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Sectoral Digital Intensity and GDP Growth After a Large Employment Shock: A Simple Extrapolation Exercise*

Giovanni Gallipoli and Christos A. Makridis †

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Abstract

We examine the dynamics of GDP following an economy-wide pandemic shock that curtails physical mobility and the ability to perform certain tasks at work. We examine whether greater reliance on digital technologies has the potential to mediate employment and productivity losses. We employ industry-level indices of task-based digital intensity and ability to work from home ("home-shorability"), in conjunction with publicly available data on employment and GDP for Canada, and document that: (i) employment responses after the onset of the shock are milder in digitally-intensive sectors; (ii) conditional on the size of employment changes, GDP responses are less extreme in IT-intensive sectors. We suggest a simple state-dependent algorithm for predicting output dynamics as a function of employment across industries and locations with different digital intensity. In our baseline scenario, aggregate output returns to pre-crisis levels eight quarters after the initial shock onset, although we find significant heterogeneity in recovery patterns across sectors.

Keywords: Output, Digital Intensity, Employment, Canada, Coronavirus, Structural Change

JEL Codes: E32, E66, J21, J23

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1 Introduction

While the pandemic episode of 2020, and the resulting confinement restrictions, has led to substantial declines in employment (Bartik et al., 2020; Coibion et al., 2020), the effects have been heterogeneous across sectors (Cajner et al., 2020; Devereux and Lahiri, 2020). These employment declines may pose significant consequences for aggregate productivity (Makridis and Hartley, 2020), especially if a permanent rise in unemployment leads to declines in consumer demand (Guerrieri et al., 2020) and permanently scars consumer confidence (Kozlowski et al., 2020).

The primary contribution of this paper is to quantify the anticipated effects of the pandemic on aggregate and sectoral output in Canada. While a full analysis will require time and the collection of detailed data on output and other determinants of social welfare, we suggest a simple strategy for estimating the likely effects on GDP growth across industries and locations. The approach relies on estimates of the elasticity between GDP and employment obtained using publicly available data and, crucially, it allows for heterogeneity across sectors that differ in their occupational concentration of digital tasks (Gallipoli and Makridis, 2018).[1] We exploit variation unique to the 2008-09 financial crisis as the closest and most recent example of a sharp drop in employment, and employ estimates of sectoral elasticities to project output trajectories for the 2020 recessionary episode under various assumptions about the speed of the recovery.

We begin by quantifying the heterogeneous effects of restricted mobility regimes in Canada on employment declines, allowing for variation across sectors. We create an index to measure sectoral resilience using the product of occupational digital task intensity and home-shorability. We provide the first comprehensive evidence that sectors with a higher share of digitally-intensive occupations

[1] We use digital intensity and information technology (IT) intensity interchangeably.

and home-shorable jobs experienced substantially milder employment declines: a percentage point rise in the resilience of workers is associated with 0.65 percentage point higher employment growth between February to April 2020, suggesting that they have upheld the economy under turbulence.

The second part of the paper examines employment and real GDP growth across sectors to recover an elasticity that is suitable for extrapolating sectoral output. Motivated by the strong correlation between employment growth and digital intensity, home-shorability, and resilience during the pandemic, we allow elasticities to vary across two broad sectors corresponding to high and low resilience scores. Estimates of the elasticities are based on variation that is unique to the 2008-09 financial crisis since that historical event presents the closest analogue to the magnitude of employment declines observed over the course of the pandemic. These estimates are instrumental to obtain a simple, state-dependent rule to infer likely patterns of disaggregated output.

The third part of the paper examines sector-specific recovery durations. We posit that durations of sectoral recoveries are broadly consistent with historical observations following the large employment losses of the 2008/09 recession. Specifically, the path and duration of sectoral employment recoveries back to pre-crisis levels depend on both the size of initial job losses and on the (proportional) behavior of employment headcounts after the 2008/2009 recession. These assumptions are motivated by the easy availability of data on (i) short-term employment losses (February to April) after the onset of the 2020 shock, and (ii) accurate historical records from the severe recession of the late 2000s. In robustness checks, we experiment with departures from baseline employment scenarios and extrapolate a range of alternative state-dependent outcomes for GDP.

The procedure outlined above is convenient to project a path for aggregate GDP under alternative hypothesis about employment recoveries. Once estimates of alternative aggregate paths are available, we shift our focus to the dynamics of GDP in different industries and locations.

We assume that sectoral vulnerabilities to productivity losses due to workers' confinement depend on the distribution of occupations within each industry, namely their digital intensity and the "homeshorability" of tasks. We assume that sectoral elasticities are inversely proportional to industry-specific resilience measures and, through a functional form assumption, we relate the prevalence of high-resilience tasks within an industry to that sector's capacity to sustain productivity and output in circumstances of restricted population interaction. This allows us to separately extrapolate GDP growth rates for each two-digit industrial sector as well as examine potential heterogeneity in GDP growth across provinces. We also benchmark our results by comparing the disaggregated GDP values of March and April with the estimates produced by our model. Finally, we compare our results with similar calculations in which we use an alternative index of sectoral sensitivity to confinement disruptions based on contact intensity (Dingel and Neiman, 2020).

One advantage of the approach we develop is its simplicity: by relying on the interaction of cross-sectional occupational task intensity with the home-shorability measures that are likely to mediate the effects of the aggregate shock, we can obtain reasonably reliable and sharp real-time estimates from employment data for aggregate GDP.[2] A second advantage of the approach is that its predictions transparently reflect the underlying conjectures about employment dynamics, facilitating hypothetical comparisons. Our approach relies on assumptions about sectoral elasticities of GDP with respect to employment. While the empirical content of this assumption can only be verified as more information becomes available over time, the functional form assumption itself can be tweaked to improve performance as new data becomes available. Lack of initial accuracy is

[2]Using an even simpler approach that proportionally allocated reductions in GDP based on the share of digitally-intensive workers, Makridis and Hartley (2020) found that the aggregate costs of a two month national quarantine came to roughly 10%, matching the 8% figure estimated by the IMF.
https://www.cnbc.com/2020/06/24/imf-global-economy-to-contract-with-coronavirus-recovery-slow.html

the price one pays to make long-term projections about sectoral GDP and productivity responses with minimal data requirements, but can help policymakers make real-time decisions.

Of course, assuming any given path for employment dynamics is a simplification that ignores equilibrium feedbacks working through prices. Nonetheless, to the extent that public health constraints limit the ability of workers to perform tasks on the jobs regardless of prices, positing specific employment paths for recoveries seems a reasonable approximation. As confinement becomes progressively less stringent, one can provide a set of potential paths for the employment and GDP recovery, and assess sectoral differences over short and medium horizons.

By recovering GDP-employment elasticities using data from the large recession of 2008/09, we can capture possible non-linear responses of GDP following unusually large shifts in worker headcounts. Through this approach, we consider three possible employment recovery scenarios. Our baseline results suggest that Canada might experience an overall annualized decline in real GDP of 5.4% between February 2020 and February 2021. The decline would be larger (7.8%) in the case of a severe second wave of infections after the Summer of 2020. For the last three quarters of 2020, we estimate a decline in real GDP of about 7.8% under the baseline scenario, and of 8.4% in the case of a severe second wave.[3] In the baseline scenario we expect that aggregate employment will likely get back to pre-crisis levels by the first quarter of 2022.

Industry-specific heterogeneity in projected growth rates is large: while sectors like restaurants and hospitality may experience year-on-year drops between 27.6% and 39.9% between February 2020 and February 2021, other industries like Wholesale and Retail Trade would likely only shrink between 5.6% and 8.2% over the same 12-month horizon. The most digitally-intensive sectors—

[3]For comparison, the IMF estimates that Canada's annualized real GDP will decline over the same period by 6.2%, whereas OECD estimates even larger losses at 8.4% in the base case and 9.4% in case of a second wave. A study by Trading Economics suggests an average decline of 4% in the last three quarters of 2020.

professional, scientific and technical services—may experience even smaller year-on-year output drops between 1.5% and 2.2% and may ultimately expand due to structural change.

2 Data and Measurement

Our primary data on sectoral economic activity comes from publicly available data from Statistics Canada on real gross domestic product (GDP) in chained 2012 prices by industry up until March 2020 and on employment by industry and province up until May 2020.

We refine the task-based index of digital intensity of Gallipoli and Makridis (2018), which is constructed from several sub-indices in the Department of Labor's O*NET database.[4] While we do not have an analogue of the O*NET for Canada, we can cross-walk occupations from their U.S.-based standard occupational classification (SOC) code into the corresponding Canadian code, which operates at roughly a three-digit SOC-level. Using a novel database based on a Canada-wide occupation-level risk tool, we create a unique score for two-digit industries in a given province using the proportion of workers working from home in each four-digit occupation level before the pandemic. For each province, by taking a weighted average of this score with the number of workers in the two-digit industry, we create a measure of home-shorability. [5] A similar method is used to create a HS index for all industries at a national level. Thus, for the purposes of our paper, we are able to combine the digital intensity and HS measures by taking their product within each industry and province. By so doing, we create a novel, merged measure that we call "resilience".

[4]These sub-indices include: knowledge about computers and electronics, activities interacting with computers, programming, systems evaluation skills, quality control analysis, operations analysis, activities with updating and using relevant knowledge, technology design, activities analyzing data and information, activities processing information, knowledge with engineering and technology, activities managing material resources.

[5]Our new data on occupational characteristics was developed at the Vancouver School of Economics (2020) at UBC. We use home-shorability measure and HS measure interchangeably.

A high resilience would signify a high score for the combination of digital intensity and HS.

Descriptive statistics. We begin by providing several descriptive statistics from our measures. For each province (and for the whole of Canada), Figure 1 plots the share of workers classified as digitally-intensive as per Gallipoli and Makridis (2018), the share of workers with home-shorable jobs (as per Vancouver School of Economics (2020) 'risk tool'), and the share of workers with high resilience. We find a correlation of 0.71 between the digital intensity and HS measures at the provincial level. Interestingly, there is little cross-sectional variation in the digital intensity measures across the major provinces with the average share of high digital intensity workers in a province around 53%, whereas we see more inter-provincial variation with the average province-specific HS measure around 7.2%. This suggests that the task-based measure of digital skills is more comprehensive, whereas home-shorability reflects whether a job can be performed at home.

Next, we examine the distribution of these measures across industries. Figure 2 documents variation across two-digit industries in the share of digital workers, ranging from the low of 25% in accommodation and food services to the high of 85% in professional and technical services. There is similar variation when using the HS measure, ranging from accommodation and food services (again) with the lowest at 0.6% to professional and technical services at 11%. Agriculture exhibits an outlying value of 36.8%: this exception exists because many people who work in the agricultural sector both live and work on their farms. The correlation between these two measures across industries (excluding agriculture) is 0.62.

We also perform robustness checks using the measure of contact-intensity developed by Dingel and Neiman (2020). However, we note that the resilience measure corresponds more closely with our hypothesis that industry-level productivity might be significantly affected by the constraints

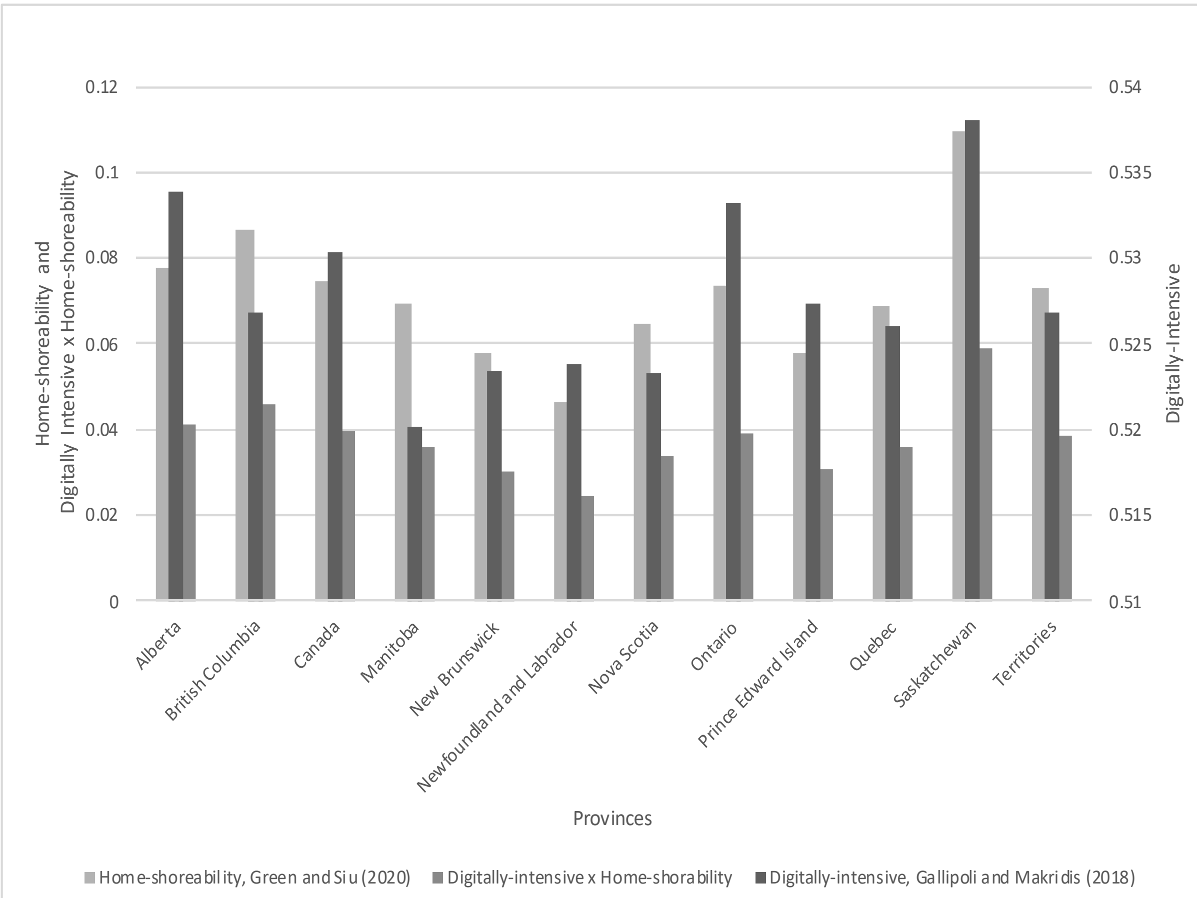


Figure 1: Index for Digitally-intensive and Home-shoreable Employees, by Province

Note.—Sources: StatsCanada, IPUMS Canada, Gallipoli and Makridis (2018), and Vancouver School of Economics (2020) occupation risk tool. The figure plots an index for digitally intensity and home-shorablity of jobs based on occupation and industries measures of Tasks in the United States (for Digital Intensity) and Canada (for Home-shorability). Section A.1 in the appendix describes the process to compute these heterogeneity scores. The third bar plots the province-specific resilience, i.e. the product of the digitally intensive and HS measure for each provinces.

imposed by self-isolation, social distancing and quarantine.

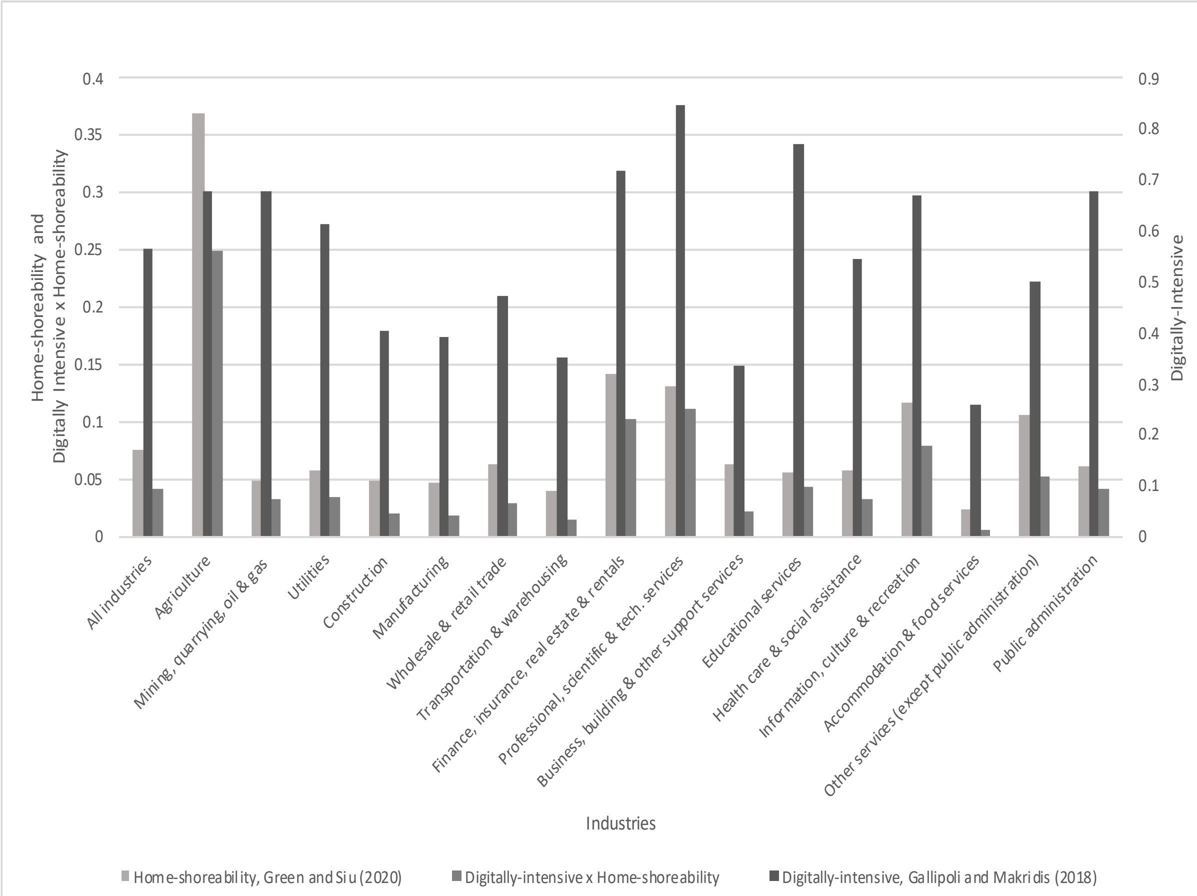


Figure 2: Index for Digitally-intensive and Home-shoreable Employees, by Industry

Note.—Sources: StatsCanada, IPUMS Canada, Gallipoli and Makridis (2018), and Vancouver School of Economics (2020) occupation risk tool. The figure plots an index for digitally intensity and home-shoreablity of jobs based on occupation and industries measures of Tasks in the United States (for Digital Intensity) and Canada (for Home-shorability). Section A.1 in the appendix describes the process to compute these heterogeneity scores. The third bar plots the industry-specific resilience, i.e. the product of the digitally intensive and HS measure for each industry.

3 Tracing Out GDP Recoveries

Reliably modelling the behavior of output after a period of extreme turbulence is challenging. For the pandemic episode under examination the challenges are even more severe because the turbulence is due to unusual circumstances, such as restrictions on social and economic activities, for which there is little or no precedent in recent history. Finally, the difficulty is compounded by our interest in the dynamics of GDP by sector and location, and the fact that data for employment and output across industries and locations is released with a lag, often months after the initial aggregate estimates become available. We provide a stripped-down state-dependent extrapolation approach that can be used with easy-access publicly available aggregate data.

Given our focus on post-crisis output dynamics, we focus on the relationship between output and employment as mediated by a third, intangible factor that changes the sensitivity of different sectors to employment (headcount) losses. We posit an output function that reflects how the number of workers maps into post-crisis output changes given employment losses and industry-specific resilience. We define output y in the post-onset period t and sector i as

$$y_{it} = e_{it}^{\gamma} \times f(e_{it}, z_i) \tag{1}$$

where e_{it} is sectoral employment (headcounts) and $f(e_{it}, z_i)$ is a function capturing differential responses of y to e across industries due to heterogeneity in resilience z_i.[6] For the empirical implementation below, we assume $f(e_{it}, z_i) = z_i^{\zeta \times t} + e_{it}^{\xi \times z_i}$, so that the heterogeneity in z_i is reflected in post-recovery growth trend and sensitivity to employment levels. We explicitly consider these forms of heterogeneity in the empirical analysis below.

The idea that some sectors might do better than others in terms of employment and GDP losses is intuitive, given that sectors are heterogeneously exposed to the coronavirus restrictions. To the extent that HS and IT intensity can reduce the blow from social distancing measures, one should observe heterogeneous responses across industries. To explore this possibility in a simple and transparent way, we proceed in two ways.

[6]Given our focus on short- and medium-term recoveries after the initial onset of the crisis, we abstract from physical capital.

First, we assume that the sectoral resilience z_i reflects the adoption and penetration of digital and IT technology in production practices. We follow Gallipoli and Makridis (2018) and partition industries into two groups (digitally and non-digitally intensive) based on whether they fall above or below the median share of IT-intensity, as defined by the tasks performed in their daily occupation. Panel A of Figure 3 supports the hypothesis that higher prevalence of digitally-intensive jobs mitigates the impact of confinement shocks on an industry: a strong positive relationship exists between digital intensity and employment growth between February and April 2020, right after confinement measures became widely adopted across Canadian provinces. Industries with a 10% higher share of IT intensive workers have a 4.1% higher growth rate of employment.

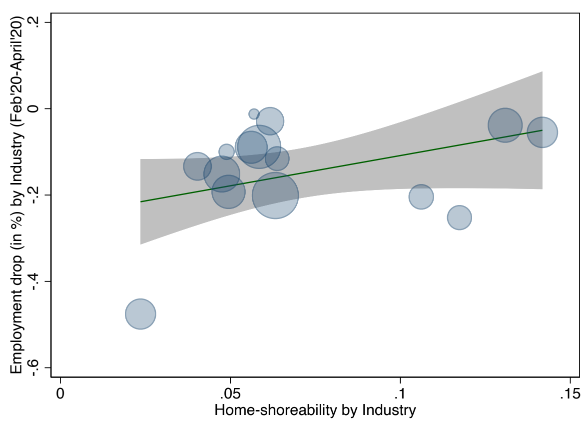
Panels B and C of Figure 3 replicate these patterns using the measures of home-shorability and of overall resilience; the latter is defined as the product of digital intensity and home-shorability. By combining variation about both digital intensity and home-shorability, we obtain a more encompassing proxy for gauging the responsiveness of industries to the pandemic shock.

Sectoral elasticities. Are there differences in the dynamic responses of sectoral output to employment after the initial crisis onset? This is a harder question as it requires information about the evolution of headcounts which is not readily available. For this reason, we estimate a linear approximation for the growth rates of the sectoral output function in Equation 1, describing GDP responses to employment changes. We use different sample intervals between January 2001 and April 2020 at a monthly frequency to establish whether this relationship is significantly different after a large crisis like the recession of 2008 and consider regressions of the form:

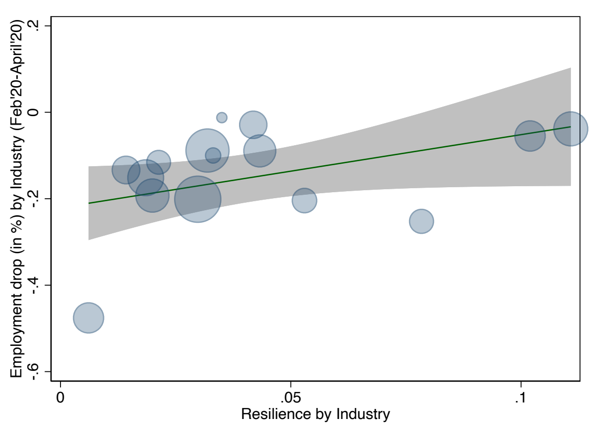
Figure 3: Employment Declines After Onset of the Pandemic Across Sectors

Panel A: Employment Declines & Digital Intensity

Panel B: Employment Declines & Home-shorability



Panel C: Employment Declines & Resilience



Note.—Sources: StatsCanada, IPUMS Canada, Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupation risk tool. The figures plots employment growth between February and April 2020 within an industry and digital-intensity score, home-shorability and resilience in Panel A, B and C respectively.

$$\Delta y_{it} = \gamma \Delta e_{it} + \zeta z_i + \xi(\Delta e_{it} \times z_i) + \epsilon_{it} \tag{2}$$

where Δy_{it} denotes the year-to-year growth rate of (real) GDP in industry i and month-year t, Δe_{it} denotes the year-to-year growth rate of employment for the same industry-period pair, and z denotes a binary indicator for whether the industry is in a relatively more resilient group, that is, above or below median according to a measure of choice. We estimate the latter relationship for two groups (high and low resilience), rather than for each industry, to improve precision; better data quality, and additional sources of variation, would allow for more flexible estimation.

Given evidence from Figure 8, we expect that $\xi < 0$, meaning that the more digitally intensive sectors should experience less of a decline over the pandemic. We estimate Equation 2 under several specifications: with and without the z interaction, over the extended sample and for the subsample corresponding to the recovery following the 2008-2009 recessionary episode. The latter, restricted subsample is especially informative as it exploits variation unique to GDP-employment changes after a deep and wide economic downturn, shedding light on the way different industries respond, particularly during periods of significant economic turbulence when the elasticity is large.

Table 1 documents the findings from this exercise. Starting with column 1, we see that a 1pp rise in employment is associated with a 0.33pp rise in GDP. However, given the potential for reverse causality, we instrument for employment growth using two to three month lags following Arellano and Bond (1991); this delivers statistically indistinguishable (and slightly higher) coefficient estimates in column 2. Interestingly, when we restrict the sample to the turbulent 2008-2009 period, we estimate an elasticity that is nearly twice as large: a 1pp rise in employment is associated with

Table 1: Elasticity of GDP Growth to Employment Growth

Dep. var. =	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Employment Growth	.33***	.37***	.72***	.51***	.49***	.86***
	[.02]	[.03]	[.05]	[.03]	[.04]	[.05]
High Resilience				.01***	.01***	.03***
				[.00]	[.00]	[.00]
× Employment Growth				-.33***	-.23***	-.59***
				[.04]	[.05]	[.09]
R-squared	.12	.11	.40	.15	.14	.56
Sample Size	3488	3440	384	3488	3440	384
Sample	All	All	2008-09	All	All	2008-09
Instrument	No	Yes	No	No	Yes	No

Notes.—Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. The table reports the coefficients associated with regressions of industry × month real GDP growth (year-to-year, in chained 2012 prices) on employment growth, interacted with an indicator for whether the sector has high resilience (high IT intensive and home-shorable jobs). The latter exposure is measured using IPUMS Canada 2011 data in conjunction with the Gallipoli and Makridis (2018) IT-intensity measure and the home-shorability measure. We instrument the potentially endogenous employment growth with two and three month lagged values of the year-to-year growth rate. The first-stage F-statistic are strongly significant.

a 0.72pp rise in GDP. Results are similar when we allow for differences in resilience across sectors. Focusing on column 6, which restricts our sample to the so-called Great Recession period, we see that a 1pp rise in employment is associated with a 0.86pp rise in GDP in low resilience sectors, but with only a 0.27pp rise in GDP in the high resilience sectors. This evidence suggests that job resilience acts as a mediating force that mitigates the impact of employment changes on output during times of economic turbulence.

4 Projecting Recovery Paths

4.1 Baseline: "Great Recession" Recovery Path

In the first and baseline case, we assume a linear employment recovery starting in May 2020 and leading back to the level of employment last observed in February 2020. We posit that the duration of the employment rebound is analogous to what was observed after the recession of the late 2000s. Then, it took an average of 21 months for employment in low resilience industries to go back to pre-crisis levels, whereas it took about 30 months in high resilience industries.

Table 2: Year-on-Year Employment Growth Rates, between May 2019 and May 2020

	StatsCanada	Estimated
Low Resilience	-16.6%	-17.9%
High Resilience	-8.4%	-8.4%
All Industries	-13.5%	-14.3%

Note.—Source: Gallipoli and Makridis (2018) and StatsCanada. The table reports the annual (year-on-year) employment growth rates reported between May 2019 and May 2020 by Statistics Canada and the same annual employment growth rates as estimated by our baseline employment recovery scenario.

One way to indirectly validate the assumed duration of employment recoveries is to compare the year-on-year employment growth rates between May 2019 and May 2020 (as measured by Statistics Canada) with the ones implied by a linear recovery path mimicking that of the previous recession. As shown in Table 2, predicted and actual employment drops are close, providing some corroboration for the assumed pace and horizon of the employment recovery. At least initially, it appears that the baseline conjecture about the evolution of headcounts is reasonable.

Next, we use employment changes to project GDP changes consistent with the baseline elasticity estimated in column 6 of Table 1. We normalize output in February 2020 to 1 and plot GDP levels in both low resilience and high resilience industries, as well as for all industries. Plots, in Figure 4, indicate that aggregate output bottomed out in April 2020, at roughly 89% of its pre-crisis level. The recovery starting in the Summer of 2020 would bring GDP back to its pre-crisis level by the end of the first quarter of 2022. Peak-to-through output losses are likely to be much shallower, at around 2.9%, in high resilience industries, as opposed to a loss of roughly 18.4% for low resilience industries. Despite a longer assumed duration of the employment recovery in high resilience sectors (30 months to get back to pre-crisis employment levels, vis-a-vis 21 months

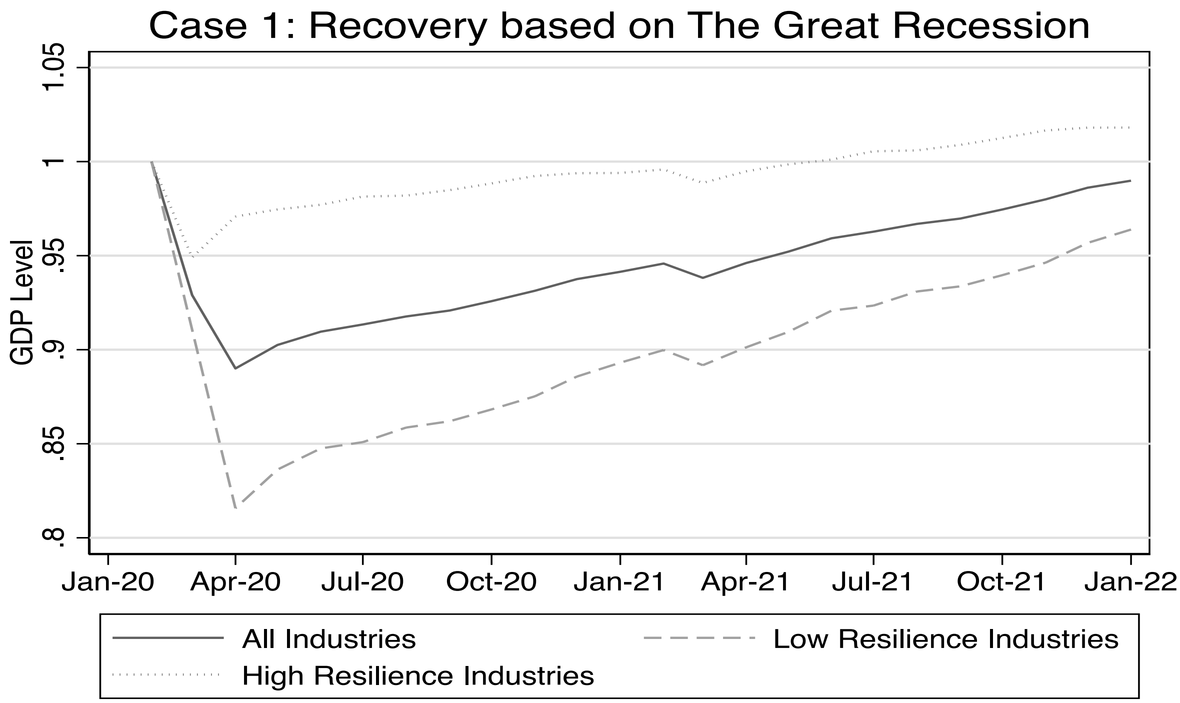


Figure 4: GDP Projection Based on Great Recession, by Digital Intensity

Note.—Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. The graph reports GDP levels for low resilience sectors, high resilience sectors and all industries calculated using the values of GDP predicted using our model in equation 2 for a baseline employment recovery. These values are normalized in terms of the GDP of February 2020 which is considered 1. The GDP Levels are reported in Table 4

in low resilience sectors), the recovery is likely to bring GDP of the high resilience sector back to pre-crisis levels by May 2021. The aggregate GDP, however, would still be 1.4% below the pre-crisis level by the end of 2021.

Year-on-Year Output Growth Rates. An alternative way to summarize the baseline estimates for the post-crisis evolution of GDP is presented in Figure 13, where we report the yearly GDP growth rates for high and low resilience industries in different quarters. The figure also reports the aggregate annual growth rate, showing a return to year-on-year growth in the second quarter of 2021. Annual GDP growth rates are expected to increase almost twice as fast in low resilience sectors after the second quarter of 2021, making up for larger initial losses in 2020. The higher volatility of the low resilience sector (larger drops and stronger recovery) is consistent with the employment losses reported in Table 2 and the higher GDP elasticity estimates in Table 1.

4.2 Faster Employment Rebound: An Optimist's View

March and April 2020 saw large losses in national employment levels, although high resilience industries experienced employment losses proportionally much smaller than low resilience industries. As many jurisdictions began easing mandatory confinement of workers and businesses started to re-open with social distancing measures in place, the Canadian economy witnessed a month-on-month increase in employment in May 2020, with about 290,000 jobs added to the employment tally. Given this rebound, the elimination of strict mobility curbs may be sufficient to bring back many of the furloughed workers to active employment.[7] That is, one might take the hopeful view that employment would recover faster than it did after the recession of 2008/09.

We next consider an alternative, and optimistic, scenario that assumes an accelerated recovery. Specifically, we posit comparatively large gains in employment in June and July 2020, similar to those observed in May. After a Summer spike in hiring, we assume that employment keeps growing at a more gentle pace till we get back to pre-crisis levels of employment, and growth around March 2021 in the non-IT industries and November 2021 in IT intensive industries. As before, the different time span across industries reflects the observation that recovery was faster in the non-IT sectors after the recessionary episode of 2008.

The recovery duration for employment under this scenario is roughly 60% of that assumed in

[7] For example, Huang et al. (2020) use high-frequency data from the United States to show that the removal of the stay-at-home orders and nonessential business closures were associated with a roughly 20-26% increase in employment and hours worked in retail and hospitality sectors. However, the increase thus far has not been enough to offset the initial decline in labor market conditions.

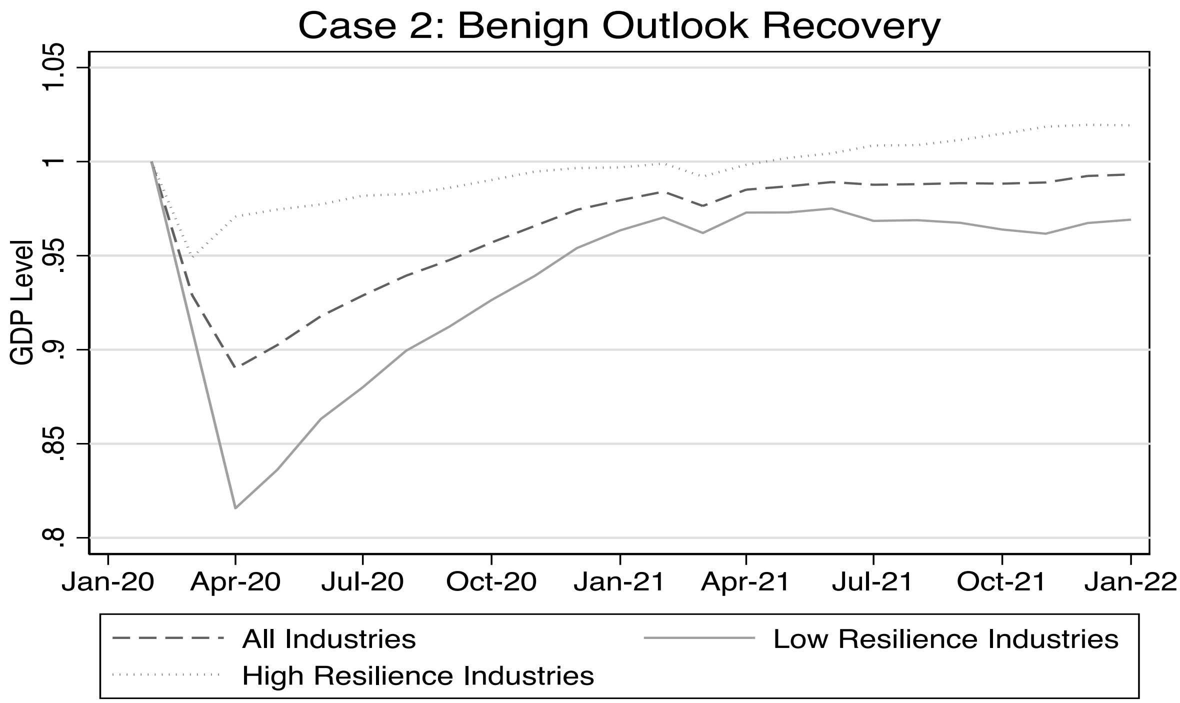


Figure 5: Optimistic GDP Forecast, by Digital Intensity

Note.—Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. The graph reports GDP levels for low resilience sectors, high resilience sectors and all industries calculated using the values of GDP predicted using our model in equation 2 for a more optimistic employment recovery. These values are normalized in terms of the GDP of February 2020, which is considered 1. The GDP levels are reported in Table 4

the baseline case. Figure 5 shows the evolution of normalized GDP, suggesting the economy might get back to pre-crisis output levels by the end of 2021 or the beginning of 2022. Figure 14 reports the annual GDP growth rates for different quarters of the recovery under this alternative scenario. Positive year-on-year growth would, in this case, would return within the first few months of 2021.

4.3 Delayed Recovery: a Severe 'Second Wave'

The previous two scenarios are based, to different extents, on fairly benign views of the ability of different jurisdictions to contain the health emergency and allow for a staggered but monotonic return to pre-crisis employment. It is equally interesting to consider the possibility of a second wave of infections in the Fall of 2020, leading to re-emergence of confinements and reduced employment. Specifically, we assume that strong employment growth in June and July, similar to what was observed in May 2020, will translate into higher infection rates and new restrictions in the Fall of 2020. This would bring about a new tide of employment losses.

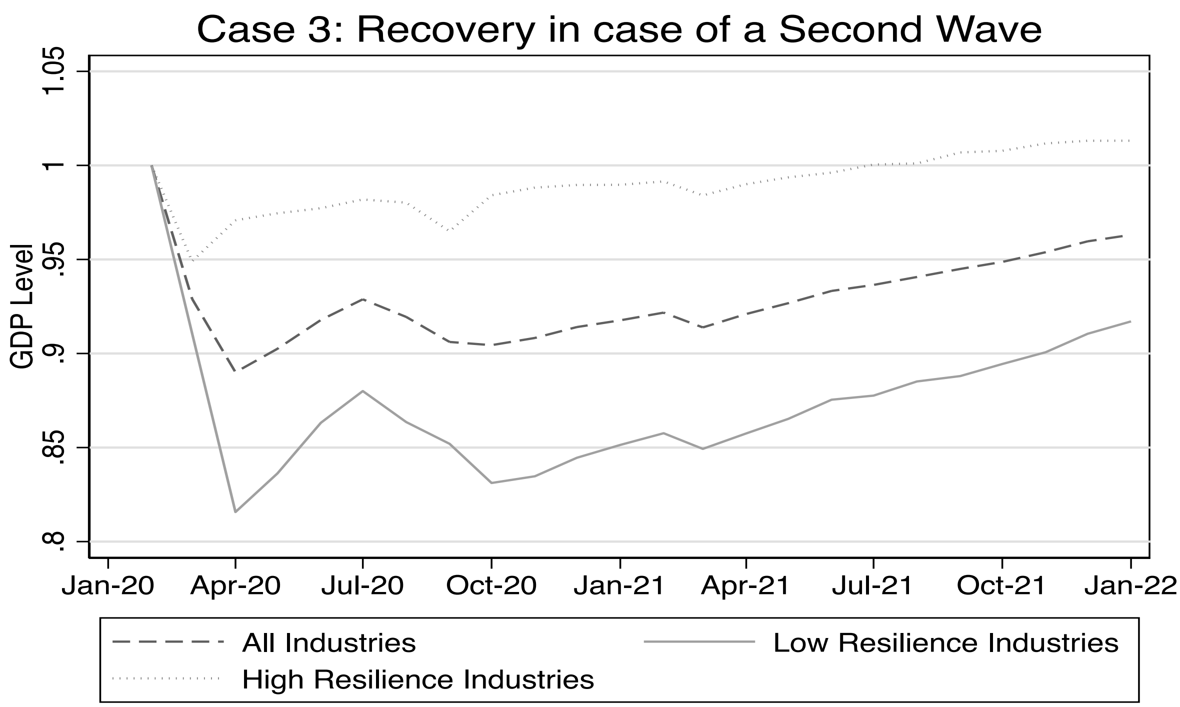


Figure 6: Pessimistic GDP Forecast, by Digital Intensity

Note.—Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. The figure reports GDP levels for low resilience sectors, high resilience sectors and all industries calculated using the values of GDP predicted using our model in equation 2 in case the Canadian economy experiences a second wave. These values are normalized in terms of the GDP of February 2020 which is considered 1. The GDP levels are reported in Table 4.

However, while new rounds of job losses might stretch out until November 2020, they are unlikely to be of the same magnitude as those suffered in the March-April 2020 period because jurisdictions would be better prepared to handle the health emergency. Moreover, starting in December 2020 a linear recovery in employment would take hold, qualitatively similar to that of the baseline scenario in terms of duration (that is, taking the same number of months to get to pre-crisis employment as in the post-2008 recovery).

One justification for the assumptions in this scenario could stem from the possibility that better therapies or a vaccine will become available between January and March 2021. This would help control the pandemic and set the economy on a path to steady recovery. The GDP levels under this scenario are plotted in Figure 6, which shows a double-dip recession with GDP testing the lowest levels in both Spring and Fall 2020. Aggregate GDP would still be roughly 4% lower than its pre-crisis level by the end of 2021. Annualized (year-on-year) growth rates for different quarters are reported in Figure 15 and suggest that, under this less benign view, aggregate annual growth would turn positive in the second quarter of 2021, but would be subdued until the end of 2021.

4.4 Comparing Three Recovery Scenarios

Taking stock, the three cases outlined above correspond to alternative scenarios for the path of employment following the initial onset of the shock. To facilitate comparisons, Figure 7 plots in the same graph the post-onset evolution of (normalized) aggregate GDP in each of the three cases.

Under all scenarios, GDP is likely to shrink by more than ten percentage points at its lowest post-onset level. Most of the uncertainty concentrates around the period of early 2021, as outcomes crucially depend on whether a severe second wave of infections occurs. The difference in predicted GDP levels between the delayed and benign views of the recovery in January 2021 is large (6.2 percentage points). This gap shrinks as we approach the end of 2021 and some of the uncertainty is resolved. The truth may reside between the estimates for these alternative scenarios.

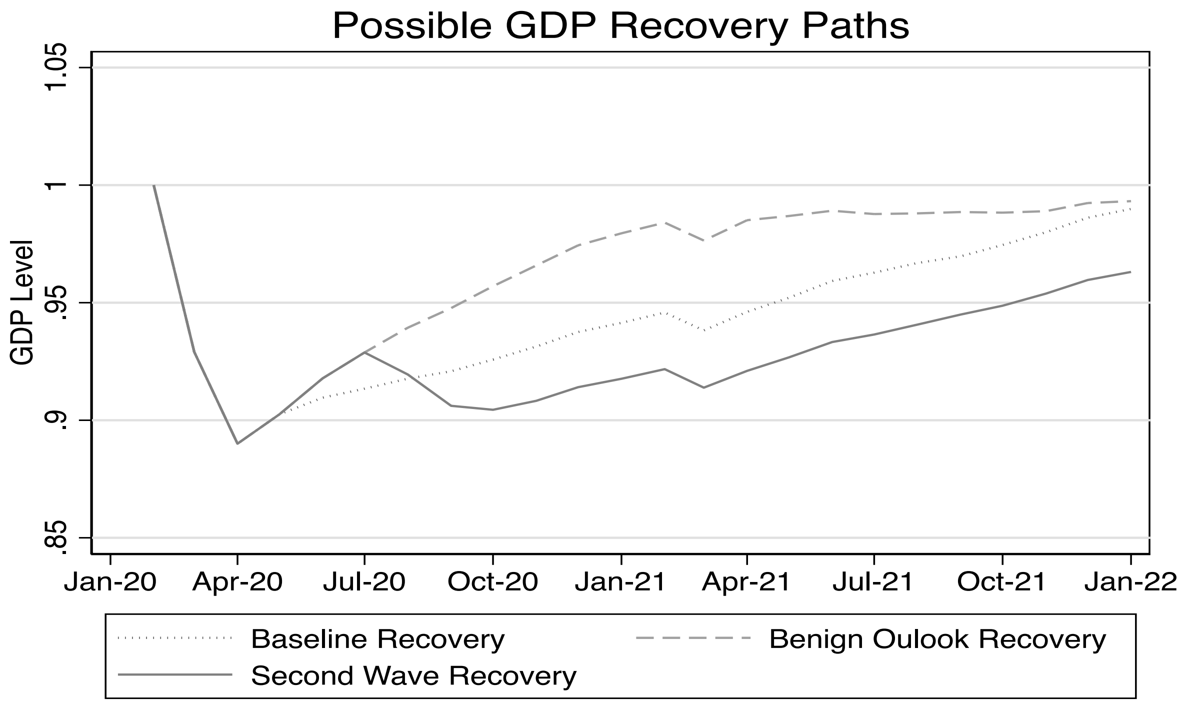


Figure 7: Summary of Possible GDP Paths

Note.—Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. The graph reports the aggregate GDP levels calculated using the values of GDP predicted using our model in equation 2 for all three recovery paths discussed above. These values are normalized in terms of the GDP of February 2020 which is considered 1. The GDP Levels are reported in Table 4

5 Sectoral and Provincial Heterogeneity in GDP Paths

Data on industry-specific and/or provincial GDP changes is only made available over an extended period of time. Yet, it is often necessary to venture in the risky business of estimating potential patterns of GDP. Our stylized approach can deliver conditional estimates of potential GDP changes across industries after the onset of the shock.

We use the share of digitally-intensive jobs, compounded by the HS measure, in each industry. This measure is used to proportionally scale real output within each period $\times$ industry unit. For example, an industry with an 80% share of digitally-intensive workers who can be productive at home might be able to sustain a smaller output loss during periods of reduced social interactions than an industry where only 20% of tasks are digitally intensive.

Functional Form Restrictions. To capture the sectoral sensitivity of GDP while preserving aggregation, we calibrate period-specific (month-year) GDP response elasticities ϵ_m relative to baseline values in February 2020. In practice this allows us to rescale sectoral output to be a fraction of its pre-crisis level under the constraint that, in any given month, aggregate output is taken as given. This simple calibration exercise can be repeated for every month during the recovery period: each ϵ_m parameter captures GDP changes for period m and can be used to project sectoral output to a specific month during the employment recovery.

Crucially, the sectoral GDP projections depend also on industry-specific digital resilience, as in Equation 3:

$$Y_m = \sum_{i=1}^{n} y_{FEB \times i} \left(1 - \frac{\epsilon_m}{r_i}\right) \tag{3}$$

The Y_m refers to the aggregate GDP in a given month m, $y_{FEB \times i}$ is the baseline GDP of industry i in February 2020 and r_i is the resilience of industry i (defined as the product of the weighted-average of occupation-specific IT intensities and HS measure in that industry). We use the estimates of aggregate GDP by month, obtained in the previous section, in conjunction with industry-specific real GDP data for February 2020 (as released by Statistics Canada), and resilience based on Gallipoli and Makridis (2018) and Vancouver School of Economics (2020) occupational risk tool. These are enough to compute a sequence of elasticities ϵ_m, one for each month.

This set of elasticities is used to calculate the projected GDP for each industry i in a given month m using Equation 4. The latter Equation simply defines each element in the right-hand side summation of Equation 3; that is, we denote GDP in industry i and period m as:

$$y_{m \times i} = y_{FEB \times i} \left(1 - \frac{\epsilon_m}{r_i}\right) \tag{4}$$

We follow this procedure for both baseline and delayed recovery scenarios, and measure GDP growth for each industry between February 2020 and February 2021. Implied year-on-year growth rates by industry are reported in Figure 8.

Not surprisingly, industries that rely on consistent social interactions (e.g. accommodation/food services) are likely to suffer much larger output drops, which can exceed 39% year-on-year in the worst case scenario. By the same token, professional and scientific industries and education services are likely to experience much milder drops, around 2.2% and 5.6% respectively in the worst case scenario. This large heterogeneity reflects the assumption that digital intensity and home-shoreability may mitigate and diffuse the severity of both employment and productivity losses.

GDP Growth Rates by Province. One can follow a similar approach to project GDP growth for different provinces. That is, the relationship in equation 4 holds if index i identifies a location, rather than an industry. The main difference lies in the fact that we do not currently have real GDP data disaggregated by province for February 2020. Hence, we recover the February baseline GDP values by calculating the GDP contribution of each province in February 2020 using the most recent GDP share data released by StatsCan for the year 2019.

We then estimate unique, month-specific values of the elasticity of GDP for each province,

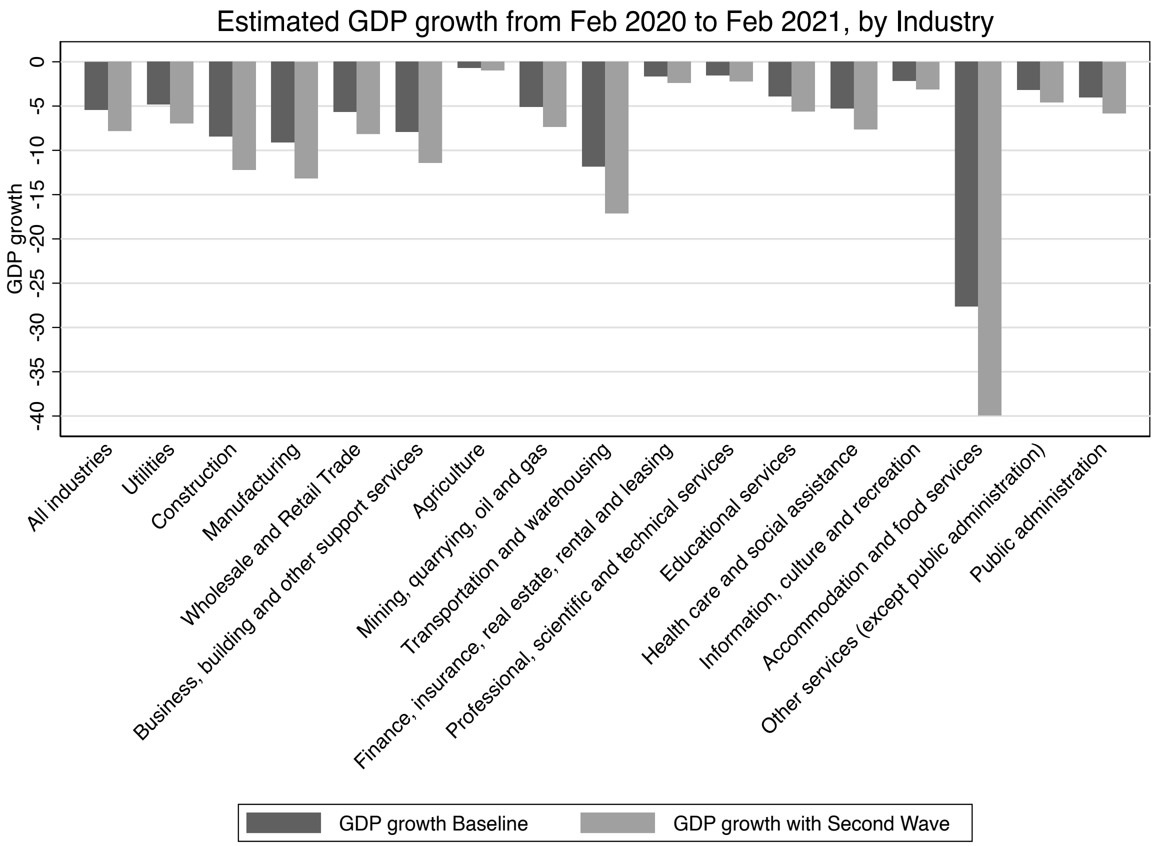


Figure 8: Expected GDP Growth in 2020 Using Occupational Resilience Measures, by Industry

Note.—Sources: StatsCanada, IPUMS Canada. Based on author's calculations of resilience using Gallipoli and Makridis (2018)'s IT intensity index and Vancouver School of Economics (2020) index of home-shoreability, we estimate GDP values with Equation 2. We then use the process explained in Section 5 to estimate GDP by Industry for 2020 and report GDP growth from Feb 2020 to Feb 2021. Table 6 provides estimated GDP growth values for each of Industry.

based on province-specific resilience measures (the same measures we reported in Table 1). We also impose an adding-up constraint, so that provincial GDP values sum up to the aggregate GDP in each month. Figure 9 documents the results for our baseline and delayed growth scenarios.

While the IT-intensity measures do not markedly vary across provinces, the resilience does. The projected year-on-year GDP drops between February 2020 and February 2021 is seen to be highest for Newfoundland and Labrador with 8.9% and 12.8% and smallest for Saskatchewan with 3.7% and 5.3% in the baseline and delayed scenario respectively. It is important to recognize that exact drop for each province will depend on its ability to restrain the spread of infection

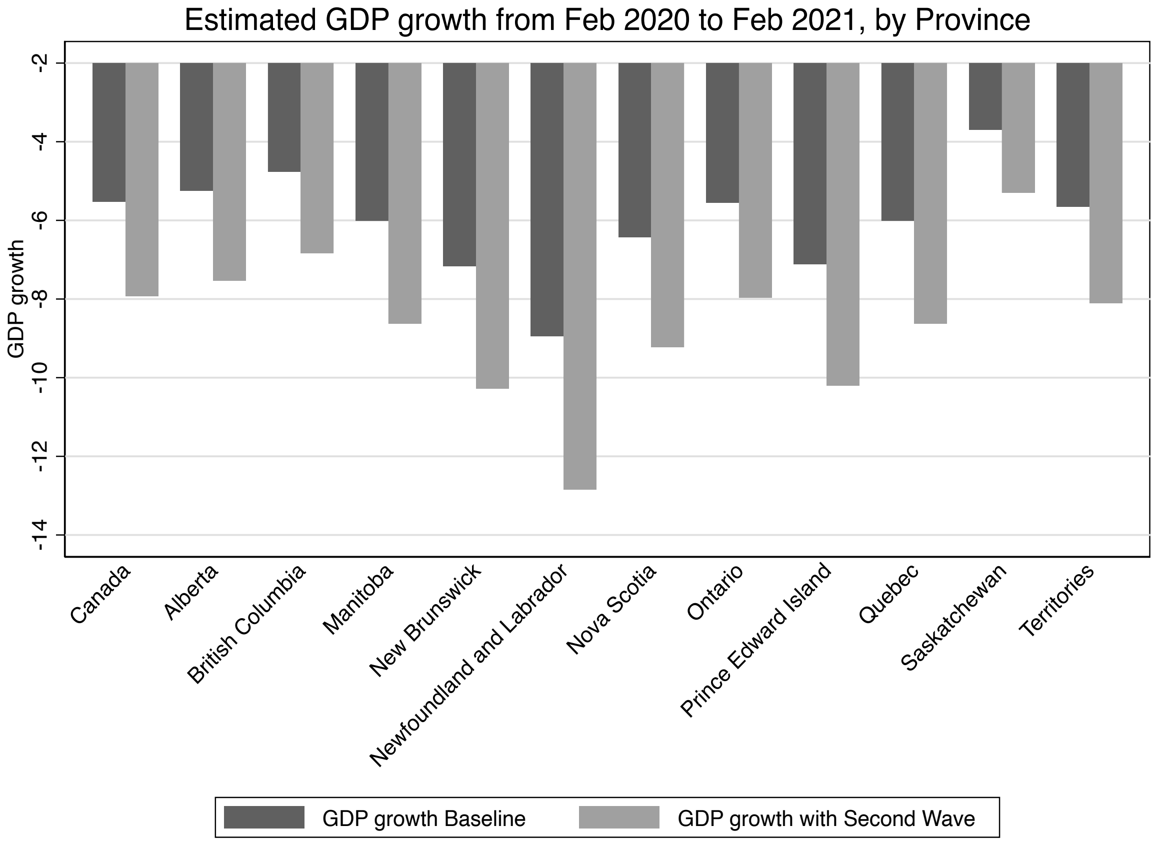


Figure 9: Expected GDP Growth in 2020 Using Occupational Resilience Measures, by Province

Note.—Sources: StatsCanada, IPUMS Canada. Based on author's calculations of resilience using Gallipoli and Makridis (2018)'s IT intensity index and Vancouver School of Economics (2020)'s home-shoreability, we estimate GDP values with equation 2. We then use the process explained in Section 5 to estimate GDP by Province for 2020 and report GDP growth from Feb 2020 to Feb 2021. Table 7 provides estimated GDP growth values for each of Province. We were not able to calculate exact growth rates for each Territory as StatsCan doesn't provide specific data required to make these estimations.

which our model doesn't take into account. While many provinces might experience varied year-on-year GDP drops, where they will end up depends on the effectiveness of population behaviors and measures aimed at reducing infection. Therefore, realized (ex-post) differences in provincial growth rates are likely to be more dispersed since they will reflect heterogeneity in the severity of local infections.

6 Extensions and Robustness

6.1 A Validation Exercise

A simple validation exercise can help establish whether the procedure explained in Section 5 gives reasonable results. Using preliminary industry GDP estimates released by Statistics Canada for April 2020, we can assess whether the cross-industry variation in GDP drops estimated using our approach is close to realized variation. Figure 10 reports both predicted and realized GDP drops, by industry, between February and April 2020. While the model slightly under-predicts the GDP drops in all industries, our cross-industry variation is accurately captured.

6.2 Work from Home and Industry Heterogeneity

Results so far focus on industry heterogeneity in resilience, reflecting IT tasks intensity and home-shorability of jobs. Yet, other sources of heterogeneity across industries may affect their responses during a pandemic event. For example, much attention has been devoted to measures of industry-specific contact intensity. These measures capture the adaptability of sectors to work-from-home arrangements by measuring the need for human contact when performing job tasks.

One such task-based set of measures has been popularized by Dingel and Neiman (2020). Not unexpectedly, their measures are highly correlated with both digital intensity and home-shorability. However, their focus is different enough to make them suitable for simple robustness exercises that illustrate how our simple state dependent extrapolation algorithm can be easily adapted to explore alternative sources of sectoral heterogeneity.

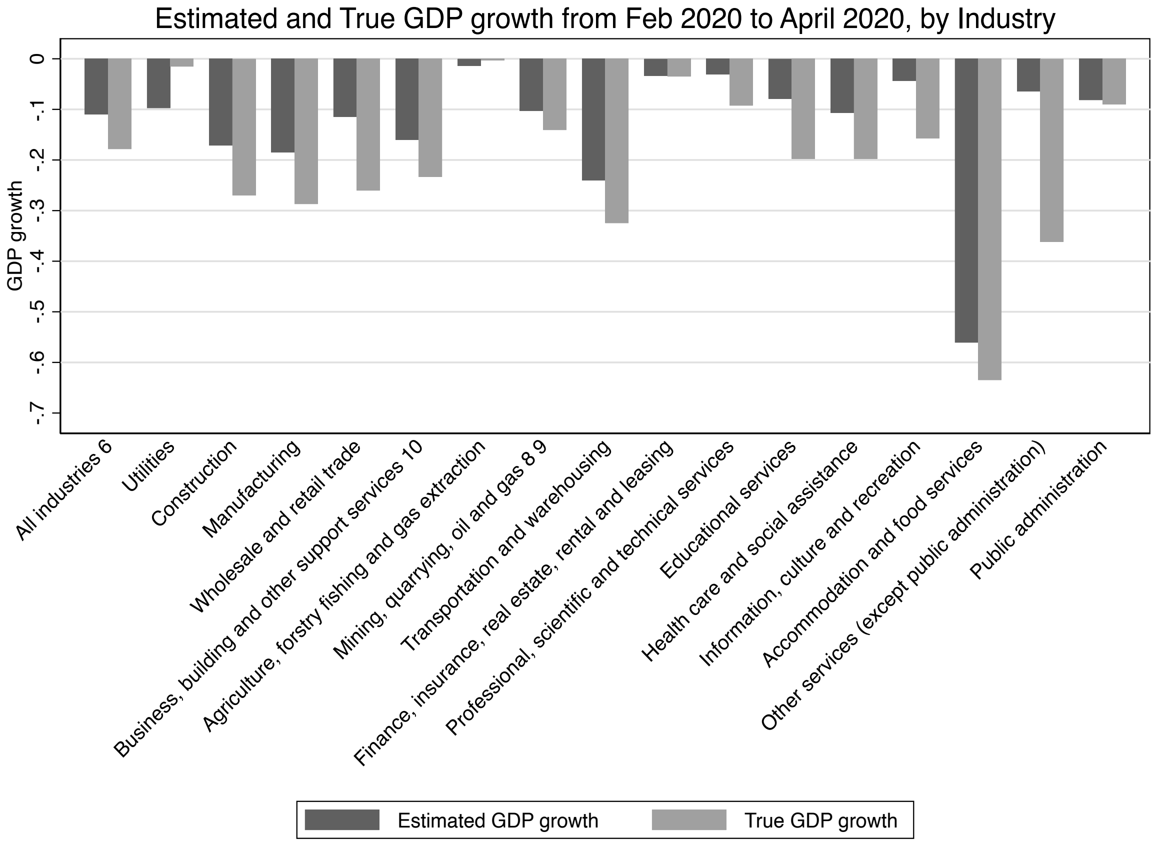


Figure 10: Estimated and Realized GDP changes between Feb 2020 and April 2020, by Industry

Note.—Sources: StatsCanada, IPUMS Canada. Based on author's calculations of resilience using Gallipoli and Makridis (2018)'s IT intensity index and Vancouver School of Economics (2020) occupational risk tool's home-shorability, we estimate GDP values with equation 2. We then use the process explained in Section 5 to estimate GDP by Industry for April 2020. We then calculate the growth rate from February 2020 to April 2020 for the estimated value and for the true value (released by StatsCan). This figure provides us with a comparative graph for GDP growth rates.

To this purpose, we classify industries into high and low contact intensity groups (above and below median) and re-estimate the GDP-employment elasticities for these sectors. The estimates, presented in column (6) of Table 3, can be used to generate estimates of GDP growth by industry and location following the onset of confinement shocks. Figure 11 plots estimates of year-on-year GDP growth between February 2020 and February 2021 based on differences in industry-specific contact intensity. While it is perhaps unsurprising that the magnitude of aggregate GDP drops is similar to our benchmark results, it is interesting to observe that also industry-specific responses

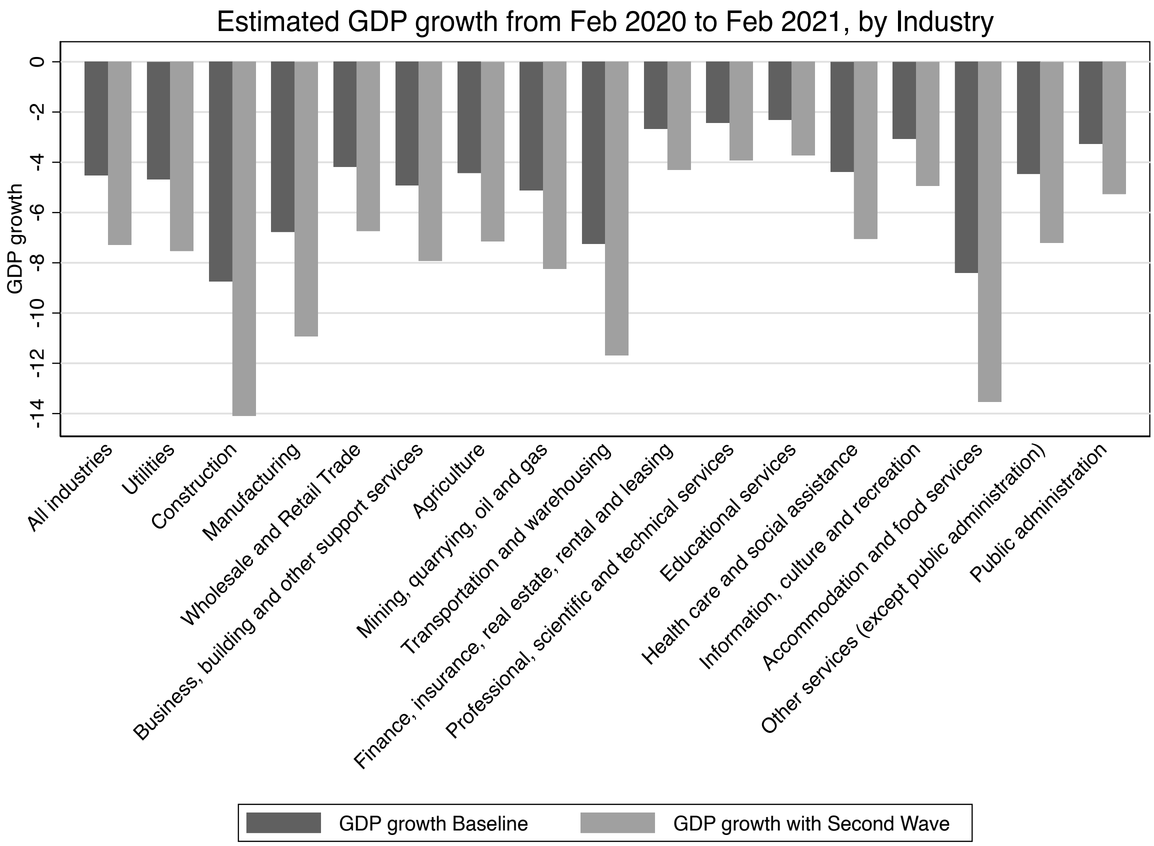


Figure 11: Expected GDP Growth in 2020 following Dingel and Neimann (2020), by Industry

Note.—Sources: StatsCanada, IPUMS Canada. Based on author's calculations using Dingel and Neiman (2020)'s work from home index to estimate GDP values with equation 2. We then use the process explained in Section 5 to estimate GDP by Industry for 2020 and report GDP growth from Feb 2020 to Feb 2021. Table 8 provides estimated GDP growth values for each of these Industries.

are broadly in line with those estimated using our resilience measures. Ability to perform jobs with limited human contact is, in itself, a form of occupational resilience during a pandemic. However, contact-intensity measures are hardly identical to our baseline dimensions of resilience and some discrepancies are clearly apparent. However, these discrepancies are not sufficient to change the broader conclusion about the sectors that are most likely to suffer from the confinement shock. One also observes that relative differences in industry-specific growth rates are roughly similar to those reported in our benchmark analysis, suggesting that the simple state-dependent algorithm is fairly robust to changes in the type and magnitude of the measures used to capture sectoral heterogeneity in jobs' resilience during the pandemic event.

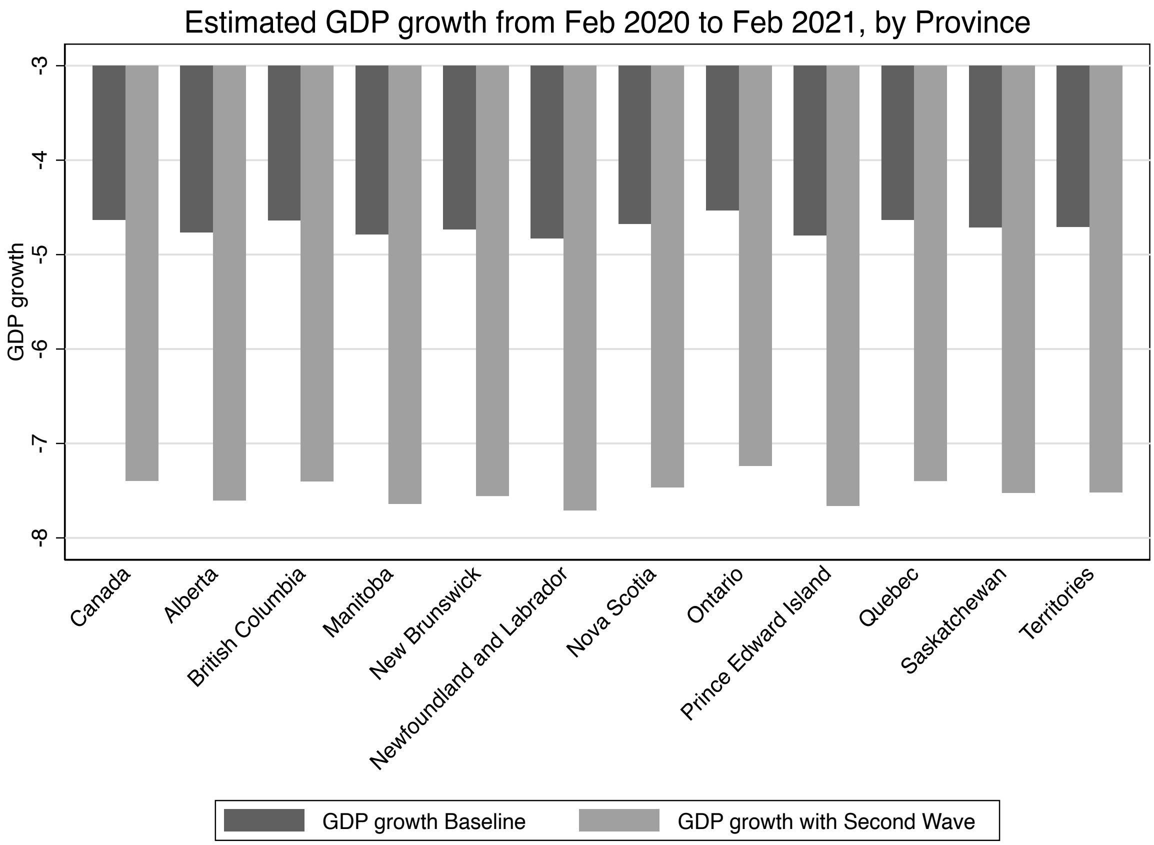


Figure 12: Expected GDP Growth in 2020 following Dingel and Neimann (2020), by Province

Note.—Sources: StatsCanada, IPUMS Canada. Based on author's calculations using Dingel and Neiman (2020)'s work from home index to estimate GDP values with equation 2. We then use the process explained in Section 5 to estimate GDP by Province for 2020 and report GDP growth from Feb 2020 to Feb 2021. Table **??** provides estimated GDP growth values for each of Province. We were not able to calculate exact growth rates for each Territory as StatsCan doesn't provide specific data required to make these estimations.

Finally, Figure 12 shows projections of year-on-year growth rates for different provinces. We estimate less heterogeneity across locations than we do across industries. In fact, there is clearly less variation across provincial GDP growth rates than in the baseline analysis where we use a richer resilience measure. Realized provincial growth rates will likely be very different from each other in reality, as they will reflect the local severity of the infection spread.

Nonetheless, one message of this robustness exercise is that, given the simplicity of the state-dependent approach used to project growth rates, one could combine different measures of industry heterogeneity to generate a richer set of estimates. The scalability of the extrapolation approach is in fact one of its main advantages.

Table 3: Elasticity of GDP Growth to Employment Growth

Dep. var. =	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Employment Growth	.33***	.37***	.72***	.39***	.40***	.81***
	[.02]	[.03]	[.05]	[.03]	[.03]	[.04]
High Contact Intensity				.01***	.01***	.04***
				[.00]	[.00]	[.00]
× Employment Growth				-.17***	-.07	-.56***
				[.04]	[.06]	[.10]
Constant	.02***	.02***	-.01***	.01***	.01***	-.02***
	[.00]	[.00]	[.00]	[.00]	[.00]	[.00]
R-squared	.12	.11	.40	.13	.13	.58
Sample Size	3488	3440	384	3488	3440	384
Sample	All	All	2008-09	All	All	2008-09
Instrument	No	Yes	No	No	Yes	No

Notes.—Source: Gallipoli and Makridis (2018), Dingel and Neiman (2020) and StatsCanada. The table reports the coefficients associated with regressions of industry × month real GDP growth (year-to-year, in chained 2012 prices) on employment growth, interacted with an indicator for whether the sector has high exposure to information technology-intensive (IT-intensive) jobs. The latter exposure is measured using IPUMS Canada 2011 data in conjunction with the Gallipoli and Makridis (2018) IT-intensity measure. We instrument the potentially endogenous employment growth with two and three month lagged values of the year-to-year growth rate. The first-stage F-statistic are strongly significant. (†) Column 7 reports the coefficients associated with regressions of industry × month real GDP growth (year-to-year, in 2012 prices) on employment growth, interacted with an indicator for the sector's ability to transition jobs to "work from home" jobs based on Dingel and Neiman (2020)'s contact intensity index.

7 Conclusion

When a sudden and wide-reaching shock hits the economy, there is invariably some urgency to come up with estimates about its likely impacts and longer term implications. The 2020 pandemic event has, in fact, generated much speculation about its consequences for aggregate and sectoral growth. Using readily available data on sectoral output and employment dynamics during the large recession of 2008/09, we develop a simple state-dependent procedure to quantify the magnitude of likely GDP declines in the Canadian economy and document how these declines might vary across industries with different occupational concentration of digital tasks. The procedure we propose does relies on easily accesibile data and has the advantage of being easily scalable to encompass different measures of industry and geographic heterogeneity.

We present evidence that sectors with greater digital intensities and home-shorability are less exposed to confinement shocks such as those occurring during a pandemic. We estimate the degree of heterogeneity in sectoral elasticities of real GDP to employment growth, and employ these estimates to extrapolate bounds for GDP growth over the months and years following the onset of the shock: a percentage point rise in the resilience of workers is associated with 0.65 percentage point higher employment growth between February to April 2020.

We consider three alternative scenarios to describe potential paths for GDP and employment. Under the baseline view, the economy is likely to shrink by over 10% during the Spring of 2020, and then gradually recover to resume year-on-year positive growth by the Spring of 2021. However, the pre-crisis GDP level is likely not to be reached before the second quarter of 2022. These aggregate patterns hide significant variation across sectors: the decline is likely to be most severe in low resilience sectors, where year-on-year GDP drops are predicted to be roughly five times as large relative to high resilience industries. We also consider a more benign scenario, in which employment headcounts recover faster than in previous recessionary episodes: under this view, aggregate GDP might return to pre-crisis levels by the end of 2021. Finally, we consider a double-dip downturn possibility, which might be associated to renewed confinement measures due to a second wave of infections in the Fall of 2021. Under this scenario, aggregate GDP would likely still be 4 percentage points below pre-crisis level by the beginning of 2022.

While time will tell how (in-)accurate these forecasts are, they provide a data-driven and transparent way to gauge the impact of the large pandemic shock on aggregate and sectoral output.

The analysis highlights the importance of differences in occupational task intensities, specifically related to the digital economy, in mediating employment and output declines. Projected GDP growth rates vary significantly across industries, with a handful of them shouldering most of the output losses in the year following the initial onset of the shock. Future research might explore how organizations in different sectors have adapted to the changes over the course of the recovery and how sustained increases in layoffs in certain sectors translate into lower future GDP.

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A Online Appendix: Procedures, Tables and Figures

A.1 Procedures to Compute Heterogeneity Scores

IT Intensity scores for Industries (Figure 2) There is a binary value for high and low it intensity (1 and 0) given according to the z-itscores for 3-digit SOC levels. We merge this with the cleaned IPUMS file and collapse the binary values by industry. This gives us a unique score for each industry. This score is plotted in Figure 2.

IT intensity score for provinces (Figure 1) We use employment data of Provinces by Industry from 2019 and merge it with the unique industry score calculated above. We calculate the product of this industry IT score and number of people in the industry in that province (*ind_prov_highit_occ*). We then find the sum of *ind_prov_highit_occ* for each province and divide it by the number of working people in that province. This gives us a unique value for each province which is the province-specific IT intensity plotted in Figure 1.

Home-shorability score for Industries for Canada (Figure 2) We have the number of people (*n_workers*) in a 4-digit occupation and the proportion of people working from home (*wfh*) in that occupation throughout Canada. We collapse the number of people working in 4-digit occupations by 2-digit industries (called *n_total*) to find the number of people in an industry. We find the share of people from an occupation working in an industry (*share_occ_ind*) by dividing *n_workers* by *n_total*. We then find the product of the *wfh* and *share_occ_ind* and collapse it by industry. This gives us a unique score for each industry for Canada, reported in (Figure 2).

Home-shorability score for Provinces (Figure 1) Using the same procedure defined above, we can calculate a unique score for each industry in a given province. We then calculate the share of workers from an industry in a particular province (*share_ind_prov*) by dividing the number of workers in an industry with the number of workers in that province. Then we find the product of the unique industry score and share of workers in that industry in the province and call it *score_share_prov*. When we collapse this, we get a unique number for the given province. This can be repeated for each province to find the score which is then reported in (Figure 1).

Resilience (Figure 1 and 2) It is the product of the IT intensity score and home-shorability score for each province and industry.

A.2 Tables and Figures

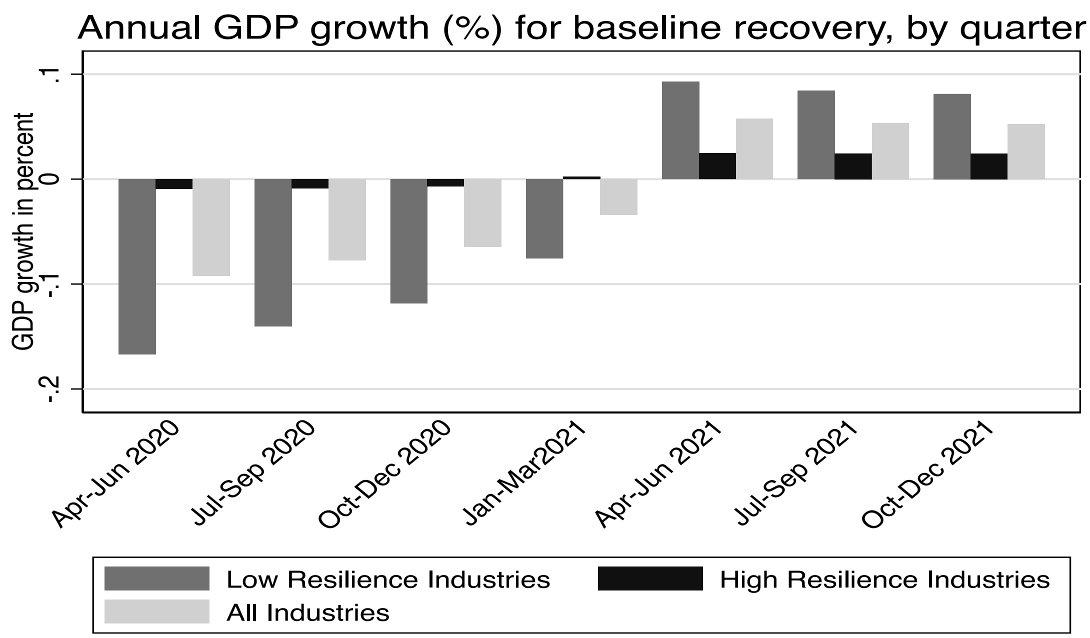

Figure 13: Quarterly GDP Growth rates for Baseline Scenario

Note.— Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. GDP growth for each quarter is defined as the average of the annual growth rate estimated for each month of the quarter for the baseline scenario. The annualized GDP growth rates from February 2020 to January 2022 are reported in Table 5

Table 4: GDP Levels (Feb 2020 normalized to one)

	Baseline			Optimistic			Second wave		
	Aggregate	Low Resilience	High Resilience	Aggregate	Low Resilience	High Resilience	Aggregate	Low Resilience	High Resilience
Feb-20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Mar-20	0.929	0.911	0.949	0.929	0.911	0.949	0.929	0.911	0.949
Apr-20	0.890	0.816	0.971	0.890	0.816	0.971	0.890	0.816	0.971
May-20	0.903	0.836	0.975	0.903	0.836	0.975	0.903	0.836	0.975
Jun-20	0.910	0.848	0.977	0.918	0.863	0.977	0.918	0.863	0.977
Jul-20	0.913	0.851	0.981	0.929	0.880	0.982	0.929	0.880	0.982
Aug-20	0.918	0.859	0.982	0.939	0.899	0.983	0.919	0.864	0.980
Sep-20	0.921	0.862	0.985	0.948	0.912	0.986	0.906	0.852	0.965
Oct-20	0.926	0.868	0.988	0.957	0.926	0.990	0.904	0.831	0.984
Nov-20	0.931	0.875	0.992	0.966	0.939	0.995	0.908	0.835	0.988
Dec-20	0.938	0.886	0.994	0.974	0.954	0.997	0.914	0.845	0.990
Jan-21	0.941	0.893	0.994	0.980	0.963	0.997	0.918	0.851	0.990
Feb-21	0.946	0.900	0.996	0.984	0.970	0.999	0.922	0.858	0.991
Mar-21	0.938	0.892	0.989	0.976	0.962	0.992	0.914	0.849	0.984
Apr-21	0.946	0.901	0.995	0.985	0.973	0.998	0.921	0.858	0.990
May-21	0.952	0.909	0.999	0.987	0.973	1.002	0.927	0.865	0.994
Jun-21	0.959	0.921	1.001	0.989	0.975	1.004	0.933	0.875	0.996
Jul-21	0.963	0.923	1.005	0.988	0.968	1.009	0.936	0.878	1.000
Aug-21	0.967	0.931	1.006	0.988	0.969	1.009	0.941	0.885	1.001
Sep-21	0.970	0.934	1.009	0.989	0.967	1.011	0.945	0.888	1.007
Oct-21	0.975	0.940	1.013	0.988	0.964	1.015	0.949	0.894	1.008
Nov-21	0.980	0.946	1.017	0.989	0.962	1.019	0.954	0.901	1.012
Dec-21	0.986	0.957	1.018	0.992	0.967	1.020	0.960	0.910	1.013
Jan-22	0.990	0.964	1.018	0.993	0.969	1.019	0.963	0.917	1.013

Note.—Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. This table gives us the levels of GDP for a month when compared with the level of GDP of February 2020 (which is considered to be 1). We have three different scenarios- baseline, optimistic and second wave. Each scenario has the GDP level reported for aggregate GDP, GDP of low resilience industries and GDP of high resilience industries. We use equation 2 to estimate annual GDP growths given an assumed path of employment growth for each scenario. This GDP growth rate is then used to calculate GDP values which is further used to estimate GDP levels as presented in this table. Throughout all three scenarios, we only observe an unexpected drop in employment levels in March and April 2020. This gives us a sudden drop in the employment and GDP levels for March 2021 as they depend upon the employment levels in March 2020. To overcome this challenge of our model, we calculate the employment growth rate of March 2021 with respect to the average employment level of March and April 2020 i.e. ((employment in March'21- average of employment in March'20 and April'20)/(average of employment in March'20 and April'20)). This employment growth rate is then used as per the model to compute GDP growth rate and levels.

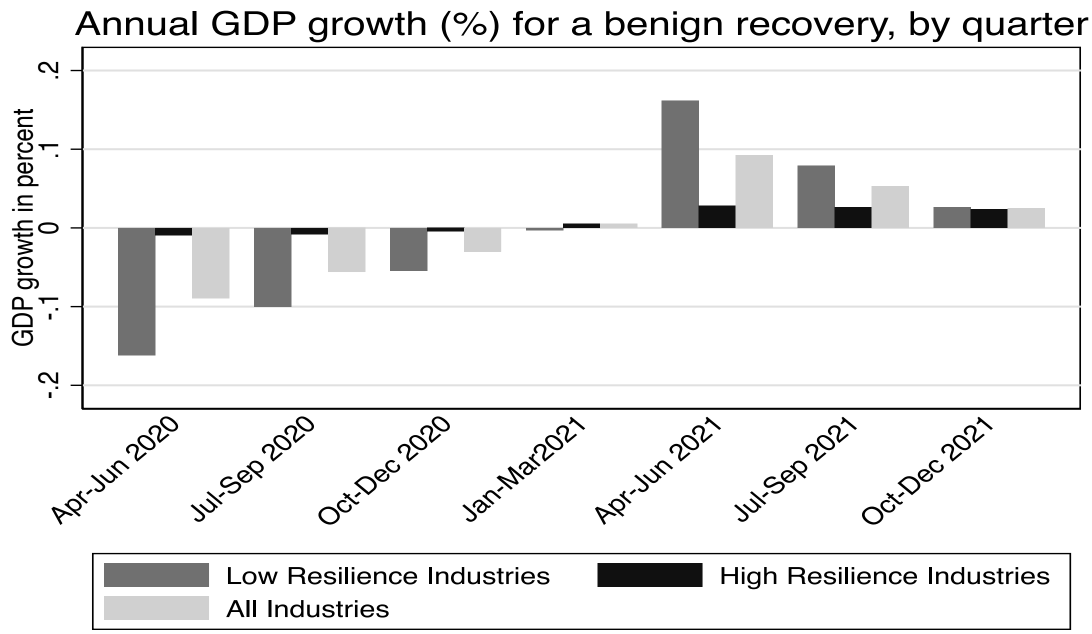

Figure 14: Quarterly GDP Growth rates for the benign outlook

Note.— Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. GDP growth for each quarter is defined as the average of the annual growth rate estimated for each month of the quarter for a benign outlook. The annualized GDP growth rates from February 2020 to January 2022 are reported in Table 5

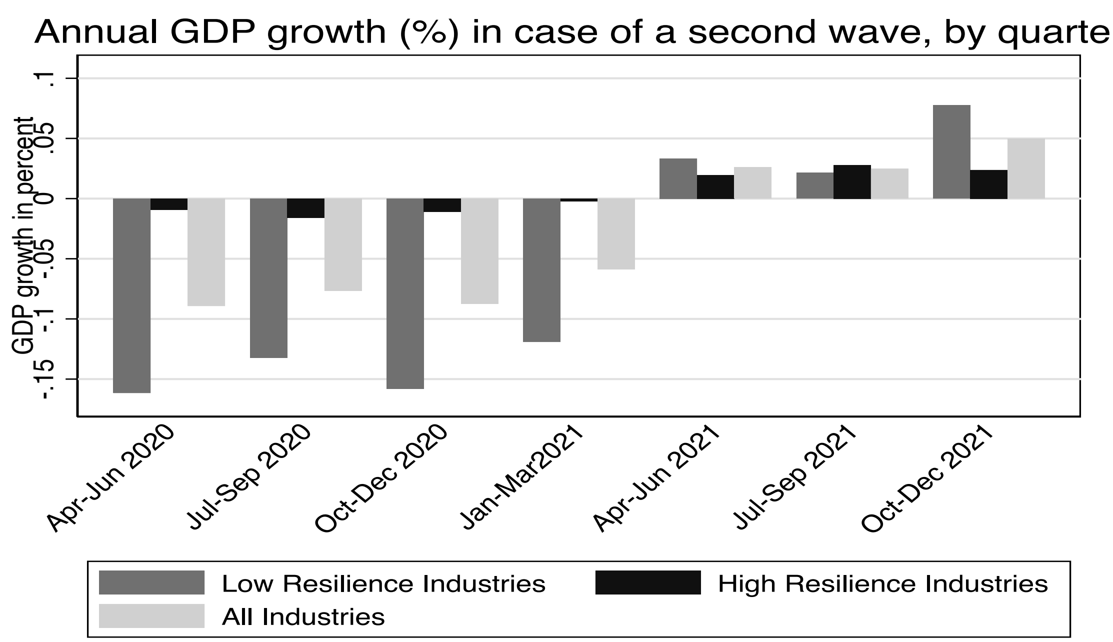

Figure 15: Quarterly GDP Growth rates in case of a Second Wave

Note.— Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. GDP growth for each quarter is defined as the average of the annual growth rate estimated for each month of the quarter in case Canada experiences a second wave. The annualized GDP growth rates from February 2020 to January 2022 are reported in Table 5

Table 5: Annualized GDP Growth Rates (percentages)

	Baseline			Optimistic			Second wave		
	Aggregate	Low Resilience	High Resilience	Aggregate	Low Resilience	High Resilience	Aggregate	Low Resilience	High Resilience
Feb-20	2.21	1.93	2.52	2.21	1.93	2.52	2.21	1.93	2.52
Mar-20	-5.74	-6.17	0.59	-5.74	-6.17	0.59	-5.74	-6.17	0.59
Apr-20	-10.07	-18.27	-0.98	-10.07	-18.27	-0.98	-10.07	-18.27	-0.98
May-20	-9.01	-16.32	-0.94	-9.01	-16.32	-0.94	-9.01	-16.32	-0.94
Jun-20	-8.55	-15.47	-0.91	-7.73	-13.91	-0.89	-7.73	-13.91	-0.89
Jul-20	-8.04	-14.63	-0.83	-6.49	-11.71	-0.78	-6.49	-11.71	-0.78
Aug-20	-7.75	-13.94	-0.97	-5.57	-9.84	-0.89	-7.57	-13.44	-1.14
Sep-20	-7.46	-13.51	-0.85	-4.76	-8.46	-0.72	-8.93	-14.51	-2.85
Oct-20	-6.95	-12.58	-0.85	-3.82	-6.73	-0.67	-9.10	-16.32	-1.28
Nov-20	-6.38	-11.69	-0.66	-2.92	-5.23	-0.42	-8.71	-15.78	-1.07
Dec-20	-6.07	-11.17	-0.55	-2.38	-4.32	-0.28	-8.43	-15.30	-0.97
Jan-21	-5.76	-10.60	-0.48	-1.94	-3.56	-0.19	-8.14	-14.78	-0.91
Feb-21	-5.42	-10.02	-0.42	-1.60	-2.97	-0.10	-7.83	-14.24	-0.85
Mar-21	0.98	-2.08	1.58	5.10	5.64	1.93	-1.64	-6.74	1.11
Apr-21	6.30	10.49	2.47	10.68	19.27	2.83	3.48	5.12	1.98
May-21	5.50	8.75	2.46	9.35	16.35	2.82	2.69	3.46	1.96
Jun-21	5.46	8.64	2.46	7.77	12.96	2.78	1.68	1.42	1.93
Jul-21	5.40	8.53	2.45	6.34	10.05	2.72	0.82	-0.27	1.89
Aug-21	5.36	8.43	2.45	5.18	7.71	2.65	2.31	2.50	2.12
Sep-21	5.31	8.32	2.44	4.31	6.04	2.57	4.28	4.23	4.34
Oct-21	5.26	8.22	2.44	3.27	4.04	2.48	4.89	7.61	2.40
Nov-21	5.22	8.12	2.44	2.39	2.38	2.40	5.02	7.90	2.38
Dec-21	5.18	8.02	2.43	1.84	1.40	2.31	4.99	7.81	2.37
Jan-22	5.15	7.93	2.43	1.40	0.59	2.25	4.95	7.71	2.37

Note.—Source: Gallipoli and Makridis (2018), Vancouver School of Economics (2020) occupational risk tool and StatsCanada. This table shows the annualized growth rate as calculated by our model in equation 2 in percentage. Annualized growth rate refers to the rate of growth between a month from year to year. This has been reported for all three scenarios for aggregate GDP, low resilience industries and high resilience industries.

Table 6: Expected GDP Growth (%) in 2020 following Gallipoli and Makridis (2018), by Industry

Industries	GDP Growth (Baseline)	GDP Growth (Delayed)
All industries	-5.42	-7.83
Agriculture	-0.68	-0.98
Mining, quarrying, oil and gas	-5.09	-7.34
Utilities	-4.81	-6.95
Construction	-8.45	-12.20
Manufacturing	-9.11	-13.15
Wholesale and Retail Trade	-5.65	-8.17
Transportation and warehousing	-11.85	-17.11
Finance, insurance, real estate, rental and leasing	-1.65	-2.39
Professional, scientific and technical services	-1.52	-2.20
Business, building and other support services	-7.91	-11.42
Educational services	-3.89	-5.62
Health care and social assistance	-5.28	-7.63
Information, culture and recreation	-2.15	-3.11
Accommodation and food services	-27.64	-39.92
Other services (except public administration)	-3.18	-4.59
Public administration	-4.03	-5.81

Note.—Sources: StatsCanada, IPUMS Canada. Based on author's calculations of resilience using Gallipoli and Makridis (2018)'s IT intensity index and Vancouver School of Economics (2020) occupational risk tool's home-shoreability, we then use the estimates of GDP values calculated in section 4 in the baseline and delayed scenario to follow the process explained in Section 5 to estimate GDP by Industry for 2020 and report GDP growth from Feb 2020 to Feb 2021 in this table.

Table 7: Expected GDP Growth (%) in 2020 following Gallipoli and Makridis (2018), by Province

Provinces	GDP Growth (Baseline)	GDP Growth (Delayed)
Canada	-5.526	-7.930
Newfoundland and Labrador	-8.949	-12.842
Prince Edward Island	-7.111	-10.205
Nova Scotia	-6.429	-9.226
New Brunswick	-7.164	-10.280
Quebec	-6.010	-8.624
Ontario	-5.553	-7.969
Manitoba	-6.013	-8.630
Saskatchewan	-3.690	-5.296
Alberta	-5.247	-7.529
British Columbia	-4.762	-6.834
Territories	-5.650	-8.108

Note.—Sources: StatsCanada, IPUMS Canada. Based on author's calculations of resilience using Gallipoli and Makridis (2018)'s IT intensity index and Vancouver School of Economics (2020) occupational risk tool's home-shoreability, we then use the estimates of GDP values calculated in section 4 in the baseline and delayed scenario to follow the process explained in Section 5 to estimate GDP by Province for 2020 and report GDP growth from Feb 2020 to Feb 2021 in this table. We were not able to calculate exact growth rates for each Territory as StatsCan doesn't provide specific data required to make these estimations.

Table 8: Expected GDP Growth (%) in 2020 following Dingel and Neimann (2020), by Industry

Industries	GDP Growth (Baseline)	GDP Growth (Delayed)
All industries	-4.52	-7.29
Agriculture	-4.43	-7.14
Mining, quarrying, oil and gas	-5.11	-8.24
Utilities	-4.68	-7.54
Construction	-8.75	-14.10
Manufacturing	-6.78	-10.92
Wholesale and Retail Trade	-4.18	-6.74
Transportation and warehousing	-7.25	-11.69
Finance, insurance, real estate, rental and leasing	-2.67	-4.30
Professional, scientific and technical services	-2.43	-3.92
Business, building and other support services	-4.92	-7.93
Educational services	-2.31	-3.72
Health care and social assistance	-4.38	-7.05
Information, culture and recreation	-3.06	-4.93
Accommodation and food services	-8.40	-13.54
Other services (except public administration)	-4.47	-7.20
Public administration	-3.27	-5.27

Note.—Sources: StatsCanada, IPUMS Canada. Based on author's calculations using Dingel and Neiman (2020)'s Work from home index, we estimate GDP values for a baseline and delayed scenario with equation 2 and elasticities in column ($7^{\dagger}$) of Table 3. We then use the process explained in Section 5 to estimate GDP by Industry for 2020 and report GDP growth from Feb 2020 to Feb 2021 in this table.