Population Health and Demographic Structure in North America

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ABSTRACT

The aim of this paper is to empirically analyze the population health conditions in Canada and the United States. Health status inequalities are estimated and decomposed with FGT indexes. The approaches are illustrated using comparable survey data in both two countries. Also, we seek to understand how demographic and socio-economic disparities between these two countries behavior. The study finds that differences in health achievement in Canada and the USA are due to the dissimilarities in their health care system.

Key words: population health, demographic and socioeconomic health inequalities, Health Utility Index (HUI), FGT index, decomposition analysis

I. INTRODUCTION

International comparisons of health status and health systems across countries, in the era of globalization, are of increasing interest [6]. This is certainly also true for Canada and the United States, the two nations who share an open border and similar culture in North America. Government and public health policy analysts often make a comparison between the Canadian and American health care systems [9][14]. The health care services in these two countries are similar in many ways until the Canadian health system began reforming in the 1960s and 1970s. The starting point of this study is to review background information on the Canadian and American health system and their institutional changes.

Canada and the United States had similar health care systems in the early 1960s, but now they have different mix of funding mechanisms. The universal health care system in Canada is funded by seventy percent of public plus thirty percent of private funding, whereas the U.S. is the only wealthy industrialized country that lacks some form of universal health care [18]. Canada's single-payer and publicly funded system, also called Medicare, is oriented from the first Saskatchewan provincial hospital insurance program in 1947, which introduced by Prime Tommy Douglas with an idea of providing universal health care. In 1957, the Hospital Insurance and Diagnostic Service (HIDS) Act was passed by the government and agreed to fund half of the expenses in selected provinces. Following the success of the program in

Saskatchewan, the Medical Care Act was introduced in 1966 to extend HIDS Act cost-sharing to allow each province to establish a universal health care plan as well as to setup the Medicare system. Canada Health Act was passed in 1984 to prohibit user fees and extra billing by doctors. The health care in whole Canada became free of charge, and every citizen in Canada receives the same level of health care, which is covered by a health card easily to use. The central structural difference between Canada and the U.S. is in health insurance. The Canadian system provides public coverage for private delivery (hospitals are controlled by private boards and doctors are in the private sector).

The major features of American health system differ from those of Canada. In the U.S., direct government funding of health care is limited to Medicare (covers most of the population 65 and older or persons with disabilities), Medicaid (covers the very poor), the State Children's Health Insurance Program (SCHIP) for children coverage, and the Military Health System for Activity Duty personnel and their families. For others else, health insurance must be paid for privately. About 15 percent of the population in the U.S. is without public or private insurance. Issues regarding publicly funded health care are frequently the subject of political debate. In history, there were several attempts of health reforms in the USA [19]. Back to early 1912, a universal coverage was proposed during an election but finally was failed. During the period of year 1974 and year 1982, a comprehensive health-care system effected nationwide to mandate all the companies buy the health insurances for their employees. In 1990s,

Health Insurance Portability and Accountability Act of 1996 (HIPAA) helped employees to maintain their insurances even if they were laid off. President Bill Clinton attempted a significant restructuring of health care, but the effort collapsed under public pressure against it. Although many efforts were being made in the past century, the medical expenses in the U.S. were still too heavy to afford and many personal bankrupts were partly due to medical debts. In this situation, President Obama signed SCHIP in February 2009 and then proposed a health care reform that everyone can afford to medical care and The Affordable Health Care for America Act was passed in November 7, 2009.

With the two countries' ongoing national health surveys on populations, it enables researchers to study the effect of variations in health systems, health care and health status. With a system of universal health insurance, Canada spends about half as much on health care per capita as does the United States, yet Americans live 2 to 3 years shorter [10]. Some comparisons suggest that the American System underperforms Canada's system. For example, the World Health Organization (2000) ranked Canada 30th and the U.S. 37th in health care system performance [17]. Gordon H. Guyatt et al. [5] concluded in *Open Medicine*, "Available studies suggest that health outcomes may be superior in patients cared for in Canada versus the United States, but differences are not consistent." Nevertheless, the findings of June O'Neill and Dave O'Neill [11] contradict the allegation that Canada's health care system delivers better health outcomes than the U.S. multi-payer system. Comparisons of the severity of health

inequality can provide direct evidence of a nation's progress in health care outcomes.

In this paper, we focus our analysis of health status differences on using population-based data from the Joint Canada/USA Survey of Health (JCUSH)[1] and employing the Health Utility Index (HUI)[2] as the indicator of health status. Our objective is to find appropriate economic instruments, such as FGT index, to decompose the difference in health achievement between Canada and the U.S. from demographic characteristics and socioeconomic status, to identify which part is due to demographic structure differences and which part is due to differences in health achievement within each socioeconomic group. We also sought to explore whether universal health insurance can mitigate disparities in health.

The remaining of the paper is organized as follows. Section II outlines previous literature on the measurement of health inequality and health status in the recent decades, as well as theories that relate to the study of decomposition analysis. Section III presents the methodology framework. The decomposable population health index is introduced in this section. Section IV is devoted to the analysis based on the data from JCUSH. This section examines the aggregate population health in the United States and Canada, as well as their subgroup population health. Finally Section V concludes the paper.

[1] Details of JCUSH are interpreted in Section IV.
[2] HUI are detailed in Section II.

II. PREVIOUS LITERATURE:
MEASURING HEALTH INEQUALITY AND DECOMPOSING MEASURED DIFFERENCE

i. Previous Findings from the JCUSH

Since this analysis will be using the JCUSH dataset to draw specific comparisons, it is relevant to review some published findings from JCUSH. Sanmartin et al. examined basic trends and health differences present in this sample of Americans and Canadians [13]. Their descriptive findings indicate that most respondents report being in good health status, although differences between good and bad health are most polarized in the United States, particularly with respect to women reporting poorer health than men. McGrail et al used the JCUSH data to test the underlying causes of disparities in health [8]. Specifically, their work sought to identify the potential influence of healthcare and other policies on income-related inequalities in health by utilizing a health utility index based upon multiple health attributes. Income inequality is the primary focus of this work, which might cause bias on the results since we noticed that JCUSH is limited on the collected data with regard to income in both countries (see Section IV data description part).

ii. Health Inequality and Health Utility Index (HUI)

In the literature on health inequalities, there are two distinct strands [4][21]. The first examines overall (or "pure") inequalities in health. The second looks at a subset of health inequalities, namely those occurring across the distribution of some measure of

socioeconomics status (SES). Wagstaff A. et al. [15][16] sought to bring together these tow approaches in a unified measurement methodology. They assumed that a scalar measure of health is increasing in good health and ranked individuals by their health, beginning with the least healthy. Then obtain the Lorenz curve for health, by describing the cumulative proportion of individuals ranked by health on the x-axis and graphing the cumulative proportion of health. The Loren curve equals the Gini coefficient, the measure of "pure" health inequality. Also, they supposed that a scalar measure of SES is increasing in SES and ranked individuals by their SES, beginning with the most disadvantaged. Then derive the concentration curve for health, by graphing the cumulative proportion of individuals ranked by SES on the x-axis and depicting the cumulative proportion of health on the y-axis. Their result suggested that socioeconomic inequalities may well comprise only a minority of "pure" health inequality.

As a generic health status index, HUI is able to synthesize both quantitative and qualitative aspects of health. It has a theoretical range between -0.36 (living in a state worse than death) and 1 (fully healthy), where 0 indicates death status. Developed at McMaster University, HUI is identified to show health conditions with a mass of circumstances with different kinds of groups and individuals. Intentionally, HUI captures an individual's overall health utility on the basis of responses to a series of questions coving eight attributes: vision, hearing, speech, mobility, dexterity, cognition, emotion, and pain and discomfort; and then these domains are transformed

into an overall score by a multi-attribute utility function.

III. THE METHDOLOGICAL FRAMEWORK

Martin Ravallion and Monika Huppi [12] analyzed the changes in poverty using household survey data from Indonesia before and after external shocks and the subsequent structural adjustment program in the mid-1980s. They outlined two techniques which are stochastic dominance conditions and decomposable poverty index (FGT class), and applied them into disaggregating aggregated poverty into various components, such as the changes among population subgroups. A class of additively decomposable measures is that proposed by Foster, Greer, and Thorbecke (1984; hereafter FGT) [3], which we will also use it in this paper.

Not limited in poverty measurement, the FGT index can also be used in health status measurement. Set the poverty line z as 1 (the healthiest state, we will call z as fully healthy line as interchangeable term of poverty line), by defining:

$$FGT = \frac{1}{N}\sum_{i=1}^{N}(1-u_i)^{\alpha} \qquad (1)$$

where N is the total population size, u_i denotes the value of HUI variable for individual i derived from the JCUSH data, and α is inequality aversion parameter. In the expression (1), 1 - u_i means health deviation compared to perfect health. With the same property of FGT poverty index, FGT index of health status measure increases as u_i decreases. However, because we set the poverty line to the highest possible value,

the index cannot be interpreted as a poverty index but as an index of the deviation from perfect health. Throughout the analysis, we will be choosing α as to 1, 2 and 3. The measure is the average health gap in the population for α=1. For example, a value of 0.2 means the aggregate deficit of the health relative to the fully healthy line, when averaged over all individuals, representing 20 percent of the fully healthy line. The measure is more sensitive to the distribution of health among the unhealthy for α=2, 3.

As the FGT index of equation (1) represents the deviation from perfect health, we can use it to build a population health index H that takes the following form:

$$H_\alpha = 1 - \frac{1}{N}\sum_{i=1}^{N}(1-u_i)^\alpha \qquad (2)$$

where α is the inequality aversion parameter again.

When α=1, H reflects the average health status. When α=2, it takes into account inequality in health status. When α=3, it indicates even more inequality aversion. The intuition of H is that, the bigger it is, the healthier in population.

Similar as the FGT index, the population health index is decomposable within population subgroups. If we split the population into l groups with population size N_i, then

$$N = \sum_{i=1}^{l} N_i$$

Let θ_i denote population share, then we have

$$\theta_i = \frac{N_i}{N}$$

With the decomposable property, H_α can be expressed as:

$$H_\alpha = \sum_{i=1}^{I} \frac{H_{\alpha i} N_i}{N}$$

which is the population-weighted mean of the subgroup population health index.

The subgroup health status index $H_{\alpha i}$, derived from the equation (2), can be written as following form:

$$H_{\alpha i} = 1 - \frac{1}{N_i} \sum_{j=1}^{N_i} (1 - u_{ij})^\alpha \qquad (3)$$

where u_{ij} denotes the HUI value for individual j in subgroup i.

To compare the health status within two different countries, we continue to study the changes caused by various factors. Further, we can decompose the difference of integrated health status into several elements by using the following formula:

$$\Delta H_{uc} = \frac{1}{2}\left\{\sum_{i=1}^{I}(\theta_i^{us} - \theta_i^{ca})H_i^{us} + \sum_{i=1}^{I}(\theta_i^{us} - \theta_i^{ca})H_i^{ca}\right\} + \frac{1}{2}\left\{\sum_{i=1}^{I}(H_i^{us} - H_i^{ca})\theta_i^{us} + \sum_{i=1}^{I}(H_i^{us} - H_i^{ca})\theta_i^{ca}\right\}$$

(4)

where θ_i represents the population share, and $\theta_i^{us} - \theta_i^{ca}$ is the population share difference of each subgroup i between two countries, the United States and Canada. We can apply different inequality aversion parameter α in the above equation during the decomposition analysis. ΔH_{uc} represents the difference of population health index in the USA and Canada (equals to H^{us}-H^{ca}), and it consists of two parts, which the first part assesses the impact of a change in demographic composition and the

second part estimates the impact of a change in the distribution of health within demographic groups. This decomposition shows not only the inter-group effect but also intra-group effect, that is, the inter-group effect can be calculated by the following equation:

$$\frac{1}{2}\left\{\sum_{i=1}^{I}(\theta_i^{us}-\theta_i^{ca})H_i^{us}+\sum_{i=1}^{I}(\theta_i^{us}-\theta_i^{ca})H_i^{ca}\right\} \quad (5)$$

and the intra-group effect can be evaluated by the equation as follows:

$$\frac{1}{2}\left\{\sum_{i=1}^{I}(H_i^{us}-H_i^{ca})\theta_i^{us}+\sum_{i=1}^{I}(H_i^{us}-H_i^{ca})\theta_i^{ca}\right\} \quad (6)$$

The stochastic dominance test is another aspect in our analysis. In the literature, ordinal comparisons of health status involve using classes of distributive indices [1]. These classes are defined by referring to "order of normative judgements", and order being denoted as s=0,1,2,... A dominance test of order s servers to test whether some distributive ranking is valid for all of the indices of a class of order s. When two dominance curves of a given order do not intersect, all indices that obey the ethical principles associated to this order of dominance then rank identically the two distributions. As the order s of the class of distributive indices increases, the indices become more and more sensitive to the distribution of health status. The dominance test of order s says, if distribution A dominates B, then distribution A exhibits healthier than does distribution B.

IV. THE DATA AND RESULTS

(i) Data source and variables

Our data came from the Joint Canada/United States Survey of Health (JCUSH), a cooperative program by Statistics Canada and the National Centre for Health Statistics (NCHS) of the U.S. for the purpose of disease control and prevention [13]. JCUSH was conducted by means of a telephone survey of residents of Canada and the U.S. aged 18 and older living in private dwellings with telephones. To get comparable health data in the U.S. and Canada, the program provide telephone survey with questions in chronic conditions, functional status, determinants of health and health care utilization for each household in both countries. The data were collected during the period November 2002-March 2003 and the final samples include 3505 Canadians and 5183 Americans who were randomly selected. The U.S. samples were stratified by four geographic regions (Northeast, Midwest, West, and South) and the Canadian sample by province. Due to different backgrounds and health care systems, the program set separate questions in various areas of two countries and health insurance coverage questions were only asked for the U.S. residents. Post-stratification adjustments were made and weights were applied to ensure that the sample reflected population estimates. The auxiliary variables, age and gender, were used to create the post-stratification adjustments.

The outcome variable of interest was health-related quality of life as measured by the HUI. As we introduced before, HUI is a multidimensional, preference-based cardinal

measure of health that has been used both in clinical settings and in studies of population health [7]. There are some factors associated with individual-level health and thus may be related to decomposition of inequalities in health status at the population level. These variables included demographic characteristics (such as age), socioeconomic status (for example, education and income), and insurance coverage type (especially for the U.S. residents since the Canadians are universally covered). Respondents were dropped if their HUI was greater than one. The final samples used in the analyses included 3389 respondents in Canada and 4967 in the U.S. It is worth noting that we do not use income factor in our analysis because there are high-proportionately missing data of income for both countries (numbers of those did not state their income: 489 in Canada and 1165 in the United States).

The appendix (Figure 1-6) presents the histograms of the samples for the two countries with respect to the population shares of subgroups, which are age group, insurance group and education group respectively. The code and description of each subgroup can be seen from the Code Table in the appendix as well.

(ii) Overall population health

A density curve visually represents the kernel density distributions of a population's proportion as a function of the HUI and it provides broad summary statistics. With the HUI measured on the vertical axis, Figure 7 and 8 show how the distributions of HUI look like in Canada and USA respectively—give the density of individuals at that

level of HUI (range from -0.36 to 1.0). This gives us an illustration of overall pattern of distribution. From Figure 7, we can see that most people are healthy in Canada, with a HUI value of close to 1. Similar observation in the United States obtained in Figure 8. It is not easy to derive the comparison from these two density curves. Therefore, we first examine the overall health status in both countries and how the difference is.

Table 1 gives our estimates of population health index in both nations by using the equation (2). For all α choices (health gap or distributionally sensitive), apparently the estimates in Canada are significantly larger than the ones in America respectively. Thus, the overall population health in Canada is better than in the United States.

Table 1. Aggregate Health Measures, Canada and the United States

health line:1 (variable: HUI)			
	Canada population health index: H^{ca}	USA Population health index: H^{us}	Health difference $H^{us} - H^{ca}$
α=1	0.882149	0.867697	-0.014452
α=2	0.947912	0.937329	-0.010583
α=3	0.964302	0.956231	-0.008071

(iii) Decomposition Results

Demographic Characteristics (Age) Analysis

Next, we will examine how the health difference changes among the demographic structure. We decomposed the aggregate population health index by age groups (see code table in the appendix for subgroup description).

Table 2. Population health index in each age group

When α =1			
Age Group	H^{us}	H^{ca}	H^{us} - H^{ca}
1	0.906108	0.915139	-0.009031
2	0.915493	0.919314	-0.003821
3	0.893508	0.897914	-0.004406
4	0.844633	0.877272	-0.032639
5	0.795679	0.811371	-0.015692
When α =2			
Age Group	H^{us}	H^{ca}	H^{us} - H^{ca}
1	0.961237	0.967183	-0.005946
2	0.968578	0.971489	-0.002911
3	0.953469	0.953273	0.000196
4	0.923361	0.951643	-0.028282
5	0.890479	0.900751	-0.010272
When α =3			
Age Group	H^{us}	H^{ca}	H^{us} -H^{ca}
1	0.972598	0.978473	-0.005875
2	0.981024	0.984187	-0.003163
3	0.969385	0.966214	0.003171
4	0.94525	0.969332	-0.024082
5	0.920239	0.926578	-0.006339

Table 2 shows the estimates of population health index in the U.S. and Canada for various measures in different age groups. As we can see in the table, the health status is much related to the age. The younger the individuals are, the healthier of their bodies. All three measures (α=1,2,3) indicate that the health achievements in Canada are everywhere better than the U.S., except for subgroup 3 (those who aged from 36 to 45) given that α is equal to two or three. But the differences are pretty small. When α is equal to two, the healthy gap is only 0.000196; and when α is equal to three, the gap is 0.003171. The largest disparity in all five age groups is in group four (for those who aged from 46 to 59) regardless of α. In general, we found that most people live in

Canada are healthier than those who live in the USA.

Table 3. Demographic structure in each group

for α =1,2,3			
Age Group	population share θ^{us}	population share θ^{ca}	θ^{us} -θ^{ca}
1	0.131281	0.145625	-0.014344
2	0.20182	0.186672	0.015148
3	0.218588	0.21984	-0.001252
4	0.244224	0.250244	-0.00602
5	0.204087	0.19762	0.006467

Table 3 gives the distributions of population shares in different age groups in the U.S. and Canada, where exists similarities. Group four (aged 46-59) takes the largest population share (approximately one quarter) and group one (aged 18-25) takes the least (about 3/20) in both two countries. By comparing the population shares in two countries in each group, we found that the shares in group two and group five were bigger in the USA while the other three groups were greater in Canada. Furthermore, the largest difference is in group two, where the population share in the U.S. is 0.015148 larger than the one in Canada. And the least difference is in group three, where US population share is only 0.001252 smaller. Figure 1 and 2 in the appendix give us the pictures of age distribution in both countries.

Table 4 shows the decomposition effects and overall effects of the change in aggregate health. The overall effects are calculated by equation (4). The intra-group effects are caused by health difference within the demographic groups, which are derived from the equation (6). Similarly, the inter-group effects are caused by health

difference in demographic structure, which are calculated by the equation (5). The observation shows less inter-group effects than intra-group effects for all values of α. All negative numbers illustrate that Canada made stronger accomplishment in health than the U.S., and that the intra-group and inter-group effects reinforce each other.

Table 4. Decomposition of change in health into intra-group effects, inter-group effects and overall effects

	Intra-group effects	Inter-group effects	Overall effects (ΔH_{uc})
α=1	-0.014179704	-0.000273123	-0.014452827
α=2	-0.010401165	-0.000182001	-0.010583166
α=3	-0.007959783	-0.000111467	-0.008071251

Socioeconomic Status (Education) Analysis

Winkleby et al. [20] noted that education was the strongest marker of individual health status. We are interested to investigate how strong the educational attainment is correlated to health status. The aggregated health status index was decomposed into educational subgroups. Educational attainment was divided into four categories: less than high school (lowest), high school diploma, technical education and university degrees (highest).

From Table 5, we found that education level is consistently and highly related to the health status in both nations. The population health index increases with the enhancement of education, regardless of the value of α. The reason could be that people with lower level of education usually earn less income, and most of them are

dealing with physical works. Most people with university degrees or higher are white-collars with higher income and savings, and then they are affordable to buy food with enough energy and nutrition, as well as medicines, thereby showing excellent health conditions. The disparities decrease with the rise of educational level. For the same education level, people in Canada again universally presented better health status than in the USA, with an exception that those with university degree in the U.S. showed better health status than in Canada.

Table 5. Population health index in each education group

When α =1			
Education attainment group	H^{us}	H^{ca}	$H^{us} - H^{ca}$
1 (lowest)	0.758286	0.808351	-0.050065
2	0.859055	0.888334	-0.029279
3	0.865799	0.892126	-0.026327
4(highest)	0.918953	0.920278	-0.001325
When α =2			
Education attainment group	H^{us}	H^{ca}	$H^{us} - H^{ca}$
1	0.852913	0.896055	-0.043142
2	0.934297	0.953608	-0.019311
3	0.93635	0.956054	-0.019704
4	0.97306	0.972354	0.000706
When α =3			
Education attainment group	H^{us}	H^{ca}	$H^{us} - H^{ca}$
1	0.884435	0.921152	-0.036717
2	0.954874	0.969703	-0.014829
3	0.955752	0.972685	-0.016933
4	0.985267	0.982677	0.00259

Table 6 shows the distributions of population shares in different educational groups in the U.S. and Canada, where exists similarities in both countries. Figure 3 and 4 in the appendix also show the proportional pictures of educational distribution in both countries. People with high school diploma and university degree (including college

certificate in the U.S.) take the largest proportions and the other two types take the least. There are about 36 percent population shares with the two largest groups in the USA and nearly 30 percent ones in Canada, which may easily find jobs after graduation. The disparities are almost the same, ranged from 0.05 to 0.08. People without high school diploma in Canada are 6 percent more than the U.S., but those who with bachelor's degree are 8 percent less. Thus the educational level is higher in the USA among the interviewees.

Table 6. Demographic structure in each education group

When $\alpha=1$ Education attainment group	population share θ^{us}	population share θ^{ca}	$\theta^{us}-\theta^{ca}$
1	0.138858	0.199127	-0.060269
2	0.362433	0.30663	0.055803
3	0.136152	0.214773	-0.078621
4	0.362557	0.27947	0.083087
When $\alpha=2$ Education attainment group	population share θ^{us}	population share θ^{ca}	$\theta^{us}-\theta^{ca}$
1	0.138858	0.199127	-0.060269
2	0.362433	0.30663	0.055803
3	0.136152	0.214773	-0.078621
4	0.362557	0.27947	0.083087
When $\alpha=3$ Education attainment group	population share θ^{us}	population share θ^{ca}	$\theta^{us}-\theta^{ca}$
1	0.138858	0.199127	-0.060269
2	0.362433	0.30663	0.055803
3	0.136152	0.214773	-0.078621
4	0.362557	0.27947	0.083087

Table 7 describes the decomposition effects and overall effects of the change in aggregate health. The overall effects are calculated by equation (4). The intra-group

effects are caused by health difference within the socioeconomic subgroups, which are derived from the equation (6). Likewise, the inter-group effects are caused by health difference in socioeconomic structure, which are calculated by the equation (5). All negative intra-group effects compared with all positive inter-group effects for all values of α. And all negative overall effects illustrate that Canada made stronger accomplishment in health care than the U.S. although the educational achievement in the USA (inter-group) should have worked in favor of the U.S.

Table 7. Decomposition of change in health into intra-group effects, inter-group effects and overall effects by education

	Intra-group effects	Inter-group effects	Overall effects (ΔH_{uc})
α=1	-0.023300101	0.008848134	-0.014451968
α=2	-0.01698149	0.006399064	-0.010582426
α=3	-0.013305347	0.005235583	-0.008069764

Insurance System Analysis

In order to verify whether the differences in health status between two countries are due to the different insurance systems or not, we examine their own situations first. And then we put them together to draw the comparison. We start to decompose the American data by various insurance coverage groups.

In the USA, we grouped the data by eight types as shown in Table 8. Group 1 includes those who own private health insurance, and people in group 2 are with military health insurance. We divided medicare into two groups, group 3 is for elder people over 65 years old but with no private health insurance and group 7 is for people under

65 but with no private health insurance. The other three groups are group 4 with Indian health service, group 5 with medicaid, group 6 with other health coverage. Lastly we put the poor without insurance coverage in group 0.

Table 8. Population health index of different insurance groups in the U.S.

	H^{us}		
Insurance coverage	α=1	α=2	α=3
0	0.845936	0.925172	0.948332
1	0.893559	0.956473	0.971861
2	0.846821	0.913143	0.931117
3	0.712708	0.826786	0.868113
4	0.865177	0.953465	0.979546
5	0.671249	0.78282	0.826642
6	0.80697	0.891727	0.91591
7	0.58382	0.709384	0.770781

From Table 8, clearly with the value of α increasing, population health index of the U.S. rises for each group. When α=1, type one is the most healthy group for those who purchase private health insurance. Generally, private health care provides better services than public health care. People who enroll in Indian health service, military health service and those who do not have any insurance are also in excellent health conditions. On the contrary, the U.S. citizens in type seven and type five are with bad health conditions which need health service and medical service frequently. As a matter of fact, type seven includes people who are under 65 and take Medicare health service, who probably are disabled persons. And type five who join Medicaid health program are people with low income and less resources usually. Without adequate food and accommodation, they may easily fall into diseases. Obviously, the Medicaid is not only a health insurance program but also social welfare program.

From Table 9, we found that near 75 percent of interviewees had to purchase insurance by their companies or themselves (type 1). This is a heavy burden either to enterprises or families, especially for large companies with plenty of employees and big families with more than five family members. And approximately 13 percent of interviewees do not have any insurance (type 0). Once they get sick, they have to pay expensive medical expenses by themselves. This may lead lot of families broke. Overall, only small proportion of people's health is protected by the U.S. government although the investment of health care increases every year. Figure 6 in the appendix also presents the proportional picture.

Table 9. Demographic structure of each insurance group in the U.S.

When α=1, 2, 3	
insurance coverage	population share θ^{us}
0	0.125352
1	0.74614
2	0.01484
3	0.027575
4	0.001356
5	0.037821
6	0.039285
7	0.007631

Next, we look into the universal health insurance in Canada. With the universal health insurance system in Canada, we are unable to divide data by different insurance groups. To make comparable data with those in the USA, however, we can decompose Canadian data into two different age groups, young and older. One is people under 65 years old (type 1) and another is those above 65 (type 2). And type 3 represents the

whole group of Canadians. As we can see from Figure 5 in the appendix, around 85% people in Canada are less than 65 years old, and the older generation occupies approximately 15 percent in the national wide. Applying the equation (3) into calculation, Table 10 shows the population health index in Canada in three different types by various value of α. For all levels of inequality aversion parameter α, people in type 1 show higher health status than the average health condition in the whole group, as well as better than those older people in type 2. Older people in type 2 are always unhealthy than the average in type 3. In common sense, younger people are much healthier than elders, and this is proved from our decomposition result in all levels of inequality aversion parameter α.

Table 10. Population health index of different age groups in Canada

	Type	H^{ca}
α=1		
	1	0.89756
	2	0.79447
	3	0.882149
α=2		
	1	0.958351
	2	0.888517
	3	0.947912
α=3		
	1	0.972764
	2	0.916154
	3	0.964302

Now, we introduce the approach that involves both nations into comparison of health status under different insurance system. To make various types of insurances in the USA comparable to the universal health insurance in Canada, we regrouped these

types into three categories. Recall that we have eight types (0-7) for the U.S. insurance subgroups in Table 8. The first category includes type 0 for people in the U.S. without any insurance, and compares to Canadians less than 65 years old (i.e., type 1 in Table 10). The second category includes type 3 for older Americans (over 65 years old) with Medicare, and compares to the elders in Canada (also over 65 years old, type 2 in Table 10) with universal health insurance. Lastly, we combine type 1, 2, 4, 5, 6, and 7 together as type 8, the third category, and measure the difference with Canadians less than 65 years old (type 1 in Table 10 again).

Table 11. Comparison between the USA and Canada with regard to insurance system

Category		H^{us}	H^{ca}	H^{us} -H^{ca}
α=1				
US	Canada			
0	1	0.845936	0.89756	-0.051624
3	2	0.712708	0.79447	-0.081762
8	1	0.875963	0.89756	-0.021597
α=2				
US	Canada			
0	1	0.925172	0.958351	-0.033179
3	2	0.826786	0.888517	-0.061731
8	1	0.942727	0.958351	-0.015624
α=3				
US	Canada			
0	1	0.948332	0.972764	-0.024432
3	2	0.868113	0.916154	-0.048041
8	1	0.960269	0.972764	-0.012495

Table 11 illuminates the disparities of population health index between the U.S. and Canada through the calculation by the equation (3). Similar as the result we obtained before, the value of differences decrease gradually with the increasing of α for each category. Within groups, the largest difference is in type 3, and the smallest difference

occurs in type 8. It implies that elder Canadians are much healthier than elder Americans. However, they do not have much difference between young Americans with several types of insurance (type 8) and Canadians covered by universal health insurance (approximately -0.02 difference when α=1 and about -0.01 when α=2 and 3). Apparently, the Americans without any insurance (type 0) are less healthy than Canadians who are protected by the universal health insurance. In summary, the universal health insurance system in Canada is better than the complex insurance system in the U.S. for all kinds of types.

(iv) Stochastic Dominance Analysis

Table 12: Stochastic dominance test for whole population

Distribution 1: Canada(CAN) vs Distribution 2: the U.S.(US)	
order	overall
s=1	ND
s=2	CAN $\succ_2$ US
s=3	CAN $\succ_3$ US

Notes: ND=No dominance $\succ_2$=Second order dominance $\succ_3$=Third order dominance

Table 12 provides the result after running stochastic dominance test on HUI variable for population health distribution in Canada and the U.S. From the result, we can see that second-order dominance and third-order dominance satisfy, which state that Canadian distribution dominates American distribution. However, it is not the case for

first-order dominance since there are several crossing points among distributions, that is, no obvious dominance proof because they take turns to dominate each other. Again the results of dominance in Table 12 demonstrated an overall picture that Canadians are healthier than Americans.

If we subgroup the population by age, Table 13 shows that both 2nd-order and 3rd-order dominance established for age group 1, 2 and 4, and furthermore proved that Canadian distribution dominates American one among these groups. It is interesting that third-order satisfies for group 3 and surprisingly the American distribution dominates. Nothing conclusion for people aged more than 60 years old (age group 5).

Table 13: Stochastic dominance test for population by age groups

Distribution 1: Canada(CAN) vs Distribution 2: the U.S.(US)					
order	age group				
	1	2	3	4	5
S=1	ND	ND	ND	ND	ND
S=2	CAN $\succ_2$ US	CAN $\succ_2$ US	ND	CAN $\succ_2$ US	ND
S=3	CAN $\succ_3$ US	CAN $\succ_3$ US	US $\succ_3$ CAN	CAN $\succ_3$ US	ND

Notes: ND=No dominance $\succ_2$=Second order dominance $\succ_3$=Third order dominance

Next, Table 14 depicts the result for education subgroups. It shows that both second-order and third-order dominances hold for those with education less than university level (type 4). Not surprisingly, Canadian distribution dominates again.

However, it should be noted that the distribution with university level in the United States inversely dominates those in Canada in third-order. It could suggest that well-educated Americans are under excellent health care services because people earn more money with higher diploma and they can buy private health care which provides better services.

Table 14: Stochastic dominance test for population by education groups

Distribution 1: Canada(CAN) vs Distribution 2: the U.S.(US)

order	education			
	1	2	3	4
s=1	ND	ND	ND	ND
s=2	CAN $\succ_2$ US	CAN $\succ_2$ US	CAN $\succ_2$ US	ND
s=3	CAN $\succ_3$ US	CAN $\succ_3$ US	CAN $\succ_3$ US	US $\succ_3$ CAN

Notes: ND=No dominance $\succ_2$=Second order dominance $\succ_3$=Third order dominance

Last but not least, it comes to Table 15 which characterizes the insurance test. There is no dominance proof for the US citizens who are 65+ years old and under medicare (type 3), in contrast with the Canadian distribution. First-order, second-order and third-order satisfy for type 8 (including private insurance, military health care, indian health service, medicade for low-income families, non-private medicare for under 65 years old, and other insurance). Second-order and third-order hold for no insurance type 0. All dominances show that Canadian distribution with universal insurance dominates the American.

Table 15: Stochastic dominance test for population by insurance coverage

Distribution 1: Canada(CAN) vs Distribution 2: the U.S.(US)

	insurance coverage		
order	0	3	8
s=1	ND	ND	CAN $\succ_1$ US
s=2	CAN $\succ_2$ US	ND	CAN $\succ_2$ US
s=3	CAN $\succ_3$ US	ND	CAN $\succ_3$ US

Notes: ND=No dominance $\succ_1$ =First order dominance

$\succ_2$ =Second order dominance $\succ_3$ =Third order dominance

V. CONCLUSIONS

Some aspects of the methodology used in this paper can throw light on the comparison of population health in North America. We tested the sensitivity of health assessments and distributions, and decomposed observed difference in aggregate health status by subgroups (age, education and insurance) so as to assess their sectoral, demographic, and distributional composition. We conclude that aggregate health status in Canada is better than in the United States over the period of 2002-2003. In summary, most of Americans are less healthy than Canadians and the health system in the United States underperformed than the universal health system in Canada. We believe that Canada's single payer system could serve as a model for the U.S. when it comes to health care reform in the United States supported by President Obama.

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APPENDIX

Code Table: Description of All Subgroups

	code of subgroup	Description of subgroup
age group	1	aged under 26
	2	aged 26-35
	3	aged 36-45
	4	aged 46-59
	5	aged 60+
education group	1	less than high school
	2	high school
	3	technical education
	4	university education
insurance coverage group	0	no insurance
	1	private insurance
	2	military health care
	3	medicare for older people with 65+
	4	indian health service
	5	Medicade for low-income families
	6	other insurance
	7	medicare for under 65 and non-private (people with disablities)
	8	Subtotal type including type 1,2,4,5,6, and 7 above

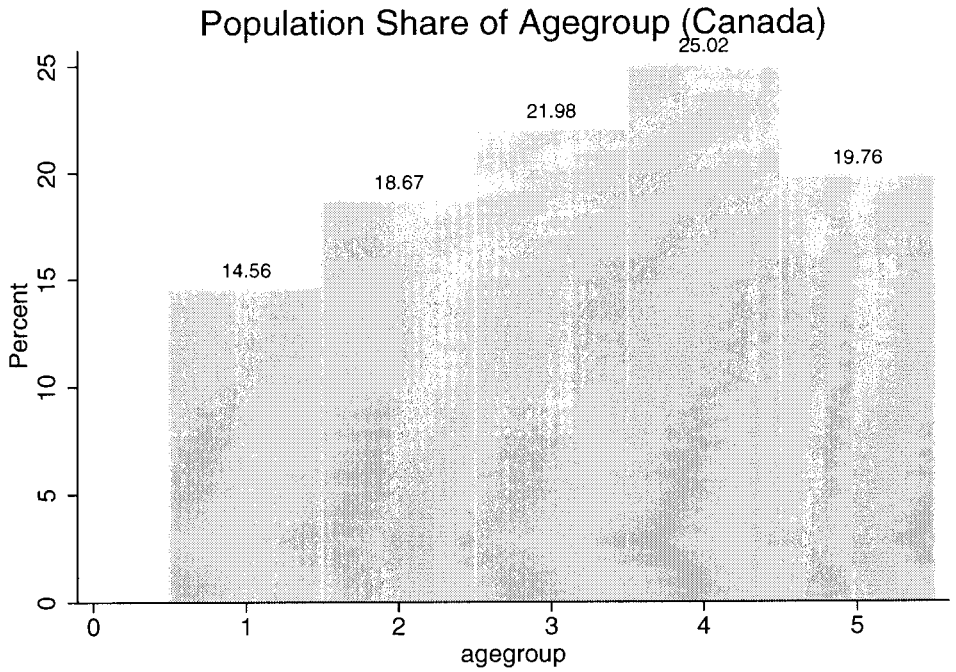

Figure 1: Population share of age group in Canada

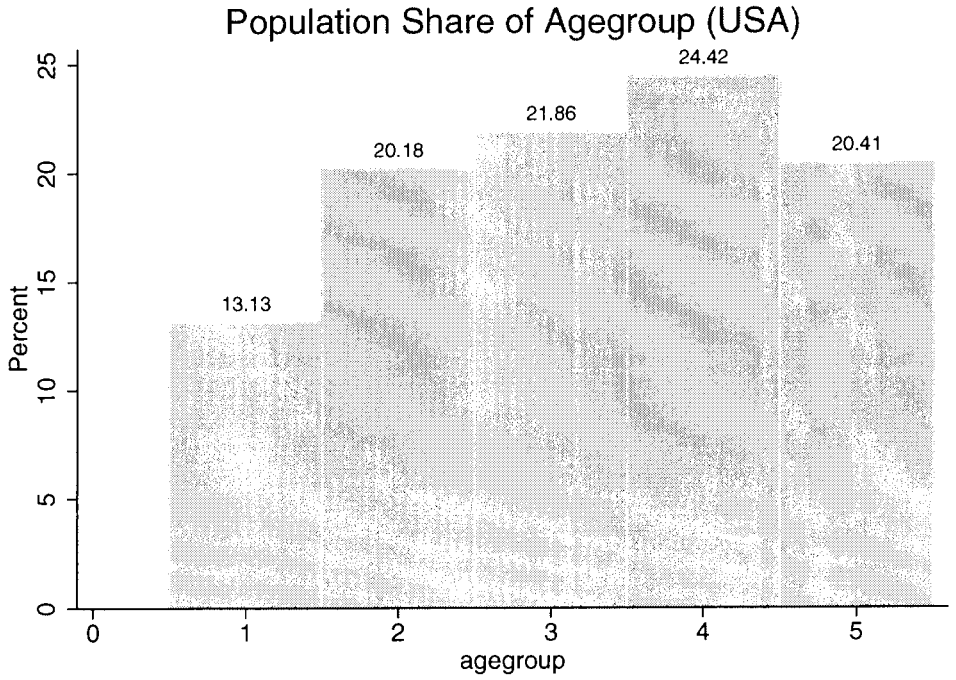

Figure 2: Population share of age group in USA

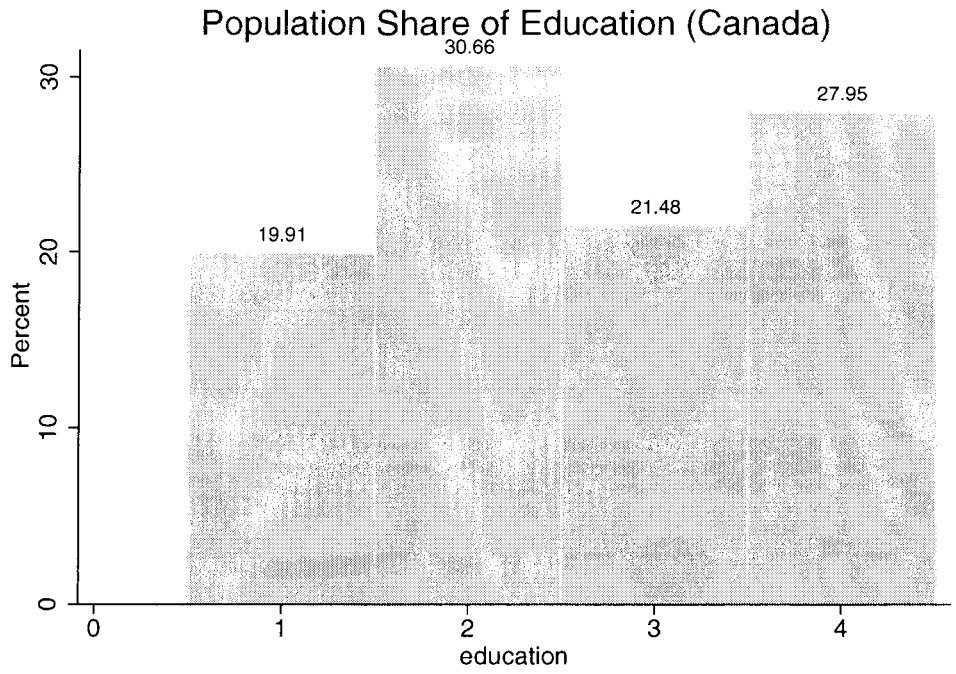

Figure 3: Population share of education in Canada

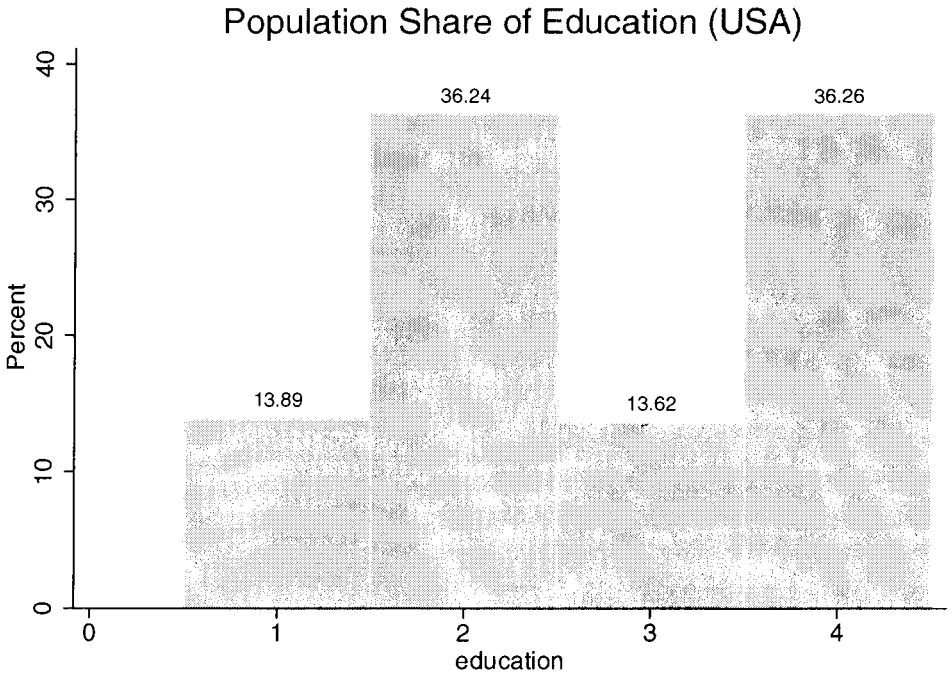

Figure 4: Population share of education in USA

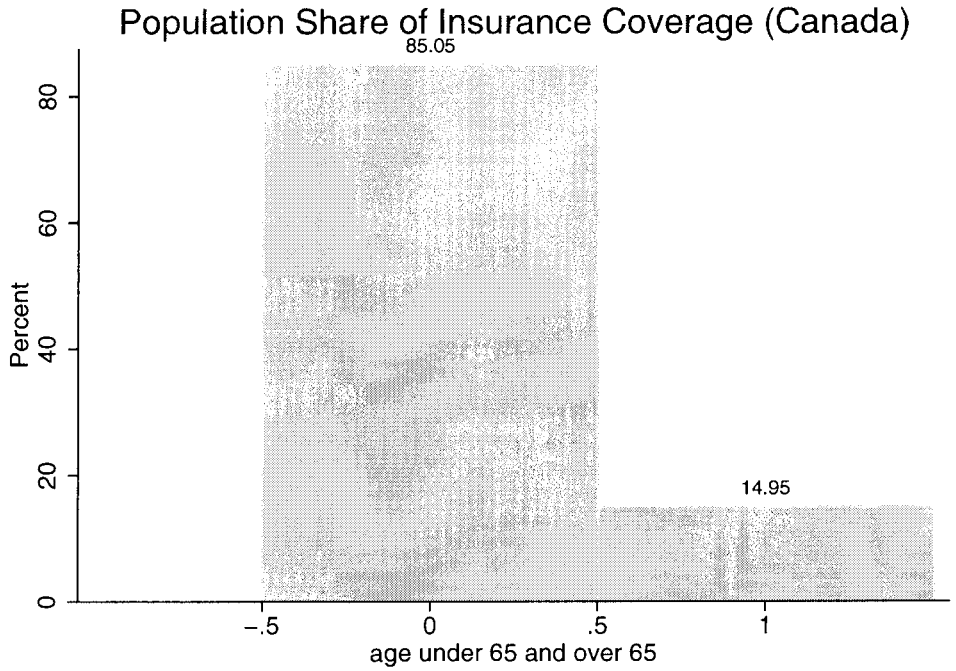

Figure 5: Population share of insurance coverage in Canada

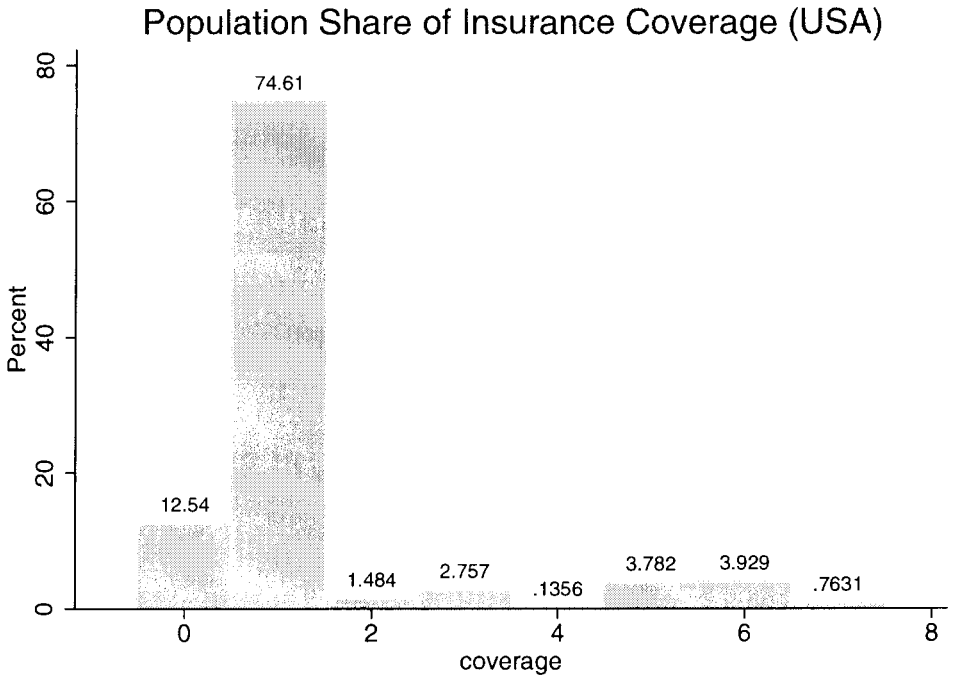

Figure 6: Population share of insurance coverage in USA

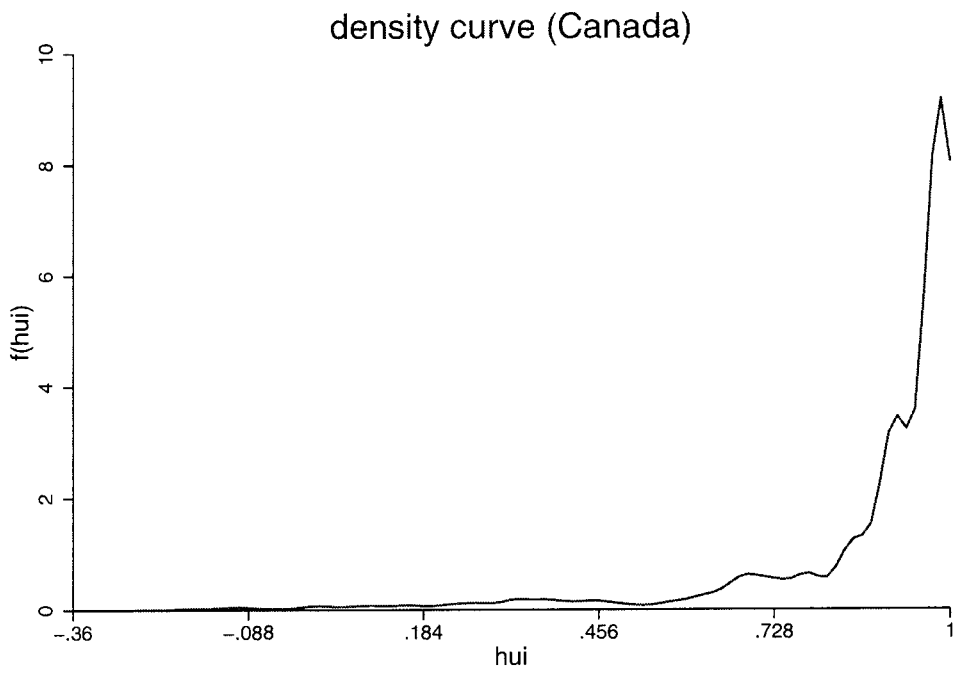

Figure 7: Density curve of Canada

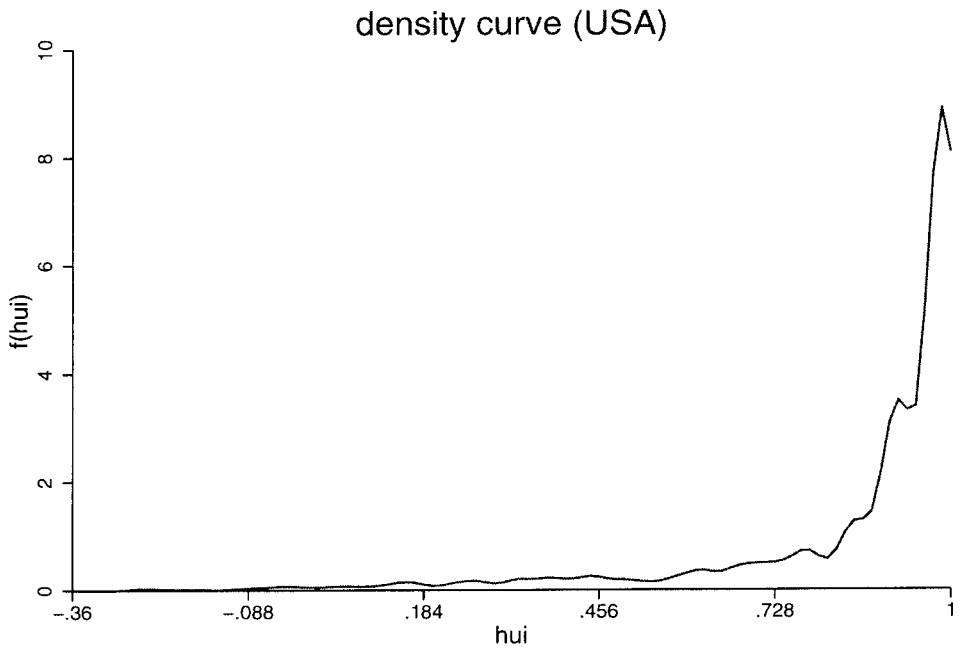

Figure 8: Density curve of USA