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Maximizing throughput:

**Strategy and policy for transportation supply chains —
building on the Minister of Transport's Supply Chain Task Force report**

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During the Covid-19 pandemic that overtook most countries including Canada starting in March 2020, human behaviour changed radically and people’s spending patterns shifted from purchasing services to purchasing consumer goods. The sudden, massive change in the nature and volume of demand sent a shock wave into supply chains, many of them originating in Asia, that overloaded factories, warehouses, ports, marine shipping, intermodal containers, drayage trucking, customs clearance, railways, intermodal terminals, local delivery trucking, and retail stores. It even depleted the supply of semiconductor chips needed for all manner of consumer goods including motor vehicles.

The shock wave caused havoc throughout supply chains. It has been a textbook case of “variation”—variation of any kind—causing constraints in the system to manifest themselves. Like kinks in a garden hose, constraints limit the flow-rate of whatever is being moved down the pipeline. When that happens, throughput always goes down, delivery times always get stretched out, levels of goods-in-transit always climb, and quality of production and transport always decrease. These negative impacts are tied to each other. They come as a package.

It wasn’t just *consumer* goods that suffered. The bunching-up of goods-in-transit—in effect, congestion—that occurred throughout the system of production, storage, and transportation clogged the flow of agricultural products and industrial goods as well, including Canadian exports like grain.

Much of the rhetoric has been about a need to increase the efficiency of transportation supply chains. That misses the point. Efficiency is a subordinate index. You can get high efficiency with low throughput, and most of the problems mentioned above will still be there. However, if we achieve high throughput, better efficiency will follow automatically. Then the performance of Canada’s transportation supply chains will return to pre-pandemic levels. And if tackled the right way, even *better* than pre-pandemic levels.

This report speaks to a recommendation in the report by the Minister’s National Supply Chain Task Force 2022 to increase the Canadian Transportation Agency’s own-motion powers for investigating actual or potential service failures by railways. Implementing that recommendation would mean changing the *Canada Transportation Act*, from which the Agency’s remit and its authorities ensue. We also go beyond own-motion powers and speak to the broader level-of-service (“LOS”) requirements in the *Act*, requirements that we see as detrimental to supply chain performance, and which could be revised in fairly straightforward ways to provide substantial benefit to Canada.

We concentrate on railway-based supply chains because they are intimately tied up in national supply chains and because, by virtue of the fixed location of their trackage, railways are far less flexible than trucking in terms of adapting to constraints and bottlenecks that occur upstream or downstream of themselves. Trucks usually can find alternate routes and add extra capacity where needed on relatively short notice, but railways generally cannot.

There are **four vital areas** on which Transport Canada should concentrate. We describe them in the following pages, and **summarize them in “Concluding thoughts” on page 8.**

Primary issue

Transportation supply chains are in the middle of what is essentially a **throughput problem**: not enough goods are getting to market, fast enough. Fixing this needs to be the main concept behind a revised policy framework.

We are facing a classic production problem. The manufacturing sector has already solved this type of problem years ago.¹ It is often called lean production.² There is a field of knowledge that explains how to do it: industrial engineering / systems optimization / systems dynamics.³

When viewed through a lens of *throughput*, other issues fall into their proper place. For example:

- The Task Force was advised that government should re-balance what shippers say is a market power difference between themselves and railways. But following that recommendation would have essentially no impact on throughput. It may or may not be desirable for other reasons, but when it comes to solving the primary problem facing transportation supply chains, it is a red herring.
- Investing in infrastructure is often perceived as a solution for increased transportation supply chain fluidity. But when viewed through a lens of throughput, it is among the last things to pay attention to. Far more important are (1) improving operational processes,⁴ and (2) supporting those operational processes with the proper data.⁵

Problem / opportunity #1: Make throughput the primary goal

This might seem like a minor point but it is not. It is probably the most important element of a revised policy framework to maximize throughput, which is synonymous with increased GDP, national wealth, and international competitiveness. Canada has a longstanding problem in the way the *Canada Transportation Act* is written. Railway-based throughput is subordinated to level-of-service (“LOS”)

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1. Some of the leading lights in manufacturing process optimization made their greatest contributions in the decades after WW II. W. Edwards Deming, Taiichi Ohno, Jay Forrester, and Eliyahu Goldratt are prominent examples. Ohno, an industrial engineer, was creator of the renowned Toyota Production System. For notes on his “seven wastes”, please see the Annex.
 2. Critics sometimes argue that “lean” is a fundamental flaw in the theory of supply chains, one that makes its practitioners cut too close to the bone. That is a misconception. The amount of leanness is adaptable to the amount of variation expected. The current supply chain problems lie with the expectation, not the theory.
 3. For a succinct introduction, see https://en.wikipedia.org/wiki/Industrial_engineering
 4. You can get far more throughput out of existing infrastructure than it is currently delivering, by improving the operational processes that control the flow of goods. Depending on how good or dysfunctional the existing processes are, the improvement can be very large indeed.
 5. Not just any data, but deterministic data that allows managers and overseers of the supply chain system to calculate key performance indicators, supported by algorithms or data analytics that reveal the state (i.e., health) of the system and that point the system’s managers directly toward the cause of a problem.

requirements. That shows up in §116. The *Act* is pursuing the wrong goal. It obliges railways to make many “local optima” by instructing the Agency to adjudicate complaints and issue orders on a one-by-one basis. That is a problem because the end result of making many local optima is certainly not the optimum for the total system.

The Minister’s Supply Chain Task Force frequently cites the fragmentation of supply chains in Canada as a serious problem. Indeed it is. Unfortunately, the *Act* encourages that fragmentation because the policy framework on which it (the *Act*) is based requires the regulator to support and increase fragmentation by adjudicating each LOS complaint in isolation⁶. Fragmentation always reduces supply chain throughput.

Things are not helped by the aspirational statement of National Transportation Policy in §5 of the *Act*, because it names eight “priorities” for the transportation system. Supply chain throughput is not one of them. No primary goal is mentioned. That exacerbates the problem arising from §116 granting higher priority to LOS than it does to supply chain throughput. And again, maximum throughput is synonymous with increased GDP, national wealth, and international competitiveness.

Seen from a national perspective, the primary goal for rail-based supply chains should be to maximize throughput. That would score a direct hit on the main problem with transportation supply chains today, as well as into the future. It does not mean abandoning railways’ responsibility to provide good service to shippers.

Policy options

Option 1. (Visionary) Change the premise of what government regulates. It currently regulates railways on the basis of LOS. Consider regulating what the U.S. Surface Transportation Board does: abuse by railways of their market power. Making this change will effectively eliminate LOS as a drag on throughput. Many shippers can be expected to object strenuously in the short term but everyone would benefit from higher throughput in the long term. If the Minister seeks to make a transformational improvement to transportation of the same lasting impact that transport ministers Pickersgill, Mazankowski, and Young did in 1967, 1989, and 1995, respectively, this is the preferred option.

Option 2. (Substantial) Change the emphasis in the *Act* by rewording the individual provisions in §116 (1.2). As it stands, §113 requires that railways first and foremost give suitable and adequate service to each shipper.⁷ Considerations of throughput are subordinate and oblique.⁸ To effect significant improvement for supply chains, make throughput of the system the primary consideration in §116, and make LOS to individual shippers secondary. Oblige the Agency to respect that priority.

Option 3. (Incremental) Add a short statement to §116 of the *Act* saying that the primary goal in rail freight transportation is to maximize supply chain throughput. This would provide guidance to participants in supply chains and to the Agency when interpreting the meaning of the *Act*. Make changes—they would not have to be large—to individual provisions in §116 (1.2) that remove any contradiction with the short statement. This option would not have the same impact as overtly elevating throughput relative to LOS, as in the “substantial” option above, but it would be helpful nevertheless.

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6. Compounding the problem, individual arbitrators in any given case are isolated from decisions made by other arbitrators, even if their decisions affect each other.
 7. §116 (1.2) says the Agency “*shall* determine that a [railway] company is fulfilling its service obligations if it is satisfied that the [railway] company *provides the highest level of service . . .*” (emphasis added).
 8. See §116 (1.2) (e) and §116 (1.2) (g) of the *Act*. They are silent on the weight these considerations are to be given.

With any of these options, the nine LOS provisions in §116 (1.2) of the *Act* should be revised to correspond better with what railways should be held accountable for. They should be expressed in a way that represents a reasonable minimum expectation—in effect, a floor—not an aspirational ceiling (“highest level of service”) as is currently the case. The provisions about reasonableness in the Supreme Court’s Patchett decision (1959) should be included verbatim.

Problem / opportunity #2: Minimize variation in transportation supply chains

Variation is Public Enemy #1 when it comes to maximizing throughput. Optimization theory holds that variation causes bottlenecks to manifest themselves, which in turn suppresses the rate of throughput. The greater the variation, the more the suppressing effect. Unfortunately, variation occurs all the time. Some forms of variation are not within the control of anyone in Canada, for example the weather and the arrival time of vessels at port. But many others are.

Railways try to minimize variation, but some, perhaps many, other participants in supply chains do not. The *Act* is silent on the subject, which is tantamount to saying that no one in transportation supply chains is responsible for minimizing variation. Here are four examples:

- a shipper can send the railway a surge of traffic that causes a great deal of variation which could have been avoided by spreading out the traffic over a period of time, or by the shipper managing its own operations differently.
- a shipper can choose to send its traffic to a terminal that does not have enough unloading capacity at the time when the railcars arrive, rather than to a terminal that does. This causes variation in delivery rates. Railcars accumulate in nearby yards. That causes congestion, which reduces the flow of inbound traffic and creates a backup to the point of origin as well as downstream to the point of consumption.
- some terminals at ports choose not to operate 24/7/365. That causes variation in daily and weekly flow-rates of cargo. The effects reverberate upstream and downstream, reducing throughput for the entire supply chain.
- grain terminals suspend the loading of ships in rainy weather at Vancouver because of as-yet-unresolved safety concerns for crews near the hatches. U.S. terminals have solved the problem. This on-again-off-again loading is a form of variation. It reduces grain throughput and causes traffic to back up to inland terminals and even Prairie farms.

In cases like these, transportation policy is effectively allowing the marketplace to behave as marketplaces do. That is a fundamental principle on which previous major improvements to the *Act* were based. But sometimes the behavior of a single participant creates negative externalities (i.e., costs) for other participants in the same system. This is one of those cases. Unrestricted variation always causes a significant reduction of overall throughput. It would be highly beneficial to supply chains if there were an incentive for participants to do as much as they reasonably can to minimize variation, or a disincentive for choosing not to do so.

Policy options

Option 1. (Substantial) Instruct the Agency to look unfavourably on any shipper’s complaint if it (the shipper) cannot demonstrate it did all it reasonably could to minimize variation.

Option 2. (Incremental) Have the *Act* state that every participant in supply chains is expected to minimize variation. That would not have the same impact as the “substantial” option above, but it would help somewhat.

Problem / opportunity #3:

Ability of the CTA to analyze system performance

There can be no doubt that Canada needs a regulatory instrument like the Canadian Transportation Agency to keep the shipper / carrier marketplace operating with a minimum of abuse, and to serve as an arbitrator of disputes where the subject matter is too technical for civil courts to process effectively.

Freight rail transportation is both a public service and a private business. Balancing the two is not easy. In a “lean production” world—which is where we are now, and probably will be for the foreseeable future—disputes between shippers and carriers are primarily about *service*.

Before lean production arrived, disputes in the railway industry were largely over price. Price is a relatively “bounded” subject for the Agency or its independent arbitrators because the effects of railway pricing for a given shipper have little impact on any other shipper. That is not the case when it comes to adjudicating service. In this new world, things are far more complex because the adding or scheduling of a shipper’s traffic on a rail network has direct and potentially large impacts on the network’s ability to serve other shippers. A mistake can cause congestion and even gridlock. Congestion is an important disruptor of flow because it reduces throughput and it can take a long time to recover.

To do a proper job of adjudicating service disputes, the regulator must understand how systems work—and especially how they respond to any kind of change, including change arising from its own regulatory decisions. In other words, the Agency needs expertise in industrial engineering / systems dynamics / system optimization. It is not clear to us that it has anywhere near enough. On the contrary, evidence suggests it is short on that particular type of expertise. An independent review of the Agency’s own-motion investigation into rail service problems at the Port of Vancouver in late 2018 and early 2019⁹ revealed some important shortfalls in the processes and the knowledge the Agency brought to bear, difficulties that almost certainly would not have arisen if the expertise noted above were strongly represented in its workforce and its practices.

This presents a problem and an opportunity. To equip the Agency for the role it needs to play in regulating service disputes in a “lean production”, supply-chain-driven world, a significant increase in its expertise in industrial engineering / systems dynamics / system optimization is almost essential. That will not be easy, inexpensive, or quick. We estimate it would take at least five years of committed effort to reach a level of expertise needed to adjudicate problems that involve system performance. But it needs to be done.

In the meantime, conferring additional powers on the Agency through legislation seems highly unwise. The Minister’s Task Force on Supply Chains recommends additional “own motion” powers, but it does not mention the increase in certain types of expertise needed to do a proper job of it. Without such an increase, serious problems like those that manifested themselves in the own-motion investigation of 2018-2019, as detailed in the report mentioned above, will surely recur.

9. “Insufficient Capacity: a retrospective on the Canadian Transportation Agency’s 2018-2019 freight rail investigation, and its implications for freight rail regulation in Canada”. Roberts, Cameron. 30 September 2022. Carleton University, School of Public Policy and Administration. <https://carleton.ca/tpic/wp-content/uploads/Insufficient-Capacity-Report-Final-2022-09-30.pdf>

The Task Force also recommends removing a provision in the *Act* that requires the Agency to obtain the Minister's approval before proceeding with an own-motion investigation. For the same reason mentioned above, we think this would be very unwise. Besides, the Minister is empowered to attach conditions to any approval he or she may grant. That is an excellent platform for the Minister to require that the Agency meet certain standards in its investigation. A shortfall in standards was a significant feature of the Agency's flawed own-motion investigation in 2018-2019 at Vancouver, as mentioned above.

It is not just own-motion powers that matter. The Task Force also recommended conferring additional authority on the Agency in other types of investigation, again without mentioning the increase in expertise needed to do a proper job of it. That too seems highly unwise.

We strongly recommend those additional powers *not* be conferred until the additional expertise has been built within the Agency, or in some other organization with high technical capability; and not until that capability can be objectively shown as being sufficient to guide decisions that affect complex systems like a freight rail network.¹⁰

We think there needs to be an independent source of oversight of the state and rate of developing that capability. As things stand, the Agency is almost certainly short of where it needs to be, and there is no outwardly-visible sign of intent or progress in building the technical expertise mentioned above.

Some readers may be inclined to say that the Federal Court of Appeal and the Supreme Court provide such oversight. Unfortunately they do not. Under the current framework, the only aspect of Agency decisions those courts will consider is whether the Agency erred in law. They (the courts) afford judicial deference to the Agency for its understanding of the facts of a case and the appropriateness of its analyses, which means there is no oversight of the contents of the Agency's analyses or the level of expertise it brings to bear on understanding the performance and behaviour of complex systems like a rail network. In other words, the courts give judicial deference to the Agency for a level of expertise it very likely does not have.

Policy options

Option 1. (Substantial) Require the Agency to submit a public report annually to the Minister on its progress towards building a competent system-level analysis capability within timelines set by the *Act* or by the Minister. Set a clear goal about the competence to be achieved and the means of gauging it. Specifics in that regard should be set out in a Ministerial letter or MOU.

Option 2. (Incremental). Maintain the current requirement that the Agency seek approval from the Minister to conduct any own-motion investigation. Include a provision that if the Minister withholds such approval, he or she may establish a panel of technical experts to conduct an investigation into the same matter and make recommendations that the Minister may instruct the Agency to enforce.

Problem / opportunity #4

The Agency adjudicates only one carrier and one shipper at a time

The Agency has considerable latitude in making its adjudications, but nevertheless the law instructs it to do certain things and its *marge de manoeuvre* beyond that is, in principle, zero. §116 (1) of the *Act* requires the Agency to investigate every shipper's complaint against a railway, and §116 (1.2) requires it to take into account nine considerations involving the railway and the shipper who filed the complaint.

10. The U.S. Surface Transportation Board would be a useful benchmark in that regard.

There is no requirement for the Agency to consider the interests, or the actions, of any participant in supply chains except those two. The *Act's* silence about other participants is seriously dysfunctional to supply chain performance and throughput. That is because perturbations, variation, constraints, and interruptions in the flow of goods can, and usually do, occur upstream or downstream of the railway and the shipper. The late arrival of vessels in port is an example. So is the large-scale shift of demand to consumer goods that overloaded marine and port capacity. So is large-scale fluctuation in the tendering of traffic by a whole industry, like grain, that can bring the railway close to congestion and force it to ration traffic to other shippers. The list is almost endless. All the Agency is allowed or expected to do is consider the other participants as part of the background context when it comes to assessing reasonableness of the shipper's traffic and the railway's carriage of it. Unfortunately, that leaves all manner of vital supply-chain issues ignored, and constrains the Agency to find (or not find) fault with the railway alone.

In fact, things are probably more dysfunctional than that. The *Act's* silence about other participants could be inferred as discouraging, or even preventing, the Agency from including them in its analyses.

Readers may point to §116 (1.2) (i) of the *Act* as giving the Agency authority to look at all manner of other participants in addition to the shipper and railway in question. But that paragraph is an oblique provision that arguably does little if anything to empower—and it certainly does not instruct—the Agency to investigate transportation supply chains from end-to-end. Yet that purview is essential to understanding the performance of the supply chain as a connected system.

Even if the Agency were to develop its own system-level analysis expertise, as the “Problem / Opportunity” section above argues it should, we think it is essential to expand the instructions it is given in the *Act* so that it analyzes supply chains on a system-wide basis, and not one shipper and one railway in isolation of everything else.

If not, the Agency will be limited to searching for, and attempting to find, fault on the part of a single participant—almost always the railway¹¹—in a system of dependent events where a shortfall in throughput and service can occur anywhere upstream or downstream. Worse, the shortfall may be caused by no one party's fault, but instead by the architecture of the transportation supply chain in combination with naturally-occurring variation and random events. In other words, by confining the Agency to examining the interaction of two parties alone, the *Act* is pointing the regulator towards serial misunderstanding the causes of, and the potential remedies for, degraded supply chain throughput.

Policy options

Option 1. (Visionary) Modify §116 (1.2) of the *Act* to require that the Agency take into account upstream and downstream performers in supply chains when examining the causes that gave rise to a

11. There is a corollary problem. The *Act* instructs the Agency to determine whether the railway in question failed to live up to its LOS obligations; and if it did not, the Agency may order a remedy. But the *Act* says nothing about ordering a remedy against a shipper if *it* failed to live up to *its* obligations. And so, despite §116 (1.2) (b) and §116 (1.2) (d) saying the Agency should take into account the shipper's actions and expectations, that is only for determining whether to let the *railway* off the regulatory hook without a sanction. It provides no hook for the shipper. The only downside shippers face for having filed an unsupported complaint is to have the complaint denied. Yet the shipper's own actions—for example by sending traffic to a terminal that does not have enough unloading capacity at the time the railcars arrive, rather than to a terminal that does; or by making “phantom orders” for cars in excess of what it actually needs but the railway is legally obliged to provide anyway—can be a main contributor to reducing throughput.

complaint. Include those performers' contribution to variation. Include the possibility of ordering a remedy against a shipper that filed the complaint, and against any other performer in the supply chain that can be found to have degraded the supply chain's throughput. Specifically include the possibility of the Agency reaching a no-fault conclusion if the problem arose from the architecture of the supply chain system in combination with naturally-occurring variation and random events.

Option 2. (Substantial) Modify §116 (1.2) of the *Act* to require that the Agency include upstream and downstream performers in supply chains when examining the causes giving rise to a complaint. Include those performers' contribution to variation. This would not have the same impact as the "visionary" option above, but it would help considerably.

Option 3. (Incremental) Have the *Act* state that every participant in supply chains is expected to do as much as it reasonably can to maximize throughput and be fully transparent with other performers with respect to its decisions, intentions, and performance-related data.

With any of these three policy options, it will be necessary in some cases to allow more than 90 days to do a proper analysis. A precedent along similar lines already exists in the *Act*.¹²

Concluding thoughts

To make serious progress in remediating the degraded performance of rail-based transportation supply chains, and to equip them for meeting Canada's future needs, the regulatory policy framework needs to be updated in four main ways:

1. Make throughput the primary goal. Be explicit about it.
2. Add measures that expect or require all participants in supply chains to take all reasonable steps to minimize variation within their control.
3. Increase the Agency's ability to analyze system performance, and do not increase its powers until that increase can be shown to have reached a satisfactory level by an expert independent body. Maintain the requirement for the Agency to obtain Ministerial approval of an own-motion investigation, and include a provision that if the Minister withholds approval, he or she may establish a panel of technical experts to conduct an investigation into the same matter and make recommendations to the Minister that he or she may instruct the Agency to enforce.
4. Expand the instructions given to the Agency to take into account all participants in rail-based supply chains, not just the shipper and railway in isolation. Give the Agency more time to conduct its investigations when a case is complex like this, and the flexibility to extend the deadline if the case is particularly complex.

Further consideration needs to be given to the question of data. The Minister's Supply Chain Task Force frequently cites the need for greater transparency that shared data enables. That is necessary but not sufficient. Data without theory is useless. There needs to be a data architecture accompanied by performance indicators that can be shown to score a direct hit on throughput. That may sound easy but it is not. To the best of our knowledge, Transport Canada's Economic Analysis Directorate has developed, and has proven expertise in applying, the most advanced indicators of fluidity (read, throughput) of a national scope in Canada. Moreover, it has established a steady input stream of deterministic data needed to support those indicators. The Directorate's capabilities and assets should be at the core of further developments in this regard.

12. See §53.81 in Part II of the *Act*, on Air Transportation.

About the author

John Coleman is a Senior Fellow at Carleton University's School of Public Policy and Administration, where he teaches and does research in transportation policy. In 2011 he retired from the National Research Council of Canada, where he held a number of senior positions including Vice President of Engineering and Director General of Surface Transportation Technology. He has made contributions to the *Canada Transportation Act* Review Panel in 2015 and the *Railway Safety Act* Review in 2017, and has served on Transport Canada's Railway Research Advisory Board since 1993. He holds a Bachelor of Engineering degree from Carleton University and an MBA from the University of Western Ontario.

Annex

Taiichi Ohno's "Seven Wastes"

Transportation supply chains are in the middle of what is essentially a throughput problem: not enough goods are getting to market, fast enough. This is a classic production problem. The manufacturing sector has already solved it. It is often called lean manufacturing, or just-in-time production.

The theoretical foundations were taken to what is probably their fullest expression to date by Elyiahu Goldratt, a physicist, who expressed it as the "Theory of Constraints". But the most prominent application is almost certainly the Toyota Production System, first reduced to practice by the founder of Toyota Motor Corporation, Sakichi Toyoda, along with his executive colleague at the firm, Taiichi Ohno. Ohno in particular is a luminary in the global pantheon of manufacturing optimization. Both Toyoda and Ohno were industrial engineers.

Ohno also developed and applied leading principles in the way organizations identify and deal with waste. His model of "Seven Wastes" has become a core element in many treatments of optimization. They are:

1. Delay, waiting, or time spent in a queue with no value being added
2. Producing more than you need
3. Over-processing or undertaking non-value added activity
4. Transportation
5. Unnecessary movement or motion
6. Inventory
7. Defects in the product