Effects of Immigrants on the Native Force Labor Market Outcomes: Examining Data from Canada and the US

By

Matija Jančec

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Supervisor: Professor John Earle

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Abstract:

In the last 20 years there has been significant increase in international migration. This growth also gives rise to a debate about the effects of immigrants on the native work force labor market outcomes. This thesis will present the analysis done on the US and the Canadian dataset that investigates the effect of immigrants on local workers' wage and employment.

In the first part of the thesis educational-experience skill cell approach is used for estimating the effect of immigrants. This estimation method shows that the effects of immigrants are more negative for US than for Canada. Furthermore evidence for spatial arbitration effect is present in both countries when more disaggregated data is used.

In the second part nested CES production function approach is used. It allows for an imperfect substitution between immigrants and natives in the same skill cell and also takes into account different elasticity of substitution between workers with various educational and experience attainment. The coefficients obtained in this way show that the long run effect of immigrants has been positive on native workers in Canada.

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INTRODUCTION

In the last 20 years there has been significant growth in international migration. According to the International Organization for Migration[1] there are 200 million immigrants around the world representing 3% of the overall world population. The same source also estimates that 20 to 30 million are unauthorized immigrants. In the US the share of immigrants in male labor force has grown from 5% in 1960 to 14.8 % in the 2005-7 year period. Furthermore this raise in immigration has spurred a debate about its social and economic effects among economists interested in the consequences of immigration on the local labor force.

There is a lot of controversy in the economic literature dealing with immigration. Borjas in his 2003, 2005 and 2006 papers finds significant effect of immigration on the local labor force. He reports that a 10% rise in immigration lowers the local absolute wage by 3 - 4 percent. In his papers, Borjas uses a skill cell approach, where he divides workers into education-experience groups. He assumes that workers in the same skill group are perfect substitutes, while workers from different skill cells are not directly competing on the same labor market. An additional interesting finding in his papers is the existence of special arbitrage, or native response on immigrant shock that tends to offset it. The inflow of immigrants in some areas does not only affect local wages but can also triggers interregional flaws of labor and capital that tends to equalize opportunities for workers of given skills across regions. Borjas (2003, 2006) shows that when one considers data at aggregate USA level, the immigrant effect is stronger than at more disaggregate levels like the states or Metropolitan Statistical Areas (MSAs). He concludes that even though the effects of immigrant workers can be small at a local level due to spatial arbitration, the overall negative effect is present. As evidence for spatial arbitrage he finds in his

[1] http://www.iom.int

2005 paper that native migration decisions are affected by immigrant share. This process, as he calls it “voting with their feet”, is more evident when smaller regions like MSA or US federal states are compared, and the cost of moving is not so high. According to Borjas natives may respond to entry of immigrants into their local labor market by moving their labor or capital to other locations until native wages and returns to capital are again equalized across areas. This helps to explain the smaller effect of immigration on lower aggregate level, because locals find it easy to move and offset the negative effect of immigration. The same conclusion that native migration decisions are affected by immigrant share can be found in Filer (1992) and Fery (1995).

On the other hand there is a significant amount of literature that claims that effect of immigrants on native workforce labor outcomes is negligible, for example Card 1990, 2001, 2005, 2007, 2009, Ottavaiano and Peri (in further usage only OP)2006, 2008 and Lewis 2003. Card’s 1990 study of the aftermath of the Mariel boatlift shows a minor negative effect of immigrants on wages and unemployment. When the variable of interest is the relative wage instead of the absolute wage of native labor force, as in Card 2005 and 2009 paper, he finds almost no effects of immigrant share. He also shows that immigrant share in MSAs does not have a significant effect on relative wages for the U.S. born labor force. Furthermore in his 2001 paper, in accordance with Kritz and Gurak (2001), he finds no connection between immigrant share and native workforce migration decisions.

Immigration to the U.S. has been highly heterogenic (Card 2000). New immigrants tend to go to communities with an already high share of immigrants from their home countries, as noted in Card (2005) and Lewis (2003). This phenomenon might explain why immigrants have disproportionally large share in three cities: New York, Los Angeles and Miami. There is a huge variation in education and potential work experience of immigrants, but compared to native labor force immigrants have higher share of low-skill workers, especially immigrants coming from Latin America[2]. According to the 2000 Census immigrants made up 13% of working age population but 28% of population with less than 8 years of schooling. This fact is mainly a consequence of US immigration policy that gives priority to family reunion. Canada on the other hand has a different immigration system, one that emphasizes on the skills of visa applicants. As a result immigration in Canada disproportionately increased the number of high-skill workers, which is noted in Aydmir and Borjas (2006).

One of the problems with examining the effect of immigrants on the local labor force is obtaining a possible spurious correlation. In the last 40 years most of the immigrants to the USA have low educational levels and compete with the low-skilled native force. In that period there has been a significant change in the technology, labor market institutions and the world trade patterns. All of these affected negatively the wages of less capable workers and it is hard to distinguish between the effect of immigrant supply shock and the effect of other components. One of the possible ways to handle this issue is to use relative instead of absolute wage, as done in Card (2005). Another, which I will use in this thesis, is to explore the educational differences between immigrants in Canada and the US. For the US it is hard to distinguish between the effect of rising immigration and of other factors that had negative effect on relative wage of the low-skilled but that should not be the case in Canada. The reason is that immigrants have skill distribution similar to Canadian born labor force. Using this approach I find that in Canada negative effect of immigrants is smaller than in the US. It even becomes insignificant on the low aggregation levels, i.e. when data in analyzed on Canadian province level.

[2] Althogh an average immigrant is less educated than average native worker, 2nd generation of immigrants, one born in US, allready has higher educatuional levels then children of non-immigrants (Borjas 2003, Card 2005).

Another question on which I focus is the substitution elasticity between immigrants and natives, as well as between different schooling and experience groups. This question was first examined in OP (2006), and later in OP (2008), Cortes (2008), Borjas, Grogger and Hanson (2008) and Card (2009). The "classical" Borjas 2003 approach assumes that there is a perfect substitution between immigrants and native work force within the same skill cell. Using two level nested CES function it is possible to calculate not only the elasticity of substitution between natives and immigrant workers but also the elasticity of substitution between different education and experience skill groups. Furthermore this approach allows to incorporate a short and long term capital response to changes in labor supply in order to obtain close form solution. Applying this method on Canadian 1971-2001 Census data, I find that there is an imperfect substitution between immigrants and native work force. Taking into account different elasticity of substitution between various educational and experience groups and assuming perfect capital adjustment my regression shows positive effect of immigrants on natives in all educational groups.

Recent literature has studied the effect of immigrants on natives in other countries besides Canada and the US. Hundson (2006) finds no evidence for negative selection of Mexican immigrants in US. Mishra (2006) and Aydemir and Borjas (2006) present evidence for positive effect of Mexican emigration to US on native Mexican labor force wages. Bonin (2006) examines German labor market using Borjas skill cell approach and reports a very small effect of immigrants on native force wages and almost no effect on employment. Wagner (2009) finds negligible effects in Austria as well. He also presents evidence that natives shift from services to manufacturing as a consequence of immigration. Using UK data Manacorda, Manning and Wadsworth (2006) show that immigrants have an insignificant effect on native force wages. All papers dealing with European data report imperfect substitution between immigrants and native force which can explain the lack of effect of immigrant supply shock on native wages. Cortes (2008) obtains the same results using US data. Furthermore her analysis shows that increase in immigrant share has an effect on prices of immigrant-intensive services like gardening and housekeeping.

The rest of the thesis is organized in the following way. Chapter one describes the data used in the regressions. Chapter two discusses the estimation using "classical" Borjas (2003) approach, and presents results obtained using that method on the US and Canadian data. Chapter three provides theoretical framework for using CES production function for estimation of different elasticity of scale. Results for Canadian data as well as short discussion are also in the chapter three. Finally thesis ends with a conclusion, and two appendixes, the one that gives detailed description of the variable construction, and the one that provides additional tables and figures.

CHAPTER I: Data overview

I use publicly available micro data (PUMS) from decennial censuses in US and Canada. The data is obtained from the web page of Integrated Public Use Microdata Series International, (**https://international.ipums.org/international/**). I use data from US censuses in 1960, 1970, 1980 1990 and 2000 and 2005-2007 American Community Survey three-year file. Censuses from 1960 and 1970 are 1% samples, while the other Censuses are 5% samples. Canadian data includes PUMS for 1971, 1981, 1991 and 2001 Census.

The analysis is limited to males participating in the labor force, between 18-65 years of age, not residing in group quarters, not attending school and having positive wage or salary income in the last year. This specification is common in the literature and can be found for example in OP (2008) and Borjas (2007). More detailed description of data sample construction as well as specific variable definition transformation from the Census data is provided in appendix A. The data sample thus restricted contains 8.8 million observations for US and 443,896 for Canada. In estimating the effect of immigrants on natives Borjas's (2003) skill cell approach is used. Workers are divided into education-experience cells, where it is assumed that workers in the same cell are competing on the same job market. Calculation of the index of congruence in occupation distribution done by Borjas (2003) shows that there is little workplace competition between workers from different skill cells. Division by education is made into four groups: high school dropouts, high school graduates, some college education and college graduates. Experience is defined as the potential experience that one can gain if they spend all their post-education life in the labor force. It is constructed as the age at the time of the census minus the expected year of entry into the labor market which depends on education. For high school dropouts it is assumed to be 17, for high school graduates 19, for college dropouts 21, and 23 for typical college graduate.

Workers are then split into 5-year experience groups, altogether 8 in 1-40 years of experience interval. Combined with 4 possible educational levels, one can use 32 different skill cells. The possible problem with this potential education approach is that it overlooks the fact that the people with lowest education work on average less than the others. This can be seen from Table 1 in Appendix B which shows that high school dropouts work on average 5 weeks less than college graduates and therefore gain less experience in any given year. This problem is handled for by allowing different effect of experience in different educational levels, which is one of the benefits of using 32 skill-cell approach.

A person is considered an immigrant if he/she is a naturalized citizen or is born abroad by parents who are not citizens of the host nation, in this case US or Canada. According to this definition the share of immigrants in US male labor force was 5.0% in 1960, 4.6% in 1970, 6.6% in 1980, 8.9% in 1990, 13.1% in 2000 and 14.8% in the 2005-7 period. In Canada, the corresponding numbers are 20.5% in 1971, 20.1% in 1981, 19.4% in 1991 and 20.1% in 2001.

The (*i*,*j*,*k*,*t*) cell defines group of workers with education *i*, experience *j*, location *k* and in time *t*. The measure of immigrant supply for this skill group is defined by:

$$p_{ijtk} = M_{ijtk} / (M_{ijtk} + N_{ijtk}) \qquad (1)$$

Where M_{ijtk} gives the number of immigrants in cell (*i*,*j*,*k*,*t*) and N_{ijtk} gives the corresponding number of natives. The more detailed overview of immigrant share in different educational and experience groups for different years can be seen in Figure 2 for US and Figure 3 for Canada that are situated in appendix B. Figure 2 clearly shows that immigrants in recent decades have been better represented in low educational groups in the US while in Canada they are more equally distributed in all educational groups. Furthermore both figures show that there is a lot of variation in immigrant share over the years, a fact that will be used to show the effect of immigration supply shock on native labor force outcomes.

All wage income variables are converted into 2009 US or Canadian dollars. When interval values are reported, for example number of weeks worked, means of the interval are used. In addition to that Canadian wage and employment data is transformed from monthly frequencies to weekly so it can be comparable with the US data.

CHAPTER II: Estimation of effect of immigrants on native workers within same skill cell

2.1 Methodology

This analysis measures the effect of immigrants on native workers in the same skill cell. The approach was first applied in Borjas (2003) and it has been used widely in the literature, for example in Parich (2007), Aydemir and Borjas (2006), Bonin (2005), OP (2006), OP(2008). Empirical analysis is done using the following equation:

$$y_{ijt} = \theta p_{ijt} + s_i + x_j + \pi_t + (s_i \times x_j) + (s_i \times \pi_t) + (x_j \times \pi_t) + \varphi \qquad (2)$$

where s_i is a vector of fixed effects indicating the group's educational attainment, x_j is a vector of fixed effects indicating the groups work experience and π_t is a vector of fixed effects indicating the time period. When the regression is done on different aggregation levels dummies for the regions are added as well as their interactions with education, experience and yearly effects. In that case equation for estimating the effect of immigrant shock will look like:

$$y_{ijt} = \theta p_{ijt} + s_i + x_j + \pi_t + r_k + (s_i \times x_j) + (s_i \times \pi_t) + (x_j \times \pi_t) + (s_i \times r_k) + (r_k \times \pi_t) + (x_j \times r_k) + \varphi \qquad (3)$$

Where the only novel mark is the one specifying region k, r_k. The effect of the immigrants will be measured in coefficient θ, where y_{ijt} represents the average native force labor outcome. This outcome is either yearly wages, weekly wages or employment given by the number of weeks worked in a given year. There are different approaches in the literature concerned with how to construct a weekly wage variable, which is not reported directly in the PUMS. Borjas (2003) and Aydemir and Borjas (2006) define the weekly wage as yearly wage divided by number of weeks worked in the last year. OP (2008) exploits the same procedure but they use an additional weight in calculating the average weekly wage. This weight is obtained as the average number of hours worked in a year, a product of weeks worked in a year and average number of hours worked in a week. The reason for using this weight is that it gives an emphasis to the people who work more and participate more actively in the labor force. I use both ways. Detailed description of variable construction can be found in appendix A.

The usage of this skill cell approach can give rise to a potential spurious correlation. Most of the immigrants in the US in the last 40 years have low educational levels and compete with the low-skill native force, as it can be seen in Figure 2 in appendix B. Card (2005) noticed that during the same time period a significant skill biased technological change (SBTC) took place, which also affected negatively the wages of the workers with the least education. Moreover there is a number of other factors that may have influenced widening of a wage gap between the low skill and high skill workers. Among those factors significant role is played by weakening power of unions, increased globalization, changes in the minimum wage and negative selection of low skill workers. All of these factors affected negatively wages of less skilled workers and it is hard to tell precisely what is the effect of immigrants and what is effect of other components. This problem can be mitigated by studying the effect of immigrants in Canada. The dissimilar educational immigration pattern in Canada and the US is a result of the different visa policy in the two countries, as noted by Borjas and Aydemir (2006). US visa is issued with emphasis on family reunion, which has resulted in high number of low-skill immigrants entering the country. On the other hand Canadian visas are given according to a points system, where the person with higher education has a higher chance of obtaining Canadian visa. As a result of this visa policy Canada has a more educationally balanced immigration structure. This can be seen from figure 3 that can be found in appendix B. The variation in US and Canada immigrant’s educational attainment can be helpful in gaining additional insight on the effect of immigrants on native force labor market outcomes, fact that is used in Bohn and Sanders (2005).

The estimation of equations (2) and (3) at different levels of aggregation provides information on possible spatial arbitrage. As Borjas (2003) argues, the inflow of immigrants in some area does not only affect local wages but can also trigger interregional flaws of labor and capital that tend to equalize opportunities for workers of given skills across regions. To account for this effect in my analysis I use the US aggregate level, US 9 census regions level, US state level, Canada aggregate level and Canada province level. The results of the regression are reported in table 1. There are two ways of using weights in calculating the effect on natives' wages; one is using the person weight variable reported in the census and the other is using the person weight multiplied with the number of hours worked in the last year. The effect on employment is analyzed by using the average number of weeks worked in a specific skill-region group. As mentioned above, the Canadian data reports only months worked last year. Because of this results are multiplied with average number of weeks per month, 4.5, to be comparable with the US findings.

2.2 Results

In the first row of table 1 results for the aggregate US level are reported. Immigrant share has a significant negative effect on labor outcomes of the native labor force. The effect is evidently most negative when one looks at the yearly wages. This result is expected since immigrants affect negatively both weekly wages and number of weeks worked per year. When compared with Borjas (2003) my analysis gives (smaller) less negative results of immigrant share effect on native workforce labor outcomes. Possible reason is the different data set used; the one in my regression has an additional data point, 2005-2007 American Community Survey (ACS) three-year file, and for 2000 I use Census PUMS file while Borjas uses the 1999-2001 Annual Demographic Supplement of the Current Population Survey. Additionally my sample is more restricted - individuals who live in group quarters, who are self employed or are still enrolled in school are not part of my analysis.

Table 1- Effect of immigrants on native labor force using skill cell approach

Table 1 - Effect of immigrants on native labor force using skill cell approach. Standard deviations are in parenthesis						
Data aggregation level		*Dependent variable*				
		(1)	*(2)*	*(3)*	*(4)*	*(5)*
		Log yearly wage (using only pwight)	*Log yearly wage (using amount of time worked as weight)*	*Log weekly wage (using only pwight)*	*Log weekly wage (using amount of time worked as weight)*	*Weeks worked in a year*
USA	US aggregate level	***-0.609*** (0.119)***	***-0.563*** (0.098)***	***-0.323** (0.107)***	***-0.497 *** (0.093)***	***-5.352** (2.494)***
	9 Census regions	***-0,243 *** (0.031)***	***-0.214*** (0,029)***	***-0.238*** (0,032)***	***-0.203*** (0.027)***	***-1,839*** (0.399)***
	US State level	***-0.095*** (0.021)***	***-0.062*** (0.022)***	***-0.104*** (0.025)***	***-0.085*** (0.021)***	***-0.343 (0.299)***
USA, without 2005-07	US aggregate level	***-0.882*** (0.14)***	***-0.605*** (0.12)***	***-0.438*** (0.133)***	***-0.497*** (0.117)***	***-13.07*** (2.69)***
	9 Census regions	***-0.304*** (0.035)***	***-0.249*** (0.0328)***	***-0.272*** (0.035)***	***-0.231*** (0.317)***	***-2.88*** (0.438)***
	US State level	***-0.097*** (0.026)***	***-0.069** (0.026)***	***-0.077*** (0.028)***	***-0.076*** (0.0251)***	***-0.281 (0.35)***
Canada	Canada aggregate level	***-0.451* (0.250)***	***-0.395* (0.245)***	***-0.420** (0.208)***	***-0.365* (0.232)***	***-3.742** (1.564)***
	Canada province level	***-0.006 (0.007)***	***-0.006 (0.007)***	***0.070 (0.069)***	***0.062 (0.068)***	***-2.244* (0.812)***

The second row in the table 1 shows the results of the analysis done on the 9 US Census levels[3] using equation 3. Here also the effect of immigrants on employment outcome of the locals is negative and significant in every specification even on 1% level. This is even more notable if one takes into account the 214 dummy variables used in this regression[4]. Furthermore all coefficients on immigrant share are less negative than in the first case when aggregate US level data is used. The same result is reported in Borjas (2003) and Borjas (2005) and can be interpreted as evidence for spatial arbitrage that tends to equalize capital and labor returns in different regions. Same conclusion can be drown from the last analysis done on the US data, the one on US federal state level which is reported in the third row of table 1. The effect of immigrants is less negative than on the higher aggregation levels and it is significant on 1% levels where logarithm of average wages is used as a depended variable. The results obtained in my analysis on the state level are again a bit less negative than the ones that Borjas reports in (2003) and (2005).

Results listed in rows 4, 5 and 6 are the ones obtained on a sample without 2005-07 ASP data. This is done in order to make my results more comparable with Borjas, and also to check if a large increase in number of immigrants from 2000 to 2005-07 has an effect on overall impact of immigrants on natives. The coefficients of estimation without 2005-07 data point are higher than the ones reported in the first three rows of the table 4. This is especially the case when the regression is weighted only by personal weight reported in the Census data. This is the same specification that Borjas used in 2003 and the results obtained with this reduced sample are much closer to the ones he reports. The higher negative effect in the sample without 2005-07 data can

[3] Those regions are: in the Northeast: New England and Middle Atlantic; in the South: South Atlantic, East South Central and West South Central; in the Midwest: East North Central and West North Central; in the West: Mountain and Pacific

[4] Those dummies are: 8 experience levels, 4 educational levels, 6 time controling varables, 9 region controling and intersection of each of them with other ones.

be explained by the slowing pace of wage inequality growth that started in the second half of the 1990s, which is reported by Katz and Kearney (2006). It is also notable that the biggest difference in the estimation with the 2005-07 data, and one without it, lies in the specification of the yearly wage in the first column, the one that gives relatively higher weight to people who work fewer hours. This difference is evident from the huge growth of the negative effect of immigrants on average number of weeks worked in the sample without 2005-07.

The analysis for Canada is done on two aggregation levels: the ten provinces and the whole of Canada. Canadian provinces, according to their population and size, could be compared to US federal states. On the aggregate Canadian level there is a 10% significant negative effect of immigrant share on native employment outcomes. This effect is (smaller) less negative when compared to US aggregate one. The same conclusion can be reached when the Canadian province level and US state level are compared. Furthermore, coefficient of immigrants share becomes (smaller) less negative as one looks at more disaggregated data level. It is even positive, but not significant, for some specifications.

Based on this analysis done for two countries one can conclude that there is a spatial arbitrage that manifests itself in the smaller negative effect that immigrants have on native workers when more disaggregated data is analyzed. It appears that workers tend to move their capital and labor endowments in response to labor shock caused by immigrants. This is in line with the findings reported in Borjas (2003) Borjas (2005), Aydmir and Borjas (2006).

Another conclusion can be reached when the Canadian and US results are compared having in mind the different education immigration patterns. The US has disproportionally represented immigrants in the lowest educational group, the one that has been highly negatively affected by changes in economy in the last couple of decades. Because of this it is possible that the US analysis suffers from spurious correlation and results in upward bias when estimating the effect of immigrants on native labor force outcomes. In Canada that possible bias is not so pronounced because of the different education distribution of the immigrants. Nevertheless, Canadian data on the highest level of aggregation shows that there is a negative effect of immigrants on natives, even though it is not significant on 5% levels. When looking at the province aggregation level the effect of immigrants is not even significant on 10% levels. One can conclude that it is not impossible that this difference in immigrant effect in the two countries comes from the fact that the regression in the US data measures more things than just the effect of immigrants on native work force.

CHAPTER III: CES production function and elasticity of substitution approach

This approach to the effect of immigration is quite recent, starting with OP (2006) and including Borjas, Grogger and Hanson (2008), OP (2008) and Card (2009). The basic idea is that one has to take into account the possible imperfect substitution between immigrants and native workers with same education and experience level, i.e. within the same skill cell. The effects of other skill groups also have to be taken into account when estimating the effect of immigrants on natives within a particular skill group. My analysis differs from all above mentioned because it is the first one using Canadian data, while all others use data from the US. My basic dataset contains the whole Canadian labor force, with additional robustness checks preformed using only male or female sample.

3.1 Theoretical background

This part of the thesis gives theoretical background on the estimation strategies for the effect of immigration and it is mostly based on OP (2008). Starting with the Cobb-Dugglas production function they assume that labor input can be represented with nested CES function. The last level of nesting is within the same education experience cell. There the substitution between immigrants and natives with the same educational and experience attainment can be estimated by equation 9 in the text below. The second level includes people with the same education aggregation. Here the elasticity of substitution between workers with different experience could be calculated, as shown in equation 8 later in this section. At the highest level of nested CES function elasticity of substitution between workers with different education could be obtained, as can be seen form equations 5, 6 and 7. The whole theoretical framework for the nested CES function, as well as the detailed steps for calculating each elasticity of substitution and other needed results are to be found in OP(2008). Here I only present the idea and the basic steps needed to calculate the parameters of the model.

The starting point is the widely used Cobb-Dugglas production function:

$$Y_t = A_t N_t^{\alpha} K_t^{1-\alpha} \tag{4}$$

where Y_t the is aggregate output, A_t is the exogenous total factor productivity (TFP), K_t is the physical capital, N_t is a CES aggregate of different types of labor, and α ∈ (0, 1) is the income share of labor. The labor aggregate is usually defined as:

$$N_t = \left[\theta_{Ht} N_{Ht}^{\frac{\sigma_{HL}-1}{\sigma_{HL}}} + \theta_{Lt} N_{Lt}^{\frac{\sigma_{HL}-1}{\sigma_{HL}}}\right]^{\frac{\sigma_{HL}}{\sigma_{HL}-1}} \tag{5}$$

where N_{Ht} and N_{Lt} are the aggregate measures of respectively the labor supplied by workers with high (H) and low (L) educational levels in year t. θ_{Ht} and θ_{Lt} are the productivity levels specific to the workers with high and low education (standardized so that $\theta_{Ht} + \theta_{Lt} = 1$ and any common multiplying factor can be absorbed in the TFP term A_t). Finally, the parameter σ_{HL} is the elasticity of substitution between the two groups. Equation 5 is very often used especially in macro and growth literature even though its oversimplification. OP (2008) go one step further and expand (5) to include for four different educational levels:

$$N_{Lt} = \left[\theta_{HSDt} N_{SHSt}^{\frac{\sigma_{LL}-1}{\sigma_{LL}}} + \theta_{HSGt} N_{HSGt}^{\frac{\sigma_{LL}-1}{\sigma_{LL}}}\right]^{\frac{\sigma_{LL}}{\sigma_{LL}-1}} \tag{6}$$

$$N_{Ht} = \left[\theta_{CODt} N_{SOCt}^{\frac{\sigma_{HH}-1}{\sigma_{HH}}} + \theta_{COGt} N_{COGt}^{\frac{\sigma_{HH}-1}{\sigma_{HH}}}\right]^{\frac{\sigma_{HH}}{\sigma_{HH}-1}} \tag{7}$$

The terms N_{kt} for $k \in \{HSD, HSG, COD, COG\}$ are aggregate measures of labor supplied by workers with, respectively high school dropouts (HSD), a high school graduates (HSG), college dropouts (COD) and a college graduates (COG). Relative productivity of those groups of workers within the aggregates N_{Lt} and N_{Ht} is captured by the parameters θ_{kt}.The elasticity of substitution σ_{LL} and σ_{HH} capture, respectively, the degree of substitutability between high school dropouts and workers that have graduated from high school in equation (6) and the substitutability between workers with some college education and those who graduated from college in equation (7). It is also possible to distinguish between workers with different experience N_{kt} and allow them to be imperfect substitutes. Then on the lower level of aggregation one can get:

$$N_{kt} = \left[\sum_{j=1}^{8} \theta_{kj} N_{kjt}^{\frac{\sigma_{EXP}-1}{\sigma_{EXP}}}\right]^{\frac{\sigma_{EXP}}{\sigma_{EXP}-1}} \tag{8}$$

where j is an index spanning experience intervals of five years between 1 and 40, so that j=1 captures workers with 1−5 years of experience, $j=2$ those with 6 − 10 years, and so on. The parameter $\sigma_{EXP} > 1$ measures the elasticity of substitution between workers in the same educational group but with different experience levels and θ_{kj} are experience-education specific productivity levels. The last nesting level of the CES production function is the one where labor supply within the same education and experience group is composed from immigrant and native workers. It is assumed that they have different productivity levels and imperfect substitution is allowed:

$$N_{kjt} = \left[\theta_{Dkj} D_{kjt}^{\frac{\sigma_{IMMI}-1}{\sigma_{IMMI}}} + \theta_{Fkj} F_{kjt}^{\frac{\sigma_{IMMI}-1}{\sigma_{IMMI}}}\right]^{\frac{\sigma_{IMMI}}{\sigma_{IMMI}-1}} \tag{9}$$

where N_{kjt} is defined as a CES aggregate of U.S.-born (domestic, D) and foreign-born (F) workers. The supply of labor by workers with education k and experience j who are, respectively, U.S.-born (Domestic) or foreign-born, by D_{kjt} and F_{kjt},. The elasticity of substitution between them is captured by $\sigma_{IMMI} > 0$. The terms θ_{Dkjt} and θ_{Fkjt} measure the specific productivity levels (relative quality) of foreign- and U.S.-born workers. They may vary across education-experience groups but (as with the θ_{kj} above) they are assumed to be invariant over time. If competitive equilibrium is assumed, as in OP (2008), then marginal productivity of US workers equals their wage. Denoting the broad education level with $b \in B \equiv \{H,L\}$, the specific education level with $k \in E \equiv \{ HSD,HSG,COD,COG \}$ and the experience level with $j = 1, 2, ..., 8$, we can write the wage of a generic U.S.-born worker (equal to her marginal productivity) as:

$$lnw_{Dbkjt} = \ln(\alpha A_t k_t^{1-\alpha}) + \frac{1}{\sigma_{HL}}\ln(N_t) + ln\theta_{bt} - \left(\frac{1}{\sigma_{HL}} - \frac{1}{\sigma_{bb}}\right)\ln(N_{bt}) + ln\theta_{kt} - \left(\frac{1}{\sigma_{bb}} - \right.$$

$$1\sigma EXP \ln Nkt + ln\theta kj - 1\sigma EXP - 1\sigma IMM \ln Nkjt + ln\theta Dkj - 1\sigma IMM \ln Dkjt \quad (10)$$

And for the foreign born the same procedure can be repeated:

$$lnw_{Fbkjt} = \ln(\alpha A_t k_t^{1-\alpha}) + \frac{1}{\sigma_{HL}}\ln(N_t) + ln\theta_{bt} - \left(\frac{1}{\sigma_{HL}} - \frac{1}{\sigma_{bb}}\right)\ln(N_{bt}) + ln\theta_{kt} - \left(\frac{1}{\sigma_{bb}} - \right.$$

$$1\sigma EXP \ln Nkt + ln\theta kj - 1\sigma EXP - 1\sigma IMM \ln Nkjt + ln\theta Fkj - 1\sigma IMM \ln Fkjt \quad (11)$$

The total labor input (hours worked) of domestic (foreign-born) workers with education k (in broad group b) and experience j is represented by D_{bkjt} (F_{bkjt}). The average wage for the same skill group is w_{Dbkjt} (w_{Fbkjt}). Here it is assumed that total factor productivity A_t, as well as the relative efficiency parameters θ*'s*, are independent of supply of foreign born and only depend on technological factors. From equation 10 and 11 the effect of immigrants on wages can be decomposed into four effects that operate through N_{jht}, N_{kt}, N_{bt}, N_t and one that works through the capital adjustment $ln(\alpha A_t k_t^{1-\alpha})$. Due to imperfect substitutability among different types of workers, workers benefits from the overall increase in aggregate supply of labor and this effect is captured with $\frac{1}{\sigma_{HL}} ln(N_t)$. The next three effects depend on the supply of labor in a more narrowly defined experience-educational group that worker belongs to, i.e. N_{jht}, N_{kt} and N_{bt}. The sign of these effects is determined by the difference between elasticity of substitution of workers in current CES production function layer and an elasticity of one layer below. It is positive if workers in the current layer are closer substitutes to those on the same level than to workers one layer lower. For example the term $-\left(\frac{1}{\sigma_{EXP}}-\frac{1}{\sigma_{IMMI}}\right)\ln\left(N_{kjt}\right)$ is positive if workers within the same experience group are closer substitutes than natives and immigrants within the same skill cell. The last term in the equations 10 and 11 takes into account a possible imperfect substitution between immigrants and natives. In the next chapters elasticity of substitution will be estimated starting from the lowest level the one between immigrants and natives and from that elasticity for larger aggregates will be calculated.

3.2 Estimation of σ_{IMMI}

The question of the existence of imperfect elasticity has become one of the most debated in the migration literature. For example OP (2006), (2008), Cortez (2008) and Card (2009) present data in favor of imperfect substitution, while Borjas Grogger and Hanson (2008) find no evidence for such a claim. One of the reasons for different results is the usage of dummies. OP (2008) argues that Borjas Grogger and Hanson (2008) estimate σ_{IMMI} imposing a very large set of controls and that the use of so many dummies is not in line with the procedure they use for estimating other elasticity.

The difference of equations 10 and 11 gives equation for estimation of σ_{IMMI}:

$$\ln\left(w_{Fbkjt}/w_{Dbkjt}\right)=\ln\left(\frac{\theta_{Fkj}}{\theta_{Dkj}}\right)-\frac{1}{\sigma_{IMMI}}\ln\left(F_{kbjt}/D_{kbjt}\right) \quad (12)$$

Where F_{kbjt}/D_{kbjt} is the relative supply of hours worked by immigrants and the native work force, w_{Fbkjt}/w_{Dbkjt} is the relative wage and $\frac{\theta_{Fkj}}{\theta_{Dkj}}$ is the relative foreign-native productivity in the skill group with experience *j*, education *k* and boarder education *b*. According to the basic model described before, it is reasonable to assume that relative productivity is constant over time but varies in different education-experience groups.

Then equation 12 can be put in more estimable form:

$$\ln\left(w_{Fbkjt}/w_{Dbkjt}\right) = I_{kj} - \frac{1}{\sigma_{IMMI}}\ln\left(F_{kbjt}/D_{kbjt}\right) \qquad (13)$$

where I_{kj} represents the fixed effects for each of 32 education-experience group. Results give an estimate of $\frac{1}{\sigma_{IMMI}}$ using equation 12 are shown in table 2. The first column restricts equation 13 to no fixed effect, the second column is the basic estimation with the education, experience and their intersect dummies. Column 3 reports results when time effects are added, column 4 when time-education intersection dummies are added and the final column when time by education effect is accounted for. Estimation of $\frac{1}{\sigma_{IMMI}}$ when no fixed effects are used is significant at the 1% level and then the value of σ_{IMMI} is approximately 22.5. When education and experience fixed effects are added the value of σ_{IMMI} drops to 14.5 and it is still significant at the 1% level. Adding time fixed effects to basic estimation gives a bit lower value for σ_{IMMI} but is also very significant. This is not the case when dummies for time-education and time-experience intersections are added. Their inclusion makes the estimation insignificant, which is not surprising knowing the limited number of observations. When separate male and female datasets are used, which is represented in rows 2 and 3 in table 5, results are comparable to the ones obtained using the whole dataset. Using male work force only is more precise than estimations done with female workers. OP (2008) reports estimates for $\frac{1}{\sigma_{IMMI}}$ going from 0.024 to 0.096 with mostly around 0.05. Card (2009) finds that σ_{IMMI} is different for different educational groups. It is smallest for the most educated workers, which are dominant in Canada, and in his paper Card estimates it to be 17. As mentioned before Borjas, Grogger and Hanson on estimation with larger set of dummies find σ_{IMMI} to be very high but less precise which leads them to the conclusion that immigrants and natives are perfect substitutes. My estimation of σ_{IMMI} for Canada is a bit lower than the ones reported in the papers using US data. One of the reasons for this could be the different educational composition of immigrants. As Card (2009) notes, as the natives become more educated they gain more unobservable skills and become less interchangeable with immigrants of the same educational levels.

Table 2 - Estimates of 1/ σ_{IMMI} for Canadian data

Table 2. Estimates of 1/ σ_{IMMI} for Canadian data. Standard deviations are in parenthesis					
Sample	No fix effects	Basic	Add time effects	Add time by experience effects	Add time by education effect
	(1)	(2)	(3)	(4)	(5)
Whole population	***0.044****** ***(0.013)***	***0.068****** ***(0.018)***	***0.070****** ***(0.019)***	***0.039*** ***(0.027)***	***0.015*** ***(0.034)***
Only males	***0.037****** ***(0.104)***	***0.070****** ***(0.211)***	***0.074****** ***(0.023)***	***0.008*** ***(0.027)***	***0.023*** ***(0.041)***
Only females	***0.048***** ***(0.018)***	***0.065***** ***(0.032)***	***0.0670***** ***(0.033)***	***0.067**** ***(0.416)***	***0.010*** ***(0.034)***

3.3 Estimation of σ_{EXP}

From equation 13 estimation for the relative productivity of immigrants and natives can be obtained using the fact that productivities in a particular skill cell are standardized to add up to one:

$$\hat{\theta}_{Fkj} = \frac{\exp(\widehat{I_{kj}})}{1+\exp(\widehat{I_{kj}})};\ \hat{\theta}_{Dkj} = \frac{1}{1+\exp(\widehat{I_{kj}})} \qquad (14)$$

Using the estimated $\hat{\theta}_{Fkj}$ and $\hat{\theta}_{Dkj}$ from 13 and $\hat{\sigma}_{IMM}$ it is possible to calculate the aggregate labor supply in education group *k*, experience group *j* in time *t* using equation 9 as

$N_{kjt} = \left[\hat{\theta}_{Dkj} D_{kjt}^{\frac{\hat{\sigma}_{imm}-1}{\hat{\sigma}_{imm}}} + \hat{\theta}_{Fkj} F_{kjt}^{\frac{\hat{\sigma}_{imm}-1}{\hat{\sigma}_{imm}}}\right]^{\frac{\hat{\sigma}_{imm}}{\hat{\sigma}_{imm}-1}}$. By aggregating the marginal pricing conditions given by equations 10 and 11 it is possible to show the relationship between aggregate labor supply in the educational group *k*, experience group *j* and time *t* with the wage in the same group is :

$$\ln(\overline{W}_{kjt}) = \ln\left(\alpha A_t^{\frac{1}{\alpha}} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\sigma_{HL}} \ln(N_t) + \ ln\theta_{bt} - \left(\frac{1}{\sigma_{HL}} - \frac{1}{\sigma_{bb}}\right) \ln(N_{bt}) + \ ln\theta_{kt} -$$

$$\left(\frac{1}{\sigma_{bb}} - \frac{1}{\sigma_{EXP}}\right) \ln(N_{kt}) + \ ln\theta_{kj} - \left(\frac{1}{\sigma_{EXP}}\right) \ln(N_{kjt}) \qquad (15)$$

where $\overline{W}_{kjt}$ represents the average wage paid to workers in the educational group *k*, experience group *j* and time *t*; $\overline{W}_{kjt} = w_{Fkjt}(F_{kjt}/N_{kjt}) + w_{Dkjt}(D_{kjt}/N_{kjt})$. Equation 15 can be empirically estimated as:

$$\ln(\overline{W}_{kjt}) = I_t + I_{kt} + I_{kj} - \frac{1}{\sigma_{EXP}} \ln(N_{kjt}) \qquad (16)$$

In equation 15 term I_t, time fixed effects, controls for $\ln\left(\alpha A_t^{\frac{1}{\alpha}} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\sigma_{HL}} \ln(N_t)$, the year by education dummies I_{kt} controls for variation in $ln\theta_{bt} - \left(\frac{1}{\sigma_{HL}} - \frac{1}{\sigma_{bb}}\right) \ln(N_{bt}) + \ ln\theta_{kt} - \left(\frac{1}{\sigma_{bb}} - \frac{1}{\sigma_{EXP}}\right) \ln(N_{kt})$, and I_{kj},education by experience fixed effects capture time constant θ_{kj} productivity. Table 3 shows the result of the estimation of equation 16, where in the first two columns the different values obtained for $\hat{\sigma}_{IMM}$ are used. Those values, $\hat{\sigma}_{IMM}$= 22.5 and $\hat{\sigma}_{IMM}$= 14.5, are results for estimation of the equation 13. In the third column of table 6 the assumption of perfect substitution between immigrants and natives is used in the estimation. Columns four and five use the same estimates for $\hat{\sigma}_{IMM}$ as columns 1 and 2, but here time by experience effects are added. Results shown in Table 6 are significant at the 1% level and give value for $1/\hat{\sigma}_{EXP}$=

10. When times by experience dummies are added the results become insignificant. Using separate male and female dataset leads to results that do not differ much from the ones gained with the whole sample. Male sample here also gives a more precise estimates compared with the female only dataset. My results obtained on Canadian data for elasticity of substitution between different experience groups are in line with the ones reported in the literature. OP (2008) report values for $1/\hat{\sigma}_{EXP}$ in a range from 0.07 to 0.16. Welch (1979) obtaines estimates for $1/\hat{\sigma}_{EXP}$ between 0.080 and 0.218. Card and Lemieux (2001) report values for $1/\hat{\sigma}_{EXP}$ going from 0.107 to 0.237 using variation in supply due to baby boomers.

Table 3 - Estimates of σ_{EXP} for Canadian data

Table 3 - Estimates of σ_{EXP} for Canadian data. Standard deviations are in parenthesis					
Sample	Basic (use 1/ σ_{IMMI}= 0.044)	Basic (use 1/ σ_{IMMI}= 0.0688)	Basic (assume σ_{IMMI}=∞)	Add time by experience effects to 2	Add time by experience effects to 3
	(1)	(2)	(3)	(4)	(5)
Whole population	***0.0982****** ***(0.027)***	***0.101****** ***(0.028)***	***0.107****** ***(0.0392)***	***0.0412*** ***(0.062)***	***0.039*** ***(0.061)***
Only males	***0.098****** ***(0.030)***	***0.100****** ***(0.029)***	***0.107****** ***(0.032)***	***0.023*** ***(0.052)***	***0.022*** ***(0.053)***
Only females	***0.113***** ***(0.049)***	***0.117***** ***(0.053)***	***0.118**** ***(0.057)***	***0.084*** ***(0.061)***	***0.075*** ***(0.073)***

3.4 Long run effects on wages

After estimating the immigration and experience elasticity of substitution, the next layer of CES function is educational aggregation. However because of the small dataset, containing only 16 observations[5], this is not possible. Because of this in further analysis I will use estimates reported in the literature. OP (2008) using 1990-2006 yearly US data, find that the elasticity of substitution between workers with at least some college education and other workers is 2. In the same paper they report that elasticity within border educational groups is much higher, between high school graduates and dropouts is 20, and the one between college dropouts and college graduates is 10. Card (2009) finds that the elasticity between college dropouts and college graduates as well as between high school graduates and dropouts is so big that it can be assumed to be infinity. He reports that elasticity of substitution between workers with at least some college education and those without any is 1.5. His regressions are based on a variation in the educational attainment of workers in different MSA. Borjas ,Grogger and Hanson (2008) use the aggregate US data, but they put a restriction in their regression: $\sigma_{LL} = \sigma_{HL} = \sigma_{HH}$. Using this approach they calculate the elasticity of substitution between different educational groups to be 2.4.

Using estimates of those authors it is possible to close the model and to calculate the effect of immigrant supply shock on natives and immigrants using the following equations:

$$\left(\frac{\Delta w_{Dbkjt}}{w_{Dbkjt}}\right)^{Total} =$$

$$\frac{1}{\sigma_{HL}} \sum_{c \in B} \sum_{q \in E} \sum_{i=1}^{8} \left(s_{Fcqit} \frac{\Delta F_{cqit}}{F_{cqit}}\right) + \left(\frac{1}{\sigma_{bb}} - \frac{1}{\sigma_{HL}}\right) \left(\frac{1}{s_{bt}}\right) \sum_{q \in E} \sum_{i=1}^{8} \left(s_{Fbqit} \frac{\Delta F_{bqit}}{F_{bqit}}\right) + \left(\frac{1}{\sigma_{EXP}} -\right.$$

1σbb1sbkti=18sFbkitΔFbkitFbkit+1σIMM−1σEXP1sbkjtsFbkjtΔFbkjtFbkjt+1−α(Δκt κt)immigration

(17)

[5] This includes four time points multipiled by four different educational levels

$$\left(\frac{\Delta w_{Fbkjt}}{w_{Fbkjt}}\right)^{Total} =$$

$$\frac{1}{\sigma_{HL}} \sum_{c \in B} \sum_{q \in E} \sum_{i=1}^{8} \left(s_{Fcqit} \frac{\Delta F_{cqit}}{F_{cqit}}\right) + \left(\frac{1}{\sigma_{bb}} - \frac{1}{\sigma_{HL}}\right) \left(\frac{1}{s_{bt}}\right) \sum_{q \in E} \sum_{i=1}^{8} \left(s_{Fbqit} \frac{\Delta F_{bqit}}{F_{bqit}}\right) + \left(\frac{1}{\sigma_{EXP}} -\right.$$

1σbb1sbkti=18sFbkitΔFbkitFbkit+1σIMM−1σEXP1sbkjtsFbkjtΔFbkjtFbkjt+1−α(Δκt

κt)immigration−1σIMMΔFbkjtFbkjt (18)

where the overall share of wages paid in year *t* to the foreign workers in the educational group *b*, subgroup *k* and experience *j* is s_{Fbkjt}. In the same way the share of the total wage bill in year *t* accounted for by all workers in educational group *b*, subgroup *k* and with experience *j* is s_{bkjt}. Equations 17 and 18 give the wage change in an individual skill cell, and aggregating them the average wage change for a particular educational group can be estimated. In both equations there is a capital adjustment term $(1-\alpha)(\frac{\Delta\kappa_t}{\kappa_t})_{immigration}$. My estimation is computed for the long run, where it is assumed that the capital is perfectly adjusted to changes in labor supply, i.e. $(1-\alpha)(\frac{\Delta\kappa_t}{\kappa_t})_{immigration}$ = 0.

The results of such estimation for the natives and the immigrants are given in table 4. In all columns my estimation for Canadian σ_{IMM}= 10 is used. In column 1 Card's estimation of perfect substitution within two broad educational groups is assumed, as well as his result of 1.5 for σ_{HL}. Estimates of the overall wage effect done with those parameters in the 1971-2001 time period are positive for all native educational groups. They are in the range of +4.5% to +2.0% with the average being +3.2%. When the effect of immigrants on wages is calculated the overall effect is smaller and even negative for the most educated group of immigrants. In the second column OP (2008) parameters are used for the education elasticity of substitution together with my estimation of the Canadian immigration and experience elasticity. Results are a bit smaller than the ones reported in column one, with the average effect on natives being +2.4%. Effect on immigrants is again smaller than the one on the natives, with average being +0.8%. Effect of immigration on immigrant's wage is negative for immigrants with college degree, the same as the one obtained with Card specification.

Table 4 - Simulated wage effects of immigrants in Canada 1971-2001, long run effects

Table 4 - Simulated wage effects of immigrants in Canada 1971-2001, long run effects					
		Own+ Card (2009)	Own + OP (2008)	Own + Labor literature	Own + Borjas and Katz (2007)
		(1)	(2)	(3)	(4)
Parameters used	σ_{IMM}	14.5	14.5	∞	∞
	σ_{HL}	1.5	2	1.5	2.4
	σ_{HH}	∞	10	∞	2.4
	σ_{LL}	∞	20	∞	2.4
	σ_{EXPI}	10	10	10	10
Effect on native labor force	Less than HS	+4.5%	+3.4%	+4.5%	+2.7%
	HS graduates	+4.0	+3.0%	+3.9%	+2.4%
	Some CO	+2.3%	+1.8%	+1.9%	+1.8%
	CO graduates	+2.0%	+1.4%	+1.1%	+0.6%
	Average Canadian born	+3.2%	+2.4%	+2.9%	+1.7%
Effect on foreign labor force	Less than HS	+4.1	+3.0%	+4.5%	+2.7%
	HS graduates	+3.7	+2.5%	+3.9%	+2.4%
	Some CO	+0.6	+0.1%	+1.9%	+1.8%
	CO graduates	-1.9%	-2.4%	+1.1%	+0.6%
	Average foreign born	+1.1%	+0.8%	+2.9%	+1.7%

The next two columns use the assumption of perfect substitution between immigrants and natives. The difference between them is that the fourth one assumes identical elasticity of substitution between all educational groups of 2.4, while the third assumes perfect substitution between college graduates and college dropouts as well as between high school graduates and high school dropouts.

The results obtained using Borjas assumptions, reported in column four, give the least positive effect of immigration on natives in period 1971 - 2001 of all of the specifications. In this case with the perfect substitution between immigrants and natives and the same elasticity of substitution for all educational groups average effect of immigration is +1.7%.

OP (2008) report effects of immigration on the wages for the US data with complete capital adjustment that are smaller than the ones presented in table 4. They estimate the change in wage to be between -0.6% to +2.2% depending on the specification used and education level of the natives. Besides the previously mentioned difference in the immigrant educational structure in the two countries, the shorter period that they use might be the reason for the smaller values they obtain.

The results shown in table 4 are the long run effects of immigrants on the native wages in Canada. The long run here assumes complete capital adjustment. There is also a second possible extreme which assumes no capital adjustments at all or constant capital. In this case from equation 4 it can be shown that the change in natives wage, Δw_t^N, depends on the change in capital-labor ratio κ_t:

$$\frac{\Delta w_t^N}{w_t^N} = (1-\alpha)\left(\frac{\Delta \kappa_t}{\kappa_t}\right)_{immigration} \qquad (18)$$

The immigrant inflow from 1971-2001 increased supply of hours worked in Canada by 19.5%. This combined with$(1-\alpha) = 2/3$, which is the usual value used in the macro and growth literature, gives a negative effect on average wages of 6,5%. OP (2008) estimate sluggish capital response for the US using yearly values of US capital at constant prices. As expected the effect of immigrant shock is more negative than the one they obtain with complete capital adjustment. Because of this it is reasonable to suspect that the results shown in table 4 are upward biased and that analysis that would allow for sluggish capital adjustment would yield more negative effects of immigrants on native wages.

The comparison with long run results that OP (2008) obtain using US data[6], numbers reported in table 4 show a more positive effect of immigrants on native wages. This is in line with chapter 2 of this thesis where a simple within skill group analysis has shown that immigrants have a smaller negative effect on Canadian than on US labor force. Furthermore in my table there is a clear pattern when immigrant influence is inspected on different educational groups. In every specification native workers with less education are more positively affected by the rising immigration. That is not the case in OP 2008 paper, where in most cases high school dropouts have the least favorable wage outcome as a consequence of immigration. The fact that the most educated gain less from immigrant inflows can be explained by closer inspection of the work hours supply in Canada. Figure 3 in appendix B shows the share of immigrants in each education group in four census years. It can be seen that immigrant share has been falling in all educational groups except the lowest one, with highest contraction in the educational groups with at least some college education. For example the share of immigrants in 1971 among high school dropouts was 18,6% while in 2001 it was 23.3%. During the same time the share of immigrants in the college dropouts fell from 26.9% to 18.9%. Just by looking at this data the incomplete picture about immigrant supply dynamics can be gained. Figure 4 in appendix B shows the change in the working hours supply between two consecutive censuses for immigrants and native force. It can be seen that immigrants have mostly increased the supply of high skill workers, sometimes even at a greater pace then natives. In the same time their share in the most

[6] Those results are shown in the table 7 in OP papaer

educated worker's group has been falling because local work force in the same educational group had a bigger base to growth from. In the period from 1971-1981, even though immigrants decreased supply in the least educated skill group, their share in it rose because natives were deceasing their supply even faster. For example, overall supply of hours worked by the immigrant college graduates grew by 9.7 times in 1971-2001 period. During the same period the only educational group where immigrants decreased their working hour supply was among workers without high school diploma. Tables 6 and 7 in appendix B show the change in hours supplied by immigrants and native workers taking 1971 as base year. The fact that in all time periods the biggest growth of supply of immigrant work hours was in the college graduates educational group can help explain why the immigrants had the least positive effect on that exact educational group among natives. Because of the imperfect substitution between educational groups huge inflow of immigrants in one educational group could be beneficial to other groups, depending on various elasticity of substitution.

Another possible explanation for why the effect of immigrants has different implications on various educational groups is the contrasting dynamics of wage inequality in the two states. Wages in the US become more unequal, with the wage gap between the most and least educated workers constantly growing. On the other hand in Canada there was even a period when the wage gap was decreasing, from 1971-1981, as noted in Katz and Autor (1999). Furthermore wage inequality has been growing slower than in the US in the period 1981-2000. This fact has been noted also in the various literature; for example in Boudarbat, Lemieux and Riddell (2003), Dinardo and Lemieux (1997), Card, Lemieux and Riddell (2003). A possible reason for the phenomena that the authors present is the difference in labor market institutions where Canada still has a stable 30% share of the labor force in unions. Another explanation is the simultaneous growth in supply of high skill workers as demand for them grew. This slow growth in the wage gap can help explain the difference in the effect of immigrants on various educational groups between the US and Canada. Supply of immigrant hours also grew in the college graduate education group in the US, but that group also saw a huge rise in their relative wage, which was mostly unconnected with immigrant supply shock. Since the situation in Canada was different this can provide a possible explanation for the different patterns of wage response on immigrant shock among educational groups.

3.5 Discussion

The estimations done in this thesis treat immigration as a labor supply shock. In this way the possible positive productivity impact, which may include scale externalities, improved efficiency or choice of better technology is overlooked, as noted in OP (2008). In my results there is a difference in coefficients obtained for the US and the ones for Canada. Using the same skill-cell approach immigrants tend to have more negative effect on the US native labor force. This difference could be caused by different educational attainment of immigrants. For example Bohn and Sanders (2005) find that almost the whole negative effect of immigration in 1980-2000 period in the US comes from the lowest educated group, one that has the disproportionally high immigrant share.

When the results for Canadian data are compared there is a discrepancy between the "classical" skill-cell approach and the one that uses the nested CES production function. The higher negative results obtained using skill-cell approach could be accounted for by closer inspection of the equation 10. From there it could be seen that wage of the native workers is not only affected by the direct partial effect of immigrants in the same educational-experience group, what "classical" skill cell approach measures, but also by the capital adjustment term plus other cross-effects produced by immigrants in other skill groups. Using the assumption that there is change in the aggregate supply N_t, N_{bt} and N_{kt}, which is almost always true, direct and overall effect of immigrants differ. In this case using CES nested function approach gives more precise estimation of overall immigrant effect. My results have shown that one has to be careful in choosing which method to use in studying the effects of immigration, because results can differ significantly, as in my case with Canadian data.

Conclusion

In this thesis I have investigated the effect of immigration on native work force labor market outcomes. When skill cell approach is used there is a significant negative effect of immigrants on native labor force both in Canada and the US. The effect is more negative in the US, which could be attributed to the different education level of immigrants. In the US most of the immigrants are in the lowest educational group, one that has been most negatively affected by changes in the wage gap in the last couple of decades, so it could be the case that the more negative results in the US data are consequences of a spurious regression. In both countries when data on lower level of aggregation is used the effect of immigration becomes smaller and even insignificant in Canada. This can be seen as a consequence of spatial arbitrage – inter regional flow of capital and labor that equalizes economical conditions in them.

When the nested CRS production function approach is used on Canadian data the effect of immigrants in the long run becomes positive. An advantage of CRS is that it allows for imperfect substitution between immigrants and natives, as well as between different types of workers. Additional benefit of the CRS production function approach is that it gives a more precise estimation of the immigration effect. The reason for this is that it takes into account the effect on wages that is a consequence of supply change in all skill groups, not only a direct partial effect from the change in same skill cell.

My regression show that immigrants and naives are imperfect substitutes, as is reported in the literature for the US data. This finding combined with the imperfect substitution between different educational and experience groups of workers yields a positive effect of immigrants if complete capital adjustment is assumed. The positive effect is the strongest for the low educated group of workers and lowest for college graduates, the group that had the highest immigrant supply shock in the last 40 years.

Further research that would aim at giving more precise estimates of the effect of immigrants would include calculating the short run adjustment rates for Canada. In that case, the restrictive assumption of perfect capital adjustment can be relaxed, and more accurate estimations for immigration effect can be obtained. Since my estimation of the immigrant as well as the experience elasticity of substitution differs from the ones normally reported for the US data, it is therefore reasonable to assume that there exists a difference in the educational elasticity of substation between Canada and the US. Calculating the Canadian educational elasticity of substitution would require additional data points, but would certainly give more exact results for the overall effect of immigrants on natives.

Appendix A – Construction of data sets and variables form PUMS data

Purpose of this appendix is to provide detailed guide to construction of data sets and variables used in this thesis starting from the PUMS data downloaded from https://international.ipums.org/international/.

A.1 Construction of variables from the US Census data

Dataset is limited to males (SEX=1) aged between 18-65. (17<AGE<66). Persons residing in group quarters, e.g. prisons, mental institutions, etc., are not included in data (group quarters variable!=3). From sample are removed persons that have person weight 0, persons who do not participated in the civil labor force and persons who are still attending school. For 1970 data that includes individuals for whom value of higraded variable ends with number 2, and for all other censuses individuals enrolled in school have variable school equal to 2. After that variables for education and experience are constructed. Person if define as high school dropout if his educrec variable is smaller then 7, high school graduate if educrec is equal 7, if educrec is 8 that person is defined as a college dropout, and if educrec is bigger than 8 person is mapped into college graduates educational group. Next the potential experience is calculated as a difference between age at the time of the Census and estimated year of entry on labor market. For high school dropout it is 17 years, for high school graduate it is 19 years, for college graduate it is 21 and for college graduates. Workers who do not have between 1-40 years of potential experience are deleted from the sample.

Person is defined as an immigrant if he is born abroad and is either a noncitizen or a naturalized citizen, i.e. if his nativity variable is equal 5. Furthermore workers who had a wage zero, or worked zero weeks in the last year are dropped from the sample. Also workers who are self employed are not kept in the data set. Reason is that there is a lot of noise in their wage variable, as noted in OP (2008). In the 1970, 1980 and 1990 wage variable has top code, so in line with the usual practice in the labor literature maximum possible earned amount is multiplied with 1.5. After that wages are converted to 2009 dollars, using CPI deflator. In 1960 and 1970 number of weeks worked in the last year was not reported directly but in intervals. When transforming those intervals to point estimates mean of the interval is taken.

Weekly wages are constructed by dividing yearly earnings by the number of the weeks worked in a year. Average native wages for particular skill cell are calculated in two ways. First way, reported in the columns 1 and 3 in the table 1 uses only person weight variable reported in the census as a weight in calculation of the average. Second way, used in specifications in columns 2 and 4 in the table 1, gives more weight to workers who work more. Weights used in average calculation are products of multiplication between personal weights reported in the census, number of weeks worked in the last year and an average number of hours worked in a week.

A.2 Construction of variables from the Canadian Census data

Canadian census is not so rich in variables as the US one. Civilian labor force, aged between 18-65, that do not live in the group quarters is the core of the used data set. Education and potential experience variables are constructed in the same was as in the US data, with same restriction used to limit potential experience to 1-40 years. When wages are top coded maximum amount is multiplied by 1.5. Here one has to be careful because there are different top codes for male and female workers. After that wages are denominated in the 2009 Canadian dollars using CPI as a deflator. Observations where reported wage is zero, reported number of hours worked is zero, or those variables are not even reported are removed from the dataset. For 1971 Census number of hours worked on an average week is not reported, so mean of 39.5 hours is used for that Census year. When calculating average wage of the natives two different weighting systems are used as in the US data set, and the process of calculating them is the same. In the chapter three supply of hours by immigrants is calculated as a number of months worked multiplied by the average number of hours worked.

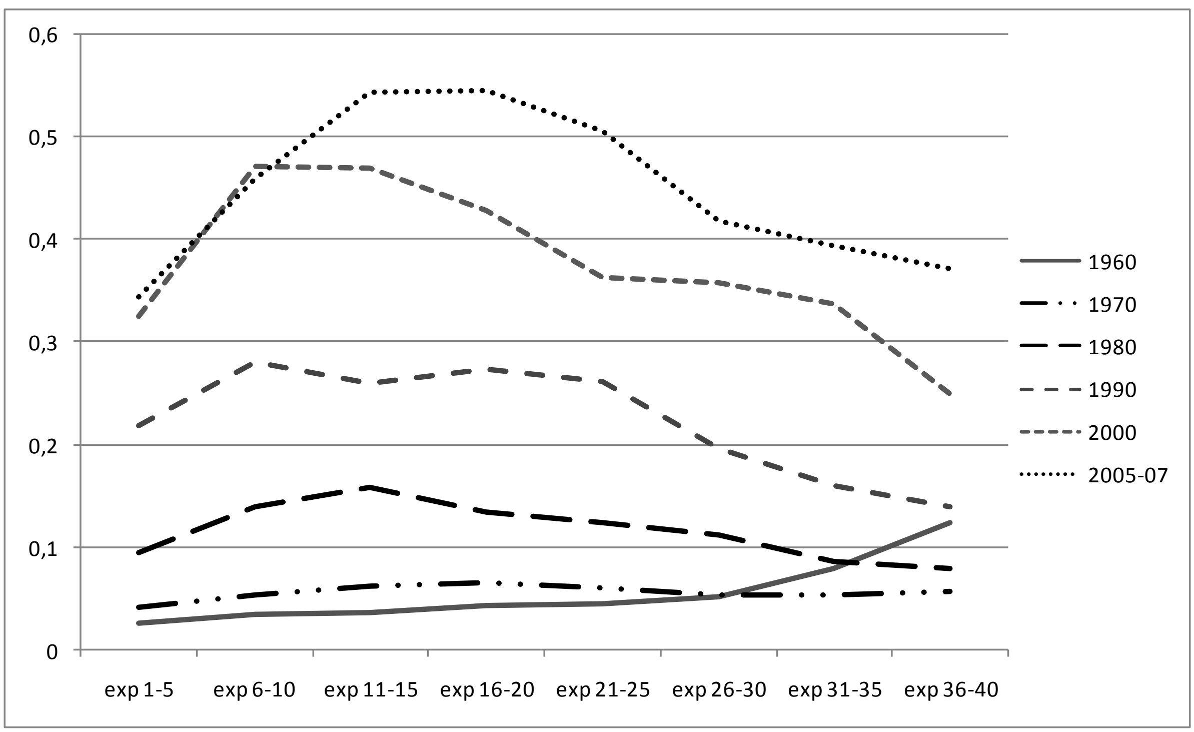
Appendix B – Additional tables and figures

Table 5 - Average number of weeks and hours worked by educational group

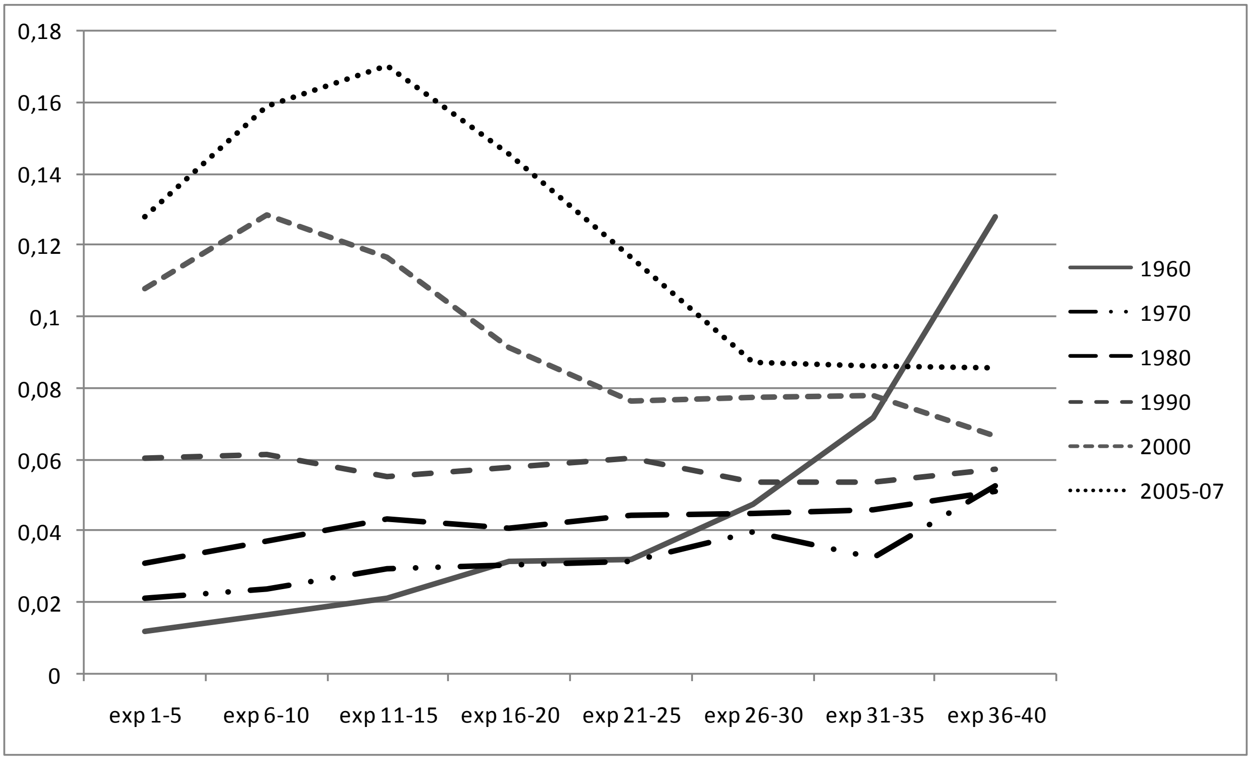
Average number of weeks and hours worked by educational group, with standard deviation in parenthesis		
Educational attainment	Mean of weeks worked in the last year	Mean of usual hours worked in a week
HS dropouts	***44.76 (12.42)***	***42.29 (11.15)***
HS graduates	***47.67 (9.77)***	***43.62 (10.52)***
College dropouts	***48.76 (8.49)***	***44.51 (10.51)***
College graduates	***49.26 (7.53)***	***45.45 (10.71)***

Figure 1 - Immigrant share in different years, by educational-experience cells, for US and Canada

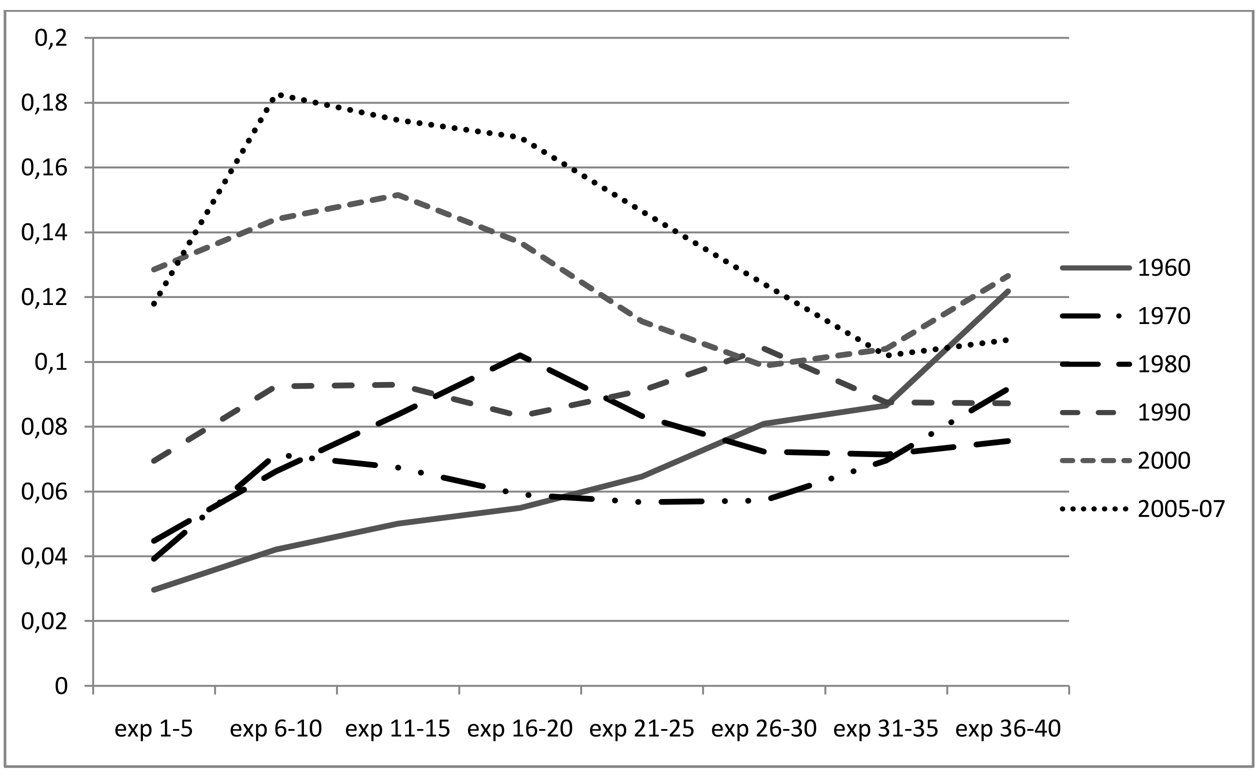
US – HS dropouts



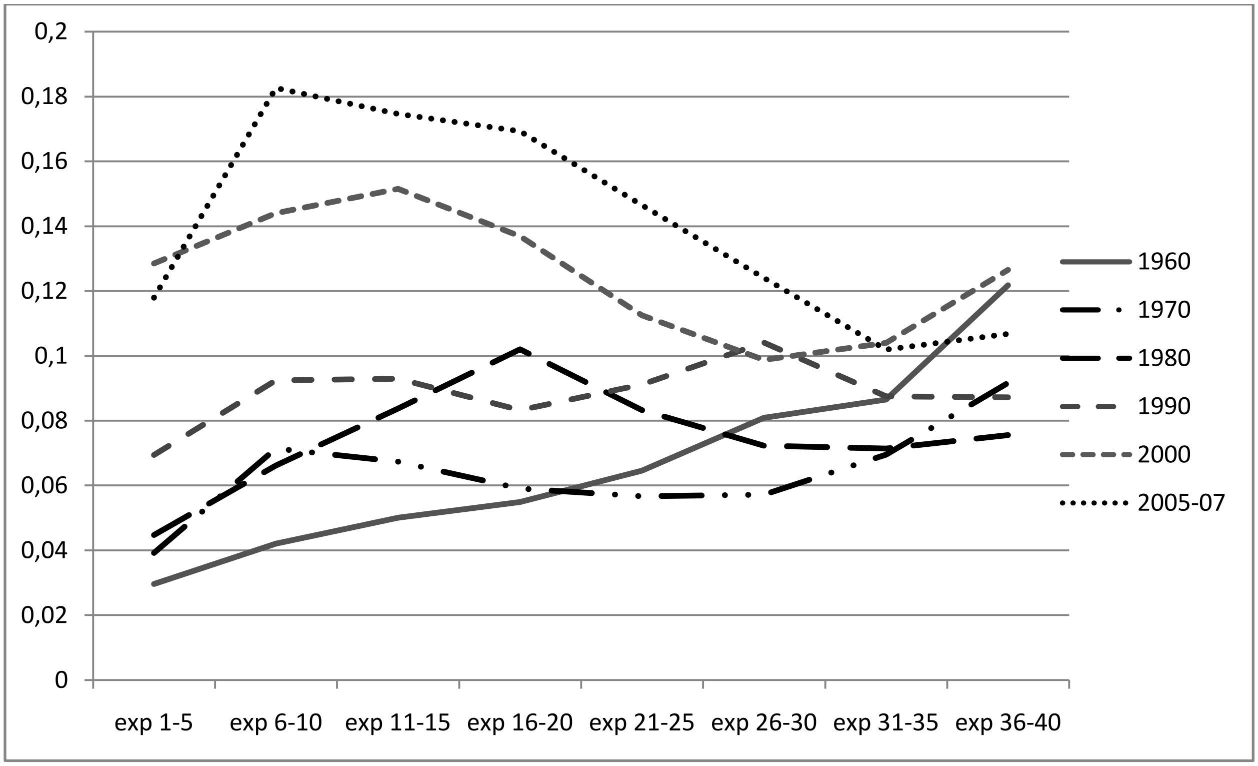
US – HS dropouts



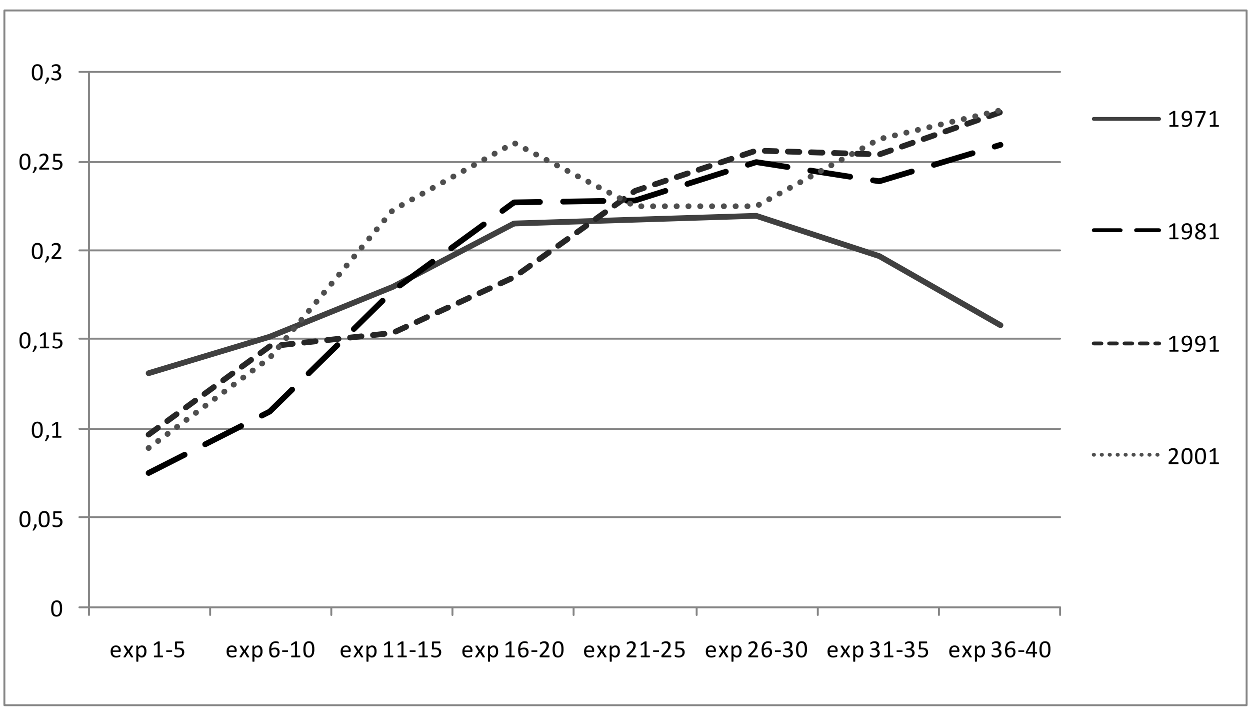
US – College dropouts



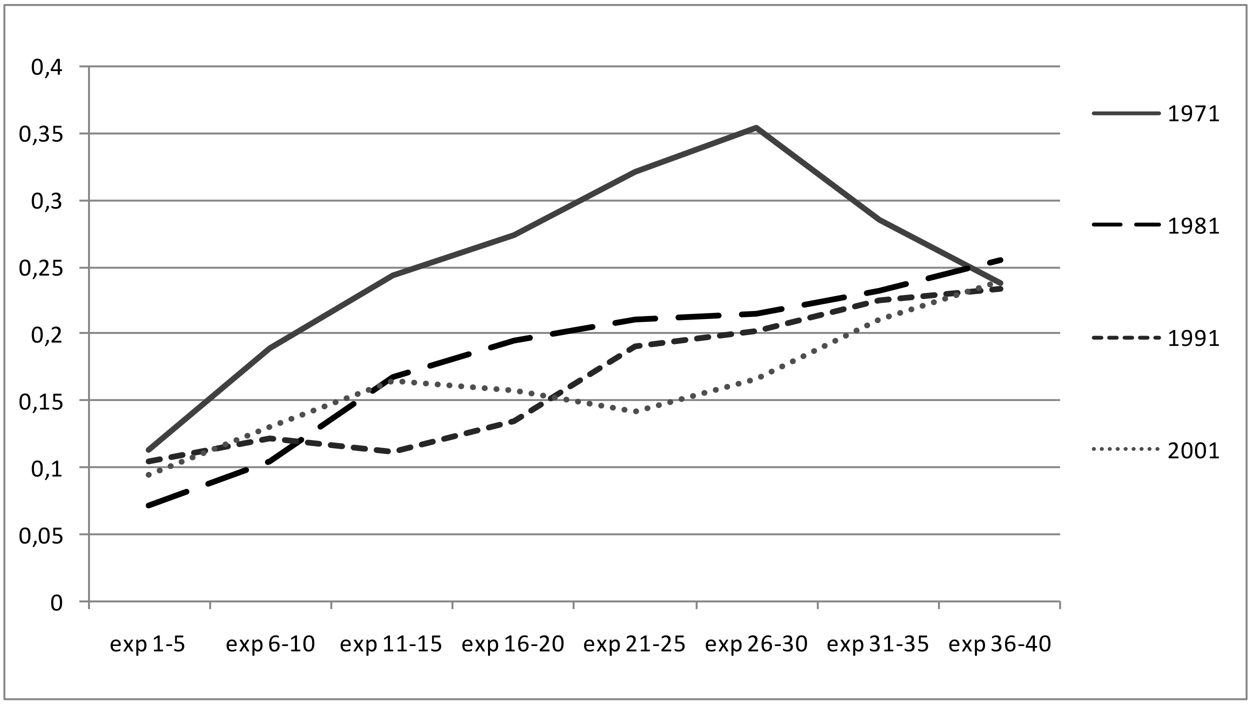
US – College graduates



Canada – HS dropouts



Canada – HS graduates



Canada – College dropouts

Canada – College graduates

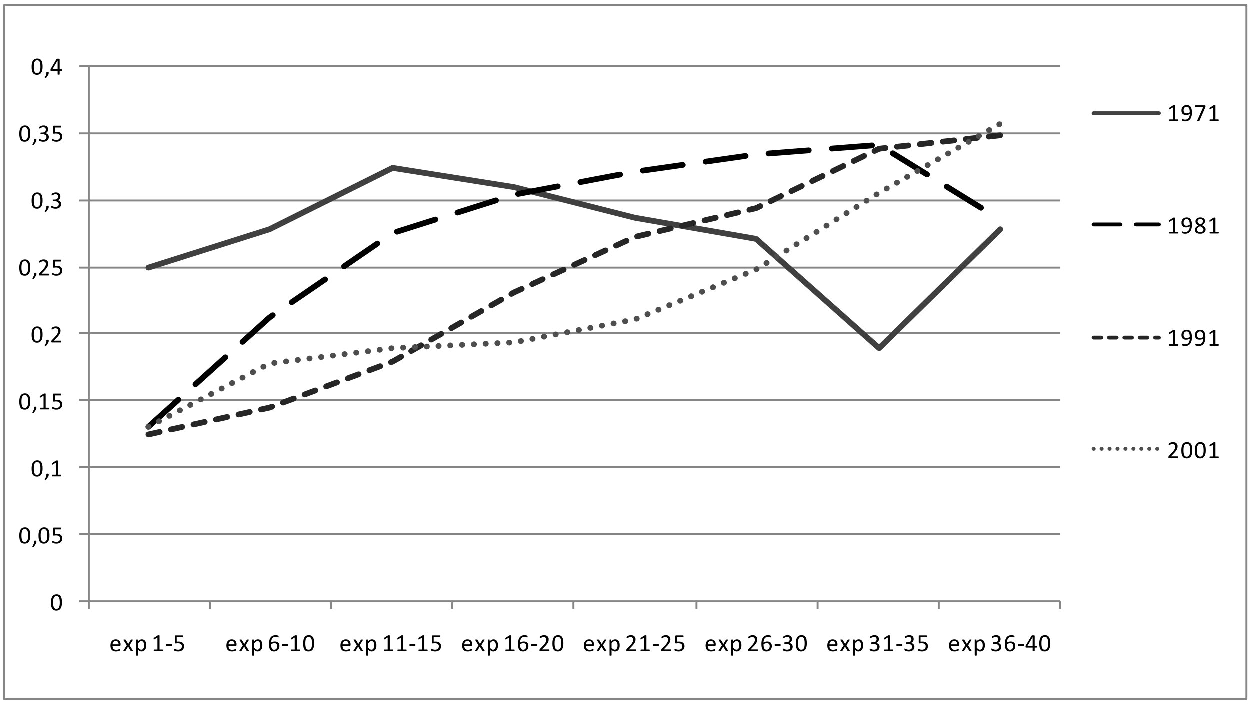


Figure 2 - Share of US immigrants in educational groups by years

Census year	educ HS dropouts	HS graduates	College dropouts	College graduates
1960	.05866	.032886	.051057	.055611
1970	.056962	.030648	.046435	.060861
1980	.113084	.040515	.051985	.072587
1990	.226517	.057849	.059428	.088414
2000	.382962	.094576	.076495	.125851
2007	.453028	.120544	.085859	.142846

Figure 3 - Share of Canadian immigrants in educational groups by years

Year	education HS dropouts	HS graduates	college dropouts	college graduates
1971	.186753	.218662	.269292	.27591
1981	.190425	.152518	.188968	.248888
1991	.207452	.153799	.195003	.206392
2001	.226776	.162197	.18972	.206026

Figure 4 - Change in supply of working hours between two consecutive Censuses

Change are given in 100 000 hours. First number represent change in immigrant supply while second is change in supply of hours worked by native labor force

Year and Education	Experience 1-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years	31-35 years	36-40 years
1971								
HS dropouts	-51.8405	-101.611	-90.9685	-76.42052	-113.843	-71.853	-11.336	97.25098
	175.207	-252.8644	-416.486	-429.2155	-491.9995	-492.112	-375.6965	-314.881
HS graduates	-93.6655	-105.302	-38.4575	-26.998	-72.3575	-96.99	-33.809	-6.2945
	-264.5955	30.06248	156.108	125.5	29.539	28.03148	-1.65896	-56.923
College dropouts	20.8945	21.566	47.4205	17.738	6.8865	-1.277	22.983	18.1545
	322.2405	310.235	215.895	136.0805	76.209	63.558	67.4395	44.7265
College graduates	169.102	385.573	460.3865	343.7995	262.661	248.433	203.184	91.208
	1420.063	1497.604	1202.3	763.0085	523.508	448.033	328.1895	217.941
1981								
HS dropouts	-46.80788	-15.40914	4.85412	.93236	74.59446	87.99188	46.93228	18.25884
	-703.3443	-423.9673	223.3776	321.1283	204.3413	231.005	57.21144	-43.6296
HS graduates	-8.45808	27.7797	-13.16864	36.3595	119.2079	84.84382	43.99619	21.11023
	-516.1805	62.77728	466.3199	614.9112	592.8596	383.4461	173.539	104.9113
College dropouts	8.23959	14.97191	11.94889	61.26304	65.84838	27.92726	3.499115	-.5072025
	-63.9228	69.32896	245.4909	242.2895	171.6632	73.6096	6.70385	-11.90593
College graduates	12.25908	-94.67468	-88.98992	133.7038	182.7482	44.89134	22.9051	20.5422
	276.563	537.1562	686.4328	879.2712	647.425	243.9249	48.05656	-27.96974
1991								
HS dropouts	-8.29458	-39.15518	8.7305	57.05308	25.2268	-24.2228	70.71536	65.337
	-17.47192	-186.8105	-407.5552	-317.6331	178.5937	191.9538	133.9685	117.3582
HS graduates	-19.59652	-46.80343	4.94546	41.20748	-1.07564	61.03252	108.0522	64.46795
	-95.43512	-426.2907	-446.5077	-8.47632	389.012	498.3015	433.5498	156.3474
College dropouts	-15.40429	-1.20317	8.26886	1.66311	9.58545	49.67744	45.51685	13.36205
	-2.52032	-40.24904	-29.72344	95.46064	201.7485	214.5267	123.2478	32.75213
College graduates	26.61756	147.1476	198.053	143.4054	173.4396	319.3197	219.1281	85.01884
	152.1488	261.3261	831.5339	1108.227	1219.077	1146.584	552.0806	113.9073

Table 6 -Hours supplied by immigrants in Census years by educational level1971=100

	Education			
Year	HS dropouts	HS graduates	College dropouts	College graduates
1971	100	100	100	100
1981	83.60384	66.26794	143.4222	605.2429
1991	90.28308	88.45378	197.7657	659.7241
2001	96.34031	103.5611	229.1205	966.0263

Table 7 -Hours supplied by natives in Census years by educational level1971=100

	Education			
Year	HS dropouts	HS graduates	College dropouts	College graduates
1971	100	100	100	100
1981	76.74127	100.9188	228.4665	659.4976
1991	75.54274	138.4715	304.6556	947.1605
2001	72.78902	148.4552	366.5043	1417.867

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