CROSS-BORDER SUPPLY CHAINS IN THE POST 9/11 SECURITY ENVIRONMENT

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Introduction

Canada and the US have a unique trading relationship. Not only is their bi-national trade volume the world's largest, but the nature of the goods traded indicates a high level of economic integration. Materials and components moving from one manufacturing facility to another account for a very large share of trade. In other words, a large proportion of Canada-US trade is generated by cross-border supply chains. Thus, fast, reliable and inexpensive cross-border freight movement is critical to the efficiency and competitiveness of manufacturers on both sides of the border.

The events of September 11, 2001 triggered a sudden increase in the level of security at the Canada-US border, resulting in increased delays, shipment costs and uncertainty at border crossings. A crucial question is whether the post 9/11 security environment has significantly undermined the economic viability of cross-border supply chains. At the present time there is surprisingly little empirical evidence related to that question. This paper proposes a step toward generating such evidence by means of an analytical framework for measuring the incremental cost of border crossing on supply chains. The discussion is set in the context of the automotive industry, which has seen intense cross-border integration of production systems for over forty years and which has been the largest sectoral category of Canada-US trade. But the basic ideas apply equally to supply chains in other manufacturing or even in economic sectors such as beef and pork production.

The paper begins with background about cross-border automotive supply chains, the impacts of 9/11 and recent policy initiatives on the border. A general framework for analyzing the incremental cost of crossing borders in supply chains is then introduced with some discussion about its empirical implementation.

Background

Cross-border Integration in the Automotive Industry

The history of investment in Canada by the Detroit Three automotive companies goes back as far as 1904, when Henry Ford built facilities in Windsor. The benefit at first was to serve not only the Canadian market but also the British Commonwealth market to which Canada had access. Until the 1960's, the Three operated on the "branch plant" model whereby assembly was duplicated in Canada behind high tariff barriers. Because of shorter Canadian production runs, assembly plants were less efficient and automobile prices were higher for Canadians than for Americans. The Canada-U.S. Automotive Products Trade Agreement of 1965 (commonly known as the Auto Pact,) allowed tariff-free movement of vehicles and components between Canada and US. This was not a true "free trade" agreement because it included a variety of restrictions including a stipulation that the value of production in Canadian plants would be at least equal to the volume of Canadian sales. (A detailed account and analysis is found in Anastakis, 2005.) The basic structure of the Auto Pact was preserved in Canada-US Free Trade Agreement (CUFTA) and the North American Free Trade Agreement (NAFTA), but a ruling by the WTO in 2000 struck down provisions of the Auto Pact. As a result of that ruling, there is no longer a stipulation maintaining a minimum Canadian production share.

The outcome of the Auto Pact was more than a rationalization of production, whereby certain models were assembled in the US and others and Canada. It resulted in a full integration of the production of most vehicles, whereby components moved across the border such that few vehicles were produced with 100% Canadian or US value content – each vehicle was a joint product of Canadian and US facilities linked together in a complex supply chain. Partly this was to

take advantage of cost differences. For example, labour was generally cheaper in Canada, so assembly, which is labour intensive, was disproportionately sited in Canada (Holmes,2004.) Also, in order to achieve scale economies large plants producing major systems such as engines and transmissions were located in both the US and Canada, each to serve assembly plants on both sides of the border. The degree of cross-border integration was dramatically demonstrated in a study of the Center for Automotive Research (Andrea and Smith, 2002,) which reported that American assembled vehicles contain an average US$1000 in Canadian content while Canadian assembled vehicles contain an average of US$7400 in US content. (These figures are in $2000 dollars, current values would be higher.)

One of the most important trends in the automotive industry has been the increasing role of the "new domestic" OEMs, especially Toyota and Honda. During a period when automotive employment was declining in Ontario, they made huge investments and created many thousands of jobs in the province. While they also rely to some extent on cross-border supply chains, their general preference for keeping tier 1 suppliers in close geographical proximity makes them somewhat less vulnerable to problems on the border.

Economic impacts of border problems in the aftermath of September 11, 2001

Rapid growth in Canada-US trade in a broad variety of goods throughout the 1990's was not met with adequate infrastructure expansion, so congestion at the border was emerging as a major problem for the automotive and other industries by the end of the decade. The heightened US security regime in the aftermath of the terrorist attacks in 2001, however, exacerbated this problem dramatically. A number studies have been undertaken in the intervening years to assess the economic cost of long border delays. A study published by the Ontario Chamber of Commerce (2004, 2005) summed up costs borne by manufacturers, carriers, and government agencies to about $10 billion per year.[1] A more focused study commissioned by Transport Canada (DAMF, 2005) estimated

[1] The Ontario Chamber of Commerce Numbers are derived from Taylor and Robideaux (2003).

that the cost of participation in US import compliance programs by Canadian trucking firms is about $290 million per year, which is 4% of total expenses on for-hire, long distance Canadian cross-border trucking services.

A more ambitious type of analysis attempts to estimate the reduction in US Canada trade precipitated by border delays and translate that into losses in output by manufacturers on both sides of the border. For example HLB Decision Economics (2004) estimated that impaired cross-border freight movement led to an annual economic contraction of over US$11 billion in the United States and US$2 billion in Canada.[2] The assumption that Canada-US trade would have been higher in the years following 2001 is by no means beyond dispute, however. Econometric studies control for a variety of other factors affecting trade (exchange rates, growth in US domestic industrial production, etc.) in order to try to isolate a measurable post-2001 border effect. While Globerman and Storer (2006) find a significant negative impact, a more recent study by Burt (2007) using a slightly different methodology found no such impact. How is this possible? Surveys conducted by MacPherson (2006) indicate that while firms that ship or receive goods across the border have suffered significant cost impacts, a relatively small share of the interviewed firms expected to reduce their dependence on cross-border trade.

For the most part, the studies described above do not address the cost of the border from a supply chain perspective. The CAR study (Andrea and Smith, 2002), however, focuses on cross-border value chains and the consequences of delayed shipments. It estimated the hourly cost in lost profit of a plant shutdown that would arise when components do not arrive on time – ranging from $60,000 for assembly plants to $7,500 to $2,000 per hour for first tier parts plants. It does not, however, attempt to estimate aggregate delay costs based on this type of cost assessment or relate such costs to policy options.

[2] The US and Canada estimates (which are in 2000 dollars) are not strictly comparable because the impacts measured in the input-output model available for Canada were less comprehensive than those for the US. If it had been possible to use identical methodology, the Canadian impact would have been larger.

Policy proposals

There have been calls to action from numerous quarters proposing a variety of approaches to addressing the border problem. Calls for infrastructure expansion predate 9/11, especially in the Windsor-Detroit corridor. A plan that will include a second downriver crossing (in addition to the Ambassador Bridge) and significant improvement to access roads on the Canadian side is under review. (Needs assessment is found in URS, 2004.) A final environmental assessment on the plan was submitted in December, 2008, but construction may be held up by a dispute with the City of Windsor over the design of access roads and threats by members of the Michigan legislature to block funding for access roads on the American side. At the same time, the Ambassador Bridge is promoting a plan to build a new span with 50% more lane capacity.

"Trusted traveler" and "trusted shipper" programs, whereby individual travelers, carriers and complete supply chains are pre-certified for accelerated clearance are now well established. These include the US Customs-Trade Partnership Against Terrorism (C-TPAT) program, the Canadian Partners in Protection (PIP) program and the bi-national Free and Secure Trade (FAST) program. A recent policy paper by the Canadian and American Chambers of Commerce (2008) calls for expansion of these programs and recommends reforms to make them more flexible and to reduce secondary inspections of certified travelers and vehicles. The same paper calls for harmonization to minimize duplication of inspections by US and Canadian officials and a significant increase in staffing and training expenditures for border officials of both countries.

The most comprehensive and radical policy prescription is to create a customs union and undertake a program of harmonization of regulations in such areas as immigration, visas, narcotics, health inspections, and product standards with the goal of eliminating the need for border clearances entirely. This "perimeter" approach, which would make the US-Canada region function much like the Schengen region in Europe, has been the subject of significant controversy in Canada (see Noble, 2005, for a review of the debate.)

Analytical Framework

A conceptual basis for the analysis of cross-border supply chains may be set in location theory, the theories of interregional and international trade, the theory of logistics and supply chains, and in models for simulating the performance of transportation and related systems. A basic principle from economic geography states that a good will be traded (shipped) from any point A to any other point B only if the cost advantage of producing the good at A is greater than the cost of moving the good from A to B. Understanding the flows of goods in space, therefore, comes down to understanding why production costs vary spatially and what factors affect the cost of movement.

Production costs may vary because of differences in local resources or market conditions. For example, labour costs are lower where workers are plentiful and labour markets are relatively unconstrained. Government policies, such as subsidies, low taxes or socialization of health and other benefits may also affect relative costs. Cost advantages may also arise out of scale economies. To use an automotive example, if engines are produced at A and made available to assembly plants at B, C, D ... etc., production at A will be cheaper than if engines are produced at lower scale on site at all assembler locations. Such a configuration will work, however, only if the costs of moving the engines from A to all other points are not greater than the cost advantage conferred by scale economies. Thus, there is a tension between scale economies and goods movement costs – if movement costs are low, production is more likely to be centralized, if they are high, production is more likely to be distributed.

In traditional location and trade theories, the cost of movement is synonymous with the cost of transportation, but in a complex and vertically disintegrated industry such as automotives there is much more involved. The broader concept of logistics costs includes procurement, warehousing, inventory carrying costs, in addition to

transportation costs[3]. The even broader concept of the supply chain recognizes the need for tight integration of production and logistics processes in systems involving a variety of spatially dispersed producers and service providers[4]. A broad view of goods movement costs has several implications. One is that not only the cost but also the speed of movement is important. Another is that *uncertainty* adds significantly to supply chain costs by requiring firms to incur inventory carrying costs for goods stockpiled to insure against late arrivals.

Cross-border cost increment

Now that the Auto Pact's guarantee of a proportionate share of Canadian production is no longer in effect, a key question is whether the incremental cost of extending supply chains across the border is sufficiently high to eliminate the benefit of integrating US and Canada automotive production activities. At the current time there is little published evidence on either the cost or benefit side of this question. The first step is to measure the incremental cost of the border on supply chain links. The remainder of this paper delineates a framework for such measurement.

When supply chains straddle the Canada-US border a number of complications arise. Since there are relatively few crossings, congestion at chokepoints is a chronic problem. While average crossing times increased considerably in the years following 2001, and while there are still periodic spikes in average times during the summer months when tourist traffic mixes with truck traffic, the overall trend has been toward reduced average crossing times. It is not clear, however, that this is the result of more efficient border operation. Much of it derives from the reduction in freight activity due to the current economic slowdown. No doubt a significant part of the improvement is due to gradually increasing participation in

[3] Modern treatments of location theory demonstrate that incorporating logistics, as opposed to just transportation, costs has significant effects on classic results. See McCann(1998).

[4]There are many texts on logistic and supply chair operations. See, for example, Christopher (1998) and Baudin (2004) and Chopra and Meindl (2007).

trusted shipper programs. But that improvement comes at a cost to shippers and carriers because of the high cost of program compliance. Compliance costs include meeting high security standards at production facilities, warehouses, truck yards, *etc.* and the certification of drivers and other people with access to goods shipped in the supply chain.

Despite the fact that the economic slowdown is keeping flows well within infrastructure capacities, the current security environment builds in further layers of uncertainty as congestion may arise due to heightened scrutiny at unpredictable times. Even in the absence of congestion, the possibility that an individual shipment may be chosen randomly for secondary inspection complicates supply chain management. As noted above, this type of uncertainty has severe economic implications because a delayed shipment could shut down a component or assembly plant. In general, the approach to insuring against such catastrophic impacts is to pre-ship and stockpile a safety inventory of any component that moves across the border in a supply chain. This implies warehousing and inventory carrying costs.

We can define the cross-border cost increment b as the additional cost of a link in a supply chain network that crosses the border over the cost that would be incurred for that link in the absence of the border. Assume that the link represents a single daily shipment by truck. The increment is made up of three components:

1. Mean delay cost (d), which is the average cost of a truck driver's time, wasted fuel and idled capital in queues at the border crossing.
2. The cost of safety inventory (ps), where s is the level of inventory in physical units necessary to insure against delivery failures and p is the price per unit of maintaining the inventory.
3. Compliance cost (c) which is the cost of membership in a trusted shipper program defined on a per-shipment basis.

So

$$b = d + ps + c$$

Assume for the moment that compliance cost c is a continuous variable. The firm chooses a level of compliance in the expectations of reductions in b. Since expenditure on c makes it possible to pass through border inspections more quickly, the mean delay cost d for an individual firm is a function of its level of c and of the mean delay in minutes, m:

$$d = d(m, c)$$

The level of safety inventory depends on the variance in border delay v, but it is also affected by a firm's expenditure on compliance c to the extent that such expenditures reduce the rate of random inspection.

$$s = s(v, c)$$

So we can redefine the cross-border cost increment as follows:

$$b = d(m, c) + s(v, c) + c.$$

Assuming that the derivatives of d and s with respect to c are negative and the second derivatives are positive, the firm will minimize its value of b by choosing a level c such that

$$\frac{\partial d(m, c)}{\partial c} + p\frac{\partial s(v, c)}{\partial c} < -1.$$

In other words, the firm will spend an extra dollar on compliance so long as the resultant savings in delay and safety inventory costs are greater than one dollar. There is one clear inference in this result. The higher is the value of carrying inventory p, the greater will be expenditure on compliance.

In practice, the firm will not have discretion over the level of compliance. Rather, it will have the option of membership in a single trusted shipper program with a fixed cost of compliance $\bar{c}$. Thus it has a choice between becoming compliant $(c = \bar{c})$ and not becoming compliant $(c = 0.)$ The firm will choose to become compliant if

$$\bar{c} < d(m, 0) + ps(v, 0) - d(m, \bar{c}) - ps(v, \bar{c}).$$

Assuming that $s(v,0) > s(v,\bar{c})$, the general conclusion that the firm will be willing to spend more on compliance the greater is its cost of inventory p still holds. The inventory cost will depend *inter alia* on the per unit value of the goods in inventory, so compliance may be worthwhile for some firms and not for others. Also, to the extent that it involves fixed costs, compliance cost defined on a per shipment basis will be lower for firms that make many shipments, so again it may be economic for some firms and not for others.

The fact that some firms are likely to choose to participate in trusted shipper programs while others are not is significant because there may be external benefits to compliance. For example, trucks crossing a bridge are in a common queue until they get close enough to inspection stations so that compliant trucks are able to use faster moving lanes. Since compliant trucks clear inspection faster, the common queue should move faster the higher is the proportion of compliant trucks. To incorporate this in the framework, define C as the proportion of carriers who are compliant. To represent the external benefit, define $d(m,c,C)$ and $s(v,c,C)$ such that derivatives of both d and s with respect to C are negative.

If such external benefits exist there is an important policy implication, since goods with positive externalities tend to be under-consumed from a social welfare perspective. This may constitute an argument for subsidizing the cost of compliance in trusted shipper programs.

Quantification

Actual measurement of the cross-border cost increment b and of its components d, ps, and c. presents a number of challenges. The mean delay cost d is relatively easy to estimate if accurate data on the mean crossing time is available along with estimates of labour, capital and energy cost per minute in queue and an estimate of the time savings from participating in a trusted shippers program. Crossing times are estimated by CBSA and CBP based on relatively informal observation methods. Surveys of carriers may be necessary to validate the quality of crossing time data.

The safety inventory cost *ps* presents more of a challenge because it requires an estimate of what level of safety inventory is necessary to offset a given observed variance in crossing time. Models from the science of supply chain management may be useful for this purpose (for example, Chapter 11 of Chopera and Meindl, 2007, deals with the estimation of safety inventories.) However it will not be generally possible to define a single relationship between *s, v* and *c* because safety inventory requirements will be highly sensitive to the nature of the supply chain in question. The best strategy might be to define a manageable number of "typical" supply chains based on delivery requirements and cost of carrying inventory and assign proportions of the aggregate freight flow at a border crossing to each of them.

The external benefits of compliance in trusted shipper programs are particularly difficult to quantify because they involve not just an individual truck trip but rather a large number of interacting truck trips. This might best be addressed by the use of simulation software that will allow estimation of the affect of different proportions of compliant trucks passing through the inspection plazas on the queue of trucks on the bridge or other cross-border infrastructure.[5]

The question of compliance cost might best be addressed via communication with and industry group such as the Canadian Trucking Alliance.

Concluding Comments

Implementation of the framework described above (or something similar to it) should go some way toward answering the question: "What are the costs of running supply chains across the Canada-US border?" But that question begs another: "What are the benefits of running supply chains across the Canada-US border?" In some sectors the answer may lie in differences in natural endowments. But for the automotive sector and some other manufacturing sectors, the

[5] Thanks to Chris Lee of the University of Windsor Department of Civil and Environmental Engineering for demonstrating how VISSIM software could be used in this context.

answer has more to do with relative costs and the ability to achieve scale economies. Given the complexity of automotive supply chains, the "benefit" question is at least as difficult to answer as the cost question.

The current crisis in the automotive industry gives greater urgency to these questions. Even if the "thickened" border has severely eroded the viability of cross-border supply chains, we would expect any adjustments to be slow because of the costs sunk in existing production facilities. In the current environment, where many facilities both in parts production and assembly are likely to be retired prematurely, the effects of increased cross-border supply chain costs may be felt much more quickly. (But this is only speculation since, as I noted earlier, we have little information on the costs and benefits of cross-border supply chains.)

A number of other trends raise questions about the future of cross-border integration in the automotive industry. These include:

- The removal of protection for Canada's share of automotive production as defined under the Auto Pact.
- Modularlization of automotive production, whereby the role of large tier 1 parts suppliers is enhanced.
- The growing importance of the "new domestic" producers, with their preference for geographical proximity of suppliers.
- The idea of "supplier parks" such as Ford's Chicago Manufacturing Campus, based on co-location of assembly and suppliers in a single property.
- The possibility of "contract manufacturing" of vehicles by tier one suppliers or by other OEMs with excess capacity.
- Divergence in collective labour agreements in the US and Canada.
- The increasing role of offshore sourcing of parts from China, India and other developing countries.

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