

## **Can Immigration Affect Age Composition When Fertility is Below Replacement?**

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### *Abstract*

The effect of immigration on the age composition of a population when fertility is below replacement level has been studied in the paper. Using Canadian example where the population in the working age-group accounts for more than two-thirds of the population, it has been shown that such an age composition is difficult to perpetuate over an extended period of time. Selective immigration may offer some advantage in the short run but the increase in old age dependency created by the process in the following years will render that strategy extremely inefficient in the long run. Thus a sustained pattern of immigration can only be helpful in preventing population decline or even its extinction when fertility continues to remain at below replacement level. The age composition of such a population is determined solely by its level of mortality and cannot be tampered with effectively by an immigration policy. That is to say, the equivalence of the limiting age composition to its own stationary population is virtually assured when the size and age composition of the annual immigrants remain constant.

### *Résumé*

Le présent article étudie l'effet de l'immigration sur la composition par âge d'une population quand la fertilité est inférieure au taux de remplacement. En utilisant l'exemple canadien où la population active représente plus des deux tiers de la population, il est démontré qu'une telle répartition est difficile à maintenir sur une période prolongée. L'immigration sélective pourrait offrir un certain avantage à court terme mais l'augmentation du ratio de dépendance des personnes âgées que créera le processus dans les prochaines années rendra la stratégie extrêmement inefficace à longue échéance. Ainsi une immigration soutenue ne peut que contribuer à prévenir le déclin de la population ou même son extinction quand la fertilité reste inférieure au taux de reproduction. La composition par âge d'une telle population se définit seulement par la loi de mortalité qui la régit et elle ne peut être efficacement manipulée par une politique d'immigration. C'est-à-dire que l'équivalence de la composition par âge limite et de la population stationnaire est pratiquement assurée quand la composition par âge et par nombre de l'immigration annuelle reste constante.

**Key Words:** immigration, labor force, population projection, stationary population

### *The Problem*

In recent years, the population in the working age-group (15-64) accounts for more than two-thirds of the total population of Canada. Indeed, from a societal point of view, an age composition of the population producing such a high ratio of the labor force to the rest of the population is highly desirable. From a demographic point of view, however, such an age composition is highly unusual since the factors that produced it and the conditions that existed in the past were similarly extraordinary. That is to say, under normal demographic conditions, such an age composition cannot be sustained for an indefinite length of time. As such, population projections into the next century carried out by following the standard procedure reveal that the age composition will remain more or less unchanged until the year 2011. Thereafter, the proportion of the population in the working age-group will continue to decline with minor fluctuations to reach a limiting value of approximately 60%.

From a theoretical perspective it may be argued that any age composition can be generated and sustained by subjecting it to continuous adjustments by movements of population in and out of the country. The feasibility of such a population policy has been studied in this paper by generating alternative scenarios based on modifications of the appropriate components that are involved in the projection exercise.

### *Projection by Standard Method*

According to this method, the projection results are based on the assumption of the continuation of the current patterns of fertility producing a total fertility rate of 1.7. Next, mortality rates are assumed to decline linearly until the year 2011 and remain constant thereafter when the male and female life expectancies become 76.8 and 83.4 years, respectively.

Finally, the crude emigration rate of .0025, the current practice of admitting an annual number of about 150,000 immigrants, and the age and sex composition of these immigrants have been assumed to remain unchanged for the entire projection periods of 200 years 1986-2186. The results of this exercise may be seen in ten-year intervals in Table 1.

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TABLE 1. PROJECTION OF CANADA'S TOTAL POPULATION, THE PROPORTION OF THE POPULATION IN THE AGE GROUP 15-64, AND THE DEPENDENCY RATIO, 1986-2186

(Annual Immigration Level = 150,000)

Year	Total Population At Beginning of Year ( <sup>000</sup> )	Proportion 15-64 (%)	Dependency Ratio
1986	25,353	68.0	47.0
1996	27,958	67.2	48.7
2006	29,794	68.3	46.4
2016	31,145	66.2	51.0
2026	31,627	62.1	60.9
2036	31,647	60.4	65.7
2046	30,890	60.4	65.5
2056	29,952	60.1	66.4
2066	29,137	60.2	66.0
2076	28,412	60.4	65.5
2086	27,727	60.3	65.8
2096	27,147	60.5	65.4
2106	26,627	60.6	65.1
2116	26,152	60.5	65.2
2126	25,746	60.6	64.9
2136	25,378	60.9	64.8
2146	25,049	60.7	64.7
2156	24,763	60.8	64.6
2166	24,505	60.8	64.5
2176	24,276	60.8	64.4
2186	24,075	60.9	64.3

Despite below replacement fertility, the population of Canada continued to increase for the first 40 years, a small part of which can of course be attributed to immigration. A large proportion of the increase is, however, due to the concentration of population at relatively younger ages. Thereafter, the population started to decline to reach its asymptotic lower limit of 24 million as the proportion in the working age-group fell from its initial value of 68% to its stable value of around 60%.

It has been shown earlier (Espenshade et al, 1982; Mitra, 1983; Mitra and Cerone, 1986; and Mitra, 1989) that under conditions of below replacement fertility (constant number immigrants, etc. as noted above), the population of the country eventually becomes stationary. That stationary population can be decomposed into two components, namely, (1) those that are native born and (2) those that are immigrants. The age

composition of the first component turns out to be proportional to the country's stationary population generated by its own life table, whereas the same for the second is determined by the fixed age composition of the annual immigrants and the mortality rates they are subjected to. Since the second component comprises a relatively small part of the total population, the age composition of the country as a whole is dominated by that of its own stationary population. That is to say, regardless of the initial age-composition of the population, the ultimate composition generated by this scenario has to resemble that of its own stationary population. As it is, in that stationary population, the proportion in the working age group (15-64) is a little over 60%.

Population projections along similar lines were attempted earlier by Health and Welfare, Canada (1989) and George, Nault and Romaniuc (1991). One of the conclusions in both of those studies was that in low mortality countries, changes in fertility have a greater impact on the age structure. In general, this is true for all mortality conditions in a closed population which eventually can be demonstrated by the mathematics of a stable population (Keyfitz, 1968) under certain simplifying but realistic assumptions. However, as mentioned earlier, it is not so when the population is not replacing itself and there is immigration characterized by constant size and age composition. Incidentally, one of the conclusions of the Health and Welfare (1989) study was that "immigration affects the overall age structure only in the short run." This is too particularistic and can be true only when the volume of immigration is comparatively large and there is a significant mismatch between the age composition of the immigrant population and that of the host population. The alternative scenarios created in those studies by assuming positive intrinsic rates of growth and varying levels of immigration produced results which cannot be compared with those presented in this paper. In other studies, where below replacement fertility has been assumed, the specific values of the relevant parameters, along with projection techniques and the nature of the constraints, produced answers to questions not raised in this study.

### *Controlling Immigration to Prevent Population Decline*

In the projection exercise just presented, the population reached its peak size of nearly 32 million showing an increase of more than 25% over a period of 40 years. Thereafter, the population started to decline to attain its limiting value of 24 million which turns out to be less than its size of

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over 25 million observed at the start of the projection period. Accordingly, the second scenario (see Table 2) has been created by manipulating the component of immigration in a manner such that the population size remains a nondecreasing function of time.

TABLE 2. ANNUAL NUMBER OF IMMIGRANTS(1) REQUIRED TO PREVENT CANADA'S POPULATION FROM EXPERIENCING A NEGATIVE RATE OF GROWTH, 1986-2186

Year	Immigrants ( <sup>'000</sup> )	Total Population At the Beginning of year ( <sup>'000</sup> )	Proportion 15-64 (%)
1986	150	25,353	68.0
		(2)	
2027	150	31,660	61.9
2028	158		61.6
2036	208		60.6
2046	241		60.8
2056	235		61.0
2066	216		61.5
2076	222		61.6
2086	219		61.3
2096	220		61.3
2106	226		61.3
2116	222		61.3
2126	222		61.3
2136	223		61.3
2146	221		61.3
2156	223		61.3
2166	222		61.3
2176	222		61.3
2186	223	31,660	61.3

(1) The number of immigrants entering in all other years, since 1986 remains at 150,000 per year.

(2) The population increases in size from 25.4 million in 1986 to 31.7 million in 2028 and remains constant thereafter.

As is apparent from Table 2, no change in the size of the immigrant population is needed for approximately the first 40 years. More specifically, the population reached its peak value of 31.66 million in the 41st year, or year 2027, and declined thereafter. In order to hold the population size at this level for the remainder of the projection period,

varying number of immigrants have to be admitted over the years. The numbers shown in Column 2 increase to reach a maximum of about 241 thousand in 2046 and decline thereafter with dampening oscillations to reach a limiting value of about 222,000 at the end of the projection period. It did not take long for the proportion in the working force to drop from its initial value of 68.0. In fact, it fell below 62% by the year 2027 with minor fluctuations thereafter, and stabilized at a value of 61.3% by 2086, midway in the projection period of two hundred years.

### *Maintain the Current Proportion of the Working-Age Population*

It appears from Table 2 that a population policy designed to prevent the population from declining is not difficult to implement in Canada. It calls for only a moderate increase in the volume of immigration over an extended period of time. One may now ask if the continuation of the favorable age structure can be extended beyond 2011, through a policy of selective population movement. The answer, of course, is in the affirmative although the policy or policies required to reach such a goal may not be appealing or may be difficult to implement. However, one may like to seriously consider the idea of admitting an appropriate number of immigrants with a predetermined age-sex composition such that the said proportion remains greater than the specified lower limit. Fortunately, this condition is met by the age-distribution of the recent immigrants where the proportion of the working age is approximately 72.5%. In the following, the task of determining the volume of immigration required at different points in time until the middle of the next century has been undertaken under alternative sets of initial conditions.

In the first, computations are based on the continuation of the current level of immigration of about 150,000 persons per year as long as the proportion of the projected population  $p$  in the working age-group does not fall by more than a tolerance level of one percentage point from its present value of 68.02%. That is to say, whenever the percentage  $p$  falls below 67.02 the new number of immigrants  $I$  needed to raise the proportion to its present level has to be determined. This can be done very simply from the equations:

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(1)

$$\frac{P(15-64) + .7250 I}{P(0+) + I} = .6802$$

whenever

(2)

$$p = \frac{P(15 - 64)}{P(0+)} < 67.02$$

In equations (1) and (2),  $P(0+)$  and  $P(15-64)$  stand for the total population and the population in the working age-group respectively. Accordingly,

(3)

$$I = \frac{.6802 P(0+) - P(15 - 64)}{.7250 - .6802}$$

For purposes of demonstrating the sensitivity of the estimate  $I$  on the tolerance level, a second scenario has been created by reducing the tolerance level from one to one-half of a percentage point. It requires a newly computed value of  $I$  from a formula such as (3) whenever  $p$  becomes smaller than 67.52. In an attempt to reduce the volume of immigration an additional scenario has been created for each of the two levels of tolerance by setting  $I$  at zero, instead of 150,000 for the years in which  $p$  is greater than the respective minimum value.

It may be suggested that in each of these examples, the volume of immigration needed to maintain the desired proportion can be made smaller through a process of selection that favors an age composition more concentrated in the working age group. Although an immigration policy with such a goal may be difficult to implement, the investigation has been carried out by assuming a hypothetical value of  $p$  of 88% compared to its current value of 72.5%. For the sake of brevity, results based only on the lower tolerance level of one half percent in combination with 150,000 annual immigrants have been presented here.

Tables 3 to 7 present the results of the five different scenarios described in the preceding.

TABLE 3. THE NUMBER OF IMMIGRANTS<sup>1</sup> REQUIRED TO MAINTAIN THE PROPORTION OF THE WORKING AGE POPULATION AT A LEVEL HIGHER THAN 67%, CANADA, 1986-2051

Year	Total Population At Beginning of Year ('000)	Immigrants ('000)	Total Population At End of Year ('000)	Proportion 15-64 (%)	Total Dependency Ratio
1986	25,353	150	25,644	68.0	47.0
2014	30,800	7,854	38,672	67.3	48.7
2017	39,125	9,000	48,236	67.3	48.5
2021	49,138	12,744	62,059	67.1	49.0
2028	64,026	14,570	78,750	67.2	48.9
2048	81,305	24,343	105,573	67.0	49.2
2051	106,105	27,878	134,212	67.3	48.6

(1) The number of immigrants entering in all other years since 1986 remains at 150,000 per year. The age composition of the immigrant population remains invariant at all times (72.5% of the immigrant population in the working age group 15-64).

TABLE 4. THE NUMBER OF IMMIGRANTS<sup>1</sup> REQUIRED TO MAINTAIN THE PROPORTION OF THE WORKING AGE POPULATION AT A LEVEL HIGHER THAN 67.5%, CANADA, 1986-2051

Year	Total Population At Beginning of Year ('000)	Immigrants ('000)	Total Population At End of Year ('000)	Proportion 15-64 (%)	Total Dependency Ratio
1986	25,353	150	25,644	68.0	47.0
1989	26,212	3,256	29,609	67.6	48.0
2015	34,542	6,782	41,329	67.6	48.0
2017	41,540	7,335	48,968	67.7	47.8
2019	49,263	8,684	58,124	67.6	47.8
2021	58,506	8,594	67,353	67.7	47.7
2023	67,800	7,785	75,889	67.8	47.6
2027	77,192	10,422	87,870	67.5	48.1
2047	90,442	15,651	105,932	67.6	47.9
2049	106,053	19,143	125,258	67.7	47.8
2051	125,619	24,985	150,924	67.6	47.9

(1) The number of immigrants entering in all other years since 1986 remains at 150,000 per year. The age composition of the immigrant population remains invariant at all times (72.5% of the immigrant population in the working age group 15-64).



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**TABLE 5. THE NUMBER OF IMMIGRANTS<sup>1</sup> REQUIRED TO MAINTAIN THE PROPORTION OF THE WORKING AGE POPULATION AT A LEVEL HIGHER THAN 67%, CANADA, 1986-2051**

Year	Total Population At Beginning of Year ('000)	Immigrants ('000)	Total Population At End of Year ('000)	Proportion 15-64 (%)	Total Dependency Ratio
1986	25,353	0	25,494	68.0	47.0
2012	26,187	7,758	33,950	67.2	48.9
2015	34,084	8,247	42,430	67.3	48.5
2019	42,841	11,465	54,467	67.1	49.0
2026	55,408	14,116	69,662	67.2	48.8
2046	69,392	20,569	89,883	67.1	49.1
2049	90,047	23,928	114,156	67.3	48.6

- (1) For all other years since 1986 there would be no immigration (i.e., the annual immigration level equals zero). The age composition of the immigrant population remains invariant at all times (72.5% of the immigrant population in the working age group 15-64).

**TABLE 6. THE NUMBER OF IMMIGRANTS<sup>1</sup> REQUIRED TO MAINTAIN THE PROPORTION OF THE WORKING AGE POPULATION AT A LEVEL HIGHER THAN 67.5%, CANADA, 1986-2051**

Year	Total Population At Beginning of Year ('000)	Immigrants ('000)	Total Population At End of Year ('000)	Proportion 15-64 (%)	Total Dependency Ratio
1986	25,353	0	25,494	68.0	47.0
1988	25,627	3,086	28,856	67.7	47.8
2013	29,749	6,192	35,933	67.6	48.0
2015	35,977	6,395	42,445	67.7	47.8
2017	42,565	7,364	50,077	67.7	47.8
2019	50,271	7,843	58,330	67.7	47.7
2021	58,589	7,151	66,006	67.8	47.5
2024	66,550	8,137	74,946	67.6	47.9
2029	75,850	9,060	85,091	67.5	48.1
2046	84,698	11,840	96,387	67.7	47.6
2048	96,332	16,947	113,306	67.7	47.8
2050	113,465	21,337	135,052	67.6	47.9

- (1) For all other years since 1986 there would be no immigration (i.e., the annual immigration level equals zero). The age composition of the immigrant population remains invariant at all times (72.5% of the immigrant population in the working age group 15-64).

TABLE 7. THE NUMBER OF IMMIGRANTS<sup>1</sup> REQUIRED TO MAINTAIN THE PROPORTION OF THE WORKING AGE POPULATION AT A LEVEL HIGHER THAN 67.5%, CANADA, 1986-2051

Year	Total Population At Beginning of Year ('000)	Immigrants ('000)	Total Population At End of Year ('000)	Proportion 15-64 (%)	Total Dependency Ratio
1986	25,353	150	25,645	68.0	47.0
2015	31,051	1,103	32,123	67.7	47.8
2017	32,247	1,435	33,660	67.6	48.0
2018	33,660	921	34,574	68.0	47.2
2019	34,574	1,435	36,013	67.9	47.2
2021	36,170	1,654	37,831	67.7	47.8
2022	37,831	1,186	39,038	68.0	47.2
2023	39,038	1,654	40,724	68.0	47.2
2025	40,906	2,107	43,043	67.6	48.0
2026	43,043	1,352	44,440	68.0	47.1
2027	44,440	2,107	46,603	68.0	47.1
2029	46,809	2,104	48,960	67.7	47.7
2030	48,960	1,301	50,315	68.0	47.1
2031	50,315	2,104	52,476	68.0	47.1
2034	52,841	2,042	54,880	67.6	48.0
2036	55,018	1,629	56,614	67.7	47.8
2039	56,779	1,480	58,155	67.6	47.8
2048	57,726	1,620	59,077	67.6	48.0
2051	58,852	2,135	60,840	67.6	47.9

(1) The number of immigrants entering in all other years since 1986 remains at 150,000 per year. The age composition of the immigrant population remains invariant at all times (88% of the immigrant population in the working age group 15-64).

As in Tables 1 and 2, the assumptions about the courses of mortality, fertility and emigration are the same for Tables 3-7. In these, detailed information has been provided only for those years in which infusions of additional immigrants become necessary to maintain the desired proportion in the working age group. As may be seen from these tables, the distributions are quite irregular in that they are characterized by sudden outbursts of unusually large numbers of immigrants. Thus, there are several years in succession when no change in the immigration policy is required only to be followed by an impractical demand of admitting millions of immigrants in just one year. So much so, that near the end of the projection period (Tables 3-6), the annual immigration level has to hover around 25 million.

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### *Summary and Concluding Remarks*

These results follow from the dynamics of the aging process and the tendency of the age composition to approach a state of stable equilibrium, primarily determined by the prevailing vital rates and the movement of population. Maintaining the age structure to its present state by force is equivalent to maintaining a state of equilibrium which is highly unstable and therefore, difficult to perpetuate over an extended period of time. Selective immigration may offer some advantage in the short run (Table 7) but the increase in the old age dependency created in the process in the following years will render that strategy equally inefficient in the long run.

Thus, a sustained pattern of immigration can only be helpful in preventing population decline or even its extinction when fertility continues to remain at below replacement level (Mitra, 1989). Such a population approaches a stationary state and its age composition is determined solely by its level of mortality. It is pretty obvious that the age composition cannot be effectively tampered with by an immigration policy and kept at that state for a long period of time. The equivalence of limiting age composition to its own stationary population is the "faits accomplis", a force to be reckoned with, and as such it should guide the planners to search elsewhere for innovative ideas and/or for existing but untapped resources.

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### *References*

- Espenshade, Thomas J., Leon F. Bouvier and W. Brian Arthur. 1982. Immigration and the Stable Population Model. *Demography* 19:125-133.

- George, M. V., F. Nault and A. Romaniuc. 1991. Effects of Fertility and Migration on Changing Age Composition in Canada. *Statistical Journal of the United Nations*, ECE 8.:13-24
- Health and Welfare, Canada. 1989. Charting Canada's Future, A Report of the Demographic Review.
- Keyfitz, N. 1968. *Introduction to the Mathematics of Population*. Reading, MA: Addison Wesley.
- Mitra, S. 1983. Generalization of the Immigration and the Stable Population Model. *Demography* 20:111-115.
- Mitra, S. and P. Cerone. 1986. Migration and Stability. *Genus* 42:1-12.
- Mitra, S. 1992. Below Replacement Fertility, Net International Migration and Canada's Future Population. *Canadian Studies in Population* 19(1)27-46.

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Special Section:

***Women in Demography: Universities and Beyond***

The four papers that follow on "Women in Demography: Universities and Beyond" represent the first time reflections have been published in *Canadian Studies in Population* on women's challenges in demography as a profession, practice and discipline. The papers are revised versions of those presented in a special session of the 1991 meetings of the Canadian Population Society in Kingston, Ontario. The impetus for the session came from the Social Sciences Federation of Canada in adopting the theme, "Women in Universities" for the 1991 Learned Societies Conference. The theme was chosen in memory of the Montreal tragedy of 6 December 1989, with the aim of "promoting the situation of women in social sciences and combating sexist bias in research" (A. Yassini, Executive Director, SSFC, Update, May 1990, 3(3):1). The CSP session on women was conceptualized and operationalized by Monica Boyd, Tom Burch and Susan McDaniel. It was chaired by Kevin McQuillan. The initiative for publishing the papers in CSP came from Susan McDaniel.

Susan McDaniel

