The Pandemic and Short-Run Changes in Output, Hours Worked and Labour Productivity: Canadian Evidence by Industry

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Abstract

The official measure of Canadian labour productivity rose by about 15 per cent (not annualized) during the first two quarters of 2020, reflecting a decline in total hours worked that exceeded an exceptional decline in output. We analyze this short-run change using monthly data disaggregated to 87 industries, focusing for analytical reasons on changes from April 2018 to April 2020 and August 2018 to August 2020. Just over one-fifth of the April labour productivity increase, and just under three-fifths of the smaller August increase, can be associated with the changing hours composition across industries. Estimated indices for the feasibility of working from home, the degree of worker health (COVID) risk, and the extent workers in the industry are customer-facing are not associated with the short-run changes in labour productivity by industry. However, there is clear evidence that industries with high work from home index values tended to have smaller reductions in output and hours.

As it has internationally, the COVID-19 crisis has had a massive and historically exceptional impact on the Canadian economy. Surprisingly, the crisis produced

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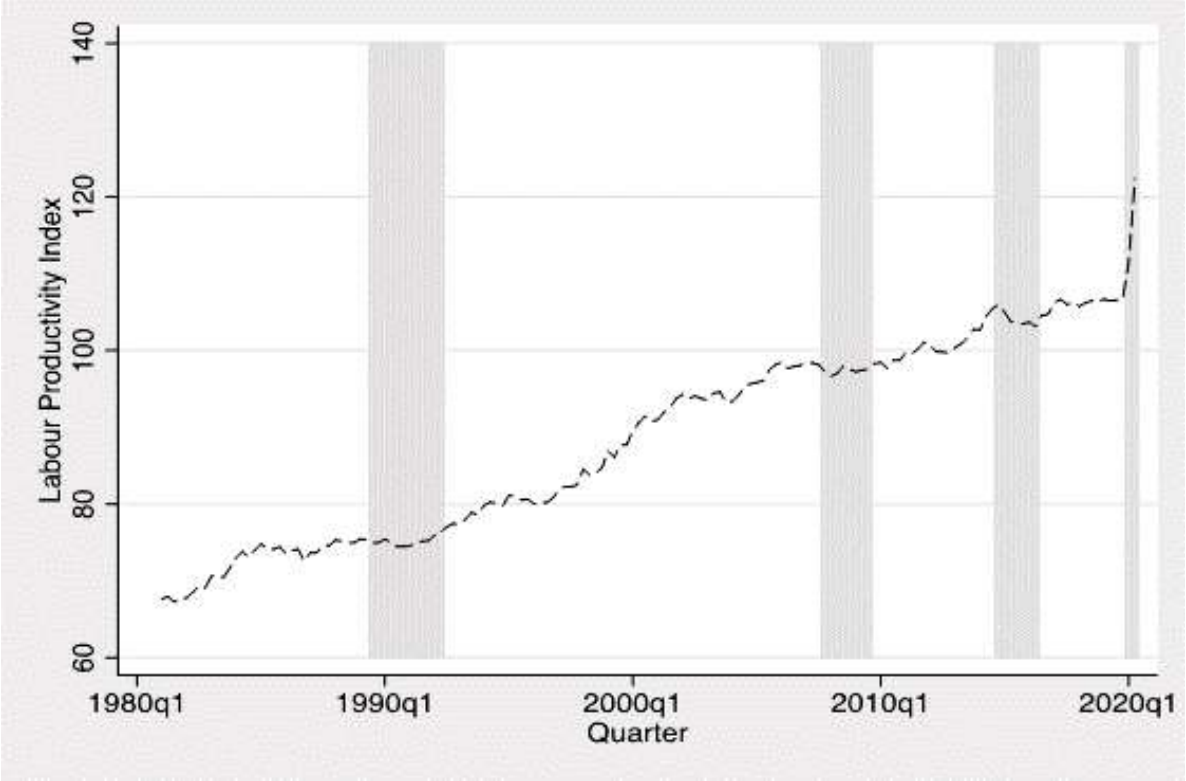
an immediate massive and unprecedented increase in measured labour productivity, as shown in Chart 1, where major economic downturns are shaded in grey and it can be seen in each other case that labour productivity actually fell. Specifically, the official Statistics Canada business sector productivity measure rose on a seasonally-adjusted basis by about 15 per cent from 2019Q4 to 2020Q2. However, far from being a sign of economic health, the sudden spike in labour productivity is the opposite. The COVID-19 pandemic appears to have caused a more than 15 per cent reduction in real business sector GDP over the same two-quarter period. However, total business sector labour hours fell by a much greater 28 per cent over that same period, resulting in the observed increase in labour productivity. Gu (2020) notes that a similar but smaller increase was already evident in first quarter 2020 data.

A number of labour market studies that have emerged since the beginning of the crisis are informative as to why hours worked fell more than real GDP. One key finding by Lemieux, Milligan, Schirle and Skuterud (2020) using Statistics Canada's Labour Force Survey data, was that the employment losses associated with the pandemic were disproportionately borne by those with low wages. This is at least a partial explanation for why total labour compensation per hour worked actually rose during the pandemic, by 20.3 per cent from 2019Q4 to 2020Q2, using data from the same Statistics Canada table as Chart 1. There was a compositional effect as workers with lower wages lost jobs and work hours disproportionately. This inequality-increasing loss of work is consistent with the measured productivity rise (as lower wage workers also make smaller measured contributions to real GDP).

Following up on the Lemieux *et al.* (2020) study and other initial LFS studies such as Gallacher and Hossain (2020), in this article we incorporate changes in real GDP and hence investigate measured labour productivity. Because we want to capture the deepest point in the trough in April, 2020 as well as obtain some idea of the extent of recovery using the most recent data (August, 2020, as the 2020Q3 data are not yet available at time of writing), we somewhat unconventionally construct our estimates using monthly data. Second, we pursue an industry approach at a relatively fine disaggregation. This allows discussion of industry composition effects and also permits some investigation of how different industry characteristics may have mattered during the pandemic. Because some industries have both business and non-business sector elements, the non-business sector is included in this analysis.

We matched real GDP data to Labour Force Survey data using the North American Industry Classification System (NAICS) 3-digit level. We find that just over one-fifth of the estimated April, 2020 rise in labour productivity can be associated with changes in industry shares of hours worked (both from net job losses as well as from changes in hours among those who remain employed). The comparable fraction for the smaller increase in August, 2020 is just under three-fifths. We then use the O*NET database to construct indices for three attributes of employment in each industry that may matter during the pandemic: the feasibility of working from

Chart 1: Business Sector Labour Productivity in Canada, 1980-2020



Note: Major economic downturns are shaded in grey.
Source: Statistics Canada, Table 36-10-0206-01

home, the health (COVID) risk to workers, and the average degree to which persons employed in that industry face customers. We then explore how short-run changes in each industry's output, hours worked and productivity per labour hour are associated with the three indices.[2]

Of the three indices, we find that only the feasibility of working from home is clearly associated with changes in real GDP and hours worked: the greater the possibility of working from home, the less was the reduction in real GDP and hours worked so far during the pandemic. While this is not surprising, some of the labour market studies (e.g. Gallacher and Hossain, 2020, who used 2-digit industries) found only weak evidence that the possibility of remote work was protective of employment. None to our knowledge extended the analysis to include real GDP or labour productivity. Our estimates do not indicate comparably strong relationships involving either the health risk or consumer facing indices. Changes in labour productivity as measured by real GDP to hours worked were not associated with any of the indices.

The first major section of the article will provide a very brief review of some of the recent and relevant literature. The second

2 Blit (2020a) performs a related analysis, examining which Canadian industries have the highest health risk index and fraction of routine employment, to determine which industries are likely to experience the most automation (and hence the largest increases in long-run productivity) as a result of the COVID-19 crisis.

section will describe the analysis. The third section concludes.

Recent Literature and Findings

In this section we provide a brief literature review that makes two essential points. First, the estimated rise in labour productivity is consistent with studies of the Canadian labour market that note that lower wage workers lost their jobs disproportionately with the pandemic. That literature also has discussed the association of job loss with working at home, one of the three factors we focus on in our discussion of industry productivity. Second, while there is so far relatively little in the literature relevant to the second factor we study, the COVID risk of working in an industry, there are some findings relevant to our third factor, the degree to which workers in the industry are customer facing. There is evidence that customer traffic fell even before government restrictions were introduced as well as evidence that customers were resistant to "facing" in certain industries.

Beginning with the labour market side, as noted, some of the earliest economic analysis of the pandemic was based on the Labour Force Survey (LFS), which is extremely timely, released within ten days of the end of the reference month. For example, Lemieux *et al.* (2020) use the LFS to document that the COVID recession reduced the employment and total hours of low-wage workers much more than for workers with higher wages. Women, particularly those with younger children (see also Qian and Fuller, 2020) lost employment and hours disproportionately as did the young and those not in unions. The findings of Beland, Fakorede and Mikola (2020) and Mo, Cukier, Atputharajah, Boase and Hon (2020) for the self-employed and business owners are similar in that businesses owned by those in historically disadvantaged demographic groups appear to have been relatively harder hit.

Still more recent work from a large project, designed in part to guide economic reopening, finds more extensive evidence that the COVID recession has worsened income inequality, which again we note is consistent with real GDP not falling as much as hours worked (Baylis *et al.* 2020).

Hossain and Gallacher (2020), Deng, Morissette and Messacar (2020) and Jones, Lange, Riddell and Warman (2020) analyze the working from home aspect. The first two papers use the DN approach[3] (Dingel and Neiman, 2020) to find that about 40 per cent of jobs in Canada can be done remotely from the workplace.[4] Hossain and Gallacher (2020) find that workers are less

3 The Dingel and Neiman approach established the usefulness of the O*NET approach that we also use in our analysis. To give some examples of their classification rules, they classify an occupation as one that cannot be performed at home if respondents say on average that their job rarely uses email, involves violent people, is often outdoors, requires exposure to disease, entails frequent minor injuries such as burns or cuts, involves considerable walking, running, moving of objects or other physical activity, requires protective or safety equipment, requires machines besides computers, involves working directly with the public, or entails repairing, maintaining or inspecting equipment or structures.

4 It is perhaps interesting that these estimates are close to the pre-pandemic estimate of Chen and Mehdi (2019) that 41.5 per cent of jobs have significant flexibility in working hours, even though flexible working hours and working from home are different.

likely to have the possibility of working remotely if they are poor, male, in the private sector (especially in smaller firms), single, seasonal, contractual or part-time, younger, non-immigrant, and have no college degree. Deng *et al.* have similar findings. Working with industry data disaggregated by 2-digit NAICS code, Gallacher and Hossain (2020) find only relatively weak evidence of a relationship between the preservation of employment at COVID onset and their estimates of the average industry possibility of remote work.

Jones *et al.* (2020) emphasize vacancy data. They apply the DN method to National Occupation Classification at the 4-digit level and then aggregate to the 2-digit level using the 2016 Census. They find no evidence of more vacancies for jobs with higher remote work potential.

Still the importance of working from home has been documented. [5] The LFS for April 2020 reported that during the reference week of April 12-18, of the 12 million Canadians that were employed and working more than 50 per cent of their usual hours, 5 million worked mostly from home. That included 3.3 million workers who normally worked in a location other than their home. Savage and Turcotte (2020), using data from the Statistics Canada nationally-representative Canadian Perspectives Survey Series, find that in June 2020 about 22 per cent of Canadian workers were working from home.[6]

Another strand of the recent literature has tried to identify the degree to which the reduction in economic activity was due to regulation ("the government shut down the economy") or to independent individual behavioural change ("the people shut down the economy"). For the United States, Goolsbee and Syverson (2020) used cellphone tracking data to find that much of the economic decline preceded restrictions. Of the average 60 per cent decline in consumer traffic, they found that only 7 percentage points could be attributed to policy.

Armstrong, Lebo and Lucas (2020) examine data for 75 U.S. and Canadian cities and find that applicable regulations designed to reduce COVID spread were not dissimilar in extent and timing across the two countries. Hence differences in outcomes are plausibly driven by individual choices and not regulation. Consistent with this, Chan (2020) finds evidence for Canada of substantial social distancing prior to regulation.

Any attempt to disentangle the effects of government regulation from individual choices will be hampered by the identification problem that in Canada, imposed restrictions were similar and fairly synchronous across provinces. Moreover, it is

5 The distinction between "working remotely" and "working from home" is not always clear. Since we use the classification approach of Dingel and Neiman (2020) we adopt their terminology of feasibility of "working from home". Among the variables that make up the index are variables such as whether a job is performed outside, that preclude working from home but do not necessarily preclude working remotely in a different outdoor location. When we refer to an article we use the term the authors most commonly use.

6 Further, while we know of no comparable estimate for Canada, Barrero, Bloom and Davis (2020) estimate that after the COVID crisis, one in ten jobs (and 20 per cent of office jobs) will have permanently switched to work from home as part of very large predicted labour market changes, with 32 per cent to 42 per cent of COVID-induced layoffs permanent.

difficult to assess when and if regulations were binding. For example, it seems clear that the relaxation of regulations in summer 2020 did correspond to increased economic output in the restaurant sector but that does not imply that further relaxation (e.g. permitting closer tables) would expand output further.

With respect to consumer attitudes, Langevin and Turcotte (2020) analyze responses to questions from Statistics Canada's Canadian Perspectives Survey Series in June, 2020 and find that 38 per cent of individuals were very concerned about going to restaurants and bars while an additional 50 per cent were somewhat concerned. Further examples of the (very concerned, somewhat concerned) numbers were for mass events (66 per cent, 27 per cent), air travel (64 per cent, 30 per cent), shopping (24 per cent, 62 per cent) and personal care appointments (17 per cent, 57 per cent).[7] We can see these concerns reflected in the change in output in some of the industries we study. Still, as mentioned and will be discussed further, we find no strong association between changes in either output or work hours and our index of customer facing. This is consistent with the view that the degree of customer facing does not matter as much as how essential the product is.

Analysis of Industry Data

As has been mentioned, in order to study the trough of the spring COVID recession in April 2020 as well as to be able to study the extent of the recovery by August, 2020 (most recent data at time of writing), we use monthly data. No official monthly data on productivity are available and even the quarterly data are not available at the level of industry disaggregation that we use. For the labour productivity calculation, our numerator is real GDP by month and our denominator is total main job hours worked by industry.[8] Because the latter is not available on a seasonally adjusted basis we used non-seasonally adjusted data (for the numerator trading-day

7 Besides imposition of and relaxation of restrictions, the other major policy initiatives have been large expenditures on income support. These presumably have affected consumer expenditure by industry although Chetty *et al.* (2020) have found using data by county, industry, and income group that in the United States, high-income individuals initially largely saved their COVID-related transfer payments. (Low-income individuals increased their spending but very little of the increase flowed to businesses most affected by the COVID-19 shock.) While we know of no comparable analysis for Canada, we note that in Canada as in the United States, second quarter 2020 saving rates were both in excess of 25 per cent, a massive increase over their normal values of around 7 per cent or less.

8 Real GDP estimates by industry, classified using North American Industrial Classification System (NAICS) 3-digit codes, are obtained from Statistics Canada, Table 36-10-0434-01. Total hours in main job were obtained from the LFS and are founf in to Table 14-10-0036-01, except the finer level of NAICS disaggregation which required access through the Statistics Canada's Real Time Remote Access (RTRA) system (https://www.statcan.gc.ca/eng/rtra/rtra). Matching the real GDP industry data by industry to the LFS industries requires a concordance to convert the Statistics Canada GDP industry codes to 2007 3-digit NAICS codes, available at: https://www.statcan.gc.ca/eng/statistical-programs/document/1301_D2_V2. The concordance of the 2007 and 2012 NAICS codes is available at: https://www.statcan.gc.ca/eng/subjects/standard/naics/2012/concordances-2007-2012-2. Note because the NAICS codes are virtually unchanged at the 3-digit level since 2007, the resulting classification is essentially the 2017 NAICS codes with a few small sub-aggregations required to fit the LFS. Also note there are aggregation issues given that real GDP estimates are chained (2012) dollars. Table 1 gives the aggregate results for the 87 industries.
The main job hours worked variable is the only industry allocation available in the Labour Force Survey. In the official productivity statistics, an estimate for all hours worked is made using unpublished historical data.

Table 1: Estimates of Per Cent Change of Real GDP and Productivity as if Labour Productivities were Constant by Industry April 2018 to April 2020 and August 2018 to August 2020

	Actual	As if Industry Labour Productivities Constant*
April 2018 to April 2020		
real GDP	-15.0	–26.1
hours worked	-29.2	-29.2
labour productivity	20.1	4.4
August 2018 to August 2020		
real GDP	-2.6	-5.0
hours worked	-8.1	-8.1
labour productivity	6.0	3.5

*Assumes only the composition of hours worked by industry changed while measured labour productivity by industry remained unchanged. Therefore the value for the hours worked row is the actual change. The value for the labour productivity row is how much labour productivity would have changed if only the composition of hours worked had changed and not labour productivity by industry nor total hours worked.
Source: Authors' calculations based on Statistics Canada data.

adjusted, the only non-seasonally adjusted option available). Following Lemieux, Milligan, Schirle and Skuterud (2020), we focus on April 2018 to April 2020 changes, skipping 2019 because the Labour Force Survey reference week for April, 2019 included Easter. For consistency, we also use August 2018 to August 2020 per cent changes. The use of April over April and August over August rates of change is intended to diminish the effects of seasonality.

As a validation exercise, we group our monthly data for April, May and June for both 2018 and 2020 and use our methods to estimate 2018Q2 to 2020Q2 per cent changes, which were -10.8 per cent for real GDP, -21.5 per cent for hours worked and 13.7 per cent for labour productivity. The Statistics Canada official estimates (Table 36-10-0206-01) were -15.2 per cent for real GDP, -26.4 per cent for hours worked and 15.3 per cent for labour productivity. It is not surprising that our estimated magnitudes for changes in real GDP and hours are smaller than the official estimates, because our estimates are for the full economy and the official estimates are for the business sector, where the non-business sector has been substantially more stable.[9]

Table 1 shows that for our focus period, April, 2018 to April, 2020, the estimated per cent changes in real GDP were -15.0 per cent, for hours worked -29.2 per cent and for labour productivity 20.1 per cent. The table also shows a calculation in which it is assumed that productivity by industry is constant and only the composition of work hours by industry changed. This "as if" calculation identifies the separate effect of shifts in work hours to industries that were always more productive, as dis-

9 The paper was completed before the 2020Q3 official productivity estimates were available but we note from their recent release that the 2018Q3 to 2020Q3 official increase in business sector labour productivity was 4.4 per cent, not too far from our August 2018 to August 2020 estimate for all-sector productivity of 6.0 per cent in Table 1, just as the 2018Q2 to 2020Q2 official value of 17.0 per cent is reasonably close to our 20.1 per cent in Table 1.

tinct from the influence of changes in productivity that occurred within industries. Under this "as if" scenario, output would have fallen by more than it actually did. Moreover, we can see that labour productivity would have increased by 4.4 percentage points from the compositional effect in changing hours worked by industry. This is just over one fifth of the actual change.

For August, the actual per cent changes in real GDP, hours worked and labour productivity are smaller, but the increase in measured labour productivity of 6.0 per cent is still substantial, where 3.5 percentage points, or about three-fifths of its total change, can be attributed to the compositional effect.

What might explain the rest? With these data we can only speculate but one possibility is compositional effects within industries (e.g. laying off office cleaners as work is shifted to home). Firms may also disproportionately lay off more poorly performing employees. Low productive firms may shut down and surviving firms may shut down their low productivity activities. Finally, firms may disproportionately lay off workers who make longer-term contributions (e.g. workers in product development) because the return to such activities is now more uncertain. Such a decision may have long-term negative effects on productivity growth.

Working from Home and Other Factors

To conduct the remaining industry analysis, we constructed indices for feasibility of working from home, health (COVID) risks and customer facing, for all 87 NAICS 3-digit industries (see Table 2 for the list of industries) for which we have monthly real GDP and aggregate hours worked. All three indices were constructed using the O*NET database by generating an index for each occupation and then aggregating to obtain an industry-level index. In particular, we convert O*NET's 974 Standard Occupational Classification (SOC) occupations into 494 4-digit Canadian National Occupational Classification (NOC) occupations using a concordance developed by the Brookfield Institute. We then compute the index for each industry as a weighted average of the index for each occupation in that industry, where the weights are the fraction of workers in the industry that are employed in each occupation (these fractions are obtained from the 2016 Canadian Census of Population).

We construct our working from home index following Dingle and Neiman (2020) who draw on nine questions from O*NET's Work Context survey and eight questions from the Generalized Work Activities Survey. We obtain the estimate that overall, 41 per cent of all Canadian jobs can be feasibly performed from home, closely matching the results for similar exercises, including the original Dingle and Neiman (DN) calculation for the United States as well as the Gallacher and Hossain (2020) and Deng *et al.* (2020) calculations mentioned above for Canada.

Our health risk index measures the risk of communicable disease and is constructed following Blit (2020b). It draws on four questions from the O*NET Work Context survey relating to whether the individual works in close proximity to others, how often they engage in face to face discussions,

Table 2: Estimated Remote Work, Health Risk and Consumer Facing Values for 3-digit NAICS Industries in Canada

NAICS code	NAICS title	Work from Home value and quartile		Health Risk value and quartile		Consumer Facing value and quartile	
113	Forestry and logging	0.152	1	0.273	1	0.347	1
114	Fishing, hunting and trapping	0.048	1	0.506	3	0.105	1
115	Support activities for agriculture and forestry	0.267	2	0.370	1	0.457	2
11A	Crop and animal production	0.455	3	0.357	1	0.351	1
211	Oil and gas extraction	0.509	3	0.425	1	0.426	2
212	Mining and quarrying (except oil and gas)	0.239	1	0.435	2	0.339	1
213	Support activities for mining, and oil and gas extraction	0.321	2	0.435	2	0.432	2
221	Utilities	0.497	3	0.467	3	0.455	2
230	Construction	0.172	1	0.461	3	0.443	2
311	Food manufacturing	0.195	1	0.424	1	0.364	1
312	Beverage and tobacco product manufacturing	0.334	2	0.423	1	0.462	2
31X	Textile, clothing and leather product manufacturing	0.244	1	0.428	1	0.312	1
321	Wood product manufacturing	0.189	1	0.405	1	0.284	1
322	Paper manufacturing	0.261	2	0.454	2	0.278	1
323	Printing and related support activities	0.484	3	0.435	2	0.436	2
324	Petroleum and coal product manufacturing	0.350	2	0.428	1	0.364	1
325	Chemical manufacturing	0.427	3	0.460	3	0.372	1
326	Plastics and rubber products manufacturing	0.246	1	0.441	2	0.302	1
327	Non-metallic mineral product manufacturing	0.273	2	0.410	1	0.417	2
331	Primary metal manufacturing	0.229	1	0.415	1	0.265	1
332	Fabricated metal product manufacturing	0.276	2	0.425	1	0.318	1
333	Machinery manufacturing	0.401	3	0.436	2	0.363	1
334	Computer and electronic product manufacturing	0.620	4	0.439	2	0.407	1
335	Electrical equipment, appliance and component manufacturing	0.475	3	0.450	2	0.398	1
336	Transportation equipment manufacturing	0.279	2	0.457	2	0.336	1
337	Furniture and related product manufacturing	0.256	2	0.457	2	0.386	1
339	Miscellaneous manufacturing	0.429	3	0.461	3	0.412	2
411	Farm product merchant wholesalers	0.465	3	0.423	1	0.561	3
412	Petroleum and petroleum products merchant wholesalers	0.557	4	0.412	1	0.579	3
413	Food, beverage and tobacco merchant wholesalers	0.412	3	0.439	2	0.598	3
414	Personal and household goods merchant wholesalers	0.616	4	0.461	3	0.643	4
415	Motor vehicle and motor vehicle parts and accessories merchant wholesalers	0.466	3	0.468	3	0.619	3
416	Building material and supplies merchant wholesalers	0.516	3	0.440	2	0.619	3
417	Machinery, equipment and supplies merchant wholesalers	0.654	4	0.448	2	0.595	3
418	Miscellaneous merchant wholesalers	0.477	3	0.431	1	0.570	3
441	Motor vehicle and parts dealers	0.375	3	0.509	3	0.628	3
442	Furniture and home furnishings stores	0.377	3	0.548	4	0.742	4
443	Electronics and appliance stores	0.404	3	0.547	4	0.743	4
444	Building material and garden equipment and supplies dealers	0.316	2	0.548	4	0.732	4
445	Food and beverage stores	0.267	2	0.594	4	0.746	4
446	Health and personal care stores	0.304	2	0.675	4	0.786	4
447	Gasoline stations	0.211	1	0.512	3	0.599	3
448	Clothing and clothing accessories stores	0.294	2	0.588	4	0.809	4
451	Sporting goods, hobby, book and music stores	0.319	2	0.586	4	0.798	4
452	General merchandise stores	0.293	2	0.585	4	0.748	4
453	Miscellaneous store retailers	0.359	2	0.562	4	0.756	4
454	Non-store retailers	0.545	4	0.474	3	0.680	4
481	Air transportation	0.267	2	0.533	4	0.766	4
482	Rail transportation	0.208	1	0.470	3	0.398	1
483	Water transportation	0.230	1	0.495	3	0.456	2
484	Truck transportation	0.193	1	0.282	1	0.573	3
486	Pipeline transportation	0.640	4	0.444	2	0.446	2
488	Support activities for transportation	0.425	3	0.423	1	0.556	2
48Z	Transit, ground passenger and scenic and sightseeing transportation	0.116	1	0.497	3	0.657	4
493	Warehousing and storage	0.402	3	0.424	1	0.461	2
49A	Postal service, couriers and messengers	0.315	2	0.413	1	0.543	2
511	Publishing industries	0.865	4	0.421	1	0.503	2
512	Motion picture and sound recording industries	0.478	3	0.484	3	0.543	2
515	Broadcasting (except Internet)	0.613	4	0.455	2	0.580	3
517	Telecommunications	0.701	4	0.445	2	0.610	3
518	Data processing, hosting, and related services	0.937	4	0.439	2	0.396	1

NAICS code	NAICS title	Work from Home value	Work from Home quartile	Health Risk value	Health Risk quartile	Consumer Facing value	Consumer Facing quartile
519	Other information services	0.589	4	0.591	4	0.632	3
524	Finance and insurance	0.961	4	0.478	3	0.710	4
52A	Financial investment services, funds and other financial vehicles	0.962	4	0.460	2	0.559	3
52X	Credit, intermediation and monetary authorities	0.970	4	0.458	2	0.604	3
531	Real estate	0.488	3	0.463	3	0.643	4
53B	Rental and leasing services and lessors of non-financial intangible assets (except copyrighted works)	0.329	2	0.483	3	0.634	3
541	Professional, scientific and technical services	0.851	4	0.446	2	0.518	2
561	Administrative and support services	0.361	3	0.460	2	0.506	2
562	Waste management and remediation services	0.216	1	0.392	1	0.441	2
611	Educational services	0.814	4	0.590	4	0.496	2
621	Ambulatory health care services	0.218	1	0.742	4	0.713	4
622	Hospitals	0.225	1	0.734	4	0.669	4
623	Nursing and residential care facilities	0.213	1	0.669	4	0.600	3
624	Social Assistance	0.266	2	0.576	4	0.491	2
713	Amusement, gambling and recreation industries	0.254	2	0.550	4	0.617	3
71A	Performing arts, spectator sports and related industries, and heritage institutions	0.526	4	0.441	2	0.513	2
721	Accommodation services	0.118	1	0.544	4	0.641	4
722	Food services and drinking places	0.057	1	0.606	4	0.715	4
811	Repair and maintenance	0.157	1	0.417	1	0.389	1
812	Personal and laundry services	0.136	1	0.706	4	0.740	4
813	Religious, grant-making, civic, and professional and similar organizations	0.705	4	0.520	3	0.636	3
814	Private households	0.310	2	0.594	4	0.308	1
911	Federal government public administration	0.655	4	0.484	3	0.611	3
912	Provincial and territorial public administration	0.672	4	0.508	3	0.640	4
913	Local, municipal and regional public administration	0.372	3	0.500	3	0.631	3
914	Aboriginal public administration	0.579	4	0.494	3	0.608	3
	Simple average of all industries	0.405		0.482		0.530	

Source: Author's calculations using 2016 Canadian Census for Population using O*Net data and the Brookfield crosswalk as described in Vu (2019).

how often their job exposes them to disease/infections, and whether they (do not) work outdoors. For each question, each occupation is assigned a percentile rank relative to the other 973 occupations. The index for an occupation is then constructed as the average of its four percentile ranks.

Lastly, our customer facing index is constructed by the occupation's percentile rank on average responses to the question "How important it is to work with external customers or the public in this job" where arguably this will in most cases imply face to face contact.

Our index values are reported in Table 2. In each case they are reported along with their quartile position for that index, so that for example 114, fishing, hunting and trapping, is in the first quartile for work from home (meaning it is difficult to work from home), the 3rd quartile for health risk (as many of those in the fishing industry work in close proximity with others), and in the first quartile for consumer facing (meaning little direct contact with customers).

Table 3 re-organizes a fraction of the above information by reporting the top 5 and bottom five values for each category. The results seem intuitive. For example, forestry and logging have low health risk from communicable disease such as COVID while the health care industries have a high risk. Note that the four types of manufacturing listed in the bottom five of customer facing are representative of many

Table 3: Bottom and Top 5 Values for Work from Home, Health Risk from COVID and Customer Facing by 3-digit Industry

Bottom five values, Work from Home		
114	Fishing, hunting and trapping	0.048
722	Food services and drinking places	0.057
48Z	Transit, ground passenger and scenic and sightseeing transportation	0.116
721	Accommodation services	0.118
812	Personal and laundry services	0.136
Top five values, Work from Home		
511	Publishing industries	0.865
518	Data processing, hosting, and related services	0.937
524	Finance and insurance	0.961
52A	Financial investment services, funds and other financial vehicles	0.962
52X	Credit, intermediation and monetary authorities	0.970
Bottom five values, Health Risk from COVID		
113	Forestry and logging	0.273
484	Truck transportation	0.282
11A	Crop and animal production	0.357
115	Support activities for agriculture and forestry	0.370
562	Waste management and remediation services	0.392
Top five values, Health Risk from COVID		
623	Nursing and residential care facilities	0.669
446	Health and personal care stores	0.675
812	Personal and laundry services	0.706
622	Hospitals	0.734
621	Ambulatory health care services	0.742
Bottom five values, Customer Facing		
114	Fishing, hunting and trapping	0.105
331	Primary metal manufacturing	0.265
322	Paper manufacturing	0.278
321	Wood product manufacturing	0.284
326	Plastics and rubber products manufacturing	0.302
Top five values, Consumer Facing		
453	Miscellaneous store retailers	0.756
481	Air transportation	0.766
446	Health and personal care stores	0.786
451	Sporting goods, hobby, book and music stores	0.798
448	Clothing and clothing accessories stores	0.809

Source: Based on Table 2.

other types of manufacturing that featured at the bottom of the list with values only slightly higher.

Table 4 presents the per cent changes from April 2018 to April 2020 and from August 2018 to August 2020 for each of the quartiles of work from home, health risk and consumer facing.

For real GDP, there only appears to be a recognizable pattern in the case of Work from Home. The reductions tend to be smaller for industries with higher feasibility of working from home, with a reduction of only 9 per cent for the quartile with highest work from home, by far the smallest April output loss. For the smaller August real GDP losses, it also appears that the reductions were less substantial in industries with high work from home indices. There are no other output patterns for the other categories, although the most substantial April output reduction was for the high health risk quartile, and this in spite of many health sectors (where health risks are highest) having expanded due to the health nature of the crisis.

Table 4: Per Cent Changes in Real GDP, Hours Worked and Measured Labour Productivity By Estimated Work from Home, Health Risk and Customer Facing Industry Quartiles, April 2018 to April 2020 and August 2018 to August 2020

Quartile	Work from Home		Health Risk		Customer Facing	
	April	August	April	August	April	August
Real GDP						
1	-29	-10	-16	-2	-25	-8
2	-32	-10	-24	-10	-19	-6
3	-20	-1	-17	-1	-17	-1
4	-9	-1	-35	-10	-30	-7
Hours Worked						
1	-37	-9	-25	-2	-25	1
2	-31	-10	-26	-6	-27	-14
3	-28	-12	-23	-6	-28	-7
4	-18	0	-42	-17	-36	-11
Labour Productivity						
1	21	4	20	6	10	-5
2	5	0	9	-1	15	15
3	16	16	12	10	21	11
4	18	4	18	9	13	4

Note: For work from home, industries in quartile 1 have the lowest per cent of workers that can work from home and quartile 4 has the highest. For health risk, industries in quartile 1 have the lowest average health risk from COVID and quartile 4 has the highest. For customer facing, industries in quartile 1 have the lowest per cent of customer facing workers and Quartile 4 has the highest.
Source: Authors' calculations.

For hours worked, the April pattern for work from home is clear, with smaller reductions in hours for the quartiles where working from home is more feasible. For August, the top quartile had no reduction in hours worked, although there is no real pattern otherwise. The high health risk quartile had a big percentage hours worked reduction in April, and health risk does appear to be inversely associated with hours worked reductions in August. There is also a weak indication that customer facing may have been associated with hours worked reductions in April, although less so by August.

With declines in real GDP and hours worked by industry both falling as the feasibility of work from home rises, and little pattern for the other categories, it is not surprising that there is no clear pattern for labour productivity. There is no evidence that the industry-by-industry variation is related to work from home, health risk or the extent to which workers in the industry are consumer facing.

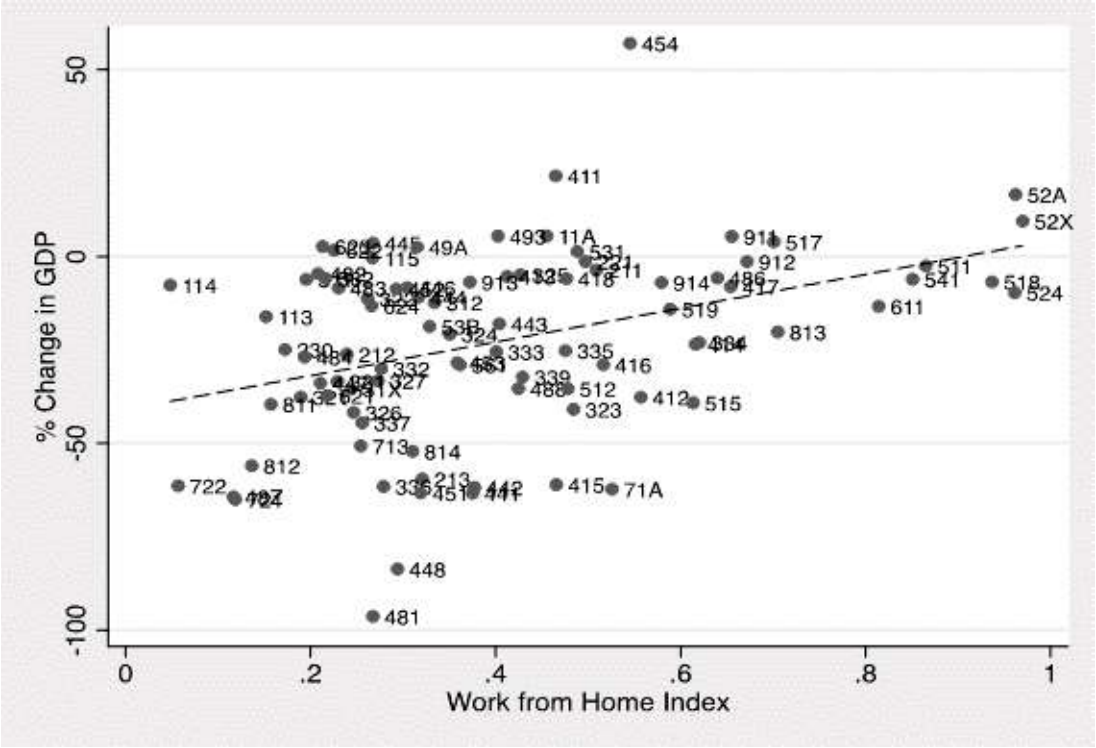
Plots and Description Regressions

Another way to look at these results is to examine the scatterplots. Because there are 3 measures, real GDP, hours worked and labour productivity, and three factors, work from home, health risk and consumer-facing, there are three multiplied by three or nine scatterplots for each of the two months, and hence 18 scatterplots in total. While these are available on request to the authors, for brevity here we present only two, for the change in real GDP for April and August against our work from home Index.

Again there is evidence of a positive association between changes in real GDP and

Chart 2: Scatterplots of Per Cent Change in Real GDP against Work from Home Index by 3-digit NAICS Industry

Panel A: April 2018 to April 2020



Panel B: August 2018 to August 2020

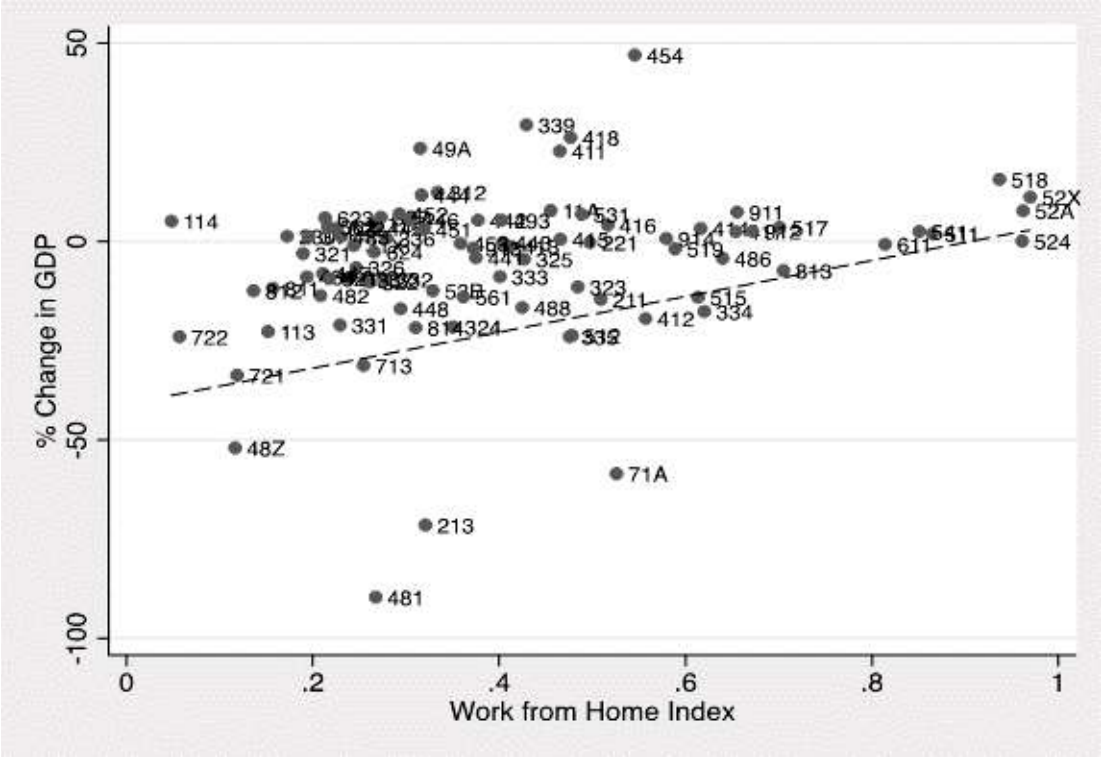


Table 5: Descriptive Multivariate Regression Results for Dependent Variables Real GDP, Hours Worked and Labour Productivity and Independent Variables Indices of Work from Home, Health Risk and Customer Facing

	GDP		Hours Worked		Labour Productivity	
	April	August	April	August	April	August
Work from Home	47.1***	24.2**	46.2***	26.0**	0.4	2.5
	(12.4)	(10.0)	(12.3)	(11.4)	(18.9)	(15.8)
Health Risk	-9.2	8.4	-15.9	-9.9	45.8	25.8
	(38.0)	(30.6)	(37.4)	(34.7)	(57.7)	(48.2)
Customer Facing	-23.7	-4.6	-25.8	-27.1	-20.6	7.8
	(21.2)	(17.1)	(20.9)	(19.4)	(32.2)	(26.9)
Constant	-24.7	-16.8	-26.5	0.96	3.4	-11.5
	(16.4)	(13.2)	(16.1)	(14.9)	(24.9)	(20.8)
R^2	0.17	0.07	0.18	0.10	0.01	0.01

Standard errors in parentheses. Statistically significant at the 5 per cent level (**) and at the 1 per cent level (***).
Source: Authors' calculations.

our work from home index, with a stronger relationship in April than in August. We notice that industries that had high work from home values and no or small real GDP reductions include 518 (data processing, hosting, and related services), 52A (financial investment services, funds and other financial vehicles) and 52X (credit intermediation and monetary authorities). 48Z (transit, ground passenger, scenic and sightseeing transportation) and 722 (food services and drinking places) are examples with low work from home values and large drops in real GDP.

While as mentioned the other scatterplots are not reproduced here, we can report that the hours/work from home scatterplots are fairly similar to the scatterplots above, with the other scatterplots much flatter. In particular the labour productivity plots are almost level.

As a final way to present this information, we present the results of descriptive multivariate regressions with all three of our indices on the right-hand-side. These are sometimes called "horse-race" regressions to convey the idea that while not necessarily having a causal interpretation, they do identify which variable has the strongest partial correlation with the dependent variable conditioning upon the remaining variables. Table 5 reinforces our finding of the relative empirical importance of work from home, as only its coefficients have conventional statistical significance in this context, and then only for the real GDP and hours worked equations. The work from home coefficients in both cases fall by about half from April to August. There is no statistically significant coefficient in the labour productivity regressions. Weighted regressions using February 2020 employment as weights are not presented but give very similar results.

Conclusion

The Canadian economy experienced a striking increase in the real GDP to hours worked ratio, a measure of the change in short-run labour productivity, during the first months of the COVID-19 pandemic. We suggest that this increase is at least

partially due to a disproportionate reduction in work hours by those with low wages, as supported for example by the evidence of Lemieux *et al.* (2020). As such individuals will also tend to make smaller measured contributions to real GDP, their employment hour losses have through a compositional effect raised real GDP per hour worked.

We augment these empirical analyses of the impact of the COVID-19 pandemic on the Canadian labour market based on the Labour Force Survey with an exploratory analysis that incorporates changes in real GDP and hence can examine labour productivity. We disaggregate to 87 industries and for analytical reasons focus on per cent changes from April 2018 to April 2020 and from August 2018 to August 2020.We find that the compositional effects across industries can account for about 4.4 percentage points of a 20.1 percentage point labour productivity increase in April, that is just over one-fifth, and 3.5 percentage points of a 6.0 percentage point increase in August, or just under three-fifths.

We also create indices for the 87 industries to estimate the feasibility of working from home, average health risk (from communicable disease) and the average degree to which jobs in the industry are consumer facing. Our examination of NAICS 3-digit industry data suggests that of the three indices we examined, the strongest association with changes in output and hours worked was the feasibility of working from home: industries where working from home was more possible fared much better. While now familiar, in retrospect the rapid economic transformation associated with the conversion to work from home was remarkable and it is clearly an important factor in the differential, inequality-increasing economic impact of the pandemic on individuals.

The changes in output and the changes in hours did not have as clear associations with the health risk index, even though the estimated associations were negative as expected. The lack of a strong relationship can in part be explained by the fact that two of the five industries with the highest health risk index (622 (hospitals) and 623 (nursing and residential care facilities)) were relatively unaffected because while some of their activities suffered, COVID-19 related activities expanded.

The changes in output and the changes in hours were negatively associated with the customer facing index, but again this includes a mix of "essential" and "nonessential" activities so it is perhaps not surprising that the estimated association is weak. In any case, we cannot in these data identify whether the association we observe is a consequence of government restrictions or independent, individual action.

In terms of labour productivity, we find that the industry composition effects are important, but there is no evidence of association with the industry characteristics that we expected to have mattered most during the COVID-19 crisis. More broadly, as the normal argument is that constraints such as those associated with COVID-19, either imposed by governments or individuals themselves, are unlikely to increase productivity, perhaps the measured productivity increases so far can best be taken as reassurance that the underlying, unmeasured losses have been so far limited. Yet while productivity as measured by output

per hour worked has increased, output per capita has clearly fallen, and improvements in that indicator are likely only attainable with continued increases in hours of employment.

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