PUTTING THE "STONE" BACK IN CAPSTONE: CONCRETE SOLUTIONS FOR REDUCING MINERAL AGGREGATE CONSUMPTION IN ONTARIO

by

Stephen Healey
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Name: **Stephen Healey**

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Title of Capstone: **Putting the "Stone" Back in Capstone: Concrete Solutions for Reducing Mineral Aggregate Consumption in Ontario**

Examining Committee:

Chair: **Nancy Olewiler**
Director, Public Policy Program, SFU

Nancy Olewiler
Senior Supervisor
Director, Public Policy Program, SFU

Jon Kesselman
Supervisor
Professor, Public Policy Program, SFU

Benoit Laplante
Internal Examiner
Adjunct Professor, Public Policy Program, SFU

Date Defended/Approved: March 19, 2010

Abstract

A number of environmental problems occur from the extraction, processing, distribution, and disposal of mineral aggregates. While aggregates are essential inputs into the construction of buildings and roads, regions that use more aggregates per capita will have more significant deleterious environmental impacts than regions that use less. This study investigates potential causes of the above average per capita use of mineral aggregates in Ontario. To discern broad factors influencing aggregates use for Canada as a whole, a panel regression on six provinces for the years 1987-2003 was undertaken. A case study contrasts aggregates use in Ontario from Quebec and British Columbia to uncover some specific ways in which Ontario differs from other provinces. The results suggest that Ontario could reduce its use to levels found elsewhere in Canada without compromising economic activity, and concludes with an analysis of policy options aimed at reducing the use of mineral aggregates in Ontario.

Keywords: Aggregates; Demand; Use; Consumption; Extraction; Landfill; Urban Form

Executive Summary

Aggregate refers to crushed stone, sand, and gravel, and is a major raw material to construct buildings, homes, roads, highways, bridges, and drainage systems. From its use, we derive important infrastructure services such as improved mobility, sanitation, and shelter. However, the extraction, processing, and distribution of mineral aggregates creates a host of environmental problems that include degradation of agricultural and natural areas, contamination of ground water, particulate and noise pollution, and greenhouse gas emissions from all phases of production. Thus, regions that use more aggregates per capita will have more significant deleterious environmental impacts than regions that use less. Ontario uses more aggregates than other Canadian provinces. This study investigates potential causes of the above average use of mineral aggregates in Ontario.

First, to discern broad factors influencing aggregates use for Canada as a whole, a panel regression on six provinces for the years 1987-2003 was undertaken. Independent variables include population density, climate, construction activity, housing composition, the price of lumber, and the unit price of aggregates. The regression involved a fixed-effects panel regression to control for factors that were province specific, but time invariant. This essentially entails specifying the model with a binary variable for each province.

The regression found most variables to be statistically significant at the 5% level with the notable exceptions of lumber price and construction activity. Additionally,

climate had the opposite sign than expected. Despite most of the variables in the regression being statistically significant, its explanatory power was low when excluding the dummy variables representing province-specific factors. This was especially evident with the regression's ability to explain inter-provincial variation in the dependent variable. The regression concludes that time-invariant, province-specific factors, which might include institutional factors, building trends, or the regulatory framework, were important in explaining some of the variation between provinces in per capita aggregates use. Furthermore, even when these time-invariant but location specific factors are incorporated into the model, through the provincial binary variables, the adjusted R^2 of only 62% suggests that there may be important factors explaining aggregates production per capita that are not explicitly stated in the panel regression.

Consequently, the second part of this paper is a case study to examine some of these factors in detail, in the hopes of explaining why Ontario may be different. It contrasts aggregates use in Ontario with that of Quebec and British Columbia, two provinces with relatively low per capita use. Factors considered include construction activity, population density, climate, prices, zoning by-laws and standards, building trends, recycling trends, as well as the regulatory framework pertaining to aggregates mining in each province.

It was found that housing stock composition, single-detached house building style, commercial building trends, trends in road growth, and off-street parking minimums for commercial buildings and restaurants were all potentially important factors in explaining the case-by-case variation in the dependent variable. The importance of urban form in explaining the inter provincial differences in per capita aggregates use was discerned from this exercise, as well as the fact that likely Ontario has room to decrease its per capita aggregates use without seriously compromising the benefits it receives from its infrastructure services.

After a thorough analysis of the policy options suggested by the case study, this paper recommends implementing both an extraction tax and a landfill tax to reduce per capita aggregates use in Ontario in the short term. Following this should be an investigation of policies aimed at improving urban density over the long-term. These would include, but are not limited to, policies such as changing of zoning by-laws, impact fees, density bonuses, infilling vacant land, and transfer of development rights. An in depth assessment of these policies needs to be done to determine which ones would work best for Ontario. In addition, there is room to improve the current regulatory regime in Ontario to reduce the negative externalities associated with aggregates use.

Dedication

To my family, who supported me the entire way, to my friends, and to all others who are close to me. You know who you are.

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I would like to thank my supervisor Nancy Olewiler for the great advice throughout the course of this project. She always kept me focused on the big picture, and prevented me from getting lost on wild tangents that I was far too eager to pursue. Without her help, I would either still be writing, or would have been hospitalized from a nervous breakdown. Thank you Nancy. I would also like to thank Dominique Gross and Benoit Laplante for their excellent suggestions regarding many key aspects of the paper, as well as Mark Jaccard, Marvin Shaffer, Doug MacArthur, and Kennedy Stewart for broadening my knowledge of environmental policy and public policy more generally.

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List of Acronyms:

Aggregate Resources Act (ARA)

Canadian Home Builders Association (CHBA)

Construction and Demolition (C&D)

Criteria Air Contaminant (CAC)

Cumulative Environmental Effect (CEE)

Development and Infrastructure Policy Standards (DIPS)

Greater Toronto Area (GTA)

Greater Vancouver Regional District (GVRD)

Greenhouse Gases (GHG)

Gross Domestic Product (GDP)

Hot Mix Asphaltic Concrete Cement (HMAC)

Ministry of Transportation of Ontario (MTO)

Natural Resources Canada (NRCAN)

Ontario Ministry of Natural Resources (OMNR)

Ontario Municipal Board (OMB)

Ontario Provincial Specification Standards (OPSS)

PALS (Preservation of Agricultural Land Society)

Pits and Quarries Control Act (PQCA)

Recycled aggregate pavement (RAP)

Reclaimed Concrete Material (RCM)

Stop the Operation of More Pits (STOMP)

The Ontario Aggregate Resources Commission (TOARC)

United States Geological Survey (USGS)

Urban Growth Boundary (UGB)

1: Introduction: Framing the Problem

One of the great challenges to public policy is the reconciliation of ongoing economic growth with environmental stewardship. Nowhere is this tug-of-war more apparent than aggregate mining industry of Ontario. Aggregate refers to crushed stone, sand, and gravel, and is a major raw material to construct buildings, homes, roads, highways, bridges, and drainage systems. This makes aggregate a key material for the functioning of an industrial economy. From its use, we derive important infrastructure services such as improved mobility, sanitation, and shelter.

At the same time, however, the extraction, use, and disposal of aggregate results in a number of negative environmental externalities. The extraction of aggregate involves the permanent alteration of the environment by the removal of nearly all vegetation, topsoil, and subsoil (Taylor & Winfield, 2005). It also involves disrupted stream flows from changing the slope of the land, and damage to aquifers[1] (Baker & Shoemaker, 1995). All of the above, plus the heavy trucking and road construction to access the site, causes considerable ecological damage (Taylor & Winfield, 2005).

While some of the aforementioned issues can be resolved via reclamation of the mine after use, many of these effects cause irreversible damages. Rehabilitated areas often loose soil quality, drainage capabilities, and agricultural potential relative to what was present before extraction (Gravel Watch, 2009). Likewise, damage to aquifers,

[1]Sand and gravel deposits formed the aquifers for groundwater storage; large scale mining of these resources can affect groundwater flow and storage in an uncertain manner

groundwater flow, and habitat loss for many plant and animal species tend to be irreversible.

Other negative externalities include criteria air contaminants (CACs), nuisance dust, noise pollution, aesthetic impacts, smog precursors, as well as greenhouse gases (GHGs) from the heavy equipment and trucks used during the extraction phase. Compounding these issues is the requirement for aggregate producers to access the resource as close as possible to markets to minimize transportation costs.[2] Finally, at the end of their useful life, aggregates become waste in the waste stream. Given the current waste disposal architecture in Ontario, this means greater use of already crowded landfills, with their own set of negative environmental externalities. In 2002, 1.2 million tonnes of construction and demolition (C&D) waste was disposed in Ontario landfills, making 10% of the total waste disposed (Baetz & Saotome, 2007).

The pervasiveness of these negative externalities in Ontario, and their growth over the years, has resulted in considerable citizen discontent. Baker and Shoemaker (1995) refer to the conflict that has pervaded since the 1970s as *"aggregate wars"* which become, they argue, *"a virtual tradition in southern Ontario over the past two decades."* Between 1980 and 1994, over 150 hearings have sought to resolve disputes between various stakeholders and aggregates producers (Baker & Shoemaker, 1995). A report by the Environmental Commissioner of Ontario notes that, *"Aggregate operations are a chronic source of complaints to MNR, to the Ministry of the Environment, and to the ECO"* (Environmental Commissioner of Ontario, 2003).

[2] The above taken from Taylor and Winfield, 2005.

How do we handle these externalities? The optimal policy would be to tax them at a rate equal to their marginal external costs. Unfortunately, the numerous issues associated with aggregate use would require a slew of taxes, one for noise, one for CACs, one for waste, one for GHG's etc, which may not be politically feasible or administratively tractable. Likewise, the suitability of these instruments in addressing the damages done to ecosystems or groundwater, which are both site-specific and an irreversible function of the production process itself, is unclear. Consequently, the current approach in Ontario involves regulating the aggregates industry to reduce negative externalities. A more thorough description of the existing regulatory regime is located in Section 2.

Given the existing level of citizen dissatisfaction, however, it is clear that the current approach does not address all the concerns of Ontario citizens (Baker and Shoemaker, 1995). One particular example of the current regulatory regime's inadequacy is in dealing with cumulative environmental effects (CEE), which are the combined effects of numerous mines in a given location. These are largely unaccounted for because government assesses the environmental impact of each mine on an individual basis (Baker & Shoemaker, 1995).

Stemming from this, one approach to improve the situation in Ontario would be to expand the existing regulatory framework to account for CEE and other issues. In investigating this possibility, I observed that Ontario produces more aggregates per person than the Canadian average, and far above comparable jurisdictions in Europe. Thus, a first-step strategy in reducing the aforementioned externalities in Ontario may be to reduce production in line with comparable jurisdictions.

This promises to be an attractive option if it is found that Ontario receives no incremental net benefit, in terms of improved infrastructure services, from its higher use, getting instead *"less with more"* from its increased production of aggregate. If, on the other hand, Ontario gets *"more with more"*- whereby the incremental benefits from above average production exceed the incremental costs- than such an approach may not be justified. Unfortunately, no complete cost-benefit analysis estimating the net benefits of above average aggregate production in Ontario was in the literature.

With this in mind, this paper investigates the policy problem that *Ontario uses too many aggregates relative to other comparable jurisdictions.* While not explicitly conducting a formal cost-benefit analysis on the subject, this paper seeks to answer the question *"Why is per capita aggregates use higher in Ontario than in other Canadian jurisdictions?"* By answering this question, this paper can shed some light on whether Ontario is receiving *"more with more"* or *"less with more"* from its above average production and, if it is receiving *"less with more"*, what policy can do about it. The structure of the paper is as follows. Section 2 provides additional background information defining the policy problem, on aggregates mining more generally, and on the regulatory history of the aggregates industry in Ontario. Section 3 outlines the methodology used in the study. Sections 4 and 5 provide the regression and case study components of the data analysis section. Section 6 and 7 provides policy alternatives and an evaluation of those alternatives. Section 8 recommends a course of action, while section 9 concludes.

Aggregates are a high bulk, low value item, where transport costs make up a considerable portion of total costs. Consequently, trade in aggregates between jurisdictions is limited. These same characteristics make storage of aggregates uneconomic. Thus, the key assumption made in this paper is that, for the majority of jurisdictions, supply equals demand and annual production of aggregates represents annual use. Thus, I refer to per capita aggregates production, per capita aggregates demand, and per capita aggregates interchangeably in this paper.

2: The use of Aggregate, Ontario's Aggregate Industry, and the Policy Problem

2.1 What are aggregates? What are their uses?

Aggregate refers to crushed stone, sand, and gravel. These commodities are inputs in the construction of buildings, homes, roads, highways, bridges, and drainage. In addition, the production of glass, paint, plastics, fertilizers, steel, and pharmaceuticals also contain aggregates.[3] Primary aggregate is the aggregate found in nature, while manufactured/secondary aggregate is the aggregate obtained as a by-product of other industrial processes. Examples of manufactured aggregates include coal-fired power station ash, blast furnace slag, incinerator ash, and slate waste. Secondary aggregate also includes recycled aggregate formed from discarded construction materials.[4]

Crushed stone comes from formations of limestone, dolomite, igneous rock, and sandstone. The suitability of crushed stone for use as aggregate depends on its strength, durability, relative density, water absorption, and absence of impurities. Stone with water absorptions below 2% have low porosity, and correspond to a quality sufficient for use as aggregate.[5]

The 2004 EU Standards define gravel as particles between 4mm and 80mm, while sand comprises smaller particles between 0.063mm and 4mm. The two only differ with respect to particle size, with both derived from the weathering and erosion of rocks by

[3] The above was taken from Taylor & Winfield, 2005

[4] Additionally, construction aggregate refers to common materials such as sand, crushed rock, and gravel. Industrial aggregate refers to precious and dimension stone.

[5] To be used in concrete, however, stone should have porosity below 1%

glacial action and wind. In addition, the extraction of sand and gravel from coastal waters occurs through a process known as marine dredging. Generally, the highest quality gravel is the youngest and the least altered. This gravel is located in the floodplains and lower terraces of large streams.[6]

2.2 Extraction, processing, and economics

The costs of transporting high-bulk aggregates, relative to their market value, means that close proximity to their target market is favourable with respect to profitable production and extraction (Taylor & Winfield, 2005). For similar reasons, the build up of inventories within the industry is practically non-existent. The near total absence of imports/exports and the absence of inventories means that, for most practical purposes, total demand is assumed to equal total production (Poulin et al., 1994).

Demand for aggregates is a derived demand, with 90% of crushed stone, and 95% of sand and gravel used in the construction industry. Public works use approximately half of all the aggregates in construction, with the remainder used for private building construction. Economic cycles and interest rates typically govern private building construction, while public works construction is frequently politically driven and a function of government funding. Generally, aggregates production follows the business cycle.[7] Other factors that are influential on aggregates demand include population, the price of substitute materials, as well as changes in the structural design of buildings and roads (O'Brian, 2006). Climate is also significant due to its impact on road maintenance costs (Natural Resources Canada, 2005).

[6] The previous three paragraphs are taken from The British Geological Survey, 2007.
[7] The above was taken from Poulin et al., 1994.

Significant economies of scale in the industry, due to large upfront capital cost requirements, have led to its increasing concentration (Poulin et al., 1994). In addition, increasing environmental regulations and land use conflicts have further promoted this concentration by forcing aggregate producers away from their core market. This has led to higher transport costs, making many smaller firms uncompetitive (Poulin et al., 1994).

Generally, crushed rock comes from quarries that are larger than sand and gravel quarries, with outputs ranging from 100,000 tonnes per year to 5 million tonnes per year. Thus, crushed rock quarries require lots of investment in both plant and equipment (British Geological Survey, 2007). The economies of scale in aggregate extraction may explain the trend of increasing use of crushed stone relative to sand and gravel (Poulin et al, 1994). Extraction of crushed rock involves the removal of overburden with hydraulic excavators, ripping, and blasting. The screening for impurities and the crushing of material into specified size grades follows (British Geological Survey, 2007).

Sand and gravel operations, on the other hand, have outputs in the range of 100,000 to 1 million tonnes per year. In practice, however, sites larger than 500,000 tonnes per year are rare. Like crushed rock, the excavation stage involves the removal of overburden.[8] Processing then consists of clay removal, separation of the sand fraction, grading into different sizes, sand classification, dewatering, and crushing of oversized gravel (British Geological Survey, 2007).

[8] The amount of overburden determines what deposits of sand/gravel are viable from an economic standpoint with overburden to mineral ratios ideally not exceeding 2:1.

2.3 The aggregate industry in Ontario

Combining its use as fill, as road bed surfacing, as ice control, and as asphalt aggregate, 49% of total sand and gravel production is somehow related to road construction and repair, while 12.6% are used in concrete (Natural Resources Canada, 2005). There are currently almost 2,800 pits and quarries on private land, and another 3,200 on Crown land, in Ontario (Taylor & Winfield, 2005). Much of the demand for aggregates within Ontario comes from the ever-expanding Greater Toronto Area (GTA), which consumes about 30 percent of total production (Baker & Shoemaker, 1995). Over 75 per cent of the GTA's aggregate comes from two key areas: the Niagara Escarpment and the Oak Ridges Moraine (Taylor & Winfield, 2005).

Table 1 compares Ontario's per capita aggregates production to a number of domestic and international jurisdictions

Table 1: Per Capita Aggregates Consumption across Jurisdictions

	Per Capita Aggregates Production	Year
Canada		
Alberta	14.4	2004
British Columbia	9.9	2004
Manitoba	12.4	2004
New Brunswick	11.2	2004
Newfoundland	14.2	2004
Nova Scotia	12.5	2002
Ontario	12.9	2004
Prince Edward Island	1.2	2002
Quebec	10	2004
Saskatchewan	12	2004
Median (Canada)	12.2	2004
International		
Austria	11.6	2006
Belgium	6.1	2006
Czech Republic	5.1	2006
Denmark	7.1	2006
France	6.6	2006
Finland	18.7	2006
Germany	6.4	2006
Italy	6.1	2006
Norway	11.1	2006
Poland	3.9	2006
Portugal	8.4	2006
Republic of Ireland	25.1	2006
Spain	10.1	2006
Sweden	8.3	2006
Switzerland	7.1	2006
UK (Great Britain)	4.8	2006
United States	10.4	2006
Median (International)	7.1	2006

*Canadian and US data were from Statistics Canada and the United States Geological survey (USGS) respectively. European Data was from Bleischwitz (2006).

Ontario's per capita production of aggregates is 12.9 tonnes per year, higher than almost all other jurisdictions, and considerably above the international median of 7.1 tonnes per person. Likewise, it is also slightly above the Canadian median of 12.2 tonnes per person. Ontario produces more aggregates per capita than any other country, except

Finland and the Republic of Ireland, and more than most Canadian provinces.[9] This snapshot of one year, however, understates the persistence of Ontario's relatively high production over the past fifteen years, as shown in Table 2.

Table 2: Ontario Aggregates Production Per Capita

Year	Aggregates Production Per Capita
1986	17.6
1987	19.3
1988	20.1
1989	19.5
1990	15.6
1991	13
1992	12
1993	12.2
1994	12.6
1995	11.9
1996	12.3
1997	12.9
1998	12.9
1999	13.7
2000	14.6
2001	14
2002	13.6
2003	13.5
2004	14
2005	13.9
2006	14.1
2007	13.5
2008	12.9

Source: Aggregate Producers Association of Ontario Website

The table illustrates that the per capita rate increased considerably in the late 1980s, followed closely by a precipitous drop in 1990. The rate continued to fall, reaching its lowest point in 1995 before rising to a rate of approximately 14 tonnes per capita in the early years of the 21st century.

The data used above, provided by the Ontario Aggregate Resources Commission (TOARC), is inconsistent with the Statistics Canada data used in Table 1.[10] TOARC

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[9] Only Alberta and Newfoundland are higher.

reports persistently higher production figures than Statistics Canada due to the calculation method used.[11]

2.4 GDP vs. population: which is the better weight?

Some argue that high economic activity necessitates the high per capita production figures seen in Ontario relative to other places. Thus, one should consider both aggregates production per capita as well as aggregates production per unit GDP when making comparisons across jurisdictions. There are viable arguments for the appropriateness of either weight. While construction of commercial buildings likely depends on the level of economic activity, and therefore the level of GDP, residential housing is probably a function of population, with more people requiring more shelter. For transport and other infrastructure, both benchmarks have their merits. More people necessitate the construction of more roadways and utilities to avoid overtaxing the existing stock. At the same time, however, greater economic activity results in greater use of infrastructure, requiring its expansion.

From the standpoint of externalities, aggregates production per person may be a more credible measure. This is because the direct economic output from aggregates use, the building of infrastructure, may have a total value that is a small fraction of GDP, yet be large with respect to physical output and environmental consequences. Thus, jurisdictions that are more service oriented than others will likely see lower aggregates production per unit of GDP, even if their per capita production is high.

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[10] Taken from the TOARC Website

[11] TOARC calculates annual production based on the amount of permits allocated rather than the amount of aggregate shipped, as was the case with Statistics Canada.

Average aggregates production per unit GDP for a selection of jurisdictions between the years 1989-2005 illustrated in Table 3.

Table 3: Aggregates use per $1000 GDP

Countries (1999-2006)	Aggregates use per $1000 GDP
UK	0.129
France	0.218
Germany	0.168
Sweden	0.278
Denmark	0.357
Austria	0.195
Belgium	0.172
Czech Republic	0.205
Hungary	0.328
Norway	0.201
Poland	0.223
Spain	0.319
Provinces (1989-2005)	
Ontario	0.357
Quebec	0.324
Alberta	0.322
British Columbia	0.357
Newfoundland	0.418
Nova Scotia	0.493
PEI	0.154
New Brunswick (1994-2005)	0.423
Manitoba (1994-2005)	0.430

Even when measured with this alternative measure, aggregates production is still high in Ontario, averaging 0.36 tonnes per $1000 of GDP over the period[12]. This compares to an average of 0.29 tonnes per $1000 of GDP across all jurisdictions. Using this measure, Ontario is no longer above other Canadian jurisdictions, which also average 0.36 tonnes per $1000 dollars. However, Canadian jurisdictions still have higher values than the European countries in the above table.

[12] GDP figures obtained from Statistics Canada, calculated using 2002 Chained Dollars

2.5 History of the aggregate industry/regulation in Ontario

The history of aggregate industry regulation in Ontario is one of consolidating provincial power at the expense of the municipalities. Prior to the 1950s, few regulations covered extraction due to the small scale of the operations, as quarries generally produced the minimum required to supply local needs. The mid 1950s, however, saw increasing economic growth and a rising suburban population. This changed the nature of aggregates mining as larger corporations, reaping economies of scale, began to develop large pits in rural areas in order to ship materials to rapidly growing cities. The growth of the industry between 1950 and 1970 was enormous. In Southern Ontario, per-capita consumption of aggregates rose from 3.86 tomes in 1950 to 14.33 tonnes in 1966.[13]

The expansion within the industry was associated with the growth of negative externalities, which engendered the sporadic introduction of various municipal laws. Control of aggregates production was at the municipal level, through the control of the establishment of new pits and quarries and by regulating their operation via the *"Official Plan"* of each municipality[14], regulatory by-laws, and restricted-area zoning by-laws (Baker et al., 2001).

Despite these measures, aggregates use continued to expand, and the issues with their extraction continued. These setbacks led to the argument that municipalities lacked perception relating to the size of the aggregates industry and its rate of expansion. The passing of the Pits and Quarries Control Act (PQCA) in 1971 established provincial control of aggregate resources though a licensing system that was enforced by the

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[13] The above paragraph was from Baker et al., 2001.

[14] The Official Plan allowed municipalities to control aggregate extraction through policies and guidelines relating to location criteria, operational regulations, and site requirements. While Official Plans were not required for municipalities to enact restrictive by-laws, once a municipality had a plan in place, all by-laws had to conform to its requirements.

Ontario Ministry of Natural Resources (OMNR). This Act applied to the major aggregate production areas of Southern Ontario, Sudbury and Sault Ste. Marie. The OMNR was to act as a central planning agency, streamlining numerous agencies and regulations that had previously complicated the management of aggregate resources (Baker et al., 2001).

Weak regulation[15] and enforcement of the Act resulted in little improvement (Baker et al., 2001). Southern Ontario continued to witness conflict as interest groups, often backed by municipal governments, tried to stop aggregate mining in environmentally sensitive areas (Taylor & Winfield, 2005).[16] A number of lobby groups against aggregates extraction such as the Preservation of Agricultural Land Society (PALS) and the Stop the Operation of More Pits (STOMP) formed during this time (Baker et al., 2001).

In theory, the Ontario Municipal Board (OMB) was to resolve conflicts over aggregates extraction and planning issues. The OMB is a quasi-judicial, provincially appointed tribunal that conducts hearings into grievances under the Planning Act[17]. Scholars have identified numerous problems with the OMB such as political influence[18], an inability to deal with CEE due to resolving conflicts on a case-by-case basis,

[15] The rehabilitation bond required for a site licence. The security deposit of $500 per acre or two cents per ton (whichever is greater) often was an insufficient fee to cover the cost of reclamation. As a result, operators often forfeited the bond money rather than rehabilitate the site.

[16] The areas where the majority of aggregates extraction takes place, The Niagara Escarpment and the Oak Ridges Moraine, are also areas natural heritage sites of considerable environmental significance (Taylor & Winfield, 2005)

[17] The Planning Act is the provincial Act from which emerged municipalities zoning powers over aggregates.

[18] Unlike the courts, which are bound by precedent, OMB rulings are made within a frame of reference that is shaped by the policies and procedures of the government of the day.

accountability issues[19], as well as the inequity of resources between citizens and aggregate companies for the hearings.[20]

A number of expensive aggregate mining cases involving the OMB, such as the Puslinch hearings of 1988-1990, led to the OMNR to incorporate citizen concerns more fully in the policy process (Baker et al., 2001). Municipalities, despite their stake in local citizen concerns, remained excluded from the policy framework due to the OMNRs justification that provincial control was necessary to ensure the supply of aggregate at a reasonable cost (Baker & Shoemaker, 1995).

In light of the above, the proclamation of the Aggregate Resources Act on January 1990 replaced the former Pits and Quarries Control Act.[21] The Act involves a licensing system with Class "A" licences (for excavation amounts > 20,000 tonnes/year) and Class "B" licences (for amounts < 20,000 tonnes/year). A successful licence application requires the submission of a detailed site plan outlining plans for progressive rehabilitation, the submission of a report regarding the expected environmental, social, and land use impacts from the pit operation, as well as the requirement that producers give public notice of the application. Producers are also required to pay an annual fee for the operation of a pit or quarry, and a production royalty of six cents per tonne of aggregate. Distribution of the fee is involves four cents going to local municipalities, one

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[19] If the case is upheld, the aggregates producer is responsible to the province and not the affected community.

[20] The above paragraph was from Baker et al., 2001.

[21] In the event that municipal by-laws or an Official Plan conflicts with the Aggregate Resources Act, the Act takes precedence and the municipal regulations are inoperative to the extent of the conflict with the Act (Baker & Shoemaker, 1995).

cent going to the Province, half a cent going to counties/regions, and half a cent going to the abandoned pit and quarry rehabilitation fund.[22]

Bill 52 amended The Aggregate Resources Act in 1997 to make the industry more accountable and to reduce government's role in its regulation. Improving accountability involved the requirement that new applicants circulate the application for public review and partake in a mandatory public consultation process. To reduce the role of government, the bill introduced new standards prescribing site requirements, and created the Aggregate Resources Trust, an industry-led body responsible for rehabilitation of abandoned pits and quarries and for managing the rehabilitation fund.[23] Some of the key environmental regulations under the ARA, as amended under Bill-52, are located in Appendix K.

2.6 Other Jurisdictions

Jurisdictions such as the United Kingdom, Denmark, and Sweden, have adopted a wide range of policies to promote the efficient use of aggregates and reduce their intensity of use. Extraction taxes have sought to make secondary materials more competitive with primary aggregates, landfill taxes have promoted recycling, and policies and guidelines have resulted in a more judicious use of aggregate. Section 6 provides more detail about the policies implemented by these jurisdictions.[24]

[22] The above paragraph is from Baker & Shoemaker, 1995.
[23] See Baker et al., 2001.
[24] The above paragraph were taken from Taylor & Winfield, 2005

3: Research Design and Methodology

The aims of the research are to identify:

- The underlying forces influencing primary aggregates demand across jurisdictions.
- Ways in which Ontario differs from a subset of Canadian cases concerning the per capita production of aggregates.
- Potential policy options for resolving the policy problem.

As mentioned previously, the study addresses the research question: *"Why is per capita aggregates use higher in Ontario than in other Canadian jurisdictions?"* Methods used include a literature review, a multivariate regression analysis of a panel of data, as well as a case study comparing Ontario with the Canadian provinces of Quebec and British Columbia.

3.1 Literature review

The literature review is to provide background information to identify key concepts related to aggregates, and to suggest potential hypotheses concerning the relationship between explanatory factors and the dependent variable. The literature identifies the setting of the study, identifies why the intensity of aggregates production is a problem, and provides background information concerning aggregates and the status quo situation in Ontario. In addition, the literature identifies previous attempts to model the production and demand for aggregates, as well as theoretical considerations regarding the factors influencing aggregates production.

3.2 Panel regression

The purpose of the panel regression is to identify the broad underlying forces that influence aggregates production across Canadian provinces and across time to see if they can provide an answer to Ontario's high per capita production.

It involved the performance of a multivariate regression on a panel of six Canadian provinces (102 observations) between the years 1987 and 2003. The provinces include Alberta, British Columbia, Newfoundland, Nova Scotia, Ontario, and Quebec. This sample is relatively large, although non-random. Even though all of the jurisdictions chosen were Canadian provinces, only a subset of the ten provinces were included due to data constraints pertaining to one of the independent variables, unit price, for Manitoba, Saskatchewan, and New Brunswick. I had to exclude PEI because it was an influential outlier. Section 4 specifies the model estimated, as well as the regression results.

The original intention was to complete a panel regression on seventeen OECD countries examining general trends amongst high-income countries. This would have been advantageous due to a larger sample size and greater variation within the panels. I obtained data for the years 2000 to 2007 for all variables except the unit price of aggregate. Unfortunately, to exclude such a key variable from the analysis would result in severe omitted variable bias, rendering questions about the validity of the results. Thus, I chose Canadian provinces. In addition, Canadian provinces control for some structural differences between Europe and North America regarding building materials.

3.3 Case study

The case study analyzes in detail a subset of Canadian provinces with relatively low per-capita aggregates production. This enables the exploration of potential factors influencing production not be easily captured in the above regression. The jurisdictions studied are Quebec and British Columbia. Factors examined include the permitting regime, residential and non-residential building trends, road building trends, off-street parking lot standards, as well as the use of recycled aggregate by jurisdiction. I look for differences between these provinces and Ontario as potential causes for their relatively low per capita aggregates production when compared to Ontario.

3.4 Limitations

The intention originally was to estimate a more extensive regression, involving additional explanatory variables identified as significant in the literature such as price of substitutes, land-use by-laws and planning policies, as well as the materials intensity per building, or per kilometre of roadway. Unfortunately, these variables were not included due to data limitations and time constraints. I instead analyze them in the case study.

In light of this setback, I wanted to undertake a quantitative component to provide information to support the panel, and help to inform the policy debate. This work would have involved a simulation exercise, taking a model, which estimated aggregates production for another jurisdiction, in another study. I would use the estimated coefficients from that model to determine the level of aggregates production per capita for the case study jurisdictions, assuming that these jurisdictions had the same dynamics influencing aggregates production as the jurisdiction in the study. The differences in fitted results would have demonstrated empirically by how much each province differed from the case in the study, allowing for some interesting cross-jurisdictional comparisons. Reproducing the same simulation for Ontario would enable one to determine how it differs relative to both the case study jurisdictions and the study jurisdiction. Unfortunately, there has been very little empirical work modelling the demand for aggregates to date. O'Brian (1996) was a possible candidate with his study on the determinants of aggregates demand in New Zealand, yet that paper did not use a regression model in its methodology. Other studies involved work by consulting firms. Unfortunately, these suffered from severe methodological flaws that cast doubt on the validity of their estimates. Consequently, I abandoned this approach in favour of a more traditional case study approach.

4: Estimation of the Broad Determinants of Aggregates Production

The purpose of the panel regression is to identify broad underlying factors influencing aggregates production across Canadian provinces and over time. If these factors sufficiently explain Ontario's per capita aggregates use, then policies aimed at reducing it may be limited. If not, then perhaps there is something unique to Ontario accounting for its persistently high consumption of aggregate.

4.1 Model

The model estimated is as follows:

AGGREGATESPROD/CAP = *f*(UNIT PRICE, CONSACT/CAPITA, POPDENS, CLIMATE, HOUSECOMPOSITION, LUMBER)

Where:

AGGREGATESPROD/CAP = Primary Aggregates Production Per Capita (In Tonnes)
UNIT PRICE = Price per tonne of aggregates ($CDN)[25]
CONSACT/CAPITA = Per Capita Construction Expenditures ($CDN)
CLIMATE = average January temperature (^{o}C)
POPDENS= Population Density (Person/Km^{2})
HOUSECOMPOSITION = Per Capita single-detached housing starts (starts/person)
LUMBER = Price Index of Softwood Lumber Prices (1997=100)

The dependent variable is primary aggregates production per capita, measured in tonnes.[26] As mentioned previously, aggregates production within jurisdictions tends to be a local market, with negligible imports and exports due to prohibitively high transport

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[25] Determined by dividing the sum of the monetary value of gravel/sand and crushed stone by the sum of their yearly production quantities (in tonnes).
[26] All Data on Provincial Aggregates Production were from the Canadian Minerals Yearbook.

costs.[27] Thus, aggregates production per capita serves as a proxy for per capita aggregates used in a jurisdiction.

In addition, inventory build up of aggregates is practically non-existent, again due to the high costs of storage relative to the value of the item stored.[28] Thus, it can be assumed that aggregates are supplied in a *"just in time"* manner. Consequently, the supply and demand curves in such a model overlap and are indistinguishable when viewed in two dimensions. Thus, the model estimated here is essentially a demand function, with per capita production representing per capita demand.

4.2 Hypotheses

The expected sign for each variable, followed by justifications for each, are below.

CONSACT/CAPITA is a measure of construction activity per capita. All else being equal, one would expect the relationship between aggregates production and construction activity to be positive, as demand for aggregates arises from demand for construction activity. I measure construction activity using total expenditures, repair and capital, on construction activity.[29] I converted the data to 1989 constant prices by subtracting the yearly rate of growth in construction (union) wage rates by the yearly rate of growth of construction expenditures in current prices to get the real rate of construction growth per year. Applying this rate forward and backwards from the 1989

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[27] For the Maritimes and BC, considerable exports of primary aggregates to the United States do occur. Relative to total production, BCs exports are small at only 1.3 million tonnes in 2003. These are more substantial for the Maritimes, a fact addressed later in this section.

[28] See Poulin et al., 1994.

[29] All data was from Statistics Canada with the exception of climate data, obtained from the website of Environment Canada, and data for unit price calculated from the Canadian Minerals Yearbook.

value generated values in 1989 constant prices. While wage growth is only one component of construction costs, I chose it due to time constraints facing the creation of a composite measure of construction price inflation.

HOUSECOMPOSITION represents the annual per capita single-detached housing starts. This variable was included as, generally, single-detached homes use more aggregates to house a family than apartment rooms. Thus, the expected sign is positive, as provinces that build more single-detached residences per capita will require relatively more aggregates, all else being equal.

Control variables include POPDENS, CLIMATE, and LUMBER.

- POPDENS measures population density per km^2, and included because countries with higher population density require fewer roadways to join cities and towns. Thus, the expected sign is negative.
- CLIMATE measures average January temperature at major airports for each province in degrees Celsius, to be representative of where most of the population and infrastructure are located (usually the capital city). Climate was included because lower temperatures tend to cause greater damage to existing roads and buildings. Consequently, lower temperatures will tend to result in higher road and building maintenance requirements, requiring the greater use of aggregates.
- LUMBER is the regional softwood lumber price index. This variable was included as lumber is a potential substitute to aggregate in construction. Thus, higher lumber prices will result in greater demand for aggregate, all else being equal. There are two issues with the data for this variable. Firstly, while provincial data exists for BC, Quebec, and Ontario, the indices used for the two Atlantic

Provinces and Alberta are regional indices, capturing price trends for Eastern Canada and the Prairies respectively. Thus, they may not correspond perfectly to the actual price fluctuations seen in those provinces. Secondly, as an index, the data does not capture price disparities between provinces, which are necessary to truly explain cross-provincial differences in aggregates use. However, the inclusion of this variable is still valuable in determining if differences in lumber prices may explain differences in aggregates use within the provinces over time.[30]

UNITPRICE is measured using constant 1987 dollars, and was included as per capita aggregates production is a proxy for demand as stated earlier. As in any other demand function, increases in the price of the good in question result in decreases in the quantity demanded, all else being equal. Thus, the expected sign is negative. This variable is a measure of the unit price of aggregates, determined by summing the yearly monetary value of gravel/sand and crushed stone, and then dividing by the sum of their yearly production.

An initial specification of the model can be expressed as follows:

$$\mathbf{AGGREGATESPROD/CAP_{ti} = \beta_0 - \beta_1 UNITPRICE_{ti} + \beta_2 HOUSECOMPOSITION_{ti} + \beta_3 CONSACT/CAPITA_{ti} - \beta_4 POPDENS_{ti} - \beta_5 CLIMATE_{ti} + \beta_6 LUMBER_{ti} + \varepsilon_t}$$

Of immediate concern is the possibility of endogeneity, where changes in the dependent variable cause changes in some of the independent variables, resulting in feedback loops that adversely impact the model results. An immediate suspect of endogeneity is UNITPRICE, as changes in price result in changes per capita aggregates

[30] I excluded the price for another substitute for aggregate in commercial buildings, steel, due to an inability to find provincial data.

production which then causes further changes in price. Thus, an instrumental variable must replace price in the model. An instrumental variable is a variable that is correlated with the variable in question, and thus explains variation in the dependent variable, but is not correlated with the errors, which is the issue of the original endogenous variable. Thus, a suitable instrumental needs to be correlated with price, but not correlated with the residuals. Lagging price for one year, we see that it is very weakly correlated with the residuals, 0.01, and strongly correlated with price, 0.91. Thus, a one-period lag of price is a good instrument, replacing the contemporaneous variable $\mathbf{UNITPRICE_{t,i}}$ with its lagged form $\mathbf{UNITPRICE_{t-1,i}}$. The new specification of model is:

$$\mathbf{AGGREGATESPROD/CAP_{ti} = \beta_0 - \beta_1 UNITPRICE_{t-1,i} + \beta_2 HOUSECOMPOSITION_{ti} + \beta_3 CONSACT/CAPITA_{ti} - \beta 4POPDENS_{ti} - \beta 5CLIMATE_{ti} + \beta_6 LUMBER_{ti} + \varepsilon_t}$$

Finally, I will be using a fixed effects specification to control for those factors that are time-invariant within the panels, but vary across panels. This provides the opportunity to control for such factors as the institutional or regulatory setting within each province. This involves including a binary variable for each of the provinces. The final specification of the model is therefore:

$$\mathbf{AGGREGATESPROD/CAP_{ti} = \beta_0 - \beta_1 UNITPRICE_{ti} + \beta_2 HOUSECOMPOSITION_{ti} + \beta_3 CONSACT/CAPITA_{ti} - \beta_4 POPDENS_{ti} - \beta_5 CLIMATE_{ti} + \beta_6 LUMBER_{ti} + \beta_7 NEWFOUNDLAND_{ti} + \beta_8 NOVASCOTIA_{ti} + \beta_9 QUEBEC_{ti} + \beta_{10} BRITISHCOLUMBIA_{ti} + \beta_{11} ALBERTA_{ti} + \varepsilon_t}$$

4.3 Descriptive statistics

4.3.1 Dependent variable

Appendix A provides province-specific statistics for aggregates production. Roughly speaking, the trend in primary aggregates production per capita across provinces can be divided into those that have seen fairly consistent decreases over the period and those that have seen more variation. Figures 1a to 1f in Appendix J give a graphic depiction of these trends.

Provinces with fairly consistent decreasing trends include Quebec, and BC. BC, for instance, has seen its per capita production fall from 18.3 tonnes per person in 1987 to 8.9 tonnes per person in 2003, a decrease of 51%. Likewise, Quebec saw a decline of 17% over the sample period.

The other group of provinces, Nova Scotia, Alberta Ontario, and Newfoundland, are more difficult to categorize. Alberta, for instance, has seen a U-shaped pattern on production, falling from 18.4 tonnes per person in 1987, to 11.6 tonnes per person in 1996, and then rising back to 14.3 tonnes per person in 2003. Nova Scotia and Newfoundland had similar trends. Ontario saw an initial decline from 16.4 tonnes per person in 1987 to 10 tonnes per person in 1991. From then on, production increased to 13.1 tonnes per person in 1994, remaining roughly constant for the rest of the period.

Provinces can also be divided according to their mean primary aggregates production per capita over the sample period. Provinces with high means (above 12 tonnes/person) include Alberta, BC[31], Nova Scotia, and Ontario. Those with low levels (<10 tonnes/person) include Quebec and Newfoundland.

Pooled data for the dependent variable is located in Appendix B. The dependent variable has a mean of 11.9 aggregates produced per capita for the panel as a whole, and has a standard deviation of 2.84, indicating some dispersion about the mean. The

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[31] Although BC has seen a persistent and dramatic decrease in per capita aggregates production over the period.

coefficient of variation of 0.24, however, indicates that this dispersion is not too critical. The maximum aggregates production per capita amongst all provinces for all years of the panel is 18.8 tonnes for Alberta in 1987, while the minimum is 5.8 tonnes for Newfoundland in 1995. Pearson Skewness-Kurtosis test for normality returned a p-value of 0.40 and so we retain the null of normality at any conventional significance level.

4.3.2 Independent variables

Appendix B also illustrates descriptive statistics for each of the independent variables. Significant dispersion about the mean exists for CLIMATE with a coefficient of variation of 1.06, while CONSACT/CAPITA, UNITPRICE, LUMBER, and HOUSECOMPOSITION tend to have less spread with coefficients of 0.44, 0.21, 0.35, and 0.25 respectively.

In addition, all of the variables except for unit price have high positive measures of kurtosis, indicating that their distributions are leptokurtic- more peaked and have a higher probability of extreme values from the mean (fat tails). In particular, with a kurtosis of 6.37, CONSACT/CAPITA is highly leptokurtic, corresponding to a very high probability of extreme measures for this variable. A positive skew exists for all of the variables except LUMBER and, with the exception of CONSACT/CAPITA and POPDENS, the variables tended to have values that were relatively close to that of a normal distribution (zero).

Appendix C displays the correlation coefficients between all of the explanatory variables. The coefficient between CONSACT/CAPITA and HOUSECOMPOSITION at

-0.66, was near the absolute value of 0.7. Although none of the other correlations approached this limit, multicollinearity may still be an issue with this dataset.

4.4 Issues with data

Data diagnostics involved test for serial correlation, a unit root, heteroskedasticity, and multicollinearity. The major data problem was one of serial correlation. A Wooldridge test yielded a p-value of 0.0006 and so we reject the null of no first order serial correlation at any significance level. A Levin, Lin, Chu test for a unit root in panel data at the one-lag specification yielded a p-value of 0.159 indicating that we retain the null of a unit root. However, under a two-lag specification we reject the null of a unit root. P-values of 0.088, 0.149, and 0.06 for HOUSECOMPOSITION, UNITPRICE, and CLIMATE respectively suggest the presence of a unit root for these variables as well.

Since only one of either heteroskedasticity or serial correlation exists, the regression can be re-run with robust standard errors to show that the findings of the regression with serial correlation are unaffected by these factors. If the p-values of the variables in the regression with robust standard errors are consistent with those in the regression with non-robust standard errors, then one can conclude that despite the presence of serial correlation, the results are sound. Multicollinearity, however, may still be present, due to the high correlation coefficient between CONSACT/CAPITA and HOUSECOMPOSITION. Some additional issues with the data, as well as a description of the aforementioned tests, are located in Appendix L.

4.5 Results

The regression results, both with and without robust standard errors, are in Appendix D. The results of the regression with robust standard errors are located in the second column of the table. Most variables are statistically significant at the 5% level and of the expected sign with the notable exceptions of LUMBER, CONSACT/CAP, and CLIMATE. Neither LUMBER nor CONSACT/CAP were statistically significant, with p-values of 0.98 in both cases. Additionally, LUMBER had the opposite sign than expected, suggesting that aggregates and lumber may be complements in production. The fact that CONSACT/CAPITA was not statistically significant is rather counterintuitive, due to its being the primary determinant of aggregates demand in the literature. Potentially explaining this is the high correlation between construction expenditure per capita with the number of single-detached housing starts per capita. Since the latter measure is a more disaggregated indicator of construction activity that represents a form of physical building activity, it is likely a better representation of the demand for aggregate than construction expenditures. This is because construction expenditures also includes changes in real expenditures for labour and land, which are not directly related to the quantity of aggregates used, a topic I revisit in the following section.

In addition, although CLIMATE was statistically significant at the 5% level, the positive coefficient indicates that higher average January temperatures result in increases in per capita aggregates production, all else being equal. This is contrary to the literature concerning temperature's impact on infrastructure, which has lower temperatures causing damage to roads and waterworks, necessitating the greater use of aggregates.

HOUSECOMPOSITION, POPDENS, and UNITPRICE were all statistically significant at the 1% level. HOUSECOMPOSITION was of high practical significance, with a 0.001 unit increase in per capita single-detached housing resulting in a 0.71 tonne increase in per capita aggregates use. Likewise, POPDENS and UNITPRICE were also of high practical significance, with a one-unit increase in both population density and the real unit price resulting in a decrease in per capita aggregates production by 1.4 and 1.1 tonnes respectively. An adjusted R^2 of 0.62 indicates that the model has high explanatory power. The absence of any major changes from the model results in Column 1, those without robust standard errors, indicates that the results are robust in the presence of serial correlation. Furthermore, the fact that the provincial dummies were all statistically significant indicates that provincial specific factors, like those described earlier in Section 5, are important determinants of per capita aggregates use.

Column 3 in Appendix D illustrates the results of the fixed effects panel regression, using a slightly different computational approach.[32] While still accounting for time-invariant, province specific factors, demonstrated by the fact that the results to this run are identical to the first run, the R^2 reported by this procedure is obtained differently, by assuming that the effects of the dummy variables are fixed quantities. By running the regression under this procedure, all of the effects of the binary variables are simply subtracted out of the calculations for the R^2, unlike the first procedure. Consequently, Column 3 reports three R^2 values, all of which are much lower than the R^2 reported under the standard procedure in Columns 1 and 2. This has profound implications for the model

[32] This was done using the xtreg, fe command on STATA.

as a predictor of per capita aggregates production in Canada, explained in greater detail in the analysis section.

4.6 Sensitivity analysis

Column 4, 5, and 6 of Appendix D estimates the model under three alternative specifications. The first, in column 4, estimates the model in log-log form, in order to incorporate nonlinearity's and to interpret the coefficients as elasticities. This specification involved the conversion of all variables to natural logarithms except for CLIMATE, due to the existence of a number of negative variables. This specification results in some significant changes. UNITPRICE, for instance, loses its significance at any standard significance level with a p-value of 0.67. On the other hand, CONSACT/CAPITA is now significant at the 10% level, with a p-value of 0.067.

The coefficient of UNITPRICE, representing the own-price elasticity of demand for aggregates, is -0.07, indicating that a 1% increase in price results in a 0.07% decrease in per capita quantity demanded. This suggests that demand for aggregates is price inelastic, with a 50% increase in the price of aggregates decreasing quantity demanded by only 3.5%.

Column 5 has changed the functional form into that of first differences for all variables; the difference between the contemporaneous value and the value of the preceding period. The possibility of spurious correlation among some of the variables, due to the presence of a unit root and the absence of cointegration, means that the results from this run may be a better indicator of the true underlying relationship between the independent and dependent variables than the earlier regression results without first differences. In this run, only two variables were significant at the 5% level:

HOUSECOMP and POPDENS. This specification has a slightly better fit when explaining the variation between the panels, however this is not the case when explaining the variation in the dependent variable within the panels over time- with a 'within' R^2 of only 18%.

The specification in Column 6 replaces the variable of single detached housing starts per capita with a variable measuring the proportion of total housing starts that are single detached-HOUSEPROP. The correlation coefficient between this new variable and CONSACT\CAPITA is only 0.21, and so the previous issue of multicollinearity clouding the regression results is no longer a problem. Sure enough, both CONSACT\CAPITA and the new variable HOUSEPROP were statistically significant at the 5% level. With an adjusted R^2 of 64%, however, this change does not profoundly affect the results.

4.7 Analysis and implications

The above results suggest that unit price, climate, housing stock composition, as well as population density, are all important drivers of the variation in primary aggregates use per capita. Elasticities for price from the translog specification indicates that demand for aggregates is own price inelastic, with implications for policy.

The fact that CLIMATE did not have the expected sign is disconcerting as it implies that warmer climates result in higher per capita aggregates production, all else being equal. A possibility for this unusual result may have to do with sample size, as 104 observations may not provide enough data variation to estimate accurately the true underlying relationship. Thus, the unexpected sign may have been an artefact of the chosen sample. The fact that BC has very warm January weather and high per capita aggregates production for the first part of the sample, suggests that this may have been the case.

Another explanation, however, is that there is a relationship between climate and aggregates use, but that it was incorrectly specified in this model. Instead of being a function of average temperatures, climates impact on road damage may be a consequence of other features of climate, such as extreme conditions, ice, rain, or temperature fluctuations (Martin, 1997). Thus, perhaps extreme January temperatures or climate variability (cycles of freezing and thawing) would have been a better measure of the impact of climate on aggregates production. Unfortunately, time prohibits probing all these climate complexities.

The implications for the difference in stated R^2 between the two procedures, as discussed previously, has important implications for policy. When using the *"xtreg"* command, three different values for R^2 are given. The 'within' measure for R^2 explains how well the variables explain variation within each panel over time. In this respect, the panel has a goodness-of-fit of 44%. This contrasts with the 'between' measure for R^2, to explain the variation between the panels at a given point in time, which is very low, only 3.6%. This brings down the 'overall' R^2 of the model to 0.6%, indicating practically no explanatory power. Under the alternative specifications, while improving somewhat from the original, the 'within', 'between', and 'overall' R^2 measures still indicate little explanatory power.

Thus, in excluding the provincial dummy variables when calculating the R^2, we see that the model does little to explain the variation in per capita aggregates production between provinces. Likewise, the significance of these binary variables from the runs in the first two columns suggests time-invariant, but location-variant factors specific to each province are important determinants of per capita aggregates production between provinces. These might include institutional factors, building trends, or regulatory factors. Furthermore, even when these time-invariant but location specific factors are incorporated into the model, in the specification under Column 2, the fact that the adjusted R^2 is only 62% suggests that there may be other important factors explaining aggregates production per capita that were not explicitly stated in the panel regression. Consequently, the second part of this paper is a case study that will examine some of these factors in detail, in the hopes of explaining why Ontario may be different.

5: Unearthing the Stone: A Case Study of Three Canadian Provinces

The case study seeks to identify factors that explain the variation in the dependent variable between provinces, as well as other important relationships not explicitly modelled, by comparing primary aggregates production in Ontario, BC, and Quebec. Since a detailed description of all the factors is beyond the scope of this paper, the case study will focus primarily on urban form of the three provinces. The assessment of urban form attributes include those related to residential and commercial buildings, road design, and off-street parking, as these three areas use the greatest amount of aggregate. The case study also entails an examination of the use of recycled aggregates in production, as well as the nature of the regime regulating the permitting of aggregates in each province, as controls.

5.1 Justification of the cases

Quebec and B.C. are both provinces with relatively low levels of per capita aggregates production, with averages of 8.9 and 10.3 respectively for the years between 1992 and 2004.[33] In contrast, the corresponding figure for Ontario was 12.6 tonnes per person. Thus, Ontario is the counterfactual case. Potential causes for Ontario's higher aggregates production emerge by identifying factors that are similar between B.C. and Quebec, but not held in common with Ontario. Another important criterion in case

[33]Data for British Columbia obtained from The Ministry of Energy, Mines, and Petroleum Resources Website http://www.em.gov.bc.ca/Mining/MiningStats/51detailconagg.htm. Data for Quebec and Ontario obtained from Statistics Canada, Canadian Minerals yearbook.

selection was the fact that all jurisdictions were Canadian provinces, allowing for consistency in federal policies and the constitutional framework in the analysis.

I begin by examining the impact of per capita construction activity on aggregates production for the three cases to rule it out as a potential factor. Average per capita construction activity for the years 1990 to 2002 were \$3523, \$2757, and \$2477 for B.C., Ontario, and Quebec respectively.[34] This ranking, however, does not correspond with their rankings in per capita aggregates production, as Ontario, the province with the highest rate of aggregates production, experienced annual per capita construction activity considerably below that of BC. Likewise, despite having higher average per capita construction expenditures than Quebec, by 11.3%, Ontario exceeds Quebec in average per capita aggregates production by almost 41.6%.

5.2 Findings

5.2.1 Residential and non-residential buildings

The construction of buildings, homes, and other structures is an important determinant of the demand for aggregates. For instance, 36% of BC aggregates were used in both residential and non-residential building construction in 2003 (BC Ministry of Sustainable Resource Management, 2003). Appendix E shows differences in trends for this category among the three provinces.

Residential

Housing composition, the different types of shelter, have different requirements with respect to aggregates. In the Greater Vancouver Regional District (GVRD), the

[34] Data was obtained from Statistics Canada

average condominium development requires 46-50 tonnes per housing unit, the average town home requires 200 tonnes per unit, while the average single-detached home, of size $182m^2$, requires 340 tonnes per unit (Seabrook, 1996). Thus, one would expect to observe the production of fewer aggregates in provinces that build more high-density buildings compared to provinces that build more single-detached homes. The regression results partially confirm this view, with the variable HOUSECOMPOSITION, yielding a positive coefficient that is statistically significant at the 5% level.

While Ontario and Quebec have virtually identical annual proportions of single-detached housing starts between 1990 and 2002, 57.7% and 57.8% respectively, the figure for BC was considerably lower, only 46.5%. Single-detached homes thus may explain at least part of the variation in per capita aggregates use between British Columbia and Ontario.

Disaggregating the proportion of housing starts that were non single-detached homes leads to further insights. In particular, Statistics Canada reports that BC also has the highest proportion of apartment and apartment type structures at 35.3%, 16.5 percentage points higher than the corresponding Ontario figure of 18.8%. Furthermore, we see that Quebec also has a relatively high value of 28.7%, lower than BC's, but still 9.9 percentage points greater than in Ontario. Thus, the greater the proportion of high-density units built in Quebec and BC, relative to Ontario, may be a contributing factor to the lower per capita aggregates production seen in those provinces.

The structural design of single-detached homes between the three provinces also differs. Data from the Canadian Home Builders Association (CHBA) Pulse Survey has annual estimates of the size of the average newly constructed single-detached home for all provinces between 1994 and 2004. Average values for the ten-year period are in Appendix E. On average, one can see that Quebec houses are, on average, considerably smaller than houses in Ontario and British Columbia, 1203 sq feet compared to 1750 sq feet for Ontario and 2010 sq feet for British Columbia.[35] Thus, as expected, the province that uses the least aggregate per capita, Quebec, also tends to build smaller single-detached homes. The results for the other provinces, however, are more ambiguous, as British Columbians build larger houses than in Ontario, yet still use fewer aggregates per capita in total.

Two possible explanations exist for this counterintuitive finding. Firstly, other factors such as housing composition may drive differences in per capita aggregates production between BC and Ontario. Secondly, while house sizes may be bigger in BC, the trends in materials use between the provinces may differ substantially. BC houses may use relatively fewer aggregates, and a greater proportion of other materials, such as lumber.

Testing this second proposition involved obtaining the quantity of aggregates used in constructing the average single-detached home for both BC and Ontario. One can see from this that despite houses in BC being larger, the quantity of aggregates used per home is still lower than in Ontario, 370[36] tonnes compared to 440 tonnes, suggesting building practices in Ontario that are more aggregates intensive than in BC (Budney, 2007). Unfortunately, data on the quantity of aggregates used per home was unavailable

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[35] Winter edition data. Data for all provinces for 1998-1999 excluded due to measurement uncertainty. Quebec data for the period 1995-1996 was unavailable.

[36] A 182m^2 size house in the GVRD required 340 tonnes of aggregates. Assuming a linear trend with respect to aggregates use and house size, one can calculate aggregates use per m2 based on this information, convert it to sq feet, and then apply it to a 2200 sq foot house to get average aggregates use per single-detached home in BC (Seabrook, 1996).

for Quebec, and so a complete comparison is not possible. It may be the case that even though Quebec homes are smaller, they use relatively larger quantities of aggregate per home, just as homes in Ontario use relatively more than BC.

Home building practices between the three provinces may suggest factors explaining why homes in Ontario use greater numbers of aggregates. In 2007, for instance, 76.5% of single-detached and row houses in Ontario have basements as their foundation, in contrast to 58% for Quebec and only 43.5% for BC.[37]

Generally, foundations are the most aggregates intensive component of homebuilding. Input from two stonemasons, a general contractor, and an excavator revealed the following consensus: A full basement of 1750 sq feet, the average size of an Ontario home, would use approximately 19.2 cubic yards of concrete for the floor, 70 yards of concrete for the walls, and 8.75 yards for the footings, totalling 97.96 Yards of concrete. Since one yard of concrete weights 2,835 pounds, 97.96 yards of concrete would weigh 277,716 pounds. Approximately 83% of one pound of concrete is aggregate-sand and crushed rock. Thus, one Ontario basement would require something like 230,505 pounds of aggregate. Converting this into tonnes, it would mean about 105 tonnes of aggregate are required for a basement alone.

Thus, not only are Ontarians building a greater proportion of single-detached units relative to other forms of habitation, but also the houses they are building are bigger than those built in Quebec, and use a greater amount of aggregates per house than in British Columbia. The evidence seems to suggest that differences in residential building patterns

[37] Data for this paragraph was obtained from NRCANs 2007 Survey of Household Energy Use

in the three provinces may be an important factor contributing to their differences in per capita aggregates use.

Non-residential

The non-residential building sector is an important factor in explaining the differences in per capita aggregates production between the three cases. Data for 2000 indicates that per capita commercial floor space is highest in Ontario, with 10.3m^2 per person, while Quebec and BC have only 9.7m^2 and 6.7m^2 per person respectively. In addition, the proportion of total floor space constructed in the 1990-1999 period was highest in Ontario at 18.4%, compared to 17.2% in Quebec, and only 15.8% in BC. [38]

These figures suggest that part of the difference, at least between BC and Ontario, may be a consequence of commercial building activity. Not only is the amount of commercial floor space per capita significantly higher in Ontario than BC, but the higher proportion of floor space constructed in the 1990s indicates that a relatively large amount of building was done in Ontario over the sample period. While both indicators are still higher in Ontario than Quebec, the difference between these two provinces is not as great, implying that other factors likely account for their difference in per capita aggregates production.

How aggregates intensive is this activity? Calculations done by engineering-consulting firm Levelton in 1996 note that the average area of a commercial/industrial building, within the GVRD, is approximately 2150 m^2, requiring 560 tonnes of aggregate per 100m^2, or 12,040 tonnes per building (Seabrook, 1996). The area of the average commercial building for BC as a whole was 1614m^2 using data from NRCANs 2000

[38] All data relating to commercial buildings were obtained from NRCANs 2000 Commercial and Institutional Building Energy Use Survey.

Commercial and Institutional Building Energy Use Survey. This contrasts to Ontario, whereby the average commercial office tower requires 16,000 tonnes of aggregate (Ontario Stone Sand and Gravel, 2006). The most plausible explanation for this is due to larger office buildings built in Ontario, with an average area of 2297m^2. Likewise, the number of buildings with two floors or below in BC was 73%, compared to 64% in Ontario. While data on the number of aggregates used per office building was unavailable for Quebec, their size indicates that it is likely similar to Ontario, with the average building having an area of 2224m^2, and the proportion of buildings with two stories and below being 65%.

Even after correcting for economic activity, Ontario still had a higher intensity of commercial space, 0.26m^2 per $1000 GDP, than British Columbia, 0.2m^2 per $1000 GDP, although not as high as Quebec with 0.31m^2 per $1000 GDP.

5.2.2 Road building design and trends:

Road construction is another area involving extensive aggregates use. In 2004, road building and maintenance used nearly 49% of the total sand and gravel produced in Ontario (Natural Resources Canada, 2005). Seeing as road construction is such a key component of demand for aggregates, it follows that it may be a possible explanation in the difference in per capita aggregates use among the three jurisdictions. Findings pertaining to this class of variables are in Appendix F. This table shows growth in road building, as well as road design specifications across the cases.

Road building- growth

A potential issue with the preceding regression analysis was the level of aggregation for construction activity, combining construction expenditures for a wide variety of functions. Thus, construction activities that are not necessarily aggregates intensive, yet involved considerable financial outlays, may have potentially driven fluctuations in the above variable, weakening its predictive power with respect to aggregates production. This is especially pertinent if those construction activities that are highly aggregates intensive (road building, house building) are a small proportion of total construction expenditures, or if they do not move exactly in tandem with overall construction activity.

One may have reason to believe that both of these factors apply to road construction. For instance, transport engineering construction activity, in which road works make up a large part, averages only $193.9 per capita for Ontario.[39] This makes up less than 10% of Ontario's average total per capita construction expenditures between 1989 and 2004. Likewise, infrastructure construction is a function of government expenditure, and thus does not need to follow the trend in overall construction activity, which follows the business cycle (Poulin, 1994).

Ideally, I would have disaggregated construction activity into those activities that primarily use aggregates, housing, road building, and major infrastructure projects, for the regression. Unfortunately, due to data constraints, such an aggregation would have considerably reduced the number of observations, limiting degrees of freedom and the explanatory power of the model. The case study, however, provides an opportunity to pursue a more detailed exploration of this component of construction expenditure.

[39] Statistics Canada.

Obtained from Statistics Canada was data of per capita capital expenditures on transport engineering construction for all three provinces between 1992 and 2002. Converting this data from current prices to 1992 constant prices involved taking the rate of growth for each year, correcting it for inflation,[40] and then applying the corrected rate forward from the base year. Transport engineering in construction includes not only road construction, but also construction of parking lots, airport runways, railway tracks, bridges, overpasses, and tunnels. Thus, it is not directly a measure of road building. However, since all of the other building activities that it includes are also aggregates intensive, it serves as a useful proxy. [41]

Calculated here are averages of per capita activity for the period as a whole, with Ontario, Quebec, and British Columbia recording values of $193.98, $192.11, and $257.46 respectively. Likewise, the rates of growth in per capita transport engineering construction correspond to 4.3%, 5.4%, and -0.88% for Ontario, Quebec, and BC respectively. Thus, the evidence is mixed. While Ontario had high rates of growth in this figure, so too did Quebec, with far lower rates of per capita aggregates production. Likewise, per capita transport expenditure is low in Ontario, only slightly higher than in Quebec and considerably below that of BC.

A similar measure of road building activity is net growth of the total road stock, which measures the growth in the provincial road stock after accounting for depreciation and destruction of existing roadways. Average values for the 1991-2001 period were: -0.6%, 1.3%, and -0.1% for Quebec, Ontario, and BC respectively (Roy, 2008). Due to differences in the item being measured, these figures are considerably different from the

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[40] Using the Rate of Growth of unionized construction wages.

growth rates in the preceding paragraph, with Ontario being the only province in the group studied that had positive growth rates of the road stock, about 1.3% per annum.

This has considerable significance for the study results. Since roads tend to require greater proportions of aggregates than do other transport infrastructure, the above rate may be a better indicator of demand for aggregates. The fact that Ontario is the only province with positive rates suggests that this may be a significant factor in explaining part of the per capita variation between the three provinces, other things equal.

Road building- materials trends

The above analysis implicitly assumes the building of roads in the same manner in each province. This, however, may not be the case. Some provinces may pave a greater proportion of their roads, while others may use different materials in road building, or design roads of different widths. All of these factors may result in greater use of aggregates in some places over others.

According to 2005 data from Transport Canada, Ontario, BC, and Quebec have 62.8%, 67.8%, and 56% respectively of their public road surface paved. This corresponds to about one kilometre of public paved road for 104, 87, and 93 people for the three provinces respectively (Transport Canada, 2008).[42] These rates seem to indicate that the proportion of paved roads does not seem to correspond with annual per capita aggregates production. Not only does Ontario have a smaller proportion than BC, despite higher per

[42] This excludes private roads. Ontario Data taken from Ningyuan et al., 2002 and only included MTO Highways.

capita aggregates use, but it also has the lowest amount of paved roads relative to its population, with roughly one km of paved road per 104 inhabitants.[43]

Another potential factor is pavement materials, due to differences in aggregates use among these materials. For instance, the use of Portland Concrete cement is relatively less aggregates intensive, 86% per tonne, compared to asphalt, 95% per tonne (Nesbit & Venta, 2000). Appendix F shows that the majority of pavement in each province consists of Hot Mix Asphaltic Concrete Cement (HMAC)- 94% in Quebec, Ontario, and the FVRD of British Columbia (Seabrook, 1996).[44] Although the GVRD tends to use relatively less HMAC-87%-at the expense of Portland cement concrete-7%- and gravel -6%- it is uncertain to what extent this compares with other large municipalities in Quebec and Ontario (Seabrook, 1996). Unfortunately, data for road building material used in BC as a whole was unavailable.

Another possible reason for the high per capita aggregates use in Ontario was average road width. Winfield & Taylor (2005), for instance, recommended a decrease in the Ontario road width from 8.5m to the 6.5m standard seen in other jurisdictions.[45] Data at the municipal level for road width were readily available. In 2005, Toronto's Development Infrastructure Policy & Standards (DIPS) released minimum standards for public local residential streets and private local streets. This resulted in a pavement widths of 8.5m for major and intermediate local streets (2 lanes), and 8.0m for minor local streets, with sidewalk width of 1.7m (City of Toronto, 2005). This roughly

[43] While road composition may have potentially changed in the fifteen years prior to the publication of the Transport Canada report, resulting in a shift in Ontario towards a greater proportion of paved roads, it is unlikely that such a change would be of a sufficient magnitude to significantly alter the Ontario production figures.

[44] A bitumen content of 5 percent for the HMAC has been assumed meaning that 95% of the HMAC is composed of aggregate and thus, for BC, it is estimated that one km of road contains 10,300 tonnes of mineral aggregate (Seabrook, 1996).

[45] No mention, however, of which jurisdictions had such a standard, were included in the report

corresponds to the average Ontario width in the Winfield & Taylor article. Furthermore, a document by the Toronto Works and Emergency Services regarding its public roads policy notes that the average sidewalk width in North York is 1.5m, with the width of a typical 2-lane pavement being 8.5m (Toronto Works and Emergency Services, 2007). Older designs in Ontario constructed many residential streets with an average of 6.5m width (Environmental Commissioner of Ontario, 2003).

Despite data for only two cities in the province, the fact that they comprise its largest urban agglomeration suggests that the average street width found here could be applied to represent Ontario as a whole. A comparison with the other two provinces, however, seems to suggest that the pavement and sidewalk widths seen in Ontario are not atypical. Taking the GVRD as representative for BC, the average municipal pavement was approximately 9m wide in 1996 (Seabrook, 1996). Another report notes that paved roadway widths in the GVRD range from 8.5m for local roads to 16m for divided arterials (BC Stormwater Planning Guidebook, 2002)

Data for Quebec municipalities, unfortunately, was not readily available

5.2.3 Parking by-laws:

Another potentially important factor in explaining aggregates use per capita are specifications regarding off street parking by-laws. Since parking makes up a considerable proportion of the total paved space within a province, it follows that provinces that build larger parking lots will use more aggregates per capita, all else being equal.

Appendices G, H, and I have residential, commercial, and space size specifications respectively for eleven Ontario municipalities and former municipalities[46], six British Columbia municipalities, and three Quebec municipalities. This analysis inevitably draws upon an analysis at the municipal levels as parking standards are set there.[47]

Residential parking

We see that for Ontario, residential parking sizes are slightly higher than in Quebec and, if anything, tend to be lower than similar spaces in Vancouver. In downtown Toronto, for instance, parking varies from 0.36 to 1.26 spaces per unit depending on the type of building concerned. Likewise, pre-amalgamation Toronto suburbs, such as North York and Etobicoke, require 1-1.5 and 1.25-1.55 spaces per residential unit respectively. This contrasts to BC where similar cities such as Vancouver, Burnaby, New Westminster, and Surrey usually require 1-2 spaces per residential unit.[48] The sole exception to this trend of slightly lower residential parking minimums in Ontario relative to BC is Mississauga, where the minimum is three spaces per non-apartment residential structure. While this exception is significant as Mississauga is a very large city within the GTA (almost 700,000 people according to the 2006 census), Ontario is generally similar to BC with respect to residential parking space requirements.

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[46] Although the boroughs of North York, East York, York, Scarborough, and Etobicoke amalgamated with the City of Toronto to form Metropolitan Toronto, each region maintained their own unique zoning by-law (and hence parking specifications) until the introduction of the 2010 New Zoning Bylaw.

[47] I obtained the following data for off-street parking minimums from the municipal zoning by-laws for Quebec and BC, and for Ontario, from zoning by-laws for London and Ottawa. I obtained the rest from Phase 2 of the Parking and Loading Standards Review, City of Toronto 2005.

[48] Burnaby requires 1-1.75

Commercial parking

While residential off street parking by-laws may not be a determining factor, the minimums for commercial establishments tell an altogether different story. Obtaining data for off-street parking minimums for general office, general retail, and restaurant functions, it is evident that Ontario has somewhat higher minimums than either British Columbia or Quebec for most cities in the sample.

Downtown Toronto requires 0.82 spots per $100m^2$ for general office space compared to 1-2 spots per $100m^2$ in Vancouver. However, the remainder of Ontario regions fare relatively poorly in this regard. For instance, North York, Etobicoke, Hamilton, and Markham require minimums of 2.1, 3.23, 3, and 3 per $100m^2$ respectively. This compares with 2.2, 2.7, and 2.5 per $100m^2$ in Burnaby, Abbotsford, and Kelowna respectively. In fact, the highest parking requirements for this category among BC municipalities are those found in New Westminster, which range from 2.2-3.2 spaces per $100m^2$.[49] Even lower minimums are found in the Quebec municipalities of Beauport and Charlesbourg, with requirements of 1-2.5 spaces per $100m^2$, and a maximum requirement of 4 spaces per $100m^2$, the only municipality to have an explicitly stated maximum.

More pronounced is the Ontario situation with respect to retail and restaurant parking by-laws. While retail parking standards are relatively low in places such as downtown Toronto, Scarborough, and Etobicoke, this contrasts to North York, Mississauga, and Markham, with minimums of 3.56-6.67, 4.9, and 3-4.5 per $100m^2$ respectively. BC cities such as Burnaby, New Westminster, Surrey, and Kelowna, on the other hand, all have minimum requirements of 2.2, 2.2-3.2, 2.6, and 2-3 spaces per $100m^2$

[49] Surrey has a parking requirement of 2.7 spaces per $100m^2$ outside the downtown core. However, within the downtown, parking spaces are determined using a different metric- one per two employees, or one per three regular employees- making its comparison with other municipalities difficult.

respectively. While Abbotsford has a relatively large requirement, 2.7-5.3 spaces per $100m^2$, Abbotsford is a relatively small CMA within Vancouver, comprising just over 123,000 people in 2006. Likewise, the minimums found there are still smaller than places such as North York and Mississauga, which have much larger populations. In Quebec, Beauport and Charlesbourg both have minimums ranging from 2-3.6 spaces per $100m^2$ and, unlike other municipalities, maximums of 3.3 to 5 spaces per $100m^2$ indicating very stringent requirements in these regions.

The parking space requirements for restaurants tell a similar story with relatively high Ontario minimums of 10.2-16.95, 2.9-14.52, 16, and 10 spaces per $100m^2$ in North York, Etobicoke, Mississauga, and Markham respectively. In contrast, New Westminster requires a minimum of 2.2-3.2 spaces per $100m^2$ and Burnaby requires only 2.2 spaces per $100m^2$ for restaurants with less than fifty seats.[50] In Quebec, Beauport and Charlesbourg have no minimums outside of the commercial centre, but have maximums of 7.7-10 per $100m^2$ that are lower than many of the minimums seen in Ontario. Within the city centre, they have minimum standards of 2-3.6 spaces per $100m^2$ and a maximum of 5.5 per $100m^2$.

Parking Space requirements

The size of individual parking spaces do not seem to differ much between municipalities, ranging from 5.5m-6m in length and 2.5m-2.9m in width in both Ontario and BC municipalities where data was available. Space measurements were unavailable for Quebec. Perpendicular parking requirements tell a similar story. One considerable

[50] Unfortunately, direct comparison between more municipalities and BC is difficult due to minimums being established on a per seat basis. For instance, Abbotsford, Surrey, and Kelowna require one space per four seats.

difference between BC and Ontario is the number of spaces allocated to small car spaces. In most BC municipalities, this amount ranges between 20% and 40%. For instance, if the total number of parking spaces provided exceeds 25 within the city of Vancouver, up to 35% can potentially be small car parking spaces. A comparable figure for Ontario municipalities is generally between 10% and 15%. This is significant, as small car spaces are smaller than regular parking spaces, requiring fewer aggregates per space.[51]

While these findings do not tell the whole story relating to parking, as prescribed minimums may not reflect the actual size of parking lots that are built, they are significant. It is likely that many commercial establishments will construct only the minimum number of parking spaces as these are costs that they may not be able to recoup especially if free parking is provided as a benefit to employees. The size of individual parking spaces also rarely deviate from the stated minimums as firms will have an incentive to maximize the number of spaces they can provide per given parcel that is consistent with municipal law.

5.2.4 Other factors

Two factors that were not directly related to urban form, but are generally considered to impact aggregates use per capita, trends in use of recycled aggregates and the regulatory regime governing aggregates production, are examined here.

Recycling

Provinces may have different rates of use of recycled aggregate in construction. Recycled aggregate can be used as a substitute to virgin aggregate to meet demand;

[51] For instance, the city of Burnaby requires small car spaces to be of minimum 4.8m in length by 2.8 metres in width.

however, they are not perfect substitutes. Each jurisdiction has standards for material specification for use in road works and other infrastructure (Glen E. Bridges & Associates Inc, 2002). These specifications can be quite extensive, covering factors such as durability, cleanliness, chemical purity[52], consistency, moisture content, and even the shape of the rocks (Glen E. Bridges & Associates Inc, 2002). Generally speaking, aggregates used to produce concrete are required to not contain rocks that unfavorably react with cement and are thus very specific with respect to the types of aggregates which are suitable.

Estimates suggest that 7% of Ontario's aggregate consumption was supplied by non-virgin materials in 2008 (Ontario Ministry of Natural Resources, 2010). This is a relatively low figure when compared to places like the UK, whereby approximately 24% of aggregate consumption was supplied by recycled aggregate. While in other jurisdictions, road construction contracts and bid-preference systems encourage the use of recycled aggregate, MTO does not use these systems, nor does the MTO monitor how much non-virgin material is used in highways (Environment Commissioner of Ontario, 2003).

Despite these factors, however, the use of recycled aggregates in Ontario is not abnormal when compared to jurisdictions within the sample. While a figure for BC as a whole was unavailable, figures for Victoria suggest a similar 7% figure to Ontario (Coulter, 2003). Unfortunately data for Quebec was unavailable.

[52] Free from reactive elements

Permit/regulatory regime

As previously mentioned, The Aggregate Resources Act of 1990 (ARA), administered by the Ontario Ministry of Natural Resources (OMNR), is the primary legislation governing aggregates excavation in the province. While there are a number of issues with the regime in Ontario, as noted in Appendix K and elsewhere in this paper, the following are problems that may specifically contribute to greater production. These include the centralization of power, as well as the proponent-driven nature of the permit regime. Critics have argued that these features make Ontario' s regime prone to favouring producers over other stakeholders, resulting in higher per capita aggregates use in Ontario. I explore each of these criticisms.

As noted in Budney (2007), the ARA process is proponent driven. The proponent, a potential aggregate producer, determines where and how they would like to extract aggregate, and then follows the permit application process. Once the OMNR determines that the application is sufficient, the proponent proceeds with the notification and consultation process, giving the public and specified review agencies at least 20 and 45 days to review and comment on the application. The proponent notifies the OMNR when it feels the consultation process is complete. If the OMNR believes that the proponent has resolved the issues, or at least made a reasonable attempt to do so, it makes a decision.[53]

Thus, the aggregates producers maintain the initiative throughout the entire process. They decide whether to enter the market, in what quantities to produce, and where to produce. The first two principles are consistent with any mixed-market economy, the latter principle, however, could be problematic due to CEE, as well as

[53] Completeness entails that either all concerns have been resolved and no objections remain, or the proponent has made a "reasonable" attempt to address all objections, but that some issues may remain unresolved

provincial regulation failing to account for site-specific considerations, such as damage done to unique ecosystems. Exacerbating this is the fact that with the ARA process, the proponent is not required to consider alternative locations for a pit or quarry, or alternative approaches to constructing, operating, or reclaiming the pit or quarry. Since the aggregates producer has no incentive to consider alternative locations, the proponent based system results in the ministry loosing the ability to allocate permits optimally taking into account certain environmental objectives.[54]

Secondly, as it stands, the ARA is the only Canadian statute giving specific recognition to aggregate resources (Budney, 2007). In other provinces, aggregates fall under existing mining and environmental legislation and not mentioned explicitly. Thus, unlike other provinces, the ARA drives the permit process in Ontario, centralizing the authority over aggregates management in the hands of the OMNR (Budney, 2007). There exists other Federal and Provincial legislation pertaining to aggregates management that are mentioned in Appendix K. Unfortunately, their frequent interpretation is that of regulations subservient to the ARA (Gravel Watch, 2009).

In Ontario, The Planning Act (1990) allows municipalities to make official plans and zoning bylaws, and enable the Crown to plan land use. Provisions in the Planning Act may control the location of aggregate extraction (Budney, 2007). Baker & Shoemaker (1995) have observed that over time, the Province of Ontario has increasingly restricted municipalities' ability to plan for and regulate mineral aggregate operations. In the event that municipal by-laws or an Official Plan conflicts with the Aggregate Resources Act, the Act takes precedence and the municipal regulations are inoperative to

[54] The above three paragraphs are taken from Budney, 2007.

the extent of the conflict with the Act (Baker & Shoemaker, 1995). This contrasts with the situation in BC and other provinces, where municipal regulations play a more central role in aggregates regulation.

This centralization of power could result in cases where the interests of the OMNR are favoured over the interests of other stakeholders. Critics of the act argue that this is currently the case, as provincial policy statements for mineral aggregate resources seem to place the requirement of a steady and cheap supply of mineral aggregate ahead of environmental and social considerations (Budney, 2007). For example, policy statement 2.5.2.5 requires municipalities to justify how any competing and use decisions that might reduce the supply of mineral aggregate resources are in the greater public interest, burdening municipalities with the onus of proof to demonstrate the value of alternative land uses (Budney, 2007).

While such problems are indeed significant, it remains uncertain as to what extent they translate into higher aggregates use per capita. The proponent driven nature of the Ontario system, for instance, need not result in higher per capita aggregates production than other jurisdictions, although they may exacerbate issues with externalities. That the permit regimes in British Columbia and Quebec are proponent driven as well suggests that this factor cannot explain Ontario’s higher per capita aggregates production.

Furthermore, while the situation regulating aggregates production in Ontario differs from other regions, due to its centralization, there are no studies showing the extent to which this factor may result in higher per capita production. Indeed, while BC aggregate producers lament the absence of such centralization in their own province, resulting in overlapping legislation that can take 3-5 years to overcome, Ontario producers note similar hurdles to obtaining permits, and cite a similar timeframe to obtain them (Seabrook, 1996). Finally, given the just-in-time nature of aggregates use, as well as its demand being relatively inelastic and derived from construction demand, it makes sense that the yearly production figures be predominantly demand driven rather than a result of peculiarities of the regulatory regime.

5.3 Lessons learned:

There were a number of lessons learned from this exercise, which could help inform policy. Firstly, the usual suspects in explaining higher per capita aggregates production in Ontario; the nature of the permitting regime, the general level of construction activity, as well as the use of recycled aggregate, do not seem to play a role in explaining the variation between the provinces in the case study. Construction activity in Ontario is considerably lower, and use of recycled aggregate no different, then that seen in BC. Likewise, the former value for Ontario is only marginally higher than in Quebec.

The permitting regime in Ontario, while suffering from a number of issues identified by the literature, it is unclear as to the extent in which these factors result in higher per capita production. Due to the relative own-price inelasticity of aggregate demand, it is also unclear as to what effect a supply side response such as this would result in lower per capita production.

Ruling out these factors made for the possibility of other explanations. It was found that housing stock composition, single-detached house building style, commercial building trends, trends in road growth, and off-street parking minimums for commercial buildings were all potentially important factors in explaining the case-by-case variation in the dependent variable.

Housing starts in Ontario showed an overwhelming focus on single-detached homes, with a considerably lower building rate for apartments and condominiums than the other provinces- 18.8%, compared to 28.7% for Quebec and 35.5% in BC. Likewise, differences in the building style of single-detached homes show that new houses built in Quebec are considerably smaller than Ontario and BC- 1203 sq feet compared to 1750 sq feet and 2010 sq feet respectively. Although Ontario homes are smaller than BC homes, they still use more tonnes of aggregate per house, with 440 tonnes compared to 370 tonnes. This is likely due to the preponderance of basements in Ontario, which are aggregates intensive. Thus, not only is Ontario building more single-detached homes, but they are also using more tonnes of aggregate, on average, per single detached home than the other provinces in the case study.

Commercial building space is also higher in Ontario, at 10.3 m^2 per person, and commercial buildings larger, at 2297m^2 per building, than the other cases. While only slightly larger than the corresponding values for Quebec, the Ontario figures are considerably larger than BC's. These differences in Ontario are unjustified by the level of economic activity, as commercial space per $1000 GDP corresponds to 0.2m^2, 0.26m^2, and 0.31m^2 for BC, Ontario, and Quebec respectively.

In addition, off-street parking minimums for retail, general office space, and restaurants were considerably higher in Ontario, suggesting the necessity of larger commercial parking lots, consuming more aggregate. So too does the higher net growth in the road stock seen in Ontario over the period, at 1.3%.

What does this mean for policy? Firstly, the variety of ways in which differences in urban form may affect aggregates use suggests that broad policies, which impact aggregates users equally, may be appropriate. This suggests that economic instruments aimed at reducing aggregates use in a number of European countries, extraction taxes and landfill taxes, may be appropriate.

Secondly, since economic activity or consumer preferences drive many of the factors identified as important in explaining the inter-provincial differences, specific targets or standards to reduce use may be inappropriate instruments when compared to economic instruments from a social welfare standpoint. A full account of potential policy options is present in the following section.

6: Policy Alternatives:

The analysis from the previous sections indicates that differences in urban form, particularly pertaining to residential and commercial buildings and off-street parking standards, contribute to differences in per capita aggregates production between the three cases. The following section suggests policy options to address the underlying policy problem. Evaluating the policy options under each criterion will lead to a recommended course of action.

6.1 Alternative 1: Status Quo

The status quo involves doing nothing. This amounts to maintaining existing regulatory framework involving aggregate, as well as the existing zoning by-laws and urban planning strategies.

6.2 Alternative 2: Extraction Tax on Aggregate

An augmented royalty, with aggregates producers charged a unit rate per tonne of aggregate produced. For example, the UK Aggregates Levy was introduced in 2002, originally set at 1.6 pounds/tonne, rising to 1.95 pounds/tonne in 2008 (EEA, 2008). The stated objectives of the tax are to internalize the environmental effects of quarrying, to reduce the demand for aggregates, and to encourage the use of alternative materials (Soderholm, 2004).

Likewise, in 1996, the Swedish Government introduced a tax on the extraction of natural gravel at SEK 5 (EUR 0.6) per tonne of natural gravel. The intention was to set the tax rate at high enough to close the price gap between gravel and its closest substitute, crushed rock, providing a clear incentive for material substitution (Legg, 2007). The tax level initially corresponded to roughly a 10% price increase on natural gravel. In 2003 the tax on natural gravel was raised to SEK 10, and was raised a second time in 2006 to SEK 13 per tonne extracted gravel (Legg, 2007)

Basing the Ontario tax on these two precedents, aggregates will be taxed a rate per tonne of aggregate extracted, with recycled materials and secondary aggregates being exempt. Revenues generated from the tax will strengthen existing regulations aimed at reducing the externalities associated with aggregates mining.[55] Pursuing a gradual implementation of the tax will involve a rate beginning at 25% of the existing price of aggregate for the first two years, and rising to 50% thereafter.

The impacts of this policy occur over both the short and long run. The immediate short run impacts of the policy will be to induce aggregates producers to lower production (or pass costs on to consumers), and construction firms to use available technologies and materials to conserve aggregates in their projects. Over the long term, the construction industry has an incentive to develop new technologies, develop new building practices, or switch to substitute materials that make the industry less aggregates intensive.

[55] Revenues raised from the UK tax are recycled to business through a 0.1%t cut in employer's insurance contributions, and through an Aggregates Levy Sustainability Fund aimed at delivering environmental benefits to areas adversely affected by environmental damages caused by aggregates extraction (EEA, 2008).

6.3 Alternative 3: Enact a Landfill/Incineration Tax

This option involves taxing waste that is disposed of via landfill or incinerated at a fixed rate per tonne. Its aim is to promote the recycling of construction and demolition (C&D) waste, and to foster an economically viable recycled aggregates industry in Ontario. Although use of recycled aggregate is no worse in Ontario than other Canadian jurisdictions, it lags behind a number of international jurisdictions, suggesting room for improvement.

European countries such as Sweden, Denmark, and the UK have all introduced landfill taxes to promote the recycling of all waste, including aggregates. Introduced in 1987, the Danish landfill tax seeks to reduce the amount of waste going to incineration or landfills and to promote recycling and conservation by companies. Since C&D waste is usually of very high volume, companies have a strong incentive to avoid its disposal by landfill, or face high absolute tax liabilities. In Denmark, the initial rate was 40 Krone/tonne of waste.[56] The rate then increased to 130 Krone/tonne in 1990, to 195 Krone/tonne disposed via landfill and 165 Krone/tonne incinerated in 1993, and finally to 335 Krone/tonne for landfill waste, 260 Krone/tonne for incineration waste, and 210 Krone/tonne for waste incinerated with combined heating and power in 1997. [57]

The proposed Ontario tax will have a gradually increasing rate structure, differentiating the tax based on the method of disposal- incinerated or placed in a

[56] This rate did not apply to private landfills or incinerators. Private landfills were only taxed beginning in 1990, and incinerators in 2003.

[57] Information on the Danish Waste Tax was taken from Andersen et al., 1997

landfill.[58] Further differentiation of the rate will be by type of waste, as is the case with the Swedish and UK taxes.[59]

As with the excavation tax, the impacts of a landfill tax occur over both the short and long term. In the short term, business will adopt available practices and technologies to reduce the amount of waste they send to landfill, as well as seek alternatives to landfill disposal (i.e. recycling). In the near-short term, recycling capacity will expand to meet the new demand for recycling services.[60] Over the long term, firms will invest in new technologies aimed at reducing waste.

6.4 Alternative 4: Look into the adoption of *"Smart Growth"* policies aimed at improving densification

The identified importance of urban form in reducing per capita aggregates use suggests the importance of policies aimed at improving urban density. Improved density will involve the construction of proportionately more multi-family dwellings, smaller off-street parking minimums, more compact commercial office buildings, more mixed-used development and public transit (to reduce the necessity of continued road building), as well as a number of other changes to urban form. All of these will result in less aggregates use per person.

Since the early 1990s, a number of American and European cities have engaged in a new wave of densification strategies known as "*Smart Growth"* (Burchall et al., 2000). This overarching strategy involves the combination of a number of sub-policies such as

[58] Reflecting the higher environmental issues associated with landfill over incineration. In the short run this will likely be a moot point due lack of incineration capacity in Ontario.

[59] This will reflect the different environmental damages resulting from the different forms of waste, although it is recognized that it will come at a trade off with respect to ease of administering the tax.

[60] Near-short term rather than long term, based on the UK experience with C&D plant establishment.

changing zoning by laws to promote clustering, urban growth boundaries, impact fees, density bonuses, infilling, and transfer of development rights (Burchall et al., 2000).

Due to the scope, the complementary nature, as well as the diversity of goals associated with these policies, this option merely suggests an investigation into other jurisdiction's experiences with smart growth policies. This approach envisions an overarching densification strategy initiated and led by the province, but involving consultations between the municipal and provincial governments. The aim will be to choose the suite of policies that will work best for Ontario, and to implement them sometime within the next decade.

One of the major barriers to a successful smart growth strategy is the possible negation of the pro-densification strategies of municipalities by the pro-sprawl policies, such as road and highway construction, initiated at a higher level of government (Burchall et al., 2000). By having the provincial government direct the strategy, it is hoped that this disconnect can be eliminated. Provincial leadership will also prevent the suburb vs. urban atmosphere that is pervasive among smart growth strategies pursued elsewhere (Litman, 2009). Litman (2009) notes that instead of perceiving smart growth as a boon to major urban centres at the expense of suburbs, it should instead be viewed as a suite of policies aimed at improving urban liveability for both the suburbs as well as the city core. Fiscal sharing[61], as was done in Minnesota-St. Paul, can further promote the development of smart growth principles outside of large metropolitan areas (Burchall et.al., 2000).

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[61] Fiscal sharing occurs when wealthier communities in a region pool some of their tax revenues and redistribute them to communities experiencing less development. The Twin Cities' Fiscal Disparities Plan narrowed fiscal disparities between rich and poor communities in the region from a ratio of 17 to 1 to 4 to 1

6.6 Assessment:

6.6.1 Assessment criteria

a) **Effectiveness in reducing use-** Measures the reduction in per capita aggregates use due to the policy.

b) **Effectiveness in reducing externalities**- Measures the reduction in the externalities associated with aggregates mining (and use) arising from the policy.

c) **Effectiveness in promoting recycling**- Measures the uptake of recycled aggregates as a result of the policy

d) **Cost/Self-sufficiency -** Refers to the revenues generated by the policy relative to the cost required to implement and run the program.

e) **Other environmental consequences-** Addresses potential co-benefits/costs to the environment of a given policy.

f) **Complexity-** Is the policy straightforward and easy to understand by those whom it impacts? Will be measured using estimated compliance costs.

g) **Equity-**

Vertical equity- Measures the extent by which entities differing in income are treated differently. This will be measured by a qualitative assessment of the impacts.

Horizontal equity- Measures the extent by which entities of the same income class are treated differently. This will be measured by a qualitative assessment of the impacts.

h) **Stakeholder acceptability-** Measures the different reactions, perceptions, feelings of the various groups affected by the policy. Involves a qualitative description of the winners and losers.

A summary of these criteria are located in Table 4 below:

Table 4: Criteria and Measures

Criteria	Definition		Measures
Effectiveness- Reducing aggregates use	How well the policy decreases per capita aggregates use.		Likely decrease in aggregates use (tonnes)
Effectiveness- Reducing Externalities	How well the policy decreases the externalities associated with aggregates mining/use		Qualitative Assessment
Effectiveness- Promoting Recycling	How well the policy promotes use of recycled aggregate		Likely increase in use of recycled aggregate (tonnes).
Cost/Self Sufficiency	What are the costs of implementing and running the program? How do these compare to the revenues generated from the program.		$
Other Environmental Consequences	How will the introduction of a particular policy impact factors other than aggregates production?		Qualitative statement of the impacts/interaction
Complexity	Is the policy straightforward to understand by those it impacts?		Estimated compliance costs.
Equity	Vertical	Are those with different incomes treated differently?	Qualitative description of the impacts.
	Horizontal	Are those with the similar incomes treated differently?	
Stakeholder Acceptability	How are different groups impacted by the policy?		State Winners/losers and in what way.

6.6.2 Status Quo:

Effectiveness- Reducing aggregates use: Currently, the status quo is ineffective in reducing per capita aggregates use. 2007 production statistics from TOARC has per capita aggregates production at 13.5 tonnes per person, above comparable jurisdictions. Likewise, per capita production has risen from 12.8 tonnes per person in 1998, almost

5.5%. Absolute production averaged 173.2 million tonnes between 2004 and 2008, up from an average of 164.8 million tonnes over the five preceding years. This works out to a 5.1% increase. Demand forecasts predict further increases (Ontario Ministry of Natural Resources, 2010). Negative externalities from extraction will continue to adversely affect individuals located near the pits, and there will be continued environmental degradation in the region.

A recently enacted policy that may potentially improve densification in Ontario is The Greenbelt Act (2005), whose aim is to prevent the further outward development of the GTA and Golden Horseshoe through development restrictions (Carter-Whitney, 2008). While cities such as London, Tokyo, Seoul, Portland[62], and even Ottawa have, or have had, Greenbelts, Ontario's is currently the largest and most ambitious of these projects in the world, stretching 1.8 million acres (Carter-Whitney, 2008).

The effectiveness of such a policy in promoting densification depends on its enforcement, as well as growth trends surrounding the boundary. Ottawa's Greenbelt, for instance, was ineffective in controlling urban growth outside the Greenbelt as satellite communities leapfrogged it and began to grow adjacent to its outer limits (Taylor et al., 1995). Consequently, evaluations of the Ottawa Greenbelt found little effect on density (Carter-Whitney, 2008).

Similar experiences characterize the Greenbelts of London and Seoul, with neither greenbelt succeeding in containing growth beyond the belt (Carter-Whitney, 2008). In the case of Seoul, the area of land occupied by the entire metropolitan region is

[62] Technically referred to as an Urban Growth Boundary, the two concepts are virtually identical in practice.

probably larger than it would have been in the absence of the greenbelt (Bengston & Youn, 2006).

Portland's experience with its Urban Growth Boundary (UGB), however, appears more successful. Between 1950 and 1980s, the average population density of the Portland area fell by a third, indicating considerable sprawl. After introducing the UGB, this downward trend reversed, and between 1980 and 1994, the metropolitan population increased by 25%, while land devoted to urban uses increased by only 16%. This contrasts to cities such as Chicago, where urbanized land rose by 46% from 1970 to 1990, but the population by only 4%. In 1984, the Portland area was building new housing at a density of five dwelling units per acre compared to an average of eight dwellings per acre in 1990. Likewise, the average new lot size in 1998 was 6200 square feet, compared to 12,800 square feet in 1978.[63]

While the experience of Portland appears impressive, it is unclear as to what effect the UGB had on these trends. It may have been the case that other factors, such as complementary pro-densification policies introduced by Portland at this time, had a greater effect. To conclude that the UGB was responsible for increasing densification in Portland merely on the fact that population density rose after its introduction would suffer from post-hoc fallacy. However, in the absence of an econometric study or baseline comparison, one is limited to the above form of analysis.

Thus, the future effectiveness of the Ontario Greenbelt in promoting densification, and reducing per capita aggregates use, is uncertain. While it may stop the surge of outward growth from the GTA, leapfrogging of the greenbelt may result in lower density

[63] The above paragraph was from Carter-Whitney, 2008.

figures than would be seen otherwise. There is already evidence of leapfrog development occurring in areas surrounding the Greenbelt, such as Simcoe County. This type of development would likely increase per capita aggregates use due to the necessity to build sewer infrastructure, water infrastructure, as well as roads and highways through the Greenbelt to service areas with few homes and jobs per square kilometre.[64] Short run trends point to a continuation of increasing aggregates use.

Effectiveness- Promoting Use of Recycled Aggregate: The status quo entails nothing additional to promote the use of recycled aggregate in construction. Currently the use of recycled aggregate is a function of its market price relative to that of virgin aggregate, tastes/preferences of the construction industry, as well as quality standards pertaining to its use by various ministries. It is unlikely that recycled aggregate will improve on its current share of 7% of total aggregates in the absence of additional policies.

Effectiveness- Reducing Externalities: Under the status quo, there is nothing additional to existing regulations to reduce the externalities associated with aggregates mining and use. The rate and extent of externality reduction in the absence of further policies remains unclear.

Cost /Self-sufficiency: Since the status quo involves no new outlays of cash, costs are zero for this option. Likewise, there is no additional generation of revenue from the status quo. Viewing all other policy alternatives as additions to the status quo allows for the measurement of their costs as incremental increases to those prevailing in the status quo.

Other environmental consequences: Due to the above, there are no other environmental consequences arising from the status quo.

Complexity: Likewise, since the status quo implies no additional legislation, there is no additional complexity to comply with the status quo.

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[64] The above paragraph was from Carter-Whitney, 2008.

Stakeholder Acceptability: Stakeholders who stand to win or lose from the proposal are as follows:

Winners:

a) *Aggregates producers:* While current policies may reduce demand for aggregates in the long run, the policies impose few tangible and immediate costs to aggregates producers. Thus, they will likely defend the status quo against any further encroachments on their ability to produce aggregate unhindered.[65]

b) *Construction industry & developers*: Under current policies, developers are free to pursue any sort of development they desire outside the Greenbelt. Although they face constraints by the Greenbelt, developers will likely favour the status quo relative to any additional legislation. Construction firms benefit from the ability to purchase a ready supply of aggregates at low prices.

c) *Homebuyers & renters:* While there is some conflicting evidence concerning the adverse impact of a Greenbelt on house prices, people who seek to buy homes, rent living space, or lease office space, will prefer the status quo as they benefit from a supply of inexpensive materials used in the building of structures

Losers:

d) *Future and current residents living near aggregates pits and quarries:* As mentioned previously, residents living near aggregates sites receive considerable disutility due to a number of factors associated with aggregates production. Likewise, residents in many small towns could potentially face these issues in the future should aggregates producers decide to establish a pit near their home.

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[65] Gravel pits and quarries face no additional restrictions due to the Greenbelt Act (2005); they can continue mining within the Greenbelt's boundary (Carter-Whitney, 2008).

Residents already living near pits and quarries experience greater costs than they would otherwise if production were lower. Likewise, the scale of production necessitates the construction of more pits than would be otherwise, affecting a greater number of residents. Environmental degradation will continue at its present rate, impacting the region more broadly.

e) *Municipal governments:* As mentioned in Baker and Shoemaker (1995), municipal governments have been steadily losing power to the centralizing tendencies of the ARA. Municipal governments also stand to lose from discontent emanating from their constituents due to the presence of nearby aggregates mines.

f) *Ministry of Natural Resources:* Although it stands to gain in the short run from centralized control over aggregate resources, the Ministry of Natural Resources is a looser from public perception of its mismanagement of aggregate resources.

Equity:

Vertical: Vertical equity measures the differential treatment of individuals who differ by income by the policy. The status quo violates vertical equity, as municipalities with different economic and fiscal situations will likely have different capacities to withstand the encroachment of aggregates pits within their boundaries.

Horizontal: Horizontal equity, by contrast, measures the differential treatment of individuals with the same income by the policy. The primary violation of horizontal equity under the status quo is that residents who live near aggregates pits are worse off than their counterparts who do not.

6.6.3 Extraction tax

Effectiveness- Reducing aggregates use: The experiences of both the UK and Swedish extraction taxes fail to provide conclusive evidence of their effectiveness in reducing the demand for aggregates, one of the cited reasons for their imposition in the first place (Soderholm, 2004; Customs and Revenue, 2002). In the Swedish case, even though gravel production fell after the introduction of the tax, Soderholm (2004) and others have noted that major declines in natural gravel production began long before the tax's introduction. This suggests that the drop seen after 1996 was merely a continuation of the prevailing trend. Reasons given for this trend include changes in road construction standards, tightened permit allocations for gravel pits, and changing consumer preferences (Legg, 2007).

Visual inspection of the data, like the analysis conducted above, is not a decisive assessment of the impacts of the policy. This is because such a before-and-after analysis fails to take into account the baseline trend in aggregates extraction had the tax not been in place. It could have been that the gravel tax hastened the rate of decline from what it otherwise would have been. An accurate analysis would require a comparison of actual production to business as usual production, to see how the policy causes a departure from the baseline trend. Alternatively, one can use regression analysis, with natural gravel production as the dependent variable, to isolate the partial effect of the tax on production, holding all other relevant factors constant.

One such analysis, undertaken in 2006 by the Swedish Geological Survey (SGU), shows a relationship between the tax and gravel production that was not statistically significant at the 5% level (Legg, 2007). However, the initially low rate of the tax, at only 10% the market price for natural gravel, likely contributed to this poor outcome.

Greater ambiguity exists regarding the effectiveness of the UK Aggregates Levy in reducing production due to a paucity of econometric work. Working with the Quarry Producers Association, the consulting firm ECOTEC used historical data to predict the short-term impacts of the levy. They found a £1.60 levy (roughly 50% of the price for a tonne of aggregate) would reduce demand by about 10%, subject to a wide margin of error (HM Customs and Revenue, 2002).

While the absolute decline in total aggregates sales for England came close to ECOTEC's prediction, declining by about 11% between 2001 and 2006, Figure 2 in Appendix J shows that per capita production hardly fell at all, only from 3.77 to 3.74 tonnes per person over the same period, roughly 0.8%. Likewise, inasmuch as there was a declining trend, it appears as if it predated the tax by a number of years. As was the case with the Swedish tax, however, this is a before and after analysis that suffers from the issues mentioned above.

In spite of there not being a comparable regression analysis as the Swedish case, movements in other variables can act as a crude proxy to substantiate whether or not the tax is having its intended effect. For instance, the production of manufactured aggregate has increased by 5.2% in England between 2001 and 2005[66], suggesting that the tax is promoting the use of substitutes to virgin aggregate. Of course, correlation does not imply causation. Just like earlier criticisms of the methodology used to determine the effectiveness of a tax, some other unforeseen factor may result in movements of these variables and not the aggregates levy.

[66] Data was taken from the 2002 and 2006 UK Minerals Survey

Overall, the effectiveness of the tax in reducing per capita aggregates use is highly uncertain. Indeed, economic theory suggests that the demand for aggregates is own-price inelastic, with changes in demand being relatively unresponsive to changes in induced by a tax, due to the paucity of substitutes as well as the demand for natural resources being a derived demand. The fact that the cost of materials make up a small proportion of total construction costs suggests that even if 100% of the tax burden in passed on to construction firms, it is unlikely to significantly reduce the use of aggregate in construction projects, or reduce the demand for construction activity.[67]

Effectiveness- Promoting use of recycled aggregate: Due to the reasons just mentioned, it is unclear as to what effect the tax will have on promoting the use of recycled aggregate. The introduction of the aggregates levy corresponded with an increase in the establishment of new C&D waste recycling plants, rising from an average of 33 new plants per annum between the years 1997 and 2001, to an average of 39 plants per annum between 2002 and 2004.[68] Unfortunately, this is unreliable as it suffers from the same *"before-and-after"* analysis that was present in the preceding analysis.

Effectiveness- Reducing externalities: The incentive to reduce most externalities from aggregates production such as noise, dust, and GHG emissions will be unaffected by the tax. This is a consequence of taxing production and not pollution, whereby firms have an incentive to reduce production but not the pollution associated with said production. While taxing the externalities directly would be ideal, it may be administratively infeasible due to the reasons mentioned previously. The extraction tax, inasmuch as it is effective in reducing aggregates production, will help reduce some, but

[67] Taken from Soderholm, 2004.
[68] Taken from BDS, 2005.

not all, of the externalities associated with aggregates production as a *"second best"* option (Soderholm, 2004).

Cost/Self-sufficiency: An ex-ante cost estimate of the Aggregates Levy indicate that administrative costs would be in the region of £2 million in the year of implementation, and £1 million a year for following years (Customs and Revenue, 2002).

The levy raised £334m, in 2008-09, indicating that net of administrative costs, the policy is self-sufficient and a considerable revenue raiser (Seely, 2009).

Other environmental consequences: The UK experience demonstrated a number of negative environmental consequences from the tax. Firstly, many of the secondary aggregates that such a policy promotes, such as slag or shale, involve production processes that are energy intensive and environmentally harmful, far more so than aggregates production (BDS, 2005).[69] Similarly, Sweden's tax on Natural gravel saw the shift towards crushed rock, whose processing is more energy intensive than natural gravel, resulting in higher GHG emissions (EEC, 2008). Although this particular shift will not occur in the Ontario case due to the taxation of natural gravel and crushed stone at the same rate, it serves to illustrate the point that policymakers must be attentive to the type of substitutes that such a policy will likely promote.

Secondly, manufactured aggregates, while previously used in construction in the UK, were restricted to local markets due to prohibitive transport costs. The aggregates levy, however, has made it possible to supply (economically) these products elsewhere, with some deliveries being in excess of 100 miles, resulting in greater GHG emissions from trucking (BDS, 2005).

[69] Higher energy intensity is only a problem if the primary energy source contributes to GHG emissions. This is indeed a possibility in Ontario as about 20% of electricity is generated using coal fired plants, although these are to be phased out by 2012.

Other issues pertain to imports, as well as the stockpiling of low value aggregates. An excavation tax in one jurisdiction but not in others will make it economical to import aggregates from other areas, thereby shifting the environmental problems associated with aggregates production to these jurisdictions. Consequently, it is imperative that the excavation tax also apply to the imports of aggregates, as was the case in the UK. Even if this is the case, however, there is still difficulty in accounting for the embedded aggregate content of products, such as cement.

Regarding stockpiling, the generation of low-value aggregate is a by-product of the quarrying process. However, these unprocessed (but taxed) materials have to compete with untaxed secondary and recycled products making their sale uneconomical (BDS, 2005). There have been criticisms that in the UK, stocks of these unsold lower quality primary aggregates have been discarded, blighting the landscape (BDS, 2005).

Simplicity: By unambiguously defining aggregate, and by making such information readily available, a tax is a very simple and transparent mechanism for those paying the pollution fees. Estimated Compliance costs calculated by KPMG (2006) amount to £0.4 million per year.

Stakeholder acceptability: The likely winners and losers associated with such a policy are as follows:

Winners:

a) *Residents:* People who live in municipalities close to aggregate pits and quarries stand to benefit inasmuch as the policy is effective in reducing the externalities associated with aggregates production and consumption. Taking contingent valuation surveys from the UK prior to the introduction of the aggregates levy, the

UK government has found significant environmental costs associated with quarrying which were valued at an average of around £1.80 per tonne, more than 50% of the market value of aggregate (Customs and Revenue, 2002). Likewise, Willis & Garrod (1999) found the disutility value of a representative quarry to be between £0.41 and £1.05 per tonne.

b) *Municipal governments:* Municipal governments stand to gain should this policy be effective in its stated goals. As mentioned previously, municipalities seek to better regulate aggregate mining within their jurisdictions as it is the cause of considerable distress amongst their constituents.

c) *Ministry of Natural Resources:* The Ministry of Natural Resources will benefit from administering the fund where the tax revenues are earmarked, thereby increasing its power and prestige.

d) *Taxpayers:* Taxpayers stand to gain from this policy. Even though the vast majority of aggregates are used in roads and public works, and so the extraction tax will result in higher government expenditure on infrastructure projects, these increased costs will be offset by a fraction of the revenues generated by the tax, since demand for aggregate is not perfectly inelastic.

Losers:

e) *Aggregates producers:* Aggregates producers stand to lose from the policy. Even if aggregates producers can pass the entire burden of the tax onto consumers of aggregates, the tax is still an inconvenience, with substantial compliance costs, that they would rather avoid. Likewise, since demand is not perfectly inelastic, producers will end up bearing part of the cost.[70]

f) *The construction industry and housing developers:* The construction industry will be able to pass some of increased materials costs to consumers, however, since demand for new houses competes with that of existing homes and is thus relatively elastic, the burden will be only partly shifted. Thus, the construction industry, which uses aggregates, will bear an indeterminate portion of the tax burden.

g) *Purchasers and renters of homes; renters of office space:* The final consumers of aggregates are ultimately those people who buy the homes and lease the offices in which aggregates are embodied. Since most of the tax burden is likely to be passed onto these consumers, due to the reasons discussed above, they will likely see the costs of new homes and rentals rise slightly.

Equity:

Vertical: The aggregates industry in Ontario consists of a small number of large- scale producers and a competitive fringe of small-scale aggregates producers. Thus, the tax will not affect all aggregates producers equally. Many small-scale producers, which are producing at the margin, will likely loose under such a policy while large-scale producers, who benefit from economies of scale, will weather the tax much better. Construction firms, facing a similar market structure, will face similar equity effects, although this depends on how high the tax is as a share of total costs at the individual

[70] My results from the earlier regression showed that for Canada as a whole, demand for aggregates was price inelastic, although not perfectly inelastic.

firm level, as well as the extent to which construction firms can shift the burden of the tax on to their consumers.

Horizontal: All else being equal, since the tax applies to only a sub-sector of the mining industry, and not all firms, those with equal incomes are taxed differently.[71] Another consideration regards construction workers, who may see their incomes fall due to the competitive consequences of the tax for the construction industry.[72] This may cause the different treatment of construction workers who have equal incomes with workers in other industries. Finally, differential treatment may result from the sort of exemptions determined by the design of the tax. For instance, by designing the UK tax to have exemptions for exports and Northern Irish producers, the impact of the tax on aggregates producers within these categories differ from aggregates producers with the same income who are not in these categories.

6.6.4 Landfill Tax:

Effectiveness- Reducing aggregates use:

Like the extraction tax, the impact of a landfill tax on reducing per capita aggregates use is unclear. Figure 3 in Appendix J demonstrates that although the introduction of the UK Landfill tax has coincided with a decrease in per capita aggregates production, from 4.1 tonnes per person in 1995 to 3.7 tonnes per person in 2001, as well as a decoupling of primary aggregates production from GDP, both of these trends began before its introduction. Thus, the decline may have been a consequence of other factors.

[71] All else, however, may not be equal, as different mining entities may pay royalties at different rates. A full analysis of the implications would require the estimation of royalties for the entire mining sector which is beyond the scope of this paper.

[72] The extent of this, of course, depends on the labour shares of total production within the sector which is again, beyond the scope of this paper.

That the landfill tax indirectly reduces the use of aggregates, by promoting the a viable recycled aggregate industry to increase the economic viability of substituting recycled aggregate for virgin aggregate, it does not seem, a priori, as if it would be a very effective policy tool in reducing use when compared to the more direct extraction tax. However, given the aforementioned fact that materials costs are only a small fraction of total construction costs, it may be that their use by construction firms is relatively unresponsive to changes in price. This may make an approach that pushes the supply of a viable alternative to be more successful in the end

Effectiveness- Promoting recycling

The evidence supporting the effectiveness of the landfill tax in promoting the use of recycled aggregate is mixed. In the case of the UK, recycling of C&D waste has risen from 9.2% in 1996 to 35% in 2000. Current data indicates that it has increased further, to 45% in 2007 (World Business Council for Sustainable Development, 2008). Another sign of its success was that for the period immediately preceding the introduction of the tax, the average number of new C&D recycling plants established was approximately 16 per year. Introduction of the landfill tax, however, resulted in an average of 33 plants established per year between 1997 and 2001, indicating greater recycling activity with respect to C&D waste (BDS, 2005). Likewise, in Denmark, waste delivered to landfills fell from 39% to 26% of the waste stream between 1985 and 1993, while the reuse of C&D waste rose from 12% to 82% (Ekins, 1999).

Unfortunately, the possibility of using recycled C&D waste for other purposes, rather than aggregate, implies that an increase in recycling of C&D waste does not automatically translate into an increase in the use of recycled aggregate. Likewise, the above are all *"before-and-after"* analyses, which fail to account for other confounding factors that may contribute to this uptake in recycling.

The UK now has the highest proportion of use of recycled aggregate in Europe, at 24%, up from only about 3.6% in 1990 (BDS, 2005). Likewise, the Netherlands, the country with the second highest proportion of use of recycled aggregate has had a landfill tax in place since 1995. Unfortunately, it is unclear as to what extent the respective taxes have contributed to these high rates of use of recycled aggregate. Denmark and Sweden, for instance, have very low use of recycled aggregate, 5% and 8% respectively, in spite of the tax.

Complicating this assessment is the varying building standards pertaining to the use of recycled aggregate across jurisdictions. Thus, a successful policy aimed at increasing the uptake of recycled aggregate must also consider this. The physical properties of coarse aggregates made from crushed demolition concrete, as well as recycled aggregate pavement (RAP) make it the preferred material for applications such as road base and sub-base (World Business Council for Sustainable Development, 2008). Unfortunately, due to concerns surrounding quality, recycled concrete can replace at most 20-30% of aggregate content for structural applications (World Business Council for Sustainable Development, 2008).

Effectiveness in reducing externalities: Like the extraction tax, inasmuch as the landfill tax it is effective in reducing aggregates production, it will help reduce some of the externalities associated with aggregates production. By generating revenues, the tax can improve the funding of existing regulations aimed at mitigating the externalities associated with aggregates use. Finally, the landfill tax directly mitigates the waste externality associated with aggregate use.

Cost/Self sufficiency: Treasury data for 2007/2008 has landfill tax receipts corresponding to £0.9 billion. Projected revenue for 2008/2009 is to increase to £1.1 billion (HM Treasury, 2008). Unfortunately, no data was available for administrative costs.

Other environmental consequences: The extent that such a tax is effective, it should result in less waste and greater recycling more broadly. After seven years of the tax, Sweden landfills less than four per cent of its waste. Incinerating now accounts for 47% of waste disposal with recycling making up the rest. This has also resulted in energy from waste now accounting for 20% of heat supplied to Sweden's district heating schemes (Legg, 2008).

Although less spectacular than in Sweden, the UK has seen its total waste going to landfill falling from 85% in 1996–97 to only 81% in 1999–2000.[73] This move away from landfills is important due to the environmental externalities associated with landfills and their use. These include groundwater pollution, aesthetic impacts, the emission of methane, noise from trucking, and other health impacts (Martin and Scott, 2003).

Negative implications of the tax include the possibility of illegal activities to subvert it, as well as possible negative energy implications. The UK experience suggests that the former may be a problem. It has been argued that due to smaller businesses

[73] Part of this relative unresponsiveness to the policy is potentially due to the relatively low pre-tax tipping fee of the UK, corresponding to 13 pounds per tonne. Considering that the initial tax was only 7 pounds per tonne, landfill costs in the UK would have risen to 20 pounds per tonne after its introduction, still below such countries as Holland, Denmark, Sweden, Germany, and Norway, with rates of 24, 28, 28, 32, and 40 pounds per tonne respectively. Subsequent increases of the tax would have likely had a greater effect than that stated above due to the relatively low level of the tax in its initial years (Morris et al.,1998).

illegally disposing of their waste through the domestic collection system, household waste going to landfill has risen by 7.9% between 1996 and 2000 (Martin & Scott, 2003). Hasegawa (2003), however, notes that a number of Dutch and Danish studies found no problems with illegal dumping in those jurisdictions (Hasegawa, 2003).

Finally, if the recycling process is more energy intensive than the aggregates extraction process, then the recycling process could be responsible for greater GHG emissions than the extraction of primary aggregates, depending on the source of primary energy. Nesbit & Venta (2000), however, note that plants for producing recycled concrete aggregate use similar equipment and energy quantities to the process of extracting virgin aggregate.

User complexity: With landfill operators taxed at a fixed fee per tonne, so long as exemptions are few and such information is readily available, then the tax is a very simple and transparent policy.

Estimated annual compliance costs calculated by KPMG include annual compliance costs of £4.2million per year (KPMG, 2006). Most of these costs accrue the requirement of quarterly collection of the tax, as well as the requirement to keep all tax records for up to 6 years (KPMG, 2006). Likewise, in the UK, landfill operators can claim a credit against their Landfill Tax payment if they make a voluntary contribution to an approved Environmental Body (Morris et al., 1998). Up to 90% of the contribution can be reclaimed but the total credit in any 12 month period must not exceed 20% of the total landfill tax bill (Morris et al., 1998) The relative complexity of this scheme likely contributes to the aforementioned compliance costs. The tax envisioned for Ontario will have none of these schemes and so compliance costs will likely be lower than in the UK.

Stakeholder acceptability: The following briefly sets out which groups stand to gain or lose with the implementation of a landfill tax.

Winners:

a) *Recycling plants:* Plants that recycle waste will likely see an increased demand for their services, as firms will seek to avoid the tax through alternatives such as recycling.
b) *Present or future residents living near aggregate pits:* Inasmuch as the tax succeeds in promoting recycled aggregate to replace virgin aggregate, municipal residents who live near pits will benefit from the reduction of the negative externalities associated with aggregates. Likewise, municipal residents who live near potential pit and quarry sites will benefit from the reduced extraction, as it decreases the reason for mines to be established in their municipality.
c) *Residents living near landfill sites:* By reducing the amount of waste sent to landfills, the externalities associated with landfills will not be as prominent. This has important health and quality of life benefits for these residents. In addition, evidence suggests that smaller landfills are easier to effectively manage, further minimizing these adverse impacts (Martin & Scott, 2003).
d) *Taxpayers:* The cost section suggests that there will be a gain in tax revenues net of administrative costs which should benefit taxpayers.

Losers:

a) *Municipal authorities:* Municipal authorities stand to lose from the imposition of a landfill tax as they will have to pay the tax to landfill operators for municipal household waste. Municipalities in the UK were opposed to the landfill tax over this very issue (Seely, 2009). In addition, any illegal dumping within their borders as a result of the tax will increase cleaning and maintenance costs.

b) *Business:* Businesses which are responsible for their own waste disposal will have to pay more to dispose of waste and landfill their goods.

c) *Landfill operators:* Although landfill operators can pass the entire burden of the tax onto consumers of landfills, they will still face compliance costs.

Equity:

Horizontal Equity: Assuming all else equal, including the marginal tax rates faced by different groups in the economy, horizontal equity will not be exacerbated by the landfill tax due to all entities being taxed at the same rate per tonne. At the same time, the taxing of individuals and firms who are more wasteful than their non-wasteful counterparts will occur, even if these people are of the same income.

Vertical equity: Wealthier municipalities, construction firms, and landfill operators, may be better able to weather the tax than poorer ones. Since the tax is a fixed rate per tonne, the tax paid on one tonne of waste is a greater proportion of a poorer firm's income than a rich one. However, a violation of vertical equity only occurs if entities with different incomes generate the same amount of waste in proportion to their incomes, which may not be the case.

7: Policy Evaluation

Based on the above assessment, the policies will be rank-ordered relative to one another for each criterion. Monetizing the criteria of other environmental consequences, and effectiveness in reducing externalities would be ideal for better comparison across options. Unfortunately, this is far beyond the scope of this paper. In order to make comparisons for these criteria, a qualitative ranking of the impacts under each option is necessary. Differential weighing of impacts are justified by the varying significance of their overall consequences. Although this is admittedly subjective, to give each option equal weight would also be subjective. In the absence of a common metric, subjectivity is unavoidable.

The results for the stakeholder acceptability and equity criteria will not be included in this analysis. This is because the ranking of stakeholder or equity concerns is ultimately the job of the politician, and not the policy analyst.

Finally, a value for administrative costs was unavailable for the landfill tax. Consequently, citing the literature, the administrative costs of landfill taxes are "*modest"* (Hasegawa, 2003). While this may not be very helpful, it may be sufficient to distinguish it from status quo, assuming that revenues from the scheme exceed administrative costs.

In the case of a tie for first, the third option will remain in last place. The ranking of the three policy options under each criterion in summarized in Table 5. The winning policy under each criterion is shaded in green and bolded, the runner up in grey and italicized, and the looser in purple.

Table 5: Evaluation Matrix

	Option 1: Status Quo	**Option 2: Extraction Tax**	**Option 3: Landfill Tax**
Effectiveness (decline in per capita aggregates use)	No Impact. Forecasts predict likely increases**.**	**Uncertain Impact**	**Uncertain Impact**
Effectiveness (Uptake in recycling)	No Impact	**Uncertain Impact**	**Uncertain Impact**
Effectiveness (Reduction of Externalities)	No Impact	**Reduced Production Reduced Waste Recycled Revenues**	**Reduced Production Reduced Waste Recycled Revenues**
Cost (Self sufficiency)	No additional Outlays. No additional revenues.	**300million collected in 2007-2008 Administrative Costs: 1 million per year.**	*900 million collected in 2007-2008* *Administrative Costs: Modest?*
Other Environmental Consequences	*None*	Positive: None Negative: Stockpiling Higher Transport distances than aggregates extraction Use of Manufactured aggregate: Higher GHG emissions than aggregates extraction	**Positive: Reduced Externalities from landfill waste.** **Negative: Illegal Dumping?**
User Complexity	**No additional Compliance Costs**	*Compliance costs of 0.4 million pounds per year.*	Compliance costs of 4.2 million pounds per year.

The above table clearly rules out the status quo as a potential option, as it scores best in only one of the six categories, user complexity, and second only in other environmental consequences. Differentiating between the landfill and extraction tax is more difficult. Their effectiveness in reducing use and promoting recycling cannot be adequately determined due to an inability to isolate the effect of the policies from the number of other confounding factors that could have influenced these trends. Likewise, the recent adoption of the above policies, combined with their introduction being *"packaged"* with a suite of supporting policies in the countries surveyed, made it virtually impossible to determine their effectiveness without some sort of formal econometric analysis. Despite this, it is unlikely that either policy has had no effect, which sufficiently differentiates them from the status quo.

Likewise, although both taxes contribute somewhat to reducing the externalities associated with aggregates mining and use, their effects are insufficiently different to rank one above the other. By reducing production, either tax can reduce the externalities associated with aggregates mining through that channel. Both taxes, however, do not create incentives for aggregates producers to reduce externalities by *"cleaning-up"* the production process. While the landfill tax creates the incentive to reduce waste associated with aggregate use, the extraction tax, given the available data, generates greater revenues that potentially strengthen existing externality-mitigating regulations.

Given the data that was available, the extraction tax fared best under cost/self-sufficiently, with the landfill tax following. There is, however, much uncertainty surrounding the results under this criterion. On the other hand, the landfill tax was the clear winner in the other environmental consequences category, with a considerable co-benefit and little in the way of perverse incentives. The extraction tax fared worst under this criterion with perverse incentives of considerable environmental consequence.

8: Recommendations:

Based on the above analysis I recommend implementing both the extraction tax and the landfill tax to reduce per capita aggregates use in Ontario over the short term. This is because neither option truly trumps the other under the preceding evaluation. Should policymakers seek to differentiate between the two, they can assess the criteria differently depending on their own subjective weights. Likewise, they can incorporate equity effects and stakeholder acceptability to inform their decision.

My recommendation is subject to a number of qualifications. Firstly, research suggests that a landfill tax is most effective when pursued with a suite of complementary policies. Denmark and Sweden, for instance, introduced regulations in 1997 and 2006 respectively to induce further gains, and to reinforce existing ones from the tax. Consequently, research should consider the appropriateness of such policies for Ontario after the introduction of the tax. Introducing an information campaign in tandem with the tax is advisable to promote the demand of recycled aggregate by the construction industry and to promote better waste management practices by economic agents more generally

Secondly, it may be worthwhile to consider differentiation of the extraction tax based on open-pit or underground mining. While there are no technological barriers to underground mining of aggregate, it remains rare due to open pit being the cheaper option. However, if one were to charge aggregate producers a tax per tonne if they mined open pit, while waiving the tax if they mined underground, the economics may shift in favour of underground mining (Thomas, 2008). Thomas (2008) suggests that the UK look to adapt their Aggregates Levy in such a fashion, as it would eliminate some of the worst externalities- such as noise, dust, and land alteration- inherent with open pit aggregate mining. Likewise, alternate land uses, such as farming, can be pursued simultaneously overtop of the mine, reducing conflict. Considering that differentiation in such a manner is currently not part of the existing extraction taxes in Europe, it is definitely something worth considering.

Thirdly, in addition to reducing production, there is room to improve the current regulatory regime to reduce the negative externalities associated with aggregates use. For instance, the revenues generated from the aforementioned taxes can help to improve monitoring and enforcement of current regulations, as well as mine rehabilitation, both of which have been identified as problems by the Environmental Commissioner of Ontario in its 2003/2004 Report (Environmental Commissioner of Ontario, 2004). Likewise, potential areas for reform also include the issues pertaining to CEE's, the centralization of the regime, as well as it being proponent driven.

Finally, I recommend investigation of other policies aimed at improving urban density over the long-term. Based on the findings of the case study, it is by building proportionately more multi-family dwellings, smaller off-street parking minimums, more compact commercial office buildings, and more mixed-use development that Ontario will see substantial declines in aggregates use per person. A number of potential policies involve those pursued by a number of European and North American cities under the umbrella of Smart Growth. They include, but are not limited to, policies such as changing of zoning by-laws, impact fees, density bonuses, infilling vacant land, and transfer of development rights. An in depth assessment of these policies needs to be done to determine which ones would work best for Ontario.

9: Conclusion

In closing, despite a thorough assessment of the issue, a clear answer to the questions, whether or not Ontario receives *"more with more"* or *"less with more"* from its above average production, is lacking. In other words, from this analysis alone, one cannot determine if Ontario receives net incremental benefits. To answer this question, a formal cost/benefit analysis needs to be undertaken. While such an analysis is beyond the scope of this paper, answering why Ontario's per capita use is above comparable jurisdictions helps with the identification of the benefits in terms of additional infrastructure services that Ontarians receive from above average use- more single detached residences, more parking spaces, greater commercial floor space etc. The identification of all the potential costs and benefits is an important first step in any cost-benefit analysis, and a necessary precondition to their quantification and monetization.

Furthermore, if the incremental benefits do not exceed the incremental costs, then this analysis provides an assessment of potential policies, and recommends a course of action for immediate consideration, actions that also have co-benefits in the form of reducing externalities from aggregate production.

Appendix A: Provincial Specific Statistics- Dependent Variable 1987-2003

Year	Ontario	Quebec	Alberta	British Columbia	Newfoundland	Nova Scotia
1987	16.4	11.9	18.8	18.3	7.6	14.9
1988	16.6	12.3	17.5	16.8	11.1	17.9
1989	14.9	11.4	16.9	17.5	8.9	14.7
1990	12.7	10.1	17.4	13.5	7.8	15.6
1991	10.0	9.6	14.9	13.3	6.6	11.1
1992	11.9	10.4	14.6	12.6	7.8	11.6
1993	12.3	9.4	13.0	12.5	8.8	10.6
1994	13.1	9.4	13.3	11.7	7.2	10.0
1995	12.1	8.6	11.6	12.2	5.8	11.5
1996	11.4	8.2	11.1	10.8	6.5	11.3
1997	12.1	8.3	13.1	9.9	8.6	11.8
1998	12.2	8.2	15.4	9.6	11.7	10.9
1999	13.6	8.3	14.1	10.0	12.8	10.8
2000	13.6	8.6	14.3	10.0	14.0	11.4
2001	13.1	8.9	14.6	9.3	13.4	12.6
2002	12.5	9.5	13.5	9.1	14.9	12.5
2003	12.5	9.5	14.3	9.0	12.2	11.2

Appendix B: Summary Statistics

	Mean	S.Dev	Max	Min	Skew	Kurtosis	Coefficient of Variation
AGGREGPR	11.9	2.84	18.8	5.8	0.29	2.68	0.24
CONSTRACT	3594	1576	9023	2014	1.92	6.37	0.41
POPDENS	7.38	5.5	17.58	1.39	0.8	2.16	0.75
CLIMATE	-4.9	5.2	6.3	-18.5	0.31	2.97	1.06
UNITPRICE	4.65	0.97	7.3	2.7	0.34	2.68	0.21
HOUSECOMP	0.0037	0.0013	0.0078	0.0018	0.78	2.91	0.35
LUMBER	76.5	19.2	114.7	40.2	-0.17	1.92	0.25

Appendix C: Correlation Coefficients

	CONSTRACT	POPDENS	UNITPR	HOUSECOMP	CLIM	LUMBER
CONSTRACT	1					
POPDENS	-0.35	1				
UNITPR	-0.2	0.01	1			
HOUSECOMP	0.66	-0.12	-0.34	1		
CLIM	-0.05	-0.1	-0.04	0.07	1	
LUMBER	-0.03	0.07	0.24	-0.36	-0.15	1

Appendix D: Regression Results (T-Values in Parentheses)

	1.	2.	3.	4.	5.
	AGGIES/CAP	AGGIES/CAP	AGGIES/CAP	LN(AGGIES /CAP)	ΔAGGIES/ CAP
CONSTANT	32.21(5.55)***	32.21(5.04)***	32.21(5.55)***	4.68(5.02)***	1.42(1.77)*
CONSTRACT	0.0000096(.03)	0.0000096(.03)	0.0000096(.03)		
UNITPRICE	-1.1(-2.52)**	-1.1(-2.05)**	-1.1(-2.52)**		
HOUSECOMP	707.5 (3.34)***	707.5 (2.89)***	707.5 (3.34)***		
POPDENS	-1.4 (-2.75)**	-1.4 (-2.34)**	-1.4 (-2.75)**		
CLIMATE	0.17 (2.6)**	0.17 (2.5)**	0.17 (2.6)**	0.01(2.13)**	
BC	-14.2 (-3.24)***	-14.2 (-3.01)***			
QC	-11.4 (-3.03)***	-11.4 (-2.9)***			
ALB	-10.4 (-2.4)**	-10.4 (-2.2)**			
NFLD	-16.8(-2.81)***	-16.8(-2.6)**			
NS	7.3 (2.52)**	7.3 (2.24)**			
LUMBER	-0.0004(-0.03)	-0.0004(-0.03)	-0.0004(-0.03)		
LOGUNITPR				-0.07(-0.48)	
LOGPOPDENS				-1.7(-5.62)***	
LOGCONSTAC				0.17(1.86)*	
LOGLUMBER				0.1(1.64)	
LOGHOUSECO				0.18(3.19)***	
ΔCONSTRACT					0.00007(0.21)
ΔUNITPRICE					0.25(0.79)
ΔHOUSECOMP					612(3.1)***
ΔCLIMATE					0.039(1.13)
ΔPOPDENS					-8.9(-2.01)**
ΔLUMBER					0.006(0.64)
Number of Observations	102	102	102	102	96
Adj. R^2	0.62	0.62			
R^2 Within			0.44	0.56	0.18
R^2 Between			0.036	0.19	0.25
R^2 Overall			0.0006	0.05	0.14

	6.
	AGGIES/CAP
CONSTANT	27.3(4.6)***
CONSTRACT	0.001(4.04)***
UNITPRICE	-1.07(-2.53)**
HOUSECOMP	11.29(4.1)***
POPDENS	-1.5(-2.75)***
CLIMATE	0.11(1.75)*
BC	-13.35(-3.1)***
QC	-11.9(-3.3)***
ALB	-15.1(-3.7)***
NFLD	-20.1(-3.5)***
NS	6.7(2.4)**
LUMBER	-0.03(-2.34)**
LOGUNITPR	
LOGPOPDENS	
LOGCONSTAC	
ΔCONSTRACT	
ΔUNITPRICE	
ΔHOUSECOMP	
ΔCLIMATE	
ΔPOPDENS	
ΔLUMBER	
Number of Observations	102
Adj. R^2	0.64
R^2 Within	
R^2 Between	
R^2 Overall	

Appendix E: Structure Design and Trends- Ontario, BC, and Quebec

<table>
<tr><th></th><th></th><th>Ontario</th><th>BC</th><th>Quebec</th></tr>
<tr><td>Residential</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Housing Composition- as a % of housing starts (1990-2002)</td><td>% Single detached</td><td>57.7%</td><td>46.8%</td><td>57.8%</td></tr>
<tr><td>%Apt and Other</td><td>18.8%</td><td>35.3%</td><td>28.7%</td></tr>
<tr><td>Structural Design</td><td>Average House Size- Including Basement (1994-2004)</td><td>1750 sqft</td><td>2010 sqft</td><td>1203 sqft</td></tr>
<tr><td></td><td>Aggregates Use per Single Detached House (ON-2006, BC-1996)</td><td>440 Tonnes per Unit</td><td>377 tonnes per unit (GVRD)</td><td>NA</td></tr>
<tr><td>% Of Single Detached or row with Basement</td><td colspan="2">76.5%</td><td>43.5%</td><td>58%</td></tr>
<tr><td>Commercial:</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Commercial Floor Space/Person (2000)</td><td colspan="2">$10.3m^2$</td><td>$6.7m^2$</td><td>$9.7m^2$</td></tr>
<tr><td>Commercial Floor Space/$1000 GDP (2000)</td><td colspan="2">$0.26m^2$</td><td>$0.2m^2$</td><td>$0.31m^2$</td></tr>
<tr><td rowspan="2">Aggregates Use</td><td>Per Building</td><td>16,000,000 tonnes</td><td>12,040,000 tonnes</td><td>NA</td></tr>
<tr><td>Per sq Foot</td><td>NA</td><td>560 tonnes</td><td>NA</td></tr>
<tr><td>Average size of a commercial building (2000)</td><td colspan="2">$2297m^2$</td><td>$1614m^2$</td><td>$2224m^2$</td></tr>
<tr><td>Growth in total floor space (1990-1999)</td><td colspan="2">18.4%</td><td>15.8%</td><td>17.2%</td></tr>
</table>

Appendix F: Road Trends- Quebec, BC, and Ontario

<table>
<tr><th></th><th></th><th>Ontario</th><th>BC</th><th>Quebec</th></tr>
<tr><td rowspan="2">Transport Expenditure Per Capita</td><td>Per Capita</td><td>$193.9</td><td>$257.46</td><td>$192.11</td></tr>
<tr><td>%Change</td><td>4.3%</td><td>-0.88</td><td>5.4%</td></tr>
<tr><td>Growth in Roadways</td><td colspan="2">1.3%</td><td>-0.1%</td><td>-0.6%</td></tr>
<tr><td>Road Width</td><td colspan="2">North York Standard: 8.5m
Toronto: 8.5m for major and intermediate local streets. 8.0m for minor local streets, with sidewalk width of 1.7m</td><td>Average in GVRD: 9m</td><td></td></tr>
<tr><td>Road: Materials Use</td><td colspan="2">HMAC 94.3% (Surface Treated Asphalt 17.6%), Composite 2.4%, Portland cement concrete 0.7%, Gravel 2.6%.</td><td>GVRD: 87% HMAC, 7% Concrete only, 6% Gravel
FVRD: 6% Gravel, 94% HMAC</td><td>Less than 5% Concrete, 95% HMAC Province Wide</td></tr>
<tr><td>Road Network (public and private)- Thousand 2 lane km (2004)</td><td colspan="2">230.6 Total
180.4 Local Roads
Total per person: 0.02</td><td>204.8 Total
188.5 Local Roads
Total per person: 0.05</td><td>228.3 Total
197.3 Local Roads
Total per person: 0.03 km</td></tr>
<tr><td>%Paved (public)</td><td colspan="2">62.8%</td><td>67.8%</td><td>56%</td></tr>
</table>

Appendix G: Parking By Laws- Residential

City	Specifications
Ontario	
Former City of Toronto	Under 25 units: 1.25 per unit. Greater than 25 units: 1.25 per 102 sq metre
Downtown Toronto	Apartment: Bachelor 0.36, Single bedroom 0.56, Two bedroom 0.81, Three bedroom and above 1.26. Condo: Single bedroom 0.7, Double bedroom 1.2.
North York	1.5 per unit North York City Centre: 1-1.2 within 500m of RT. 1.3 above 500m of RT.
Scarborough	Rental 1.3, Condo 1.4.
Etobicoke	1.25 One bedroom, 1.4 Two bedroom, 1.55 Three bedroom
East York	1.25 per unit
York	Rental: 1.1 One bedroom, 1.2 Two bedroom. Rental under 500m from RT: 0.97 One bedroom, 1.06 Two bedroom. Condo: 1.25 One bedroom, 1.45 Two bedroom Condo under 500m from RT: 1.1 One bedroom, 1.2 Two bedroom.
Mississauga	Single detached: 3 Apt:1
Markham	Single detached: 2 Apt: 1.5
Hamilton	Single detached: 2 Apt: 1.25
London	NA
British Columbia:	
City of Vancouver	1-2. Downtown plus outlying areas
Burnaby	Single family dwelling units and row house dwellings, 1 for each unit. Town homes 1-1.75 per unit.
New Westminster	1 per single *dwelling* unit and duplex, *Apartments:* 1 per bachelor unit, 1.2 per

	one bedroom, 1.5 for two bedroom, 2 per 3 bedroom and above
Abbotsford	One per *dwelling* unit. *Apartment*: studio 1, one bedroom 1.5, two bedroom 1.75, three bedroom and above 2.
Kelowna	One per bachelor, 1.25 per one bedroom, 1.5 per two bedroom, 2 per 3 or more bedroom. One per dwelling unit in the C4, C7 zone. Single Detached (2 per dwelling unit)
Surrey	2 per unit (single residential, townhome, duplex), 1.5 per one bedroom unit, 1.75 per two bedroom, 2 per three bedroom and above.
Quebec:	
Beauport and Charlesboug (Quebec City)	0.5-1.2 per unit.

Appendix H: Parking by-laws- Commercial (Per $100m^2$ of gross floor space unless otherwise specified)

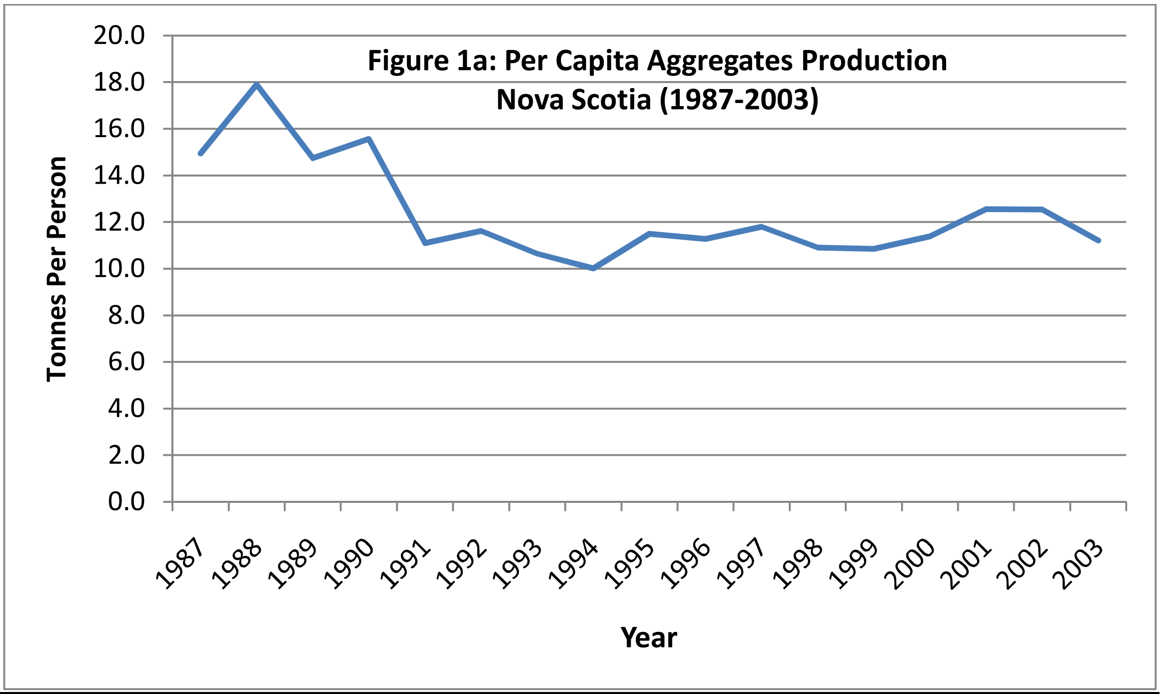
City	Specifications: General Retail	Specifications: General Office	Specifications: Restaurant
Ontario			
Former City of Toronto	N/A	0.97 per $100m^2$	N/A
Downtown Toronto	0.9-3.6 per $100m^2$	0.37-0.82 per $100m^2$	N/A
North York	3.56-6.67 per $100m^2$	2.1 per $100m^2$	10.2-16.95 per $100m^2$
Scarborough	1-3 per $100m^2$	1-3 per $100m^2$	1-10.7 per $100m^2$
Etobiocke	3 per $100m^2$	3.23 per $100m^2$	2.9-14.52 per $100m^2$
East York	3.26 per $100m^2$	1.08-2.13 per $100m^2$	2.13-20.83 per $100m^2$
York	2.13 per $100m^2$	2.13 per $100m^2$	7.14 per $100m^2$
Mississauga	4.9 per $100m^2$	N/A	16 per $100m^2$
Markham	3-4.5 per $100m^2$	3 per $100m^2$	10 per $100m^2$
Hamilton	2 per $100m^2$	3.2 per $100m^2$	0.85/five seats
London		1.25 per $100m^2$	6.67-10 per $100m^2$
British Columbia:			
City of Vancouver	1 per $100m^2$ up to $300m^2$. 2 additional for each additional $100m^2$.	1 per $100m^2$ up to $300m^2$. An additional 2 for each additional $100m^2$.	Restaurant under $250m^2$ - 2 per $100m^2$. No more than 2 spaces total required. Restaurants in C-3A, C-5, C-6: 1 per $100m^2$ up to $300m^2$ and 2 per additional $100m^2$. Restaurants in other areas - 2 per $100m^2$ up to $100m^2$, 10 per additional $100m^2$ up to $500m^2$, 5 per additional $100m^2$ over $500m^2$
Burnaby	2.2 per $100m^2$, 3.6 for each $100m^2$ of retail space	2.2 per $100m^2$	1 per every 5 seats above 50 seats. 2.2 per$100m^2$ under 50 seats.
New Westminster	2.2 per$100m^2$ for the first $278.70m^2$. 3.2 per $100m^2$ over 3,000 sqft	2.2 per$100m^2$ for the first $278.70m^2$. 3.2 per $100m^2$ over 3,000 sqft	2.2 per$100m^2$ for the first $278.70m^2$. 3.2 per$100m^2$ over 3,000 sqft
Abbotsford	2.7-5.3 per $100m^2$	2.7 per $100m^2$	1 per 4 seats
Kelowna	2 per $100m^2$ (gross floor area below	2.5 per $100m^2$	1 per 4 seats

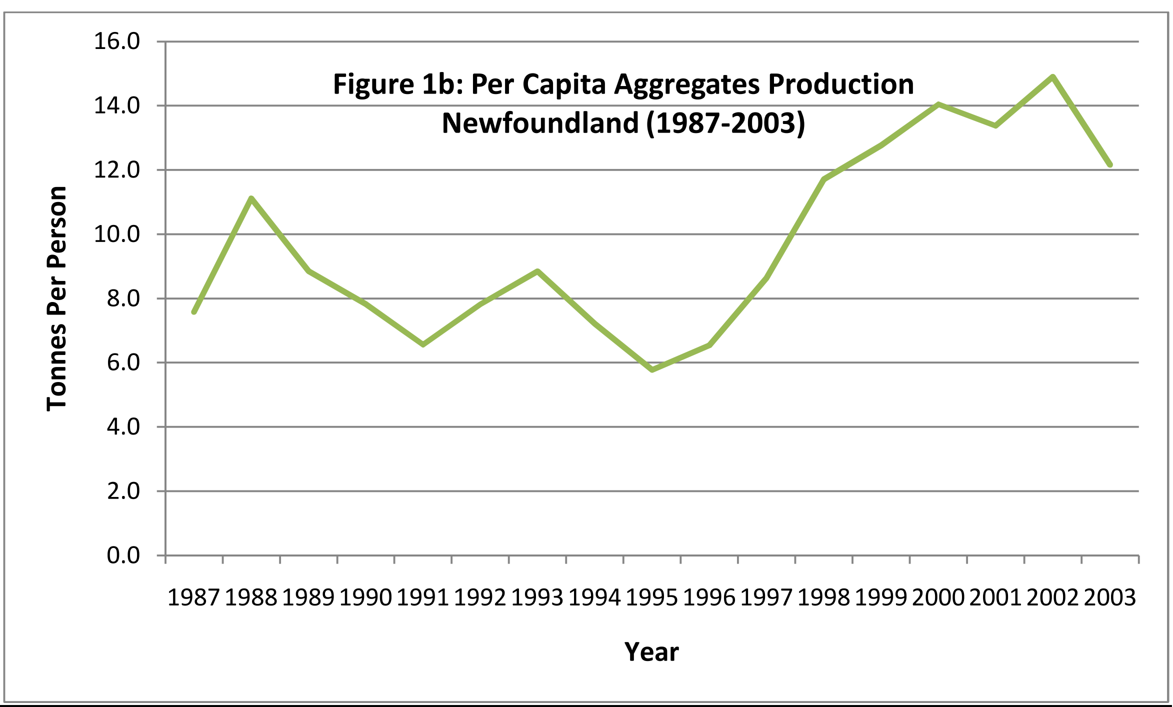
	1000m^2). 3 per 100m^2 (gross floor area above 1000m^2)		
Surrey	Downtown- 2.6 per 100 m^2 of gross floor area on the first storey and levels below the first storey, plus 1.4 spaces for each 100 m^2 on all other storeys Other areas- 80% per cent of the total calculated for the downtown. Minimum of 5 spaces for any development.	1 space for each 2 regular employees, or in C-H zoned areas, 2 spaces for each 3 regular employees, Non-downtown - 2.7 spaces per 100m^2	1 space per 4 seats and 5 spaces for each additional cash register, however, in all cases a minimum of 5 spaces shall be provided
Quebec:			
Beauport and Charlesboug (Quebec City)	Under 1000m^2- 2.5 per 100m^2 minimum, 3.3 per 100m^2 maximum Over 1000m^2- 3.3 per 100m^2 minimum, 5 per 100m^2 maximum Over 2000m^2- no maximum, 3.3 minimum.	1-2 per 100m^2. Maximum 4 per 100m^2	No minimum outside a commercial centre. Maximum 7.7-10 per 100m^2 Commercial Centre: Minimum 2-3.6 per 100m^2, Maximum 2.5-5.5 per 100m^2

Appendix I: Space Specifications (Length by Width)

City	Perpendicular	Parallel
Ontario		
Former City of Toronto	5.9m by 2.6m with a 5.5m aisle	6.7m by 2.6m with a 3.5m aisle
Downtown Toronto	5.9m by 2.6m with a 5.5m aisle	6.7m by 2.6m with a 3.5m aisle
North York	5.5m by 2.7m with a 6.0m aisle.	6.7m by 2.7m with a 3.65m aisle.
Scarborough	5.7m by 2.7m with a 6.0m aisle.	6.7m by 2.7m with a 3.0m aisle.
Etobiocke	6.0m by 2.7m with a 6.0m aisle.	6.7m by 2.7m with a 3.0m aisle.
East York	5.5m by 2.6m with a 6.0m aisle,	6.7m by 2.6m with a 3.0m aisle
York	5.7m by 2.5m with a 6.0m aisle	6.7m by 2.5m with a 3.0m aisle
Mississauga	N/A	N/A
Markham	N/A	N/A
Hamilton	N/A	N/A
London	N/A	N/A
British Columbia:	N/A	N/A
City of Vancouver	5.5m by 2.5m	N/A
Burnaby	5.5m by 2.6m	7.3m by 2.6m.
New Westminster	5.3m by 2.59m-2.74m with a 6.58m-7.01m aisle.	6.7m by 2.59m with a 3.66m aisle.
Abbotsford	5.5m by 2.7m with a 7m aisle.	7.5m by 2.7m with a 3.8m aisle
Kelowna	6.0m by 2.5m.	7.0m by 5.5m
Surrey	5.8m by 2.6m-2.9m with a 6.1m-7.1m aisle.	6.7m by 2.6m with a 3.6m aisle.
Quebec:	N/A	N/A
Beauport and Cherbourg (Quebec City)	N/A	N/A

Appendix J: Figures





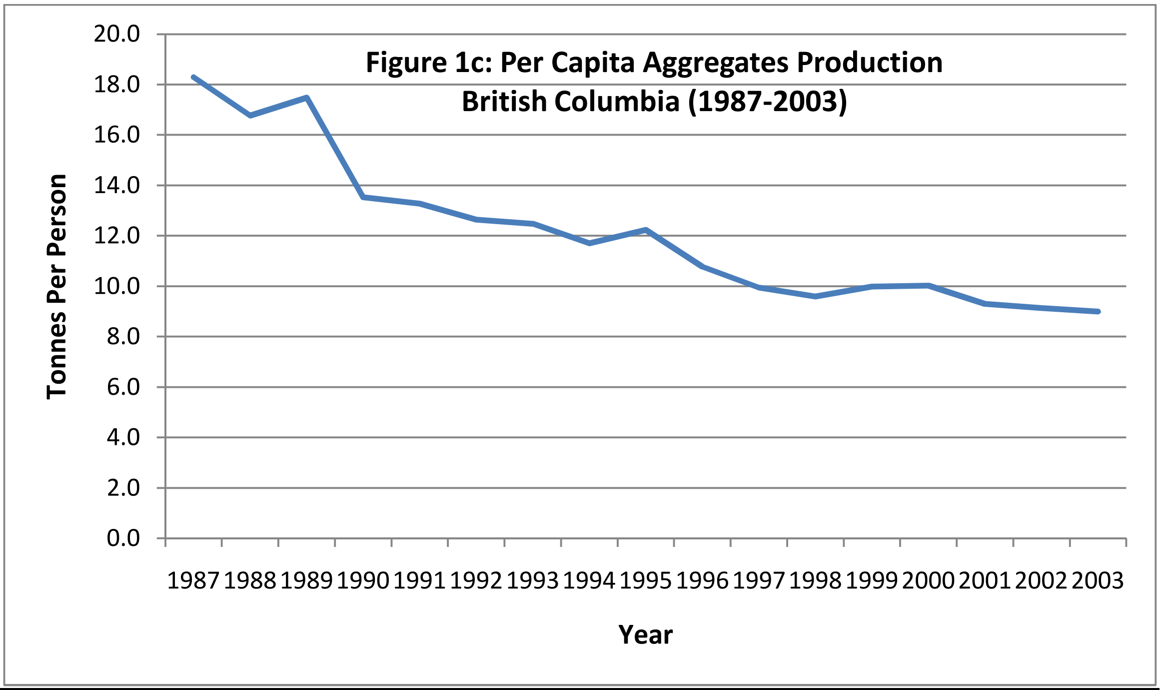


Figure 1c: Per Capita Aggregates Production
British Columbia (1987-2003)
Tonnes Per Person
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Year

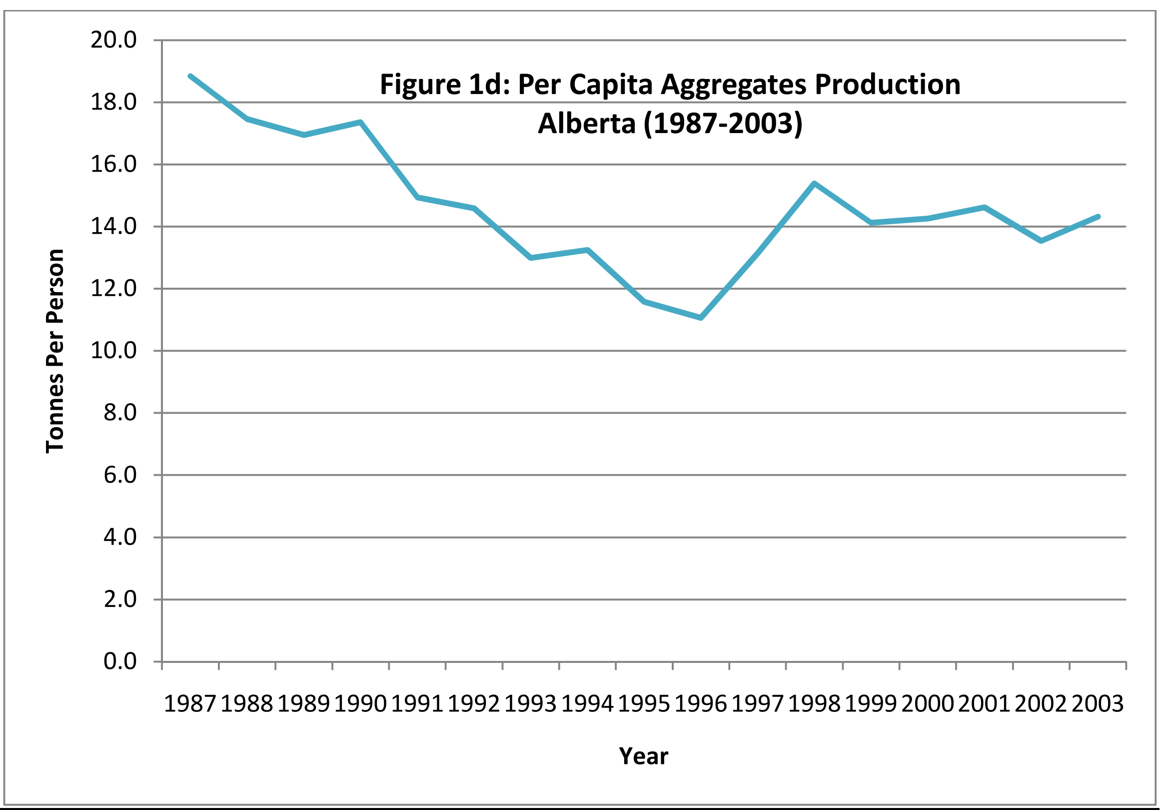


Figure 1d: Per Capita Aggregates Production
Alberta (1987-2003)
Tonnes Per Person
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Year

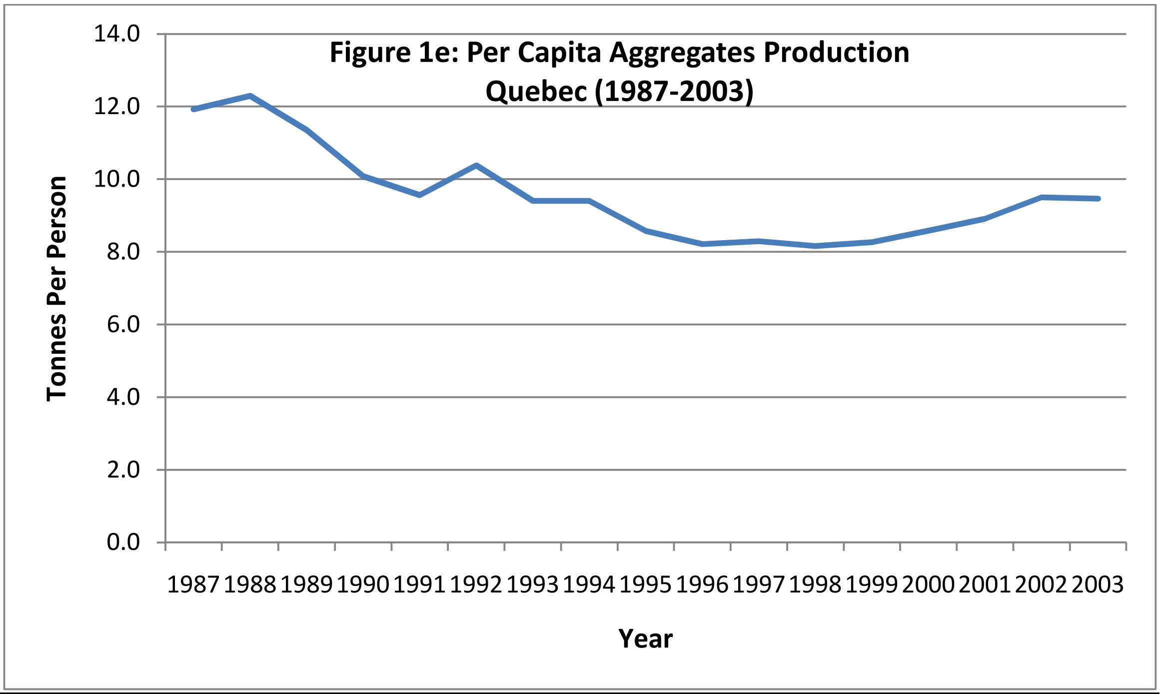


Figure 1e: Per Capita Aggregates Production
Quebec (1987-2003)
Tonnes Per Person
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Year

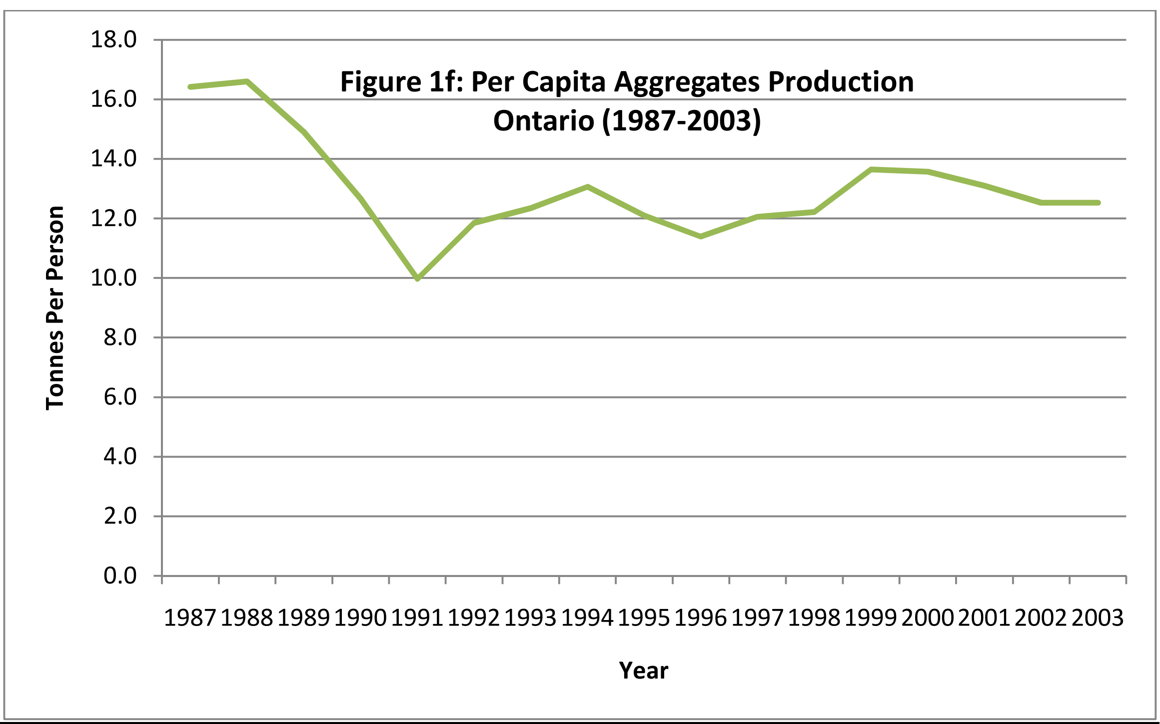


Figure 1f: Per Capita Aggregates Production
Ontario (1987-2003)
Tonnes Per Person
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Year

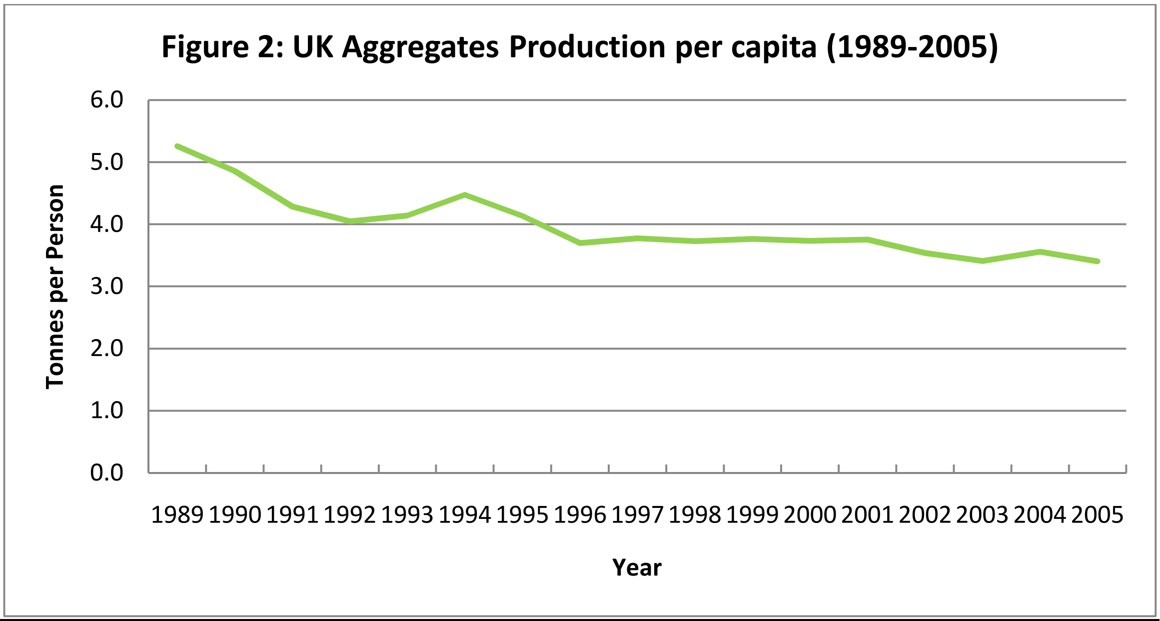


Figure 2: UK Aggregates Production per capita (1989-2005)
Tonnes per Person
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Year

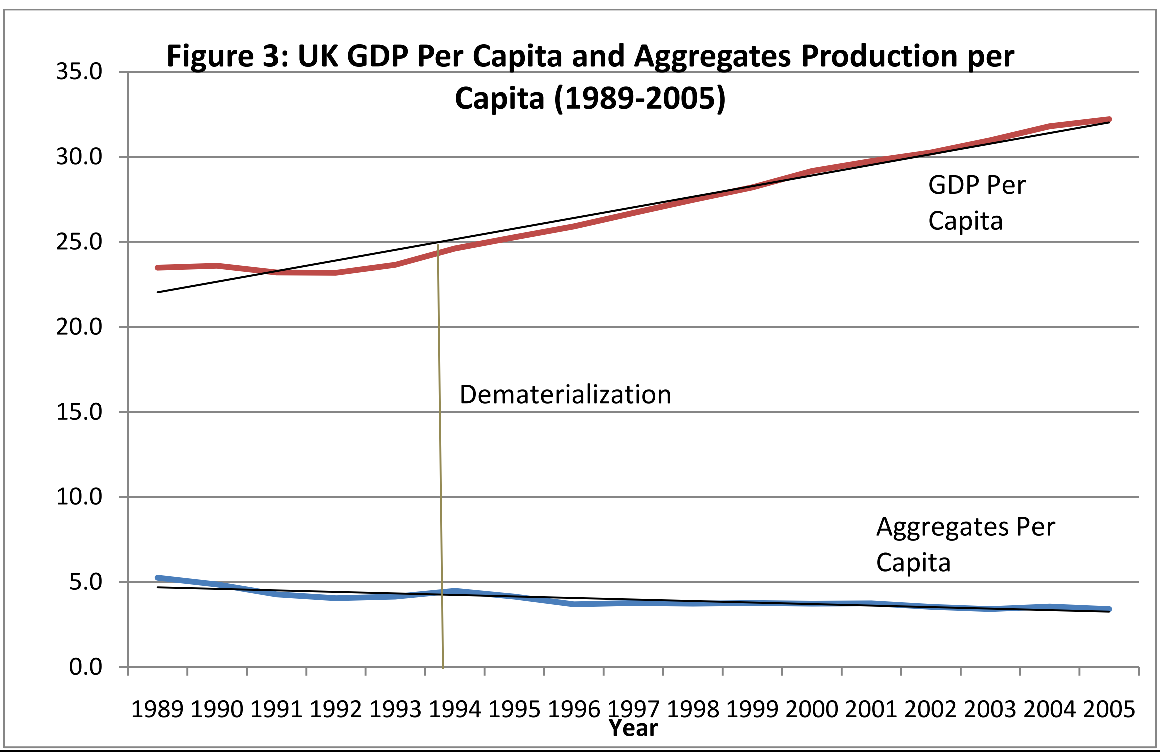


Figure 3: UK GDP Per Capita and Aggregates Production per Capita (1989-2005)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
GDP Per Capita
Dematerialization
Aggregates Per Capita
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Year

Appendix K: Ontario Aggregate Regulatory Framework

In January 2009, Gravel Watch Ontario released a publication entitled *"Aggregate Pits and Quarries: Adverse Effects and Negative Impacts on Human Health and the Environment"*, which lists and explains the implications of the numerous Provincial and Federal standards and regulations that either directly or indirectly relate to the environmental consequences of aggregates production. These include the Aggregate Resources Act, The Environmental Bill of Rights, the Environmental Protection Act, The Planning Act, The Health Protection and Promotion Act, The Ontario Water Resources Act, The Clean Water Act, The Fisheries Act, The Endangered Species Act, The Municipal Act, The Environmental Assessment Act, The Environmental Review Tribunal Act, The Consolidated Hearings Act, The Statutory Powers and Procedures Act, as well as the Fish and Wildlife Conservation Act.

While a full description of all of these regulations will not be re-stated here, the main act, the ARA, will be outlined below. While the above list suggests that aggregates production in Ontario is extensively regulated, as was mentioned in the body of the paper, there is ambiguity relating to the extent in which they are subservient to the ARA (Gravel Watch, 2009).

The Aggregate Resources Act

Applicant for Class "A" licences must submit a site plan detailing: rehabilitation plans, the environmental effects of the operations, the social and economic effects that may be expected, the location of on-site overburden, top soil, and aggregate stockpiles, and any other pertinent planning or land use considerations (Baker & Shoemaker). Some examples of the details required of site plans include the depth of excavation of the mine, the types and locations of noise and visual impacts, the hours of operation, as well as any required protection of natural heritage sites (Environmental Commissioner of Ontario, 2004). There are no performance indicators or quantifiable standards under the ARA regarding the lessening of these impacts. For instance, there are no quantitative limits on dust emissions, nor are there minimum levels of mitigation required by a pit or quarry (Gravel Watch, 2009).

As mentioned above, progressive rehabilitation is required under Section 47 of the Act (Baker & Shoemaker, 1995). However, between 1992 and 2002 less than half of the disturbed land was rehabilitated, with only 3% of the total land being reclaimed in 2002 (Taylor & Winfield, 2005). Likewise, The Rehabilitation Security Fund, earmarking 0.5 cents for each tonne of aggregate extracted for use by aggregates producers in reclamation, has a surplus of approximately $50 million at the end of 1991, indicating that rehabilitation, for the first two years of the ARA's existence, was not occurring at the expected rates (Baker & Shoemaker, 1995).

Currently, aggregate operators file their own compliance reports annually detailing how they complied with the *ARA*. OMNR then reviews the reports and carries out field checks, with a minimum target of 20% (Environmental Commissioner of Ontario, 2004). However, because of inadequate funds and staffing, OMNR routinely fails to meet this target, only auditing 13% in 2002 and 10% in 2003 (Environmental Commissioner of Ontario, 2004).

Appendix L: Data Diagnostics

Serial Correlation: To test for serial correlation, I used the Wooldridge test for serial correlation in panel data to test the null hypothesis of no first order serial correlation against the alternative of serial correlation in the dataset. Serial correlation is a problem with this dataset. An F statistic of 12.2, and the corresponding p-value of 0.017, means that we reject the null of no first order serial correlation at the 5% significance level.

Heteroskedasticity: The White test for heteroskedasticity, testing the null hypothesis of homoskedasticity against the alternative of unrestricted heteroskedasticity, provided a p-value of 0.23, indicating that we retain the null of homoskedasticity at all conventional significance levels.

Multicollinearity: As mentioned in the descriptive statistics section, severe multicollinearity may be an issue with this dataset. This is because CONSTRACT/CAPITA and HOUSECOMPOSITION has a correlation coefficient of 0.66 that approaches the 0.7 unit upper limit for severe multicollinearity. Fortunately, apart from this figure, there are no other worrying coefficients, with the two next largest correlations being for CONSTACT/CAPITA and POPDENS, at -0.35, and for CLIMATE and HOUSECOMPOSITION at -0.32. .

Non-stationary: All data that varies across time, including panels, could potentially suffer from issues related to a non-stationary mean. Performing a Levin, Lin, Chin test to test the null hypothesis that the panels contain a unit root, against the alternative of no unit root, indicate that at one lag, the dependent variable may be non-stationary. A t-statistic of -3.15, and the corresponding p-value of 0.156, means that we retain the null of a unit root. Repeating the test for two lags, however, we obtain a t-statistic of -4.08 and a p-value of 0.035, and so we reject the null of a unit root. Similar results exist for UNITPRICE, CLIMATE, and HOUSECOMPOSITION, with p-values of 0.149, 0.06, and 0.088 respectively. This test assumes common autoregressive parameters for all panels as well as the assumption that the ratio of panels to time periods tends to zero. The latter assumption holds for samples where there are relatively more years than panels, as is the situation for this study. Thus, a Levin, Lin, Chin test is appropriate in this context.

Other issues with the Data: In order to create a balanced panel, a few compromises with the data were made that will be addressed here. Firstly, creating the CONSACT/CAPITA variable involved a compilation of two series from Statistics Canada, one for the years 1991 and 2003, and another terminated series for the years 1987-1990. For the years where the second dataset overlapped the first, the data was not a perfect match, suggesting some differences in calculation for each dataset. Fortunately, however, the differences were not considerably significant.

Secondly, data for 2002-2003 aggregates production in Nova Scotia (both quantities and total values) were projections as actual data for those years were unavailable. It was felt that including the projections would not seriously compromise the dataset and would provide the benefit of having a strongly balanced panel.

Thirdly, Nova Scotia exports a considerable proportion of its total aggregates produced, exporting nearly 20% in 2003. Thus, production for this province is not a strict measure of use. However, since this factor is specific to Nova Scotia, the Nova Scotia binary variable will capture it.

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