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CULTURAL AND PUBLIC SERVICES AS FACTORS OF CITY RESILIENCE? EVIDENCE FROM BIG PLANT CLOSURES AND DOWNSIZING

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Les services culturels et publics comme facteurs de résilience des villes ? Analyse à partir des fermetures de grosses entreprises et des licenciements de masse

Kristian Behrens, Manassé Drabo et Florian Mayneris

Résumé

Nous combinons des données de recensement et des données au niveau des établissements pour la période 2001-2017 afin d'étudier l'impact des licenciements massifs dans les grandes entreprises manufacturières sur la taille et la composition des villes canadiennes. Nous constatons que les fermetures d'usines et les licenciements massifs affectent négativement la croissance démographique ultérieure, en particulier parmi les jeunes, les personnes en âge de travailler, les migrants et les personnes moins qualifiées. Il existe également des effets négatifs importants sur l'emploi local dans d'autres secteurs que l'industrie manufacturière, ce qui peut expliquer pourquoi de tels chocs négatifs de demande de main-d'œuvre affectent la dynamique démographique. Les services publics (en santé et en éducation) et les aménités culturelles et récréatives rendent les villes plus résilientes et les aident à conserver leur population après des chocs négatifs de demande de main-d'œuvre.

Mots-clés: Changements sociodémographiques / fermetures d'usines / licenciements massifs / industrie manufacturière / résilience des villes.

Codes JEL: J10; R11; R12; R23

Cultural and public services as factors of city resilience? Evidence from big plant closures and downsizing*

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Abstract

We combine census and establishment-level data for 2001–2017 to study the impact of mass layoffs of big manufacturing plants on city-level population and its composition in Canada. We find that manufacturing plant closures and downsizing lead to a decline in subsequent population growth, especially among the young, those of working age, migrants, and the less skilled. There are also sizable negative effects on the local employment in other industries, which can explain why such negative local labor demand shocks affect population dynamics. Public services (health and education) and cultural and recreational amenities are shown to make cities more resilient and help them retain population following negative local labor demand shocks.

Keywords: Socio-demographic change; plant closures; downsizing; manufacturing; city resilience.

JEL Classification Codes: J10; R11; R12; R23.

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1 Introduction

Cities are more vulnerable to political and economic dislocation than to physical destruction (Glaeser, 2021). Yet, how the demographic composition of cities changes in the wake of negative economic shocks—and what city-level characteristics favor urban resilience—are far less studied in the literature. The aim of this paper is to fill this gap.

To this end, we evaluate the impact of the closures and massive downsizing of big manufacturing plants on the growth and composition of city population. We find that: (i) plant closures lead to lower subsequent population growth; (ii) affect younger residents, single residents, and migrants more than older residents, families, and non-migrants; and (iii) have larger effects on less skilled workers. Cities that are initially better endowed in education and health services, as well as in arts and recreational amenities, are more resilient to negative local labor demand shocks. These mitigating effects are heterogeneous across socio-demographic population groups. Finally, we show that the closure and massive downsizing of big manufacturing plants negatively affect the employment growth of several other sectors in the local economy, especially in construction, cultural services, and finance-insurance-real estate (FIRE). These negative spillover effects might partly explain why negative employment shocks in the manufacturing sector have such a significant depressing effect on the demographic dynamics of cities.

Our findings are important for several reasons. First, central and local governments make substantial investments to ward off big plant closures. For example, in 2008 and 2009, the U.S. administration paid $50 billion to General Motors and Chrysler to prevent the closure of their plants, whereas the Canadian federal government paid $9.5 billion to General Motors to secure its business and thousands of jobs in Oshawa. Measuring the effects of big plant closures on local economies is thus important to understand whether the huge costs of those safeguard plans are justified compared to the short- and long-run costs of the closures. Second, the propensity to consume varies significantly across age groups, and the needs in terms of amenities and services also differ by age or family status. Assessing the heterogeneous impacts of big plant closures across population categories is thus important to better understand the potential long-run consequences of these closures on the local economy. Finally, beyond safeguard plans, it is important to identify local factors that can explain why some cities succeed at retaining certain types of residents despite large negative labor demand shocks. What makes cities resilient is a recurring question in urban and regional economics and a first-order policy concern.

To estimate the effects of big manufacturing plant closures on the size and the composition of the population of Canadian urban areas, we combine establishment-level data and population census data from 2001 to 2017. Identifying the impact of poor local economic performance on population changes is challenging due to possible reverse causality. A rich literature has shown that denser labor markets offer higher wages (e.g., Glaeser and Mare, 2001; Combes et al., 2008), while the regional concentration of particular industries could provide insurance against idiosyncratic employment shocks (e.g., Ellison et al., 2010; Overman and Puga, 2010). Put differently, local economic conditions certainly influence population dynamics, i.e., *people follow jobs*. Yet, job opportunities are not the only factor that attracts population. Several papers show that people move to cities with better amenities and higher quality-of-life (e.g. Glaeser et al., 2001; Rappaport, 2007; Albouy and Stuart, 2020). Then, firms might follow to reap the benefits from a denser labor market and a larger pool of workers (e.g., Head and Mayer, 2004). In this case, population growth determines local economic conditions, i.e., *jobs follow people*.[1] This reverse causality would lead to overestimating the impact of big plant closures on local population. Another type of issue is that plant closures are partly compensated by plant openings. If, for some reason, plant turnover varies across cities so that cities with a higher plant closure rate also have a higher plant creation rate, this would bias the estimated effect of big plant closures toward zero.

To deal with these endogeneity problems, we rely on an IV strategy. In our preferred specification, our treatment variable is the share of initial manufacturing jobs lost between 2003 and 2017 due to big manufacturing plant closures or downsizing in each Canadian city. We instrument it by the predicted growth rate of the number of manufacturing jobs computed as the interaction between the initial manufacturing composition of the city (NAICS 4-digit industries) and the observed growth rate of the number of jobs in these same industries in the US. Our instrument arguably captures global technology and trade shocks that affect manufacturing industries in both the US and Canada. Finally, we also control for observable characteristics that might influence

[1] These bidirectional causal mechanisms are well explained by "New Economic Geography" models which suggest that agglomeration economies—wherein big markets attract firms, which in turn attracts new workers and consumers—are conducive to self-reinforcing regional growth (Krugman, 1991; Fujita et al., 1999).

city-level population changes such as local temperature, proximity to the coast and to other major urban centers, as well as regional policy differences.

Our work is related to three strands of literatures. First, research on job displacement has shown that workers who lose their jobs due to big plant closures or mass layoffs suffer from long-lasting income losses (e.g., Ruhm, 1991; Jacobson and LaLonde, 1993; Couch and Placzek, 2010), longer unemployment durations (e.g., Eliason and Storrie, 2006), and other adverse outcomes.[2] Building on the literature on multiplier effects, other studies analyze the spillover effects of plant closures and mass layoffs on neighboring plants and regional labor markets (e.g., Gathmann et al., 2020; Jofre-Monseny et al., 2018).[3] However, we are not aware of any study on the relationship between plant closures and demographic changes at the local level. Yet, plant closures and mass layoffs can reshape the demographic composition of cities by displacing more mobile or educated populations, which might in turn affect the growth prospects of those cities.[4]

Second, several studies have shown that high-skilled workers and immigrants are highly responsive to local labor demand shocks in terms of labor supply (e.g., Topel, 1986; Bound and Holzer, 2000; Cadena and Kovak, 2016). This is confirmed by Albouy et al. (2019), who show that positive local labor demand shocks in the 1990s and 2000s increase the local share of residents holding a university degree in Canada, but not in the US. Beyond different mobility costs, the inelastic housing supply, the existence of social transfers, and the immigration selection criteria can explain this heterogeneous response of workers to local labor demand shocks (e.g., Glaeser and Gyourko, 2005; Notowidigdo, 2019). Based on negative employment shocks from the recent decades of deindustrialization, we provide here a different but complementary view on this issue and further analyze how the heterogeneous response depends on age and family status. Younger residents and

[2]These include reduced fertility (e.g., Huttunen and Kellokumpu, 2016), higher mortality (e.g., Sullivan and Von Wachter, 2009), higher risk of divorce (e.g., Charles and Stephens Jr., 2004), and lower income for their kids when they become adults (e.g., Oreopoulos et al., 2008).

[3]Using US data, Moretti (2010) finds that one additional manufacturing job generates 1.6 jobs in the non-tradable sector due to increased demand for local goods and services. Faggio (2019) and Jofre-Monseny et al. (2020) also find significant multiplier effects from public-sector jobs in Spain and in the UK.

[4]In the context of adverse trade shocks, Twinam (2020) and Autor et al. (2021) find some negative effects on local population dynamics, especially for foreign-born and younger residents, even though the magnitude of these effects seems to be context-specific and to depend on the size of the local units that are considered.

immigrants selected to Canada on the basis of economic criteria are much more sensitive to local economic conditions affecting employment opportunities. On the opposite, family commitments (being in a couple, having at least one child) constitute a significant mobility cost for workers.

Last, we identify some city-level characteristics that explain resilience to big manufacturing plant closures, thereby contributing to the recent literature on the resilience of local economies. Martin et al. (2011) show that French exporting firms suffered more from the 2008 trade collapse when they were located close to other exporters or were targeted by cluster policies. Behrens et al. (2020) show that plants in Canadian textile clusters are not more likely survive or to adapt by changing their main sector of activity than those outside clusters. Finally, Delgado and Porter (2017) find that industries located near other related industries experienced higher employment growth than unrelated industries during the Great Recession of 2007–2009. Whereas these studies focus on how firms adapt or survive, we adopt here a different angle by examining the performance of cities in retaining specific segments of their population following a negative shock to their local labor market. On the other hand, recent contributions investigate the role of cultural and recreational industries in local development. Using Canadian data, Polèse (2012) shows that if the presence of cultural industries fosters employment growth in other industries, this is true for specific industries and in the context of large cities only. Behrens et al. (2021) show that the presence of some cultural and creative industries in poor neighborhoods is significantly associated with subsequent gentrification. We have a different view here and show that the presence of certain services, such as education, health, arts and culture, contributes to the demographic resilience of cities.

The rest of the paper is organized as follows. Section 2 describes our data. Section 3 presents OLS and IV results on the impact of big manufacturing plant closures and downsizing on population composition. In Section 4 we estimate the impact of mass layoffs on local employment in non-manufacturing industries. Section 5 examines the heterogeneous effects along initial city characteristics, thus identifying factors of resilience. Section 6 concludes.

2 Data and descriptive statistics

In this section, we describe the establishment-level database we use to measure big manufacturing plant closures and downsizing, as well as the demographic, economic, and geographic variables we control for in the empirical analysis. We also provide descriptive statistics that motivate our subsequent analysis.

2.1 Establishment-level data and plant-closure rate

Our primary source of data are the *Scott's National All Business Directories* that contain exhaustive information on establishments operating in Canada, with an extensive coverage of the manufacturing sector (NAICS 31–33). We have these data every two years from 2003 to 2017.[5] Each plant in that database reports: a unique identifier; information on its primary 6-digit NAICS code; its opening year; its number of employees; whether it is an exporter or a headquarter; and complete address information. The latter allows us to geocode the plants and to assign them to cities.[6] Table 1 provides an overview of the geographic structure of manufacturing in Canada in 2003 and 2017, respectively. Most manufacturing plants are located in Quebec and Ontario within the 'manufacturing belt' that runs from Quebec City, QC, to Windsor, ON. Table 1 shows that the total number of manufacturing establishments in our sample has declined from 52,784 in 2003 to 34,135 in 2017. This is in line with the deindustrialization process observed in most developed countries over the past decades. Observe also that while the number of plants has sharply declined between 2003 and 2017, their average size has slightly increased, from 31 employees in 2003 to 35 employees in 2017. This suggests positive selection among survivors: more productive and larger plants are more likely to survive large negative shocks (see Bernard and Jensen, 2007).

While the Scott's database is very exhaustive, it is not a census of manufacturing plants. Yet, it is probably the best alternative to restricted-access datasets such as Statistics Canada's Annual Survey of Manufacturers or the Business Register.[7] In contrast to the first dataset, it provides more information on smaller plants. In contrast to the second dataset, it allows us to track plants and basic information about them over 15 years. Correlations of sectoral or provincial establishment counts and employment in the Scott's Data and Statistics Canada datasets are very high (about 0.95 on average), which suggests that our data provide a fairly accurate picture of the overall manufac-

[5]Data from the 2015 version are missing in our database, thus leaving us with seven cross-sections from 2003 to 2017. Since we look at long differences, we only need the first and the last year for the analysis here.

[6]More information on the geocoding procedure is provided in Appendix B.

[7]See Tables C.1, C.2, and C.3 in the Appendix for a comparison between the Scott's National All Business database and other establishment-level databases from Statistics Canada.

turing structure with respect to industrial composition, the number of plants, and employment.

Table 1: Geographic breakdown of manufacturing plants in Canada.

Region	Province	2003 # of plants	2003 Avg. # of jobs	2017 # of plants	2017 Avg. # of jobs
Western	Alberta	3,650	32.9	2,891	36.9
	British Columbia	5,923	27.7	3,966	30.6
	Manitoba	1,556	33.6	1,061	37.3
	Saskatchewan	1,291	23.5	895	25.8
		12,420	***29.5***	***8,813***	***33.0***
Atlantic	New Brunswick	1,376	32.0	740	37.2
	Newfoundland and Labrador	578	39.6	320	41.2
	Nova Scotia	1,576	26.0	816	30.7
	Prince Edward Island	303	24.0	154	34.9
		3,833	***30.0***	***2,030***	***35.1***
Ontario	Ontario	***21,758***	***35.3***	***14,277***	***36.1***
Quebec	Quebec	***14,773***	***34.5***	***8,980***	***39.4***
Canada		**52,784**	**30.9**	**34,135**	**35.0**

Notes: Data from the Scott's National All Business Directories. The table is based on manufacturing plants (NAICS 31–33). The three territories (Northwest Territories, Nunavut, and Yukon) are not reported in the table but are included in the total.

We construct measures of the manufacturing job-loss rate and plant-closure rate in city c. Our measures are based on the literature on the effects of mass layoffs that focuses on 'significant closures':[8] (i) large plants—with at least 50 employees—present in 2003 that are not present anymore in 2017; and (ii) large plants—with at least 50 employees—present in 2003 and that lost at least 30% of their employees by 2017. For each of our two definitions of 'significant closures' above, we construct the following two measures of the job loss rate for city c:

$$\text{Job loss rate}_c = \frac{\text{\# Employees in large plants present in 2003 but not in 2017 in } c}{\text{\# Employees in all plants present in 2003 in } c} \tag{1}$$

$$\text{Closure rate}_c = \frac{\text{\# Large plants present in 2003 but not in 2017 in } c}{\text{\# Plants present in 2003 in } c}, \tag{2}$$

where the former (a weighted measure) is based on the employment of big closing/downsizing

[8] See Jacobson and LaLonde (1993); Sullivan and Von Wachter (2009); Couch and Placzek (2010); Huttunen and Kellokumpu (2016), among others.

plants, whereas the latter (an unweighted measure) relies on plant counts only. In what follows, we use the job loss rate (1) measured following both definition (i) and definition (ii) of 'significant closures' as our benchmark. We show in a robustness check that our results go through when using the closure rate (2) instead.

We construct measures (1) and (2) across all industries for each city c and also for the whole of Canada by industry. Table 2 reports descriptive statistics on big manufacturing plant closures.[9]

Table 2: Descriptive statistics of big manufacturing plants closed by NAICS 3-digit sectors.

NAICS3	Manufacturing sector	(1) Closure rate closed in initial plants	(2) Job loss rate losses in initial jobs	(3) Avg. # jobs of closed big plants	(4) Relative share of exporters closed/non closed	(5) Relative share of headquaters closed/non closed
311	Food	9.7%	32.5%	152.9	1.00	0.71
312	Beverage and tobacco product	6.4%	23.3%	168.2	0.85	0.92
313	Chemical	16.2%	54.8%	164.3	0.91	0.91
313	Textile mills	7.5%	40.6%	123.7	0.78	0.62
314	Textile product mills	12.5%	47.1%	127.9	0.87	0.57
315	Clothing	5.8%	24.7%	129.3	0.95	0.10
316	Leather and allied product	9.5%	36.7%	141.5	1.03	0.91
321	Wood product	20.6%	49.2%	209.4	1.01	0.71
322	Paper	4.3%	29.6%	125.4	0.91	0.76
323	Printing and related support actv.	7.2%	26.7%	238.6	1.06	0.90
324	Petroleum and coal product	8.9%	30.3%	134.7	0.99	0.95
326	Plastics and rubber products	10.0%	32.1%	130.4	1.02	0.98
327	Non-metallic mineral product	5.4%	26.6%	127.8	1.08	0.81
331	Primary metal	13.6%	38.0%	184.3	1.00	1.22
332	Fabricated metal product	5.1%	24.2%	127.2	1.05	0.78
333	Machinery	6.4%	26.2%	119.3	0.97	0.98
334	Computer and electronic product	8.6%	34.7%	167.3	1.00	0.92
335	Electrical equipment, appliance	8.5%	31.9%	156.8	0.99	0.95
336	Transportation equipment	12.5%	39.8%	195.7	0.92	0.78
337	Furniture and related product	4.6%	25.2%	127.2	0.89	0.95
339	Miscellaneous	2.9%	28.2%	138.6	1.05	0.77
	All sectors	**7.5%**	**32.7%**	**144.9**	**0.98**	**0.82**

Notes: "Big plants" refer to 50+ establishments from 2003 that disappeared in 2017. The data are from Scott's National All Business Directories.

Column 1 reports the share of big plants that closed as a proportion of the total number of plants in 2003 (whatever their size). The (weighted) average closure rate equals 7.5%, with substantial heterogeneity across sectors.[10] Column 2 shows the share of jobs that are lost due to the closure of big plants. By construction, this share is much higher on average (32.7%) than the plant-closure

[9] Table 2 uses definition (i) for what constitutes a closing plant. See Table C.4 for the same type of descriptive statistics with definition (ii) when we account for mass layoffs on top of closures.

[10] Out of the 52,784 plants that were active in 2003, 8,941 were big plants with 50+ employees, and out of these, 3,969, i.e. 7.5% of the total number of plants, had closed by 2017 (5,188 when we add downsized plants).

rate in column 1. The sectors with the highest job loss rates are the chemical, metal, wood product, transportation equipment, and textile and clothing sectors. These sectors also have a high closure rate, which is not surprising since the correlation between the figures in the first two columns of Table 2 equals 0.84. Column 3 shows that the average size of closing establishments equals 145 employees on average. Column 4 shows the ratio between the share of exporters among big plants that closed and the share of exporters among big plants that did not close. On average, there are as many exporters among the big plants that closed as among those that did not close, even though this relative share varies substantially across sectors. Finally, column 5 shows that there are fewer headquarters among the big plants that closed compared to the big plants that did not close, in line with the fact that when a firm has several establishments, it starts by closing production establishments rather than headquarters.

Turning to the geography of plant closures, Table 3 shows that there is substantial heterogeneity across provinces. The two big manufacturing provinces, Quebec and Ontario, were the most severely hit.[11] The Western provinces were less severely hit. This is especially striking when we compare the local job-loss rate to the one observed in Canada at the level of Canadian urban areas, as shown in Figure 1. Urban areas in Western Canada have a lower manufacturing job loss rate than urban areas in Eastern Canada, especially those in the manufacturing belt.

2.2 Socio-economic and demographic data

We use data from the Canadian census released by the Computing in the Humanities and Social Sciences (CHASS) data center at the University of Toronto. These data are available for *dissemination areas*, the smallest geographic units at which census data are publicly released. We have information on socio-demographic characteristics such as the total population and the demographic composition of urban areas (in particular gender, age, education, and occupation) for the years 2001, 2006, 2011, and 2016.[12]

We aggregate the dissemination area-level information to the level of urban areas, imposing constant boundaries over time. Urban areas—defined as census metropolitan areas (CMA) and census agglomerations (CA)—consist of one or more neighboring municipalities located around a

[11] See table C.5 for a similar description when mass layoffs are also accounted for.

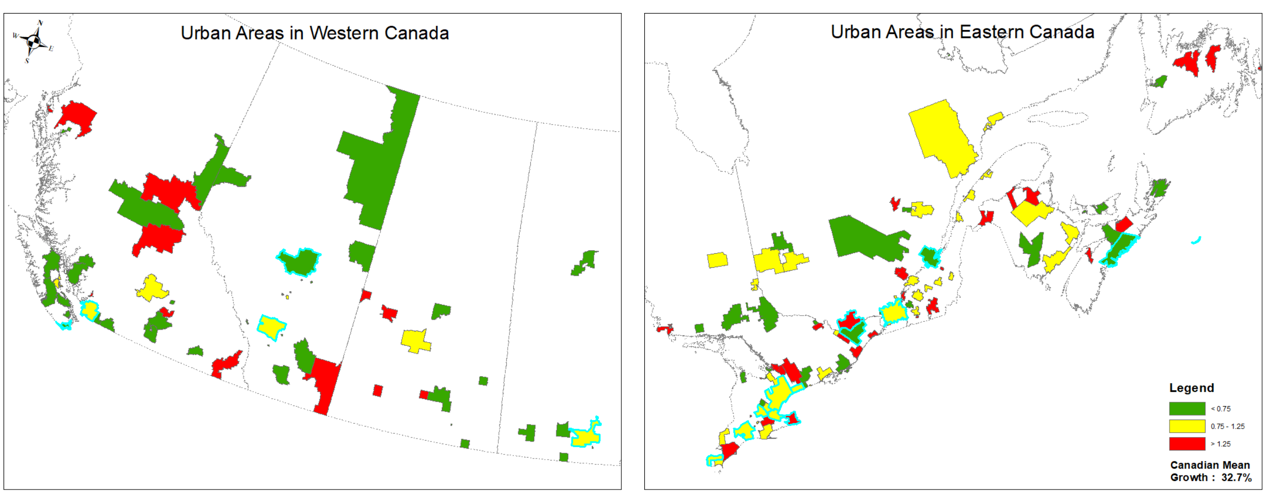
[12] Additional details are provided in Appendix A.

Table 3: Big manufacturing plant closure and job loss rates in Canada.

Region	Province	Closure rate as a % of initial plants	Job loss rate as a % of initial jobs	Avg. Jobs of large closed plants
	Alberta	6.5%	26.3%	133.4
	British Columbia	5.9%	29.5%	139.3
Western	Manitoba	7.5%	26.6%	119.9
	Saskatchewan	4.6%	29.2%	147.4
		6.1%	***28.0%***	***135.2***
	New Brunswick	6.4%	33.0%	165.1
	Newfoundland and Labrador	8.5%	37.1%	173.1
Atlantic	Nova Scotia	5.3%	29.0%	143.3
	Prince Edward Island	6.9%	39.6%	137.5
		6.3%	***32.8%***	***156.8***
Ontario	Ontario	***8.0%***	***34.2%***	***150.9***
Quebec	Quebec	***8.3%***	***33.7%***	***140.1***
Canada		**7.5%**	**32.7%**	**144.9**

Notes : "Big plants" refer to 50+ establishments as measured in 2003. The data are from Scott's National All Business Directories.

Figure 1: Relative job loss rates due to big plant closures in Canadian urban areas

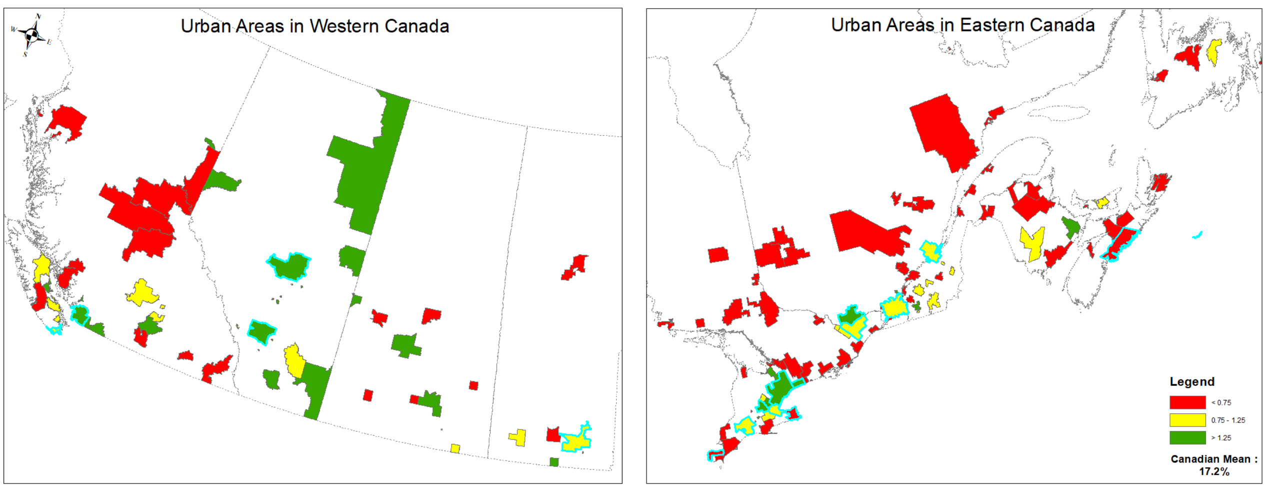


Notes: Distribution of manufacturing job loss rates due to large (50+) plant closures in Canadian Urban Areas. Canadian Urban Areas' job loss rates are measured relatively to the Canadian average. A value of 1 on the map means that the urban area's job loss rate is the same as the Canadian mean. Cyan contours outline cities with population of at least 300,000.

core area and strongly interconnected in terms of commuting flows.[13] Statistics Canada defines a CMA as an area with a total population of at least 100,000, of which 50,000 at least live in the core; whereas a CA is an area with a core population of at least 10,000. By construction, most people living in an urban area also work there. Thus, urban areas are the right spatial unit to investigate the links between plant closures and demographic changes. Given their statistical definition, the number and the boundaries of urban areas vary over time. Our analysis is based on 154 urban areas whose boundaries are stable between 2001 and 2016.[14]

Figure 2 shows there is wide variation in population growth rates across Canadian urban areas.

Figure 2: Relative population growth rates in Canadian Urban Areas



Notes: Growth rates are measured relatively to the Canadian average. A value of 1 on the map means that the urban area's growth rate is the same as the Canadian mean. Cyan contours outline cities with population of at least 300,000.

The population of Campbellton's in New Brunswick shrank the most (-18.2% from an initial population of 16,980 in 2001), while the population of Wood Buffalo in Alberta grew the fastest (+72.4% from an initial population of 42,475 in 2001). Large cities (with 300,000+ inhabitants, outlined in cyan on the figure) all experienced population growth, with growth rates usually in excess of the

[13] A description of the distribution of urban areas by province is provided in Table C.6.

[14] Statistics Canada uses population thresholds to define urban areas. Hence, their number has changed from 145 in 2001 to 156 in 2017. We keep all the areas that are urban in at least one of the census years under study. After eliminating some outliers, this leaves us with 154 urban areas. Statistics Canada also adjusts the boundaries of urban areas over time depending on the observed commuting flows. To have a stable geography for the 154 urban areas in our sample, we aggregate for each of them all of the dissemination areas contained in the envelope of the boundaries observed over the four census periods. More details are provided in Appendix B.

Canadian average. On the opposite, small- and medium-sized cities display no clear pattern. The majority of urban areas in Eastern Canada experienced lower population growth than the Canadian average, particularly in the Atlantic provinces and in the peripheral parts of Ontario and Quebec.[15] In Western Canada, below-average population growth is mostly observed in British Columbia, whereas Alberta had growth levels above the Canadian average. As panel (a) of Figure 3 shows, the situation is even more pronounced when looking at the growth of the working-age population.

On the opposite, when looking at the growth of the highly skilled population—defined as those with at least a bachelor degree—it appears that larger urban areas grew at a pace closer to the Canadian average (see panel (b) of Figure 3).

2.3 Additional data

Clearly, some cities fare better than others in terms of demographic changes as measured by population growth, labor-force growth, and growth of the highly skilled. Our goal in the subsequent analysis is to better understand if and how big manufacturing plant closures explain the contrasted demographic changes documented above. To do so, we need to control for many potential confounders, especially initial city characteristics such as human capital, geographic characteristics (climate, access to the coast) and differences in regional public policies. We also need data that allow us to better understand the mechanisms that may drive the heterogeneity in outcomes: which factors may help make cities more resilient? To this end, we use data on the initial share of the labor force working in arts and recreational employment (a measure of consumption amenities), as well as the share of the labor force in educational and health services. Additional details on the data sources used for these various covariates are provided in Appendix A and Table A.1 presents descriptive statistics for these variables.

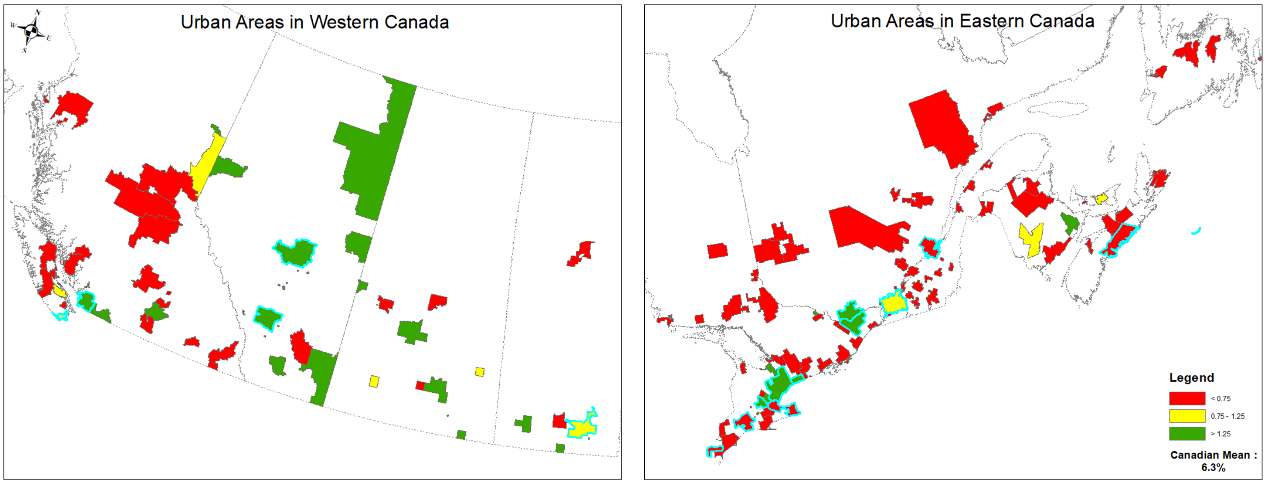
3 Plant closures and socio-demographic changes: Regression analysis

This section shows our empirical specification and our baseline results.

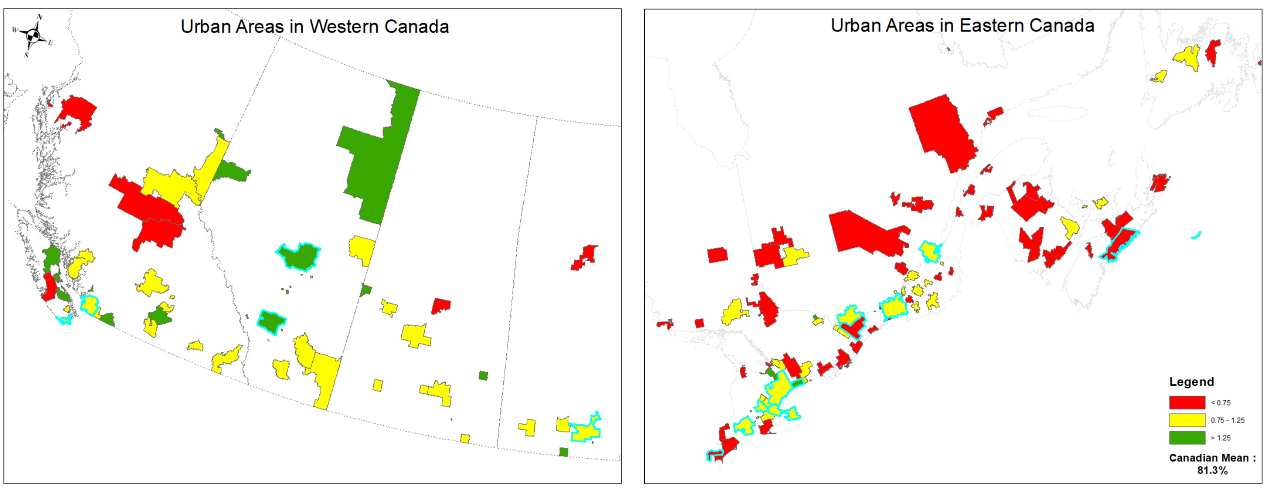
[15] See, e.g., Johnson (2002) and Polèse and Shearmur (2002) for a more detailed description of the decline of the workforce and the young population in Atlantic Canada.

Figure 3: Relative working-age and high-skilled population growth rates in Canadian Urban Areas

(a) Relative working-age population growth rates



(b) Relative high-skilled population growth rates



Notes: Working age population are people aged 20 to 54. The high-skilled are residents of age 15+ with at least a bachelor degree. The urban areas' growth rates are measured relatively to the Canadian growth rate. A value of 1 on the map means that the urban area's growth rate is the same as the Canadian mean. Cyan contours outline cities with population of at least 300,000.

3.1 Empirical specification

In our first exercise, we are interested in the effect of big manufacturing plant closures and downsizing on city-level growth rates of population type y. Our baseline specification is the following:

$$\text{growth rate of } y_{c,r}^{2001-2016} = \alpha \times \text{job loss rate}_c^{2003-2017} + \beta \times \mathrm{X}_c^{2001} + \theta_r + \varepsilon_c, \tag{3}$$

where X_c^{2001} is a vector of initial city characteristics, θ_r are regional fixed effect (Western provinces, Ontario, Quebec, and the Atlantic provinces), and ε_c is an error term. Our vector of initial city characteristics contains: (i) the log initial population in 2001; (ii) dummy variables indicating whether city c is in the top quartile in terms of its share of residents with a university degree and its share of residents aged 20–54; (iii) the January and July maximum temperatures; (iv) the log distance to the closest coast; and (v) the log distance to the closest urban center with 300,000+ inhabitants. Our variable of interest is the job loss rate between 2003 and 2017 measured, following definition (i), by the share of manufacturing jobs present in 2003 that disappeared by 2017 due to big (50+ employees) plant closures. To check the robustness of our results, we will also consider the share of jobs lost due to big plant closures and mass layoffs (at least 30% of the number of employees) as in definition (ii). All of our results go through when using the closure rate instead of the job loss rate. Regarding the dependent variable, we consider the growth rate of the total population and of specific subgroups of the population based on age, education, gender, and family characteristics.

Estimating the impact of plant closures on city-level demographic changes using OLS is likely to yield a biased estimate of α. Indeed, it is plausible that plant closures and population changes are simultaneously determined by changes in other dimensions of the local environment (changes in the quality of infrastructure or the crime rate, for example). Even more, as explained in the introduction, it is likely that equation (3) suffers from reverse causality: people may leave a city because firms close, but firms may also close because people leave the city. Finally, a higher closure rate might hide a higher turnover of establishments, so that differences in closure rates across cities might not reflect differences in net job creation.

To address these concerns, we instrument the city-level job loss rate by a predicted change in local manufacturing employment. To build our Bartik instrument, we interact the initial sectoral composition of manufacturing employment at the city-level with the growth rate of employment in the U.S. for these same sectors.[16] We thus construct the following IV for each city c:

$$\text{IV}_c = \sum_s \frac{\text{Emp}_{c,s}^{2003}}{\text{Emp}_c^{2003}} \frac{\Delta \text{Emp}_{US,s}^{2003-2017}}{\text{Emp}_{US,s}^{2003}} \tag{4}$$

where s denotes 4-digit NAICS industries. For each city, our IV is the weighted average of the

[16] We use the County Business Patterns database of the US Census Bureau that provides information on the total number of employees in the US by 4-digit NAICS industry in 2003 and 2017. This information allows us to compute the employment growth rate between these two dates for each sector. As in Canada, the vast majority of US manufacturing sectors experienced a decline in employment between 2003 and 2017, particularly in the clothing, textile and computer equipment sectors (see Table C.7 in the Appendix C).

growth rates of the number of jobs at the 4-digit level in the U.S. between 2003 and 2017, weighted by the initial share of each sector in the manufacturing employment of the city.

We think this instrument is relevant since it captures global shocks that affect manufacturing industries both in Canada and the US. Offshoring and import competition from low-wage countries, for example, have severely hit the textile, clothing, and computer and electronic industries in many developed economies around the world, including Canada and the US. Further, since Canada is small compared to the US, it is unlikely that sectoral growth rates in the US are directly affected by sectoral growth rates in Canada (which could themselves be affected by factors that directly affect city-level demographic evolutions in Canada).

Identification based on Bartik instruments implicitly assumes the exogeneity of the shocks and/or of the shares used to build the instrument (see Borusyak et al., 2020; Goldsmith-Pinkham et al., 2020). We think that we can safely consider that the shares are exogenous in our context: it is highly unlikely that demographic or amenity changes in some specific Canadian cities are directly related to the initial share in their manufacturing employment of the industries that shrunk the most in the US, especially at the 4-digit level of the industrial nomenclature and controlling for the various covariates we include in the regression. Still, we will provide some checks that make our IV strategy credible. We cluster all standard errors at the level of Canadian macro-regions (Atlantic, Western, Ontario, and Quebec).

3.2 Results

Columns (1)–(6) of Table 4 show results of the OLS estimation of equation (3) across age groups. Three outcome variables are considered: the growth rate of the total population, the growth rate of the working-age population (ages 20-54) and the growth rate of the older population (ages 55+). The treatment variables are the two definitions of job loss rates we mentioned (based on big plant closures alone, and on big plant closures plus substantial downsizing). Whatever the outcome and the treatment variables, the OLS results show that manufacturing job losses are negatively correlated with population growth at the city-level, with semi-elasticities that are very similar across age groups and range from -0.16 to -0.10, approximately. The IV regressions in columns (7)–(12) of Table 4 provide a different picture. For total population growth, the coefficient on the manufacturing job loss rate remains negative, but its size (and standard error) increases in absolute value compared to the OLS estimate. The last four columns show that the increase in the size of the coefficient and in the standard errors masks a highly heterogeneous impact of big manufacturing plant closures on population dynamics across age groups. In columns IV(3) and IV(4), we see that the growth rate of the working age population is negatively affected by big plant closures with a semi-elasticity of about -0.7 to -0.8. On the contrary, manufacturing job losses have no impact on the growth rate of the number of older residents, with a coefficient that is statistically insignificant and close to zero. The fact that the coefficient on the job loss rate becomes more negative with the IV for total population and working age population growth suggests that beyond the circular relationship between population growth and economic growth we highlighted (which should bias downward our OLS estimates), cities that are demographically more dynamic have also both higher job destruction and job creation rates. This could explain why the OLS estimates are biased toward zero for these two outcome variables. Overall, our results show that the closures of big manufacturing plants have led to population declines in Canadian urban areas, this demographic decline being concentrated among the working-age population. The effect is quantitatively sizable: a one percentage point increase in the manufacturing job loss rate causes a 0.71% decrease of the population aged 20-54. Based on the descriptive statistics provided in Table A.1, a one-standard deviation in the job loss rate due to big plant closures induces a decrease in the working-age population growth rate by 0.72 standard deviations.[17] Big plant closures have thus been an economically significant driver of the city-level dynamics of the working age population in Canada over the past twenty years.

Regarding the effects of the controls, the results are intuitive. Proximity to large urban centers is attractive for working age residents who certainly favor large markets with better employment opportunities, whereas climatic amenities matter for the older population only. Cities that are initially younger are more attractive to all categories of population in terms of age. Furthermore, we provide additional results in Appendix D where we show that the picture remains qualitatively the same if we consider manufacturing plant closure rates instead of job losses (Table D.1).

In Table 5, we look at the effect of manufacturing job losses on the evolution of the share of different age groups in the overall population. Compared to the previous results, it allows us to assess whether population growth for a given age group is affected by big plant closures differently

[17] The calculation is as follows: $\frac{0.214 \times 0.71}{0.212} \simeq 0.72$. This effect equals 0.6 of a standard deviation for total population.

Table 4: Job losses and population changes in Canadian cities

Dependent variable y: Growth of	Total Population		People aged 20-54		People aged over 55		Total Population		People aged 20-54		People aged over 55	
	OLS(1)	OLS(2)	OLS(3)	OLS(4)	OLS(5)	OLS(6)	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)
Job loss rate (Big plants)	-0.165**		-0.156**		-0.177		-0.519**		-0.711***		0.075	
	(0.042)		(0.035)		(0.082)		(0.259)		(0.243)		(0.190)	
Job loss rate (Big and downsized plants)		-0.111***		-0.107**		-0.092**		-0.553		-0.757**		0.080
		(0.011)		(0.019)		(0.024)		(0.346)		(0.351)		(0.190)
Ln Initial population	-0.030**	-0.030**	-0.020*	-0.020*	-0.050*	-0.051*	-0.023**	-0.019	-0.008	-0.004	-0.055***	-0.056***
	(0.007)	(0.007)	(0.007)	(0.008)	(0.021)	(0.020)	(0.010)	(0.017)	(0.009)	(0.017)	(0.019)	(0.019)
High initial share of people aged 20-54	0.116**	0.115**	0.128**	0.127**	0.279*	0.278*	0.120***	0.121***	0.135***	0.136***	0.276***	0.276***
	(0.027)	(0.025)	(0.032)	(0.031)	(0.097)	(0.094)	(0.029)	(0.032)	(0.036)	(0.040)	(0.078)	(0.078)
High initial share of skilled people	0.048	0.050	0.054	0.056	0.021	0.024	0.040*	0.042	0.042	0.044	0.027	0.027
	(0.023)	(0.025)	(0.031)	(0.033)	(0.050)	(0.050)	(0.023)	(0.036)	(0.026)	(0.042)	(0.042)	(0.040)
High initial share of empl. in manufacturing	-0.012	-0.009	-0.019	-0.017	-0.021	-0.022	0.011	0.042	0.017	0.059	-0.037	-0.042
	(0.017)	(0.017)	(0.020)	(0.021)	(0.018)	(0.019)	(0.019)	(0.047)	(0.018)	(0.045)	(0.026)	(0.035)
January maximum temperature	0.012*	0.012*	0.008	0.008	0.027**	0.028**	0.011***	0.011***	0.006	0.007	0.028***	0.028***
	(0.004)	(0.004)	(0.007)	(0.007)	(0.006)	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)
July maximum temperature	0.008	0.008	0.006	0.006	0.007**	0.008**	0.004	0.003	-0.000	-0.002	0.010***	0.010***
	(0.006)	(0.005)	(0.008)	(0.008)	(0.002)	(0.002)	(0.008)	(0.011)	(0.010)	(0.014)	(0.003)	(0.003)
Log distance to nearest big city	-0.007	-0.007	-0.007	-0.008	-0.001	-0.002	-0.005***	-0.005***	-0.005***	-0.004***	-0.002	-0.002
	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)	(0.005)
Log distance to nearest coastline	0.003	0.004	0.011	0.012	-0.001	0.000	0.001	0.004	0.009	0.013	0.001	0.000
	(0.011)	(0.011)	(0.013)	(0.013)	(0.009)	(0.010)	(0.008)	(0.009)	(0.010)	(0.011)	(0.008)	(0.008)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate							-0.844	-0.792	-0.844	-0.792	-0.844	-0.792
IV P value							0.001	0.000	0.001	0.000	0.001	0.000
IV Partial R2							0.09	0.09	0.09	0.09	0.09	0.09
First stage F statistic							12	35	12	35	12	35
Adjusted R2	0.32	0.30	0.38	0.37	0.29	0.28						
Urban Areas	154	154	154	154	154	154	154	154	154	154	154	154

Notes: "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.

from that of the overall population. The first four columns of Table 5 show that younger residents are definitely those within the overall population that are more likely to leave a city following big plant closures. Indeed, all else equal, the evolution of their share is negatively impacted by big plant closures. On the opposite, big plant closures cause an increase in the share of the elderly in the overall population. This is consistent with demographic changes at the city-level induced by job-related migrations of the residents: by forcing those of working age to leave, big manufacturing plant closures and downsizing have also reduced the share of the residents aged 0-19 since they are generally the children of working-age parents, leaving behind an older population.

Table 6 provides a similar analysis for different population groups in terms of gender, family status, and birthplace. Our IV results show that manufacturing job losses due to big plant closures

Table 5: Job losses and population changes across age groups in Canadian cities

Dependent variable y: Growth of	People aged 0-19		People aged 20-54		People aged over 55	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)
Job loss rate (Big plants)	-0.077***		-0.107***		0.185***	
	(0.024)		(0.010)		(0.032)	
Job loss rate (Big and downsized plants)		-0.083**		-0.114***		0.197***
		(0.034)		(0.019)		(0.052)
Ln Initial population	0.002	0.002	0.004**	0.005**	-0.006	-0.008
	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.005)
High initial share of people aged 20-54	0.001	0.002	0.006	0.006	-0.007*	-0.008
	(0.001)	(0.002)	(0.004)	(0.004)	(0.004)	(0.005)
High initial share of skilled people	0.006**	0.007**	0.002	0.003	-0.009	-0.010
	(0.003)	(0.003)	(0.005)	(0.006)	(0.008)	(0.009)
High initial share of empl. in manufacturing	0.007***	0.012***	0.001	0.007**	-0.008	-0.019***
	(0.001)	(0.004)	(0.004)	(0.004)	(0.005)	(0.007)
January maximum temperature	-0.001	-0.001	-0.001	-0.001	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
July maximum temperature	-0.001	-0.001	-0.001	-0.001	0.002	0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)
Log distance to nearest big city	-0.001**	-0.001**	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Log distance to nearest coastline	0.001	0.002**	0.002	0.003	-0.003	-0.005*
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate	-0.844	-0.792	-0.844	-0.792	-0.844	-0.792
IV P value	0.001	0.000	0.001	0.000	0.001	0.000
IV Partial R2	0.09	0.09	0.09	0.09	0.09	0.09
First stage F statistic	12	35	12	35	12	35
Urban Areas	154	154	154	154	154	154

Notes: "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.

and downsizing have gender-neutral effects in terms of population since the male-to-female ratio is unaffected. On the opposite, having a partner (married or in a common law union) and/or at least one child reduces the probability of leaving the city following a negative local labor-demand shock. This is consistent with the fact that people with family commitments have higher mobility costs than others (due to joint location decisions and school enrolement, in particular). Our results also show that immigrants are more likely to leave cities that face negative local labor demand shocks: their share in the population decreases following manufacturing job losses. This is consistent with previous studies showing that immigrants are more sensitive to local economic

Table 6: Job losses and population changes across family groups in Canadian cities

Dependent variable y: Growth of	Male to female ratio		Couples share		Parents share		Migrants share	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
Job loss rate (Big plants)	-0.015		0.039***		0.302***		-0.122***	
	(0.013)		(0.014)		(0.020)		(0.035)	
Job loss rate (Big and downsized plants)		-0.016		0.041**		0.322***		-0.131**
		(0.015)		(0.019)		(0.074)		(0.055)
Ln Initial population	0.005***	0.005***	-0.001	-0.002	-0.026**	-0.028**	0.003	0.004
	(0.001)	(0.001)	(0.002)	(0.002)	(0.011)	(0.012)	(0.002)	(0.003)
High initial share of people aged 20-54	-0.002	-0.002	0.011***	0.011***	-0.080**	-0.081**	0.017	0.018
	(0.004)	(0.004)	(0.003)	(0.003)	(0.034)	(0.035)	(0.011)	(0.012)
High initial share of skilled people	0.004	0.004	0.009***	0.009***	-0.003	-0.004	0.013***	0.013**
	(0.006)	(0.006)	(0.002)	(0.003)	(0.008)	(0.012)	(0.005)	(0.005)
High initial share of empl. in manufacturing	0.004**	0.005***	-0.005	-0.007*	-0.029	-0.047*	0.014***	0.021***
	(0.002)	(0.002)	(0.003)	(0.004)	(0.020)	(0.025)	(0.003)	(0.008)
January maximum temperature	-0.002***	-0.002***	0.000	0.000	0.004	0.004	-0.003**	-0.003**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.003)	(0.001)	(0.001)
July maximum temperature	0.001*	0.001	-0.001	-0.001	0.014***	0.015***	-0.001	-0.002
	(0.000)	(0.001)	(0.001)	(0.001)	(0.004)	(0.005)	(0.002)	(0.002)
Log distance to nearest big city	0.001***	0.001***	0.001**	0.001**	0.003***	0.003**	-0.001**	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Log distance to nearest coastline	0.001	0.001	0.001	0.001	-0.015***	-0.017***	0.002	0.003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)	(0.002)	(0.002)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate	-0.844	-0.792	-0.844	-0.792	-0.844	-0.792	-0.814	-0.756
IV P value	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000
IV Partial R2	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08
First stage F statistic	12	35	12	35	12	35	12	37
Urban Areas	154	154	154	154	154	154	153	153

Notes : "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.

opportunities (Cadena and Kovak, 2016; Albouy et al., 2019) and often work in manufacturing jobs.

Finally, in Table 7, we look at the effect of job losses in the manufacturing sector on the growth of two different education groups, more skilled residents (those with at least a bachelor degree) and less skilled residents (the rest). Columns (3) and (4) show that there is no significant effect of manufacturing job losses on the growth of skilled residents, whereas columns (5) and (6) show that job losses due to the closure of large plants lead to a significant decline in the number of unskilled residents in the city. This indicates that skilled residents are less likely to leave a city as a result of big manufacturing plant closures. Indeed, other things being equal, columns (7) and (8) show that the evolution of the share of skilled residents is positively influenced by large plant closures. The literature on the polarization of labor markets shows that medium-skilled jobs have declined over the past 30 years, whereas the share of high- and low-skilled jobs has increased. This partly stems from deindustrialization since medium-skilled jobs are more prominent in the manufacturing sector than in the economy as a whole (Goos et al., 2009; Autor and Dorn, 2013). Since we examine the closure of big manufacturing plants—which mainly employ low- and medium-skilled workers—this certainly explains why we do not see a decline in the number and share of high-skilled residents, even though the latter are generally more responsive to local labor demand shocks in terms of labor supply than less educated workers (e.g., Topel, 1986; Bound and Holzer, 2000; Albouy et al., 2019).

Table 7: Job losses and population changes across education groups in Canadian cities

Dependent variable y: Growth of	Total Population		Skilled Population		Non-Skilled Population		Skilled Share	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
Job loss rate (Big plants)	-0.519**		-0.243		-0.565**		0.033***	
	(0.259)		(0.404)		(0.272)		(0.008)	
Job loss rate (Big and downsized plants)		-0.553		-0.259		-0.602		0.035***
		(0.346)		(0.464)		(0.372)		(0.013)
Ln Initial population	-0.023**	-0.019	-0.083**	-0.081**	-0.023	-0.019	-0.001	-0.001
	(0.010)	(0.017)	(0.039)	(0.039)	(0.016)	(0.024)	(0.003)	(0.004)
High initial share of people aged 20-54	0.120***	0.121***	0.288***	0.288***	0.099***	0.101***	0.011***	0.011***
	(0.029)	(0.032)	(0.087)	(0.087)	(0.028)	(0.032)	(0.003)	(0.003)
High initial share of skilled people	0.040*	0.042	0.007	0.008	0.003	0.005	0.018***	0.018***
	(0.023)	(0.036)	(0.059)	(0.064)	(0.036)	(0.050)	(0.004)	(0.005)
High initial share of empl. in manufacturing	0.011	0.042	-0.089	-0.075	0.021	0.054	-0.008**	-0.010*
	(0.019)	(0.047)	(0.063)	(0.077)	(0.025)	(0.057)	(0.004)	(0.005)
January maximum temperature	0.011***	0.011***	0.023***	0.024***	0.012***	0.012***	0.001**	0.001**
	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.000)	(0.000)
July maximum temperature	0.004	0.003	0.029***	0.029***	-0.001	-0.002	0.002**	0.002**
	(0.008)	(0.011)	(0.009)	(0.011)	(0.010)	(0.014)	(0.001)	(0.001)
Log distance to nearest big city	-0.005***	-0.005***	-0.012	-0.011	-0.004***	-0.004**	-0.001	-0.001
	(0.001)	(0.001)	(0.008)	(0.008)	(0.001)	(0.002)	(0.000)	(0.001)
Log distance to nearest coastline	0.001	0.004	-0.024	-0.022	0.006	0.009	-0.002**	-0.002**
	(0.008)	(0.009)	(0.015)	(0.017)	(0.009)	(0.011)	(0.001)	(0.001)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate	-0.844	-0.792	-0.844	-0.792	-0.844	-0.792	-0.844	-0.792
IV P value	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000
IV Partial R2	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
First stage F statistic	12	35	12	35	12	35	12	35
Urban Areas	154	154	154	154	154	154	154	154

Notes: "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree and the "non-skilled" are residents over 15 years of age without a bachelor's degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.

3.3 Robustness checks

Several recent contributions discuss the conditions under which Bartik instruments are valid and propose procedures to ensure they can be used safely. Following the suggestions made by Borusyak et al. (2020), we make three checks.

First, we check that the Bartik IV exhibits enough variation to be relevant. With mean and a median values of -0.16, a standard deviation of 0.08, and a difference between the first and the fourth quintiles of 18 p.p., we believe it does. Another way to assess the relevance of the instrument is to measure the inverse of the Herfindahl index of the sectoral shares at the national level. In case a few specific industries represent the lion's share of national manufacturing employment, it is unlikely that sectoral shares vary enough across locations to provide a good IV. In our case, this statistic equals 42.8 (the highest industry share at the national level being no larger than 0.06), which suggests there is a reasonable degree of variation in industry shares. All in all, these statistics confirm the ten Kleinbergen-Paap tests in our regressions: the IV is relevant in our case.

Regarding the validity of the instrument, we report in Table D.2 a placebo test where the dependent variable is the population growth rate between 1991 and 2001 instead of 2001 and 2016. This placebo amounts to a test for the parallel trends assumption. All the coefficients we obtain in the IV regressions are close to 0 and statistically insignificant. Another concern with the benchmark IV regressions is that if some industries are highly concentrated in urban areas with specific unobserved trends, there could be a correlation between the instrument and the error term in the IV regressions. To take care of this issue, we build an alternative Bartik instrument from which we remove the industries that are the most highly geographically concentrated.[18] As can be seen in Table D.3, the results are very stable. Overall, these checks confirm the validity of the Bartik instrument in the context of our study.

4 The multiplier effect of big plant closures

In this section, we estimate the impact of big manufacturing plant closures and mass layoffs on the employment of other industries. Indeed, Moretti (2010) shows that jobs in the tradable sector create

[18] We define them as the industries for which the inverse of the Herfindahl index of the CMA-level shares in the overall industry-level employment is below 5 (i.e. Herfindahl index of geographic concentration above 0.2).

additional jobs in the non-tradable one, mainly through an increase in the demand for local goods and services. He estimates separate elasticities for each industry within the non-tradable sector and finds that job changes in the tradable sector have the largest effect on construction, wholesale trade, and personal service jobs. Gathmann et al. (2020) and Jofre-Monseny et al. (2018) investigate multiplier effects in the case of big plant closures and mass layoffs and find these effects are small.

Here, we examine the effect of big manufacturing plant closures and mass layoffs on employment growth in the non-manufacturing sector. Thanks to the information on local employment at the NAICS 2-digit level available in the Census data, we are able to consider: (i) construction services; (ii) arts, entertainment and recreational services; (iii) professional services composed of the information, finance, real estate, scientific and technical, management and administrative support services; (iv) trade and transportation services composed of the retail trade, wholesale trade, transport and warehousing sectors; (v) education and health services; and (vi) accomodation and food services.[19] The results are reported in Table 8.

Among the non-manufacturing industries most negatively affected by the closure of big manufacturing plants we find construction, arts, entertainment and recreational, and professional services. Trade and transportation services are also affected, but to a lesser degree in terms of marginal impact. These negative spillovers of big manufacturing plant closures and downsizing on the employment in other industries reflect both propagation of the shock to the local economy through input-output linkages (manufacturing plants consume a lot of professional and trade services for example) and through lower local demand from consumers since the manufacturing jobs destroyed by deindustrialization were on average high-paying jobs (which could explain the negative effect on arts, entertainment, and recreational services).

Education and health services are not significantly affected by big manufacturing plant closures and downsizing which certainly reflects the fact that in Canada, these services are public services that, in case of negative shocks, are maintained by public authorities longer than if they were provided privately. While we could have expected a significant negative impact on accomodation and food services, this does not seem to be the case. However, the data we have do not allow

[19]Construction services correspond to NAICS 23, arts, entertainment and recreation services to NAICS 71, professional services to NAICS 51 to 56, trade and transport services to NAICS 41, 44, 48 and 49, education and health services to NAICS 61 and 62, and finally accomodation and food services to NAICS 72.

us to investigate whether behind this apparent absence of impact there is a significant increase in turnover where high-end full service restaurants and hotels are replaced by lower-end limited services restaurants and motels, for example.

All in all, the significant negative spillovers from big plant closures we observe in several industries show that the job losses experienced at the city-level go well beyond the immediate loss related to the plant closures or downsizing. This provides a possible explanation as to why these shocks affect so significantly the demographic dynamics of the cities that are the most severely hit.

Table 8: Job losses and employment changes by sector

Dependent variable y: Growth of	Construction services		Arts, entertainment and recreation services		Professional services		Trade and transport services		Education and health services		Accomodation and food services	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)	IV(9)	IV(10)	IV(11)	IV(12)
Job loss rate (Big plants)	-0.765***		-0.697**		-0.572**		-0.450**		-0.318		-0.278	
	(0.214)		(0.335)		(0.262)		(0.224)		(0.370)		(0.319)	
Job loss rate (Big and downsized plants)		-0.814**		-0.741***		-0.610*		-0.480*		-0.339		-0.297
		(0.348)		(0.256)		(0.350)		(0.289)		(0.430)		(0.375)
Ln of sectors employment in 2001	-0.009	-0.004	-0.198***	-0.197***	-0.038**	-0.033	-0.003	0.001	-0.047***	-0.046***	-0.010	-0.008
	(0.051)	(0.063)	(0.057)	(0.056)	(0.017)	(0.021)	(0.013)	(0.020)	(0.012)	(0.014)	(0.029)	(0.035)
High initial share of people aged 20-54	-0.004	-0.003	0.093	0.095	0.145***	0.145***	0.063***	0.063***	0.156***	0.157***	0.100***	0.101***
	(0.041)	(0.043)	(0.058)	(0.062)	(0.038)	(0.036)	(0.013)	(0.016)	(0.025)	(0.029)	(0.028)	(0.026)
High initial share of skilled people	0.025	0.028	0.259***	0.263***	0.051	0.051	-0.007	-0.006	0.047***	0.048**	0.017	0.018
	(0.032)	(0.024)	(0.087)	(0.096)	(0.049)	(0.065)	(0.028)	(0.040)	(0.015)	(0.021)	(0.042)	(0.050)
High initial share of empl. in manufacturing	0.137***	0.183**	0.004	0.044	0.077**	0.112**	0.083***	0.110***	-0.021	-0.002	0.005	0.021
	(0.044)	(0.082)	(0.063)	(0.061)	(0.033)	(0.047)	(0.018)	(0.042)	(0.045)	(0.067)	(0.040)	(0.065)
January maximum temperature	-0.000	0.001	0.048***	0.050***	0.014***	0.015***	0.010***	0.010***	0.016***	0.017***	0.004	0.005
	(0.009)	(0.009)	(0.004)	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.009)	(0.009)
July maximum temperature	-0.021	-0.024	0.007	0.005	0.004	0.002	0.004	0.002	0.016**	0.016	0.015	0.014
	(0.022)	(0.026)	(0.012)	(0.013)	(0.010)	(0.013)	(0.008)	(0.010)	(0.007)	(0.010)	(0.009)	(0.011)
Log distance to nearest big city	-0.010	-0.010	-0.032**	-0.033**	-0.003	-0.003	-0.004***	-0.004**	-0.011**	-0.012***	-0.010***	-0.010***
	(0.010)	(0.011)	(0.013)	(0.013)	(0.004)	(0.004)	(0.001)	(0.002)	(0.004)	(0.004)	(0.003)	(0.003)
Log distance to nearest coastline	-0.009	-0.005	-0.004	-0.000	-0.012*	-0.008	-0.004	-0.001	-0.002	-0.000	-0.011*	-0.009
	(0.010)	(0.011)	(0.010)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)	(0.008)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate	-0.848	-0.797	-0.842	-0.792	-0.846	-0.793	-0.839	-0.787	-0.843	-0.792	-0.838	-0.786
IV P value	0.001	0.000	0.002	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000
IV Partial R2	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08
First stage F statistic	11	32	10	27	11	34	12	37	12	36	12	33
Urban Areas	154	154	154	154	154	154	154	154	154	154	154	154

Notes : "Big plants" refer to 50+ establishments. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.

5 City-level resilience to big plant closures and mass layoffs

We next examine whether certain initial city characteristics can mitigate the negative effects of big manufacturing plant closures on demographic changes. We investigate successively two dimensions: (i) the provision of educational and health services; and (ii) the provision of cultural and recreational amenities. Note that these two dimensions are very weakly correlated in our data. Hence, we capture different mechanisms when studying each of them.

The provision of local public services to the population could mitigate the negative effect of big plant closures on demographic changes by absorbing part of the consequences of the shock for those who lose their job. They might also represent an amenity that is valued and therefore can retain residents. The census data report information on the number of residents employed in educational services (NAICS 61) and in health care and social assistance services (NAICS 62). The sum of these two industries subsumes employment in schools, hospitals, and home and social assistance. We compute for each city the initial share of employment in these two industries. We then construct a dummy identifying those cities in the top quartile of the distribution, and we interact it with our measure of manufacturing job losses. The results in Table 9 are striking: cities with the highest initial population share working in public services are almost insensitive to big plant closures or mass layoffs in terms of population growth. Migrants are more sensitive to the initial presence of public services than the rest of the population, whereas no significant heterogeneity is detected along this dimensions for working age and for high-skilled residents.[20]

Turning to cultural amenities, we proxy them using data on employment in cultural (art and entertainment) and recreational services (NAICS 71). We conjecture that the impact of big manufacturing plant closures and mass layoffs on population changes is heterogeneous depending on the initial employment share in these industries. The results in Table 10 show that the presence of cultural and recreational services is a factor of resilience for cities: cities with an initial share of employment in cultural and recreational industries in the top quartile are rather insensitive to big manufacturing plant closures. This result is mainly driven by the working-age population and the high-skilled workers. However, contrary to educational and health services, it seems that cultural and recreational services do not disproportionately act as a mitigating factor for immigrants.

To summarize, the depressing effect of big manufacturing plant closures on the demographic evolution of cities can be mitigated by the presence of public services in education and health and of specific consumption amenities such as recreational services. However, the intensity and the

[20]These results hold when we remove provincial capitals or very big cities (above 1 million inhabitants), i.e., they are not driven by those cities. They are available upon request.

Table 9: Job losses, population changes, and public services in Canadian cities

Dependent variable *y*: Growth of	Total Population		Population 20-54 share		High-skilled share		Migrants share	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
Job loss rate (Big plants)	-1.043***		-0.145***		0.053***		-0.214***	
	(0.214)		(0.046)		(0.019)		(0.055)	
Big Job losses 1 x High initial share in education and health services	0.886***		0.065		-0.034		0.163**	
	(0.204)		(0.058)		(0.027)		(0.071)	
Job loss rate (Big and downsized plants)		-1.142***		-0.160***		0.058***		-0.235***
		(0.443)		(0.041)		(0.020)		(0.053)
Big Job losses 2 x High initial share in education and health services		0.990**		0.077		-0.039		0.184***
		(0.411)		(0.063)		(0.025)		(0.067)
Ln Initial population	-0.023***	-0.019	0.004**	0.005*	-0.001	-0.001	0.003	0.004
	(0.004)	(0.014)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)	(0.004)
High initial share of people aged 20-54	0.107***	0.105***	0.006	0.005	0.012***	0.012***	0.016	0.016
	(0.035)	(0.040)	(0.005)	(0.006)	(0.004)	(0.004)	(0.011)	(0.012)
High initial share of skilled people	0.067***	0.070***	0.004	0.004	0.017***	0.016***	0.015***	0.016***
	(0.005)	(0.017)	(0.006)	(0.007)	(0.003)	(0.004)	(0.006)	(0.005)
High initial share of empl. in manufacturing	0.025***	0.087**	0.002	0.011*	-0.009***	-0.012***	0.017***	0.030***
	(0.009)	(0.043)	(0.007)	(0.006)	(0.003)	(0.004)	(0.006)	(0.008)
High initial share in education and health services	-0.316***	-0.397***	-0.020	-0.028	0.013*	0.017*	-0.048**	-0.064**
	(0.055)	(0.148)	(0.018)	(0.022)	(0.008)	(0.009)	(0.024)	(0.026)
January maximum temperature	0.009	0.010*	-0.001	-0.001	0.001*	0.001*	-0.002	-0.002
	(0.007)	(0.006)	(0.001)	(0.001)	(0.000)	(0.000)	(0.002)	(0.002)
July maximum temperature	-0.001	-0.004	-0.001	-0.002	0.002***	0.003**	-0.002	-0.003
	(0.009)	(0.015)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)
Log distance to nearest big city	-0.004***	-0.005*	0.000	0.000	-0.001	-0.001	-0.001***	-0.001*
	(0.001)	(0.003)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Log distance to nearest coastline	0.001	0.005	0.002	0.003	-0.002*	-0.002**	0.002	0.003*
	(0.007)	(0.009)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate	-0.612	-0.553	-0.612	-0.553	-0.612	-0.553	-0.606	-0.546
IV P value	0.226	0.122	0.226	0.122	0.226	0.122	0.224	0.119
IV Partial R2	0.11	0.10	0.11	0.10	0.11	0.10	0.10	0.09
First stage F statistic	17	43	17	43	17	43	16	40
Urban Areas	154	154	154	154	154	154	153	153

Notes: "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.

significance of the mitigating effect vary across population groups, reflecting probably the variety of tastes and needs across age, education, and cultural groups.

6 Conclusion

We have analyzed the effect of big manufacturing plant closures and mass layoffs on subsequent demographic changes in Canadian cities. We have shown that job losses due to big plant closures and mass layoffs negatively affect population growth in urban areas in Canada between 2001 and 2016. This effect is concentrated among younger (working age) residents. The share of families and

Table 10: Job losses, population changes, and cultural services in Canadian Urban Areas

Dependent variable *y*: Growth of	Total Population		Population 20-54 share		High-skilled share		Migrants share	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
Job loss rate (Big plants)	-0.650**		-0.116***		0.021*		-0.096***	
	(0.322)		(0.017)		(0.013)		(0.030)	
Big Job losses 1 x High initial share in arts and recreation ind.	0.642***		0.039*		0.031***		-0.135**	
	(0.247)		(0.020)		(0.012)		(0.065)	
Job loss rate (Big and downsized plants)		-0.753		-0.136***		0.025		-0.116**
		(0.474)		(0.032)		(0.018)		(0.058)
Big Job losses 2 x High initial share in arts and recreation ind.		0.776**		0.079***		0.015*		-0.063
		(0.354)		(0.029)		(0.009)		(0.046)
Ln Initial population	-0.027**	-0.020	0.004**	0.005*	-0.001	-0.001	0.004**	0.004
	(0.011)	(0.015)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)
High initial share of people aged 20-54	0.101***	0.100***	0.005	0.004	0.012***	0.012***	0.022**	0.020*
	(0.023)	(0.020)	(0.004)	(0.004)	(0.003)	(0.003)	(0.011)	(0.012)
High initial share of skilled people	0.065***	0.057***	0.003	0.004	0.017***	0.016***	0.007	0.011**
	(0.008)	(0.011)	(0.005)	(0.006)	(0.004)	(0.004)	(0.006)	(0.006)
High initial share of empl. in manufacturing	0.020	0.051	0.002	0.008*	-0.006	-0.008	0.012***	0.021***
	(0.020)	(0.051)	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)	(0.008)
High initial share in arts and recreation ind.	-0.189***	-0.272**	-0.009	-0.026***	0.003	0.008	0.046*	0.026
	(0.064)	(0.114)	(0.006)	(0.009)	(0.007)	(0.006)	(0.024)	(0.019)
January maximum temperature	0.012***	0.014***	-0.001	-0.001	0.001***	0.000***	-0.003***	-0.003**
	(0.004)	(0.003)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
July maximum temperature	0.003	0.000	-0.001	-0.002	0.002**	0.002**	-0.001	-0.002
	(0.010)	(0.014)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
Log distance to nearest big city	-0.005**	-0.005**	0.000	0.000	-0.001	-0.001	-0.001***	-0.001**
	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Log distance to nearest coastline	0.002	0.006	0.002	0.003	-0.002**	-0.002**	0.002	0.003*
	(0.008)	(0.010)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate	-0.903	-0.738	-0.903	-0.738	-0.903	-0.738	-0.869	-0.694
IV P value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IV Partial R2	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08
First stage F statistic	12	15	12	15	12	15	12	15
Urban Areas	154	154	154	154	154	154	153	153

Notes: "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.

couples in the local population increases in cities where job losses are the highest, which shows they are less mobile than single people. On the opposite, the share of immigrants decreases, in line with the well-documented fact that immigrants are more mobile and their location decisions are more driven by job opportunities. Some initial city-level characteristics such as the provision of public services (education, health and social services), as well as consumption amenities (arts and recreational services) help to mitigate the negative effect of plant closures on subsequent demographic changes for certain categories of population. One implication of our results is that investments in education, health and social services, or in cultural and recreational services might have long-run effects by fostering the ability of cities to retain their most mobile residents in case of bad shocks. These insights might be particularly relevant for thinking about the possible demographic consequences of the COVID-19 crisis for cities.

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Appendix material

This set of appendixes is organised as follows. Appendix A describes the data used in our analysis. Appendix B provides definitions of the variables and details the process we followed to geocode our database. Appendix C provides additional descriptive statistics and Appendix D displays additional results.

Appendix A Data

Census data The Census data released by the Computing in the Humanities and Social Sciences (CHASS) data center at the University of Toronto contain a great deal of information on the socio-demographic characteristics of the residents as well as on the jobs thy occupy. We use them to construct several of our controls on top of our dependent variables.

The literature has shown that certain initial socio-economic characteristics of the population affect city-level population growth. Among them, the level of schooling—of human capital—of the population is strongly correlated with subsequent city growth (see, e.g., Glaeser et al., 1995; Moretti, 2004). Our proxy for the initial human capital is the share of residents holding at least a bachelor degree in 2001. We are also interested in which factors make cities more resilient. We focus more specifically on the presence of cultural and recreational activities, and on the presence of education and health services. In this purpose, census data allow us to compute the share of residents employed in these specific industries in 2001.[21]

Table A.1 presents descriptive statistics on the variables used in this study. The average population growth rate observed across Canadian urban areas is equal to 14.3%. In 2001, in Canadian urban areas, half of the population was part of the working age population defined as 20-54 year-old residents, 12% had a university degree on average, and 14.1% of employment was in manufacturing on average. In addition, 18% of the residents worked in educational, health and social assistance services, and 2% in cultural and recreational services. However, as the table illustrates, there is a great deal of variation across urban areas for all of these initial characteristics that are helpful for our estimations.

Geographic Data We control in our regression analysis for several relevant geographic characteristics that may influence city-level population growth.

Distance Data. Proximity to the coast, which contributes to moderating extreme temperatures, is strongly positively correlated with population growth in the U.S. (see Rappaport and Sachs, 2003). We thus measure the distance between the centroid of each city and the nearest maritime coast. It has also been shown that cities that are close to the top metropolises in the urban hierarchy are more attractive to firms and workers

[21] See more details here: https://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVD&TVD=307532

Table A.1: Descriptive statistics, urban area variables.

Variable	Obs	Sample Mean	Std. Dev.	Minimum	Maximum	Population Mean
Growth rate						
Total Population	154	0.143	0.181	-0.184	0.953	0.172
People aged between 20-54 years	154	0.012	0.212	-0.333	0.902	0.063
People aged over 55 years	154	0.633	0.257	0.153	1.934	0.606
People with university degree at bachelor or above	154	0.765	0.436	0.010	2.721	0.813
People with non-university degree at bachelor or above	154	0.222	0.184	-0.094	1.179	0.213
Changes in shares						
Male to female ratio	154	0.005	0.021	-0.067	0.059	0.004
Couple families (married and common-law couples)	154	0.040	0.027	-0.016	0.108	0.038
People with one or more children	154	0.007	0.112	-0.262	0.463	-0.078
Immigrant people	153	0.019	0.035	-0.037	0.156	0.044
Closures rate						
% big plants closed	154	0.070	0.050	0	0.263	0.075
% big and downsized plants closed	154	0.091	0.062	0	0.333	0.098
Job losses rates						
% job losses of big plants closed	154	0.304	0.214	0	0.921	0.327
% job losses of big and downzised plants	154	0.358	0.212	0	0.921	0.389
Initial level						
Initial population (2001)	154	158,226	510,705	7,720	4,677,175	30,000,000
% Initial working age population	154	0.498	0.038	0.343	0.608	0.516
% Initial people with university degree	154	0.118	0.044	0.054	0.309	0.169
Labor force (industry)						
% Initial share of employment in manufacturing	154	0.141	0.080	0.016	0.342	0.140
% Arts and recreational employment	154	0.019	0.011	0.005	0.097	0.019
% Public services (educational and health) employment	154	0.178	0.032	0.104	0.292	0.163
Geographic variables						
Maximum January temperature (C)	154	7	3	-2	14	7
Maximum July temperature (C)	154	31	2	21	38	31
Distance to nearest coast (m)	154	206,044	199,927	0	858,863	206,044
Distance to nearest big urban area (m)	154	202,455	285,300	0	990,837	202,455

Notes: A big city is a city with at least 300,000 residents. The source of data is Scott's National All Business Directories.

(see Partridge et al., 2009). We thus calculate the distance separating each urban area from the largest urban area of at least 300,000 inhabitants.

Weather Data. Climatic conditions, as proxied by temperatures, are also among the amenities identified in the literature as a determinant of the residential attractiveness of cities (see Glaeser et al., 2001; Rappaport, 2007). We use the monthly climate summaries from the Canadian Centre for Climate Services of Environment and Climate Change to measure, for each city, the average daily warmest temperatures attained in January and July from 2001 to 2016.[22]

Regions. Regional Development Agencies support manufacturers across Canada.[23] Specific regional

[22]These data are available from stations that produce daily data from 2001 to 2016.

[23]These agencies are Atlantic Canada Opportunities Agency for Atlantic regions, Federal Economic Development Initiative and Federal Economic Development Agency for Ontario, Canada Economic Development for Quebec, and

public policies might also influence city-level population growth; we can think of Quebec, which has its own immigration policy, partly determined by its needs in terms of workforce. We thus build specific dummy variables for the Atlantic regions (New Brunswick, Newfoundland and Labrador, Nova Scotia, Prince Edward Island), the West (Alberta, British Columbia, Manitoba, Saskatchewan), Quebec and Ontario.[24]

Appendix B Data processing and variable description

B.1 Variable definitions

Arts, entertainment and recreation: This industry comprises establishments that produce, promote or participate in public performances, exhibitions or other events; provide artistic products and performances; preserve and exhibit objects and sites of historical, cultural; and operate facilities or provide services that enable their clients to participate in sports or recreational activities or to engage in hobbies and entertainment. It corresponds to the NAICS code 71 (Statistics Canada definition).

Big downsizing plant: This refers to an establishment with 50+ employees in 2003 that has lost at least 30% of its workforce by 2017.

Closure rate: This variable is calculated using data from Scott's National All databases. It refers to the number of 50+ manufacturing plants present in 2003 that no longer exist in 2017 divided by the initial number of manufacturing plants in 2003 in the urban area.

Distance to big urban area: It refers to the distance in meters to the nearest urban area with at least 300,000 inhabitants. We compute it thanks to a GIS software. We calculate the distance between the centroids of the two different urban areas.

Distance to coast: It refers to the distance in meters to the nearest coastline. We compute it thanks to a GIS software. We have 76904 water layer polygons, representing Canadian coasts, provided by Statistics Canada. This allows us to calculate the distance between an urban area's centroid and the nearest Canadian coast.

Educational services industry: This sector comprises establishments primarily engaged in providing education and training in a wide variety of fields by specialized establishments, such as schools, colleges, universities and training centres. It corresponds to the NAICS code 61. (Statistics Canada definition)

Health care and social assistance: This sector comprises establishments primarily engaged in providing

Western Economic Diversification Canada for Western region.

[24] We do not use provincial dummies in our regressions because in some provinces, there are too few cities, such as in Atlantic Canada or in Manitoba and Saskatchewan, to allow for statistical inference based on within-province variations (see Table C.6 in the Appendix).

health care, providing residential care for medical and social reasons, and providing social assistance, such as counselling, social welfare, child welfare, community housing and food services, vocational rehabilitation and child care. It corresponds to the NAICS code 62. (Statistics Canada definition)

Immigrants: People that have immigrant or non-permanent status in private households. The term "immigrant" refers to a person who is or has been a landed immigrant/permanent resident. "Non-permanent resident" refers to a person from another country who has a work or study permit or is a refugee claimant, and any family members born abroad and living in Canada with them.

Job loss rate: This variable is calculated using data from Scott's National All databases. It refers to the number of jobs in the 50+ manufacturing plants that were active in 2003 but that no longer exist in 2017 divided by the number of jobs in the manufacturing plants that were active in 2003 in the urban area.

January and July temperatures (maximum): This is the average of the warmest temperature attained on each day of January and July from 2001 to 2016. We compute them using GIS software and historical weather data.

Manufacturing industry: This sector comprises establishments primarily engaged in the chemical, mechanical or physical transformation of materials or substances into new products that may be ready for use or consumption, or a raw material that an establishment can use in further manufacturing. It corresponds to NAICS codes 31, 32 and 33. (Statistics Canada definition)

Parent people: People that are couples or lone-parent in private households with at least one child.

Population (Total): It refers to the number of persons living within a dissemination area, aggregated at the CMA/CA level.

Residents in couples: People that are couple families i.e married couples or common-law couples in private households.

Skilled people: Residents aged 15+ in private households with a university certificate, diploma or degree at bachelor level or above such as bachelor's degree, university certificate or diploma above bachelor level, degree in medicine, dentistry, veterinary medicine or optometry, master's degree or earned doctorate.

Urban area: An urban area is a census metropolitan area (CMA) or a census agglomeration (CA), defined by Statistics Canada as a group of one or more adjacent municipalities centred on a population centre. A CMA must have a total population of at least 100,000 of which 50,000 or more must live in the core. A CA must have a core population of at least 10,000. To be included in the CMA or CA, other adjacent municipalities must have a high degree of integration with the core, as measured by commuting flows derived from previous census place of work data.

Working age population: Population aged 20-54.

B.2 Data processing

Geographical structure. Census Metropolitan Areas (CMA) and Census Agglomerations (CA) are the ideal spatial units in Canada for the analysis of local labor markets since their boundaries are delineated based on the commuting patterns of residents. Provinces are too coarse a spatial scale, whereas dissemination areas (census blocks) are too fine to analyze population dynamics following local labor market shocks, because a worker could easily work in one dissemination area and reside in another. Since each dissemination area belongs to a given urban area (CMA/CA), we aggregate the Census data available at the level of dissemination areas at the urban area level.

We obtain census data at the urban area (CMA/CA) level for 145 urban areas in 2001, 148 in 2006, 151 in 2011 and 157 in 2016. The differences between years are explained by the fact that from a statistical point of view, an urban area can lose its census agglomeration status and disappear, or (re)gain it and (re)appear. Note for example that if the population of the core of a CA declines below 10,000, the CA is removed. However, once an urban area becomes a CMA, it remains a CMA even if its total population declines below 100,000 or if the population of its core falls below 50,000.

There are 164 unique urban areas in total (CMA/CA) between 2001 and 2016, of which 136 are present in the 4 census years, 10 in 3 census years, 8 in 2 census years, and 10 in a single census year. We overlay each urban area for every year it appears, and we take the envelope of the overlaid boundaries. Magog (present in 2001) has been added to Sherbrooke in 2006, so we merge them. Saint-Jean-sur-Richelieu (present in 2001, 2006, 2011) has been added to Montreal in 2016, so we merge them. We get 162 urban areas whose boundaries in terms of municipalities are stable over time. Indeed, in this study, we want to capture demographic changes that are related to labor market shocks, not to changes in geographical boundaries.

We keep in the sample only those agglomerations that have at least 10,000 inhabitants on average over the whole 2001-2016 period and for which we have all the necessary information for the econometric analysis. We end up with 154 stable urban areas. We calculate a population ratio which is the ratio between the total population of the urban area in a given census year as measured by Statistics Canada and the total population of the "stabilized" urban area as we measure it. On average, we can see in Table B.1 that this ratio is equal to 0.96 over the period 2001-2016, which means that the demographics of stabilized urban areas are quite similar to the demographics of the original urban areas.

Table B.1: Population ratio between the actual and the stabilized urban areas

	Year			
	2001	2006	2011	2016
Minimum	0.535	0.393	0.407	0.404
Mean	0.953	0.967	0.972	0.972
Maximum	1	1	1	1
Std. error	0.086	0.074	0.082	0.085

The boundaries of "actual" urban areas are those defined by Statistics Canada in a given census year. The boundaries of "stabilized" urban areas are defined by the envelope of the boundaries observed across the various census years.

Geocoding process. The raw Scotts data provide some geographical coordinates for the establishments but after several checks, they do not seem extremely reliable. We thus geocode the dataset again.

The geocoding is a process through which an algorithm transforms an address into a pair of coordinates that can be positioned on a map of the surface of the earth. Throughout the process, in addition to the coordinates (longitude, latitude), the geocoder provides the actual addresses related to the coordinates of the points that it returns.

We first start by geolocating the Scotts Database on a postal code basis. To geolocate plants based on postal codes of the Scotts Database, we use latitude and longitude data of postal code centroids obtained from Statistics Canada's Postal Code Conversion Files (PCCF). The problem with zip code geolocation is that a zip code is relatively accurate for large cities, and more imperfect for small cities since the surface area of postal codes is larger in low-density places. We consider the geocoding of the Scott's database based on the postal codes to be "approximate". We thus also run geocoding processes based on the address of the establishments.

The Scott's database provides information on the company name and its full address (street number, street name, postal code, city and province). We use this information to geocode again the database in three ways. First, we use a commercial API on the Google Map server and we provide as input to the geocoder the full address line of each plant. Second, we used th same API of the Google Map server but we combine the company name with the full address line of the plant to generate the input for the geocoder. In this case, the geocoder is supposed to collect the exact location of the plant even if the plant has changed its location after the date on which the Scotts dataset was compiled. Third, we use an alternative API and the DMTI dataset which is an extensive database containing more than 15 million of feature points representing addresses in Canada. This private dataset records the location of addresses in Canada with their related geographic coordinates with a rooftop precision. From the DMTI, we construct an Address-Locator using ArcGIS tools and we geocode all the Scotts addresses via this alternative process.

We find that the geocoding of Google Maps is "rooftop", meaning that the plant is geocoded accurately down to the street address. The geocoding of DMTI is either "range interpolated", meaning that the plant is geocoded by interpolation of two precise points, or "rooftop".

In the end, we assign to each establishment the geographical coordinates that are the most precise among those that are available. First, when both the Google geocoding and the DMTI geocoding report the same coordinates, we retain these coordinates. If the returned coordinates differ, we first select the one based on the company name and the complete address line (Google 2) if available, otherwise we select the geocoding based on the complete address line only (Google 1), otherwise we select the DMTI geocoding, otherwise we maintain the postal code geocoding.

Following this procedure, nearly 88% of our data has a very precise location (rooftop accuracy). The rest is range interpolated or approximate accuracy (postal code geocoding). Table B.2 shows the distribution of Canadian manufacturing plants according to the geocoding chosen between 2001 and 2016.

Table B.2: Manufacturing plants data geocoding.

	Scott's 2001	Scott's 2003	Scott's 2005	Scott's 2007	Scott's 2009	Scott's 2011	Scott's 2013	Scott's 2017
Geocoding process								
Google 2 (Plant name & address)	33,744	33,080	32,198	31,240	30,521	29,529	25,972	23,746
Google 1 (Address)	11,350	11,115	10,661	10,033	9,466	8,904	7,242	6,204
DMTI (Address)	2,750	2,699	2,552	2,333	2,188	2,072	1,544	1,458
SCOTTS (PCCF)	6,500	5,890	5,153	4,682	4,474	4,119	3,343	2,727
Total Manufacturing plants	**54,344**	**52,784**	**50,564**	**48,288**	**46,649**	**44,624**	**38,101**	**34,135**
Geocoding Accuracy								
Rooftop	45,235	44,607	43,421	41,977	40,724	39,296	33,900	30,744
Range Interpolated	2,609	2,287	1,990	1,629	1,451	1,209	858	664
Postal Code	6,500	5,890	5,153	4,682	4,474	4,119	3,343	2,727
Total Manufacturing plants	**54,344**	**52,784**	**50,564**	**48,288**	**46,649**	**44,624**	**38,101**	**34,135**

The geocoding process was done by Postal Code Conversion Files (PCCF), Google's commercial API and DMTI spatial.

Appendix C Additional tables and figures

C.1 Tables on data

Table C.1: Comparing the Scott's National All database to the Annual Survey of Manufacturing (ASM).

	2001		2003		2005		2007		2009		2011	
Province	ASM	Scott's	ASM	Scott's	ASM	Scott's	ASM	Scott's	ASM	Scott's	ASM	Scott's
Alberta	4,843	3,935	4,882	3,650	7,750	3,482	8,091	3,723	7,852	3,597	7,003	3,477
British Columbia	7,085	6,212	6,933	5,923	11,942	5,400	12,179	5,267	11,605	5,031	11,552	4,946
Manitoba	1,465	1,654	1,481	1,556	2,307	1,489	2,351	1,405	2,323	1,280	1,918	1,302
New Brunswick	986	1,392	963	1,376	1,533	1,262	1,496	1,167	1,412	1,181	1,381	1,030
Newfoundland	525	576	522	578	706	544	738	517	657	482	660	432
Nova Scotia	1,097	1,677	1,106	1,576	1,944	1,506	1,904	1,354	1,817	1,312	1,760	1,184
Ontario	21,514	21,289	21,470	21,758	34,184	20,996	33,634	20,301	31,991	19,670	29,046	18,721
Prince Edward Island	233	328	211	303	299	327	369	309	358	282	342	260
Quebec	15,191	15,933	15,251	14,773	23,042	14,200	22,324	12,992	21,149	12,660	19,272	12,091
Saskatchewan	1,044	1,348	1,008	1,291	1,664	1,318	1,845	1,203	1,861	1,109	1,410	1,140
Territories		0		0		40		50		45		41
Canada	53,983	54,344	53,827	52,784	85,371	50,564	84,931	48,288	81,025	46,649	74,344	44,624
Cross-industry correlation	***0.973***		***0.972***		***0.945***		***0.935***		***0.932***		***0.881***	

Notes: Data are from the Scott's databases and Statistics Canada Annual Survey of Manufacturing (and Logging Industries) Table 16-10-0054-01 and Table 16-10-0038-01. The 2001 and 2003 ASMs report only employer plants with sales exceeding C$30,000 whereas the 2005 to 2009 ASMs report information for manufacturing plants (including logging industries, which is absent in the 2001 and 2003 ASMs) for all plants. The descriptive statistics reported as "cross-industry" in the bottom panel of the table are computed across all 3 digits manufacturing industries (NAICS 311–339).

Table C.2: Comparing the Scott's National All database to the Canadian business counts (CBC).

	2001		2005		2009		2013		2017	
Province	CBC	Scott's	CBC	Scott's	CBC	Scott's	CBC	Scott's	CBC	Scott's
Alberta	5,843	3,935	5,416	3,482	5,351	3,597	4,882	3,144	4,095	2,891
British Columbia	8,797	6,212	8,261	5,400	7,697	5,031	6,933	4,148	5,984	3,966
Manitoba	1,883	1,654	1,741	1,489	1,605	1,280	1,481	1,108	1,049	1,061
New Brunswick	1,446	1,392	1,195	1,262	1,018	1,181	963	873	431	740
Newfoundland	757	576	629	544	508	482	522	364	244	320
Nova Scotia	1,832	1,677	1,483	1,506	1,225	1,312	1,106	970	666	816
Ontario	25,006	21,289	23,220	20,996	21,673	19,670	21,470	15,933	16,722	14,277
Prince Edward Island	354	328	292	327	256	282	211	199	114	154
Quebec	18,349	15,933	17,026	14,200	15,238	12,660	15,251	10,378	9,939	8,980
Saskatchewan	1,378	1,348	1,259	1,318	1,151	1,109	1,008	948	877	895
Territories		0		40		45		36		35
Canada	65,645	54,344	60,522	50,564	55,722	46,649	53,827	38,101	40,121	34,135
Cross-industry correlation	***0.908***		***0.939***		***0.937***		***0.931***		***0.773***	

Notes: Data are from Scott's National All databases and CBP (Table 33-10-0028-01 ,Table 33-10-0035-01). The descriptive statistics reported as "cross-industry" in the bottom panel of the table are computed across all 3 manufacturing digits industries (NAICS 311–339).

Table C.3: Comparing the Scott's National All databases to the Labor Force Survey (LFS) by Cities (>100K).

	2001		2003		2005		2007		2009		2011		2013		2017	
Census Metropolitan Area	LFS	Scott's	LFS	Scott's	LFS	Scott's	LFS	Scott's	LFS	Scott's	LFS	Scott's	LFS	Scott's	LFS	Scott's
Abbotsford - Mission	10.6	6.7	9.9	6.7	9.9	7	10.4	6.7	8.5	6.3	7.5	5.8	8.2	4.9	9.7	5.1
Barrie	13.1	6.5	14.8	6.5	17.4	7.3	15.4	7.9	10.4	6.9	14.4	5.7	14.8	5.7	15.5	5.3
Brantford	15.8	9.6	17.4	10.2	17.7	15.2	15.8	14.1	14.5	13.4	13.6	10.8	13.8	10.5	14.4	9.5
Calgary	51.2	47.9	53.4	46.9	42.6	46.5	47.3	52	42.5	50	46.1	46.3	46.2	40.2	39	36.1
Edmonton	48.4	40.9	50.2	43.4	48.8	47.8	53.5	55.2	44.2	52.6	51.4	51.1	58.7	47.2	41.5	45.6
Gatineau	6.8	3.8	6.7	4.6	8	5	7.5	4.4	6.7	3.6	7	3.4	6.3	3	7	3.2
Greater Sudbury	3.6	3.6	4.3	4	4.4	4	3.7	3.7	3.5	3.6	3.9	3.5	3.3	3.4	3.1	3
Guelph	19.7	18	19.8	19.5	20.2	18.7	19.2	16.2	15.3	16.6	15.6	15.7	14.7	15.2	16.8	16.8
Halifax	11.5	11.1	10.8	12.1	9.9	10.9	12.5	12.2	11.8	12.9	11.4	12.7	10	10.6	10.5	8.7
Hamilton	73.7	37.4	76.2	38.5	69.2	39	58.1	37.5	51.1	35.3	49.3	34.4	46.6	31.8	49.8	29.3
Kelowna	6.5	5	7.8	5.4	6.4	6	8.3	5.9	6.6	5.4	6.3	5	4.4	5.9	5	4.7
Kingston	6.6	4.2	6	3.7	6.1	3.2	5.2	2.9	4.1	3	4.4	2.9	4	2.4	3.9	3.4
London	36	21.5	41.7	24	39.4	25.4	35.1	25.8	29.9	24.7	29.2	19.9	27.4	19.2	29.8	15.6
Moncton	6	5.2	5	6	4.4	6.1	4.3	5.6	5.9	6	5.4	5	4.6	5.2	4.2	4.1
Montreal	314.4	271.5	291.4	253.7	286.9	242	246.2	219.6	242.8	218.9	224.2	205.7	225.7	171.6	226	156.2
Oshawa	32.1	9.7	33.6	11	32.5	10.8	26.8	9.8	20.5	8.6	19.4	7.4	20.5	6.2	17.1	6.2
Ottawa	35.8	18.7	28.2	18.5	30.3	18.1	36	19.7	29.2	20.5	20.3	21.9	17	17.8	17.7	16.7
Peterborough	7.1	5	7.6	4.7	7.2	4.4	8.2	4.8	6	4.8	5.9	4.4	4.8	4.7	3.8	5.3
Quebec	32.4	29.5	33	29.6	40.7	34.9	39.3	34.4	32.3	34.8	32.2	32.4	28.4	32.1	32.1	28.4
Regina	5	6.5	5.5	5.9	6.4	6.1	6.5	6.8	7.5	6.3	6.8	7	7	5.4	8.3	5.5
Saguenay	11.2	7.5	10.2	7.5	10.6	8.3	11	8.6	9.1	8.8	8.6	9.2	9.3	6.8	7.8	6
Saint John	5.1	5.9	5.1	5.6	4.1	5.5	6	5.2	5.4	5.6	5.5	3.4	4.4	3.7	5.9	3.3
Saskatoon	10.1	11.8	9.2	12.5	11.8	11.2	11.3	10	11.1	9.7	9.1	10	11.4	8.8	8.8	8.4
Sherbrooke	19.7	16.7	23.1	15.7	17.6	14.8	14	11.6	12.4	11.9	13.3	11.8	11.9	10.9	14.8	11.1
St John's	3.5	6.8	3.4	5.9	3.9	5.4	5.2	6	4.4	6	3.8	5.7	5.1	6	3.7	4.5
St. Catharines - Niagara	32.4	22.1	30.5	21.8	26.9	20.7	25.6	18.7	20.6	16.6	21	15	21.8	12.8	21.6	12.6
Thunder Bay	7	3.6	6.7	3.7	5	3.7	4.4	3.4	2.9	2.8	2.9	3.5	4.2	2.5	3.2	2.1
Toronto	452.3	359.8	466.6	382.8	457.1	372	397.6	353.8	328.4	340.6	331.9	308.1	334.1	278.2	336.8	251.7
Trois-Rivieres	11.7	7.5	11	8.2	11.4	7.8	10.5	7.8	9.7	8.3	8.3	7.7	8.3	6.5	9.6	5.9
Vancouver	104.2	97.6	112.7	96.5	101.2	93	105.6	96.9	86.1	94.3	85.1	91.4	84.7	75.8	99.9	75.3
Victoria	6.3	5.3	8.5	6.1	7.7	5.7	6.7	5.7	6.2	5.9	5.9	5.7	5.8	5.4	7.2	4.8
Waterloo	63.2	42.6	63	46.1	63.7	46.8	59	43.6	49.8	40.9	49.3	35.9	52.3	30.3	51.3	30.5
Windsor	46.3	25.1	48.2	27.3	48	26.5	35.5	27.7	29.6	25.5	30.7	21.5	31.4	19	38.4	18.6
Winnipeg	50.5	37.9	47	38.2	45.7	38.4	48	35.6	40.5	33.1	37.5	33.6	41.3	29.7	42.8	25.2
Cross-employment correlation	***0.995***		***0.996***		***0.996***		***0.997***		***0.995***		***0.997***		***0.996***		***0.995***	

Notes: Distribution of Census Metropolitan Areas' employment (x1000) of manufacturing plants (NAICS 311–339). Data are from Scott's National All databases and Labor Force Survey Statistic Canada (Table 14-10-0098-01). The descriptive statistics reported as "cross-industry" in the bottom panel of the table are computed across all 3 digits industries.

Table C.4: Descriptive statistics of big (and downsized) manufacturing plants closed by NAICS 3-digit sectors.

NAICS3	Manufacturing sector	(1) Closure rate closed in initial plants	(2) Job loss rate losses in initial jobs	(3) Avg. # jobs of closed big plants	(4) Relative share of exporters closed/non closed	(5) Relative share of headquaters closed/non closed
311	Food	12.0%	37.6%	143.7	1.01	0.18
312	Beverage and tobacco product	9.1%	29.1%	146.8	0.98	0.26
313	Chemical	20.0%	64.8%	156.7	0.83	0.34
313	Textile mills	9.8%	48.8%	113.6	0.85	0.18
314	Textile product mills	15.7%	55.6%	120.6	0.89	0.15
315	Clothing	10.5%	44.7%	130.1	1.05	0.33
316	Leather and allied product	11.8%	42.8%	132.5	1.04	0.19
321	Wood product	25.4%	54.4%	187.6	1.02	0.21
322	Paper	5.5%	34.3%	113.8	0.94	0.23
323	Printing and related support actv.	11.1%	31.3%	181.6	1.08	0.27
324	Petroleum and coal product	12.2%	38.1%	124.2	0.93	0.38
326	Plastics and rubber products	12.9%	38.0%	119.8	1.00	0.23
327	Non-metallic mineral product	7.0%	31.5%	116.8	1.07	0.31
331	Primary metal	17.1%	44.9%	173.4	0.96	0.29
332	Fabricated metal product	7.0%	29.2%	110.0	1.03	0.25
333	Machinery	8.5%	30.9%	106.3	0.98	0.33
334	Computer and electronic product	12.4%	42.6%	142.9	1.09	0.36
335	Electrical equipment, appliance	12.1%	40.5%	140.2	1.04	0.26
336	Transportation equipment	16.1%	48.7%	185.5	0.94	0.29
337	Furniture and related product	6.2%	32.3%	120.4	0.90	0.31
339	Miscellaneous	4.1%	34.8%	122.3	1.09	0.27
	All sectors	**9.8%**	**38.9%**	**132.0**	**0.76**	**0.65**

Notes: "Big plants" refer to 50+ establishments from 2003 that disappeared in 2017 and "big downsized plants" to 50+ establishments that lose at least 30% of their workforce between 2003 and 2017. The data are from Scott's National All Business Directories.

Table C.5: Big (and downsized) manufacturing plants closure and job loss rates in Canada.

Region	Province	% Big plants closed in initial plants	% Big job losses in initial jobs	Avg. Jobs of big plants closed
Western	Alberta	8.5%	33.5%	129.7
	British Columbia	7.4%	34.9%	130.0
	Manitoba	9.6%	33.1%	115.3
	Saskatchewan	6.2%	34.4%	130.6
		7.9%	***34.1%***	***127.7***
Atlantic	New Brunswick	8.1%	38.5%	151.5
	Newfoundland and Labrador	10.2%	43.1%	166.9
	Nova Scotia	6.7%	33.3%	129.8
	Prince Edward Island	8.3%	44.9%	130.7
		7.9%	***38.0%***	***145.2***
Ontario	Ontario	***10.5%***	***40.4%***	***135.5***
Quebec	Quebec	***11.0%***	***40.5%***	***127.3***
Canada		**9.8%**	**38.9%**	**132.0**

Notes : "Big plants" refer to 50+ establishments from 2003 that disappeared in 2017 and "big downsized plants" to 50+ establishments that lose at least 30% of their workforce between 2003 and 2017. The three territories (Northwest Territories, Nunavut and Yukon) are removed from the table but not from total. The data are from Scott's National All Business Directories.

Table C.6: Geographical breakdown of urban areas in Canada.

Region	Province	Total urban areas	Census metropolitan areas (CMA)	Census agglomeration CA	Minimum average population	Maximum average population
Western	Alberta	17	3	14	10,893	1,170,165
	British Columbia	26	4	22	14,038	2,222,570
	Manitoba	6	1	5	12,490	726,738
	Saskatchewan	10	2	8	10,215	261,208
		59	***10***	***49***	***10,215***	***2,222,570***
Atlantic	New Brunswick	7	2	5	15,435	131,695
	Newfoundland and Labrador	5	1	4	10,270	189,048
	Nova Scotia	5	1	4	25,733	379,475
	Prince Edward Island	2	0	2	16,423	64,940
		19	***4***	***15***	***10,270***	***379,475***
Ontario	Ontario	***46***	***16***	***30***	***10,245***	***5,296,808***
Quebec	Quebec	***30***	***6***	***24***	***12,243***	***3,815,543***
Canada		**154**	**36**	**118**	**10,215**	**5,296,808**

Notes : The table is based on manufacturing plants (NAICS 31-33) of 50+ employees, from 2003 that disappeared in 2017. The average population is that over our period of analysis (2001-2016). The data are from Scott's National All Business Directories.

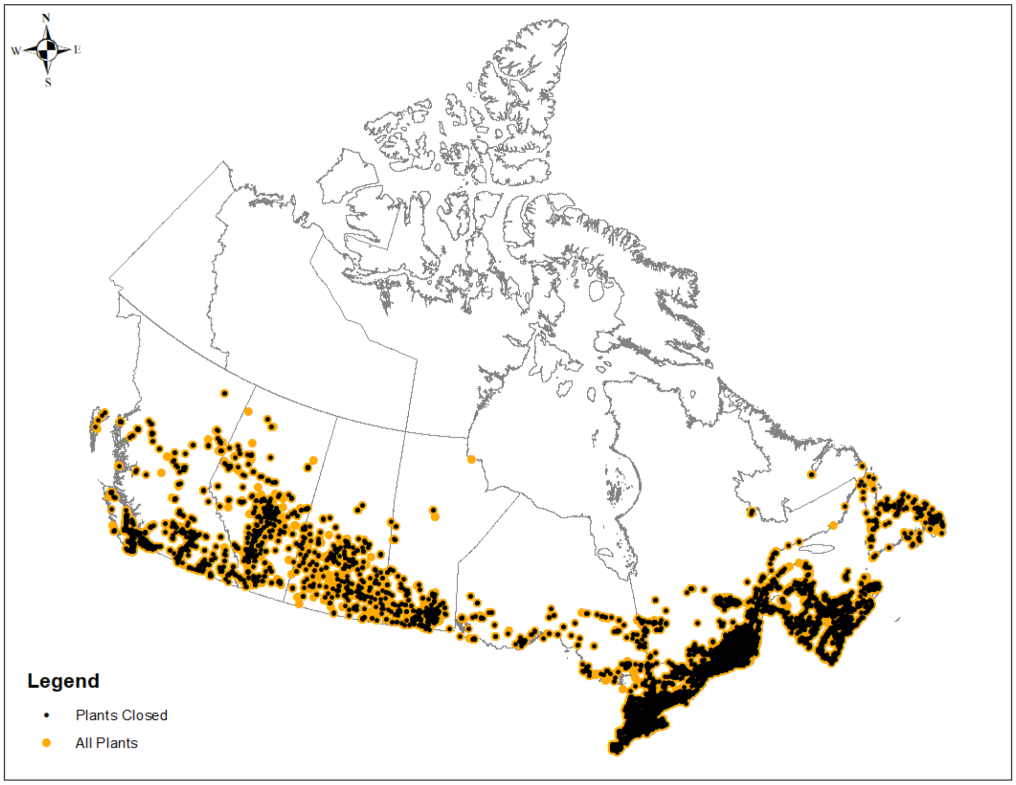
Table C.7: Growth rates of U.S employment by NAICS 4-digits industries.

NAICS4	U.S manufacturing sector	Growth rate	NAICS4	U.S manufacturing sector	Growth rate
3346	Reproducing magnetic and optical media	-78.24%	3359	Other electrical equipment and component	-17.99%
3341	Computer and peripheral equipment	-77.27%	3274	Lime and gypsum product	-17.73%
3151	Clothing knitting mills	-75.06%	3272	Glass and glass product	-16.78%
3159	Clothing accessories and other clothing	-68.91%	3273	Cement and concrete product	-16.35%
3152	Cut and sew clothing	-68.60%	3334	Ventilation, heating, air-conditioning and refrigeration	-15.86%
3132	Fabric mills	-66.03%	3363	Motor vehicle parts	-15.13%
3343	Audio and video equipment	-64.12%	3261	Plastic product	-14.32%
3131	Fibre, yarn and thread mills	-60.91%	3321	Forging and stamping	-14.05%
3161	Leather and hide tanning and finishing	-57.56%	3313	Alumina and aluminum production and processing	-13.33%
3133	Textile and fabric finishing and fabric coating	-53.88%	3312	Steel product from purchased steel	-11.82%
3141	Textile furnishings mills	-51.77%	3314	Non-ferrous metal production and processing	-9.41%
3325	Hardware manufacturing	-49.57%	3391	Medical equipment and supplies	-9.03%
3342	Communications equipment	-48.63%	3251	Basic chemical	-8.33%
3352	Household appliance	-43.28%	3118	Bakeries and tortilla	-8.21%
3322	Cutlery and hand tool	-43.13%	3329	Other fabricated metal product	-8.17%
3271	Clay product and refractory	-43.01%	3256	Soap, cleaning compound and toilet preparation	-7.72%
3122	Tobacco manufacturing	-41.88%	3255	Paint, coating and adhesive	-7.25%
3371	Household and institutional furniture	-39.73%	3328	Coating, engraving, cold and heat treating	-5.70%
3231	Printing and related support activities	-36.56%	3324	Boiler, tank and shipping container	-4.00%
3326	Spring and wire product	-35.08%	3345	Navigational, measuring, medical and control instruments	-2.90%
3221	Pulp, paper and paperboard mills	-34.74%	3114	Fruit and vegetable preserving and specialty food	-2.19%
3169	Other leather and allied product	-34.47%	3323	Architectural and structural metals	-2.02%
3399	Other miscellaneous	-33.46%	3361	Motor vehicle	-1.46%
3344	Semiconductor and other electronic component	-33.15%	3253	Pesticide, fertilizer and other agricultural chemical	-1.08%
3162	Footwear manufacturing	-32.71%	3254	Pharmaceutical and medicine	-0.76%
3315	Foundries	-32.50%	3252	Resin, synthetic rubber, and artificial and synthetic fibres	-0.46%
3333	Commercial and service industry machinery	-31.97%	3113	Sugar and confectionery product	2.02%
3149	Other textile product mills	-29.95%	3112	Grain and oilseed milling	2.84%
3351	Electric lighting equipment	-29.02%	3366	Ship and boat building	2.93%
3379	Other furniture-related product	-27.51%	3116	Meat product	3.05%
3212	Veneer, plywood and engineered wood product	-27.45%	3327	Machine shops, turned product, and screw, nut and bolt	3.57%
3332	Industrial machinery	-25.99%	3339	Other general-purpose machinery	4.42%
3372	Office furniture (including fixtures)	-25.78%	3364	Aerospace product and parts	4.60%
3311	Iron and steel mills and ferro-alloy	-25.68%	3111	Animal food	6.17%
3222	Converted paper product	-25.32%	3331	Agricultural, construction and mining machinery	6.24%
3262	Rubber product	-24.39%	3336	Engine, turbine and power transmission equipment	7.46%
3259	Other chemical product	-24.00%	3241	Petroleum and coal product	7.52%
3353	Electrical equipment	-22.71%	3279	Other non-metallic mineral product	8.36%
3211	Sawmills and wood preservation	-21.81%	3115	Dairy product	10.77%
3219	Other wood product	-20.57%	3362	Motor vehicle body and trailer	14.02%
3117	Seafood product preparation and packaging	-19.65%	3365	Railroad rolling stock	19.29%
3369	Other transportation equipment	-19.65%	3119	Other food manufacturing	31.30%
3335	Metalworking machinery	-18.46%	3121	Beverage manufacturing	57.40%

Notes: Growth rates are between 2003 and 2017 for 4-digit sectors employment. Data are from U.S Bureau County Business Patterns.

C.2 Figures on data

Figure C.1: Manufacturing plants in Canada in 2003.



Appendix D Additional results

Table D.1: Closures and population changes across age groups in Canadian Urban Areas

	Dependent Variables : Growth of											
Dependent variable *y*: Growth of	Total Population		People aged 20-54		People aged over 55		Total Population		People aged 20-54		People aged over 55	
	OLS(1)	OLS(2)	OLS(3)	OLS(4)	OLS(5)	OLS(6)	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)
Closure rate (Big plants)	-0.719		-0.596		-1.000		-4.984***		-6.102***		-0.723	
	(0.351)		(0.282)		(0.621)		(1.260)		(1.818)		(1.262)	
Closure rate (Big and downsized plants)		-0.162		-0.066		-0.304		-5.097**		-6.240***		-0.739
		(0.120)		(0.109)		(0.157)		(1.980)		(2.290)		(1.497)
Ln Initial population	-0.032**	-0.033**	-0.021**	-0.023	-0.051*	-0.054*	-0.023	-0.038*	-0.010	-0.028	-0.052***	-0.054***
	(0.006)	(0.008)	(0.007)	(0.010)	(0.021)	(0.019)	(0.019)	(0.023)	(0.023)	(0.030)	(0.014)	(0.017)
High initial share of people aged 20-54	0.115**	0.113**	0.127**	0.126**	0.279*	0.275*	0.124***	0.087***	0.139***	0.092***	0.278***	0.273***
	(0.023)	(0.025)	(0.029)	(0.031)	(0.092)	(0.092)	(0.032)	(0.027)	(0.042)	(0.034)	(0.075)	(0.078)
High initial share of skilled people	0.046	0.052	0.053	0.057	0.018	0.025	0.013	0.040	0.010	0.043	0.020	0.024
	(0.025)	(0.024)	(0.035)	(0.033)	(0.045)	(0.046)	(0.030)	(0.058)	(0.042)	(0.077)	(0.029)	(0.035)
High initial share of empl. in manufacturing	0.010	-0.011	-0.002	-0.025	0.013	-0.011	0.202***	0.333*	0.245***	0.407*	0.000	0.019
	(0.027)	(0.011)	(0.024)	(0.017)	(0.051)	(0.023)	(0.057)	(0.195)	(0.054)	(0.213)	(0.068)	(0.117)
January maximum temperature	0.012*	0.013*	0.008	0.009	0.028**	0.028***	0.012	0.020***	0.007	0.017**	0.028***	0.029***
	(0.005)	(0.005)	(0.008)	(0.007)	(0.005)	(0.005)	(0.008)	(0.005)	(0.012)	(0.008)	(0.004)	(0.002)
July maximum temperature	0.008	0.009	0.006	0.007	0.007*	0.008**	0.000	-0.002	-0.004	-0.007	0.008***	0.007*
	(0.006)	(0.005)	(0.008)	(0.007)	(0.003)	(0.002)	(0.012)	(0.018)	(0.016)	(0.022)	(0.003)	(0.004)
Log distance to nearest big city	-0.008	-0.008	-0.008	-0.008	-0.002	-0.002	-0.006***	-0.012**	-0.006***	-0.013**	-0.002	-0.003
	(0.005)	(0.005)	(0.006)	(0.007)	(0.006)	(0.005)	(0.001)	(0.005)	(0.001)	(0.006)	(0.004)	(0.005)
Log distance to nearest coastline	0.003	0.004	0.011	0.012	-0.001	0.001	-0.002	0.010	0.004	0.019	-0.001	0.001
	(0.011)	(0.011)	(0.013)	(0.013)	(0.009)	(0.010)	(0.014)	(0.018)	(0.018)	(0.023)	(0.009)	(0.007)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate							-0.090	-0.088	-0.090	-0.088	-0.090	-0.088
IV P value							0.001	0.000	0.001	0.000	0.001	0.000
IV Partial R2							0.03	0.02	0.03	0.02	0.03	0.02
First stage F statistic							11	19	11	19	11	19
Adjusted R2	0.31	0.28	0.37	0.35	0.30	0.28						
Urban Areas	154	154	154	154	154	154	154	154	154	154	154	154

Notes : Table reports OLS and 2SLS estimates. "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.

Table D.2: Placebo Test : Job losses and population changes in Canadian cities

Dependent variable y: (1991-2001) Growth of	Total Population		Population 20-54 share		High-skilled share		Migrants share	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
Job loss rate (Big plant closures)	0.004		-0.016		0.005		0.021	
	(0.215)		(0.010)		(0.014)		(0.029)	
Job loss rate (Big plant closures + Downsizing)		0.004		-0.017		0.005		0.022
		(0.228)		(0.013)		(0.016)		(0.027)
Ln Initial population	-0.081***	-0.081***	-0.001	-0.001	0.005**	0.005*	-0.000	-0.000
	(0.016)	(0.016)	(0.002)	(0.002)	(0.003)	(0.003)	(0.001)	(0.002)
High initial share of people aged 20-54	0.084***	0.084***	0.002	0.002	0.013**	0.013*	0.006	0.006
	(0.017)	(0.017)	(0.007)	(0.007)	(0.006)	(0.007)	(0.004)	(0.004)
High initial share of skilled people	0.053***	0.053***	0.007***	0.007***	0.042***	0.042***	-0.002	-0.003
	(0.012)	(0.012)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
High initial share of empl. in manufacturing	-0.093***	-0.093***	0.006*	0.007**	-0.005	-0.005	-0.002	-0.003
	(0.011)	(0.021)	(0.003)	(0.003)	(0.004)	(0.005)	(0.004)	(0.005)
January maximum temperature	0.026***	0.026***	0.001***	0.001***	0.001	0.001	-0.000	-0.000
	(0.003)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
July maximum temperature	0.009	0.009	0.000	0.000	-0.000	-0.000	0.001	0.001
	(0.009)	(0.009)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log distance to nearest big city	-0.008**	-0.008**	0.000	0.000*	-0.002*	-0.002*	-0.001***	-0.001***
	(0.003)	(0.003)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Log distance to nearest coastline	-0.021*	-0.021	0.002***	0.002***	0.001	0.001	-0.003*	-0.003*
	(0.013)	(0.013)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate	-0.844	-0.792	-0.844	-0.792	-0.844	-0.792	-0.844	-0.792
IV P value	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000
IV Partial R2	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
First stage F statistic	12	35	12	35	12	35	12	35
Urban Areas	154	154	154	154	154	154	154	154

Notes: "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 1991-2016 and boundaries files, Environment Canada's weather data.

Table D.3: Alternative IV: Job losses and population changes in Canadian cities

Dependent variable *y*: Growth of	Total Population		Population 20-54 share		High-skilled share		Migrants share	
	IV(1)	IV(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
Job loss rate (Big plant closures)	-0.542**		-0.104***		0.040***		-0.136***	
	(0.269)		(0.014)		(0.008)		(0.040)	
Job loss rate (Big plant closures + Downsizing)		-0.569		-0.109***		0.042***		-0.144**
		(0.365)		(0.025)		(0.013)		(0.061)
Ln Initial population	-0.022**	-0.019	0.004**	0.005**	-0.001	-0.001	0.003	0.004
	(0.011)	(0.017)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)	(0.004)
High initial share of people aged 20-54	0.121***	0.122***	0.006	0.006	0.011***	0.011***	0.018	0.018
	(0.030)	(0.032)	(0.004)	(0.004)	(0.003)	(0.003)	(0.012)	(0.013)
High initial share of skilled people	0.040*	0.042	0.003	0.003	0.018***	0.018***	0.012**	0.013**
	(0.023)	(0.037)	(0.005)	(0.006)	(0.004)	(0.005)	(0.005)	(0.006)
High initial share of empl. in manufacturing	0.013	0.044	0.001	0.007	-0.009**	-0.011*	0.015***	0.023**
	(0.019)	(0.049)	(0.004)	(0.004)	(0.004)	(0.006)	(0.004)	(0.009)
January maximum temperature	0.010***	0.011***	-0.001	-0.001	0.001***	0.001***	-0.003**	-0.003**
	(0.004)	(0.004)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
July maximum temperature	0.004	0.002	-0.001	-0.001	0.002**	0.002**	-0.001	-0.002
	(0.008)	(0.011)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Log distance to nearest big city	-0.005***	-0.005***	0.000	0.000	-0.001	-0.001	-0.001*	-0.001
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Log distance to nearest coastline	0.001	0.004	0.002	0.003	-0.002**	-0.002**	0.002	0.003
	(0.008)	(0.009)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV estimate	-0.770	-0.733	-0.770	-0.733	-0.770	-0.733	-0.741	-0.698
IV P value	0.003	0.000	0.003	0.000	0.003	0.000	0.002	0.000
IV Partial R2	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06
First stage F statistic	9	22	9	22	9	22	10	21
Urban Areas	154	154	154	154	154	154	153	153

Notes: Instruments used in regressions removes industries that are highly concentrated geographically. "Big plants" refer to 50+ establishments and "downsized plants" to 50+ establishments in 2003 that lose at least 30% of their workforce in 2017. "High initial share" means to be in the top quartile of the cities in our sample. The "skilled" are the 15+ residents with at least a bachelor degree. A big city is a city with at least 300,000 residents. Temperatures are in Celsius and distances in meters. Standard errors in parentheses are clustered at the level of big Canadian regions. Significance levels 0.10 * 0.05 ** 0.01 ***. Data are from Scott's National All databases, Statistic Canada's Census 2001-2016 and boundaries files, Environment Canada's weather data.