent variable for all five indices ranging between 0.555 and 0.924, compared to the 0.448-0.943 range under the employment-based measures. Based on the notion that the five diversity indices are arbitrary and sensitive to the level of industry aggregation used because the assumption of equi-proportionality lacks any theoretical justification, all five diversity indices as modeled as strictly exogenous, IV-style, regressors through a one-way deterministic link. Results are similar in all respects to the comparator. We conclude that the differentiation of our diversity measures into IV-style or GMM-style variables do not significantly change the overall results. In all, our results show that the two-step system GMM estimator handles well the endogenous regressors by generating internal instruments from their lagged values for them. This strategy also augurs well for our static-dynamic and diversity-diversification debates.

Chapter 5: Summary and Conclusions

5.1 Context of Study

This thesis has provided empirical evidence enabling us to better understand various issues related to intranational and international trade, fiscal decentralization, trade openness, AIT, economic diversity, resource curse and economic growth. In addition to employing new estimation and inference procedures for our empirical models, using a Canada-US sub-national framework in all three substantive chapters provided a unique opportunity to draw attention to the larger implications of our research hypotheses.

Chapter 2 applies the gravity model of trade to assess bilateral trade flows between Canada and the US, based on a large annual panel data set spanning three five-year intervals from 1997 to 2007 and covering all 10 provinces and 50 states. This follows a more standard formulation of the gravity model developed by Anderson van Wincoop (2003), but augmented with a contiguity dummy, differences in relative factor endowments and per capita income. In the interest of keeping the model and robustness tests as simple as possible, we perform the tests for the baseline model first and then compare our results with those obtained from other models. We then offer possible interpretations of the results in light of the estimation strategies employed.

Among other things, we examine the performance of seven different econometric methodologies under the gravity model specification. This provides new estimates on the extent to which trade costs, modeled by distance and contiguity, influence the magnitude and direction of both east-west and north-south trade in Canada and the US – after controlling for size and other jurisdiction-specific characteristics that may obscure parameters of interest. The same framework is also used to test the Heckscher-Ohlin proposition and the Linder hypothesis.

In chapter 3, we investigate the impact of fiscal transfers on economic growth while addressing the problems related to the endogenous nature of net fiscal transfers in the specified model. Premised on the economic argument that most countries organized along federalist grounds maximize efficiency gains from common markets as a result of free trade and factor mobility, we use a dynamic panel of Canada-US data to estimate the importance of redistributive flows by regressions based on the relationship between personal income after federal taxes and transfers, and pretax personal income. This gives a direct measure of the degree to which fiscal transfers impact on inequalities in regional incomes. The reviewed literature establishes one thing: the decentralization-growth question remains open, as most cross-country econometric studies provide weak evidence chiefly because results change depending on the countries examined. This serves as a guide for our sub-national empirical investigation.

This chapter also looks at trade openness, and the Canadian AIT policy – negotiated in 1994 and executed in 1995. No known study has attempted to empirically evaluate its impact on income growth, while controlling for fiscal federalism. The analysis is extended by applying the DiD methodology to better capture the effect of the AIT policy. With net fiscal transfers, trade openness and other control measures endogenous in the model, a number of refinements are introduced in the estimation methods in order to increase the reliability of our econometric estimates. In particular, the difference and system GMM estimators play important roles in the modeling process – under a Canada-US sub-national panel data environment.

Chapter 4 aims at contributing to the debate on economic diversity, resource curse and economic growth across Canadian and US jurisdictions by using the most recent techniques of DPD models. While some see economic diversification as a long-term economic growth strategy that can help mitigate unforeseen problems in the event of structural economic changes, others argue otherwise. Economic diversification has long been believed to be the cure to the resource curse challenge. While the benefits of diversification as well as the importance of key economic, demographic, geographic and institutional factors that explain it remain widely acknowledged, explaining the specific reasons why diversification helps some economies to succeed where others fail remain a mirage. Most empirical investigations of the diversification-growth relationship provide inconclusive evidence, leaving the question open. Most econometric studies provide weak evidence, mainly because results depend largely on the parameters of interest.

Resource curse pioneers argue that an indirect consequence of natural wealth is the resource curse. Contemporary evidence on the curse yields a conundrum; most recent studies conclude that the transmission mechanism of the curse is more important. A major motivation for this chapter lies on the need to take a closer look at the twin issues of diversification and the resource curse from a regional growth perspective.

5.2 Thesis Objectives

Below are the central objectives of chapter 2:

Ours is the first chapter to use a Canada-US regional panel data framework to jointly test an extended gravity model, incorporating factor endowments and per capita income differentials. These additional variables allow us to test the Heckscher-Ohlin proposition-type factor endowment differences and Linder hypothesis-style taste differences, respectively.

The second goal is the attention given, again in a Canada-US panel data environment, to the following three econometric problems: unobserved heterogeneity, log-linearization of the gravity equation in the presence of heteroscedasticity, and logarithmic estimation of zero trade flows. Most previous studies that jointly addressed these three issues did so using a cross-country framework. The other few that considered them with regional data did so either individually for Canada or the US, but not for regions in both countries together.

This chapter provides updated results and garners further evidence in support of the home bias argument. Both international and within-country border effects are estimated, with particular attention paid to the estimation procedures.

The central objectives of chapter 3 are:

To use a dynamic panel of Canada-US data selected over three-year periods to estimate the importance of redistributive flows by regressions based on the ratio of personal income after federal taxes and transfers, and pretax personal income. This gives a direct measure of the degree to which fiscal transfers reduce inequalities in regional incomes.

To empirically evaluate the impact of the Canadian AIT policy on income growth, while controlling for fiscal federalism. This analysis is extended by applying the DiD methodology to better capture the effect of the policy.

To account for the endogenous nature of net fiscal transfers, trade openness and other control measures in the model. Applying both system and difference GMM estimation techniques that eliminate biases associated with omitted variables, endogeneity and unobserved heterogeneity within a regional income framework is a major advance.

To provide updated results with Canada-US sub-national data on the fiscal transfers-growth discussion, under different fiscal policy measures and scenarios.

To provide updated results with Canada-US sub-national data on the impacts of trade openness, educational attainment and physical capital stock on economic growth.

The central objectives of chapter 4 are:

To contribute to the debate on economic diversity, resource curse and economic growth across Canadian provinces and US states by using the most recent techniques of DPD models.

To closely examine the robustness of five major economic diversity indices to GDP- and employment-based measures, as well as the relationship between economic diversification and growth over the 1987-2010 period.

To employ an empirical growth model to explain growth in real per capita income at the US state and Canadian provincial level as a function of natural resources and a set of variables drawn from the existing literature.

To look at the twin issues of diversification and the resource curse, with special attention on economic diversity as the transmission channel of the curse.

5.3 Summary of Empirical Findings

5.3.1 Gravity Model

Summarized, the following five principal hypotheses are advanced under chapter 2:

H_1: There is a positive effect of economic size on bilateral trade flows between trading partners.

H_2: There is a negative effect of geographical distance on bilateral trade flows between trading partners.

H_3: There is a stronger negative effect of the border on state-province trade, compared to interstate and interprovincial trade.

H_4: There is a stronger negative effect of the border on interprovincial trade, compared to interstate trade

H_5: There is a positive relationship between factor endowment differentials and bilateral trade flows.

H_6: There is a negative relationship between per capita income differentials and bilateral trade flows.

To recap, our findings in chapter 2 are presented below:

The coefficients of exporter's GDP and importer's GDP are approximately equal to 1 with OLS and FGLS, and about 2 for PPML. The fixed effects results show significantly lower estimates.

In the truncated zeros sample, the estimated effect of distance on trade flows is the same for OLS and FGLS at -1.077. We conclude that bilateral distance reduces trade by 1.1% for every percentage increase in the distance itself. Across the board, the PPML method has the highest effect at -1.761 when zero bilateral trade flows are retained. This is followed by OLS at -1.237 when zero trade flows are replaced.

Generally speaking, the income elasticity of trade is close to the theoretical value of 1, with the coefficients of exporter's GDP much higher than for importer's GDP. A 1% increase in exporter's GDP is associated with an increase in bilateral trade flows of 0.4%; a 1% increase in importer's GDP will increase trade by 0.6%.

The FEM finds modest effects on trade from economic sizes and distances. A 1% increase in exporter's GDP is associated with an increase in bilateral trade flows of 0.4%. Likewise, a 1% increase in importer's GDP will increase trade by 0.6%, compared to 1.2% for exporter's GDP and importer's GDP using the baseline technique.

The lower estimates of the FEM, compared to other estimators shows a tradeoff: fixed effects account for multilateral resistance. Again, this confirms that unobserved heterogeneity does have a huge impact on the results of gravity model estimates.

The hypotheses on the positive effect of economic size on bilateral trade, and the negative effect of distance on bilateral trade, are strongly supported. We notice that compared to other international gravity trade studies, the point estimate of the distance variable is somewhat large. One reason is adduced: the fact that most of North American trade goes by air and land, compared to most global trade which is transported by water. That is in addition to the fact that water transport is much cheaper than other modes of transport.

Subsamples results are generally comparable with those based on the full sample, in terms of statistical and economic significance of coefficients. The log of exporter's GDP, log of importer's GDP and log of bilateral distance each has a coefficient estimate of 1.330, 1.067 and -1.657 in the baseline model, compared with 0.962, 0.938, and -0.875 for US-US trade and 1.010, 0.823 and -1.249 for Canada-Canada trade.

Most notably, the point estimate of importer's GDP for the Canada-Canada sample turns out to be negative when estimated with the FEM, though it is not statistically significantly. Also, the distance effect is higher for interprovincial trade than interstate trade. We attribute this to the higher population density in the US, compared to Canada.

Our results lend support to the hypothesis that jurisdictions that share a common border tend to trade more. Generally speaking, it is established that the extent to which the presence of a border affects the intensities of economic exchange between a jurisdiction-pair, after controlling for bilateral distance, turns out to be more pronounced under the PPML than when OLS is used.

The presence of a border between two jurisdictions in the sample increases bilateral trade flows by 38%, 111% and 38% for the OLS, PPML and FGLS techniques, respectively. Similar to the marginal effect for the distance variable, the estimated border effect is exactly the same under OLS and FGLS.

The estimated coefficients of 0.299 for state-province trade and 0.362 for state-state are highly significant, statistically and economically, and support the hypothesis that there is a negative effect of the border on bilateral trade flows, with a stronger negative effect expected on state-province trade, compared to interstate trade. We conclude that sharing a common border has a greater influence on US-US trade than Canada-US trade does.

We establish interstate, international and interprovincial border effects of 43.5%, 33.6% and 1.92%, respectively. Compared to McCallum's 22-to-1, we establish a border effect of 17-to-1 (i.e. 33.6%-to-1.92%) for interprovincial trade. After controlling for scale and distance, interprovincial trade is about 17 times more important than international trade.

This chapter lends further support to Obstfeld and Rogoff's (2000b) home bias puzzle in international macroeconomics. Our results present new estimates for the Canada-US border effect.

Equally, we establish a border effect of roughly 1-to-1 (i.e. 33.6%-to-43.5%) for interstate trade –compared to Anderson van Wincoop's 1.6. The relatively small interstate border effect is attributed to the smallness in size of the Canadian economy, compared to the US.

Based on the PPML and OLS techniques, distance effects of 1.44 and 1.20 kilometers are estimated, respectively. We conclude that the estimated distance effects are not significantly different from the average bilateral distance value. This confirms that the unrealistically high distance elasticities in our regressions do not help the predictive powers of the methods deployed.

The Linder hypothesis is supported, while the Heckscher-Ohlin factor endowment proposition is refuted. It is expected that a 100% increase in per capita income differential will dampen trade by 7.5% and 19.4% for the low and high estimates, respectively. In stark comparison, negative signs on the coefficients of both the human capital differential and physical capital stock differential refute the Heckscher-Ohlin hypothesis that jurisdictions should trade more, the more different their factor endowments. Similar to the Linder scenario, the Heckscher-Ohlin coefficients are economically and statistically significant, ranging from a high absolute value of 0.305 to a low value of 0.198.

5.3.2 Fiscal Transfers

We advance the following five principal hypotheses:

H_1: There is a positive relationship between net fiscal transfers and GDP per capita.

H_2: There is a different impact of fiscal flows on GDP per capita for prosperous and poor regions.

H_3: There is a stronger effect of fiscal transfers and lagged income on GDP per capita, compared to the lone effect of fiscal transfers.

H_4: There is a positive relationship between trade openness and GDP per capita

H_5: The combined effect of lagged income and trade openness on GDP per capita is much stronger than the individual effect of trade openness on GDP per capita.

H_6: There is a positive relationship between the AIT policy and GDP per capita.

H_7: The combined effect of lagged income and the AIT policy on GDP per capita is much stronger than the individual effect of the policy on GDP per capita.

To recap, our findings under chapter 3 are presented below:

The US state of Connecticut with -14.2% net fiscal transfers (NFT) and -4.5% relative NFT (RNFT), and the Canadian province of Alberta with (-17.3% NFT and -5.7% RNFT) are the highest net contributors to the fiscal redistributive regimes in their respective countries for the 2008-2010 period.

Likewise, Tennessee (-6.9% NFT and 3.7% RNFT) and the Atlantic province of Newfoundland and Labrador (-2.4% NFT and 11.3% RNFT) are the highest net recipients.

Newfoundland, the Canadian province with the highest net fiscal receipts, received more than its US equivalent, Tennessee, both in absolute and relative terms. The converse is true for Alberta and Connecticut: the former contributed more than the latter both in absolute and relative terms. This Gumbel-type distribution, with extreme values in both directions, underscores the relative pointedness of the intergovernmental fiscal policy in Canada, compared to the US.

The US state of Louisiana and the Canadian province of New Brunswick each emerges the top candidate in terms of regional economic openness at 17.5% and 40.5%, respectively. Hawaii and Nova Scotia, at 1.1% and 13.3%, are the least open economies. This finding is consistent with a large body of literature on both the determinants of country size and trade openness – which suggests that generally speaking, smaller countries tend to have more open trade policies.

For the largest and least capital intensive regional economies, we find 318% and 60% capital stock differential (as a share of output) respectively. Similarly, educational attainment at 38.5% and 7.3% for the highest- and lowest-achieving jurisdictions corroborates the finding on capital stock, albeit to a lesser degree. These results show the high variability in our Canada-US regional sample.

The OLS estimator provides evidence for the negative effect of fiscal transfers on per capita income, with estimated coefficient of -1.341 on NFT. Further, the OLS estimated coefficient for $\mathrm{Y}_{\mathrm{it}-1}$ $is\ 0.952$, while the FEM returns a coefficient value of 0.515. The lower estimate from the FEM is in line with the conclusion of Roodman (2009) and Bond (2002) that a credible estimate of the lagged value of the dependent variable should lie below 1:00. These coefficients confirm the validity of our estimates.

Based on the selected models, our DPD-method produces a coefficient of 0.875 on the RNFT variable in specification 4; specification 5 produces a statistically insignificant coefficient. In contrast, the non-DPD FEM estimators produce statistically significant coefficients ranging from -2.272 to -2.381 for the RNFT-based specifications. All listed coefficients are significant at the 1% level.

Based on the FEM, on average, net fiscal transfers impede output growth; the statistically significant system GMM technique suggests the opposite. We find the exact opposite (for both FEM and system GMM) when we model relative transfers simply as the ratio of disposable income to personal income – like Checherita *et al.* This shows that the DPD estimators are highly sensitive to the particular specification of the model and its instruments. This cautious note guides all policy recommendations in this chapter.

The FEM produces -2.467, -2.051, -1.205 and -2.354 for the lagged per capita output coefficients for our below-average, above-average, net receiving and net contributing jurisdictions, respectively. This clearly establishes a two-way negative impact of net fiscal transfers on real GDP per capita. This is a clear incidence of "immiserising growth" (Bhagwati, 1958). Fiscal transfer has a detrimental effect on growth in general; economic growth in receiving jurisdictions declines by less than in contributing regions.

The coefficient of the interaction variable between fiscal transfers and lagged per capita GDP shows no evidence that lagged income distribution has any effect on the intensity of the impact fiscal transfers have on growth. The same conclusion applies under the OLS, FEM, difference GMM and system GMM.

All coefficient estimates on trade openness are statistically insignificant. The same goes for the interaction term between the lagged dependent variable and the trade openness measure. These results support the battery of studies on the inconclusive evidence regarding the trade-growth debate.

The AIT dummy is not statistically significant across all specifications. The interaction between the lagged dependent variable and the AIT dummy is statistically and economically significant under the FEM and system GMM with a lag length of five: with coefficient values of 0.290 and -0.183 and 5% and 1% statistical significance, respectively. This implies that under FEM, there is evidence of the impact of lagged income on economic growth through the AIT policy, while we conclude that the same policy has inhibited growth in a system GMM environment.

Results are robust to both the logarithmic and quadratic functional specifications. The FEM coefficient estimates for RNFT give -2.376 for the quadratic form and -2.167 for its logarithmic equivalent. Results provide evidence that net fiscal transfers used for regional redistribution impede output growth in the receiving regions.

The use of personal current transfer receipts as an alternative measure of net transfers produces a somewhat complicated outcome. Only the FEM produces a statistically significant coefficient of -0.312 on the RNFT variable, albeit the smallest marginal impact of fiscal transfers on output in the entire analysis.

With the fifth and sixth lags used, the coefficient on the lagged dependent variable turns out to be insignificant for the Canada-only sample. Combining a lagged dependent variable and fixed effects under a small sample implies a short panel bias. We conclude that the appropriate remedy here lies in using a static panel method to model this part of the study. The model performance across all six specification improves drastically for the US-only sample – since this is fairly large compared to the Canada-only sample.

5.3.3 Diversity-Resource Curse

At a high level, the following hypotheses are used to test the research questions in this chapter:

H_1: There is a positive relationship between economic diversification and economic growth

H_2: There is a negative relationship between resource abundance and economic growth

H_3: The outcome of the interactions between resource abundance and economic diversity is the key determinant of the existence, or otherwise, of the resource curse.

Our findings are presented below:

In the US, Wyoming (with 1.89 on Entropy, 0.67 on AGV, 0.83 on QGV and 0.18 on HHI) and North Dakota (1.82 on Entropy, 0.96 on QGV and 0.18 on HHI) come first and second, respectively, among the group of the five most diverse states. For the five least diverse group, Nevada (1.62 on Entropy, 0.89 on AGV, 1.96 on QGV and 0.30 on HHI) and New York (1.61 on Entropy, 0.90 on AGV, 1.89 on QGV and 0.29 on HHI) are the top two candidates.

For Canada, Saskatchewan emerges as the most diverse province, coming first all of the four times it appears under the five most diverse group. Nova Scotia settles for the last position, having come last four times under the five least diverse group. When all 60 jurisdictions are combined, Saskatchewan and Wyoming compete for the first position overall, while Nova Scotia beats Nevada with a higher modal number of appearances.

Results on the choice of the most diverse (or least diverse) jurisdiction are based on the notion of equiproportional employment share or economic activity. We conclude that diversity measures are arbitrary because both the absolute and relative specialization measures, on which they are based, are arbitrary. Likewise, we agree that results are qualified, to the extent that larger jurisdictions naturally tend to be more economically diverse than smaller ones.

The coefficient on for Y_{it-1} is positive and statistically significant in all cases; this confirms that the GMM estimators generally work as expected in estimating the coefficient on our dynamic panel's lagged dependent variable in the presence of endogenous explanatory variables.

The OLS estimator produces a higher absolute coefficient value for Y_{it-1}, compared to the FEM in all five specifications. OLS coefficients on the lagged dependent variable (for all five specifications) range from 0.738 (KRUG) to 0.787 (AGV); the FEM returns 0.272 (QGV) and 0.532(KRUG) in estimated coefficient forY_{it-1}. This finding helps in focusing on the two-step GMM estimator.

In addition to the findings under the FEM and OLS estimators, our GMM strategy suggests that economic diversity is associated with increased levels of economic growth. Economic diversification is an economic growth strategy that can help mitigate unforeseen problems in the event of structural changes in a regional economy.

The hypothesis that a higher degree of economic diversity is associated with higher GDP per capita is confirmed. We join other researchers who have established a positive direct relationship for the diversity-growth nexus (e.g. Hackbart and Anderson, 1975; Dissart, 2003; and Pede, 2013). We also improve on the work of O'Donoghue (1999) and Pede by using the DPD methodology which incorporates the GMM estimation strategy.

The GMM framework does not provide us with predictive power to test the resource curse proposition. This is the same with the interactive effect of diversity on resources. We rely on the estimates of the KRUG index in the FEM to estimate the partial impact of an increase in natural resource abundance on growth, since it provides statistically and economically significant coefficients for natural resources.

Above 0.209, the marginal contribution of natural resources to economic growth is higher for a relatively more diversified regional economy than a less diversified one. The reverse is true when our diversity measure based on the Krugman Index is below 0.209. This chapter provides clear prediction on the role of economic diversity as a transmission channel of the curse.

Under the alternative GDP-based diversity measures, our two-step system GMM estimation technique shows that coefficients of the lagged dependent variable for all five indices are positive, statistically significant and range between 0.555 and 0.924, compared to the 0.448-0.943 range under the employment-based measures. Similar to our finding under the employment-based measures, we conclude that economic diversity has a growth-promoting effect. The coefficients on the natural resource measure are also not statistically significant here; so are those on the interaction of diversity on resources. We therefore do not have evidence on the harmful effect of resources on growth. Neither are we able to establish diversity as medium of channel of the effect of natural resources on growth.

When all five diversity indices are modelled as strictly exogenous, IV-style, regressors, results reveal that diversity is positively related to growth under the Entropy index. The coefficients on natural resources and interaction of diversity on resources all turn out to be statistically insignificant. Modeling diversity indexes as IV-style or GMM-style variables does not significantly change the overall results. We also reach the conclusion that the five diversity indices are arbitrary and sensitive to the level of industry aggregation used because the assumption of equi-proportionality lacks any theoretical justification.

5.4 Policy Implications

The results in all three empirical chapters, taken together, have interesting policy implications. Deepening economic ties, globalization, border security, shifts in technology, intergovernmental fiscal dynamics, demand for natural resources and geopolitics continue to shape Canada-US relations. From our analysis and discussion so far, we have no pretention of offering perfect policy solutions to the various issues. As always, each challenge must be addressed case by case, with a regional strategy. We present key policy implications that may be relevant to academics as well as practitioners below.

Our analysis in chapter 2 shows that interstate, interprovincial and state-province borders represent large barriers to trade flows, since they impede the integration of markets, with negative welfare consequences. Policy implications specific to chapter 2 are presented below:

We conclude that there is a stronger negative effect of the border on interprovincial trade, compared to interstate trade. This has huge policy implications for Canada. The share of trade in the Canadian economy has risen over the decades. Trade increased by 34 percentage points during the 1990s, and especially with NAFTA execution, which eliminated many trade-dampening tariff barriers between Canada and its two important trading partners—Mexico and the US. Any further reductions in US-Canada trade barriers will benefit Canada more disproportionately.

In theory, it is to Canada's advantage to continue to favour policies focused on furthering such integration. However, this is far from reality. For instance, statistics from Canadian and US border agencies show that 15 years of post-9/11 border innovations have not brought down the costs associated with border crossing significantly. In addition, border security-related public expenditures have gone up remarkably since the 9/11 attacks. This is not surprising because addressing the challenges related to border thickening come at a cost. In recognition of the huge costs attributable to border thickening, the Canadian and US governments issued a joint declaration in 2011 tagged, "Beyond the Border: A Shared Vision for Perimeter Security and Economic Competitiveness". This policy is geared towards addressing the trade-off involving border security and trade relations.

According to Moens and Gabler (2012), while the US is more concerned about security threats emanating from Canada, the Canadian authorities are more concerned about the impact of bilateral trade dampening-border security measures from the Americans. Such asymmetric policy preferences require cautious treatment by the concerned authorities. Closely related to this is the notion that Canada needs to reduce its reliance on bilateral trade with the US, at the expense of multilateral trade with other regions of the world. Premised on the expectation of economic growth outside of North America, Helliwell (2002) argues that increasing the intensity of Canada-US economic exchanges may dampen Canada's ability to pursue independent economic and social policies. A good policy example here is the contentious Canada-US softwood lumber trade dispute. Nurturing and sustaining Canada–US economic relations is one of the most fundamental foreign policy objectives of any Canadian leader. This is understandable given the importance of a healthy relationship to Canadian prosperity; however, the asymmetry in the influence level is a source of economic tension. While economic shocks emanating from the US have significant impacts on Canada, the reverse is not true. Further eliminating border-related trade barriers between both countries is therefore key to generating further opportunities for trade. Canada needs to continue to take advantage of the increased importance that the U.S. attaches to border issues to negotiate beneficial trade deals.

Advances in technology and communications continue to help deepen trade and the intensity of economic exchanges; Canada and the US are no exception. The increasingly globalized market continues to provide incentives for exchanges of people, capital, goods, services and knowledge across borders. The direct implication of this is that international technology spillovers are key to increasing trade, enhancing productivity and raising welfare. As discussed under the review of literature, Canada has historically had a large gap in the level of technology per capita relative to the US. A study by Sharpe and Andrews (2012) concludes that nominal ICT investment growth in Canada in 2010 was 3.1 per cent, while the US had 7.1 per cent. To the extent that the Canadian and US authorities continue to carefully manage existing cross-border policy trade-offs for optimal results, north-south productivity differentials will provide a major incentive for major policy refinements.

Results in chapter 2 refute the Heckscher-Ohlin proposition that jurisdictions should trade more, the more different their factor endowments. The international trade literature agrees that empirically translating the Heckscher-Ohlin theory into a testable form is difficult. The World Trade Organization in its 2008 review concluded that most of the researchers that empirically tested the Heckscher-Ohlin model used inappropriate methods, with irrelevant outcomes. Added to that, using exporter's GDP and importer's GDP as proxies for size in the gravity specification may be understating the obvious for trade flows between bilateral pairs that trade significantly on intermediate goods. With constant changes in the role of vertical specialization, using GDP as the proxy for size will possibly erode the explanatory power for a country-pair like Canada-US where value-chain trade is increasingly more important than customs-based merchandise trade – which does not capture well US-Canada's broader participation in bilateral value chains. Thus, evidence-based prediction consistent with a Heckscher-Ohlin proposition that suggests skills, natural and physical capital determine welfare impacts of trade policy is not within our reach. Nonetheless, our specified model supports the argument that technological differences and home bias and relative factor abundance are all vital ingredients for sound trade policy analysis.

Policy implications from chapter 3 are presented below:

One of the major goals of fiscal transfers from central governments is to promote equalization of basic public services through narrowing of fiscal disparities across the various sub-national regions. We garner support for two propositions in this chapter: (i) relative net fiscal transfers as an alternative measure of fiscal transfers and (ii) the relative importance of fiscal capacity in both countries' intergovernmental fiscal policy. By implication, therefore, the design and implementation of intergovernmental transfer payments will create incentives that have, according to Shah (2006), "strong implications for national, regional, and local fiscal management; macroeconomic stability; distributional equity; allocative efficiency; and public services delivery."

Another interesting result is that the Canadian province with the highest net transfers received more than its US equivalent both in absolute and relative terms. The converse is true. This Gumbel-type distribution, with extreme values in both directions, underscores the relative pointedness of the intergovernmental fiscal policy in Canada, compared to the US. Without over flogging issues, balancing both the fairness and efficiency arguments are important in any intergovernmental fiscal regime. It is no surprise therefore that fiscal equalization is a major component of any serious fiscal union, to the extent that it is purely unconditional. The US should take a cue from this; it remains perhaps the world's only developed federalist nation with no federal equalization policy to address sub-national fiscal disparities. Like Canada, this country can adopt an Equalization policy with a sound legislative framework that guides and determines the appropriate level fiscal capacity and fiscal need. This will present a better alternative to the complex and highly politicized Grants-in-Aid model.

Our results on fiscal transfers reveal a clear incidence of immiserising growth. A major policy implication is that while regional fiscal disparity may be bad for growth, policy designs that focus on taxes and transfers may even cause more harm than good. Drawing specific conclusions on the negative effect of redistributive policies is indeed a dilemma. As pointed out by Okun (1975) in his popular book, Equality and Efficiency: The Big Tradeoff, economic efficiency is achieved at a cost: inequalities in income and wealth. Okun underscores, yet again, the trade-off facing policy makers: a clear choice between an efficient economy or an egalitarian society. This implies that certain economic policies designed to reduce regional fiscal disparities may end up producing weakened economic efficiency as unintended consequence – due to negative production incentives.

The dynamics of the inequality-redistribution-growth nexus can often assume varying degrees of complexity. Policy makers need to first unbundle the different components of a redistributive fiscal policy and weigh carefully the pros and cons of each specific component, before making a decision on the optimal redistributive policy for a regional economy.

Policy implications specific to chapter 4 are presented below:

Results from the preliminary analysis section show that all five indices are quite arbitrary because both the absolute and relative specialization measures are arbitrary. This has immense policy implications, particularly in economic development. Regional economic diversification policies are often based on the changing the structure of a regional economy. In a way, this challenges the conventional wisdom that increasing regional economic diversity is a recipe for economic prosperity. To the extent that diversification is the outcome of structural transformation, a dynamic reallocation of resources from less productive to more productive sectors may provide greater potential for productivity gains. While it is okay for policymakers to focus on diversification as a regional economic development policy goal, further and indiscriminate diversity of employment should be pursued with discretion as inherent regional diversity may be a potent tool, in itself, that can help offset the risks from dependence on one or a few industries.

Our analysis in chapter 4 also reveals, through the QGV specification, the growth promoting stance of economic diversity; this led us to conclude that economic diversity is associated with increased levels of economic growth. This has practical implications for how diversified economies influence the growth of leading industry sectors and vice versa. This also speaks to the fact that diversified economies support and sustain growth through various industry lifecycles. For instance, we established earlier in chapter 4 that larger regional economies tend to be more economically diversified than smaller, remote centres. Policy makers need to be cognizant of the fact that while industry specialization can lead to clustering, dependence on a limited number of industries in rural or remote regions can produce detrimental economic outcomes. This brings to the forefront the need to constantly invest in innovation and competitiveness through infrastructure, technology and human capital.

Last but not least, we find that above the 0.209 diversity threshold, the marginal contribution of natural resources to economic growth is higher for a relatively more diversified regional economy than a less diversified one. The direct policy implication here is that unlike its counterparts without natural resources, governments of resource-endowed regions may be indirectly faced with incentives to pursue growth-deterring policies. This is because resource endowments mean citizens expect much more from their leaders, and these leaders are in turn under a lot of pressure. They may end up pursuing policies that crowd out investment and allocate productive resources away from more profitable sectors, with diminishing marginal returns that impact inefficiently on the economy.

5.5 Research Limitations

Our gravity analysis in chapter 2 is based on annual panel data set covering all 10 Canadian provinces and 50 US states for 1997, 2002 and 2007. The bilateral trade data come from three sources: (i) interprovincial trade data from Statistics Canada's Input-Output Division (ii) interstate trade data from the US Census Bureau's Commodity Flow Survey and (iii) state-province data from Industry Canada's Trade Data Online. Considering that our analysis is based on five yearly intervals, the most recent interstate and interprovincial trade data are for 2012, with the former released in December 2014 and the latter in November 2015. Such non-availability restricts the ability of the study to capture recent dynamics in Canada-US trade relations. In the words of Baldwin (2009), "World trade experienced a sudden, severe and synchronized collapse in late 2008 – the sharpest in recorded history and deepest since WWII". Exclusion of 2008 -2012 data implies that we miss capturing the dynamics of the 2008-2009 great trade collapse and the aftermath of the recovery.

We admit under chapter 2 that for the economic size and trade cost effects predicted by the gravity model, one has to be careful interpreting the economic size effect as it is perfectly plausible that the causation runs in the opposite direction – in which case a higher level of trade flows increases GDP. While the DPD framework would allow the lags of variables to be used as instruments, the challenge with this method is that PPML and related methods cannot then be used. This is a trade-off that we accept; a more thorough treatment of it is not pursued in order to focus on the other more critical gravity-specific estimation issues outlined.

The estimation under chapter 3 defines net fiscal transfers as the ratio of personal income after federal taxes and transfers to pretax personal income. This gives a direct measure of the degree to which fiscal transfers impact on inequalities in regional incomes. Personal current transfer receipt is also used as an alternative measure. The lack of comparable fiscal transfers data between all 10 provinces and 50 states implies that vital information on intergovernmental fiscal transfers – e.g. Equalization payments –are not captured. This is a major limitation.

Furthermore, our trade openness measure is narrowed down to the ratio of exports to GDP as discussed under data constraints. This constitutes a major restriction on the predictive ability of the specified model.

As discussed, the notion of equiproportional employment share or economic activity is problematic to the extent that the indices are sensitive to the level of industry aggregation. The diversity indices are based on 10 industry sectors; the five indices are going to be sensitive to this level of industry aggregation. Such relatively highly aggregated nature of our data does not allow for much diversity to be picked up. To attempt to move to higher aggregation level is to risk the deletion, from our sample, data points that are suppressed to meet confidentiality requirements. This will limit the applicability and interpretation of indices. Nonetheless, these are trade-offs beyond our control; they qualify the results.

5.6 Directions for Future Research

Among other things, the central ideas of each chapter and the main objective of the thesis can be extended in a number of directions. First, it is hoped that a single unified framework that incorporates all the major issues can be constructed to help provide better insights.

As stated under chapter 2, our point estimates of the distance variable under the different estimators are unnecessarily large, compared to other international studies. This, in turn, affects our estimate of the width of the Canada-US border in that chapter. McCallum (1995) opines that high distance elasticity of trade may be because most North American trade goes by air and land, compared to most global trade which is transported by water. Also, water transport is much cheaper than other modes of transport.

Clearly, among many of the factors that shape bilateral trade flows, transport costs constitute a major one. Canada-US sub-national transport costs data are more difficult to come by compared to geographic information data such as the bilateral distance between capital cities in both countries. This explains the choice of distance as the proxy for transport costs in this thesis. Apart from distance, to the extent that other transport cost drivers – e.g. fuel costs and transport technology – influence not just the volume of trade, but also the pattern and modal choice, it is important to appropriately model these for robust trade policy analysis. We hope this will be looked into by future researchers.

As mentioned earlier, only data on trade in goods are available; trade in services is not included in our estimation. The notion of Canada-US merchandise trade representing bilateral trade flows is nothing but simplification of reality. Also, to the extent that Canada-US trade is largely focused on intermediates, the use of GDP as a determinant of trade flows may be inadequate. Predicted results may be influenced by such simplifying assumptions. As a suggestion, further research should consider using the DPD framework – with the Heckscher-Ohlin and Linder hypotheses included – to perform a Blinder-Oaxaca nonlinear type decomposition to filter the Canada-US border effects into transaction costs, tariff measures, non-tariff measures and other unobserved components.

As clearly stated in chapter 3, US states were not party to the AIT policy; this provides a good opportunity to leverage an important capability of the DiD strategy in estimating the coefficient of the AIT dummy. However, we also recognize that the timing of the signing of AIT may be correlated with other economically significant developments in Canada. This coincidence is expected to obscure any measure of the extent to which the AIT policy has influenced income convergence in Canada. To draw any meaningful conclusions from the estimates, it is important to get Mexico-US and Canada-Mexico sub-national export and import data. With the Canada-Mexico portion of the data partly available, and the Mexico-US part totally unavailable, it is recommended for future researchers in this area to look into this.

Any meaningful policy recommendation on increased trade openness must recognize the equally important nature of imports and exports. Due to constraints on data availability, our analysis on trade openness in chapter 2 is based on exports only; imports are excluded. While exports are generally known to be beneficial for economic prosperity, imports also provide, among other things, a veritable opportunity to access foreign intermediate inputs that can increase firms' competitiveness and profits. Again, future research in this area must look for ways to fill this lacuna.

As observed in this study, inequality is a major determinant of growth, even after controlling for redistributive fiscal transfers. Addressing economic growth concerns using fiscal redistribution as a policy tool, under the assumption that regional inequality will take care of itself in the process, will likely result in immiserising growth as established in this study. It is therefore necessary to employ an econometric framework with the ability to simultaneously model the impacts of redistributive fiscal transfers and regional inequality on economic growth, while also disentangling the various components and channels of the individual issues. This will be a major contribution to the sub-national literature on fiscal transfers and economic growth.

According to Wagner (2000), it is important to account for spatial autocorrelation effects among regions because such interdependency is very important in explaining any link between diversity and growth and instability. Pede (2013) equally concludes that spatial econometrics provides a framework for the true factors at the origin of spillovers to be modelled by geographical distance. We therefore recommend that future work on the diversity-resource-institution-growth nexus should consider applying spatial econometric techniques. Among other things, this strategy will add robustness by offering a basis for comparison with the few studies out there.

Appendices

Appendices to Chapter 2

Appendix 2.1: Capital Cities of All 60 Jurisdictions

Jurisdiction	Capital City	Jurisdiction	Capital City
Alberta	Edmonton	Massachusetts	Boston
British Columbia	Victoria	Michigan	Lansing
Manitoba	Winnipeg	Minnesota	Saint Paul
New Brunswick	Fredericton	Mississippi	Jackson
Newfoundland & Labrador	St. John's	Missouri	Jefferson City
Nova Scotia	Halifax	Montana	Helena
Ontario	Toronto	Nebraska	Lincoln
Prince Edward Island	Charlottetown	Nevada	Carson City
Quebec	Quebec City	New Hampshire	Concord
Saskatchewan	Regina	New Jersey	Trenton
Alabama	Montgomery	New Mexico	Santa Fe
Alaska	Juneau	New York	Albany
Arizona	Phoenix	North Carolina	Raleigh
Arkansas	Little Rock	North Dakota	Bismarck
California	Sacramento	Ohio	Columbus
Colorado	Denver	Oklahoma	Oklahom City
Connecticut	Hartford	Oregon	Salem
Delaware	Dover	Pennsylvania	Harrisburg
Florida	Tallahassee	Rhode Island	Providence
Georgia	Atlanta	South Carolina	Columbia
Hawaii	Honolulu	South Dakota	Pierre
Idaho	Boise	Tennessee	Nashville
Illinois	Springfield	Texas	Austin
Indiana	Indianapolis	Utah	Salt Lake City
Iowa	Des Moines	Vermont	Montpelier
Kansas	Topeka	Virginia	Richmond
Kentucky	Frankfort	Washington	Olympia
Louisiana	Baton Rouge	West Virginia	Charleston
Maine	Augusta	Wisconsin	Madison
Maryland	Annapolis	Wyoming	Cheyenne

Notes: Among many factors that shape bilateral trade flows, transport costs constitute a major one. Canada-US sub-national transport costs data are more difficult to come by compared to geographic information data such as the bilateral distance between capital cities in both countries. This explains our choice of distance as the proxy for transport costs. Data on road distances are measured in kilometers based on the capital city of each jurisdiction, and are obtained from the distance data website which uses Google Maps: http: www.worldatlas.com/aatlas/infopage/howfar.htm. In addition to Google Maps, this site incorporates a supplementary list of cities from around the world to find the latitude and longitude of the two jurisdictions.

Appendix 2.2: Jurisdictions with Zero Trade Flows

Year	Trade Flow Type	Exporter	Importer
1997	Export	Alaska	Nevada
1997	Export	Alaska	Ohio
1997	Export	Alaska	South Carolina
1997	Export	Alaska	South Dakota
1997	Export	Alaska	West Virginia
1997	Export	Delaware	Hawaii
1997	Export	Hawaii	Nebraska
1997	Export	Hawaii	New Hampshire
1997	Export	Hawaii	New Mexico
1997	Export	Hawaii	Rhode Island
1997	Export	Hawaii	West Virginia
1997	Export	Wyoming	Hawaii
1997	Import	Hawaii	Delaware
1997	Import	Hawaii	Wyoming
1997	Import	Nebraska	Hawaii
1997	Import	Nevada	Alaska
1997	Import	New Hampshire	Hawaii
1997	Import	New Mexico	Hawaii
1997	Import	Ohio	Alaska
1997	Import	Rhode Island	Hawaii
1997	Import	South Carolina	Alaska
1997	Import	South Dakota	Alaska
1997	Import	West Virginia	Alaska
1997	Import	West Virginia	Hawaii
2002	Export	Alaska	Delaware
2002	Export	Alaska	Iowa
2002	Export	Alaska	Maryland
2002	Export	Alaska	Nebraska
2002	Export	Alaska	New Hampshire
2002	Export	Alaska	North Dakota
2002	Export	Alaska	West Virginia
2002	Export	Hawaii	Maine
2002	Export	Hawaii	Massachusetts
2002	Export	Hawaii	Montana
2002	Export	Hawaii	South Dakota
2002	Import	Delaware	Alaska

2002	Import	Iowa	Alaska
2002	Import	Maine	Hawaii
2002	Import	Maryland	Alaska
2002	Import	Massachusetts	Hawaii
2002	Import	Montana	Hawaii
2002	Import	Nebraska	Alaska
2002	Import	New Hampshire	Alaska
2002	Import	North Dakota	Alaska
2002	Import	South Dakota	Hawaii
2002	Import	West Virginia	Alaska
2007	Export	Alaska	Maine
2007	Export	Alaska	South Carolina
2007	Export	Hawaii	Idaho
2007	Export	Hawaii	Indiana
2007	Export	Hawaii	Montana

Notes: The presence of zero trade flows in our data poses a major estimation issue. While the Newtonian gravitational force between two masses can be very small, but never zero, it is the case that our sample features zero bilateral trade flows between many jurisdiction-pairs. In the presence of such zeros, the use of logarithmic transformation for the dependent variable poses a problem since the logarithm of zero is undefined. Appendix 2 shows these jurisdiction-pairs and the corresponding years.

Appendices to Chapter 3

Appendix 3.1: Properties of Estimators

Property	OLS	FEM	GMM
Unobserved Heterogeneity	No	Yes	Yes
Endogeneity	No	No	Yes
Dynamic Panel Data	No	No	Yes
Second Order Serial Correlation	Yes	Yes	No

Note: Compared to the difference GMM, we use the system GMM extensively because it allows us to capture the full effect of the various policy changes modeled. Unlike the difference GMM, the system GMM brings back the level equation; this helps in explaining the full impact of policy changes like the AIT.

Appendix 3.2: Relative Income and Transfers (2007-2010 Average)

Jurisdiction	RRGDP (%)	RGDP($'000)	RNFT (%)	NFT (%)
Alabama	76.5	36.4	2.0	-8.4
Alaska	145.1	68.8	2.0	-8.4
Arizona	83.4	39.6	2.1	-8.3
Arkansas	75.0	35.6	1.7	-8.7
California	111.2	52.8	-1.2	-11.3
Colorado	107.0	50.8	-0.3	-10.4
Connecticut	136.9	65.0	-4.5	-14.2
Delaware	131.8	62.6	-0.2	-10.4
Florida	83.3	39.6	2.2	-8.3
Georgia	90.2	42.8	0.9	-9.4
Hawaii	104.2	49.5	1.2	-9.1
Idaho	74.9	35.6	1.8	-8.6
Illinois	107.0	50.8	-0.3	-10.4
Indiana	89.6	42.6	0.7	-9.5
Iowa	96.5	45.8	1.4	-8.9
Kansas	93.0	44.2	0.6	-9.7
Kentucky	78.5	37.3	0.9	-9.4
Louisiana	99.7	47.3	1.8	-8.5
Maine	80.8	38.4	1.0	-9.3
Maryland	112.6	53.4	-1.6	-11.7
Massachusetts	125.8	59.8	-2.8	-12.7
Michigan	81.5	38.7	1.0	-9.3
Minnesota	106.3	50.5	-1.2	-11.2
Mississippi	66.8	31.7	3.1	-7.4
Missouri	89.3	42.4	0.9	-9.4
Montana	77.4	36.8	0.9	-9.4
Nebraska	102.3	48.6	1.3	-9.1
Nevada	96.5	45.9	1.7	-8.6
New Hampshire	98.5	46.7	1.6	-8.8
New Jersey	118.6	56.3	-1.9	-11.9
New Mexico	84.0	39.9	2.4	-8.1
New York	125.3	59.5	-4.1	-13.9
North Carolina	92.6	44.0	0.7	-9.6
North Dakota	103.0	48.9	1.6	-8.8
Ohio	89.4	42.4	0.1	-10.1
Oklahoma	82.5	39.2	1.7	-8.7
Oregon	102.1	48.5	-0.5	-10.7
Pennsylvania	95.6	45.4	-0.2	-10.4
Rhode Island	96.6	45.9	0.5	-9.7
South Carolina	75.5	35.9	2.1	-8.3

South Dakota	96.6	45.9	3.6	-7.0
Tennessee	84.3	40.0	3.7	-6.9
Texas	100.4	47.7	2.2	-8.2
Utah	89.3	42.4	1.1	-9.2
Vermont	87.0	41.3	1.2	-9.1
Virginia	109.7	52.1	-1.0	-11.1
Washington	112.7	53.5	2.2	-8.2
West Virginia	72.7	34.5	1.2	-9.1
Wisconsin	93.1	44.2	0.0	-10.2
Wyoming	143.0	67.9	1.0	-9.3
Newfoundland	115.6	50.4	11.3	-2.4
Prince Edward	71.8	31.3	11.2	-2.5
Nova Scotia	79.9	34.8	5.6	-7.4
New Brunswick	80.1	34.9	8.8	-4.6
Quebec	85.2	37.1	1.5	-11.0
Ontario	97.2	42.3	-0.7	-12.9
Manitoba	91.1	39.7	2.1	-10.5
Saskatchewan	111.9	48.8	2.1	-10.5
Alberta	151.6	66.1	-5.7	-17.3
British Columbia	96.0	41.8	1.4	-11.1

Appendix 3 shows relative real per capita GDP (RRGDP), relative net fiscal transfers (RNFT), real per capita GDP (RGDP) and net fiscal transfers (NFT) – based on the 2008-2010 average; sorted on RRGDP. In a way, this gives a picture of how fiscal flows support the relative income of poor regions and reduce that of rich regions.

Appendix 3.3: Below-Average Jurisdictions (Full Sample)

Year	Jurisdiction	RNFT (%)	Year	Jurisdiction	RNFT (%)
1995	Newfoundland	20.3	2007	West Virginia	2.2
1998	Newfoundland	19.1	2010	Manitoba	2.1
1992	Newfoundland	19.1	2010	Arizona	2.1
1995	Prince Edward	16.7	2010	South Carolina	2.1
1992	Prince Edward	16.4	1992	Florida	2.1
2001	Newfoundland	15.9	2001	Florida	2.1
1998	Prince Edward	15.2	2010	Saskatchewan	2.1
2001	Prince Edward	14.7	1995	Florida	2.0
2007	Newfoundland	13.5	1995	New Mexico	2.0
2004	Newfoundland	13.0	1992	Arkansas	2.0
2007	Prince Edward	12.3	2007	Iowa	2.0
2004	Prince Edward	11.7	1995	West Virginia	2.0
2001	New Brunswick	11.5	2004	Washington	2.0
2010	Newfoundland	11.3	2007	Alabama	2.0
1998	New Brunswick	11.2	1992	Texas	2.0
1992	New Brunswick	11.2	2010	Alaska	2.0

2010	Prince Edward	11.2	2010	Alabama	2.0
1995	New Brunswick	10.6	2004	Idaho	2.0
2007	New Brunswick	10.2	2001	Hawaii	2.0
2004	New Brunswick	10.0	2007	Quebec	1.9
1998	Nova Scotia	9.5	2001	Arizona	1.9
1995	Nova Scotia	9.3	2001	Utah	1.9
2010	New Brunswick	8.8	1995	Arkansas	1.9
2001	Nova Scotia	8.1	2010	Louisiana	1.8
1992	Nova Scotia	7.9	2004	Alabama	1.8
2007	Nova Scotia	7.2	2010	Idaho	1.8
2001	Saskatchewan	6.4	1998	Idaho	1.8
2004	Nova Scotia	6.3	1992	Wyoming	1.8
1995	Saskatchewan	5.7	2004	West Virginia	1.8
2010	Nova Scotia	5.6	2004	Arkansas	1.8
2004	Saskatchewan	5.6	2007	Oklahoma	1.8
2001	South Dakota	5.3	1998	Iowa	1.8
1992	Manitoba	5.0	2004	Iowa	1.8
2007	Saskatchewan	5.0	2007	South Carolina	1.8
2001	Mississippi	4.9	2004	Florida	1.8
1998	South Dakota	4.8	2004	Wyoming	1.8
2001	North Dakota	4.7	2007	Nebraska	1.8
2001	Tennessee	4.7	2007	New Hamp	1.8
1992	Saskatchewan	4.4	2010	Nevada	1.7
1998	Saskatchewan	4.4	1998	Oklahoma	1.7
2004	South Dakota	4.1	1992	West Virginia	1.7
2007	South Dakota	4.1	1998	Nebraska	1.7
1998	Mississippi	4.0	2010	Arkansas	1.7
2001	Manitoba	4.0	1998	Florida	1.7
1992	South Dakota	4.0	2004	Nebraska	1.7
2007	Manitoba	4.0	2001	Kentucky	1.7
1998	North Dakota	3.9	2004	Oklahoma	1.7
2004	Manitoba	3.9	2001	Kansas	1.7
2007	Mississippi	3.9	2010	Oklahoma	1.7
2001	Louisiana	3.8	1995	Wyoming	1.7
2001	Alaska	3.7	1995	Washington	1.6
2001	New Mexico	3.7	2004	Montana	1.6
1995	South Dakota	3.7	2001	Vermont	1.6
2010	Tennessee	3.7	1998	Hawaii	1.6
2001	West Virginia	3.6	1998	South Carolina	1.6
2007	Tennessee	3.6	1998	Maine	1.6
2010	South Dakota	3.6	1992	New Hamp	1.6
1992	Mississippi	3.5	2010	North Dakota	1.6
1998	Tennessee	3.4	2010	New Hamp	1.6

2004	Tennessee	3.3
2001	Alabama	3.3
1995	Manitoba	3.3
2001	Arkansas	3.3
2010	Mississippi	3.1
1995	Mississippi	3.1
2004	North Dakota	3.1
2007	North Dakota	3.1
2004	Mississippi	3.1
2001	Montana	3.0
1998	West Virginia	3.0
2007	Alaska	3.0
2001	Texas	2.9
1998	New Mexico	2.9
1992	North Dakota	2.8
1992	Tennessee	2.8
2001	Iowa	2.8
2007	Louisiana	2.7
2001	Oklahoma	2.7
1998	Louisiana	2.7
1998	Manitoba	2.7
1998	Arkansas	2.7
2007	Texas	2.6
2004	Alaska	2.6
1995	Tennessee	2.6
1998	Alaska	2.6
1995	North Dakota	2.6
1995	Louisiana	2.6
2004	Texas	2.6
2001	South Carolina	2.6
1998	Montana	2.5
2007	New Mexico	2.5
1992	Louisiana	2.5
1998	Texas	2.4
2010	New Mexico	2.4
2007	Arkansas	2.3
2001	Nebraska	2.3
1998	Alabama	2.3
2004	Louisiana	2.3
2007	Washington	2.3
1995	Texas	2.2
2004	New Mexico	2.2
2010	Texas	2.2
2001	Indiana	1.6
1992	Alabama	1.6
1995	Alaska	1.5
1992	Nebraska	1.5
2001	Maine	1.5
2010	Quebec	1.5
1992	Montana	1.5
2007	Idaho	1.5
1995	Montana	1.5
1995	New Hamp	1.5
1995	Alabama	1.5
2007	Florida	1.5
2004	South Carolina	1.4
2010	Iowa	1.4
2001	Missouri	1.4
2004	British Colum	1.4
1995	Maine	1.4
2004	Arizona	1.4
2007	Montana	1.4
2007	Arizona	1.4
1998	Vermont	1.4
2004	New Hamp	1.4
2010	British Colum	1.4
2001	Nevada	1.3
1995	Nebraska	1.3
1992	Washington	1.3
2007	Missouri	1.3
1992	Quebec	1.3
1998	Washington	1.3
2010	Nebraska	1.3
2007	Maine	1.3
1998	Arizona	1.2
2010	Hawaii	1.2
1995	Oklahoma	1.2
2007	Kentucky	1.2
2007	Vermont	1.2
2010	West Virginia	1.2
2010	Vermont	1.2
1995	South Carolina	1.2
1995	Arizona	1.1
1992	Arizona	1.1
1992	South Carolina	1.1
1998	Quebec	1.1

2010	Washington	2.2	1998	New Hamp	1.1
2001	Idaho	2.2	2004	Utah	1.1
1992	New Mexico	2.2	2010	Utah	1.1
2010	Florida	2.2			

Notes: Our full sample is divided into two, on the basis of the median value of 1.1% for the RNFT variable. Jurisdictions with median values above 1.1% are named below-average jurisdictions, while those below are tagged above-average jurisdictions.

Appendix 3.4: Above-Average Jurisdictions (Full Sample)

Year	Jurisdiction	RNFT (%)	Year	Jurisdiction	RNFT (%)
2007	Michigan	1.0	1998	Virginia	-0.3
2001	North Carolina	1.0	2004	Illinois	-0.3
2007	Kansas	1.0	1992	Michigan	-0.3
2001	Wyoming	1.0	2001	Illinois	-0.3
2010	Wyoming	1.0	1992	Virginia	-0.4
1992	Maine	1.0	1992	Colorado	-0.4
1995	Vermont	1.0	1992	California	-0.4
2010	Michigan	1.0	1998	Ohio	-0.4
2004	Kansas	1.0	1992	Ohio	-0.4
2004	Vermont	1.0	1995	Virginia	-0.4
2010	Maine	1.0	2001	Delaware	-0.5
2010	Montana	0.9	2001	Colorado	-0.5
2007	Nevada	0.9	2010	Oregon	-0.5
2007	Wyoming	0.9	2004	Oregon	-0.5
2010	Missouri	0.9	1992	Illinois	-0.5
2004	Nevada	0.9	1998	California	-0.5
2004	Missouri	0.9	2007	Delaware	-0.6
2001	British Columbia	0.9	2004	Delaware	-0.6
2010	Georgia	0.9	2007	Oregon	-0.6
2010	Kentucky	0.9	2001	Minnesota	-0.6
1998	Utah	0.9	1995	Ohio	-0.6
1992	Alaska	0.8	1992	Wisconsin	-0.6
1998	Kansas	0.8	2010	Ontario	-0.7
1998	Kentucky	0.8	1998	Illinois	-0.7
1998	Missouri	0.8	1995	Colorado	-0.7
1995	Quebec	0.8	1998	Michigan	-0.7
1992	Idaho	0.8	1995	Illinois	-0.7
2007	Indiana	0.8	1998	Oregon	-0.7
2001	Washington	0.8	1998	Colorado	-0.7
2007	Utah	0.7	1998	Wisconsin	-0.8
2010	Indiana	0.7	1992	Oregon	-0.8

2004	Maine	0.7	2004	Ohio	-0.8
2007	Hawaii	0.7	2007	Virginia	-0.8
1998	Wyoming	0.7	2004	California	-0.8
1995	Iowa	0.7	2007	Minnesota	-0.9
1998	Nevada	0.7	1995	Michigan	-0.9
2010	North Carolina	0.7	1995	Wisconsin	-0.9
2004	Quebec	0.7	1998	British Colum	-1.0
1995	Idaho	0.7	2004	Virginia	-1.0
1992	Oklahoma	0.7	2001	Virginia	-1.0
1992	Kansas	0.6	2004	Minnesota	-1.0
2001	Pennsylvania	0.6	2010	Virginia	-1.0
1998	Rhode Island	0.6	1992	New Jersey	-1.1
2001	New Hampshire	0.6	1992	British Colum	-1.1
1995	Kansas	0.6	2010	Minnesota	-1.2
1992	Missouri	0.6	1992	Hawaii	-1.2
2010	Kansas	0.6	2010	California	-1.2
1992	Utah	0.6	2007	California	-1.3
1992	Iowa	0.5	1992	Minnesota	-1.3
2001	Rhode Island	0.5	1998	New Jersey	-1.3
2010	Rhode Island	0.5	1995	New Jersey	-1.3
2007	Georgia	0.5	1995	Oregon	-1.3
2004	Hawaii	0.5	2001	Maryland	-1.5
1995	Missouri	0.5	2004	New Jersey	-1.5
1998	North Carolina	0.5	1992	Connecticut	-1.6
2001	Georgia	0.5	1995	Ontario	-1.6
2007	North Carolina	0.5	1992	Delaware	-1.6
1992	Vermont	0.5	2010	Maryland	-1.6
1995	Rhode Island	0.4	1998	Ontario	-1.6
1992	Kentucky	0.4	1995	Delaware	-1.7
1998	Indiana	0.4	2007	Ontario	-1.7
1995	Hawaii	0.4	2007	Maryland	-1.7
2007	Wisconsin	0.4	1992	Alberta	-1.7
2007	British Columbia	0.4	1995	Minnesota	-1.8
2001	Ohio	0.3	1998	Delaware	-1.8
1992	Rhode Island	0.3	2007	New Jersey	-1.8
2004	Kentucky	0.3	2010	New Jersey	-1.9
2001	Michigan	0.3	2004	Ontario	-1.9
2007	Rhode Island	0.3	2001	Ontario	-1.9
1995	California	0.2	2004	Maryland	-1.9
1992	North Carolina	0.2	1998	Minnesota	-1.9
1995	Nevada	0.2	1995	British Colum	-2.0
1995	Kentucky	0.2	1995	Maryland	-2.0
2004	Georgia	0.2	2001	New Jersey	-2.1

2004	North Carolina	0.2	1992	Maryland	-2.1
2001	Wisconsin	0.2	1992	New York	-2.2
2004	Indiana	0.2	1992	Massachusett	-2.2
2007	Pennsylvania	0.1	1998	Maryland	-2.2
2010	Ohio	0.1	1995	New York	-2.3
1992	Nevada	0.1	1992	Ontario	-2.4
1998	Pennsylvania	0.1	2001	California	-2.5
2004	Pennsylvania	0.1	1995	Massachusett	-2.5
1995	North Carolina	0.1	1998	New York	-2.5
1992	Georgia	0.1	2001	Alberta	-2.5
2004	Michigan	0.1	2004	Massachusett	-2.6
1998	Georgia	0.1	2010	Massachusett	-2.8
1995	Utah	0.1	2007	Massachusett	-2.9
1992	Pennsylvania	0.0	1995	Connecticut	-2.9
2010	Wisconsin	0.0	1995	Alberta	-2.9
2001	Quebec	0.0	2004	Alberta	-3.2
1995	Pennsylvania	0.0	2004	New York	-3.3
2004	Colorado	0.0	1998	Massachusett	-3.5
1992	Indiana	-0.1	2001	New York	-3.6
2007	Ohio	-0.1	1998	Alberta	-3.7
1995	Georgia	-0.1	2004	Connecticut	-3.7
2004	Rhode Island	-0.1	2010	New York	-4.1
2004	Wisconsin	-0.1	2007	New York	-4.2
2007	Illinois	-0.2	2007	Alberta	-4.4
2010	Pennsylvania	-0.2	2010	Connecticut	-4.5
2010	Delaware	-0.2	2007	Connecticut	-4.6
2007	Colorado	-0.2	1998	Connecticut	-4.6
2001	Oregon	-0.2	2001	Massachusett	-4.8
2010	Illinois	-0.3	2001	Connecticut	-5.4
2010	Colorado	-0.3	2010	Alberta	-5.7
1995	Indiana	-0.3			

Notes: The full sample is divided into two, on the basis of the median value of 1.1% for the RNFT variable. Jurisdictions with median values above 1.1% are named below-average jurisdictions, while those below are tagged above-average jurisdictions.

Appendix 3.5: Net Recipients (Full Sample)

Year	Jurisdiction	RNFT (%)	Year	Jurisdiction	RNFT (%)
1995	Newfoundland	20.3	2004	Oklahoma	1.7
1998	Newfoundland	19.1	2001	Kansas	1.7
1992	Newfoundland	19.1	2010	Oklahoma	1.7
1995	Prince Edward	16.7	1995	Wyoming	1.7
1992	Prince Edward	16.4	1995	Washington	1.6

2001	Newfoundland	15.9	2004	Montana	1.6
1998	Prince Edward	15.2	2001	Vermont	1.6
2001	Prince Edward	14.7	1998	Hawaii	1.6
2007	Newfoundland	13.5	1998	South Carolina	1.6
2004	Newfoundland	13.0	1998	Maine	1.6
2007	Prince Edward	12.3	1992	New Hampshire	1.6
2004	Prince Edward	11.7	2010	North Dakota	1.6
2001	New Brunswick	11.5	2010	New Hampshire	1.6
2010	Newfoundland	11.3	2001	Indiana	1.6
1998	New Brunswick	11.2	1992	Alabama	1.6
1992	New Brunswick	11.2	1995	Alaska	1.5
2010	Prince Edward	11.2	1992	Nebraska	1.5
1995	New Brunswick	10.6	2001	Maine	1.5
2007	New Brunswick	10.2	2010	Quebec	1.5
2004	New Brunswick	10.0	1992	Montana	1.5
1998	Nova Scotia	9.5	2007	Idaho	1.5
1995	Nova Scotia	9.3	1995	Montana	1.5
2010	New Brunswick	8.8	1995	New Hampshire	1.5
2001	Nova Scotia	8.1	1995	Alabama	1.5
1992	Nova Scotia	7.9	2007	Florida	1.5
2007	Nova Scotia	7.2	2004	South Carolina	1.4
2001	Saskatchewan	6.4	2010	Iowa	1.4
2004	Nova Scotia	6.3	2001	Missouri	1.4
1995	Saskatchewan	5.7	2004	British Columbia	1.4
2010	Nova Scotia	5.6	1995	Maine	1.4
2004	Saskatchewan	5.6	2004	Arizona	1.4
2001	South Dakota	5.3	2007	Montana	1.4
1992	Manitoba	5.0	2007	Arizona	1.4
2007	Saskatchewan	5.0	1998	Vermont	1.4
2001	Mississippi	4.9	2004	New Hampshire	1.4
1998	South Dakota	4.8	2010	British Columbia	1.4
2001	North Dakota	4.7	2001	Nevada	1.3
2001	Tennessee	4.7	1995	Nebraska	1.3
1992	Saskatchewan	4.4	1992	Washington	1.3
1998	Saskatchewan	4.4	2007	Missouri	1.3
2004	South Dakota	4.1	1992	Quebec	1.3
2007	South Dakota	4.1	1998	Washington	1.3
1998	Mississippi	4.0	2010	Nebraska	1.3
2001	Manitoba	4.0	2007	Maine	1.3
1992	South Dakota	4.0	1998	Arizona	1.2
2007	Manitoba	4.0	2010	Hawaii	1.2
1998	North Dakota	3.9	1995	Oklahoma	1.2
2004	Manitoba	3.9	2007	Kentucky	1.2

2007	Mississippi	3.9	2007	Vermont	1.2
2001	Louisiana	3.8	2010	West Virginia	1.2
2001	Alaska	3.7	2010	Vermont	1.2
2001	New Mexico	3.7	1995	South Carolina	1.2
1995	South Dakota	3.7	1995	Arizona	1.1
2010	Tennessee	3.7	1992	Arizona	1.1
2001	West Virginia	3.6	1992	South Carolina	1.1
2007	Tennessee	3.6	1998	Quebec	1.1
2010	South Dakota	3.6	1998	New Hampshire	1.1
1992	Mississippi	3.5	2004	Utah	1.1
1998	Tennessee	3.4	2010	Utah	1.1
2004	Tennessee	3.3	2007	Michigan	1.0
2001	Alabama	3.3	2001	North Carolina	1.0
1995	Manitoba	3.3	2007	Kansas	1.0
2001	Arkansas	3.3	2001	Wyoming	1.0
2010	Mississippi	3.1	2010	Wyoming	1.0
1995	Mississippi	3.1	1992	Maine	1.0
2004	North Dakota	3.1	1995	Vermont	1.0
2007	North Dakota	3.1	2010	Michigan	1.0
2004	Mississippi	3.1	2004	Kansas	1.0
2001	Montana	3.0	2004	Vermont	1.0
1998	West Virginia	3.0	2010	Maine	1.0
2007	Alaska	3.0	2010	Montana	0.9
2001	Texas	2.9	2007	Nevada	0.9
1998	New Mexico	2.9	2007	Wyoming	0.9
1992	North Dakota	2.8	2010	Missouri	0.9
1992	Tennessee	2.8	2004	Nevada	0.9
2001	Iowa	2.8	2004	Missouri	0.9
2007	Louisiana	2.7	2001	British Columbia	0.9
2001	Oklahoma	2.7	2010	Georgia	0.9
1998	Louisiana	2.7	2010	Kentucky	0.9
1998	Manitoba	2.7	1998	Utah	0.9
1998	Arkansas	2.7	1992	Alaska	0.8
2007	Texas	2.6	1998	Kansas	0.8
2004	Alaska	2.6	1998	Kentucky	0.8
1995	Tennessee	2.6	1998	Missouri	0.8
1998	Alaska	2.6	1995	Quebec	0.8
1995	North Dakota	2.6	1992	Idaho	0.8
1995	Louisiana	2.6	2007	Indiana	0.8
2004	Texas	2.6	2001	Washington	0.8
2001	South Carolina	2.6	2007	Utah	0.7
1998	Montana	2.5	2010	Indiana	0.7
2007	New Mexico	2.5	2004	Maine	0.7

1992	Louisiana	2.5	2007	Hawaii	0.7
1998	Texas	2.4	1998	Wyoming	0.7
2010	New Mexico	2.4	1995	Iowa	0.7
2007	Arkansas	2.3	1998	Nevada	0.7
2001	Nebraska	2.3	2010	North Carolina	0.7
1998	Alabama	2.3	2004	Quebec	0.7
2004	Louisiana	2.3	1995	Idaho	0.7
2007	Washington	2.3	1992	Oklahoma	0.7
1995	Texas	2.2	1992	Kansas	0.6
2004	New Mexico	2.2	2001	Pennsylvania	0.6
2010	Texas	2.2	1998	Rhode Island	0.6
2010	Washington	2.2	2001	New Hampshire	0.6
2001	Idaho	2.2	1995	Kansas	0.6
1992	New Mexico	2.2	1992	Missouri	0.6
2010	Florida	2.2	2010	Kansas	0.6
2007	West Virginia	2.2	1992	Utah	0.6
2010	Manitoba	2.1	1992	Iowa	0.5
2010	Arizona	2.1	2001	Rhode Island	0.5
2010	South Carolina	2.1	2010	Rhode Island	0.5
1992	Florida	2.1	2007	Georgia	0.5
2001	Florida	2.1	2004	Hawaii	0.5
2010	Saskatchewan	2.1	1995	Missouri	0.5
1995	Florida	2.0	1998	North Carolina	0.5
1995	New Mexico	2.0	2001	Georgia	0.5
1992	Arkansas	2.0	2007	North Carolina	0.5
2007	Iowa	2.0	1992	Vermont	0.5
1995	West Virginia	2.0	1995	Rhode Island	0.4
2004	Washington	2.0	1992	Kentucky	0.4
2007	Alabama	2.0	1998	Indiana	0.4
1992	Texas	2.0	1995	Hawaii	0.4
2010	Alaska	2.0	2007	Wisconsin	0.4
2010	Alabama	2.0	2007	British Columbia	0.4
2004	Idaho	2.0	2001	Ohio	0.3
2001	Hawaii	2.0	1992	Rhode Island	0.3
2007	Quebec	1.9	2004	Kentucky	0.3
2001	Arizona	1.9	2001	Michigan	0.3
2001	Utah	1.9	2007	Rhode Island	0.3
1995	Arkansas	1.9	1995	California	0.2
2010	Louisiana	1.8	1992	North Carolina	0.2
2004	Alabama	1.8	1995	Nevada	0.2
2010	Idaho	1.8	1995	Kentucky	0.2
1998	Idaho	1.8	2004	Georgia	0.2
1992	Wyoming	1.8	2004	North Carolina	0.2

2004	West Virginia	1.8	2001	Wisconsin	0.2
2004	Arkansas	1.8	2004	Indiana	0.2
2007	Oklahoma	1.8	2007	Pennsylvania	0.1
1998	Iowa	1.8	2010	Ohio	0.1
2004	Iowa	1.8	1992	Nevada	0.1
2007	South Carolina	1.8	1998	Pennsylvania	0.1
2004	Florida	1.8	2004	Pennsylvania	0.1
2004	Wyoming	1.8	1995	North Carolina	0.1
2007	Nebraska	1.8	1992	Georgia	0.1
2007	New Hampshire	1.8	2004	Michigan	0.1
2010	Nevada	1.7	1998	Georgia	0.1
1998	Oklahoma	1.7	1995	Utah	0.1
1992	West Virginia	1.7	1992	Pennsylvania	0.0
1998	Nebraska	1.7	2010	Wisconsin	0.0
2010	Arkansas	1.7	2001	Quebec	0.0
1998	Florida	1.7	1995	Pennsylvania	0.0
2004	Nebraska	1.7	2004	Colorado	0.0
2001	Kentucky	1.7			

Notes: Full sample is divided into two, on the basis of the sign of the RNFT variable. Jurisdictions with positive RNFTs are called net recipients while those with negative values are called net contributors.

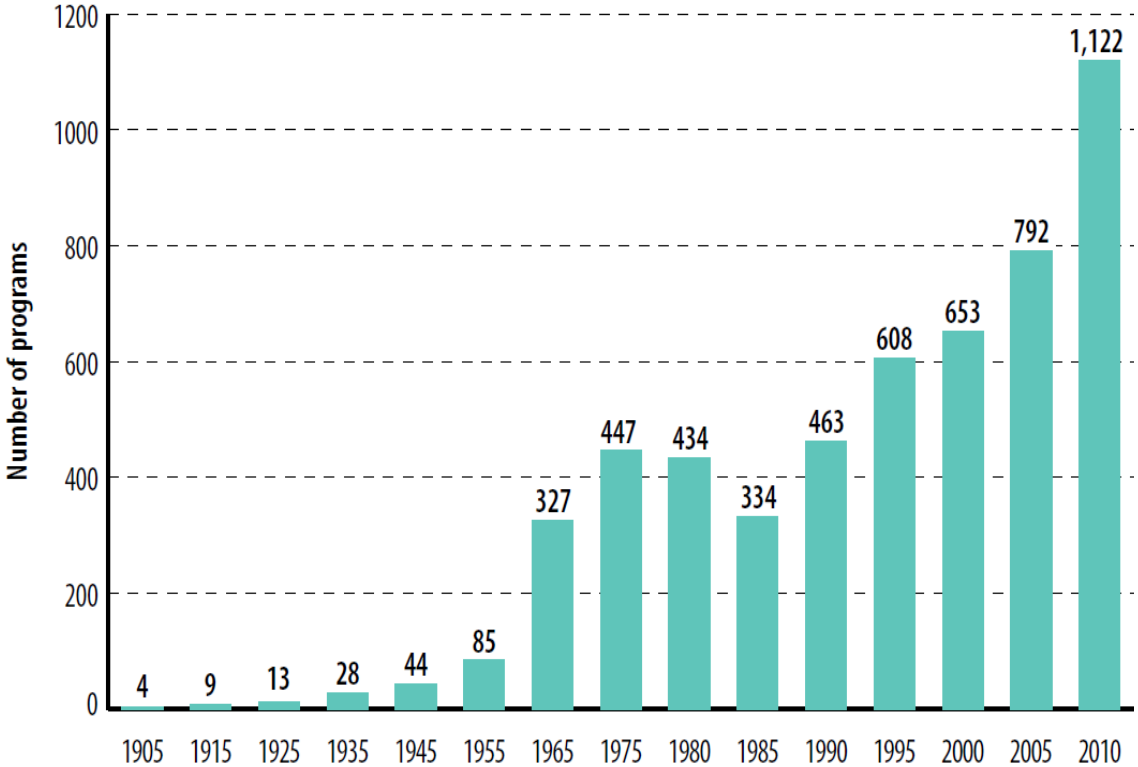
Appendix 3.6: Net Contributors (Full Sample)

Year	Jurisdiction	RNFT (%)	Year	Jurisdiction	RNFT (%)
1992	Indiana	-0.1	2010	California	-1.2
2007	Ohio	-0.1	2007	California	-1.3
1995	Georgia	-0.1	1992	Minnesota	-1.3
2004	Rhode Island	-0.1	1998	New Jersey	-1.3
2004	Wisconsin	-0.1	1995	New Jersey	-1.3
2007	Illinois	-0.2	1995	Oregon	-1.3
2010	Pennsylvania	-0.2	2001	Maryland	-1.5
2010	Delaware	-0.2	2004	New Jersey	-1.5
2007	Colorado	-0.2	1992	Connecticut	-1.6
2001	Oregon	-0.2	1995	Ontario	-1.6
2010	Illinois	-0.3	1992	Delaware	-1.6
2010	Colorado	-0.3	2010	Maryland	-1.6
1995	Indiana	-0.3	1998	Ontario	-1.6
1998	Virginia	-0.3	1995	Delaware	-1.7
2004	Illinois	-0.3	2007	Ontario	-1.7
1992	Michigan	-0.3	2007	Maryland	-1.7
2001	Illinois	-0.3	1992	Alberta	-1.7
1992	Virginia	-0.4	1995	Minnesota	-1.8

1992	Colorado	-0.4	1998	Delaware	-1.8
1992	California	-0.4	2007	New Jersey	-1.8
1998	Ohio	-0.4	2010	New Jersey	-1.9
1992	Ohio	-0.4	2004	Ontario	-1.9
1995	Virginia	-0.4	2001	Ontario	-1.9
2001	Delaware	-0.5	2004	Maryland	-1.9
2001	Colorado	-0.5	1998	Minnesota	-1.9
2010	Oregon	-0.5	1995	British Colum	-2.0
2004	Oregon	-0.5	1995	Maryland	-2.0
1992	Illinois	-0.5	2001	New Jersey	-2.1
1998	California	-0.5	1992	Maryland	-2.1
2007	Delaware	-0.6	1992	New York	-2.2
2004	Delaware	-0.6	1992	Massachusetts	-2.2
2007	Oregon	-0.6	1998	Maryland	-2.2
2001	Minnesota	-0.6	1995	New York	-2.3
1995	Ohio	-0.6	1992	Ontario	-2.4
1992	Wisconsin	-0.6	2001	California	-2.5
2010	Ontario	-0.7	1995	Massachusetts	-2.5
1998	Illinois	-0.7	1998	New York	-2.5
1995	Colorado	-0.7	2001	Alberta	-2.5
1998	Michigan	-0.7	2004	Massachusetts	-2.6
1995	Illinois	-0.7	2010	Massachusetts	-2.8
1998	Oregon	-0.7	2007	Massachusetts	-2.9
1998	Colorado	-0.7	1995	Connecticut	-2.9
1998	Wisconsin	-0.8	1995	Alberta	-2.9
1992	Oregon	-0.8	2004	Alberta	-3.2
2004	Ohio	-0.8	2004	New York	-3.3
2007	Virginia	-0.8	1998	Massachusetts	-3.5
2004	California	-0.8	2001	New York	-3.6
2007	Minnesota	-0.9	1998	Alberta	-3.7
1995	Michigan	-0.9	2004	Connecticut	-3.7
1995	Wisconsin	-0.9	2010	New York	-4.1
1998	British Colum	-1.0	2007	New York	-4.2
2004	Virginia	-1.0	2007	Alberta	-4.4
2001	Virginia	-1.0	2010	Connecticut	-4.5
2004	Minnesota	-1.0	2007	Connecticut	-4.6
2010	Virginia	-1.0	1998	Connecticut	-4.6
1992	New Jersey	-1.1	2001	Massachusetts	-4.8
1992	British Colum	-1.1	2001	Connecticut	-5.4
2010	Minnesota	-1.2	2010	Alberta	-5.7
1992	Hawaii	-1.2			

Notes: In Appendix 7, our full sample is divided into two, on the basis of the sign of the RNFT variable. Jurisdictions with positive RNFTs are called net recipients while those with negative values are called net contributors.

Appendix 3.7: US Federal Aid to the States



Source: Fraser Institute (2013)

Appendix 3.8: OLS Estimation Results for Chapter 3

	[1]	[2]	[3]	[4]	[5]	[6]
Dependent Variable	**lnRRGDP**	**lnRRGDP**	**lnRGDP**	**lnRGDP**	**lnRRGDP**	**lnRGDP**
Log of lagged RGDP			0.835***	0.795***		0.913***
			[0.025]	[0.064]		[0.081]
Log of lagged RRGDP	0.952***	0.952***			0.955***	
	[0.020]	[0.019]			[0.019]	
NFT			-1.341***			-6.964
			[0.329]			[6.015]
RNFT	-0.006	-0.018		2.662	-0.019	
	[0.126]	[0.160]		[5.237]	[0.146]	
Log of lagged RGDP x NFT				-0.389		0.624
				[0.518]		[0.589]
Log of lagged RRGDP x RNFT		-0.089			-0.073	
		[0.275]			[0.263]	
Capital stock	0.018***	0.017**	0.007	0.003	0.018*	0.023
	[0.006]	[0.007]	[0.017]	[0.021]	[0.007]	[0.018]
Educational attainment	0.078**	0.076**	0.233	0.219	0.092*	0.410***
	[0.039]	[0.038]	[0.188]	[0.189]	[0.050]	[0.138]
Constant	-0.036**	-0.035**	1.606***	2.028***	-0.035*	0.779
	[0.014]	[0.014]	[0.227]	[0.641]	[0.021]	[0.831]
Year dummies	No	No	No	No	Yes	Yes
Year fixed effects	No	No	No	No	No	No
Observations	360	360	360	360	360	360
R-Squared	0.960	0.960	0.905	0.905	0.962	0.947

Note: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. RGDP stands for relative GDP per capita; RRGDP stands for relative real GDP per capita; NFT stands for net fiscal transfers; RNFT stands for relative net fiscal transfers.

Appendices to Chapter 4

Appendix 4.1: Mining, GDP Per Capita and EFI (2008-2010)

Jurisdiction	MGDP (%)	RGDP ($'000)	EFI
Wyoming	32.9	67.9	7.6
Newfoundland	28.3	50.4	7.8
Alaska	26.4	68.8	7.6
Alberta	19.2	66.1	8.2
Saskatchewan	12.7	48.8	7.9
West Virginia	12.5	34.5	7.3
Oklahoma	11.3	39.2	7.6
Texas	9.3	47.7	7.7
Louisiana	8.8	47.3	7.5
New Mexico	7.7	39.9	7.3
Montana	5.4	36.8	7.4
North Dakota	5.2	48.9	7.5
Colorado	4.2	50.8	7.6
Nevada	4.1	45.9	7.6
Kentucky	3.6	37.3	7.3
British Columbia	3.0	41.8	7.7
Utah	2.8	42.4	7.6
Nova Scotia	2.4	34.8	7.3
Arkansas	2.1	35.6	7.4
Arizona	2.0	39.6	7.4
Alabama	1.7	36.4	7.4
Mississippi	1.6	31.7	7.2
Manitoba	1.6	39.7	7.5
Idaho	1.6	35.6	7.5
Kansas	1.4	44.2	7.5
New Brunswick	1.3	34.9	7.4
Pennsylvania	1.1	45.4	7.5
California	0.9	52.8	7.5
Vermont	0.8	41.3	7.3
Virginia	0.7	52.1	7.5
Ohio	0.6	42.4	7.4
Minnesota	0.5	50.5	7.5
Indiana	0.5	42.6	7.5
Tennessee	0.5	40.0	7.5
Ontario	0.5	42.3	7.6
Missouri	0.4	42.4	7.5
South Dakota	0.4	45.9	7.5
Quebec	0.4	37.1	7.4

Illinois	0.4	50.8	7.6
Georgia	0.3	42.8	7.6
Michigan	0.3	38.7	7.4
North Carolina	0.3	44.0	7.6
Iowa	0.2	45.8	7.6
Wisconsin	0.2	44.2	7.4
Florida	0.2	39.6	7.4
Nebraska	0.2	48.6	7.6
Washington	0.2	53.5	7.5
Oregon	0.2	48.5	7.6
South Carolina	0.2	35.9	7.4
New Hampshire	0.2	46.7	7.6
Hawaii	0.1	49.5	7.3
Prince Edward	0.1	31.3	7.2
Maryland	0.1	53.4	7.5
New York	0.1	59.5	7.5
Rhode Island	0.1	45.9	7.3
Connecticut	0.1	65.0	7.6
New Jersey	0.1	56.3	7.4
Massachusetts	0.0	59.8	7.5
Maine	0.0	38.4	7.3
Delaware	0.0	62.6	7.7

Notes: Appendix 8 depicts the mining share of GDP (MGDP), real GDP per capita and Economic Freedom Index (EFI) for all 60 Canadian and US jurisdictions for the 2008-2010 period, sorted on MGDP. As previously discussed, Wyoming and Delaware in the US and Newfoundland and Prince Edward Island in Canada take the first and last positions, respectively. The table also reveals that there is actually no much variation in EFI for all the regions. On average though, Canadian provinces seem to have a higher level of economic freedom than their US counterparts.

Appendix 4.2: Employment-based Diversity Indices (2008-2010)

Jurisdiction	QGV	AGV	ENT	HHI	KRUG
Massachusetts	2.03	0.85	1.60	0.30	0.15
Rhode Island	1.86	0.78	1.61	0.29	0.12
Nevada	1.85	0.85	1.64	0.28	0.19
New York	1.84	0.89	1.62	0.28	0.13
Maryland	1.74	0.87	1.64	0.27	0.13
Florida	1.72	0.85	1.66	0.27	0.14
Nova Scotia	1.68	0.85	1.70	0.26	0.13
Hawaii	1.67	0.93	1.62	0.26	0.16
British Columbia	1.66	0.80	1.74	0.26	0.10
Virginia	1.61	0.87	1.67	0.26	0.12
Pennsylvania	1.60	0.78	1.71	0.26	0.09
New Jersey	1.56	0.81	1.70	0.26	0.10
California	1.55	0.80	1.72	0.25	0.06

Michigan	1.54	0.79	1.70	0.25	0.10
Newfoundland	1.54	0.82	1.72	0.25	0.20
Connecticut	1.53	0.81	1.70	0.25	0.10
Quebec	1.52	0.82	1.75	0.25	0.08
Ontario	1.51	0.79	1.76	0.25	0.06
Vermont	1.50	0.81	1.70	0.25	0.11
New Brunswick	1.50	0.77	1.77	0.25	0.09
Colorado	1.49	0.81	1.73	0.25	0.09
Illinois	1.48	0.75	1.73	0.25	0.08
New Mexico	1.46	0.88	1.71	0.24	0.18
Ohio	1.44	0.76	1.73	0.24	0.08
Minnesota	1.44	0.75	1.72	0.24	0.06
New Hampshire	1.43	0.78	1.73	0.24	0.11
Arizona	1.43	0.82	1.74	0.24	0.08
Georgia	1.36	0.76	1.76	0.23	0.05
Manitoba	1.36	0.72	1.84	0.24	0.09
Oregon	1.35	0.76	1.74	0.23	0.07
Missouri	1.35	0.76	1.73	0.23	0.04
Prince Edward	1.34	0.76	1.76	0.23	0.23
Washington	1.33	0.78	1.75	0.23	0.08
North Carolina	1.32	0.77	1.75	0.23	0.09
Maine	1.29	0.68	1.70	0.24	0.09
Tennessee	1.29	0.73	1.76	0.22	0.09
Delaware	1.28	0.65	1.68	0.25	0.09
Montana	1.23	0.79	1.76	0.21	0.16
Alberta	1.23	0.68	1.89	0.22	0.20
Louisiana	1.22	0.75	1.83	0.22	0.14
South Carolina	1.22	0.77	1.77	0.22	0.13
Utah	1.21	0.76	1.79	0.22	0.09
West Virginia	1.21	0.80	1.80	0.22	0.19
Indiana	1.21	0.76	1.78	0.22	0.15
Wisconsin	1.20	0.75	1.76	0.21	0.15
Texas	1.17	0.70	1.83	0.21	0.09
Alaska	1.17	0.82	1.84	0.22	0.35
Alabama	1.12	0.74	1.80	0.21	0.15
Saskatchewan	1.12	0.66	1.94	0.21	0.20
Idaho	1.11	0.73	1.79	0.20	0.11
Nebraska	1.09	0.71	1.79	0.20	0.10
Kansas	1.08	0.72	1.81	0.20	0.14
Kentucky	1.06	0.72	1.81	0.20	0.15
Mississippi	1.05	0.75	1.81	0.20	0.21
Oklahoma	1.04	0.73	1.82	0.20	0.18
South Dakota	1.03	0.72	1.78	0.19	0.11
Arkansas	1.03	0.71	1.83	0.20	0.17
Iowa	1.00	0.69	1.80	0.19	0.14
North Dakota	0.98	0.74	1.81	0.19	0.19

Wyoming	0.80	0.66	1.90	0.17	0.35

Notes: Appendix 9 shows our five diversity measures which are based on the distribution of employment across 10 industry sectors; sorted on QGV. Considering that diversity measures are sensitive to the number of industries used, we include four and six broad categories for the goods- and services-producing sectors, respectively. Our employment variable is the annual employment in full-time equivalents, a common indicator for industry structure.

Appendix 4.3: GDP-based Diversity Indices (2008-2010)

Jurisdiction	QGV	AGV	ENT	HHI	KRUG
West Virginia	3.12	1.03	2.19	0.52	0.89
Delaware	1.47	0.93	1.68	0.25	0.39
New York	1.36	0.93	1.71	0.24	0.27
Massachusetts	1.32	0.88	1.72	0.23	0.21
Rhode Island	1.13	0.86	1.78	0.21	0.19
Maryland	1.10	0.90	1.78	0.21	0.23
Connecticut	1.09	0.85	1.78	0.21	0.20
Virginia	1.09	0.85	1.81	0.21	0.19
Hawaii	1.03	0.90	1.79	0.20	0.34
Nevada	1.03	0.75	1.88	0.20	0.25
Florida	1.00	0.79	1.85	0.20	0.18
Pennsylvania	1.00	0.77	1.87	0.20	0.11
New Jersey	0.98	0.76	1.83	0.20	0.15
Colorado	0.97	0.75	1.91	0.20	0.15
California	0.95	0.79	1.88	0.20	0.08
New Hampshire	0.94	0.77	1.84	0.19	0.10
Illinois	0.87	0.74	1.89	0.19	0.10
Ontario	0.87	0.78	1.89	0.19	0.15
Missouri	0.86	0.73	1.91	0.19	0.08
Washington	0.86	0.77	1.90	0.19	0.10
Minnesota	0.84	0.73	1.92	0.18	0.09
Vermont	0.84	0.74	1.91	0.18	0.09
Oregon	0.84	0.80	1.89	0.18	0.30
Indiana	0.83	0.75	1.91	0.18	0.34
Michigan	0.83	0.76	1.89	0.18	0.12
Maine	0.82	0.73	1.90	0.18	0.09
British Columbia	0.80	0.69	1.97	0.18	0.14
Ohio	0.79	0.76	1.91	0.18	0.11
Newfoundland	0.78	0.72	1.98	0.18	0.51
Tennessee	0.78	0.71	1.92	0.18	0.14
Georgia	0.78	0.70	1.92	0.18	0.07
North Carolina	0.77	0.81	1.90	0.18	0.21
Wyoming	0.75	0.63	1.99	0.18	0.72
Wisconsin	0.75	0.76	1.92	0.17	0.15
Prince Edward	0.74	0.66	1.95	0.17	0.32
New Mexico	0.73	0.72	1.97	0.17	0.36
Arizona	0.73	0.69	1.96	0.17	0.12

Quebec	0.71	0.69	1.96	0.17	0.15
Alaska	0.70	0.72	1.96	0.17	0.74
Nova Scotia	0.68	0.63	2.02	0.17	0.17
South Carolina	0.66	0.72	1.94	0.17	0.20
Utah	0.64	0.69	1.98	0.16	0.12
South Dakota	0.61	0.63	2.01	0.16	0.28
Kansas	0.60	0.66	2.02	0.16	0.18
Alabama	0.57	0.67	2.01	0.16	0.22
New Brunswick	0.57	0.56	2.04	0.16	0.17
Iowa	0.56	0.67	2.01	0.16	0.24
Arkansas	0.53	0.60	2.05	0.15	0.18
Idaho	0.52	0.61	2.06	0.15	0.16
Montana	0.52	0.61	2.08	0.15	0.29
Kentucky	0.51	0.63	2.05	0.15	0.24
Mississippi	0.51	0.63	2.05	0.15	0.28
Alberta	0.51	0.60	2.11	0.16	0.33
Manitoba	0.50	0.55	2.08	0.15	0.18
Nebraska	0.49	0.57	2.05	0.15	0.21
Texas	0.46	0.52	2.08	0.15	0.25
Louisiana	0.45	0.56	2.08	0.15	0.35
Oklahoma	0.45	0.55	2.08	0.14	0.30
North Dakota	0.28	0.43	2.18	0.13	0.33
Saskatchewan	0.28	0.44	2.23	0.14	0.39

Notes: Following Appendix 9 above, some authors (e.g. Palan, 2010) suggest the use of an alternative variable, other than employment, in the construction of the indices. This is in order to address issues related to productivity biases. Appendix 10 therefore shows the same five diversity measures (still sorted on QGV), but this time, based on the distribution of GDP across the same 10 industry sectors.

Appendix 4.4: OLS Estimation Results (Resource-Diversity-Growth Nexus)

Dependent Variable	lnRGDP	lnRGDP	lnRGDP	lnRGDP	lnRGDP
Diversity Index Used	**Herfindahl**	**Absolute Ogive**	**Quadratic Ogive**	**Entropy**	**Krugman**
Log of lagged RGDP	0.778***	0.787***	0.774***	0.763***	0.738***
	[0.029]	[0.023]	[0.030]	[0.029]	[0.019]
Diversity	-0.020	-0.044	0.007	-0.105	0.009
	[0.116]	[0.250]	[0.065]	[0.302]	[0.012]
Natural resources	-0.003	0.009	0.008**	-0.007	-0.011**
	[0.031]	[0.014]	[0.004]	[0.030]	[0.005]
Diversity x natural resources	-0.007	0.009	-0.002	0.026	-0.451***
	[0.019]	[0.03]	[0.011]	[0.048]	[0.133]
Capital stock	0.044	0.048*	0.041	0.043	0.036
	[0.028]	[0.025]	[0.029]	[0.029	[0.022]
Educational attainment	0.195***	0.197***	0.196	0.197***	0.228***
	[0.036]	[0.036]	[0.036]	[0.037]	[0.032]
Constant	2.703	2.636***	2.787***	2.961***	3.110***
	[0.426]	[0.291]	[0.356]	[0.381]	[0.00]
Year dummies	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No
Observations	360	360	360	360	360
R-Squared	0.895	0.595	0.895	0.896	0.902

Notes: Figures in parentheses are robust standard errors. * significant at 10%; **significant at 5%; ***significant at 1%; no sign means not significant at 1%, 5% and 10%. The natural resources variable is constructed as the mining share of GDP; all five diversity measures are constructed using employment distribution for the 10 chosen sectors.

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