Transport Costs and Regional Wage Differentials: Evidence from Canadian Microdata

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In his 1981 study of transport costs and their effect on real income in the Atlantic provinces, McRae (1981) found that interregional transport costs do not contribute significantly to regional income disparities. Using industry-level data, McRae estimated transport costs as a percentage of value added and found an average tariff equivalent of 2.15 percent. Pointing out that McRae's approach is valid only for exportable sectors using nothing but exportables as inputs, Anderson (1982) showed that in the more general case in which the peripheral region imports inputs (that is, intermediate commodities) from the central region, transport costs will have a greater effect on real income than that reported by McRae.

This note reports the preliminary findings of an applied research programme on transport costs and their effect on the spatial distribution of economic activity. Specifically, estimates of equilibrium wage differentials by industry and by distance from the central region are reported for Canadian manufacturing industries. These are obtained using a methodology similar to that used by McRae (1981). Specifically, input-output data from Statistics Canada, transport costs from the National Transportation Agency, and market-value-by-weight data from the Canadian Transport Commission are used to test the predictions of a simple two-region model of a spatial/regional economy. The predictive power of the resulting estimates is then evaluated using provincial value-added data.

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In this note a description of the methodology and data is followed by a report on equilibrium wage differentials by distance and by industry. The next major section examines the predictive power of the estimates using provincial value-added data by industry.

Methodology and Data

Consider a two-region model consisting of a central region c and a peripheral region p (Losch 1954; Christaller 1966). Following McRae (1981) and Anderson (1982), the central region is assumed to be large, and the peripheral region is assumed to be small. Product prices (input and output prices), it therefore follows, are determined in the central region; the peripheral region is a price taker. Industry output requires capital, labour, and intermediate inputs. Technology is assumed to be free, or identical, across regions.

Let a_{ij} = cost of commodity i (intermediate input) per dollar of industry j output;

b_{ij} = value of commodity i (final product) per dollar of industry j output;

k_j^l = cost of capital per dollar of industry j output in the lth region (l = c, p);

w_j^l = cost of labour per dollar of industry j output in the lth region (l = c, p); and

v_i = weight per dollar of commodity i (i = 1, ... , n).

Assuming that the industry structure in both regions is competitive, industry equilibrium for each of the n industries can be described by

$$\sum_{i=1}^{m} a_{ij} + w_j^c + k_j^c = \sum_{i=1}^{m} b_{ij} \qquad \forall j = 1, \ldots, n \qquad (1)$$

Next, let $t_{ij}^{\mu}(d)$ represent the cost of transporting a_{ij} worth of commodity i from the central region to the peripheral region and $t_{ij}^{\varepsilon}(d)$ the cost of transporting b_{ij} worth of output i from the peripheral region to the central region. The distance between the two regions is d.

The effect of transport costs on regional wages and hence on regional wage differentials will depend on the extent of trade between the two regions. As Anderson (1988: 262) points out, without scale economies each region (assuming free technology) will have a "full set of manufacturing industries producing products for local consumption". Scale economies, however, give rise to regional specialization and interregional trade and, hence, to transport costs. As is well known, the incidence of transport costs much depends on the relative size of a region. In most regional models, the periphery, with its small population, absorbs the transport costs of exportables (McRae 1981) as well as the transport costs of importables (Anderson 1982). The relevant accounting identity for such a region is given by

$$\sum_{i=1}^{m} [a_{ij} + t_{ij}^{\mu}(d)] + w_j^p + k_j^p = \sum_{i=1}^{m} [b_{ij} - t_{ij}^{\varepsilon}(d)] \qquad \forall j = 1, \ldots, n \qquad (2)$$

The peripheral region must incur the additional costs of importing the intermediate inputs, as well as the additional costs of exporting the outputs to the central region. The former is viewed as a cost and thus enters with a positive sign. The latter is also viewed as a cost but enters with a negative sign. The right-hand side of the equation should be viewed as the "net-back" price in the peripheral region. It therefore would follow that for industry j to exist in the peripheral region, labour, capital, or both must absorb the transport costs. If we assume that capital is perfectly mobile between regions and that labour is perfectly immobile, it would follow that labour absorbs all the transport costs. The resulting transport cost-induced equilibrium wage differential is derived by solving equations (1) and (2) for w_j^c and w_j^p, the costs of labour in the central and peripheral regions, respectively. This yields the absolute wage differential, $\delta_j(d)$, defined as

$$\delta_j(d) = w_j^c - w_j^p = \sum_{i=1}^{m} t_{ij}^{\mu}(d) + \sum_{i=1}^{m} t_{ij}^{\varepsilon}(d) \qquad \forall j = 1, \ldots, n \qquad (3)$$

Since transport costs increase as the distance (d) between the two regions increases, it follows that the wage differential increases in the same fashion. Estimates of $\delta_j(d)$ were obtained for 89 manufacturing industries (LINK 14-103) using a methodology similar to that of McRae (1981). Values for a_{ij} and b_{ij} were obtained from the 1975 input-output table *(Large)* produced by Statistics Canada (1984). Because these input-output tables relate commodities to industries, transport costs per dollar input and per dollar output are derived at the industry level.[1] Specifically, the use-input table was used to derive input transport costs, and the make-output table was used to derive output transport costs for each of the 89 Canadian manufacturing industries contained in the input-output table. The transport costs of input i per dollar of industry j output—$t_{ij}^{\mu}(d)$—were derived using

$$t_{ij}^{\mu}(d) = |\tau_i(d) a_{ij}| / v_i \qquad \forall\ i = 1, \ldots, m; \quad j = 1, \ldots, n \qquad (4)$$

1. Services, or non-traded intermediate inputs, were excluded from the analysis. Thus, transport costs were calculated for commodities LINK 1-500, with certain exceptions.

The transport costs of output i per dollar of industry j output—$t^r_{ij}(d)$—were derived using

$$t^r_{ij}(d) = [\tau_i(d) b_{ij}]/v_i \qquad \forall\ i = 1, \ldots, m; \quad j = 1, \ldots, n \qquad (5)$$

Thus, the transport costs for input i in industry j are equal to the product of $\tau_i(d)$, the cost per pound of transporting input i over distance d; a_{ij}, the cost of commodity i per dollar of output j; and $1/v_i$, the reciprocal of the value per pound of input i. Similarly, the transport costs for output i in industry j are equal to the product of $\tau_i(d)$, the cost per pound of transporting output i over distance d; a_{ij}, the cost of commodity i per dollar of output j; and $1/v_i$, the reciprocal of the value per pound of output i.

The input-output values reported by Statistics Canada are net of any transportation margins. Estimates of transport costs for a_{ij} and b_{ij} were derived using data from three sources. First, value-per-weight data were obtained from a Canadian Transport Commission study (1978) on unit values of commodities moving in overseas trade.[2] Estimates of transport costs at the commodity level were obtained from rail cost data made available by the National Transportation Agency.[3] Specifically, average revenue per ton mile (ARTM) by distance (measured in 250-mile intervals) data were obtained for 320 commodities. ARTM was then regressed against distance for each commodity classification, providing estimates of the relevant commodity freight rate schedules by distance.[4] Finally, values for a_{ij} and b_{ij} were obtained from Statistics Canada (1984).

Equilibrium Wage Differentials

Distance-specific values for $\delta_j(d)$, the equilibrium wage differential, are reported in Table 1 for the worst possible case[5]—that is, the case in

2. McRae (1981) cites Statistics Canada's *Export Statistics of Canada* as his source of unit values (value per weight) for the 644 commodities in the large matrix. For a number of reasons, we were unable to replicate his results. For example, while Export Commodity Classification codes 00000-40000 are reported by weight and total value, thus providing the relevant unit values, Export Commodity Classification codes 40001-99999 are reported by physical units and value, thus requiring supplementary information on weight per unit. In view of these complications, we opted for the value-per-weight data contained in Canadian Transport Commission (1978).
3. Transport data for 1975 were not available. Thus, transport costs for 1981 were deflated using a producer's price index.
4. The resulting freight rate schedules were mostly non-linear in distance.
5. The equilibrium wage differentials reported here should be viewed as those corresponding to the worst possible scenario--that is, the equilibrium wage differentials required to establish a manufacturing industry in a Loschian hinterland. The more attributes a particular region has in terms of intermediate

TABLE 1 Equilibrium Wage Differentials by Manufacturing Industry (M-level) and by Distance (percent)

		Distance (miles)					
LINK	Industry	250	500	750	1,000	1,250	1,500
8	Food	99	178	254	328	402	475
9	Beverage	20	33	44	54	65	75
10	Tobacco products	3	4	5	6	7	7
11	Rubber products	7	10	12	14	15	17
12	Plastic products	16	29	42	55	68	80
13	Leather and allied products	279	557	835	1,114	1,392	1,670
14	Primary textile and textile products	73	146	218	290	362	434
15	Clothing	460	921	1,382	1,843	2,303	2,764
16	Wood	49	66	79	90	110	110
17	Furniture and fixtures	29	40	50	57	64	70
18	Paper and allied products	74	135	193	251	307	361
19	Printing, publishing, and allied pdts.	199	396	593	790	986	1,183
20	Primary metal	25	44	62	79	96	112
21	Fabricated metal products	16	21	26	30	33	37
22	Machinery	7	11	15	18	21	24
23	Transportation equipment	8	13	18	22	26	29
24	Electrical and electronic products	13	24	34	44	54	64
25	Non-metallic mineral products	234	328	409	483	554	622
26	Refined petroleum and coal products	267	432	575	706	828	945
27	Chemical and chemical products	235	462	686	911	1,136	1,357

which industry j in the peripheral region must import all of its intermediate commodities and export all of its output. We see that wage differentials, expressed as a percentage of w^c_j (wage cost per dollar output in industry j in the central region), varies from a low of 3 percent in the tobacco product industries to a high of 460 percent in the clothing industries.[6] Thus, for the tobacco product industries to locate in the peripheral region, labour costs must be 3 percent lower than in the central region. For the clothing industries, labour costs must be 460 percent lower than in the central region (and labour would have to be heavily subsidized). Perhaps this explains the absence of the garment industry in the hinterland. The clothing industry in Canada is concentrated heavily in Montreal and Toronto, where it is composed of low-wage, mostly immigrant labour.

Figure 1 plots industry (M-level) equilibrium wage differentials against distance in miles for six M-level industries: plastic products

input availability, labour productivity, or organizational superiority, the more likely it is to attract industry.

6. McRae (1981) reports rates of effective distance protection based on transport costs as a percentage of product value. It was felt, however, that given our purpose of determining the effect of transport costs on regional wages, the relevant rate is that measured relative to labour's contribution to value added. This eliminates cases of low transport costs when measured relative to product value but of high transport costs when measured relative to labour value added.

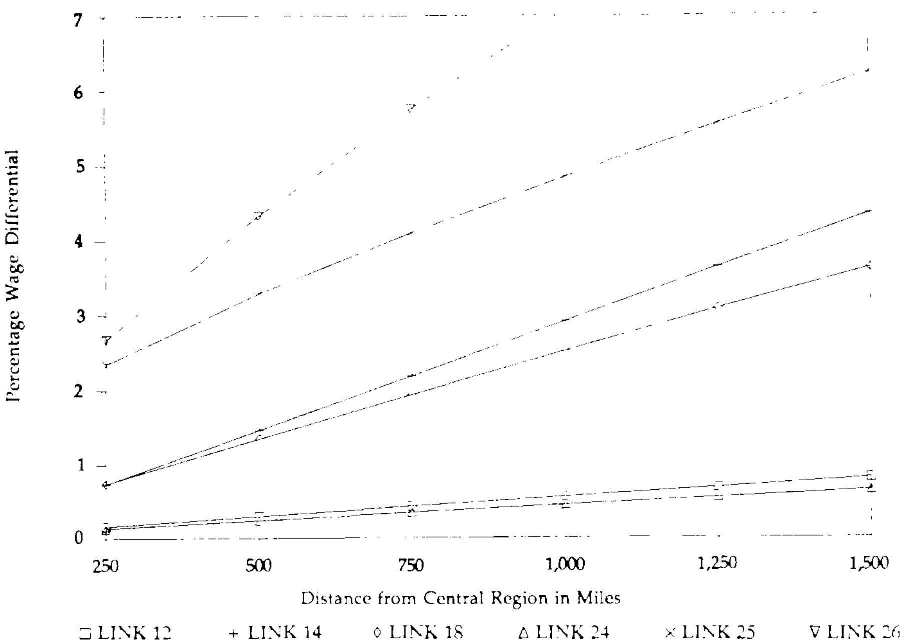

FIGURE 1 Equilibrium wage differentials

(LINK 12); primary textile and textile products (LINK 14); paper and allied products (LINK 18); electrical and electronic products (LINK 24); non-metallic mineral products (LINK 25); and refined petroleum and coal products (LINK 26).[7] LINKs 12 and 24 can be described as low-wage differential industries and thus those most likely to locate in the peripheral region. LINKs 14 and 18 are less likely to locate in the periphery, and LINKs 25 and 26 are highly unlikely to locate in the periphery, as to do so would involve a negative wage or a negative rate of return on capital. In all cases, equilibrium wage differentials increase as the distance from the central region increases.[8] Particularly noteworthy is the fact that despite non-convex transportation costs (in distance), the reported wage differentials are, for the most part, linear in distance from the central region.

Given our assumptions, these estimates represent the upper limit of equilibrium wage differentials. All intermediate inputs originate in

7. Statistics Canada (1984) reports 182 L-level industries, 63 M-level industries, and 25 S-level industries. The estimates presented aggregate across a number of L-level industries.
8. One should view the origin as the central point in the heartland. In this context, Kingston, located halfway between Montreal and Toronto, would be the relevant central point.

the central region, and all final outputs are shipped there. Were these assumptions relaxed in whole or in part on a case-by-case basis, it would stand to reason that the resulting wage differentials would be lower than those reported above. In fact, in some cases they may be eliminated altogether. This would be the case where some, if not all, the intermediate inputs are available in the region, and where some, if not all, the final outputs are sold in the region. Another assumption pertains to the relative size of the regions. Specifically, the central region is assumed to be larger than the peripheral region. Relaxing this assumption also would lower the wage differentials reported above. The larger the peripheral region, the more likely it is to be a final destination for outputs and the more likely it is to manufacture intermediate inputs. In the limiting case, the wage differentials would be eliminated altogether.

These results allow us to conclude that transport costs are an important determinant of industry (and thus firm) location and, moreover, are an important cause of wage differentials for central Canada (southern Ontario and southern Quebec)—that is, for industry to locate in the peripheral regions of Canada, wages in all industries must be lower than in the heartland. Our results also confirm the contention by Anderson (1982) that when inputs have to be imported from the central region, transport costs are an important source of regional wage, and thus income, disparities. Not only does the incidence of transport costs of the final product to the market—in this case central Canada—fall on labour, but labour also must bear the costs of transporting the intermediate inputs.

Empirical Validity

The estimates reported in Table 1 are based on various assumptions about, among other things, industry structure and technology.[9] In this section we subject our results to empirical scrutiny by testing the main prediction of the implied regional model, which is that regional industrial activity will decrease as the industry wage differential increases.[10] To see why, suppose that while wage rates differ across

9. The empirical validity of the unit value data used in this study (Canadian Transport Commission 1978) was verified by comparing the weight of one dollar's worth of inputs (use-input) with the weight of one dollar's worth of outputs (make-output). For the complete sample of industries, output weighed 73 percent of input. This is consistent with the basic principles of regional/spatial analysis in which industries can be classified according to weight-gain or weight-loss.
10. That regional activity is not zero in high wage differential industries can be explained in terms of either differential regional efficiency (presence of superior firms), the fact that the relevant inputs are available in the region and thus are

industries, they are identical within industries independent of location. In this case, by locating in the peripheral region, the firm incurs differential costs (relative to locating in the heartland) in the form of transport costs (inputs and outputs). Thus, on average, firms in industries with high transport cost wage differentials will be less likely to locate in the peripheral regions. To test this hypothesis, an analysis of variance was conducted using the wage differentials (M-level) reported above and provincial industry value-added data (M-level of aggregation). Data limitations, specifically the lack of observations at the detailed L-level of aggregation, precluded the use of detailed estimates.[11] Underlying this exercise was the assumption that Ontario and Quebec form the central region and New Brunswick, Manitoba, British Columbia, and Nova Scotia the relevant peripheral regions. Table 2 presents the resulting matrix of Pearson correlation coefficients. Two measures of industry value added were used: absolute and relative (to the level of national value added).

The results establish the empirical validity of the wage differentials reported above. Absolute and relative value added by industry are decreasing in the industry equilibrium wage differential. For example, the correlation coefficient between the equilibrium wage differential and the level of value added in New Brunswick is –0.213, which indicates that industry output is decreasing with transport costs. Manitoba, British Columbia, and Nova Scotia also report negative correlation coefficients. When provincial value added is measured relative to total value added, the results are in general unaffected. Provincial value added continues to be correlated negatively to the wage differential, the exception being Manitoba where the coefficient is now positive. The relationship is strongest for New Brunswick, British Columbia, and Nova Scotia, which, it turns out, is what regional/spatial economics would predict. The farther a region is from the centre, the higher the wage differential and thus the less likely it is to attract manufacturing industry.

Summary and Implications

This note has presented evidence that corroborates the long-standing view in Canada that transport costs are a source of asymmetric industrial development across and between the heartland regions and the hinterland regions. Moreover, they are an important source of

not imported, or the fact that the region is non-negligible in terms of its population and hence thus size.

11. The equilibrium wage differentials at the L-level of aggregation (LINKs 14-103) are available from the author on request.

TABLE 2 Pearson Correlation Coefficient Matrix (n = 20)

	WD[a]	NB	MAN	BC	NS	NBCAN	MANCAN	BCCAN	NSCAN
WD	1.000								
	(0.001)[b]								
NB	-0.213	1.000							
	(0.366)	(0.001)							
MAN	-0.104	0.491	1.000						
	(0.661)	(0.027)	(0.001)						
BC	-0.180	0.666	0.256	1.000					
	(0.446)	(0.001)	(0.274)	(0.001)					
NS	-0.263	0.926	0.620	0.528	1.000				
	(0.261)	(0.001)	(0.003)	(0.016)	(0.001)				
NBCAN	-0.265	0.925	0.338	0.740	0.768	1.000			
	(0.257)	(0.001)	(0.144)	(0.001)	(0.001)	(0.001)			
MANCAN	0.273	0.131	0.663	-0.019	0.135	0.136	1.000		
	(0.243)	(0.581)	(0.001)	(0.933)	(0.567)	(0.566)	(0.001)		
BCCAN	-0.112	0.451	0.057	0.932	0.262	0.616	-0.029	1.000	
	(0.636)	(0.045)	(0.810)	(0.001)	(0.264)	(0.003)	(0.900)	(0.001)	
NSCAN	-0.310	0.896	0.463	0.567	0.922	0.817	0.096	0.363	1.000
	(0.183)	(0.001)	(0.039)	(0.009)	(0.001)	(0.001)	(0.684)	(0.114)	(0.001)

a. The variables are: WD = equilibrium wage differential by M-level industry; NB = New Brunswick value added by M-level industry; MAN = Manitoba value added; BC = British Columbia value added; NS = Nova Scotia value added; NBCAN = ratio of New Brunswick to Canada value added; MANCAN = ratio of Manitoba to Canada value added; BCCAN = ratio of British Columbia to Canada value added; and NSCAN = ratio of Nova Scotia to Canada value added.

b. Prob > $|\rho|$ under $H_0: \rho = 0$.

income differentials across the geographically dispersed regions of Canada. The latter results from two distinct yet related phenomena. First, transport costs put downward pressure on regional manufacturing wages, thus contributing to the presence of transport cost-induced regional wage and income differentials. Second, where wages are not flexible downward (for example, because of the presence of countrywide collective bargaining), transport costs discriminate against peripheral regions for the location of manufacturing industry.

This does not imply, however, that industry cannot or will not locate in the peripheral regions. It is important to keep in mind that our results are based on a number of important assumptions. For example, we assume that technology is identical across regions. But, in reality, production technology varies from one region to another, creating a situation in which higher productivity could potentially offset location-specific differential costs (such as for transport). The problem with this hypothesis lies with explaining why a firm with a superior technology would not locate in the central region, which would enable it to collect the associated technological rents for itself.

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Appendix: Provincial Value Added by Industry (thousand dollars)

LINK	Industry[a]	WD[b]	NB	MAN	BC	NS	CAN
8	Food	0.03	336,138	402,879	805,428	335,571	9,737,560
9	Beverage	0.20	71,078	85,034	24,919	21,332	2,735,851
10	Tobacco products	0.03	0	0	0	0	808,572
11	Rubber products	0.07	0	0	0	0	1,268,351
12	Plastic products	0.16	13,756	46,971	96,050	18,148	1,748,953
13	Leather & allied products	2.79	0	14,313	0	0	634,023
14	Primary textile & textile products	0.73	0	14,572	34,628	38,382	2,301,449
15	Clothing	4.60	2,863	164,567	91,591	0	2,807,924
16	Wood	0.49	122,795	75,435	2,071,578	59,959	4,623,796
17	Furniture & fixtures	0.29	8,095	58,485	58,377	6,665	1,798,055
18	Paper & allied products	0.74	317,337	97,529	1,359,229	225,910	7,555,162
19	Printing, publishing, & allied pdts.	1.99	27,841	209,979	422,335	56,281	5,982,606
20	Primary metal	0.25	0	272,260	408,317	0	7,006,289
21	Fabricated metal products	0.16	43,068	139,098	425,377	52,464	6,638,084
22	Machinery	0.07	14,199	101,685	250,235	8,180	3,634,949
23	Transportation equipment	0.08	0	125,726	408,743	89,512	14,089,453
24	Electrical & electronic products	0.13	0	160,468	151,284	43,568	6,676,956
25	Non-metallic mineral products	2.34	0	78,681	90,000	13,735	3,047,145
26	Refined petroleum and coal pdts.	2.67	0	0	265,512	0	2,614,211
27	Chemical and chemical products	2.35	29,875	78,861	286,630	10,553	7,625,282

Source: Statistics Canada. 1988. *Manufacturing Industries of Canada: National and Provincial Areas*, Cat. No. 31-203. Ottawa: Supply and Services Canada.

a. M-level.

b. See note a, Table 2.