Chapter 19:
The North American Integration Model

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1. Introduction

Peter B. Dixon and Maureen T. Rimmer, professors at Victoria University, Melbourne, Australia, together with Shenjie Chen and Catherine Milot from the Department of Foreign Affairs, Trade and Development, Ottawa, Canada, discussed their paper on the North American Integration model (NAIM). NAIM is being developed in a cooperative research project between the Centre of Policy Studies (CoPS) at Victoria University and the Canadian Department of Foreign Affairs, Trade and Development (DFATD).

The aim of the project is to give DFATD a quantitative analytical tool for assessing the effects on Canada and its North American trade partners of changes in trade policies. These include proposed efforts that are sometimes grouped under the heading NAFTA2 and that are limited to the NAFTA partners, such as further streamlining the passage of goods and harmonizing the quality and safety standards for sales of goods and services. This presentation discusses how the NAIM model was constructed and explains challenges the authors encountered in ensuring that the model reflected reality, along with promising solutions.

2. Constructing the NAIM Model

The starting point for constructing NAIM was USAGE (U.S. Applied General Equilibrium), a dynamic CGE model of the U.S. economy that has proved effective in analyses of a wide range of policies. The first step was to build a one-country model for Canada, CANAGE, which in its theoretical structure is identical to USAGE:

CANAGE = USAGE computer code implemented with Canadian data.

Second, USAGE and CANAGE were combined into a single model containing two unconnected countries by adding a country subscript to every variable and coefficient in the USAGE code. For example, the coefficient

V1BAS(*c,s,j*) became V1BAS(*c,s,j,k*)

where V1BAS(*c,s,j*) refers to the basic value of commodity *c* from source *s*—the United States, Canada, or the rest of world (ROW) in the present version of NAIM—that is used as an intermediate input in industry *j*, and *k* identifies the location of industry *j* (Canada or the United States). Thus, at this stage:

NAIM-1 = USAGE code + country subscript implemented with U.S. and Canadian data

This is an unconnected model in the sense that shocks to Canadian variables have no effect on U.S. variables and vice versa. Dixon et al. were able to check NAIM-1 by making sure that it generated results for the effects of shocks to the U.S. economy that were identical to those from stand-alone USAGE and results for the effects of shocks to the Canadian economy that were identical to those from stand-alone CANAGE.

The third step was to iron out the inevitable differences in the NAIM-1 database between Canadian imports from the United States and U.S. exports to Canada, and between U.S. imports from Canada and Canadian exports to the United States. It was convenient to believe the import data for both countries.

The fourth step, and theoretically the most interesting, was to add equations to the USAGE code that allow U.S. exports to Canada to be driven by Canadian demands for imports from the United States and Canadian exports to the United States to be driven by U.S. demands for imports from Canada. With these connections Dixon et al. obtained:

NAIM-2 = USAGE code + country subscript + Canada/U.S. connecting equations

implemented with U.S. and Canadian data.

3. Test Application

For an initial application of NAIM-2, the authors conducted two simulations concerned with the short-run effects of stimulating absorption (private and public consumption and investment) in the United States and Canada. In the first simulation they imposed a 1 percent increase in U.S. absorption. The idea was to show a stimulatory macroeconomic policy. In keeping with a short-run focus, they assumed that there was no effect on capital stocks by industry or on real wage rates in either the United States or Canada. The second simulation was the same as the first, except that the stimulatory macro policy was carried out in Canada rather than the United States.

Macro results from the two simulations are in table 1. Industry results are given in Dixon et al. (2014). The results in table 1 are percentage differences. For example, in the northwest quadrant we see entries of 1.00 for C (consumption), I (private investment), and G (government spending) in the United States, reflecting the imposed 1 percent increase in absorption. The table reveals several assumptions besides the ones about capital and wages that have already been mentioned. First, the authors assume that each country manages its monetary policy so that a stimulus has no effect on the price level measured by the price deflator for GDP (line 14 in the north and south halves of table 1). Second, they assume that public and private consumption are locked together (lines 1 and 3 in the north and south halves). This assumption is obvious for the stimulated country: they simply impose 1 percent increases in both real public and private consumption. For the other country, they assume that real public consumption adjusts in line with real private consumption, which in turn moves with real GDP. Third, they assume that a stimulus has an effect on investment-to-capital ratios that is uniform across industries: a 1 percent increase in the stimulated country and no change in the other country. With no change in capital stocks, table 1 shows zero effect for aggregate investment in the non-stimulated country (line 2 northeast and southwest).

Table 1. Macro Effects of U.S. and Canadian Stimulation, Percentage

		Stimulation of US absorption		Stimulation of Canadian absorption	
	US macro				
1	C	1.000		-0.003	
2	I	1.000		0.000	
3	G	1.000		-0.003	
4	X	-4.641		-0.028	
5	to Can		-2.002		0.993
6	to ROW		-5.080		-0.197
7	M	1.889		-0.018	
8	from Can		0.597		-0.978
9	from ROW		2.128		0.160
10	GDP	0.148		-0.003	
11	K	0.000		0.000	
12	L	0.360		-0.002	
13	Pc	-0.346		0.001	
14	Pgdp	0.000		0.000	
15	TofT	1.611		0.000	
16	with Can	1.002	1.002		-0.358
17	with ROW	1.720	1.720		0.066
	Canada macro				
1	C	0.028		1.000	
2	I	0.000		1.000	
3	G	0.028		1.000	
4	X	-0.008		-1.100	
5	to US		0.597		-0.978
6	to ROW		-1.843		-1.467
7	M	-0.029		1.060	
8	from US		-2.002		0.993
9	from ROW		1.920		1.126
10	GDP	0.028		0.373	
11	K	0.000		0.000	
12	L	0.033		0.502	
13	Pc	0.056		-0.161	
14	Pgdp	0.000		0.000	
15	TofT	-0.206		0.409	
16	with US		-1.002		0.358
17	with ROW		0.614		0.489

Note: C=Consumption, I=Investment, G=Government spending, X=Exports, M=Imports, GDP= Gross Domestic Product, TofT=Terms of trade, K=Capital stock, L=Labor force, Pc=Price deflator for Consumption, and P= GDP deflator.

The headline results in table 1 are for aggregate employment. In the United States, 1 percent absorption stimulation increases employment by 0.360 percent (line 12, northwest), while in Canada, 1 percent absorption stimulation increases employment by 0.502 percent (line 12, southeast).

A useful starting point for explaining the results for aggregate employment is the labour market equilibrium condition:

$$W = P_{gdp} * MPL\left(\frac{K}{L}\right) \tag{1}$$

where W is the wage rate; P_{gdp} is the price deflator for GDP and represents the price of goods and services produced in the economy; and MPL is the marginal product of labour, which is an increasing function of the capital-to-labor ratio, K/L. Equation (1) can be rewritten as

$$\frac{W}{P_c} = \frac{P_{gdp}}{P_c} * MPL\left(\frac{K}{L}\right) \tag{2}$$

where P_c is the price deflator for consumption and represents the price of goods and services purchased by households. In the stimulus simulations, the authors assume that real consumer wages (W/P_c) are fixed. Thus, the left-hand side of (2) is unchanged by stimulus. On the right-hand side, P_{gdp}/P_c increases in the stimulated country. This can be seen from lines 13 and 14 in the northwest and southeast quadrants of table 1. P_{gdp}/P_c increases because stimulus improves a country's terms of trade (line 15 northwest and southeast), defined as the price of exports divided by the price of imports. An improvement in the terms of trade usually generates an increase in P_{gdp} relative to P_c because P_{gdp} includes the price of exports, but not imports, whereas P_c includes the price of imports but not exports.[32] Terms-of-trade improvement arises mainly because stimulus restricts a country's ability to supply exports, thereby allowing their price to increase. With an increase in P_{gdp}/P_c and no change in W/P_c, MPL must fall. With no change in K, L must rise. Thus, we see that the stimulus increases aggregate employment.

However, P_{gdp}/P_c and equation (14) can't be the whole story. In the northwest quadrant of table 1, the increase in P_{gdp}/P_c is more pronounced than in the southeast quadrant (0.346 percent compared with 0.161 percent), yet the percentage employment increase in the northwest quadrant is less than in the southeast quadrant (0.360 percent compared with 0.502 percent). This raises two questions. Why is P_{gdp}/P_c larger in the northwest quadrant than in the southeast quadrant? And what is the extra employment effect in Canada relative to the United States beyond that which can be explained by P_{gdp}/P_c and equation (14)?

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[32] More accurately, an improvement in the terms of trade generates an increase in P_{gdp}/P_{gne} where P_{gne} is the price deflator for gross national expenditure (C + I + G). Because C is the dominant component of GNE, an improvement in the terms of trade *usually* generates an increase in P_{gdp}/P_c.

The key to the first question is trade shares. Trade shares for Canada are larger than those for the United States (29 percent of Canadian GDP is exported, whereas only 12 percent of U.S. GDP is exported). Thus, larger percentage changes in trade volumes are required in the United States than in Canada to facilitate a given percentage expansion in non-traded production. This explains why the movements in trade volumes in the northwest quadrant of table 1 involve larger percentages than those in the southeast quadrant (-4.641 and 1.889, compared with -1.100 and 1.060). The larger percentage changes in trade flows explain the larger terms-of-trade gain for the United States relative to Canada (1.611 percent compared with 0.409 percent). Even though the U.S. terms-of-trade effect is four times that for Canada, the P_{gdp}/P_c effect is only about twice that for Canada. Broadly, terms-of-trade effects are translated into effects on the P_{gdp}/P_c ratio via the share of exports in GDP.

The key to the second question about employment effects is factor intensities. In Dixon et al. (2014), the authors showed for a two-sector model that if the expanding sector (non-traded production) is more labor intensive than the contracting sector (traded production), then stimulus produces positive employment effects beyond those that can be explained by movements in P_{gdp}/P_c. In view of this finding, they looked at labor intensities implied by the NAIM-2 database. Dixon et al. defined the non-traded sector as the set of industries for which the share of exports in output and the share of imports in sales on the domestic market are less than 0.1 for both the United States and Canada. All other industries are in the traded sector. Under these definitions, NAIM-2 data imply that Canada's non-traded sector is more labor intensive than the traded sector: the labor share in returns to primary factors in the non-traded sector is 72.1 percent, compared with 55.5 percent in the traded sector (table 2). By contrast, the U.S. traded sector is more labor intensive than the non-traded sector (72.9 percent compared with 58.6 percent, table 2). Thus, differences in factor intensities between the non-traded and traded sectors contribute positively to the employment effect of stimulus in Canada and negatively in the United States. As described in Dixon et al. (2014), the authors established the validity of the factor intensity explanation by conducting simulations with the database adjusted to eliminate both differences in factor intensities across U.S. industries and differences in factor intensities across Canadian industries.

The off-diagonal panels in table 1 show that stimulation of the U.S. economy is more important to Canada than stimulation of the Canadian economy is to the United States. For example, the Canadian employment effect in the southwest quadrant is an increase of 0.033 percent, while the U.S. employment effect in the northeast quadrant is a decrease of 0.002 percent.

Table 2. Factor Shares in 2010, NAIM-2 Database

	USA			Canada		
	Labor	**Capital**	**Share in GDP**	**Labor**	**Capital**	**Share in GDP**
Non-traded	0.586	0.414	0.669	0.721	0.279	0.583
Traded	0.729	0.271	0.331	0.555	0.445	0.417
Total	0.633	0.367	1.000	0.652	0.348	1.000

The greater sensitivity of Canada to the United States than of the United States to Canada was to be expected, given the relative sizes of the two economies. Perhaps a more interesting point is that the off-diagonal results are generally very small relative to the diagonal results. Thus, NAIM-2 implies that stimulus policy in the two countries can be conducted in relative isolation. While the business cycles in Canada and the United States are closely correlated, NAIM-2 implies that this correlation does not reflect strong causal links between the two economies. Rather, the shocks that drive the business cycle in one economy must simultaneously drive the business cycle in the other.

4. Learning from the Test Applications: Improving the Compatibility Between the Input-Output Data for Canada and the United States by the Common-Technology Assumption

The most interesting aspect of NAIM simulations is the comparison between results for Canada and those for the United States. Whenever NAIM results are produced, this comparison will inevitably be the main focus of attention. In the macro test simulations reported in section 3 and in a further test simulation of the effects of reductions in wholesaling requirements for Canadian and U.S. exports (see Dixon et al., 2014), the authors explained differences between results for the two countries in terms of five features of their data:

1) a larger share of imports and exports in GDP for Canada than for the United States;
2) a greater dependence of Canada on trade with the United States than vice versa;
3) a higher labor intensity of non-traded production in Canada than in the United States;
4) higher wholesale margins per unit of export in the United States than in Canada; and
5) higher capital intensity of the Canadian wholesale industry than the U.S. industry.

While features 1) and 2) seem reflections of reality, the authors doubt that the same can be said for features 3), 4) and 5). They suspect that 3), 4) and 5) reflect data incompatibilities.

When Dixon et al. started the NAIM project, they thought that Canadian input-output data would be closely comparable to that for the United States. Both countries use the North American Industrial Classification System (NAICS), and they hoped that differences in production technologies implied by their input-output data could be interpreted as genuine differences. However, the differences that they found are too great to be plausibly interpreted as real-world technological differences between two adjacent countries at similar stages of development. While both countries may adhere to the same statistical conventions, it is clear that there are considerable differences in the way people are interpreting and implementing the conventions governing the compilation of input-output data. It is not possible to conclude that industry *j* and commodity *c* in Canadian statistics are directly comparable with industry *j* and commodity *c* in U.S. statistics.

Problems of input-output incompatibilities similar to those experienced for Canada and the United States are often encountered in modeling for multiple regions within a single nation. Intuitively, it seems reasonable to build a multi-regional model for a country around input-output tables compiled for each region. However, this approach often fails. The problem is that regional input-output tables are never compiled on quite the same basis. In these circumstances, *real* differences between regions in the technology (input structure) of industry *j* can be swamped in the input-output data by differences in statistical implementation. Rather than persevering with regional input-output tables, our colleagues at the Centre of Policy Studies have found it preferable to make the bold assumption that the technology in industry *j* is the same in all regions throughout a nation.[33] This means that a regional model for a nation can be compiled on the basis of a national input-output table. Of course, an immediate objection is that the technology for generating electricity, for example, in one part of the country might be coal-based whereas in other parts it is hydro-based. Thus, the inputs to electricity generation can vary sharply across regions. But the solution to this problem is not regional input-output tables. The solution is industry disaggregation. The industries in a multi-regional model should include coal-powered electricity, hydroelectricity, and so on. It is reasonable to suppose that the technology for coal-powered electricity is uniform across regions, that the technology for hydroelectricity is uniform across regions, etc.

Given the apparent incompatibilities between Canadian and U.S. input-output data and in view of their experience with multi-regional CGE models, the authors decided to form a new version of NAIM—NAIM-3—under the common-technology assumption. The authors recompiled the data for NAIM so that the input-structure for industry *j* in Canada is the same as that for the United States. Macro differences between the two countries in labor productivity were preserved: That is, the data were set up so that output per worker and real wages differed between the two countries.

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[33] See, for example, Horridge et al. (2005) and Wittwer (2012). For a comprehensive survey of multi-regional CGE modeling see Giesecke and Madden (2013).

Provided that the modeling is done at a high level of industry disaggregation, the authors think that the common-technology assumption for Canada and the United States is a good working hypothesis. Consequently, little is lost by adopting it. The gain is that result interpretation is not bedeviled by spurious differences between Canadian and U.S. simulation responses associated with data incompatibilities rather than real-world differences. Adoption of the common-technology assumption leaves in place many genuine differences between countries. Potentially, a U.S.-Canada model produced under the common-technology assumption can reliably reflect differences between the two countries in their responses to policy changes and other shocks, based on real differences in:

- the industrial composition of their output and employment;
- the commodity composition of their exports and imports;
- the structure of their taxes and tariffs;
- the destinations of their exports and the sources of their imports;
- the size of the public sector and the nature of its activities;
- household preferences (the commodity composition of household expenditures);
- wage-fixing systems; and
- natural resource endowments.

As reported in Dixon et al. (2014), NAIM-3 produced results for their test simulations in which the effects on the results of spurious intercountry data differences were eliminated. By adopting the common-technology assumption, the authors have produced a model in which differences between the results for Canada and the United States reflect believable differences in the characteristics listed in the bullet points above.

5. Concluding Remarks

Building an economic model that can make a lasting contribution to policy analysis requires a journey along a difficult road. Only a small percentage of projects that start along that road reach the desired destination. In this paper, Dixon et al. have documented the journey so far for NAIM. The milestones that the NAIM project has passed are as follows: (1) development of a methodology for converting a well-established single-country model into a multi-country model; (2) analysis of test simulations; and (3) resolution of data incompatibilities by implementing the common-technology assumption.

There are many more milestones to pass. Perhaps the most important milestone for NAIM is the performance of a live policy simulation. It is only when the results matter that they are given critical scrutiny by people outside the modeling group. At that stage, the model will take a major step along the road to becoming a tool for practical policy analysis. Consequently, Dixon et al. hope that the NAIM team will soon be tasked with contributing to the analysis of emerging issues of importance to the NAFTA partners.

References

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