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MODELING EMPLOYMENT TRANSITIONS IN THE GTAP-RD MODEL: AN ILLUSTRATION OF CUSMA

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1. INTRODUCTION



1. INTRODUCTION

1. Public debates on the benefits of free trade and globalization at home and abroad.
2. The key element of this debate is that trade doesn't benefit all. Winners compensate losers?
3. The new generation of the trade agreement needs to ensure that all segments of society can benefit and take advantage of the opportunities that flow from future trade agreements
4. Sustaining support for trade in a trade dependent country like Canada is critical.



THE TRADITIONAL CGE MODELLING APPROACH

Based on a concept of economic efficiency. CGE model to project

- Changes in terms of trade (efficiency)
- Changes in trade patterns (allocative efficiency)
- Changes in GDP, consumption, income

Main shortcomings:

- No information about economic well-being of different economic agents.
- No friction in the labour market. Assume full employment and equilibrium labour market.
- Capture only part of the working age population; unemployment and people not in the labour force are excluded.
- Impacts on genders and age groups are missing.



THE NEW MODELLING APPROACH WITH LABOUR MARKET MODULE

- Efficiency gains remain a cornerstone of the overall economic impact assessment.
- It also focus on the people. Economic well-being of workers, occupations, gender and age.
- Complete working age population with gender, occupation, income, including unemployment and people not in the labour force.
- Inter-temporal labour market adjustment with age with an overlapping generations structure.



MAPPING BETWEEN ISOC FROM ILO TO GTAP'S 5 OCCUPATIONS

ISOC	GTAP 5OCC
1. Managers	off_mgr_pros
2. Professionals	tech_aspros
3. Technicians and associate professionals	tech_aspros
4. Clerical support workers	clerks
5. Service and sales workers	service_shop
6. Skilled agricultural, forestry and fishery work	ag_othlowsk
7. Craft and related trades workers	ag_othlowsk
8. Plant and machine operators, and assemblers	ag_othlowsk
9. Elementary occupations	ag_othlowsk

Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



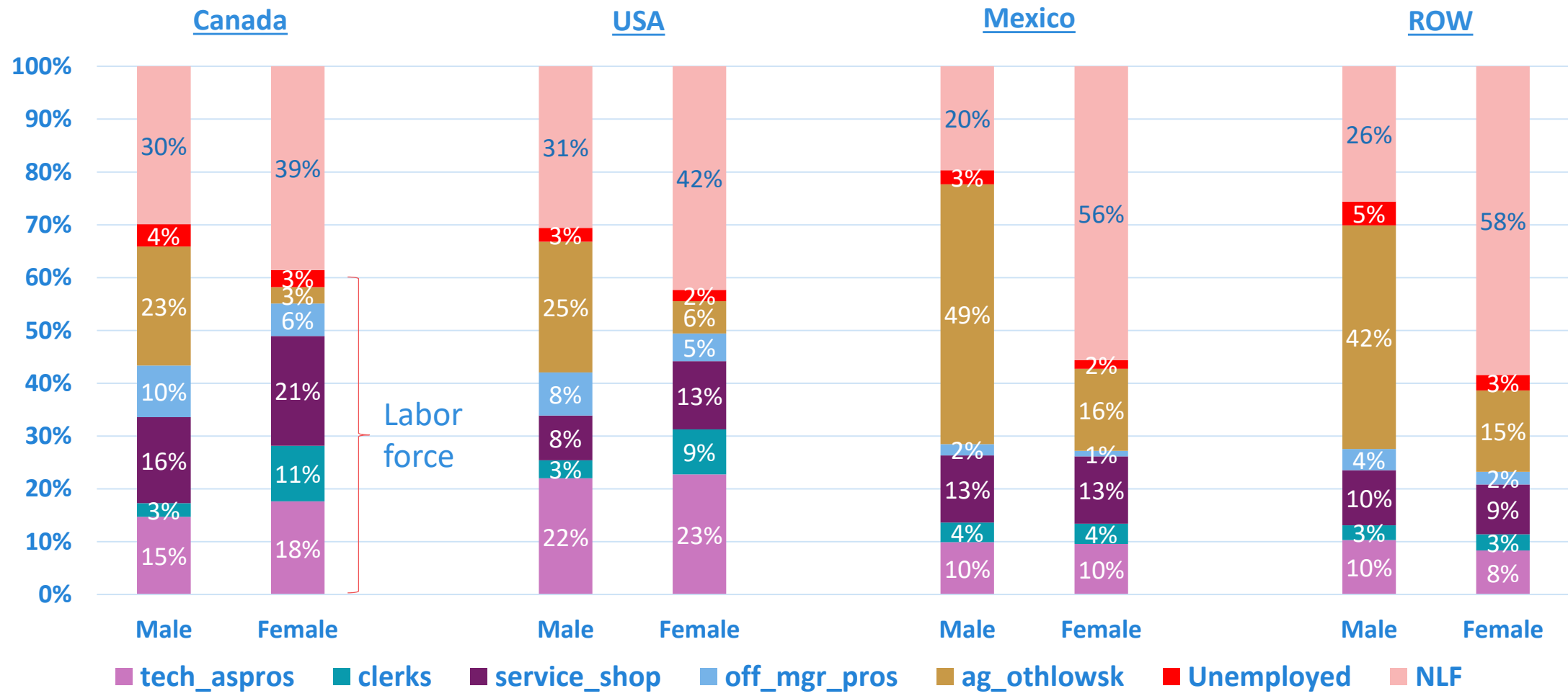
BASE DATA IN 2019: WORKING AGE POPULATION (WAP), AGE 15+

	Canada		USA		Mexico		ROW	
('000 people)	Male	Female	Male	Female	Male	Female	Male	Female
tech_aspros	2,235	2,746	29,396	31,405	4,451	4,607	276,338	224,650
clerks	390	1,642	4,592	11,748	1,656	1,842	73,954	81,747
service_shop	2,463	3,239	11,299	17,834	5,704	6,110	280,079	252,952
off_mgr_pros	1,485	955	10,925	7,266	967	504	106,640	64,007
ag_othlowsk	3,413	488	33,036	8,425	22,059	7,479	1,132,861	413,441
Unemployment (UEMP)	641	503	3,526	2,919	1,199	777	121,098	78,354
Not in the Labor Force (NLF)	4,534	6,006	40,872	58,439	8,820	26,717	684,859	1,568,600
Total	15,161	15,579	133,646	138,036	44,856	48,035	2,675,827	2,683,751
Unemployment Rate	6.0%	5.3%	3.8%	3.7%	3.3%	3.6%	6.1%	7.0%
Participation Rate	70%	61%	69%	58%	80%	44%	74%	42%

Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



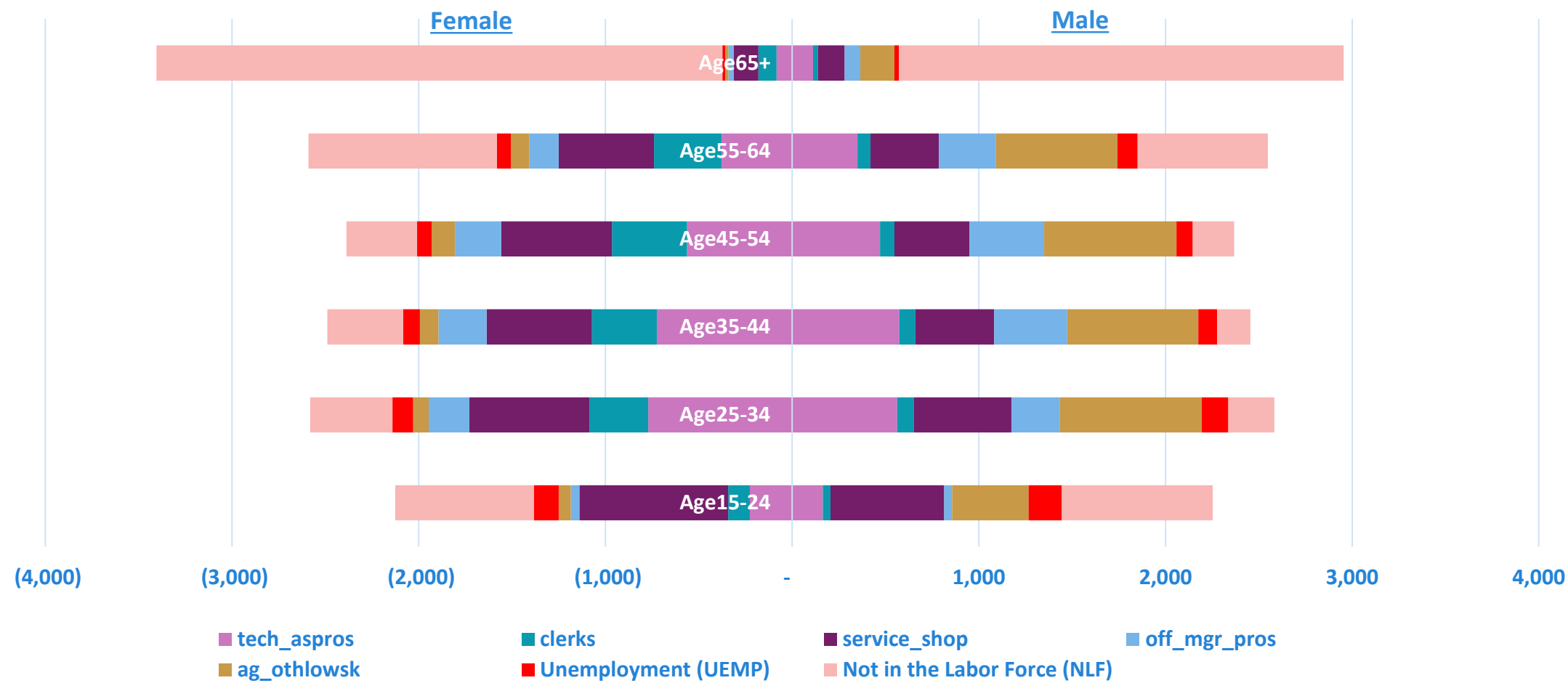
SHARE OF ACTIVITIES OF THE WORKING AGE POPULATION (WAP) IN EACH REGIONS



Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



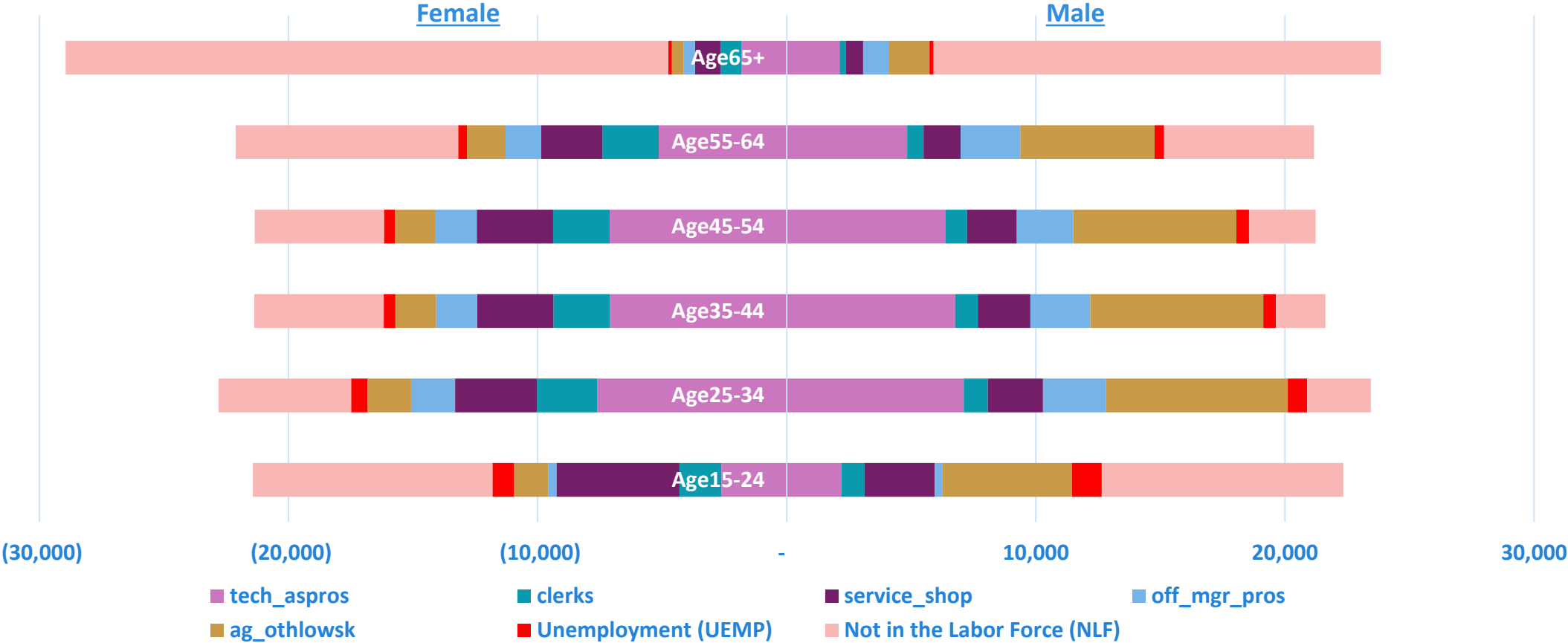
BASE DATA IN 2019: ACTIVITIES BY AGE GROUP IN CANADA (UNIT: '000 PEOPLE)



Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



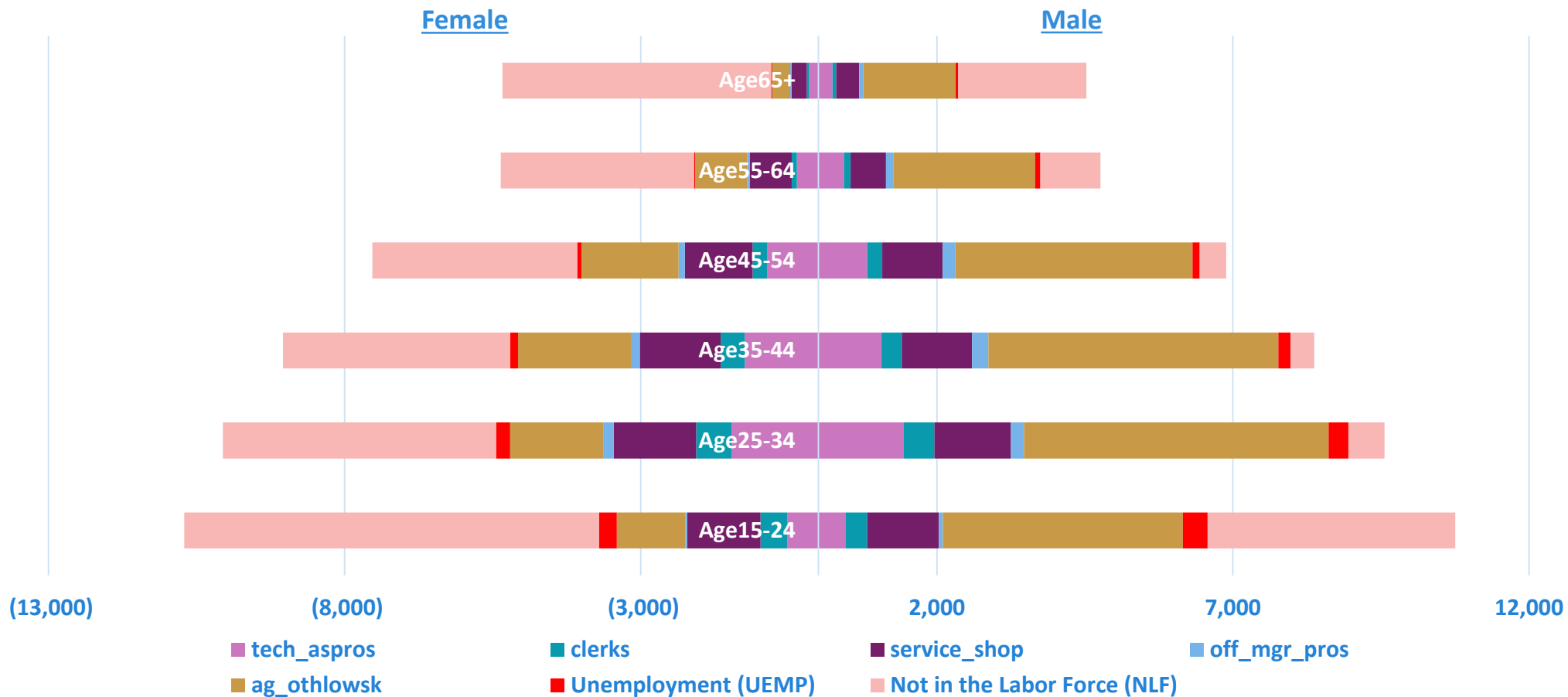
BASE DATA IN 2019: ACTIVITIES BY AGE GROUP IN USA (UNIT: '000 PEOPLE)



Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



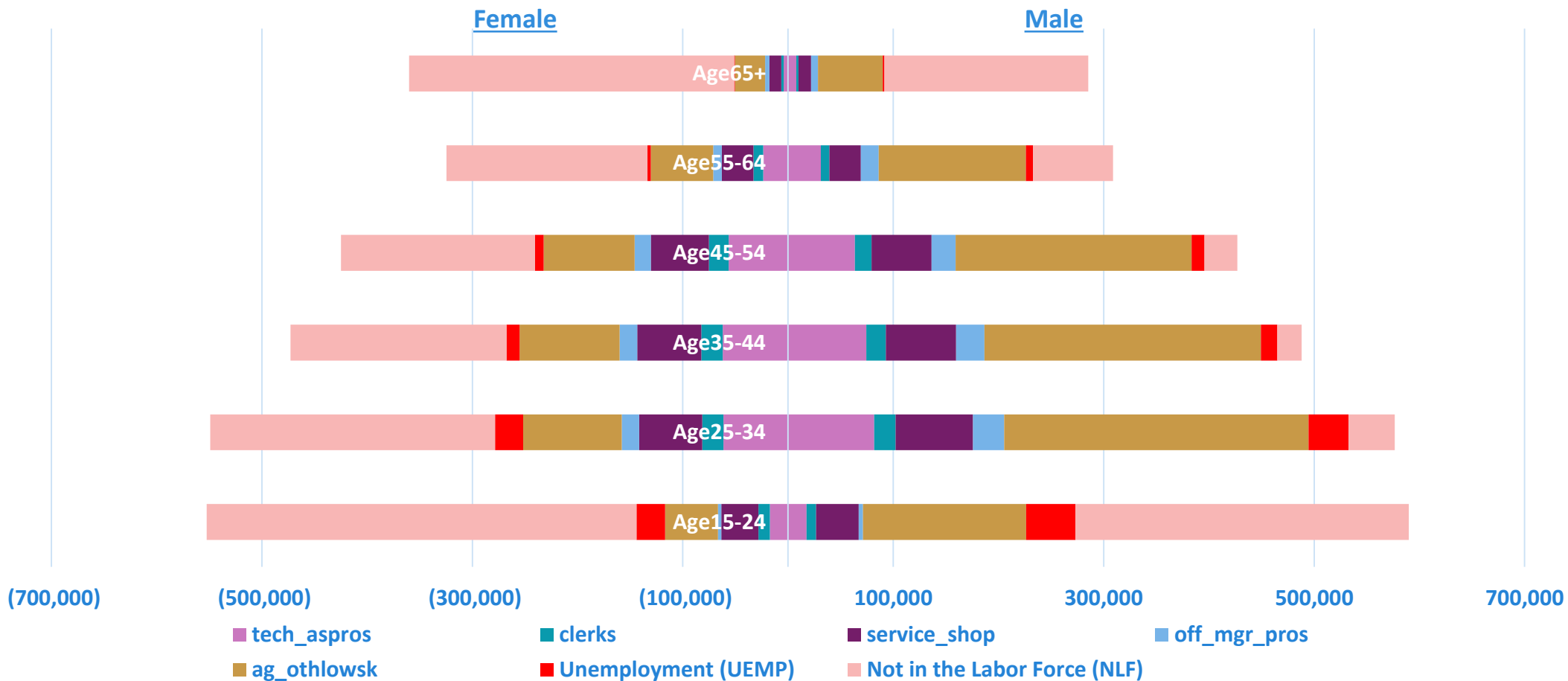
BASE DATA IN 2019: ACTIVITIES BY AGE GROUP IN MEXICO (UNIT: '000 PEOPLE)



Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



BASE DATA IN 2019: ACTIVITIES BY AGE GROUP IN THE REST OF WORLD (UNIT: '000 PEOPLE)



Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



DISTRIBUTION OF LABOR ACROSS SECTORS IN EACH REGION

	Canada		USA		Mexico		ROW		Global Average
	Male	Female	Male	Female	Male	Female	Male	Female	
Agriculture	3%	2%	2%	1%	16%	3%	25%	24%	18%
Mining	6%	2%	1%	0%	1%	0%	1%	0%	1%
Manufacturing	13%	5%	14%	7%	18%	19%	14%	14%	13%
Electricity Gas and Distribution	2%	1%	2%	1%	0%	0%	1%	0%	1%
Water	0%	0%	1%	0%	1%	0%	1%	0%	0%
Construction	12%	2%	14%	2%	15%	1%	14%	2%	10%
Trade	13%	13%	11%	9%	16%	23%	13%	15%	13%
Accommodation, Food and service activities	3%	4%	4%	5%	5%	10%	2%	4%	3%
Transportation and storage	6%	2%	10%	4%	8%	1%	9%	1%	7%
Communication	2%	2%	5%	3%	1%	1%	2%	1%	2%
Finance and Insurance	6%	8%	7%	8%	1%	2%	2%	2%	3%
Real estate activities	1%	1%	2%	2%	0%	1%	1%	1%	1%
Business services nec	6%	6%	12%	10%	6%	6%	4%	4%	6%
Recreational and other services	9%	8%	4%	6%	5%	15%	4%	10%	6%
Public Administration and defense	8%	18%	3%	4%	4%	5%	4%	3%	4%
Education	4%	12%	5%	14%	3%	9%	3%	9%	6%
Human health and social work activities	7%	16%	5%	24%	2%	5%	2%	8%	6%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%



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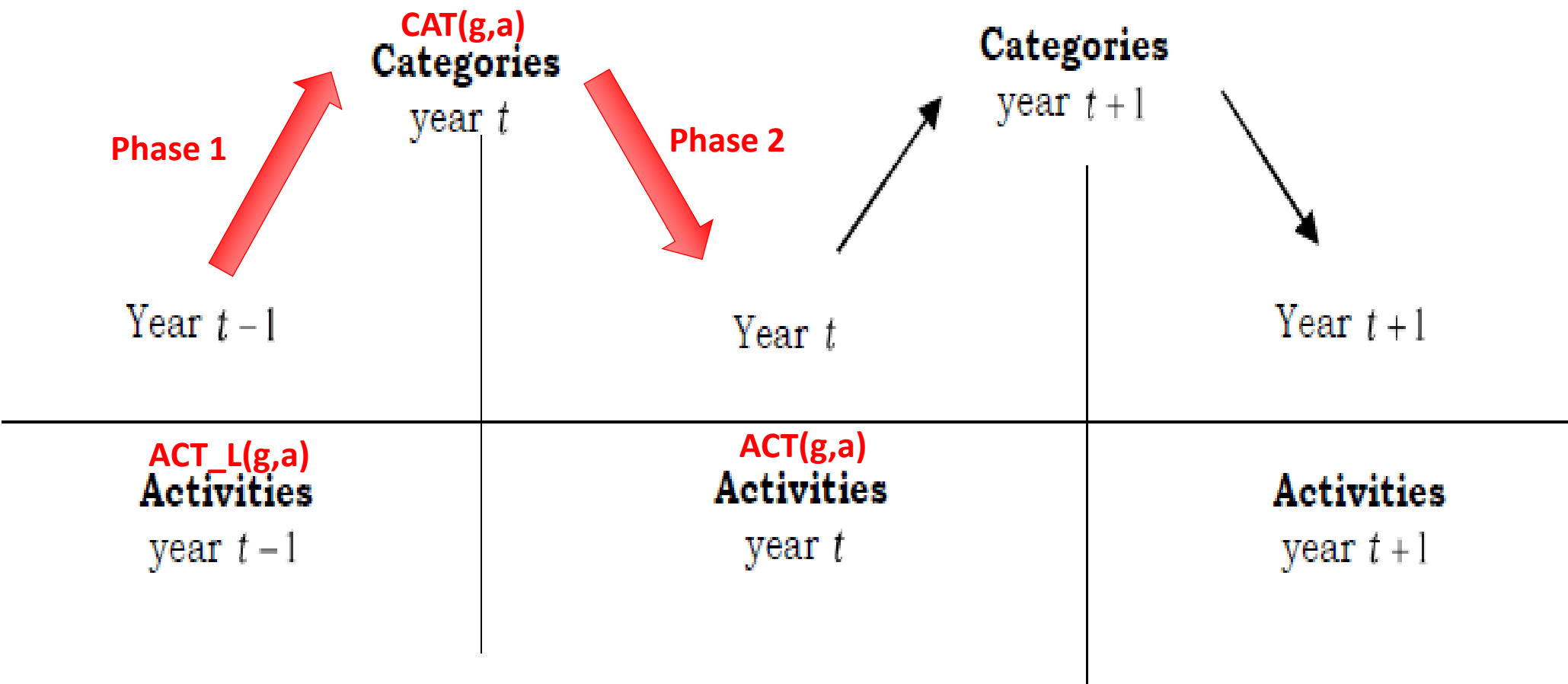


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2. DERIVATION OF LABOUR SUPPLY



FIGURE 2.1: LABOUR MARKET MODELING FRAMEWORK





PHASE 1: FROM ACTIVITIES AT T-1 TO CATEGORIES AT T (UPWARD ARROWS IN FIG 2.1)

Categories represent labour supplied at the beginning of a year, t . They are the people who performed activities in the previous year $t-1$:

$$CAT(o,g,a) = \sum_{aa \in AGE} ACT_L(o,g,aa) * T(o,aa,a) \quad (E2.1)$$

$$o \in EUF^2; g \in GEN; a \in AGE.$$

$CAT(N,g,a)$: New entrants for gender g , and age a . They are determined exogenously.

Where

$CAT(o,g,a)$ is the number of people in category o , gender g and age a at the beginning of year t ;

$ACT_L(o,g,aa)$ is the number of people who performed activity in the previous year $t-1$, given their gender g , and age aa ;

$T(o,aa,a)$ is the proportion of people who were in age aa in $t-1$, are allocated to age a at the start of year t .



TRANSITION MATRIX (OVERLAPPING GENERATIONS)

	None	6	2 clerks	2 female	All AGE	All AGE	1 Canada
TRANSITION	1 age15	2 age25	3 age35	4 age45	5 age55	6 age65	Total
1 age15	0.899600	0.100000	0	0	0	0	0.999600
2 age25	0	0.899350	0.100000	0	0	0	0.999350
3 age35	0	0	0.899000	0.100000	0	0	0.999000
4 age45	0	0	0	0.897600	0.100000	0	0.997600
5 age55	0	0	0	0	0.893850	0.100000	0.993850
6 age65	0	0	0	0	0	0.947090	0.947090
Total	0.899600	0.999350	0.999000	0.997600	0.993850	1.047090	5.936490

Source: Statistics Canada, Annual Demographic Estimates

Example: 89.9% female clerks stay in the age group 35-44, 10% move to the age group 45-54 next year. The mortality rate for this age group is 0.1%, the mortality rate for age group 65+ is much higher (100%-94.7% = 5.3%).



PHASE 2: LABOUR SUPPLY FROM CATEGORIES TO ACTIVITIES (OPTIMIZATION FROM THE SUPPLY SIDE)

Workers chooses their activities by maximizing utility

$$\begin{aligned} \text{Max} \quad & U(c) = \left[\sum_{a \in \text{EUNF}} (B(c;a) * ATW(a) * L(c;a))^{\frac{n}{1+n}} \right]^{\frac{1+n}{n}} \\ \text{subject to} \quad & \sum_{a \in \text{EUNF}} L(c;a) = CAT(c) \end{aligned}$$

Where

EUNF is a set of all activities for WAP excluding those below age 15;

$U(c)$ is the utility function for category c ;

$B(c;a)$ captures preference that may motivate people from category c to offer their labour to activity a ;

$ATW(a)$ is the real after-tax wage rate in activity a ;

$L(c;a)$ is labour supply from category c to activity a ; and

$CAT(c)$ is the number of people in category c at the start of year t .



DERIVED LABOUR SUPPLY (DOWNWARD ARROWS IN FIG 2.1)

The solution of the previous optimization:

$$L_t(c; a) = CAT_t(c) * \left[\frac{(B_t(c; a) * ATW_t(a))^\eta}{\sum_q (B_t(c; q) * ATW_t(q))^\eta} \right] \quad (E2.5)$$

The explicit form of labour supply $L(c; a)$ in (E2.5) can be expressed as $L(o, g, a)$, which represents the number of persons of gender g , and age a , moving to activity o . L is a function of total number in category (CAT), wage (ATW), and preference (B).



TRANSFORMATION ELASTICITY ACROSS ACTIVITIES FOR MALE IN AGE GROUP 35-44 IN CANADA

		None	2	All EUF	All EUF	male	age35	Canada
R001	tech_aspros	clerks	service_shop	off_mgr_pros	ag_othlowsk	UEMP	NLF	Total
tech_aspros	0	-1.22	-1.22	-0.61	-1.22	-1.83	-1.22	-7.30
clerks	-1.22	0	-2.43	-1.22	-2.43	-3.65	-2.43	-13.39
service_shop	-1.22	-2.43	0	-1.22	-2.43	-3.65	-2.43	-13.39
off_mgr_pros	-0.61	-1.22	-1.22	0	-1.22	-1.83	-1.22	-7.30
ag_othlowsk	-1.22	-2.43	-2.43	-1.22	0	-3.65	-2.43	-13.39
UEMP	-1.83	-3.65	-3.65	-1.83	-3.65	0	-3.65	-18.26
NLF	-1.22	-2.43	-2.43	-1.22	-2.43	-3.65	0	-13.39
Total	-7.30	-13.39	-13.39	-7.30	-13.39	-18.26	-13.39	-86.42

Source: Chief Economist Office, GAC

Compare to high-skilled workers, low skilled workers are relatively easy to substitute. Unemployed people are more ready to supply their labor, so more sensitive to wage than who are not in the labor force.



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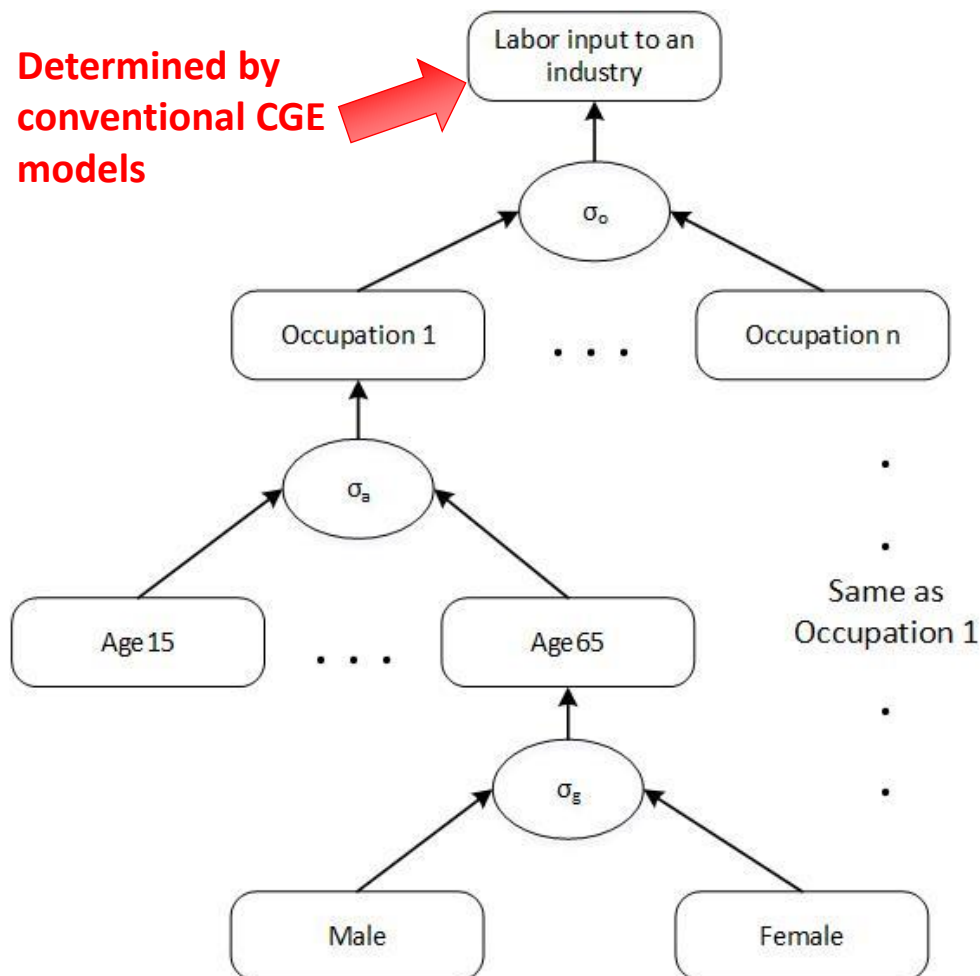
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3. DERIVATION OF LABOUR DEMAND



NESTING STRUCTURE OF LABOUR DEMAND AND SUBSTITUTION

1. Low substitution between occupations (elasticity of 0.35)
2. Relatively high substitution possibilities across different age groups of the same occupation (elasticity of 5)
3. High substitution elasticity between male and female workers in the same occupation (elasticity of 7.5)





OPTIMIZATION FROM THE DEMAND SIDE

Within industry j 's labor input, the demand for labor by gender, age and occupation is determined by a nested CES cost minimization problem.

$$\text{to minimize } \sum_{g,a,o} BTW_t(g,a,o) * D_t(g,a,o,j) \quad (\text{E2.11})$$

$$\text{subject to } D_t(j) = CES_o \left[D_t(o,j) \right] \quad (\text{E2.12})$$

$$D_t(o,j) = CES_a \left[D_t(a,o,j) \right] \text{ for all occupations } o, \quad (\text{E2.13})$$

$$\text{and } D_t(a,o,j) = CES_g \left[D_t(g,a,o,j) \right] \quad (\text{E2.14})$$

for all occupations o and age a .



DERIVED DEMAND FOR LABOUR

The derived demand for labor in industry j follows the conventional labor demand specification, which is a function of: the industry's capital stock; the real before-tax wage rate; and other variables:

$$D_t(j) = f_j(BTW_t(j); K_t(j); A_t(j)) . \quad (E2.9)$$

The overall real wage to industry j is the average real wages of various type of L

$$BTW_t(j) = g_j(BTW_t(g, a, o) \text{ for all } g, a \text{ and occupations } o) , \quad (E2.10)$$

Along with the constraints in (E2.12) – (E2.14), we obtain the derived demand for labor

$$D_t(g, a, o, j) = D_t(j) * h_{g,a,o,j}(BTW_t(gg, aa, oo) \quad \forall \text{ } gg, aa \text{ and occupations } oo) \\ \text{for all } g, a \text{ and occupations and industries } o \text{ and } j. \quad (E2.15)$$

These can be aggregated across industries to determine aggregate demand for (g,a) workers in occupation o as:

$$D_t(g, a, o) = \sum_j D_t(g, a, o, j) \quad \text{for all } g, a \text{ and occupations } o . \quad (E2.16)$$

We assume employment of (g,a) worker in occupation o , $E_t(g,a,o) = D_t(g,a,o)$.



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4. WAGE ADJUSTMENT & MARKET CLEARING MECHANISM



WAGE RATES AND WAGE ADJUSTMENT

Relationship between after-tax and before-tax wage rates:

$$ATW_t(g, a, o) = BTW_t(g, a, o) * (1 - T) \text{ for all } g, a \text{ and occupation } o$$

T is the tax rate. For unemployed, the ATW are social security payments or other supports.

Wage Adjustment

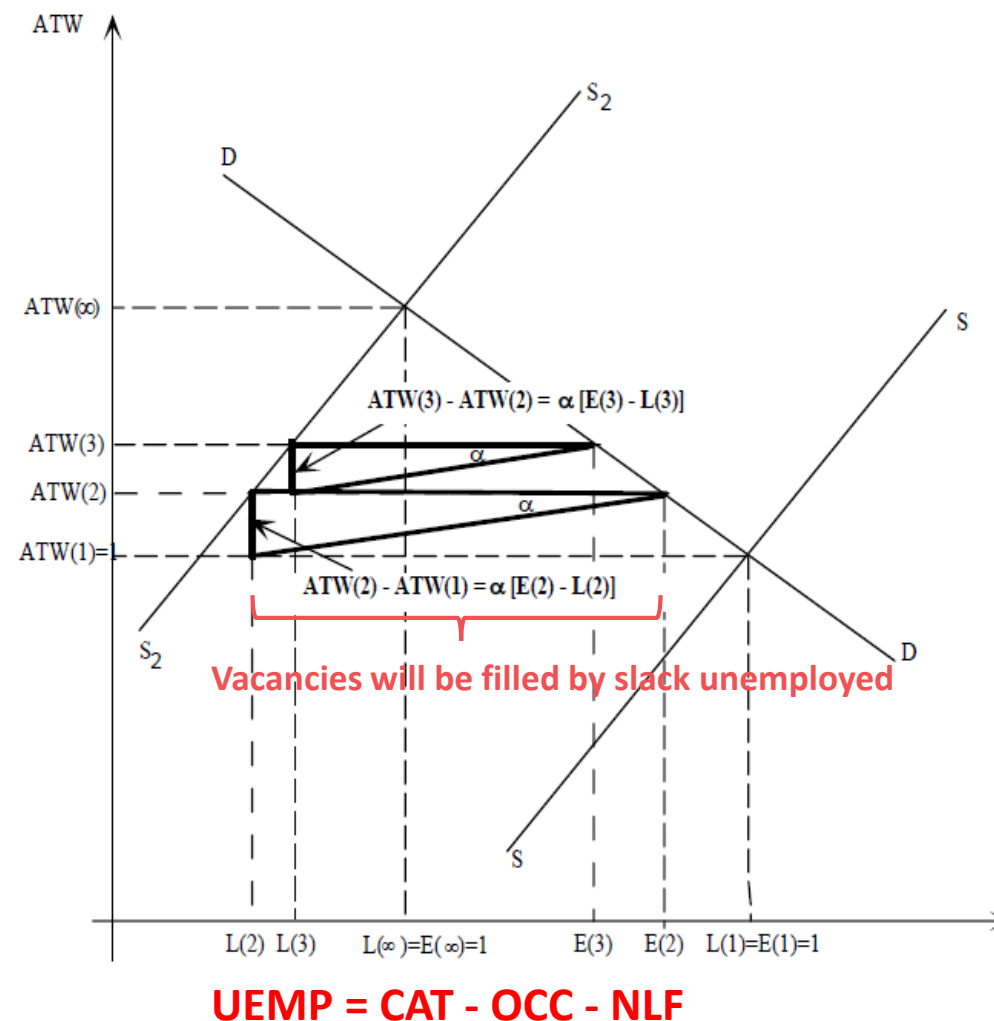
$$\frac{ATW_t(g, a, o)}{ATW_t^{base}(g, a, o)} - \frac{ATW_{t-1}(g, a, o)}{ATW_{t-1}^{base}(g, a, o)} = \beta \left(\overset{\text{Demand from E2.16}}{\frac{D_t(g, a, o)}{D_t^{base}(g, a, o)}} - \overset{\text{Supply from E2.6}}{\frac{L_t(g, a, o)}{L_t^{base}(g, a, o)}} \right),$$

for all (g,a) and all occupations o (E2.18)

where the superscript “base” refers to values in the basecase forecast and β is a positive parameter. In periods in which a policy has elevated demand relative to supply, real wages will grow relative to their basecase values.

WAGE ADJUSTMENT IN A STEADY STATE WITH ONE TYPE OF EMPLOYMENT: A SUPPLY SHOCK

- The basecase was generated under steady-state assumptions in which technology, consumer tastes, capital etc, affecting the demand for labor is unchanged from year to year (DD curve fixed).
- A policy simulation (e.g. a decrease in labour supply due to COVID) involving a shift in the supply curve in year 2 to S_2 from SS .
- Then employment decreases from $E(1)$ to $E(2)$ to ... $E(\infty)$, labor supply decreases from $L(1)$ to $L(2)$, and then rises from $L(2)$ to $L(3)$ to ... $L(\infty)$, due to wages rise from $ATW(1)$ to $ATW(2)$ to ... $ATW(\infty)$.





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5. AN EMPIRICAL ILLUSTRATION



APPLICATION OF THE EXPANDED CGE MODEL TO CUSMA

Scenario: Potential economic impact of CUSMA compared to “no-NAFTA” under which the U.S. withdraws from NAFTA and continues to impose Section 232 tariffs on steel and aluminum.

The net incremental changes under the CUSMA to be assessed include:

- New TRQs market access for agricultural products;
- Customs administration and trade facilitation, and origin procedures.



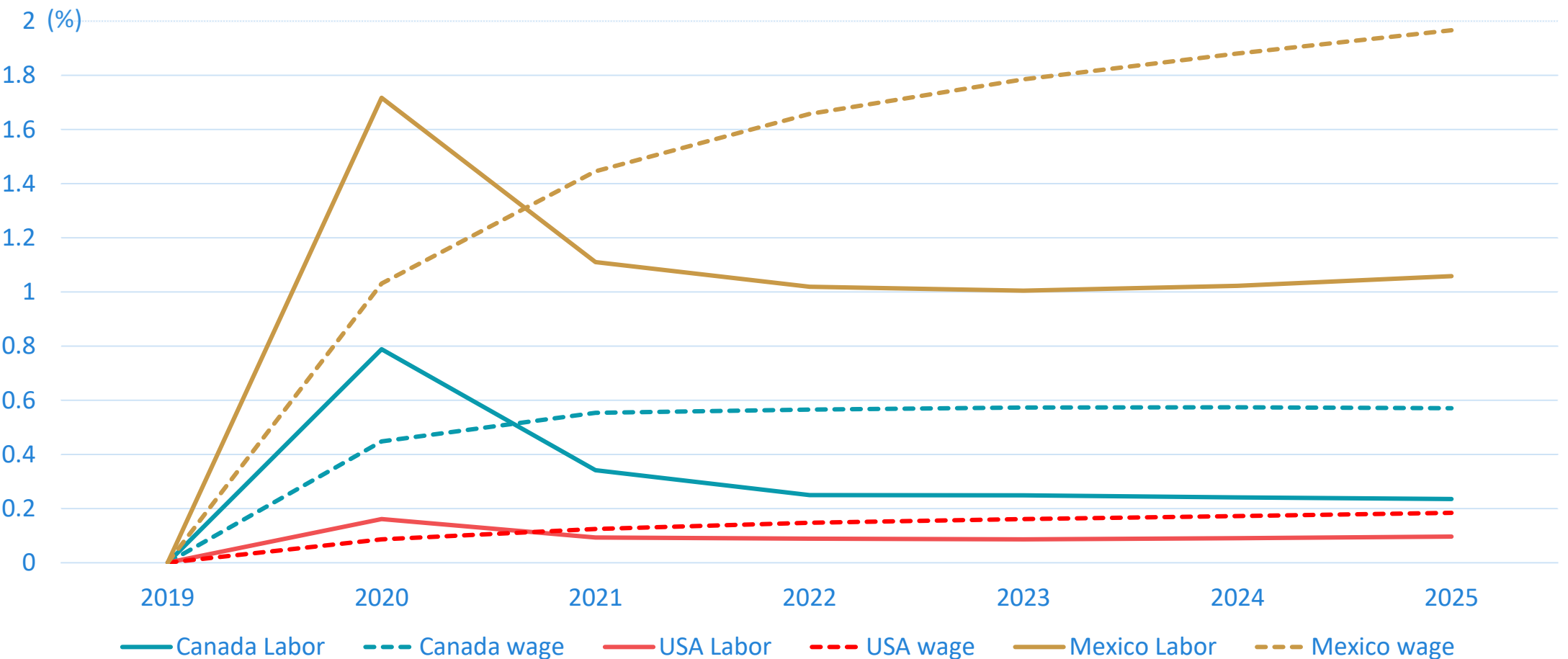
MACROECONOMIC IMPACTS OF CUSMA OUTCOMES COMPARED TO NO-NAFTA IN 2021 AND 2025

% change	2020				2025			
Major macroeconomic indicators	Canada	USA	Mexico	ROW	Canada	USA	Mexico	ROW
Real GDP	0.51	0.05	0.42	-0.02	0.18	0.08	0.86	-0.03
Terms of trade	0.45	-0.16	1.95	-0.03	0.37	-0.08	1.77	-0.03
GDP by expenditure (weighted)								
Consumption	0.93	0.04	1.38	-0.04	0.45	0.05	1.61	-0.05
Investment	1.19	0.47	4.91	-0.20	0.58	0.78	6.66	-0.20
Government expenditure	0.55	-0.02	0.98	-0.03	0.07	-0.05	0.58	-0.03
Total exports of goods & services	1.92	2.19	3.05	0.09	2.32	1.84	4.02	0.05
Total imports of goods & services	3.11	2.22	7.73	-0.11	2.55	2.59	8.22	-0.12
Factor markets								
Capital stock	0.00	0.00	0.00	0.00	0.16	0.15	1.02	-0.05
Real wages	0.45	0.09	1.03	-0.02	0.57	0.18	1.97	-0.04
Jobs	0.79	0.16	1.72	-0.04	0.23	0.10	1.06	-0.03

Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



THE DEVIATIONS OF LABOR AND REAL WAGE FROM BASELINE



Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



POTENTIAL GENDER IMPACTS OF CUSMA ON EMPLOYMENT

	Canada		USA		Mexico		ROW	
	Male	Female	Male	Female	Male	Female	Male	Female
tech_aspros	-224	2,699	20,423	29,308	23,192	61,474	-50,815	-77,944
<i>% change</i>	<i>-0.01</i>	<i>0.09</i>	<i>0.07</i>	<i>0.09</i>	<i>0.48</i>	<i>1.25</i>	<i>-0.02</i>	<i>-0.03</i>
clerks	-64	2,985	1,887	9,279	7,620	33,721	-11,514	-35,356
<i>% change</i>	<i>-0.02</i>	<i>0.17</i>	<i>0.04</i>	<i>0.08</i>	<i>0.42</i>	<i>1.72</i>	<i>-0.01</i>	<i>-0.04</i>
service_shop	3,597	10,177	7,437	18,128	27,750	113,098	-47,282	-111,207
<i>% change</i>	<i>0.14</i>	<i>0.30</i>	<i>0.07</i>	<i>0.10</i>	<i>0.45</i>	<i>1.73</i>	<i>-0.02</i>	<i>-0.04</i>
off_mgr_pros	2,672	2,696	9,333	7,861	6,304	7,304	-20,685	-22,916
<i>% change</i>	<i>0.17</i>	<i>0.27</i>	<i>0.09</i>	<i>0.11</i>	<i>0.61</i>	<i>1.37</i>	<i>-0.02</i>	<i>-0.03</i>
ag_othlowsk	17,703	5,045	40,688	14,068	182,213	164,811	-281,428	-216,484
<i>% change</i>	<i>0.49</i>	<i>1.00</i>	<i>0.12</i>	<i>0.17</i>	<i>0.77</i>	<i>2.08</i>	<i>-0.02</i>	<i>-0.05</i>
Total	23,685	23,601	79,767	78,644	247,080	380,409	-411,723	-463,907
<i>% change</i>	<i>0.22</i>	<i>0.25</i>	<i>0.09</i>	<i>0.10</i>	<i>0.66</i>	<i>1.74</i>	<i>-0.02</i>	<i>-0.04</i>

Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



POTENTIAL IMPACTS IN AGE GROUPS OF CUSMA ON EMPLOYMENT IN CANADA

	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+
tech_aspros	645	391	-40	-145	851	774
<i>% change</i>	<i>0.17</i>	<i>0.03</i>	<i>0.00</i>	<i>-0.01</i>	<i>0.12</i>	<i>0.36</i>
Clerks	424	301	183	101	1,046	866
<i>% change</i>	<i>0.27</i>	<i>0.07</i>	<i>0.04</i>	<i>0.02</i>	<i>0.25</i>	<i>0.62</i>
service_shop	5,255	1,630	1,010	879	2,764	2,234
<i>% change</i>	<i>0.38</i>	<i>0.13</i>	<i>0.09</i>	<i>0.08</i>	<i>0.32</i>	<i>0.72</i>
off_mgr_pros	289	968	1,119	1,034	1,292	665
<i>% change</i>	<i>0.34</i>	<i>0.19</i>	<i>0.16</i>	<i>0.15</i>	<i>0.29</i>	<i>0.54</i>
ag_othlowsk	3,416	4,018	3,745	4,031	5,111	2,428
<i>% change</i>	<i>0.74</i>	<i>0.44</i>	<i>0.42</i>	<i>0.45</i>	<i>0.70</i>	<i>1.09</i>
Total	10,029	7,308	6,017	5,901	11,065	6,967
<i>% change</i>	<i>0.41</i>	<i>0.16</i>	<i>0.13</i>	<i>0.14</i>	<i>0.35</i>	<i>0.69</i>

Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



POTENTIAL IMPACTS IN AGE GROUPS OF CUSMA ON EMPLOYMENT IN USA

	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+
tech_aspros	5,727	9,715	9,028	9,243	9,690	6,330
<i>% change</i>	<i>0.12</i>	<i>0.07</i>	<i>0.06</i>	<i>0.07</i>	<i>0.10</i>	<i>0.16</i>
Clerks	3,027	1,231	1,070	1,189	2,538	2,111
<i>% change</i>	<i>0.11</i>	<i>0.04</i>	<i>0.03</i>	<i>0.04</i>	<i>0.09</i>	<i>0.19</i>
service_shop	10,218	2,736	2,395	2,639	4,031	3,547
<i>% change</i>	<i>0.13</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.11</i>	<i>0.21</i>
off_mgr_pros	858	3,339	3,096	3,164	4,199	2,537
<i>% change</i>	<i>0.13</i>	<i>0.08</i>	<i>0.07</i>	<i>0.08</i>	<i>0.11</i>	<i>0.18</i>
ag_othlowsk	13,438	8,813	7,745	8,287	10,847	5,625
<i>% change</i>	<i>0.20</i>	<i>0.10</i>	<i>0.09</i>	<i>0.10</i>	<i>0.16</i>	<i>0.28</i>
Total	33,268	25,834	23,334	24,521	31,304	20,149
<i>% change</i>	<i>0.15</i>	<i>0.07</i>	<i>0.07</i>	<i>0.07</i>	<i>0.12</i>	<i>0.20</i>

Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



POTENTIAL IMPACTS IN AGE GROUPS OF CUSMA ON EMPLOYMENT IN MEXICO

	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+
tech_aspros	13,167	24,041	18,153	13,929	9,572	5,804
<i>% change</i>	<i>1.33</i>	<i>0.79</i>	<i>0.73</i>	<i>0.75</i>	<i>1.00</i>	<i>1.43</i>
Clerks	15,157	10,668	6,174	4,370	2,949	2,023
<i>% change</i>	<i>1.79</i>	<i>0.90</i>	<i>0.77</i>	<i>0.77</i>	<i>1.21</i>	<i>1.96</i>
service_shop	43,405	24,291	20,321	19,139	20,577	13,116
<i>% change</i>	<i>1.74</i>	<i>0.86</i>	<i>0.74</i>	<i>0.80</i>	<i>1.30</i>	<i>1.95</i>
off_mgr_pros	1,327	3,522	3,094	2,534	1,868	1,265
<i>% change</i>	<i>1.37</i>	<i>0.86</i>	<i>0.70</i>	<i>0.73</i>	<i>0.95</i>	<i>1.46</i>
ag_othlowsk	99,194	57,306	53,424	49,606	51,362	36,134
<i>% change</i>	<i>1.89</i>	<i>0.81</i>	<i>0.73</i>	<i>0.80</i>	<i>1.31</i>	<i>2.00</i>
Total	172,249	119,827	101,166	89,577	86,327	58,342
<i>% change</i>	<i>1.78</i>	<i>0.83</i>	<i>0.74</i>	<i>0.79</i>	<i>1.25</i>	<i>1.90</i>

Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



POTENTIAL IMPACTS IN OCCUPATION BY INDUSTRY OF CUSMA ON EMPLOYMENT IN CANADA

	tech_a		service	off_mg	ag_oth				tech_a		service	off_mg	ag_oth		
	spros	clerks	_shop	r_pros	lowsk	Total			spros	clerks	_shop	r_pros	lowsk	Total	
Agriculture	-105	-45	-118	-221	-1,001	-1,489	Machinery and equipment nec	28	10	9	11	11	70		
Mining	-806	-192	-120	-388	-890	-2,394	Motor vehicles and parts	645	233	388	820	4,489	6,575		
Beverages and tobacco	-5	-4	-15	-20	-48	-92	Transport equipment nec	-371	-83	-89	-165	-538	-1,245		
Textiles	159	138	308	366	1,382	2,352	Manufactures nec	-175	-100	-154	-219	-913	-1,560		
Wearing apparel	1,294	965	3,441	2,100	8,835	16,635	Electricity, Gas distribution	181	71	48	108	112	521		
Leather products	237	230	718	362	1,466	3,014	Water	5	4	3	12	7	31		
Wood products	-44	-23	-37	-80	-462	-647	Construction	749	813	388	991	6,554	9,495		
Paper products, publishing	-711	-216	-323	-491	-1,129	-2,870	Trade	462	446	4,616	1,084	407	7,016		
Petroleum, coal products	-10	-3	-4	-21	-29	-66	Accommodation, Food and service	188	83	3,592	236	24	4,122		
Chemical products	311	129	208	359	987	1,995	Transport and storage	71	98	114	29	-113	198		
Basic pharmaceutical	134	56	89	154	417	850	Communication	-206	-80	-278	-147	-196	-907		
Rubber and plastic products	570	237	381	661	1,824	3,673	Finance and Insurance	-68	-54	-57	-156	-6	-341		
Mineral products nec	3	3	3	-1	-21	-13	Real estate activities	50	36	15	9	-5	105		
Ferrous metals	558	230	385	723	3,094	4,990	Business services nec	36	64	32	-94	-110	-72		
Metals nec	152	43	82	195	614	1,087	Recreational and other services	256	90	262	-76	-159	372		
Metal products	-64	-50	-56	-99	-592	-860	Public Admin and defense	1,029	262	788	55	-10	2,125		
Computer, electronic products	-373	-93	-129	-229	-478	-1,302	Education	188	139	162	-37	-31	421		
Electrical equipment	-147	-37	-51	-91	-197	-522	Human health and social work	-1,749	-478	-831	-371	-548	-3,976		

Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



POTENTIAL IMPACTS IN OCCUPATION BY INDUSTRY OF CUSMA ON EMPLOYMENT IN USA

	tech_a		service	off_mg	ag_oth				tech_as		service	off_mg	ag_oth		
	spros	clerks	_shop	r_pros	lowsk	Total			pros	clerks	_shop	r_pros	lowsk	Total	
Agriculture	7,055	1,645	3,144	2,384	5,865	20,094	Machinery and equipment nec	12,509	2,813	5,280	4,111	10,344	35,058		
Mining	16	16	29	0	18	79	Motor vehicles and parts	8,206	1,845	3,462	2,706	6,778	22,998		
Beverages and tobacco	330	84	154	110	284	961	Transport equipment nec	1,990	464	875	652	1,661	5,642		
Textiles	4,423	986	1,853	1,455	3,655	12,372	Manufactures nec	2,650	725	1,274	843	2,197	7,689		
Wearing apparel	2,718	607	1,137	893	2,240	7,594	Electricity, Gas distribution	-881	-144	-287	-311	-751	-2,374		
Leather products	431	97	182	142	357	1,208	Water	-8	22	22	-13	-2	21		
Wood products	676	160	301	226	568	1,931	Construction	25,570	4,826	10,330	8,949	25,731	75,407		
Paper products, publishing	534	139	266	155	429	1,524	Trade	-132	332	1,082	-277	-23	982		
Petroleum, coal products	-44	-9	-17	-16	-36	-122	Accommodation, Food and service	-1,813	-428	-678	-557	-1,287	-4,764		
Chemical products	1,169	280	525	379	967	3,319	Transport and storage	-2,159	-250	-678	-836	-1,969	-5,892		
Basic pharmaceutical	-710	-149	-281	-238	-587	-1,967	Communication	-1,050	-138	-276	-448	-1,035	-2,948		
Rubber and plastic products	2,548	582	1,094	836	2,106	7,167	Finance and Insurance	-5,054	-1,281	-1,908	-1,552	-3,187	-12,982		
Mineral products nec	540	128	240	168	440	1,516	Real estate activities	-487	-70	-69	-177	-293	-1,096		
Ferrous metals	-15,457	-3,423	-6,439	-5,112	-12,797	-43,228	Business services nec	10,818	3,101	5,698	3,187	7,601	30,406		
Metals nec	-426	-86	-170	-140	-351	-1,173	Recreational and other services	-5,222	-1,410	-2,320	-1,585	-2,961	-13,499		
Metal products	15,556	3,491	6,570	5,142	12,870	43,629	Public Admin and defense	-2,331	-473	-666	-755	-1,396	-5,622		
Computer, electronic products	-1,645	-316	-595	-547	-1,331	-4,434	Education	-6,546	-1,637	-2,334	-1,864	-2,878	-15,259		
Electrical equipment	6,709	1,500	2,834	2,212	5,548	18,804	Human health and social work	-10,750	-2,863	-4,072	-2,929	-4,014	-24,628		

Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



POTENTIAL IMPACTS IN OCCUPATION BY INDUSTRY OF CUSMA ON EMPLOYMENT IN MEXICO

	tech_a		service	off_mg	ag_oth				tech_as		service	off_mg	ag_oth			
	spros	clerks	_shop	r_pros	lowsk	Total			pros	clerks	_shop	r_pros	lowsk	Total		
Agriculture	-6,829	-1,756	-6,389	-1,585	-27,883	-44,442	Machinery and equipment nec	-5,104	-1,906	-6,427	-844	-16,376	-30,656			
Mining	-1,021	-345	-1,136	-206	-4,148	-6,856	Motor vehicles and parts	43,993	17,700	57,818	7,110	146,610	273,229			
Beverages and tobacco	-1,001	-339	-1,169	-164	-3,056	-5,728	Transport equipment nec	-826	-316	-1,044	-134	-2,670	-4,989			
Textiles	6,904	2,775	9,088	1,110	22,978	42,855	Manufactures nec	-3,957	-1,376	-4,771	-652	-12,612	-23,368			
Wearing apparel	27,301	10,871	35,720	4,422	90,722	169,036	Electricity, Gas distribution	-13	7	18	-3	10	20			
Leather products	1,027	427	1,399	170	3,520	6,543	Water	93	87	213	10	480	883			
Wood products	-1,070	-389	-1,277	-172	-3,417	-6,326	Construction	32,251	12,319	41,628	6,706	153,352	246,256			
Paper products, publishing	-1,836	-698	-2,252	-306	-5,959	-11,051	Trade	28,594	12,992	46,089	4,115	96,378	188,169			
Petroleum, coal products	-43	-6	-21	-9	-76	-154	Accommodation, Food and service	-5,173	-1,477	-4,303	-763	-10,118	-21,833			
Chemical products	-5,324	-2,020	-6,612	-872	-17,278	-32,106	Transport and storage	-6,055	-1,914	-6,631	-1,345	-25,144	-41,090			
Basic pharmaceutical	6	20	67	-1	92	183	Communication	-303	-72	-263	-65	-1,094	-1,797			
Rubber and plastic products	109	102	339	10	599	1,158	Finance and Insurance	-708	-199	-520	-115	-1,786	-3,329			
Mineral products nec	1,439	603	1,979	229	4,923	9,174	Real estate activities	33	44	181	1	291	549			
Ferrous metals	840	357	1,201	132	2,917	5,446	Business services nec	4,670	2,272	7,741	699	17,296	32,679			
Metals nec	-1,906	-748	-2,468	-309	-6,268	-11,699	Recreational and other services	-1,757	87	570	-343	88	-1,355			
Metal products	-2,026	-752	-2,403	-334	-6,334	-11,850	Public Admin and defense	1,634	942	3,678	225	6,422	12,902			
Computer, electronic products	-5,455	-1,556	-5,390	-870	-15,646	-28,917	Education	-1,276	-34	396	-216	-1,204	-2,333			
Electrical equipment	-12,027	-4,433	-14,729	-1,931	-38,512	-71,631	Human health and social work	-517	74	524	-91	-79	-89			

Source: Simulations by Global Affairs Canada, Office of the Chief Economist.



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ANNEX:

A1. SETS

Symbol	Dimension	Description/Elements
OCC	5	1) tech_aspros, 2) clerks, 3) service_shop, 4) off_mgr_pros, 5) ag_othlowsk
UEMP	1	UnEMPloyed.
NEWENT	1	New entrants (N), which includes domestic residents who turn 15 and new overseas arrivals.
NLF	1	Not in the Labour Force (NLF).
EU	6	Labour force (OCC + UN).
EUNF	8	Labour categories (OCC + UEMP + NLF + NEWENT).
EUF	7	Labour activities (OCC + UEMP + NLF).
GEN	2	Male and Female.
AGE	6	(1) 15-24; (2) 25-34; (3) 35-44; (4) 45-54; (5) 55-64; (6) 65 +.



A2.COEFFICIENTS AND DIMENSIONS

Coefficient	Dimension	Description
LS(o,g,a)	EUNF * GEN * AGE	The activity matrix in year t. This matrix refers to the number of adults in each labour market activity by gender g, and age a in (E2.5)
ACT_L(o,g,a)	EUf * GEN * AGE	The lagged activities matrix for year t-1. This matrix is similar in dimensions to ACT(o,g,a), but is defined for the preceding year. It is used in equation (E2.1)
CAT(o,g,a)	EUNF * GEN * AGE	The number of adults in category c at the start of year t . This matrix shows the number of adults in each labour market category c who belong to gender g, and age group a at the start of year t . An additional category, new entrant (N) is exogenously added at the beginning of each year.



A3. CRESH FUNCTION

$$\bar{x}_{(r*)j} = \bar{z}_j^{(0)} + \sigma_{(r*)j}^{(0)} \left(\bar{p}_{(r*)j}^{(0)} - \sum_{r=1}^{N(j)} H_{(r*)j}^{*(0)} \bar{p}_{(r*)j}^{(0)} \right), \quad r = 1, \dots, N(j),$$

where

$$\sigma_{(r*)j}^{(0)} = 1/(h_{(r*)j}^{(0)} - 1), \quad r = 1, \dots, N(j),$$

$$H_{(r*)j}^{*(0)} = \sigma_{(r*)j}^{(0)} H_{(r*)j}^{(0)} \left/ \sum_{r=1}^{N(j)} \sigma_{(r*)j}^{(0)} H_{(r*)j}^{(0)} \right., \quad r = 1, \dots, N(j),$$

and

$$H_{(r*)j}^{(0)} = P_{(r*)j}^{(0)} X_{(r*)j}^{(0)} \left/ \sum_{r=1}^{N(j)} P_{(r*)j}^{(0)} X_{(r*)j}^{(0)} \right., \quad r = 1, \dots, N(j).$$

- (a) The ease of transformation between composite commodities r and s in industry j is indicated by their partial transformation elasticity (τ_{rs}^j) defined by

$$\tau_{rs}^j = - \sigma_{(r*)j}^{(0)} \sigma_{(s*)j}^{(0)} \left/ \sum_{r=1}^{N(j)} \sigma_{(r*)j}^{(0)} H_{(r*)j}^{(0)} \right., \quad r \neq s.$$

$H_{(r*)j}^{(0)}$ is, as defined in Table 27.1, the revenue share for the r^{th} composite commodity.

$$(\mathbf{all}, \mathbf{o}, \mathbf{EUF})(\mathbf{all}, \mathbf{g}, \mathbf{GEN})(\mathbf{all}, \mathbf{a}, \mathbf{AGE}) \text{ ADJSHR_LS}(\mathbf{o}, \mathbf{g}, \mathbf{a}) = \text{ELAS_LS}(\mathbf{o}) * \text{OFFER_TO}(\mathbf{o}, \mathbf{g}, \mathbf{a}) / \sum\{\mathbf{oo}, \mathbf{EUF}, \text{ELAS_LS}(\mathbf{oo}) * \text{OFFER_TO}(\mathbf{oo}, \mathbf{g}, \mathbf{a})\};$$

Equation E_lfcoffer_b

$$(\mathbf{all}, \mathbf{o}, \mathbf{EUF})(\mathbf{all}, \mathbf{g}, \mathbf{GEN})(\mathbf{all}, \mathbf{a}, \mathbf{AGE}) \text{ emp_jobslrd}(\mathbf{o}, \mathbf{g}, \mathbf{a}) - \text{f_emp_jobslrd}(\mathbf{o}, \mathbf{g}, \mathbf{a}) = \text{lfcoffer_oio}(\mathbf{g}, \mathbf{a}) + \text{ELAS_LS}(\mathbf{o}) * [\text{real_wage_ptd}(\mathbf{o}, \mathbf{g}, \mathbf{a}) + \text{b_pref}(\mathbf{o}, \mathbf{g}, \mathbf{a}) - \text{rwptd_cat}(\mathbf{g}, \mathbf{a}) - \text{ave_b_pref}(\mathbf{g}, \mathbf{a})];$$

Equation E_rwptd_cat_b # average potential real wage post-tax for $\mathbf{oo}, \mathbf{g}, \mathbf{a}$ #

$(\mathbf{all}, \mathbf{g}, \mathbf{GEN})(\mathbf{all}, \mathbf{a}, \mathbf{AGE})$

$$\text{rwptd_cat}(\mathbf{g}, \mathbf{a}) = \sum\{\mathbf{o}, \mathbf{EUF}, \text{ADJSHR_LS}(\mathbf{o}, \mathbf{g}, \mathbf{a}) * \text{real_wage_ptd}(\mathbf{o}, \mathbf{g}, \mathbf{a})\};$$

Equation E_ave_b_pref_b # average preferences based on strength of offers #

$(\mathbf{all}, \mathbf{g}, \mathbf{GEN})(\mathbf{all}, \mathbf{a}, \mathbf{AGE})$

$$\text{ave_b_pref}(\mathbf{g}, \mathbf{a}) = \sum\{\mathbf{o}, \mathbf{EUF}, \text{ADJSHR_LS}(\mathbf{o}, \mathbf{g}, \mathbf{a}) * \text{b_pref}(\mathbf{o}, \mathbf{g}, \mathbf{a})\};$$



BASE DATA IN 2019: ACTIVITIES BY AGE GROUP IN CANADA

('000 people)	Male						Female						Total
	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+	
tech_aspros	165	563	574	471	351	112	226	771	725	563	378	83	4,981
clerks	41	90	87	77	69	27	117	315	348	403	361	97	2,032
service_shop	609	522	422	401	367	142	796	642	564	592	511	133	5,702
off_mgr_pros	41	261	391	402	307	84	47	218	258	248	156	28	2,441
ag_othlowsk	410	759	702	708	650	184	64	83	99	124	99	18	3,901
Unemployment (UEMP)	178	143	102	87	108	23	134	111	90	79	75	14	1,144
Not in the Labor Force (NLF)	809	246	178	222	698	2,382	742	440	405	378	1,009	3,031	10,540
Total	2,253	2,583	2,455	2,367	2,548	2,954	2,126	2,581	2,489	2,387	2,590	3,405	30,739
Unemployment Rate	12.3%	6.1%	4.5%	4.1%	5.8%	4.1%	9.7%	5.2%	4.3%	3.9%	4.7%	3.9%	5.7%
Participation Rate	64.1%	90.5%	92.8%	90.6%	72.6%	19.4%	65.1%	82.9%	83.7%	84.2%	61.0%	11.0%	65.7%

Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



BASE DATA IN 2019: ACTIVITIES BY AGE GROUP IN USA

('000 people)	Male						Female						Total
	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+	
tech_aspros	2,183	7,110	6,761	6,382	4,835	2,124	2,626	7,606	7,101	7,110	5,138	1,824	60,802
clerks	944	959	912	861	658	257	1,682	2,427	2,265	2,268	2,260	845	16,340
service_shop	2,810	2,217	2,108	1,990	1,491	683	4,941	3,282	3,064	3,068	2,462	1,017	29,132
off_mgr_pros	320	2,525	2,401	2,266	2,393	1,020	320	1,768	1,651	1,653	1,427	447	18,191
ag_othlowsk	5,197	7,303	6,945	6,555	5,393	1,643	1,380	1,750	1,634	1,636	1,546	480	41,461
Unemployment (UEMP)	1,189	776	509	506	375	171	868	652	468	433	353	146	6,445
Not in the Labor Force (NLF)	9,695	2,554	1,982	2,672	6,019	17,950	9,612	5,321	5,191	5,191	8,937	24,188	99,312
Total	22,338	23,444	21,619	21,232	21,164	23,848	21,429	22,805	21,372	21,359	22,124	28,948	271,682
Unemployment Rate	9.4%	3.7%	2.6%	2.7%	2.5%	2.9%	7.3%	3.7%	2.9%	2.7%	2.7%	3.1%	3.7%
Participation Rate	56.6%	89.1%	90.8%	87.4%	71.6%	24.7%	55.1%	76.7%	75.7%	75.7%	59.6%	16.4%	63.4%

Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



BASE DATA IN 2019: ACTIVITIES BY AGE GROUP IN MEXICO

	Male						Female						
('000 people)	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+	Total
tech_aspros	454	1,441	1,065	821	430	240	521	1,462	1,246	860	363	155	9,058
clerks	368	519	341	257	112	59	457	600	404	252	89	40	3,498
service_shop	1,212	1,292	1,190	1,019	600	391	1,237	1,391	1,365	1,144	712	262	11,814
off_mgr_pros	66	220	272	211	130	67	30	173	141	105	34	21	1,471
ag_othlowsk	4,055	5,143	4,899	4,010	2,390	1,562	1,158	1,580	1,915	1,640	884	302	29,538
Unemployment (UEMP)	417	333	203	118	88	41	297	237	134	72	20	16	1,976
Not in the Labor Force (NLF)	4,181	610	401	447	1,014	2,167	7,006	4,614	3,837	3,461	3,263	4,537	35,537
Total	10,753	9,558	8,372	6,884	4,763	4,526	10,706	10,056	9,041	7,534	5,364	5,333	92,891
Unemployment Rate	6.3%	3.7%	2.5%	1.8%	2.3%	1.7%	8.0%	4.4%	2.6%	1.8%	1.0%	2.0%	3.4%
Participation Rate	61.1%	93.6%	95.2%	93.5%	78.7%	52.1%	34.6%	54.1%	57.6%	54.1%	39.2%	14.9%	61.7%

Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



BASE DATA IN 2019: ACTIVITIES BY AGE GROUP IN THE REST OF WORLD (ROW)

	Male						Female						
('000 people)	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+	Age15-24	Age25-34	Age35-44	Age45-54	Age55-64	Age65+	Total
tech_aspros	17,627	81,909	74,425	63,529	31,062	7,786	17,189	61,276	62,066	56,502	23,590	4,027	500,988
clerks	9,025	20,341	18,483	15,777	8,309	2,019	10,977	20,155	20,415	18,585	9,247	2,368	155,701
service_shop	40,495	73,580	66,858	57,069	29,901	12,175	35,240	60,047	60,821	55,369	30,132	11,343	533,031
off_mgr_pros	4,170	29,519	26,822	22,895	16,812	6,423	3,237	16,565	16,779	15,274	8,104	4,048	170,647
ag_othlowsk	154,875	289,241	262,815	224,338	139,983	61,609	50,214	93,745	94,953	86,440	59,281	28,808	1,546,302
Unemployment (UEMP)	46,915	38,049	15,647	12,112	6,849	1,525	27,176	26,716	12,443	8,136	3,312	572	199,452
Not in the Labor Force (NLF)	316,770	43,953	23,098	31,322	75,942	193,775	408,344	270,650	205,303	184,518	190,865	308,921	2,253,459
Total	589,877	576,592	488,148	427,042	308,858	285,311	552,377	549,154	472,779	424,823	324,531	360,087	5,359,579
Unemployment Rate	17.2%	7.1%	3.4%	3.1%	2.9%	1.7%	18.9%	9.6%	4.7%	3.4%	2.5%	1.1%	6.4%
Participation Rate	46.3%	92.4%	95.3%	92.7%	75.4%	32.1%	26.1%	50.7%	56.6%	56.6%	41.2%	14.2%	58.0%

Source: Chief Economist Office, GAC; International Labour Organization (ILO); Statistics Canada



THE END...THANKS!