Policy Experiments in Rail: Assessing Alternative Grain Transportation Regulatory Policies in the Laboratory

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Introduction

- Recent developments, grain transportation in Canada
- Brief review of experimental economics and transportation policy
- Model description
- Preliminary Findings
- Next steps
- Conclusions

Research objectives

- Develop a viable economic experiment that mirrors the current Western Canadian grain handling supply chain
- What incentives does current policy give to participants
- Assess how experimental participants perform compared to reality
- Explain these outcomes in the context of behavioral/regulatory economics

Current policy situation

- Considerable recent controversy in Canadian grain transportation - strong push for changes from both shippers and carriers
- May 16, 2017: Bill C-49 (amendments to the Canada Transportation Act) is currently before parliament for review
- C-49 recommends maintenance of MRE for grain movement (with slight modifications to the formula), along with a significant expansion of (long-haul) interswitching (i.e. reciprocal switching) – the latter will be a future extension to this experimental environment
- Surprising to many since both regulations on grain movement were maintained moving forward
- C-49 also recommends looser restrictions on foreign ownership for CN Rail
- Early impressions are that C-49 is very favorable to shippers

Basis for the experiment - Canadian rail rate regulation (on grain)

- From 2001 crop year, freight rates for export-bound grain in Western Canada have been regulated by the maximum revenue entitlement policy (effectively an average revenue cap) - applies to so-called "major" grains - wheat, barley, canola, oats, rye, flax
- If reported grain revenues > MRE in a given year, railways are penalized
- Took some time for participants to get used to the MRE (6-8 years for the railways, by some estimates) – now railways typically exceed their MRE by about 1% of their total grain revenue – indicating they have learned how to optimize profits under MRE
- Farmers remain generally positive about MRE since it limits overall grain rates – these have remained relatively stable over time
- Railways slightly less positive – recent concerns about MRE effects on rail investment – 2015 CTA commissioned report advised getting rid of rail regulations

Canadian MRE formula - (average) revenue cap on grain

= [A/B + ((C-D) x $0.022)] x E x F;

where

A is the railway's revenue for the movement of grain in the base year

B is the number of tonnes of grain moved by the railway in the base year

C is the average length of haul for grain movement in that crop year as determined by the CTA

D is the average length of haul for the movement of grain in the base year

E is the number of tonnes of grain moved by the railway in the crop year as determined by the CTA

F is the volume-related composite price index as determined by the CTA.

Points about the MRE

Was initially difficult for railways to optimize profits under MRE

General heuristic - in effect, railways now try to just hit or exceed their computed MRE, otherwise revenue is "left on the table"

Note that the MRE formula is sensitive to certain parameter changes, including

the (composite) price index

the average length of haul for grain

By way of example (all else equal):

1) if price index grows by 5%, MRE cap increases by approx. $20 million

2) If grain hauls get longer (i.e. associated with lower railway costs), the amount of the allowable revenue under the cap can remain the same even with decreased volumes moved

Experimental economics as a sub-field - Nobel prizes

Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel, 2002

Vernon Smith (Chapman) - "for the use of laboratory experiments as a tool in empirical economic analysis, in particular, for the study of different market mechanisms" - **founder of experimental economics**

Daniel Kahneman (Princeton) - founder of behavioral economics.

Why use experiments

Plott (1982, p. 1509): "The art of posing questions rests on an ability to make the study of simple special cases relevant to an understanding of the complex. General theories and models by definition apply to all special cases. Therefore, general theories and models should be expected to work in the special cases of laboratory markets. As models fail to capture what is observed in the special cases, they can be modified or rejected in light of experience. The relevance of experimental methods is thereby established."

Plott (1982, p. 1482): "While laboratory processes are simple in comparison to naturally occurring processes, they are real processes in the sense that real people participate for real and substantial profits and follow real rules in doing so. It is precisely because they are real that they are interesting."

Components of an economic experiment

Environment:

- Preferences, technologies, initial endowment
- implemented by appropriate monetary incentives

Institution (Rules of the game)

- Feasible actions
- Sequence of actions
- Information conditions

Lab experiments often (implicitly or explicitly) define some kind of game situation => game theory and experimental economics are strongly linked

- **Framing** of instructions

Research benefits often associated with economic experiments

- Subjects are randomly assigned to treatment conditions – thus no selection bias
- Known by researcher which variables are exogenous and which are endogenous – allowing causal inferences
- Experimenter can make *ceteris paribus* changes in the exogenous variables – allowing for isolation of cause
- Replicability – provides a basis for statistical tests – or critics can run their own experiments
- *External validity* (strength of generalizability) and *ecological validity* (real world accuracy) – as we shall see, the latter could be a criticism of this work, but this is also something of a "wind-tunnel" effort

Experiments and Transport Policy

- To our knowledge, only a limited number of prior related efforts have made use of economic experimental methods to shed light on transportation policies, including rail
- Of interest is that one early published work in experimental economics was that of Hong and Plott (1982), which sought to test pricing systems for US inland water transportation
- Another important work was that of Cox et al. (2002), who conducted experiments to evaluate open access rail regimes for the Netherlands
- Several more logistically based experiments were also conducted in relation to the Swedish rail network, including the use of auctions for track scheduling (e.g. Nilsson, 1999)
- More recent work in the OR literature has focused on experimental supply chain design

The MRE experiment

- Continuing controversy over the MRE, combined with the lack of research about its consequences led to this research
- (Average) revenue cap literature (including Cowan, 1997) asserts that under a variety of circumstances, average revenue caps (on monopolist) are inferior to other types of price or rate regulation
- Background footwork indicates that the MRE formula was developed by the Canadian Transportation Agency without much (if any) consultation
- As written, the formula should encourage the railway to serve longer average hauls – with economies of scale, this should generate greater profits, all else equal
- In effect while the MRE formula focuses on revenues, rail costs are also important to growing profits – we hope to shed light on this in an experimental framework

The MRE Experiment

- We sought to build an economic experiment to replicate the MRE operating environment, ultimately helping us better understand participant behavior
- To simplify the experimental environment, we assume a single railway serves four grain shippers – shippers profit by moving their grain to a single (port) destination
- Railway offers each grain shipper/elevator a freight rate (per unit volume), cognizant that they will be penalized if they exceed their calculated MRE
- Each grain shipper has one nearer and one farther away grain elevator, and two of the shippers are relatively large (more grain to move), while two are relatively smaller
- Grain shippers and the railway are profit maximizers, and we also assume shippers can costlessly move as much grain as they want between their elevators

MRE hypotheses

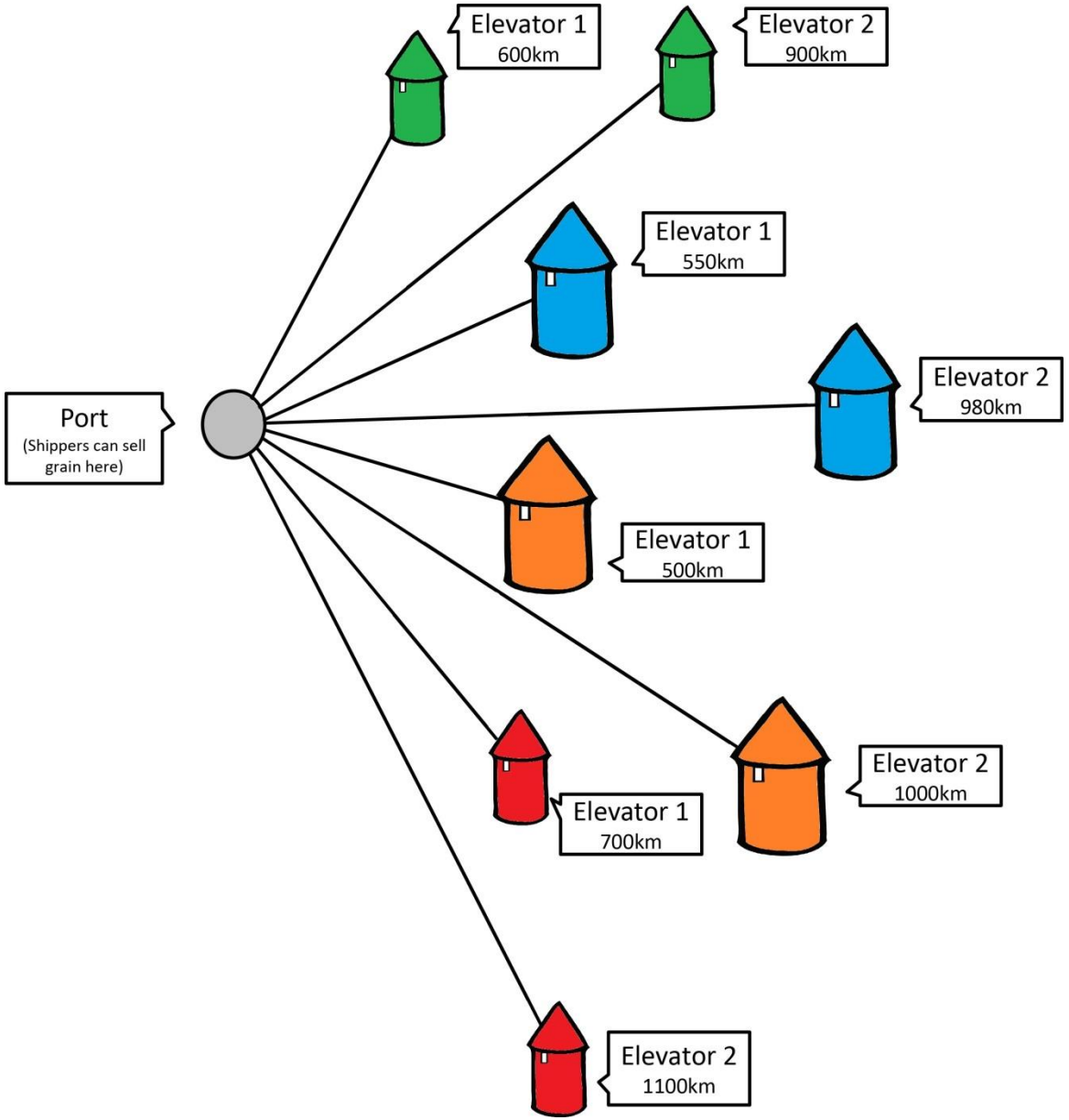
- Assert that the MRE policy has certain flaws, and hope to shed light on this in an experimental setting
- Based on this, we formulated two hypotheses relevant to this experiment;

1) Superior railway knowledge of MRE regime - railway player should be able "learn" how to operate under MRE (i.e. incur effectively a zero MRE penalty) after about 6-8 periods (as in reality). This would reflect on the ability of the railway(s) to gain control of this market to their advantage, even with regulation

2) (Unintended) incentives created by the MRE formula - the best railway MRE equilibrium should be associated with declining service offered to the nearer elevators – but in turn, our grain shippers can adjust to these signals by moving grain (subject to capacity constraints) to their farther elevators

MRE experiment session details

- Experiment was run in the Experimental Decision Laboratory at the University of Saskatchewan
- Five participants per session recruited by the EDL, randomly assigned to roles
- Shippers were paid according to relative performance (i.e. profits), while the railway player was paid relative to pilot participant performance
- Funds needed to conduct the experiment were provided by the provincial Ministry of Highways and Infrastructure, and SCETI (U. of Saskatchewan)
- Experiment was coded using the Z-Tree software
- Pilot sessions were used to check for clarity and timely completion
- To date, we have run 12 experimental sessions, plus 5 pilot sessions


Elevator 1
600km
Elevator 2
900km
Elevator 1
550km
Elevator 2
980km
Port
(Shippers can sell grain here)
Elevator 1
500km
Elevator 2
1000km
Elevator 1
700km
Elevator 2
1100km

Suggest Rates:

The following tool assumes that all rates are accepted; however, that outcome will depend on the shipper players' responses.

To reject an offer, please enter a value of "0" into the rate field below. If you reject an offer, you will not purchase any grain from that elevator or travel to its location.

Enter your rates into the fields below:

Shipper 1: Elevator 1
Grain available (tonnes): **[tonnes]**
Distance from port (km): **[distance]**

Rate/tonne ($): [ ]
Revenue ($): **[S1E1Revenue]**
Costs ($): **[S1E1Costs]**
Profit ($): **[S1E1Profit]**

Shipper 1: Elevator 2
Grain available (tonnes):**[tonnes]**
Distance from port (km): **[distance]**

Rate/tonne($): [ ]
Revenue ($): **[S1E2Revenue]**
Costs ($): **[S1E2Costs]**
Profit ($): **[S1E2Profit]**

Shipper 2: Elevator 1
Grain available (tonnes): **[tonnes]**
Distance from port (km): **[distance]**

Rate/tonne ($): [ ]
Revenue ($): **[S2E1Revenue]**
Costs ($): **[S2E1Costs]**
Profit ($): **[S2E1Profit]**

Shipper 2: Elevator 2
Grain available (tonnes): **[tonnes]**
Distance from port (km): **[distance]**

Rate/tonne ($): [ ]
Revenue ($): **[S2E2Revenue]**
Costs ($): **[S2E2Costs]**
Profit ($): **[S2E2Profit]**

Enter your rates into the fields below:

Shipper 3: Elevator 1
Grain available (tonnes): **[tonnes]**
Distance from port (km): **[distance]**

Rate/tonne ($): [ ]
Revenue ($): **[S3E1Revenue]**
Costs ($): **[S3E1Costs]**
Profit ($): **[S3E1Profit]**

Shipper 3: Elevator 2
Grain available (tonnes): **[tonnes]**
Distance from port (km): **[distance]**

Rate/tonne($): [ ]
Revenue ($): **[S3E2Revenue]**
Costs ($): **[S3E2Costs]**
Profit ($): **[S3E2Profit]**

Shipper 4: Elevator 1
Grain available (tonnes): **[tonnes]**
Distance from port (km): **[distance]**

Rate/tonne ($): [ ]
Revenue ($): **[S4E1Revenue]**
Costs ($): **[S4E1Costs]**
Profit ($): **[S4E1Profit]**

Shipper 4: Elevator 2
Grain available (tonnes): **[tonnes]**
Distance from port (km): **[distance]**

Rate/tonne ($): [ ]
Revenue ($): **[S4E2Revenue]**
Costs ($): **[S4E2Costs]**
Profit ($): **[S4E2Profit]**

Grain Transactions:
Total Revenue ($): **[Revenue]**
Total Costs ($): **[Costs]**
Total Profit ($): **[Profit]**

MRE (system revenue) outcomes:
MRE Target ($): **[MRE]**
Penalty Incurred ($): **[MREPenalty]**

Total Profit ($): [RailwayProfit]

Recalculate

Submit Offer

Respond to Rates:

Please decide whether you'd like to accept or reject each of the following rates.

If you accept a rate, your grain will be transported to port where it will sell for $[worldgrainprice]/tonne. If you reject an offer, your grain from that elevator will be lost.

Elevator 1:
Grain available (tonnes): **[GrainAllotted] + [Grain Moved]**
Maximum elevator capacity (tonnes): **[Capacity; see Globals]**
Distance from port (km): **[Distance; see Globals]**

Railway Rate ($/tonne): [Rate]
Elevator Cost if Accepted ($): [Cost]
Elevator Revenue if Accepted ($): [Revenue]
Elevator Profit if Accepted ($): [Profit]

Accept Rate | Reject Rate

Elevator 2:
Grain available (tonnes): **[GrainAllotted] + [Grain Moved]**
Maximum elevator capacity (tonnes): **[Capacity; see Globals]**
Distance from port (km): **[Distance; see Globals]**

Railway Rate ($/tonne): [Rate]
Elevator Cost if Accepted ($): [Cost]
Elevator Revenue if Accepted ($): [Revenue]
Elevator Profit if Accepted ($): [Profit]

Accept Rate | Reject Rate

Submit

(Very) initial findings

With respect to our hypotheses;

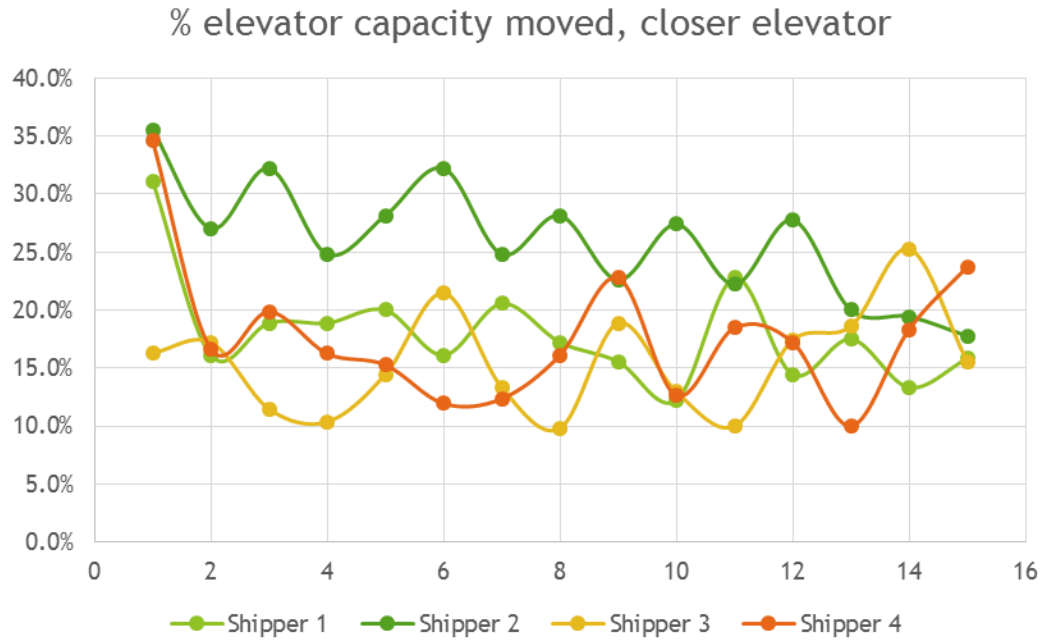
How difficult was it for the railway player to figure out how to optimize under MRE? In at least 5 sessions, the rail player never figured out how to "zero out" their MRE penalty

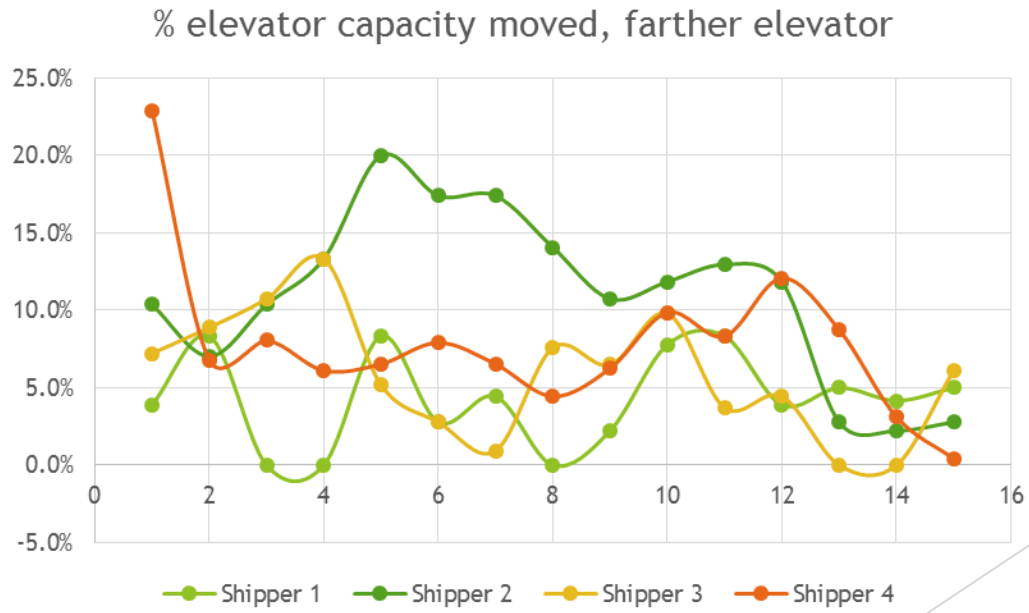
In addition, several sessions did not get to their planned conclusion (1.5 hours, 15 rounds) – many players spent a lot of time considering their decisions

In spite of this, we found that over all sessions on average, a rail player "learned" how to "zero out" their MRE penalty after about 8 rounds – similar to what actually occurred

However, even when "zeroing out" their MRE penalty, we did not observe the rail player focusing on optimizing profits by moving (mostly) grain located farther away from the destination

Example experimental data/output


% elevator capacity moved, closer elevator
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
0
2
4
6
8
10
12
14
16
Shipper 1
Shipper 2
Shipper 3
Shipper 4


% elevator capacity moved, farther elevator
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
-5.0%
0
2
4
6
8
10
12
14
16
Shipper 1
Shipper 2
Shipper 3
Shipper 4

Interpreting our data/findings

- While this initial attempt at building an appropriate experimental environment to study MRE helped support the overall concept, we did overlook some key aspects relevant to this issue
- Primarily the less than optimal MRE equilibrium found by the majority of railway players is entirely consistent with a (lazy) monopolist story – in lieu of other mechanisms or incentives, this generated consistent sub-optimal performance by rail players
- While we designed the game to be simplest possible representation of the situation, economically rational behavior by (in particular) rail participants exposed pieces of the experiment that need to be fixed moving forward

Next steps

To update our MRE experimental environment, we are considering two alternatives:

1) re-run sessions with two railway players – will require more paid players ($) to maintain consistency with what has already been done

2) re-run with a single railway, but build in a strong reminder that the railway player should focus their efforts in thinking about all of their decision variables (rates, locations) in order to best optimize their profits under MRE

Next, we will incorporate long-haul interswitching (i.e. reciprocal switching) into the experimental choice environment

The latter will permit better assessment of the relative merits of the two regulatory policies currently used for Canadian grain movement

This will also require a different virtual rail network as well as additional assumptions about rate negotiations between railways and shippers

Comments appreciated!
Thanks for your attention