COVID-19-Induced Automation and Reallocation: Impacts on Waterloo Region

Joel Blit*
Department of Economics
University of Waterloo
jblit@uwaterloo.ca

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Abstract

The evidence suggests that much of the automation and reallocation that increases aggregate productivity occurs during recessions. The COVID-19-induced economic downturn will be no different, and in fact is likely to spur an even bigger transformation because superimposed on top of the usual forces are the health-related incentives to automate. I examine which occupations, industries, income groups, and regions are likely to experience the biggest economic transformation as a result of COVID-19. The Region of Waterloo is somewhat sheltered in that many of our jobs do not face particularly high COVID-19 health risks and hence relatively low incentives to automate. However, jobs in the region are disproportionately routine and hence easily automatable. Understanding which occupations, industries, and income groups will be most affected can help the region develop a plan that embraces technological change and its associated wealth, while ensuring that all residents benefit.

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1. Introduction

COVID-19 may have started as a health-crisis, but it quickly turned into an economic crisis as well. In the second quarter of 2020, Canadian real GDP fell an unprecedented 11.5%. Between February and April, the peak and trough, respectively, 5.5 million Canadians either lost their job or saw their hours reduced by half or more. The impacts were disproportionately felt by the most financially vulnerable Canadians: low-wage workers, part-time workers, the self-employed, and recent immigrants.

While employment made a dramatic recovery in the three months to July, recovering 71% of peak to trough losses (see Figure 1), the pace of recovery is slowing and a full recovery remains distant. The Bank of Canada forecasts the a full recovery may not happen until 2022. It is clear that reopening our economy does not imply a return to normal. Also clear is the fact that we are in the midst of an unprecedented economic downturn.

In order to predict what may be long-run consequences of this crisis on the labour market, it may thus be useful to examine the lasting impacts of previous recessions. In this regard, Jaimovich and Siu (2020) find evidence that in the U.S., since the beginning of the information and communications technology (ICT) revolution (but crucially not before) each recession resulted in the permanent loss of routine jobs. Non-routine jobs, on the other hand, were either untouched or recovered following the recession. Blit (2020a) finds similar, and in fact bigger, effects of recessions on routine jobs in Canada.

Consistent with this, Hershbein and Kahn (2018) find that U.S. geographic regions that were hardest hit by the Great Recession saw more investment in automation technology and more upskilling. Anghel, De la Rica, and Lacuesta (2014) similarly find accelerating routine job losses in Spain during the Great Recession and Zhang (2019) finds that during recessions, U.S. firms with higher shares of routine labour invest more in machines and decrease routine employment more. Blit (2020b) presents Canadian evidence that during recessions, routine employment decreases more than non-routine employment, even controlling for long-term trends. The evidence thus suggests that recessions are periods of accelerating within-firm automation and between-firm reallocation (the transfer of market share and resources from less to more productive firms).

The same is likely to occur during this COVID-19 crisis, but at a much larger scale, and this for two reasons. First, because this is a deeper economic downturn than previous ones. Second, because superimposed on top of the usual recessionary forces for automation and reallocation, are health-related incentives to automate. The best way for organizations to mitigate the ongoing risks of COVID-19 to their operations (and to the health of their employees) is by transforming their operations. In some cases, this entails asking workers to work from home. In other cases, particularly when the work must be performed while being physically present, risks can be mitigated by replacing person-person contacts with person-machine contacts, or better yet by altogether replacing workers with machines.

For these reasons, we can expect technological transformation to be greatest in sectors that face the highest health-related risks from COVID-19. I measure the health risks associated with any occupation by constructing an index of COVID-19 health risk using O*NET data on the extent to which different occupations require close physical proximity, face to face interactions, are performed indoors, and are subject to significant risks of infection (see Blit 2020b for more details on the construction of the index). The ranking of occupations by COVID-19 health risk is presented in Table 1.

However, just because an occupation presents significant automation incentives does not imply that it can feasibly be automated given current technologies. An important other factor is the feasibility of automation, which I measure by constructing an index of routine task intensity using O*NET data on the extent to which an occupation uses automation, is repetitive, requires exactness, is structured, and follows the pace set by a machine (Blit 2020b). Table 2 presents the routine task intensity index and its components for the different occupations.

Occupations and industries that present significant health-related incentives to automate (high health risks) and where automation is feasible (high routineness) are likely to experience the biggest transformation as a result of the COVID-19 crisis. Two such sectors are retail trade and accommodation and food services. These sectors have already seen a significant transformation and this is likely to continue. But where we might see the biggest break from previous trends is in sectors that have not traditionally been seen as automatable but where health incentives are high. Two such industries are healthcare and education, which coincidentally are the third and fourth biggest employers in Waterloo Region.

This paper begins by examining previous recessions and showing that routine jobs were primarily impacted during these periods (while high health-risk jobs actually gained). The initial stages of this crisis have been different in that it has primarily been high health-risk jobs that have been impacted. While some of these jobs will return (and many already have), others will be automated or reallocated. The paper then examines which occupations, industries, income groups and cities will be most impacted. Waterloo Region faces the lowest health-related risks of the regions studied, but is among those whose occupations are more automatable. Overall, then, Waterloo is likely to see more transformation than Canada's biggest cities (which tend to be low in both respects), but less than most other regions.

2. Previous Recessions in Canada

Figure 1 shows routine and non-routine employment per capita between January 1987 and May 2020. During this period, non-routine employment has trended up while routine employment has slumped. But the decline in routine jobs has not been consistent. Instead, the entirety of routine jobs were lost during the three recessions. Moreover, those losses proved to be permanent. Figure 2 shows this more clearly by narrowing in on each of the recessions.

The analysis can also be broken down by occupations. Figure 3 plots the average change in per capita employment over the three recessions against routineness for different occupations. A strong relationship between drop in employment and routineness is apparent. Figure 4 plots the change in employment against the health risk index. Occupations with high health risk actually increased employment during the recessions, especially in health and law occupations. These patterns are consistent with the findings of Blit (2020b) who examines these relationships in a more formal regression framework.

3. COVID-19 Crisis

The COVID-19 crisis, to date, has been different than previous recessions. In response to a highly infectious disease that we knew little about and for which we were ill prepared, the government made the decision to impose a general shut-down of the economy. In addition, many individuals chose to adopt a self-imposed lockdown in the face of real and perceived health risks. The result was an unprecedented economic downturn, which in turn will spur an economic

transformation through automation and reallocation. Below, I examine how the extent of this transformation is likely to differ across occupations, industries, income groups, and regions.

3.1 Impact Across Occupations

Figure 5 shows how changes in employment differed across occupations between February 2020 (the peak prior to the COVID-19 crisis) and April 2020 (the trough) versus each occupation's degree of routineness. While more routine occupations suffered a bigger downturn, the relationship is not significant unlike in previous recessions. That is because these initial job losses were not the result of firms automating or reallocation, but rather a response to health risks. As shown in Figure 6, the initial job losses from COVID-19 were primarily in high health-risk occupations. This is particularly true if we exclude health occupations from the analysis, which, given their exceptional nature since COVID-19 is a health crisis, did not shed as much employment. The loss of jobs posing significant health risks is a significant departure from previous recessions, where these types of jobs typically increased.

Many of the jobs that were lost in the initial two months of the crisis have since returned, but many more will be permanently lost as firms automate and as resources are reallocated in the economy. As discussed, the long run transformation is likely to be biggest in occupations that present high health risks (strong incentives to automate) and routineness (automation is feasible). Figure 7 shows where each of 40 occupation groups lie along these two dimensions. Some of the occupations that are likely to be most impacted by automation and reallocation are health support, sales support, office support, distribution coordinators, and manufacturing machine operators.

3.2 Impact Across Industries

A similar analysis can be conducted at the industry level. To obtain industry-level indices of health risk and automation, I take a weighted average of the index of each occupation in that industry, with the occupations' share of that industry's employment as weights. Figure 8 plots each of 19 Census Industry Groups along the two dimensions of associated health risk and routineness. In general, industries that are most easily automated (manufacturing, transportation and warehousing, utilities, mining and oil extraction) tend to face the lowest health risks, and the

converse. This suggests that the transformational impacts are likely to be spread across many industries.

However, there are outliers that are likely to be most affected. Among these, retail trade and accommodation and food services stand out as the only two industries where both indices are above the mean. Retail trade, in particular, is the industry that is likely to be most impacted. In fact, changes are already apparent in this sector, including both within-firm automation (Walmart announcing the first cashierless store) and between-firm reallocation (brick and mortar stores losing market share and resources to online stores). The latter reallocation resulted in the recent announcements by Amazon that they intend to open two delivery stations in Waterloo Region late this year.

Hotels are also undergoing COVID-induced changes. One example is keyless entry, which might ultimately obviate the need for hotel check-in clerks. Restaurants are adopting online menus (and ordering) and shifting from eat-in to pick-up or delivery, all of which may reduce the need for wait staff. This sector has also experienced a reallocation of market share from restaurants to home meal delivery services like Goodfood and HelloFresh.

As discussed, the fact that industries with higher levels of health risk are generally less routine, and the converse, suggests that the upcoming technological transformation might be more broadly distributed across industries than in past recessions. In particular, we may finally see automation and reallocation in industries that over the last decades have seen relatively limited productivity upgrading. Two such prime candidates are healthcare and education. In the health sector, long seen as relatively non-automatable, the shift to virtual care has created numerous new possibilities for increasing efficiencies, and forced the rethinking of antiquated processes. For example, prescription refills often required paper forms and medical support staff that would communicate with drug stores. In the new environment where doctors or staff are working from home, the transfer of paper has become difficult and fully automated online prescription services like Prescribe IT have seen accelerating adoption. Such productivity enhancing changes will not be reversed.

The education sector is also undergoing a transformation, with the most visible change being a move to remote teaching, particularly is post-secondary education. Since online courses do not require the physical presence of an instructor, they are more easily scalable. An unlimited number of students can use the same online module and even if lectures are delivered live, room

capacity is no longer a constraint on the number of students. Another potential impact of the shift to remote teaching is that students and faculty need not be present in any one particular location. For Waterloo Region, which is home to three large post-secondary institutions, this is a concern. It could result in the loss of many white collar jobs to other regions (instructors may choose to live in Toronto or further afield) and of income for the businesses that offer student services like accommodations, restaurants, grocery stores.

3.3 Impact Across Income Groups

The impacts of the economic transformation are unlikely to be felt equally across all income groups. To examine which groups are likely to be most affected by automation and reallocation, I compute the indices for each income group based on the occupation mix within that group and the extent to which these occupations face significant health risks and are routine. Figure 9 presents the findings, where for ease of presentation a combined likelihood of automation score (the geometric mean of health risks and routineness) is shown on the y-axis. Worryingly, the biggest impacts are likely to be felt toward the bottom of the income distribution, among families earning between $15,000 and $45,000 a year. Individuals in this income range tend to hold jobs that both face strong health-related incentives to automate and are feasibly automated. For the region of Waterloo, this could imply an increase in poverty and increased demand for social support services.

4. Impacts on Waterloo Region

Waterloo region has a large share of employment in routine sectors. According to the classification of routine and non-routine employment proposed by Blit (2000a), 43.6% of employment in the Kitchener-Cambridge-Waterloo Census Metropolitan Area (KCW CMA) is routine. This is a relatively high fraction compared to the 38.1% for Canada as a whole. This presents both a challenge and an opportunity for the region. On the one hand, it suggests that the region could be significantly affected by the oncoming economic transformation and in particular that many jobs could be lost. On the other hand, it suggests that the region has a significant opportunity to increase productivity and with it the standard of living.

Table 3 lists the fraction of employment in the KCW CMA for each of the 19 Census industries. The biggest employer in the region is manufacturing, followed by retail trade, and

health. All three of these sectors are above average in terms of likely impacts from automation, as measured by the geometric mean of the two indices. In fact, health care and retail trade are the two sectors most likely to be impacted. Waterloo region especially stands out for its high share of employment in manufacturing (16.8%), at almost twice the Canadian average (8.7%), a sector that has a long history of automation.

I also conduct an analysis to determine which CMA/regions across Canada are likely to be most impacted. I construct indices at the level of the CMA/region by taking a weighted average of the index values for all occupations in the region, where the weights correspond to the occupation's fraction of employment in that region. Figure 10 shows the health risk and routine task intensity indices for 23 of Canada's biggest CMA/regions. In general, larger cities (Toronto, Montreal, Vancouver, Calgary, and Ottawa) are less likely to be impacted by automation and reallocation, as the two indices are generally lower than those of smaller centres. The region of Waterloo is an outlier in that it is among the regions with the most automatable jobs, but conversely is the region facing the lowest health risks. This suggests, that Waterloo Region is likely to experience automation in ways more similar to previous recessions, with health-related automation playing a smaller role than in other regions. To the extent that the workplace is an important vector for COVID-19 transmission, the region's relatively low health risk index also suggests that we may suffer fewer and less severe COVID-19 outbreaks than other regions.

5. Conclusion

In every Canadian recession since the beginning of the ICT revolution, routine jobs have disappeared, never to come back. This suggests that recessions play a crucial role in transforming our economy through automation and reallocation. The same is likely to be true during this COVID-induced economic downturn, except that the transformation is likely to be greater because superimposed on top of the usual recessionary pressures to automate, are health incentives for doing so. A good way for businesses to mitigate COVID-19 risks to their operations is to automate their processes.

The COVID-induced transformation is likely to differ across occupations, industries, income groups, and regions, with the most change likely to occur in units that both face strong health incentives and where automation is feasible. The occupations that are likely to experience the biggest changes include health support, office support, sales support, distribution

coordinators, and manufacturing machine operators. Retail trade is the industry that is likely to experience the biggest transformation, along with accommodations and food services. However, even traditionally non-routine sectors like healthcare and education are likely to see a transformation due to strong incentives to automate.

Job losses are unfortunately most likely to be felt by some of our lowest income workers who will be disproportionately impacted because they are performing routine jobs with high health risks.

The Region of Waterloo has a strong tradition in manufacturing and of embracing technological change. Many of the jobs in the region are highly routine and thus subject to automation. However, due to the region's employment mix workers face the lowest health risks of any of the 23 Canadian MSA/regions examined, suggesting that the overall impact may not be as great as in some of our surrounding municipalities.

Nonetheless, the region needs to prepare for a significant technological transformation. We must embrace change, because automation and reallocation will increase aggregate productivity, increasing our standard of living. However, because the benefits may not be broadly shared, the region must partner with other levels of government and play its role to ensure that all citizens benefit from the forthcoming revolution. This paper aims to inform planning for such action by informing where the impacts are likely to be largest.

With the right policies in place, a richer and fairer Waterloo Region may emerge from the crisis.

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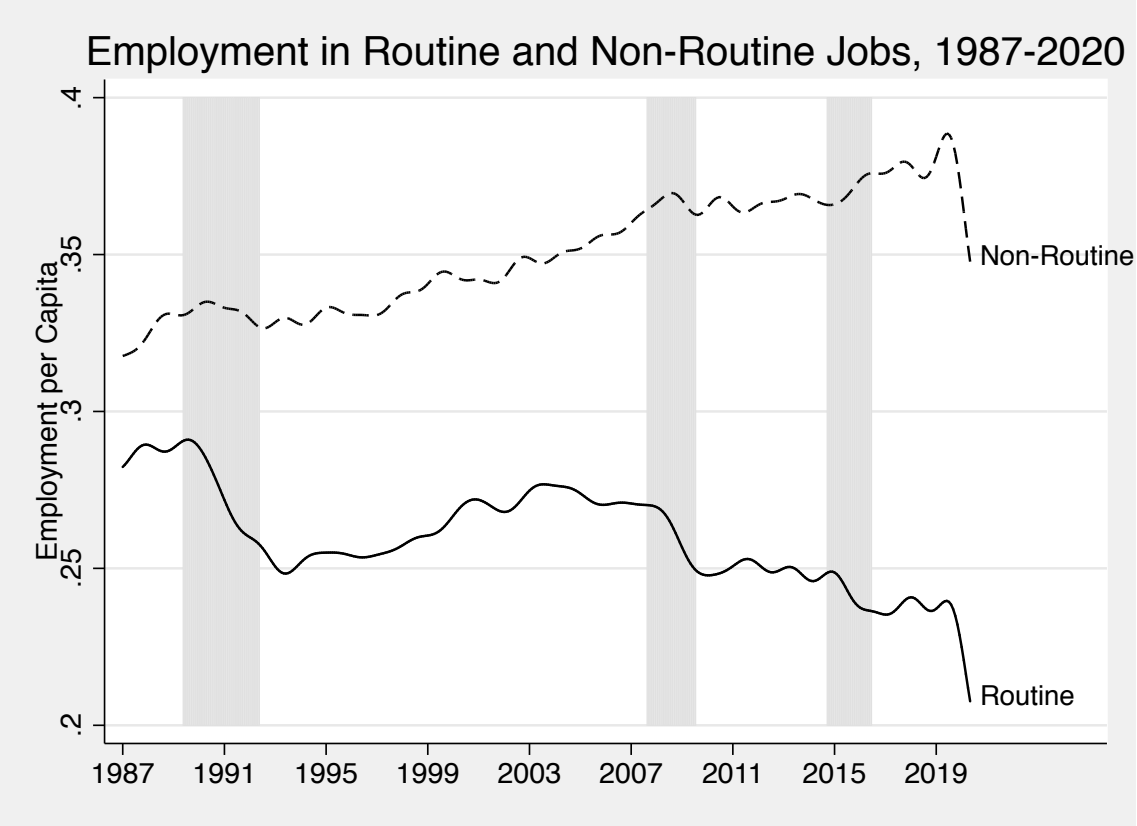
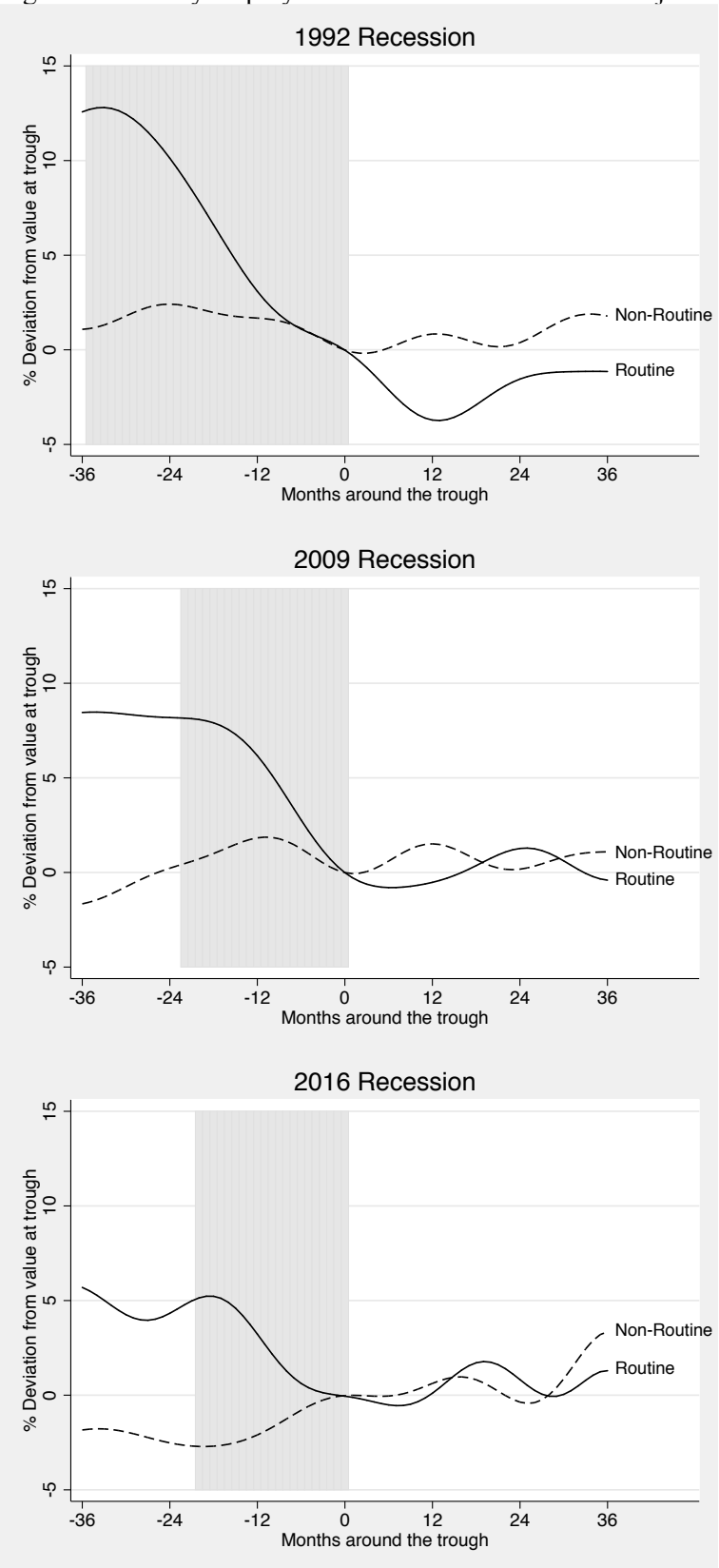
Figures

Figure 1: Canadian monthly employment in routine and non-routine jobs



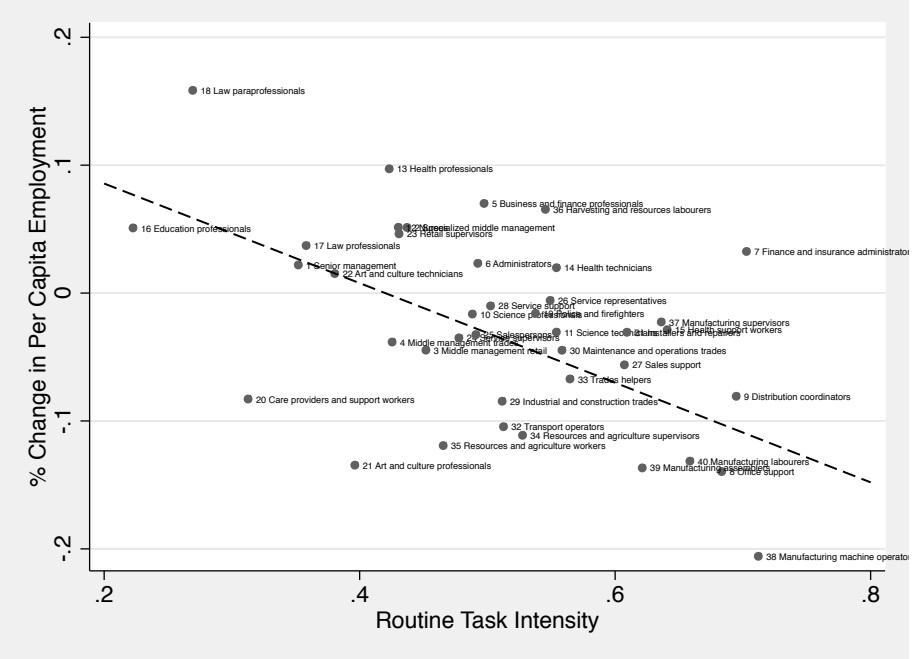
Notes: Time range is January 1987 to May 2020. Shaded periods represent the three most significant economic downturns. Employment series has been smoothed. Source: Blit (2020a).

Figure 2: Monthly employment in routine and non-routine jobs for the 1992, 2009, and 2016 recessions



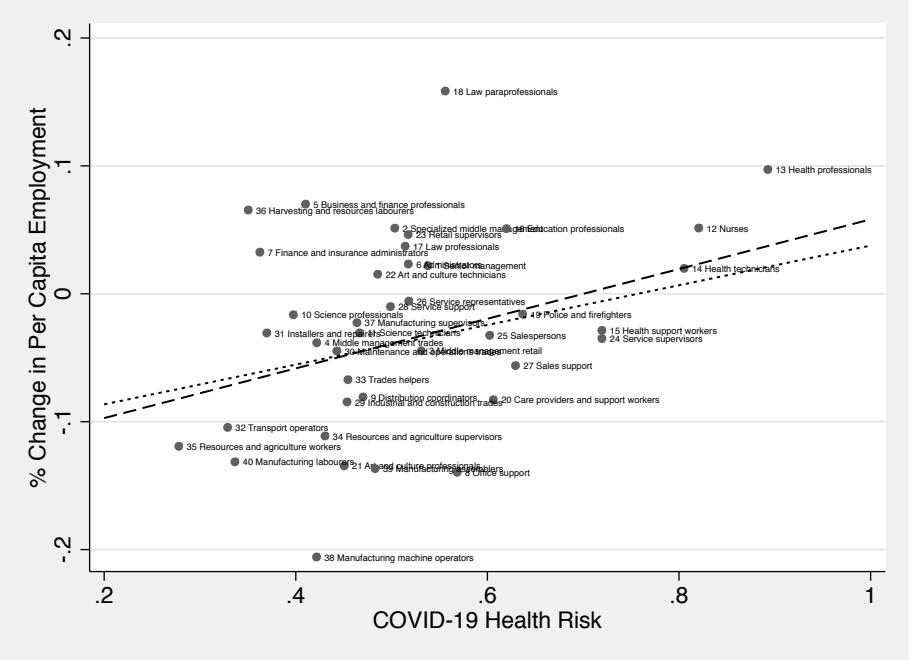
Source: Blit (2020a)

Figure 3: Average percent change in employment per capita over the three recessions and routine task intensity



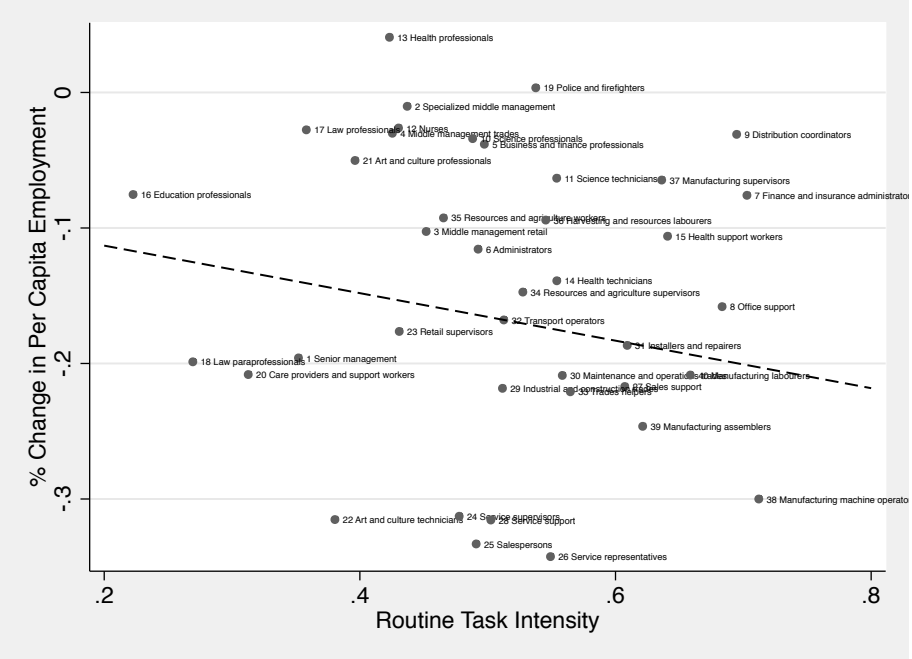
Notes: Average percent peak to trough change in per capita employment for the three recessions. Descriptions of the 40 LFS occupations have been shortened for ease of illustration. WLS fit line with employment as weights. Source: Blit (2020b)

Figure 4: Average percent change in employment per capita over the three recessions and COVID-19 health risk



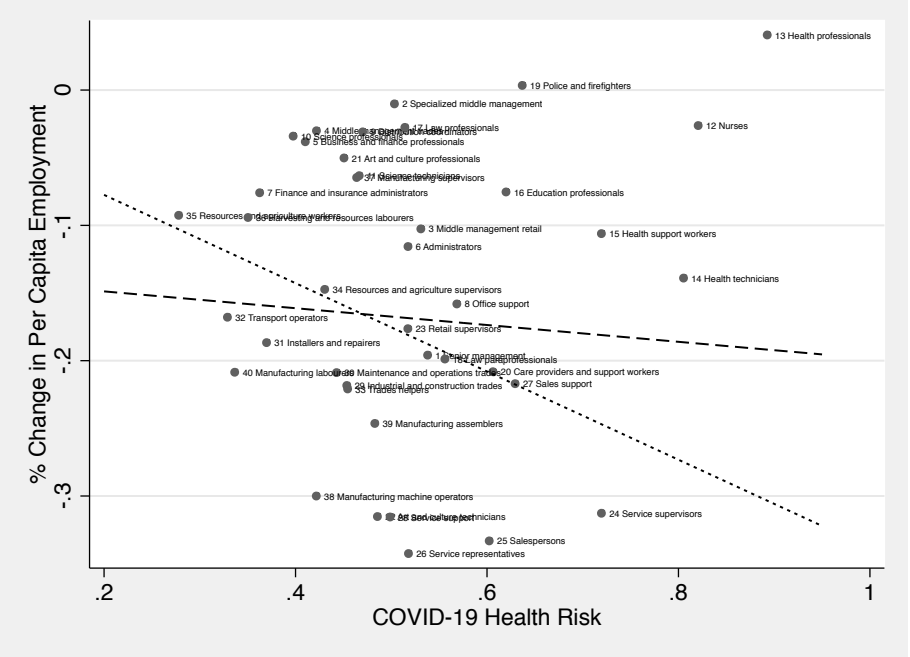
Notes: Average percent peak to trough change in per capita employment for the three recessions. Descriptions of the 40 LFS occupations have been shortened for ease of illustration. Dashed line represents WLS fit line with employment as weights for the full sample. Dotted line is WLS fit line without health (12-15) occupations. Source: Blit (2020b)

Figure 5: COVID-19 peak to trough percent change in employment per capita and routine task intensity



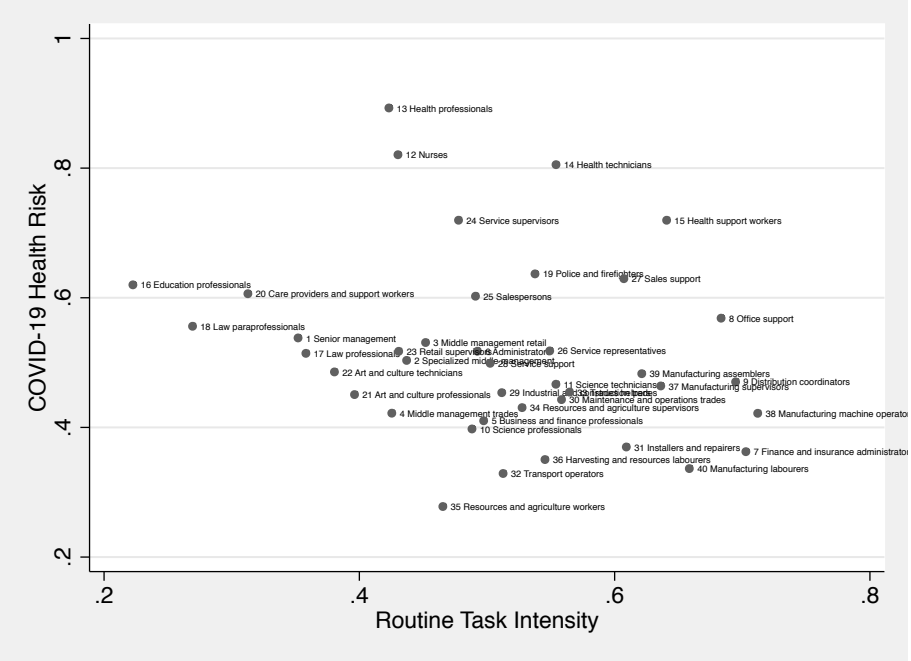
Notes: Percent peak to trough (February to April 2020) change in per capita employment by occupation. Descriptions of the 40 LFS occupations have been shortened for ease of illustration. WLS fit line with employment as weights. Source: Blit (2020b)

Figure 6: COVID-19 peak to trough percent change in employment per capita and COVID-19 health risk



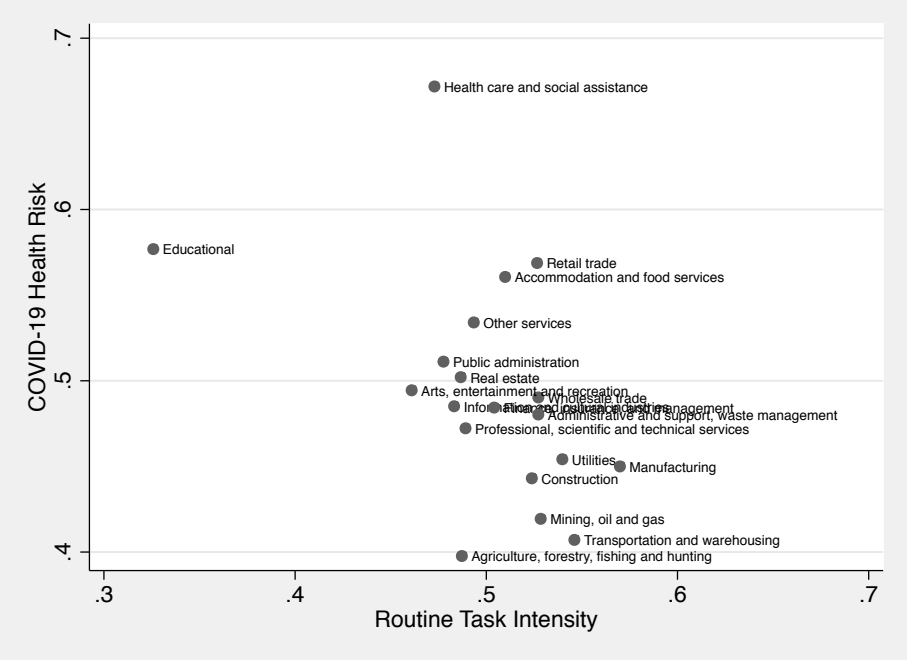
Notes: Percent peak to trough (February to April 2020) change in per capita employment by occupation. Descriptions of the 40 LFS occupations have been shortened for ease of illustration. Dashed line represents WLS fit line with employment as weights for the full sample. Dotted line is WLS fit line without health (12-15) occupations. Source: Blit (2020b)

Figure 7: Occupation COVID-19 health risk and routine task intensity



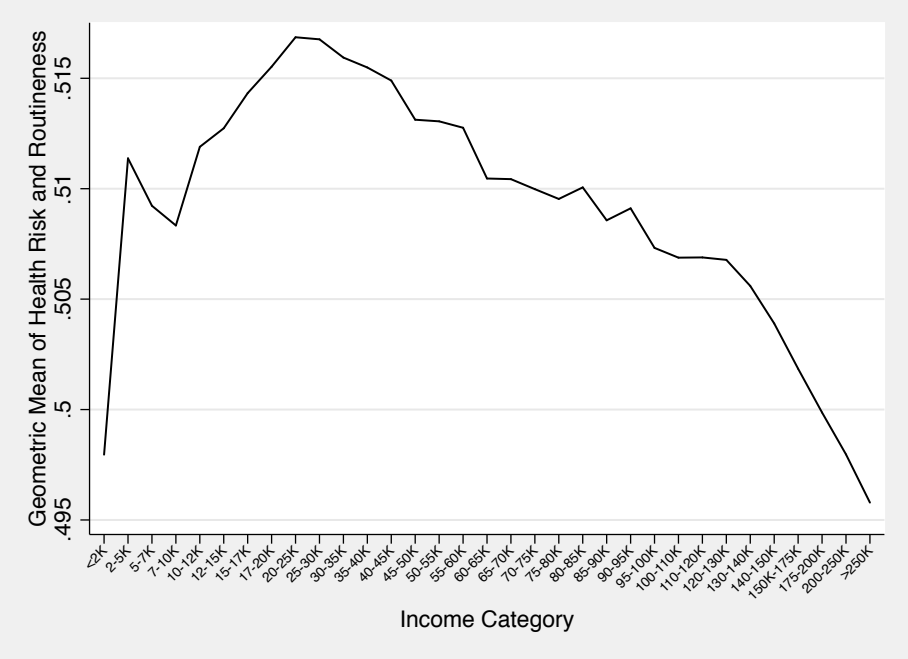
Notes: Indices of COVID-19 health risk and routine task intensity for each of 40 LFS occupation groups. Source: Blit (2020b)

Figure 8: Industry COVID-19 health risk and routine task intensity



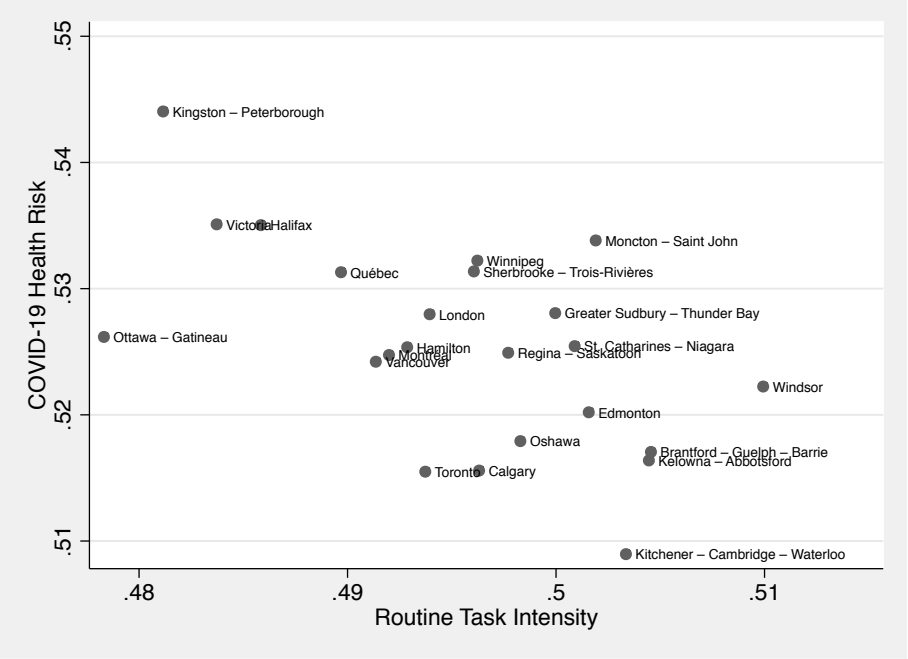
Notes: 19 Census PUMF industry sectors (based on NAICS 2012). Source: Blit (2020b)

Figure 9: Geometric mean of COVID-19 health risk and routine task intensity by family income



Notes: Income is total income of Census family. Source: Blit (2020b)

Figure 10: Canadian metropolitan areas COVID-19 health risk and routine task intensity



Notes: Census PUMF 23 Census Metropolitan Areas or Census agglomerations based on current residence. Some agglomerations have been combined. Source: Blit (2020b)

Tables

Table 1: Index of COVID-19 health risk and subcomponents for each of 40 LFS occupation categories

Occupation	Proximity	Facetoface	Indoor	Exposure	Health index
13 Professional occupations in health (except nursing)	0.90	0.88	0.85	0.94	0.89
12 Professional occupations in nursing	0.89	0.80	0.64	0.96	0.82
14 Technical occupations in health	0.88	0.63	0.78	0.93	0.81
24 Service supervisors and specialized service occupations	0.77	0.62	0.78	0.71	0.72
15 Assisting occupations in support of health services	0.91	0.37	0.66	0.94	0.72
19 Occupations in frontline public protection services	0.82	0.75	0.10	0.88	0.64
27 Sales support occupations	0.74	0.44	0.69	0.65	0.63
16 Professional occupations in education services	0.64	0.60	0.57	0.67	0.62
20 Care providers and educational, legal and public protection support occupations	0.87	0.35	0.37	0.84	0.61
25 Sales representatives and salespersons wholesale and retail trade	0.65	0.87	0.33	0.57	0.60
8 Office support occupations	0.40	0.47	0.81	0.61	0.57
18 Paraprofessional occupations in legal, social, community and education services	0.64	0.43	0.39	0.76	0.56
1 Senior management occupations	0.32	0.82	0.47	0.54	0.54
3 Middle management occupations in retail and wholesale trade and customer services	0.46	0.69	0.50	0.47	0.53
26 Service representatives and other customer and personal services occupations	0.68	0.25	0.62	0.52	0.52
6 Administrative and financial supervisors and administrative occupations	0.21	0.56	0.69	0.60	0.52
23 Retail sales supervisors and specialized sales occupations	0.51	0.70	0.44	0.42	0.52
17 Professional occupations in law and social, community and government services	0.28	0.62	0.61	0.54	0.51
2 Specialized middle management occupations	0.26	0.74	0.62	0.40	0.50
28 Service support and other service occupations, n.e.c.	0.52	0.25	0.59	0.64	0.50
22 Technical occupations in art, culture, recreation and sport	0.59	0.42	0.47	0.46	0.49
39 Assemblers in manufacturing	0.59	0.61	0.51	0.22	0.48
9 Distribution, tracking and scheduling coordination occupations	0.38	0.56	0.47	0.47	0.47
11 Technical occupations related to natural and applied sciences	0.47	0.59	0.41	0.39	0.47
37 Processing, manufacturing and utilities supervisors and central control operators	0.51	0.56	0.31	0.48	0.46
33 Trades helpers, construction labourers and related occupations	0.62	0.56	0.05	0.59	0.45
29 Industrial, electrical and construction trades	0.58	0.55	0.34	0.34	0.45
21 Professional occupations in art and culture	0.53	0.32	0.56	0.39	0.45
30 Maintenance and equipment operation trades	0.51	0.58	0.25	0.43	0.44
34 Supervisors and technical occupations in natural resources, agriculture and related production	0.56	0.57	0.11	0.49	0.43
4 Middle management occupations in trades, transportation, production and utilities	0.35	0.75	0.20	0.39	0.42
38 Processing and manufacturing machine operators and related production workers	0.46	0.30	0.63	0.29	0.42
5 Professional occupations in business and finance	0.25	0.51	0.72	0.17	0.41
10 Professional occupations in natural and applied sciences	0.24	0.49	0.64	0.22	0.40
31 Other installers, repairers and servicers and material handlers	0.50	0.47	0.16	0.35	0.37
7 Finance, insurance and related business administrative occupations	0.19	0.33	0.65	0.29	0.36
36 Harvesting, landscaping and natural resources labourers	0.77	0.14	0.02	0.47	0.35
40 Labourers in processing, manufacturing and utilities	0.51	0.23	0.46	0.14	0.34
32 Transport and heavy equipment operation and related maintenance occupations	0.42	0.20	0.13	0.56	0.33
35 Workers in natural resources, agriculture and related production	0.35	0.23	0.09	0.44	0.28

Source: Blit (2020b)

Table 2: Index of routine task intensity and subcomponents for each of 40 LFS occupation categories

Occupation	Automation	Repetitive	Exact	Structured	Pace	Routine index
38 Processing and manufacturing machine operators and related production workers	0.78	0.57	0.47	0.81	0.92	0.71
7 Finance, insurance and related business administrative occupations	0.74	0.95	0.84	0.65	0.35	0.70
9 Distribution, tracking and scheduling coordination occupations	0.80	0.87	0.65	0.49	0.67	0.69
8 Office support occupations	0.71	0.94	0.75	0.64	0.38	0.68
40 Labourers in processing, manufacturing and utilities	0.71	0.53	0.21	0.92	0.93	0.66
15 Assisting occupations in support of health services	0.54	0.77	0.63	0.72	0.55	0.64
37 Processing, manufacturing and utilities supervisors and central control operators	0.75	0.64	0.46	0.44	0.90	0.64
39 Assemblers in manufacturing	0.44	0.52	0.62	0.71	0.82	0.62
31 Other installers, repairers and servicers and material handlers	0.55	0.48	0.56	0.64	0.82	0.61
27 Sales support occupations	0.48	0.63	0.56	0.84	0.53	0.61
33 Trades helpers, construction labourers and related occupations	0.40	0.44	0.42	0.72	0.84	0.56
30 Maintenance and equipment operation trades	0.36	0.48	0.64	0.60	0.73	0.56
14 Technical occupations in health	0.40	0.69	0.70	0.48	0.51	0.55
11 Technical occupations related to natural and applied sciences	0.65	0.55	0.56	0.50	0.51	0.55
26 Service representatives and other customer and personal services occupations	0.59	0.64	0.44	0.68	0.39	0.55
36 Harvesting, landscaping and natural resources labourers	0.71	0.12	0.06	0.89	0.94	0.55
19 Occupations in frontline public protection services	0.41	0.72	0.69	0.43	0.44	0.54
34 Supervisors and technical occupations in natural resources, agriculture and related production	0.53	0.49	0.29	0.48	0.84	0.53
32 Transport and heavy equipment operation and related maintenance occupations	0.41	0.35	0.28	0.77	0.76	0.51
29 Industrial, electrical and construction trades	0.40	0.34	0.48	0.64	0.71	0.51
28 Service support and other service occupations, n.e.c.	0.56	0.35	0.19	0.79	0.63	0.50
5 Professional occupations in business and finance	0.71	0.57	0.67	0.38	0.16	0.50
6 Administrative and financial supervisors and administrative occupations	0.47	0.81	0.53	0.36	0.30	0.49
25 Sales representatives and salespersons wholesale and retail trade	0.56	0.69	0.33	0.58	0.30	0.49
10 Professional occupations in natural and applied sciences	0.60	0.47	0.50	0.55	0.32	0.49
24 Service supervisors and specialized service occupations	0.41	0.41	0.37	0.54	0.65	0.48
35 Workers in natural resources, agriculture and related production	0.55	0.27	0.14	0.64	0.74	0.47
3 Middle management occupations in retail and wholesale trade and customer services	0.63	0.58	0.38	0.25	0.42	0.45
2 Specialized middle management occupations	0.58	0.53	0.52	0.28	0.27	0.44
23 Retail sales supervisors and specialized sales occupations	0.63	0.54	0.55	0.22	0.22	0.43
12 Professional occupations in nursing	0.32	0.62	0.76	0.24	0.20	0.43
4 Middle management occupations in trades, transportation, production and utilities	0.64	0.33	0.26	0.29	0.61	0.43
13 Professional occupations in health (except nursing)	0.45	0.50	0.69	0.19	0.28	0.42
21 Professional occupations in art and culture	0.20	0.47	0.51	0.51	0.29	0.40
22 Technical occupations in art, culture, recreation and sport	0.31	0.33	0.33	0.50	0.43	0.38
17 Professional occupations in law and social, community and government services	0.41	0.38	0.47	0.38	0.16	0.36
1 Senior management occupations	0.55	0.43	0.29	0.11	0.38	0.35
20 Care providers and educational, legal and public protection support occupations	0.20	0.26	0.21	0.65	0.25	0.31
18 Paraprofessional occupations in legal, social, community and education services	0.22	0.24	0.17	0.61	0.11	0.27
16 Professional occupations in education services	0.16	0.23	0.14	0.37	0.21	0.22

Source: Blit (2020b)

Table 3: Employment shares and routine and health risk indices for Waterloo Region and Canada

	Employment Shares		Indices		
Industry	Waterloo	Canada	Routine	Health risk	Geo. Mean
31-33 Manufacturing	0.168	0.087	0.570	0.450	0.506
44-45 Retail trade	0.116	0.120	0.527	0.569	0.547
62 Health care and social assistance	0.096	0.117	0.473	0.672	0.564
61 Educational services	0.095	0.075	0.326	0.577	0.434
54 Professional, scientific and technical services	0.073	0.073	0.489	0.472	0.481
72 Accommodation and food services	0.070	0.074	0.510	0.561	0.535
23 Construction	0.064	0.075	0.524	0.443	0.482
52 Finance and insurance/55 Management of companies and ente	0.060	0.042	0.504	0.484	0.494
48-49 Transportation and warehousing	0.043	0.047	0.546	0.407	0.471
56 Administrative and support, waste management and remediat	0.040	0.045	0.527	0.480	0.503
81 Other services (except public administration)	0.039	0.045	0.493	0.534	0.513
41 Wholesale trade	0.038	0.034	0.527	0.490	0.508
91 Public administration	0.034	0.062	0.478	0.511	0.494
51 Information and cultural industries	0.026	0.021	0.483	0.485	0.484
71 Arts, entertainment and recreation	0.015	0.022	0.461	0.494	0.477
53 Real estate and rental and leasing	0.012	0.016	0.487	0.502	0.494
11 Agriculture, forestry, fishing and hunting	0.008	0.024	0.487	0.398	0.440
22 Utilities	0.002	0.006	0.540	0.454	0.495
21 Mining, quarrying, and oil and gas extraction	0.001	0.014	0.528	0.419	0.471

Notes: Data is for Kitchener-Cambridge-Waterloo CMA and is based on the 2016 Census Individual Files PUMFs. The geometric mean variable is the geometric mean of the routine task intensity and health risk indices.