Measuring Spatial and Temporal Market Structure in a Transportation Sector: For-hire Grain Trucking on the Alberta-Saskatchewan Border in Canada

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While the trucking industry across North America is now fully de-regulated, truck markets and movements are diverse enough that the level of competition in truck transportation almost certainly varies across space, commodities, and even time. Most studies of market power in transportation do not measure or account for spatial or temporal variation in levels of competition, and in addition, it is not clear to what degree such variation affects shippers. For example, there is anecdotal evidence that trucking of certain commodities in Western Canada is characterized by considerable market power that only manifests at certain times of the year. In this light, we examine both spatial aspects as well as the dynamics of rates in the medium-to-long-haul grain trucking sector in West-Central Alberta and East-Central Saskatchewan on the Canadian prairies. We attempt to characterize market power over both space and time within this regional trucking sector. This is done using a unique and detailed data set of trucking rates charged to shippers (farmers) for grain transportation to a common destination (Lloydminster, AB) from the numerous dispersed farms in the region.

To frame the unique spatial aspects of this issue, we begin by using geographic information systems (GIS) software to build freight rate contours for this trucking market through space. A set of suppositions regarding the possible shape of these contours as they relate to transportation market structure is also developed. Subsequently, a subset of the data is used to conduct an econometric estimation of short-run freight rate dynamics. These latter estimates reveal evidence of less than competitive transportation markets through time and space. Ultimately, we find that market power in trucking is not persistent within this market, but we do observe uncompetitive pricing behavior at certain times of the year. Given that trucking is deregulated, the latter finding is somewhat unexpected. We suspect that this set of conditions very likely affects trucking rates across more markets and regions than the one examined here.

INTRODUCTION

Inefficiencies in freight transportation can seriously affect industry competitiveness in today's globalized marketplace. Trucking is the most important freight mode with respect to value transported, both worldwide and within North America. Canada, with its vast geography and dispersed population, is more economically dependent upon efficient transportation systems, including trucking, than many other industrialized nations.

The trucking industry was first regulated in Canada in the 1940s as a result of pressure to protect the rail industry from this relatively new form of competition. Changes in the political and regulatory atmosphere led to substantial deregulation of the Canadian trucking industry throughout the 1980s (Woudsma et al. 1996). For example, in 2004, trucking represented just under one third of all transportation activity, employed 168,000 people, and contributed $14.8 billion to the economy (Statistics Canada 2004).

A survey of studies prepared at various times for the government of Saskatchewan reveals the importance of for-hire grain trucking, particularly in the agri-processing sector. In 1998, grain hauls by truck in the province were 17 times greater than in the 1970s on a tonne-kilometer basis (Ray Barton Associates 1998). Furthermore, hauls to processing facilities represented 1.4 billion tonne-kilometers of traffic, which is twice the level of traffic moving from farms to primary elevators. This study also found that grain deliveries peak in September and October, while reaching a low in April and May. Extended to all of Western Canada, grain movement to processors comprises about 6 billion tonne-kilometers (Trimac Consulting Services Ltd. 1999).

In Western Canada, agriculture is highly dependent on trucking for the movement of grain. Today, virtually all prairie grain is hauled via truck from the farmgate to the elevator or processor before entering the domestic or export supply chain. However, there have been surprisingly few published studies of market structure in Canadian trucking since deregulation. Furthermore, in spite of what appears to be a generally successful deregulation transition in Canadian trucking, there is continued anecdotal evidence from this sector that the level of trucking competition (as reflected in rates and service) varies noticeably across time and space. Evaluating the level and structure of competition in this sector is important because a less than competitive trucking industry ultimately leads to higher transportation costs for farmers, lowering profits in an industry that often operates on tight margins.

To address these issues, we collected trucking rate data in order to evaluate the dynamics of transportation market structure within a region where one of the primary industries is grain handling and transportation. A set of free-on-board grain trucking rate records for a canola processor located in Lloydminster, Alberta, was assembled, creating a panel of trucking rates charged to farmers for canola delivery to Lloydminster from the numerous origins (farms) in the region. To illustrate some of the unique aspects of the data and analysis, we begin by using geographic information systems (GIS) software to develop visible freight rate contours for this transportation market through space. We first discuss how these contours should look under varying market structures, and then examine in detail a set of the generated contour maps for indications of uncompetitive pricing. Subsequently, we use a detailed subset of the data to perform an econometric estimation of short-run rate dynamics in this trucking market, using impulse response analysis to assess evidence about the degree and scope of competition in this market. After interpreting and comparing the results of these approaches for the measurement of market power in transportation, a final section concludes.

LITERATURE REVIEW

Trucking in North America and Canada

Throughout much of the 20th century, the trucking industry in North America was regulated over prices, entry, and service. One common argument historically used in support of trucking regulation was that without government regulation, shippers located in rural areas would face higher rates and reduced service. An excellent review of the theory and history of trucking regulations in the United States and Canada can be found in Sloss (1970). Sloss also examines the historical differences between the trucking industry in the province of Alberta, which was generally not regulated, and that of the province of Saskatchewan, which was highly regulated up to the more recent era of deregulation.

With deregulation of the competing freight rail sector, the for-hire trucking sector was finally deregulated in both the U.S. and Canada through the 1980s (Viscusi et al. 1996; Bonsor 1995). In fact, there exists a considerable empirical literature about the U.S. experience with trucking deregulation. Most of this research indicates that deregulation was responsible for improved safety, greater efficiency, and lowered rates in the United States (Beilock and Freeman 1987; Carlton and Perloff 2005).

With respect to agricultural transportation, research on the grain elevator industry in the U.S. has evaluated the transportation characteristics of elevators in the Great Plains Region (Vachal and Tolliver 2001). Their survey of elevator managers examined their perceptions of grain trucking availability during harvest and non-harvest periods, as well as overall competition within the trucking industry. Rates were also surveyed for harvest and non-harvest periods, for distances of 50, 100, and 200 miles (80, 160, and 320 kilometers, respectively). They found that rates increased during harvest and decreased per loaded mile as distance increased. So for certain U.S. grain producing regions, evidence exists of seasonality in grain trucking rates.

One of the few Canadian-based studies that analyzed the effects of trucking deregulation was that of Woudsma and Kanaroglou (1996). Utilizing a mix of data from Statistics Canada, the authors analyzed a set of commodity groups and traffic corridors in the Ontario trucking market to determine if freight rates and service levels were consistent among urban and non-urban routes. They found no significant change in rate setting or service provision following deregulation.

Woudsma and Kanaroglou (1996) offered two possible interpretations for their unexpected results. The first possibility was that Canadian regulation was so ineffective that the removal of these regulations did not result in any significant changes to the business environment. The second interpretation was that the effects of deregulation within the trucking industry are inherently difficult to assess using aggregated data, since each corridor and commodity has its own unique characteristics. In fact, evidence for the latter was observed in the measured effects of deregulation in the Ontario provincial trucking market, where they found some commodities that were affected positively, some negatively, and some not at all by deregulation. Our research differs from their work because this analysis uses disaggregated rate data on just a single commodity moving from multiple origins to one destination. In addition, our rate data have been collected directly from the shipper and thus are less likely to contain any measurement bias.

Empirical Studies of Market Structure in Transportation Industries

De Vany and Walls (1996) proposed in their research that spatial arbitrage will affect goods prices only if there exists a flow of goods between the spatial markets. In unregulated markets, these opportunities will be exploited until delivered prices are equalized across markets and supranormal profit is dissipated – this is the classic law of one price. However, if there is no link between dispersed markets, or the flow between the two markets is restricted, then De Vany and Walls (1996) offer that goods prices will no longer be bound by these arbitrage limits and that opportunities for supranormal profit will persist.

In their work on the U.S. natural gas market, De Vany and Walls (1996) found that if their test of the law of one price failed, it occurred either because there were no physical links between markets allowing for product to flow, or there were capacity/flow constraints. Applying impulse response analysis with their time series model, they showed that when the law of one price holds, any variation in spot prices was dampened very quickly. In related work, De Vany and Walls (1999) again applied their empirical time series arbitrage framework, this time to deregulated electricity markets. The latter study also contains a discussion of seasonality issues in electricity markets. They conclude that during off-peak periods, price shocks can be absorbed in the local market, without much effect on other markets. However, during peak periods, the local market is less able to handle price shocks, and the effects ripple through the connecting markets.

Finally, Miljkovic (2001) examined pricing practices of U.S. railways by constructing an econometric model measuring freight rate convergence between regions. He tested the possibility that markets might exhibit partial adjustment (incomplete convergence) when some degree of market imperfection, such as a transportation monopoly, exists in that market. When freight rates were found to converge across regions, Miljkovic (2001) suggested that this occurred because many movements in his data set had access to competing forms of transportation, including trucking and river barges. In those cases when freight rates did not converge, he argued that this was likely due to an origin being served by a monopoly transportation provider (a railway). In the econometric portion of this research, we will use a similar specification as these authors, which will allow us to assess the speed at which freight rate shocks dissipate in various markets.

EVALUATING SPATIAL MARKET POWER AND DYNAMICS IN TRANSPORTATION

In the study of competitive markets, one of the traditional prerequisites for the existence of a perfectly competitive industry is that markets are somehow localized, with considerations of space usually subsumed in assumptions about equivalent delivered pricing, which in itself helps define the relevant market for analysis (Viscusi et al. 1996). With respect to transportation industries, it is clear that the element of space is a crucial factor in market structure. This reality renders it more difficult to identify and understand market structure in transportation markets in a traditional sense.

Since trucking route and pricing restrictions in Canada were lifted under deregulation, we would expect, *ceteris paribus*, that few constrained transportation flows should remain between these regional trucking markets. In effect, trucking firms will respond to price signals by moving excess service capacity to those markets where there are profits to be earned. This reallocation of resources in a competitive market should eventually generate a single transportation price for a comparable service (e.g., commodity, location, etc.). Alternatively, when transportation flows are constrained or restricted, such as when supply tightens during the peak-load grain movement period at harvest, we expect that transportation rates should rise due to a decrease in competitive pressure. However, in a deregulated market, trucking rates should eventually return to arbitrage-free equilibrium when these restrictions disappear. And during other times, if an abnormally high rate is observed for a particular origin/destination pairing over an extended period, it is highly likely to be an indication of reduced transportation competition in that market.

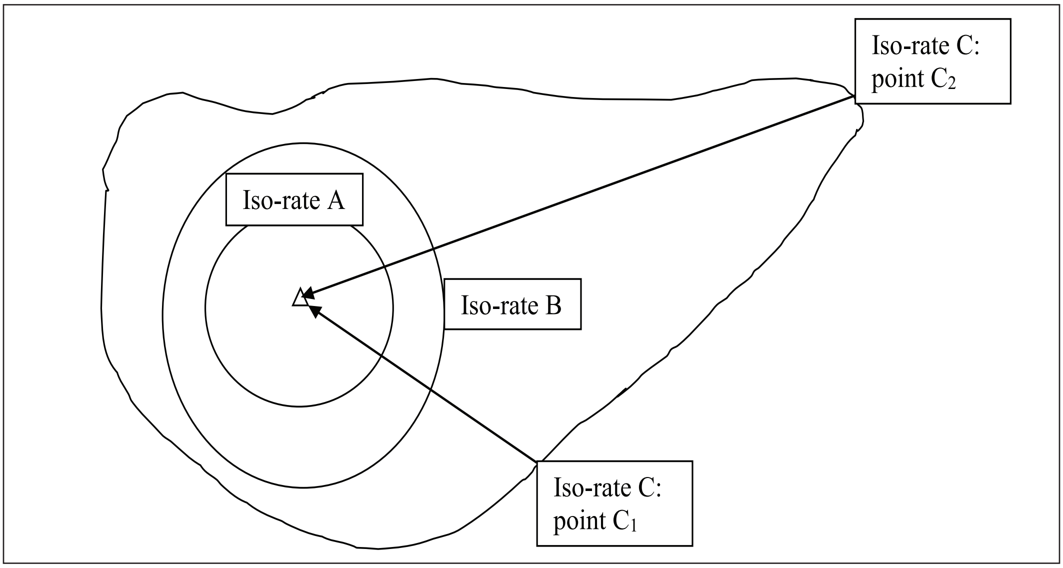
For these shippers and this market, considering off-peak periods such as the period before grain harvest, regional, and local trucking companies should be able to manage any transitory changes in transportation demand. In this case, rates may fluctuate briefly in certain markets, but these changes should not affect other origin/destination pairings to a significant degree. However, during peak movement periods, the local trucking market may not have enough capacity to meet increased demand. Therefore, not only will freight rates rise in the local market, but supply will likely be drawn in from other markets, reducing available supply, and increasing rates in those markets as well.

Rate Structures and Spatial Context - Iso-rate Contours[1]

To examine the nature and structure of competition in this regional trucking market, we begin by developing a spatial representation of the rate data. In effect, we generate a set of iso-rate, or "same-rate," contours for the trucking market using ArcInfo GIS software. As we shall see below, these contours can reveal interesting spatial patterns in the base freight rate data.[2] All iso-rates created for this study are centered on the single destination or delivery point for all freight traffic in the data set (the town of Lloydminster, Alberta).

With reference to the importance of space in transportation, the following interpretation is offered concerning the shape and relative smoothness of these transportation iso-rate contours (see Figure 1). In a competitive transportation market, transportation rates should depend mostly on cost. And since transportation cost is in most cases proportional to distance, it should be the case that competitive freight rates vary in proportion to changes in the distance between origin and destination in that transportation market. Therefore, all else being equal, freight rates set competitively should increase (decrease) equi-proportionately as distance increases (decreases) relative to a common origin or destination (i.e., the market). Regarding a mapping of rate contours, this means that a competitive transportation market should generate relatively smooth and symmetric iso-rate level curves with minimal distortions in the contour. Examples of this are shown with the hypothetical iso-rate contour representations A and B in Figure 1, each measured relative to the central origin/destination (represented by the small triangle in the figure).

Figure 1: Possible Iso-rate Shapes for Transportation



Allowing for the fact that the exact shape of iso-rates in a particular transportation market can also depend on specific geographic factors, such as the existence of impassable barriers (i.e. rivers and lakes) and the physical design of the transportation network, all else being equal, iso-rate curves generated within a competitive transportation market should approximate a smooth circular or elliptical shape. Given this supposition about the shape of competitive iso-rates, we suggest that the converse can also be the case - that marked distortions or irregularities in mapped freight rate contours that are not readily attributable to any obvious physical or geographic factors affecting route choice may instead be attributable to varying levels of competition through the transportation market at that point in time. The latter situation is shown using the stretched or distorted iso-rate C in Figure 1. Using the assumptions, the identical rate paid at the closer physical location to the origin/destination (point C_1) compared with the more distant point C_2 would be attributable to relatively less competition in the vicinity of point C_1.

Rate Dynamics Through Time and Space – Vector Autoregression

This regional trucking market is multi-faceted. Rates may depend not only on market structure, but also on long-term relationships, time, and capacity. In fact, rate setting in the sector may give rise to relationships that mask collusive and/or monopolistic behavior on the part of trucking firms. Given this, we will supplement the spatial mapping analysis with econometric estimates and impulse response analysis using a subset of the same data to identify the structure of rate dynamics associated with a set of origins (De Vany and Walls 1996). A series of vector autoregressions on trucking rates will be estimated between pairs of some key origins in the sample. Specifically, the econometric pair-wise relationships estimated have the following structure (for the analysis, all data were transformed using logarithms):

$$p_{a,t} = p_{a,t-1} + p_{a,t-n} + p_{b,t-1} + p_{b,t-n} + DI_t + DI_{t-1} + DI_{t-2} + W_t + W_{t-1} + W_{t-2} + spring + summer + winter + \mu_t$$

$$p_{b,t} = p_{b,t-1} + p_{b,t-n} + p_{a,t-1} + p_{a,t-n} + DI_t + DI_{t-1} + DI_{t-2} + W_t + W_{t-1} + W_{t-2} + spring + summer + winter + \mu_t$$

Here, $p_{(a,t)}$ is the trucking rate from origin A to destination at time T, DI is the diesel price index, and W is an averaged (monthly) wage rate for equipment operators (variable names used in the analysis are listed in Table 2 and Appendix E). The reason to include a diesel price index (see Appendix B) and the wage rate in the estimates is that these two factors alone comprise between 48% to 60% of the total operating cost for commercial trucks (Trimac Consulting Services Ltd. 2001; Bulk Plus Logistics 2002; Bulk Plus Logistics 2003; Logistics Solution Builders Inc. 2005). Since rates are almost certainly affected by significant cost variation no matter what the structure of the market, these variables need to be included in a study of rate movements at the market level.

Inclusion of these exogenous variables also prevents freight rate variance from being falsely attributed to variation at the other origin. Furthermore, lag structures in the variables are used to capture time adjustments to rates, since the rate setting process along each route at each location may not adjust immediately to changes in variable trucking costs.[3] We also selected two period lags in the exogenous variables, since it is the understanding of the authors that trucking firms in this sector typically do not adjust prices immediately in the very short term because of expected future price changes. However, we postulate that in a typical competitive operating environment, it is highly unlikely delays in rate adjustment longer than two time periods (two months in our sample) would be observed.

Subsequently, impulse response functions (or IRFs) will be generated using simulated (price) impulses or shocks for each equation pair. As a well-established graphical diagnostic technique used in VAR modeling to examine system dynamics, Schmidt (2004) offers an excellent description of impulse response estimation and interpretation. The reason we will generate IRF's in this situation is that related research in other industries has argued that due to arbitrage across markets, competitive freight rate setting processes should necessarily react to mitigate rate/price impulses or shocks relatively quickly. This means a competitive transportation market modeled with a VAR (and associated IRFs) on rates should completely dissipate a (simulated) rate shock/impulse within the short run, with the latter as defined by the data series (De Vany and Walls 1996; Wilson and Thoma 2007). Conversely, a less competitive freight rate setting will not dissipate a simulated rate shock as quickly. In the latter case, rate adjustments must be occurring in relative isolation from other markets, thus slowing or limiting the possibility of competitive price arbitrage to dissipate any supernormal profits from the rate shock.

DATA

The data used in this study were provided by a canola processor located in Lloydminster, Alberta. Sixty-eight months of transportation rate data were compiled from January 2001 to August 2006. In the analysis, the monthly rates used are averaged over that month. The data include month and year of delivery, origin, as well as the rate paid to the trucking firm for the movement. Freight rates are listed as Canadian dollars per metric tonne, and observations are all based on a common convention of 40 net metric tonnes of canola seed delivered per truck movement. While the common destination or delivery point is Lloydminster (see the detail map in Appendix A), those origins from where the product is delivered to Lloydminster are found across the expanse of East-Central Alberta to West-Central Saskatchewan.

Once assembled, a small percentage of observations were discarded, mostly due to odd sized loads or trucking rates that were flat rates. Additional supplementary data relating to costs were obtained from Statistics Canada (2006a, 2006b), including the retail diesel price index for the Prairie region, as well as the average weekly wage rate for transport and equipment operators in Alberta and Saskatchewan.

The data had to be organized in two ways. To more readily construct the maps or contours of the trucking rates around the single delivery point, the data were aggregated into quarters. Ultimately, only "spring" and "fall" (harvest) periods were mapped for this study, and industry realities (to be discussed in detail later) suggest these quarters would be most likely to show evidence of any non-competitive pricing practices. Table 1 lists the number of origins present in each period for the various iso-rate maps. With respect to the overall shape of the iso-rate maps, it is worth noting that another interesting aspect of this study is that the region possesses a very dense rural road network, typically offering several possible routings for many of the movements contained in the data set. In fact, the province of Saskatchewan has the highest road density per capita of any jurisdiction in North America (Barry et al. 1999). And while the quality of the road varies in Saskatchewan, the route choices for grain movement remain surprisingly numerous.

Table 1: Number of Locations by Season Used in the Construction of the Iso-rate Maps

	Spring	Harvest
2001	82	64
2002	48*	10*
2003	45	64*
2004	38	64
2005	82*	50
2006	45*	

* For clarity, these iso-rate maps were omitted from this analysis. However, all the iso-rate maps are available upon request from the authors.

To assemble appropriate data for the examination of rate dynamics in this industry and region, some data issues had to be addressed. We note that while there were 10,059 individual observations in the full data set (a basic summary of the complete data set is in Appendix C) associated with more than 30 origins, only seven origins were ultimately chosen for the econometric portion of the analysis because they yielded by far the most consistent rate data through the entire sample. Four of these seven origins are actually aggregates of two or three proximate origins in the original data, but this helps maintain the overall continuity of this data set. The names of the origins used in the econometric analysis of rate dynamics are listed in Table 2. In total, the chosen origins generated 3,723 observations, or 37% of the total rate data.

Table 2: Locations Selected for VAR, Variable Names (Appendix E) in Boldface

Location	Province	Distance to Lloydminster (KM/Miles)	Elevator or Farms	General Compass Direction (from Lloyd)	Total Number of Observations	Months with Observations (out of 68)
Wetaskiwin **(Weta)**	AB	266/165	Farms	W/SW	508	57
Biggar/Perdue/Asquith **(Big)**	SK	250/155	Farms	E/SE	390	49
Hamlin/North Battleford **(Ham)**	SK	151/96	Elevator	E	553	48
Allan **(All)**	SK	337/209	Elevator	E/SE	371	43
Radisson/Borden **(Rad)**	SK	210/130	Farms	E	172	39
Prince Albert/Birch Hills **(PA)**	SK	348/216	Farms	E/NE	185	38
Unity **(Uni)**	SK	164/102	Elevator	SE	1,544	37

But as shown in Table 2, none of the selected origins generated consistent observations through the full sample period. For instance, while Unity, SK generated 15% of the total data set, Unity rate data was observed in only 37 of the 68 sample months. So in order to construct a proper temporal data set for comparative analysis, non-coincident observations in time across these chosen origin pairings were discarded, as well as any missing observations. The latter process reduced the data set for the econometric analysis considerably. As an example, while Wetaskiwin and Allan as origins (to Lloydminster) generated almost 900 rate observations between them in the 68 months of raw data (see Table 2), rates from Wetaskiwin to Lloydminster and Allan to Lloydminster were observed at the same point in time (i.e., the same month) on just 38 occasions in the data (see the first entry in Table 3). Ultimately, we identified a set of such trip pairings (pairs of origins) that generated a minimum of 25 concurrent observations over the sample. This left us with 16 possible trip pairings across the region to be examined in the econometric portion of the analysis (see Table 3).

Table 3: Concurrent Observations for VAR Pairings (Origins to Lloydminster)
(Asterisk Indicates a Stable VAR Pairing)

Wetaskiwin	Allan	38		Biggar	Allan*	32
	Biggar*	43			Hamlin*	41
	Hamlin*	43			Prince Albert*	31
	Prince Albert	33			Radisson	29
	Radisson	33			Unity*	25
	Unity	26				
				Allan	Prince Albert	27
Hamlin	Allan	37			Radisson	26
	Prince Albert*	32				
	Radisson	29				

EVALUATING THE SPATIAL NATURE OF TRUCKING RATES AND DYNAMICS THROUGH TIME

Iso-rate Maps

A set of representative rate contour maps are illustrated in Appendix D, Figures 2 to 7, and we also refer the reader to the detail map in Appendix A, highlighting the location of Lloydminster and the major highway in the region, Highway 16. Each iso-rate map effectively represents a snapshot of the prevailing trucking rates at that time for travel to the plant in Lloydminster. One element that stands out about the contour maps was the distortionary influence of the main highway running through the region. Provincial Highway 16 runs east-west through Lloydminster and connects the city to major population centers in both Alberta (Edmonton) and Saskatchewan (Saskatoon). Many of the illustrated contours appear to be formed into a stretched elliptical shape centered on the highway. Since Hwy 16 is the main feeder route for traffic moving east-west in the region, this finding is not entirely unexpected. In addition, the influence of Hwy 16 on the contours might also be attributed to the fact that while high in density, much of the regional rural road network (especially in Saskatchewan) was moving into disrepair around this time (Nolan 2003). This combined effect seems to really stretch some of the iso-rate contours along the highway within Saskatchewan (see Figures 2 and 3 for example). We conclude that that local road conditions in this sector at that time must have strongly affected routing decisions.

Another interesting finding was that a number of the constructed iso-rate contours were not very smooth (round or elliptical), even accounting for the effects of Highway 16. As described earlier, a jagged contour implies that a trucking company operating from the more distant origin was paid the same rate as a trucking company moving the commodity from an origin closer to the destination, even when both shipments were made at approximately the same time. Ceteris paribus, since the more distant location necessarily generates greater transportation costs, the closer carrier moving the commodity would seem to have been over-paid (i.e., operated in a less competitive market) relative to the more distant carrier.

While of interest because this finding stands in some contrast to common perceptions about the trucking industry in general, in all cases identified in the contour data, conditions indicative of reduced transportation competition were not static and the mapped rate contours often changed markedly from one season to the next. As an example, when observing contours that would appear to indicate reduced transportation competition, such as the jagged and pointy set of contours through the eastern portion of Figure 4, if we examine the same contours one year later (Figure 5) they are much smoother by comparison, a result consistent with increasing competition over time. And conversely, we observe in Figure 6 that the iso-rates are generally smoother compared with those found in Figure 7 (again, the latter are observations from one year later), where the iso-rates are more jagged or irregular.

Our observation that iso-rate roughness did not persist and was of relatively short duration in the sample accords with an observation by DeVany and Walls (1999) with respect to electricity markets, who found that periods experiencing capacity constraints were characterized by above normal rates. For grain trucking in this region, the iso-rates seem to show that most of the time and on aggregate trucking rates were set competitively, but there were certain times and places where less competitive rates could be identified, and in most cases only transitionally. Perhaps not surprisingly, the contour maps also show that the latter situation occurred more often in times where demand for trucking services and capacity (i.e., at harvest time) would likely come under the greatest strain.

Rate Dynamics - Econometric Analysis[4]

Next, the dynamics of the 16 trucking rate origin pairings shown in Table 3 were examined in more detail using time series methods. Initial unit root testing on the data series within the origin pairs revealed that many of the series were non-stationary, so all the rate series were first differenced to achieve stationarity. Ultimately, seven data pairings stabilized for further analysis (see Table 2 and Appendix F), and the set of coefficient estimates are listed in Appendix E.[5] The VAR models estimated are labeled as Models 1 through 7, grouped in the table by common origins across the models as much as possible.

Overall, the VAR estimates account for approximately 45% of variation within the various trucking rate time series. Harvest or "fall" as defined in the study was expected to generate the highest trucking rates compared to the other seasons, since the greatest volume of grain moves at harvest time in the region. We found that several of the dummy seasonality variables had negative coefficient estimates (with six of the seven models showing this effect), meaning that time periods other than harvest were generally characterized by comparatively lower rates. We also found that diesel prices (including lags in some cases) were significant in five of the seven models, while four of these significant coefficients were positive (the expected sign). Wages were also found to be significant in four of the seven models, but only one of these coefficients was positive (the expected sign). Finally, while we must be careful not to infer too much from the estimated price coefficients, they do offer insight about the structural dynamics within each estimated system (Schmidt 2004). Observe that while every model had at least one significant own-price coefficient, only three of the seven had significant cross price coefficients. Taken together, this implies that the level of market integration varied considerably among the chosen origin pairings.

Vector Autoregression Impulse Responses

Impulse response functions are simulated responses to one standard deviation shocks to each estimated equation in VAR model and are used to analyze the ability of the estimated system to absorb and dampen out rate "shocks' over time. For the trucking rate VAR pairwise models estimated here, each impulse response graph is shown in Appendix F, Figures 8 to 14. Note that each graph shows the dampening process associated with each rate equation in the two equation systems, initiated through a simulated shock to the listed rate variable. With the exception of a single example (Figure 12 – Biggar/Allan), none of the simulated system shocks dampen very quickly. In fact, the average duration from shock to dissipation in the origin parings is approximately six to seven months.

As noted previously, relatively fast dampening of such impulses is expected within a competitive market. But leaving trucking competition considerations aside, there are other possible reasons for the extended shocks in these origin pairs. These include the restricted flow of information between trucking firms, as well as the actual rate setting process at the canola processor in Lloydminster. Since at the time there was no central market for truck freight in the region, obtaining rates from competing firms was not a simple process and involved significant transaction costs. If a certain trucking firm asked for a high or uncompetitive rate from a given origin, that information would be slow to disseminate to other trucking firms. Thus, any movement of market resources as a reaction via arbitrage would occur slowly, if at all.

The actual rate setting process at this processing facility represents an interesting study in transaction costs and also confirms that mapped distortions in the iso-rate lines were attributable to varying levels of spatial competition in the trucking sector serving the canola processor.[6] During the contracting process with sellers, the processor would offer to coordinate with trucking firms regarding on-farm pickup of the product as a convenience service. If this option was accepted, the trucking rate would be negotiated and set during this process, and was typically based on common expectations of the current market rate for truck freight. Once this contract was settled, the negotiated rate became a deduction from the final price paid to the farmer for the product. The trucking firm would be paid from this deduction, but it is important to note it was possible that the negotiated rate and actual rate paid were not the same. Of course, if the processor could find a trucking firm willing to transport the load for a lower rate than what was contracted initially, this would result in a net gain to the processor. However, incentives for the staff at the processor to try to find a lower trucking rate were not strong. This was because any profits obtained in this way were likely to be small in comparison with other possible non-transportation-related profit opportunities at the facility, while searching for lower truck freight rates had a high opportunity cost.

There is also evidence of weak market integration and diminished trucking competition between certain origins in this sub-sample (see Appendix A map) of the trucking rate data. We note that figures 8 and 13 (both associated with a Prince Albert, SK, origin) show impulses that persist relatively longer as compared with others found in the sub-sample. While the city of Prince Albert is located approximately the same distance to Lloydminster as the town of Allan, Prince Albert is not on Highway 16, like Allan. Overall, the impulse responses indicate that Prince Albert is less connected to Lloydminster than Allan or any other of the Saskatchewan origins found in the sub-sample (i.e., Unity and Biggar).

In fact, the route to travel from Prince Albert to Lloydminster is more circuitous compared with the other locations identified in the VAR analysis. Such routing issues would also likely reduce the number of trucking companies who are willing to participate in this particular market. Combined with the observation of a lower overall traffic volume (Prince Albert had the second lowest number of observations in the sample), the impulse responses would seem to buttress the fact that there were simply fewer opportunities for market arbitrage in the Prince Albert-Lloydminster market, possibly because there were simply fewer trucking companies serving it. Although not conclusive, in light of the persistent shocks present in the relevant impulse response functions, it seems that relatively less trucking competition was present in the Prince Albert to Lloydminster route during this time.

On the other hand, evidence for competitive market structure in the other regional trucking markets can be seen by examining Figures 10, 12, and 14. In each of these market pairs, at least one of the locations generated rate shocks that converged to zero relatively fast. These responses to the price shocks indicate that the chosen pair of origins was well integrated in at least one direction, meaning that competition in the market was relatively strong. In fact, the impulse responses shown in Figure 12 indicate mutual market integration, with shocks that dissipate quickly in both directions. This result is likely due to the fact that both of these particular origins (Biggar/Allan) are relatively close together geographically, so that trucking from either origin uses the same routing. In addition, both of these origins are located close to a population center (Saskatoon), meaning that shipments from either could also be serviced by trucking firms located in Saskatoon, along with the regional trucking firms. Given this, it is not surprising that greater trucking competition in these areas was identified through the impulse responses, a finding in some contrast to some of the more remote origins in the region that would likely only be served by local trucking firms.

On its own, finding that no impulse responses generated through the trucking rates were dissipated very quickly (none of them dampen in less than five months) was somewhat surprising. In fact, many argue that the trucking industry is almost hyper-competitive, and that there are simply too many trucks on the road throughout North America (Belzer 2000). What is clear is that the trucking industry as a whole is extremely competitive, meaning that any arbitrage opportunities on rates should be everywhere quickly and fully dissipated down to purely competitive levels. But since the impulse responses generated within this trucking market took on average approximately six to seven months to dissipate, it seems that portions of this particular market were not always extremely competitive all the time, as is commonly assumed.

In conjunction with the results from our iso-rate analysis, we identified variations in competition levels through space and time in what is considered by many without question to be a highly competitive industry at all times and in all places. Even considering the nature of the commodity market being served and other specific factors about the region, there were still instances and places where the de-regulated trucking market serving this region appeared to be considerably less competitive than expected. So while we conclude that perfect competition is still an appropriate economic paradigm to describe the broader North American trucking sector, we uncovered evidence showing that within the region and for this type of movement, trucking was not perfectly competitive consistently over both time and space.

CONCLUSION

This research examined the medium- to long-haul agricultural trucking sector serving West-Central Alberta and East-Central Saskatchewan. Considering some persistent anecdotal evidence about the trucking market in the region, our objective was to evaluate the level and scope of competition within this particular trucking sector over the sample period.

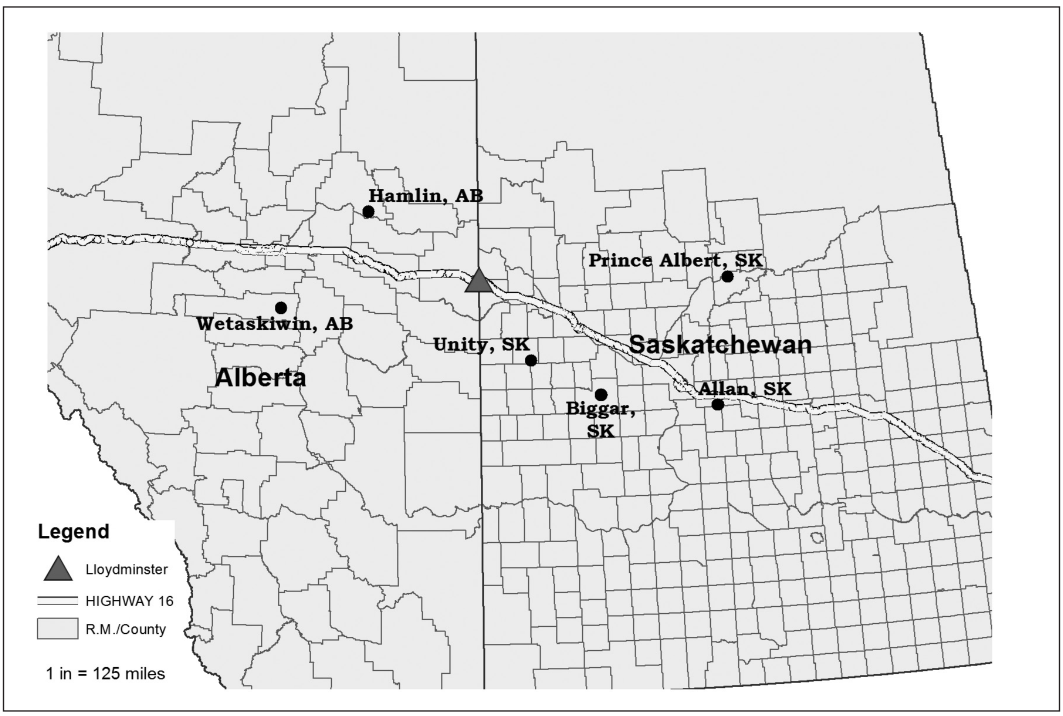
Due to the nature of the agricultural commodity being moved, iso-rate contours for spring and harvest quarters were constructed using geographic information system software. We motivated and described a set of general suppositions regarding the shape of these iso-rates in relation to market structure. While we found that some portions of the maps appear to be indicative of non-competitive pricing behaviour in relation to our expectations, these effects were not found to last very long. While an uncompetitive market structure is not persistent within this trucking sector, we did identify certain times and locations where non-competitive behavior could play an unexpectedly important role.

To buttress the mapping analysis, a sub-sample of the rate data set was used to estimate a pairwise VAR system (and associated impulse response functions) across several key origins in the region. Surprisingly, none of the impulses generated with this trucking data dissipated very quickly, a finding in contrast to what would be expected in a fully competitive market. However, the duration of the impulses was not long enough to conclude that the market as a whole was non-competitive. But on a practical level, our findings highlight concerns about the level of trucking competition that existed on at least one important transportation corridor in the region (Prince Albert-Lloydminster).

While the data used here in these analyses were extensive, additional variables would improve any future studies of spatial and temporal market power in transportation. These might include rates charged on outgoing loads, region-specific diesel prices, and trucking-specific wage rates. Extending the model to include outgoing freight rates would provide additional validity, as examining incoming loads alone cannot completely capture the nuances of this transportation market. In addition, diesel prices differ across provinces as a result of varying taxation rules and supply issues. Using province-specific rates would allow the exercise to better account for such subtle differences, while the same could be said for the use of trucking-specific wage rates. Finally, while not pursued in this preliminary analysis, it would be instructive to estimate a larger VAR system that accommodates all identified origins simultaneously. As noted above, pairwise modeling restricts the possible sources of variation within the model, and could result in omitted variable bias as a consequence. Running all locations simultaneously would remove this bias, and would give a much better idea of how rates propagate throughout the study region and not just in selected pairings.

In suggesting ways to improve the current study, consider the quote from Norton (1971): "is there any complex industry about which too much can be known?" (p.453). The grain trucking industry in this region certainly seems to fall into this category and is worthy of continued analysis.

Appendix A: Detail Map of the Region (Including Lloydminster, Hwy 16 and Key Origins)



Appendix B: Short-haul Trucking Price Index

2000-2001 Crop Year				2001-2002 Crop Year			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
100.0	102.5	102.5	102.5	102.5	102.5	102.5	100.0

2002-2003 Crop Year				2003-2004 Crop Year			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

2004-2005 Crop Year				2005-2006 Crop Year
Q1	Q2	Q3	Q4	Q1
100.0	100.0	108.8	111.3	114.7

Source: Quorum Corp. 2002

Appendix C: Full Data Set - Location Summary by Year

	% of Observations in Most Popular Origins			
Year	**Top 6**	**Top 12**	**Top 21**	**Total Observations**
2006	59.6%	69.7%	77.2%	1,549
2005	49.2%	74.1%	85.7%	2,609
2004	46.0%	57.1%	66.4%	1,202
2003	51.3%	60.6%	67.5%	1,356
2002	29.9%	40.8%	52.5%	777
2001	21.9%	34.6%	47.6%	2,566

2006	**Distance (KM)**	**# of Observations**	**2005**	**Distance (KM)**	**# of Observations**
Unity	164	452	Unity	164	499
Hamlin	151	134	Morinville	281	288
Dundurn	318	126	Wetaskiwin	266	143
Wetaskiwin	266	110	Allan	337	143
Allan	337	74	Hamlin	151	141
Saskatoon	277	36	North Battleford	140	73
Biggar	230	27	Biggar	230	67
Asquith	287	25	Perdue	260	61
Eston	301	24	Westlock	332	52
Ferintosh	262	24	Leask	302	47
Radisson	210	24	Prince Albert	348	47
Albertville	381	23	Quill Lake	451	43

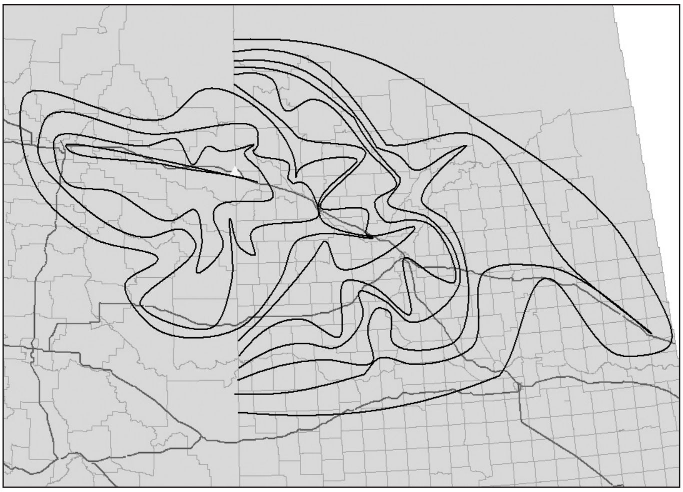
2004	Distance (KM)	# of Observations	2003	Distance (KM)	# of Observations
Unity	164	311	Unity	164	302
Prince Albert	348	72	Killam	185	152
Allan	337	55	Wetaskiwin	266	120
Wetaskiwin	266	50	Edmonton	249	42
Provost	124	37	Saskatoon	277	40
Leask	302	31	Allan	337	40
Biggar	230	28	Ferintosh	262	37
Bawlf	237	27	Provost	124	20
Borden	223	23	Sedgewick	193	20
Cutknife	119	22	Arlee	234	18
Watrous	393	20	Naicam	462	17
Bassano	463	18	Meadow Lake	189	14

2002	Distance (KM)	# of Observations	2001	Distance (KM)	# of Observations
Hamlin	151	54	Westlock	332	133
Unity	164	47	Provost	124	123
Saskatoon	277	39	Vermillion	58	82
Allan	337	31	Viking	199	80
Wetaskiwin	266	31	Saskatoon	277	79
Balcarres	607	30	Wilkie	191	66
Thorhild	271	17	Edgerton	87	60
Indian Head	602	16	Olds	462	60
Edam	145	15	Hamlin	151	58
Cutknife	119	13	Wetaskiwin	266	58
Kelvington	556	12	Milden	326	48
Sheho	537	12	Biggar	230	42

Appendix D: Selected Iso-rate Maps

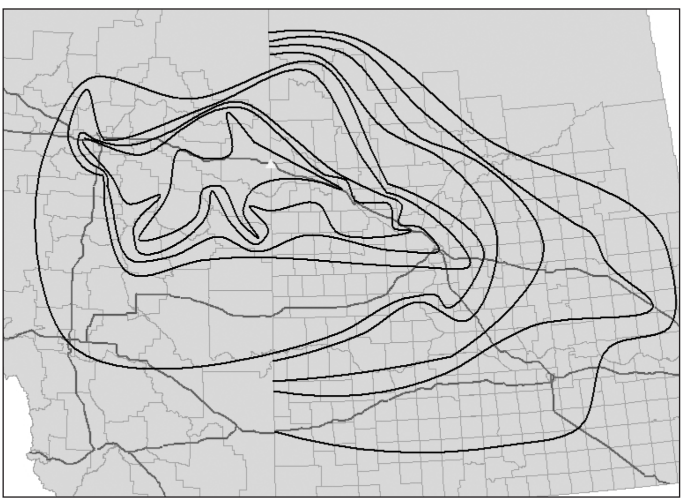
Note - North is up, scales are approximately 130-140 miles/inch, depending on the map. Lloydminster is the small white triangle located just to the left and above the center of each map. Highway 16 is the gray line passing diagonally from northern Alberta to the southeastern portion of Saskatchewan, through Lloydminster. Rate #1 is the innermost contour on each map (centered around Lloydminster), while successive rates lie outside of the prior rate. Units for the rate bounds are measured in C$ per metric tonne.

Figure 2: Spring, 2001



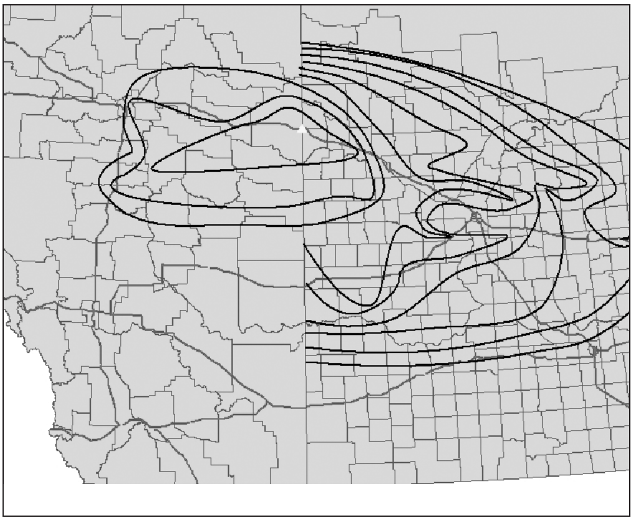
Rate	Lower Bound	Upper Bound
1	5.00	6.00
2	6.01	7.00
3	7.01	8.00
4	8.01	9.00
5	9.01	10.00
6	10.01	12.00
7	12.01	13.00
8	13.01	15.00
9	16.01	17.00
10	19.01	20.00

Figure 3: Harvest, 2001



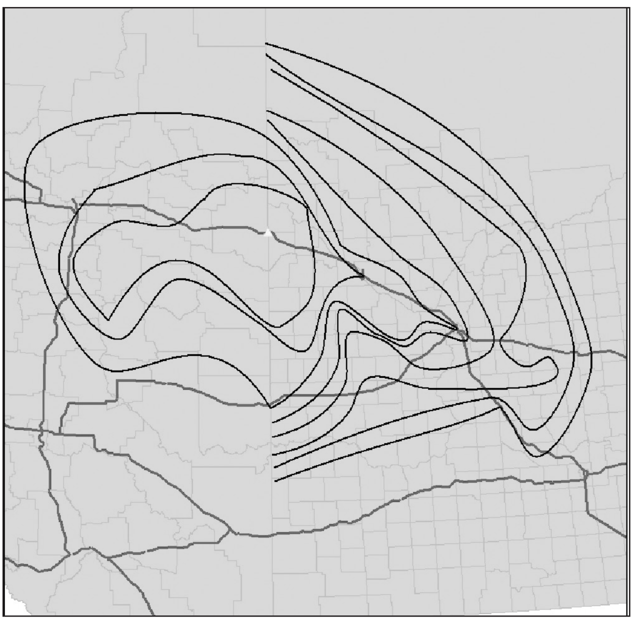
Rate	Lower Bound	Upper Bound
1	6.00	7.00
2	7.01	8.00
3	8.01	9.00
4	9.01	10.00
5	10.01	12.50
6	12.51	14.50
7	14.51	17.50
8	17.51	19.00
9	19.01	20.00
10	20.00	25.00

Figure 4: Spring, 2003



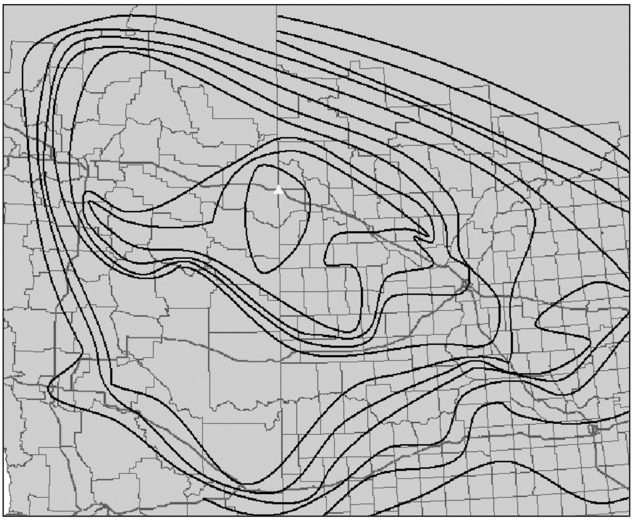
Rate	Lower Bound	Upper Bound
1	5.00	7.00
2	7.01	8.00
3	8.01	9.00
4	9.01	11.14
5	11.15	12.60
6	12.61	15.75
7	15.76	17.50
8	17.51	19.50
9	19.51	24.00

Figure 5: Spring, 2004



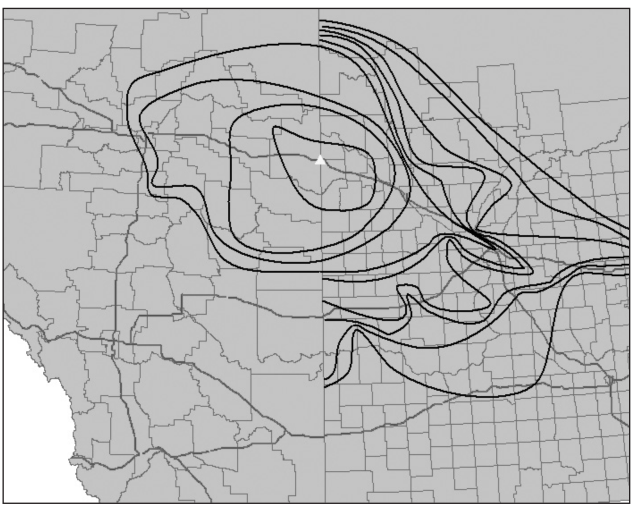
Rate	Lower Bound	Upper Bound
1	7.00	8.00
2	8.01	9.00
3	9.01	10.00
4	10.01	11.25
5	11.26	13.56
6	13.57	15.12
7	15.13	17.00
8	17.01	20.00

Figure 6: Harvest, 2004



Rate	Lower Bound	Upper Bound
1	5.00	6.00
2	9.00	10.00
3	10.01	11.00
4	11.01	12.00
5	12.01	14.00
6	14.01	17.00
7	17.01	18.00
8	18.01	19.00
9	19.01	20.00
10	20.01	21.50
11	21.51	24.00
12	26.00	30.00

Figure 7: Harvest, 2005



Rate	Lower Bound	Upper Bound
1	7.00	9.00
2	9.01	11.00
3	11.01	11.75
4	11.76	13.33
5	13.34	15.15
6	15.16	17.00
7	17.01	18.00
8	18.01	20.75
9	20.76	24.33

Appendix E: Selected Pairwise (by origin) VAR Estimates

Dependent variables are the applicable trucking rates, lagged variables as indicated. *Die* is the diesel fuel price index, *wage* is the wage rate and the seasonal dummies are labeled as such (Fall excluded). AIC diagnostics are also listed for each model. ** denotes significance at the 95% level, while * denotes significance at the 90% level, t-statistics are in square brackets.

	Model 1		Model 2	
	Weta	Big	Weta	Ham
Variables				
C	0.011416	0.027295*	0.021349	0.008001
	[0.63758]	[2.03295]	[1.15729]	[0.68378]
Weta (t-1)	-0.2818	0.302242**	-0.5469**	-0.47383**
	[-1.66711]	[2.38449]	[-2.92279]	[-3.99246]
Weta (t-2)			-0.14174	-0.5646**
			[-0.74377]	[-4.67118]
Big (t-1)	0.092033	-0.4648**		
	[0.51969]	[-3.50023]		
Big (t-2)				
Ham (t-1)			0.418152**	-0.44624**
			[2.31535]	[-3.89561]
Ham (t-2)			0.138297	-0.09932
			[0.72889]	[-0.82530]
Die	0.22505	-0.13775		
	[0.93988]	[-0.76722]		
Die (t-1)	-0.08691	-0.12629	-0.00922	0.76803**
	[-0.35486]	[-0.68768]	[-0.03336]	[4.37924]
Die (t-2)				
Wage	0.171715	-0.01756		
	[0.44190]	[-0.06027]		
Wage (t-1)	-0.21372	-0.1756	0.359127	0.424248*
	[-0.50868]	[-0.55736]	[0.95056]	[1.77045]
Wage (t-2)				
spring	-0.00134	-0.00988	-0.01131	-0.01805
	[-0.06543]	[-0.64467]	[-0.52325]	[-1.31652]
summer	-0.00058	-0.03924**	-0.01409	-0.00854
	[-0.02626]	[-2.37984]	[-0.60835]	[-0.58103]
winter	-0.02599	-0.02292	-0.02806	0.012882
	[-1.09579]	[-1.28889]	[-1.14901]	[0.83179]
AIC	-2.92118	-3.49693	-2.85007	-3.76064
AIC (model)		-6.46737		-6.71738
R-squared	0.202372	0.500266	0.331968	0.672475

	Model 3		Model 4		Model 5	
	Big	All	Big	Ham	Big	PA
Variables						
C	0.039343**	0.002016	0.035471*	-0.0091	0.086268**	0.052365**
	[2.18314]	[0.11592]	[1.78340]	[-0.48060]	[5.82290]	[3.15934]
Big (t-1)	-0.36673*	-0.0472	-0.49595**	-0.2198	-0.09971	0.249132
	[-2.01307]	[-0.26850]	[-3.00810]	[-1.40053]	[-0.68496]	[1.52972]
Big (t-2)					-0.34816**	0.159065
					[-2.83496]	[1.15774]
All (t-1)	0.071619	-0.38828**				
	[0.37826]	[-2.12501]				
All (t-2)						
Ham (t-1)			0.354416*	-0.25205		
			[1.97186]	[-1.47316]		
Ham (t-2)						
PA (t-1)					-0.00965	-0.77679**
					[-0.05548]	[-3.99208]
PA (t-2)					0.361588*	-0.26117
					[2.02237]	[-1.30564]
Die	-0.16224	0.178884	-0.33828*	0.046822		
	[-0.65322]	[0.74630]	[-2.02566]	[0.29454]		
Die (t-1)	-0.06198	-0.12978	0.075655	0.679063**		
	[-0.26043]	[-0.56504]	[0.44709]	[4.21574]		
Die (t-2)			-0.09813	-0.05952	0.040745	0.236305*
			[-0.49092]	[-0.31281]	[0.33935]	[1.75919]
Wage	-0.07051	-0.01674	0.323802	-0.14842		
	[-0.20401]	[-0.05018]	[0.89037]	[-0.42872]		
Wage (t-1)	0.080692	-0.72753*	0.598368	-0.45576		
	[0.21868]	[-2.04301]	[1.62842]	[-1.30299]		
Wage (t-2)			0.34819	-0.67585**	0.026342	-0.07897
			[1.09704]	[-2.23697]	[0.12818]	[-0.34347]
Spring	-0.00847	0.02628	-0.01988	-0.00174	-0.06467**	-0.05615**
	[-0.40378]	[1.29752]	[-0.92542]	[-0.08507]	[-3.59318]	[-2.78868]
Summer	-0.05927**	0.002238	-0.05777**	0.020294	-0.10597**	-0.04447**
	[-2.73876]	[0.10715]	[-2.37425]	[0.87623]	[-6.44397]	[-2.41696]
Winter	-0.03484	0.009009	-0.02225	0.018691	-0.08447**	-0.06027**
	[-1.41986]	[0.38051]	[-0.94831]	[0.83681]	[-4.50481]	[-2.87291]
AIC	-3.0395	-3.11064	-3.07504	-3.17361	-3.96743	-3.74299
AIC (model)		-6.43553		-6.2507		-7.71961
R-squared	0.477737	0.421642	0.496382	0.546429	0.805102	0.604294

	Model 6		Model 7	
	Big	**Uni**	**Ham**	**PA**
Variables				
C	0.038609	0.065098**	0.013568	0.024827*
	[1.26687]	[2.74145]	[0.64226]	[1.92250]
Big (t-1)	-0.33709	-0.09012		
	[-1.08227]	[-0.37136]		
Big (t-2)				
Uni (t-1)	-0.05293	-0.65005**		
	[-0.21308]	[-3.35855]		
Uni (t-2)				
Ham (t-1)			-0.28783	-0.25737
			[-1.03267]	[-1.51045]
Ham (t-2)				
PA (t-1)			-0.27231	-0.45814**
			[-0.93420]	[-2.57106]
PA (t-2)				
Die	-0.33664	-0.76043**	0.340703	0.076999
	[-1.07823]	[-3.12589]	[1.62820]	[0.60194]
Die (t-1)			0.118687	0.344192**
			[0.52058]	[2.46956]
Die (t-2)			0.135537	0.083268
			[0.71868]	[0.72226]
Wage	-0.10541	0.322864	0.086144	-0.26252
	[-0.21549]	[0.84705]	[0.22929]	[-1.14302]
Wage (t-1)			-0.34113	-0.10926
			[-0.82375]	[-0.43159]
Wage (t-1)			-0.18717	-0.47951**
			[-0.51181]	[-2.14483]
Spring	-0.01549	-0.05851**	-0.02148	-0.02192
	[-0.44887]	[-2.17633]	[-0.88620]	[-1.47937]
Summer	-0.04164	-0.03167	-0.01492	-0.02601*
	[-1.19567]	[-1.16702]	[-0.64273]	[-1.83307]
Winter	-0.02231	-0.06468**	-0.0089	-0.01643
	[-0.62304]	[-2.31844]	[-0.35338]	[-1.06693]
AIC	-2.82659	-3.32565	-3.10805	-4.09235
AIC (model)		-6.41407		-7.37511
R-squared	0.324896	0.605745	0.285887	0.619669

Appendix F: Pairwise Impulse Response Graphs for Each VAR Model

Note: The y-axis has no units and represents only relative magnitude of the price shock. The x-axis is in months. Relative location to Lloydminister is indicated by (**W**)est or (**E**)ast.

Fig 8: Hamlin (W)/Prince Albert (E) (Model 7)

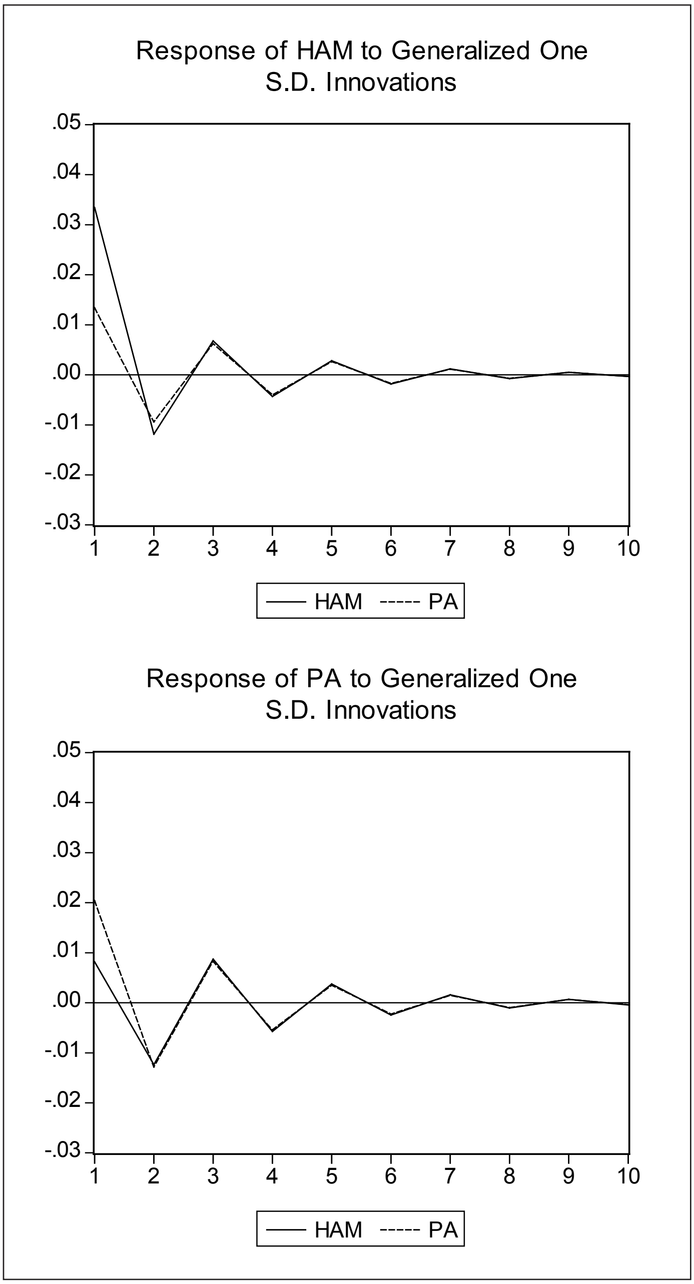


Fig 9: Wetaskiwin (W)/Hamlin(W) (Model 2)

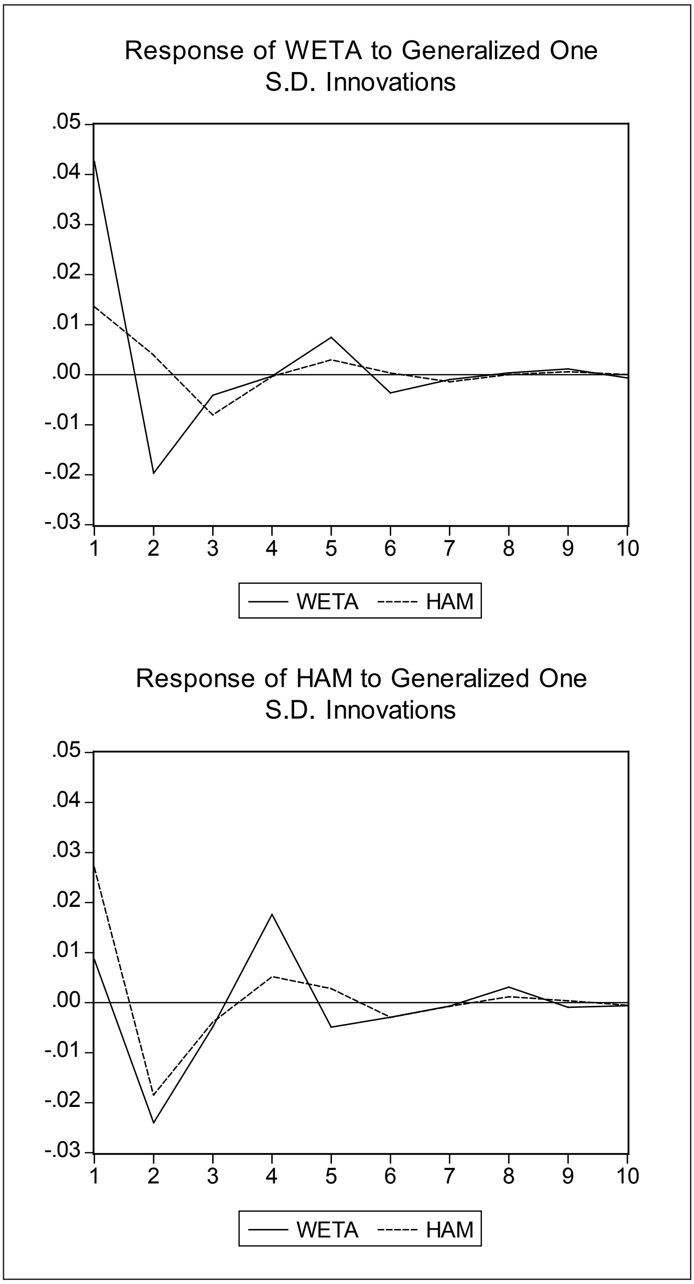


Fig 10: Wetaskiwin(W)/Biggar(E) (Model 1)

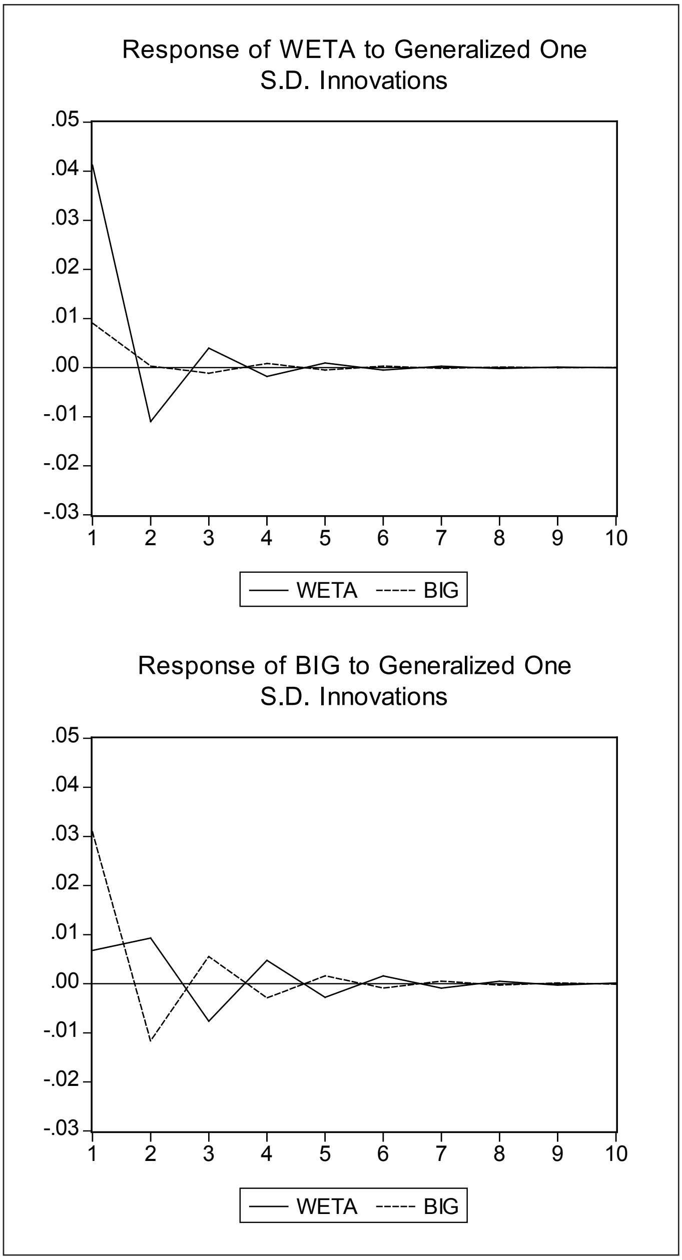


Fig 11: Biggar(E)/Hamlin(W) (Model 4)

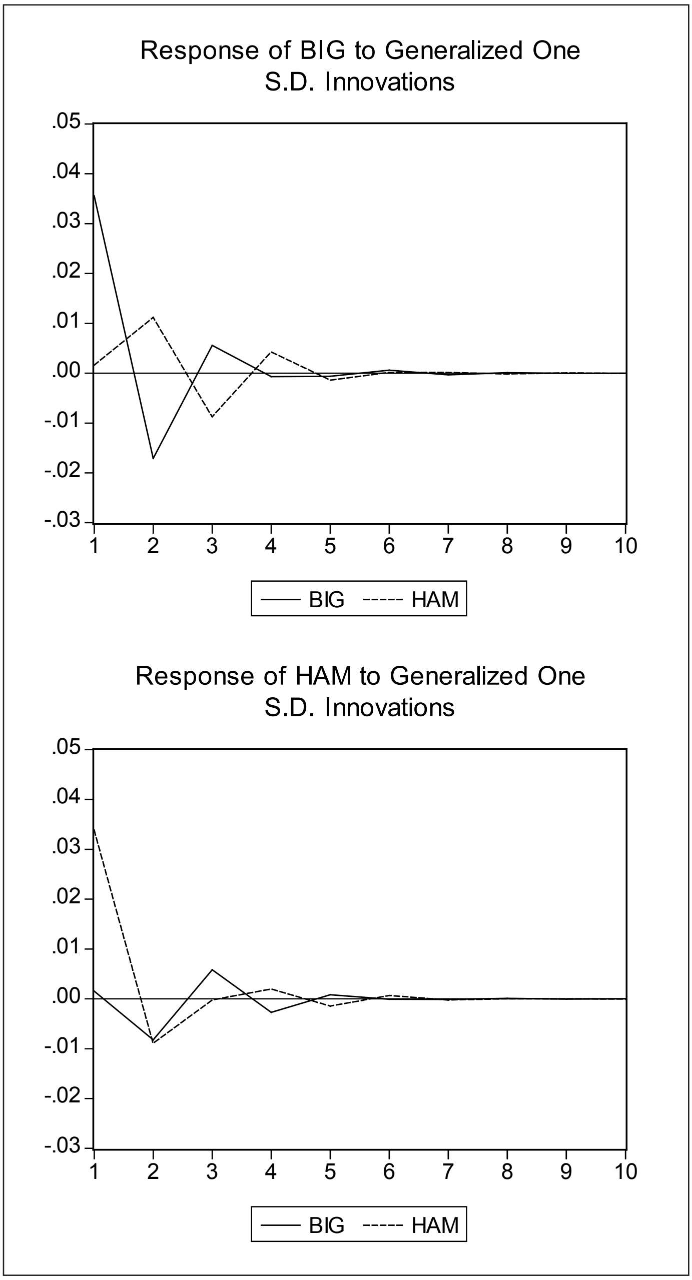


Fig 12: Biggar (E)/Allan(E) (Model 3)

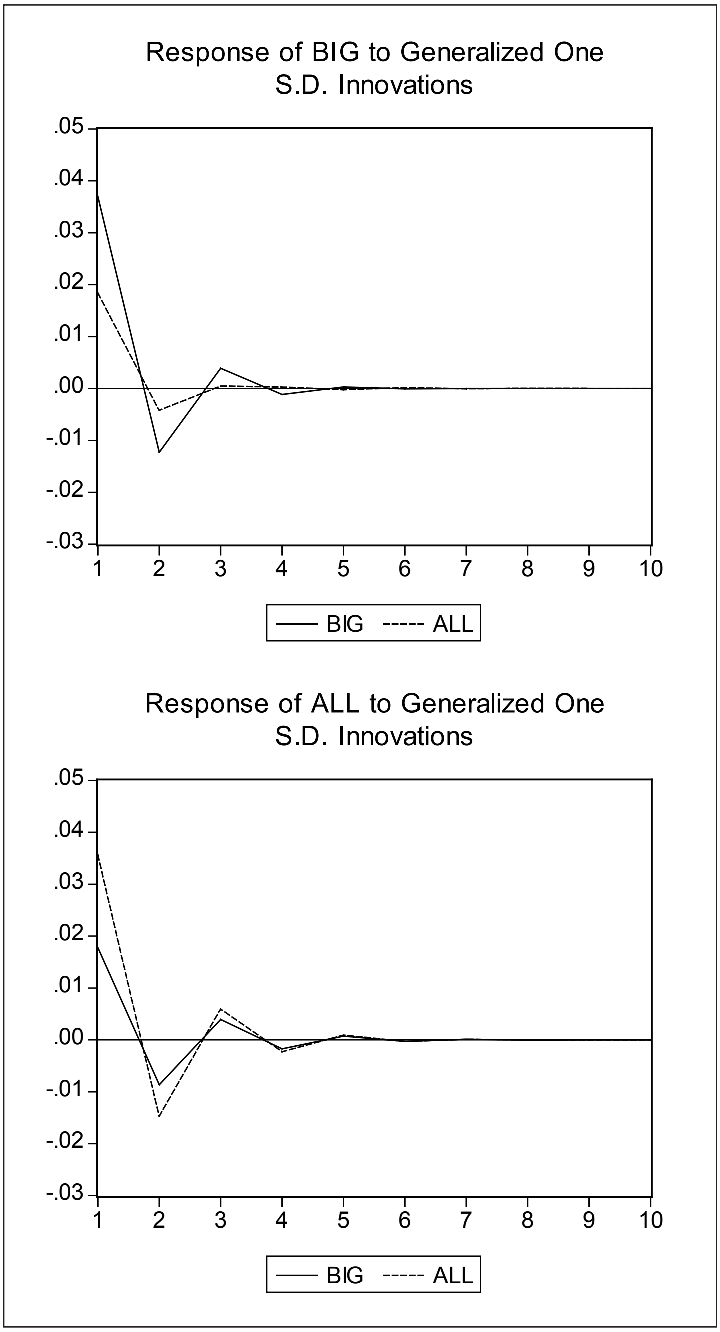


Fig 13: Biggar(E)/Prince Albert(E) (Model 5)

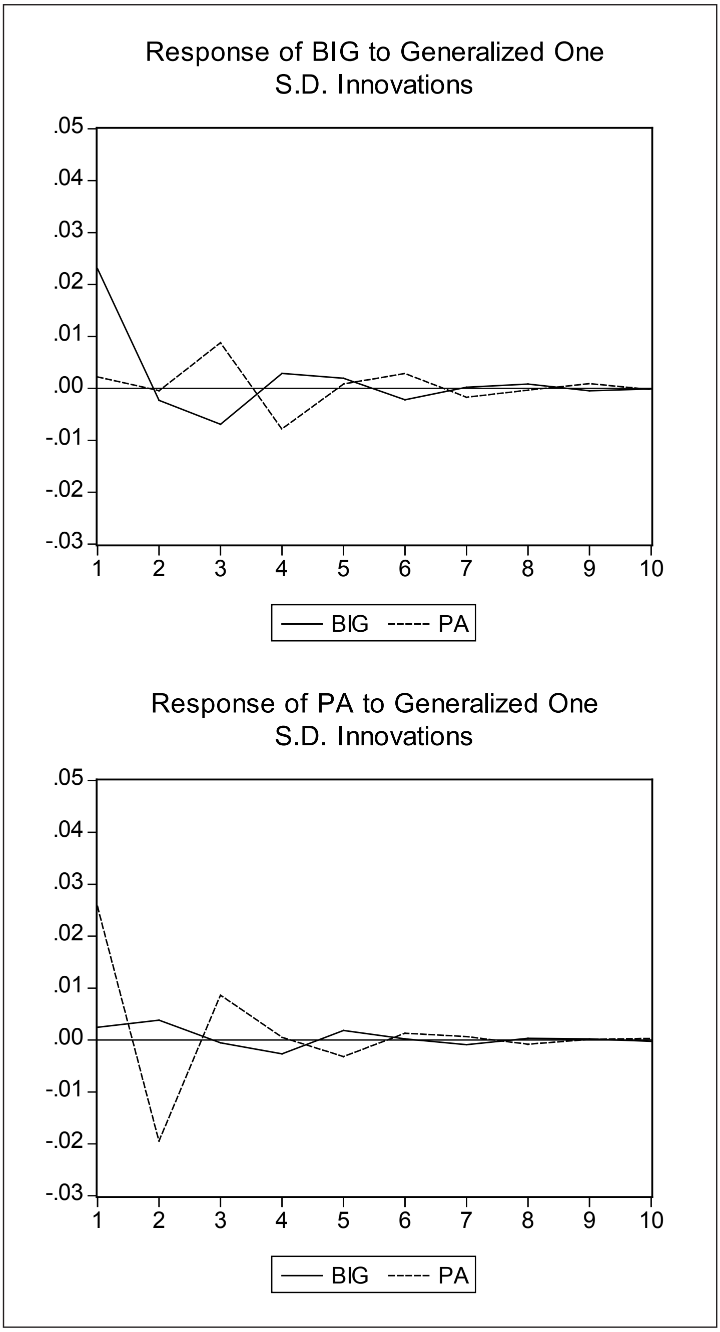
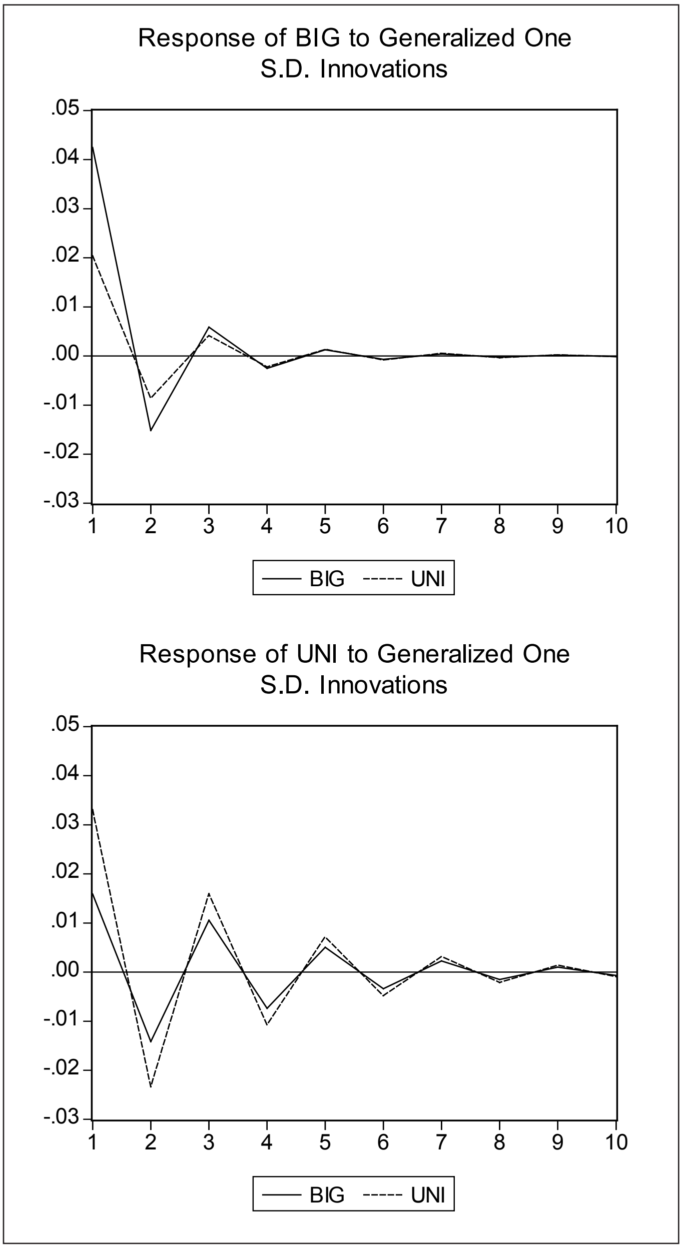


Fig 14: Biggar(E)/Unity(E) (Model 6)



Endnotes

1. The material discussed in this section was developed by the authors, motivated by the work of Newell (1980).

2. Despite considerable search efforts, we have been unable to find prior research examining rate contours in this context. Nor have we yet found or developed a suitable statistical test of "shape" for the contours (i.e., "smooth" vs. "irregular"). Work on this issue is on-going.

3. One co-author (Laing) had personal experience in the industry, indicating that this was common practice.

4. As a data mining exercise that ultimately generates trucking rate impulse responses in order to assess market power and market integration, our brief discussion about the estimated VAR coefficients is offered merely for exposition. By comparison, DeVany and Walls (1996, 1999) did not discuss properties of their VAR coefficient estimates, although they were listed in each paper. Finally we note that each of the specified VAR models converged with either one or two variable lags, while the reported Akaike Information Criterion (AIC) was used to assess relative model stability (Murray 2006).

5. Kim and McMillin (2003) observed that a large number of insignificant coefficients are often generated from this type of analysis.

6. As alluded to in a previous footnote, one of the co-authors of the paper (Laing) was directly involved in this process while the data were collected.

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