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12 October 2008
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Abstract

In this paper, we assess the influence of the U.S. BEA series “value of motor vehicle output” on the rest of the economy over the period 1968-2007. We statistically assess the causal relationship between real motor vehicle output (RMVO) and real gross domestic product (RGDP) less RMVO, called RGDP other than RMVO, or RGDPO. This is accomplished with the estimation of vector error correction models. Both variables are non-stationary, but are first-order difference stationary and cointegrated. Three separate estimates were generated: over the entire time period (1967.1 to 2008.1) and two sub-periods (1967.1 to 1988.1 and 1988.2 to 2008.1). Over the period, we find a strong quantitative relationship between RMVO and RGDPO. The Wald test indicates the presence of bi-directional causality (in the sense of Granger) and is consistent for the full period and two sub-periods. Over all three periods tested, the estimated error-correction coefficients have the expected signs and are comparable in magnitude. In the error-correction models we present, contemporary changes in RMVO and RGDPO are expressed in terms of past changes in both variables out to four periods. The estimated coefficients of the differenced values of past RMVO on current changes in RGDPO are positive in 11 of 12 cases, and are always cumulatively positive, quantitatively important, and consistent in magnitude over the preceding four quarters. The estimated coefficients for differenced values of past RGDPO on current RMVO change are inconsistent across subperiods. In addition to the statistical experiments, the estimated quantitative relationships are evaluated graphically. The empirical evidence implies a strong relationship between multi-quarter declines in RMVO and an overall decline in economic activity. Our findings, given the recent declines in RMVO indicate an impending recession.

JEL classification: C22; C53; E17; E32; L91

Definitions.

Before proceeding, we note that words matter. Careful attention to several “vehicle” words and their meaning is necessary. When used here, the word vehicle includes cars, automobiles (BEA Input/Output model commodity code number 336111), light trucks (BEA I/O code 336112, this includes utility vehicles), other trucks, buses and truck trailers; heavy duty truck manufacturing (BEA I/O code 336120) (Stewart, Stone and Streitweiser, 2007). The BEA NIPA “supplemental series” motor vehicle output (U.S. Bureau of Economic Analysis, 2008), — which is used in this paper — includes BEA I/O codes 336111, 336112, and 336120. Other transportation equipment (code 336B, which includes railroad equipment, ships and boats) is not included. Aircraft are not included.
Car and automobile have a very similar meaning (U.S. Environmental Protection Agency, 2007; Stewart, Stone and Streitweiser, 2007). The separate category light trucks includes vans, pickup trucks and sport utilities.

Santini and Poyer (2007, 2008) noted that motor vehicles are both consumption and investment goods. According to recent Bureau of Economic Analysis (2008b) estimates for the first two quarters of 2008, the business share of new auto purchases dropped from about 40% in January, to 36% in June, and for light trucks dropped from 42% to 41%. Santini and Poyer’s (2008) plot of an index of private fixed investment in new motor vehicles vs. an index for all motor vehicle output implied that the share of motor vehicle output accounted for by business investment rose considerably in the 1990s, and that the drop in business investment in motor vehicles in the 2001 recession was considerably sharper than for the motor vehicle output series as a whole.

**Selected Literature**

Hamilton, in 1988, stated the “sectoral shifts” hypothesis, asserting that the effects of oil price shocks on the macroeconomy were likely transmitted through variation in passenger car output. He reiterated this position in 1996.

In a number of papers, Hamilton uses the word “car” (1988, 1996, and 2003). However, it was not used in the sense implied by the definitions previously given. For example, in his 1996 paper references the word “car” in terms equivalent to “a small foreign car or a large SUV,” where “SUV” is the acronym for sport utility vehicle. SUVs are found in BEA code 336112, while small foreign cars are found in code 336111. There is no indication that Hamilton meant heavy duty trucks, or that he considered private fixed investment in new motor vehicles as a part of his sectoral shifts hypothesis (see Poyer and Santini, 2008).

Barsky and Killian (2004), who claimed to have examined and refuted the hypothesis, stated that the principal theoretical “propagation mechanism is that an oil price increase will depress purchases of energy using goods such as automobiles.” They took Hamilton’s use of the word “car” literally and narrowly, only testing for a link between cars (automobiles) and real GDP. Their investigation examined only passenger cars (BEA I/O code 336111), and only investigated unit sales, not value of output. Further, they used total passenger car sales, not domestic sales. In evaluating the effects of motor vehicle output on GDP, it is more appropriate to consider only domestic output.

Barsky and Killian argue

[that they] have investigated several leading theoretical explanations for a contractionary effect of oil price increases, but found little empirical support for any one explanation, either because the magnitude of the predicted effect can be shown to be small a priori, or because the theory has implications that are not supported by U.S. macroeconomic data.
Thus, Barsky and Killian argue that Hamilton’s sectoral shifts model is not supportable.

In papers by Santini, it was argued that intermittent dramatic declines in purchases and production of motor vehicles reduce real GDP (Santini, 1984, 1985, 1987, 1988, 1989, 1994). Santini argued that significant fluctuations in sales and output of motor vehicles were not only caused by oil price shocks, but also by technological changes, whether self-imposed by the industry itself or by regulators (Santini, 1984, 1988, 1989, 1994). Santini’s investigations leading to this conclusion spanned two centuries, and included investigations of ships and boats, railroad locomotives, passenger cars, light trucks, buses and aircraft (Santini, 1989). Thus, Santini’s arguments imply that motor vehicle output broadly, both as a business investment good and consumption good, is more closely linked to GDP changes than are oil price shocks, since oil shocks are only one factor affecting the output of motor vehicles.

According to a recent interpretation of the literature by Jones, Leiby and Paik (2004), no analyst has yet provided convincing evidence in support of the sectoral shifts hypothesis.

Hamilton in 1983 estimated that oil price shocks had Granger-caused post WWII recessions up to that time. With respect to the effects of energy cost shocks on consumption, Santini later investigated changes in share of household consumption on gasoline, natural gas, and electricity from World War II through the early 1980s, finding that only changes in the gasoline share had a Granger causal effect on economic growth and unemployment (Santini, 1987). In effect, Santini argues that transport fuel cost shocks, which occur within the motor vehicle market, spill over into other sectors, resulting in recessions. Until 2007, neither Santini nor Hamilton had presented a statistical evaluation directly supporting this hypothesis.

However, in 2007 Santini and Poyer presented results from preliminary research that assessed the effects of the real dollar value of U.S. domestic “motor vehicle output” on real GDP. This series (Bureau of Economic Analysis, 2008a) has been compiled by the Bureau of Economic Analysis since 1967. The results did not indicate conclusive statistical support for the hypothesis that real motor vehicle output (RMVO) causes real gross domestic product (RGDP). However, the results were “close” to statistical significance, and represented the first time (known to the authors) that this statistical series was used within this context. Thus, the results were considered worthy of publication (Santini and Poyer, 2008), and of additional investigation. This paper digs deeper and reformulates the variables used.

**Methodology**

Santini and Poyer demonstrated that there were potential flaws associated with the use of sales of passenger cars to evaluate the sectoral shifts hypothesis. They argued that automobiles (cars) are only one type of motor vehicle. It was also noted that motor vehicles are not only consumer goods, they are also investment goods. They contend in
order to understand the causes of fluctuations of the dollar value of output of motor vehicles in the aggregate, the consideration of them as both investment and consumption goods must be made.

As an aside, it should also be noted that services provided by motor vehicles have an investment attribute as well – as a means of transporting inputs (including labor) used in production. Conceptually, motor vehicles used for this purpose could be appropriately defined as an investment good. However, it is difficult practically to separate the use of passenger vehicles for consumption and production use.

Santini’s simple theoretical model (1988) involved an economy in which the vehicle produced in the market center was a generic vehicle used to exchange products between the market center and agricultural hinterlands. In brief, Santini argued that transportation infrastructure collectively (vehicles and their supporting route infrastructure) is a fundamental input enabling economic growth. According to the theory, transport infrastructure investment causes economic growth, not the reverse. Such arguments have been made by others, many of whom influenced Santini. Surprisingly, there is not much said (with one exception) about this issue in the economics literature. The economic historian Blaug (1985) writes of the rich, but generally ignored, role of transportation in economic growth.

The existence of the RMVO series, now over 40 years long, gives an unprecedented opportunity to test the relationship of transport vehicle output to GDP. While Santini (and many others) argue for a long-term linkage, the issue at hand is primarily short-run in nature. Hamilton (1983) identified a post WWII linkage of oil prices to economic output and unemployment with about a four quarter lag, statistically implying that oil prices cause recessions. Thus, if this paper is to examine the possibility that Hamilton’s sectoral shifts hypothesis is correct, it needs to establish evidence of a relatively short term link between RMVO and RGDP. We will not in this paper examine the effects of oil or gasoline price or cost shocks. It is first necessary to establish whether there is a causal link between RMVO series and RGDP — with that some support is provided to Hamilton’s sectoral shifts hypothesis.

In the 1980s, the concept of co-integration and error correction was being developed and refined (Engle and Granger 1987). The idea is based on the idea of the existence of some underlying long-term/equilibrium relationship among variables, which is manifested in the cointegration equation. The types of series investigated in detail by Engle and Granger were typical economic series, which generally exhibit a pattern of growth. The levels (values) in such series usually grow significantly over a period of time. GDP is an example, whether nominal or real. So is motor vehicle output. Granger had in 1974 called the strong statistical association of two series that both grow steadily over time as “spurious” regressions. Conceptually, the problem of spurious time series regressions can be solved by taking first differences, leading to a “stationary” series. As Cleary and Levenbach point out,
… when a regression model is performed on raw time series, it is not clear just what information will result. If both series have rising trend and corresponding strong seasonality, the regression will very likely show a very high R-squared statistic. Alternatively, if there is a strong underlying relationship between variables but their seasonal patterns differ, the regression may appear insignificant.

As a rule, data should be adjusted for those possible sources of variation in which one is not interested in order to study the relationships with respect to those forces whose effects are of primary interest.

In this paper, our primary interest is to determine whether there is some evidence in support of the sectoral shifts hypothesis, where it is asserted that there is a causal chain from energy price shocks (or some other shock) to motor vehicle output fluctuations to recessions, all occurring in a relatively short period of time – about four quarters.

Also of interest is the long-term relationship (the RMVO share of RGDP), and whether it is stable over the 1967.1 to 2008.1 period. In their earlier studies, neither Santini, nor Hamilton explicitly addressed this issue. However, the VEC model provides an amenable framework within which this issue may be addressed.

Engle and Granger proposed a methodology for testing whether two economic series had a tendency to remain at an equilibrium value (co-integration), by isolating the “errors” in the available statistical information about this equilibrium. We use a version of the recommended technique – vector error correction – that has recently become available in the SAS software (the VARMAX Procedure, SAS 2004).

As established by Engle and Granger in their seminal paper, a pure VAR model in the presence of cointegrated variables will be lead to a mis-specified system. According to Engle and Granger (p. 259), “vector autoregressions estimated with [cointegrated] data will be mis-specified if the data are differenced, and will have omitted important constraints if the data are used in levels.”

Over a 40 year period, it is possible that the motor vehicle output share of potential GDP may change and as a consequence the cointegrating relationship between RMVO and RGDPO is likely to change. Kouparitsis (2005), for example, tested several different methods of estimating the long term trend of GDP, to properly isolate “cyclical components” (errors, in Engle and Granger’s terminology) from the “trend component”. We do not address this issue in this paper but do recognize its importance.

A plot of the RMVO share of RGDP is shown in Fig. 1. Visual inspection indicates it ranges around 3.5%. The series is skewed. The skewness statistic reported by Excel is -0.87. Fitting a simple trend line to quarter number leads to an estimate that there has been a mild, but statistically significant upward trend in share of MVO in GDP over the last 40 years.
If in fact the RMVO share is increasing over time, the “opportunity cost” of increasing RMVO over time would fall, i.e., the change in RGDPO with respect to RMVO would become absolutely smaller.

![Graph showing the share of MVO in GDP over the sample period.](image)

**Fig. 1 Share of MVO in GDP over the sample period.**

Hamilton (1983) was able to establish an empirical link between oil price shocks and economic activity using quarterly data. Santini (1987) went further back in time, but was only able to use annual data, and had to combine and splice data from different sources. Behavior during WWI and WWII presented confounding behavior in the series that Santini used, so he constructed “peacetime” series and examined sub-periods between the two World Wars. Compared to the earlier efforts of Hamilton and Santini, the RMVO series provide us with a more recent data series which contains more observations. Testing for instability between WWII and the OPEC era (as Hamilton initially did) will not be possible with this series. On the other hand, compared to the time of Hamilton’s sectoral shifts hypothesis there is now about twice as much data available.

In 1983, Hamilton estimated that oil price shocks had Granger-caused post WWII recessions up to that time. A concern that existed then and has remained in the years since is that the coefficients of oil shocks on macroeconomic aggregates are unstable. Considerable effort has been made using different functional forms to define what an oil shock is (Hamilton, 2003). Given the concern over coefficient instability, it seems appropriate that we consider this issue. Santini (1987), only testing for Granger causality, did not examine the magnitude of coefficients. However, he did look for consistency in
signs at consistent lags across sub-periods. He found that the consistency of statistically weak sub-period relationships led to statistically strong full period relationships. In other words, the length of the series (size of the sample) can be critical in the ability to estimate a consistent, but relatively widely spaced, intermittent relationship.

In this paper we confine our sub-period analysis to two periods of roughly equal lengths. These are the pre- and post-hypothesis periods, separated at 1988.2. As of this writing, there have been only two recessions since Hamilton stated the sectoral shifts hypothesis in mid 1988. The period before contains four.

In our prior paper we tested for the “Granger causal” influence of RMVO on RGDP. In an earlier presentation of our research, it was suggested that we remove RMVO from RGDP and test for the influence of RMVO on the rest of GDP. Accordingly, we have defined RGDP as RGDP(O) namely Real GDP Other than RMVO. By testing for the effect of RMVO on RGDP(O) within the context of a vector-error correction model, we simultaneously evaluate the effect of an “error correction” process on changes in RMVO and RGDP(O).

The vector error correction model underlying theses analyses explicitly assumes a long-run/equilibrium relationship between the contemporaneous values of RMVO and RGDP(O) (normalization is done using the RGDP(O) variable). At this point we are interested in the theoretical question of existence of a causal effect, the size and sign of coefficients for purposes of possible prediction, and the temporal consistency of the estimates between sub-periods.

Data Description

Our analysis covers the first-quarter of 1967 to first-quarter 2008 (U.S. Department of Commerce, Bureau of Economic Analysis, 2008a). Although both RMVO and RGDP are reported by the BEA, in most recent reports the RMVO series only goes back to the first-quarter of 1990. In order to extend RMVO back further, we needed to construct an alternative real motor vehicle output series using the nominal motor vehicle output and the motor vehicle price index (the index is equal to 100 in 2000). In doing so, we were able to extend the RMVO series back to the first-quarter of 1967.

Descriptive statistics of the data are shown in Table 1. The data set contains 165 observations. Average real domestic output (in 2000 dollars) is approximately $6,851 billion. Average RMVO is about $246 billion and RGDP(O) is approximately $6,605 billion. When looking at the overall economy in terms of real motor vehicle output vs. real GDP, RMVO constitutes on average about 3.6% of real GDP.

Over the 165 quarters covered, RMVO ranges from $76 (fourth-quarter 1970) to $451 (third-quarter 2005) billion and RGDP(O) from $3,355 (second-quarter 1967) to $11,327 (first-quarter 2008) billion.
Table 1 Simple Summary Statistics (Billions of 2000 $)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real GDP other than MVO</td>
<td>165</td>
<td>$6,605</td>
<td>$2,351</td>
<td>$3,355</td>
<td>$11,327</td>
</tr>
<tr>
<td>Real MVO (motor vehicle output)</td>
<td>165</td>
<td>$246</td>
<td>$97</td>
<td>$76</td>
<td>$451</td>
</tr>
</tbody>
</table>

Model Description

The working hypothesis is the importance of real motor vehicle output in the determination of economic activity in other sectors of the economy. It fundamentally rests on the idea that shocks to the system are importantly transferred through the motor vehicle sector with a time lag to other sectors of the economy.

In its simplest form, the model can be hypothesized as follows:\(^1\)

\[
RGDPO_t = \beta_0 + \beta_1 RMVO_t + \varepsilon_t
\]  

(1)

where \( RGDPO_t \) and \( RMVO_t \) denote real GDP less real motor vehicle and real motor vehicle output respectively. Equation (1) can be a satisfactory econometric representation of the long-run relationship between \( RGDPO \) and \( RMVO \) on the proviso that \( RGDPO_t \) and \( RMVO_t \) are either stationary or cointegrated and that \( \varepsilon_t \) is simple white noise (expectation of zero, constant variance and not autocorrelated). If equation (1) truly represents a long-term relationship in \( RGDPO \) and \( RMVO \) then \( \varepsilon_t \) may be viewed as a disturbance or shock moving \( RGDPO \) from its long-run relationship with \( RMVO \).

From period \((t-1)\) to period \(t\), the change in \( RGDPO \) and \( RMVO \) can be represented respectively by the following equations.

\[
\Delta RGDPO_t = \alpha_{10} + \alpha_{11}(RGDPO_{t-1} - \beta_0 - \beta_1 RMVO_{t-1}) + \tau_t
\]  

(2)

\[
\Delta RMVO_t = \alpha_{20} + \alpha_{21}(RGDPO_{t-1} - \beta_0 - \beta_1 RMVO_{t-1}) + \upsilon_t
\]  

(3)

The parameters \( \alpha_{11} \) and \( \alpha_{21} \) are the error correction coefficients, which measure the response of \( RGDPO_t \) and \( RMVO_t \) to the cointegrating error term, \( \varepsilon_t \) (R. Carter Hill 2008, 346-351). The model represented by equations (1), (2), and (3) fully describes a simple one-period lag model, but unfortunately, there is no guarantee that the one-period lag model is statistically the most appropriate. A more general error-correction model is represented by equations (4) and (5).

\(^1\) If \( RGDPO_t \) and \( RMVO_t \) are nonstationary, integrated of order one and cointegrated (R. Carter Hill 2008, 348)
After preliminary experiments with VAR models tested for various lag lengths, we chose to test and present a vector error-correction model represented by equations (1), (4), and (5), with $\rho = 5$ (Tables 2 and 3).

According to the cointegration rank test we find that the two series are cointegrated. Furthermore, it was determined that individually each was integrated of order one. Our tests indicate that there is bi-directional causality in the two series. The estimated error correction coefficients are -0.0123 in the $\Delta RGDPO$ equation as shown in Table 2 and 0.0036 in the $\Delta RMVO$ equation as shown in the Table 3 (the coefficient estimates associated with $RGDPO_{t-1}$). The estimates have the expected signs. However, the magnitude of the estimates indicate a rather slow adjustment process – only slightly more than a 1% correction in the difference in the lagged value of RGDPO and its cointegrating value will be made-up per quarter. The relatively small estimate for the error correction coefficient in the RMVO equation indicates that it does not respond strongly to the cointegrating error.

The spillover effect from the motor vehicle sector to other sectors seems to be substantial. The sum of the $\gamma_i$ coefficients (Table 2) is 1.13, implying that the cumulative effect of a sustained dollar increase in RMVO will be a $1.13 dollar increase in RGDPO. The net effect of the sustained dollar change in RMVO on itself over the next four quarters is negligible. Summing the $\tau_i$ coefficients (Table 3) leads to an estimate of an increase of future RMVO of $0.02 over four quarters in the event of a decline of $1 in the current quarter.
Table 2 Change in RGDPO caused by prior change in RMVO (1967.1 to 2008.1)

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Std Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>22.109</td>
<td>5.9348</td>
<td>3.73</td>
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<tr>
<td>RGDPO (t-1)</td>
<td>-0.0123</td>
<td>0.0041</td>
<td>N/A</td>
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<tr>
<td>ΔRGDPO (t-1)</td>
<td>0.1010</td>
<td>0.0814</td>
<td>1.24</td>
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<td>ΔRGDPO (t-2)</td>
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<tr>
<td>ΔRGDPO (t-3)</td>
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<td>0.0834</td>
<td>-0.94</td>
</tr>
<tr>
<td>ΔRGDPO (t-4)</td>
<td>-0.0735</td>
<td>0.0813</td>
<td>-0.90</td>
</tr>
<tr>
<td>RMVO (t-1)</td>
<td>0.4063</td>
<td>0.1363</td>
<td>N/A</td>
</tr>
<tr>
<td>ΔRMVO (t-1)</td>
<td>0.3813</td>
<td>0.2205</td>
<td>1.73</td>
</tr>
<tr>
<td>ΔRMVO (t-2)</td>
<td>0.1166</td>
<td>0.2251</td>
<td>0.52</td>
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<tr>
<td>ΔRMVO (t-3)</td>
<td>0.0860</td>
<td>0.2222</td>
<td>0.39</td>
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<tr>
<td>ΔRMVO (t-4)</td>
<td>0.5488</td>
<td>0.2134</td>
<td>2.57</td>
</tr>
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</table>

N = 165. Granger-causality Wald test Chi-sq. = 21.9; d.f. = 5; pr> chi-sq. = 0.0005
Portmanteau test: cross correlation of residuals to lag 6 Chi. Sq. = 4.96, pr> chi-sq. = 0.29
AICC = 12.73: Cointegration rank test using trace = 25.3 vs.5% critical value of 15.3.

Table 3 Change in RMVO caused by prior change in RGDPO (1967.1 to 2008.1)

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Std Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.4205</td>
<td>2.2902</td>
<td>1.93</td>
</tr>
<tr>
<td>RMVO (t-1)</td>
<td>-0.1171</td>
<td>0.0526</td>
<td>N/A</td>
</tr>
<tr>
<td>ΔRMVO (t-1)</td>
<td>-0.1673</td>
<td>0.0851</td>
<td>-1.97</td>
</tr>
<tr>
<td>ΔRMVO (t-2)</td>
<td>-0.0819</td>
<td>0.0869</td>
<td>-0.94</td>
</tr>
<tr>
<td>ΔRMVO (t-3)</td>
<td>0.0753</td>
<td>0.0857</td>
<td>0.88</td>
</tr>
<tr>
<td>ΔRMVO (t-4)</td>
<td>0.1535</td>
<td>0.0824</td>
<td>1.86</td>
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<tr>
<td>RGDPO (t-1)</td>
<td>0.0036</td>
<td>0.0016</td>
<td>N/A</td>
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<tr>
<td>ΔRGDPO (t-1)</td>
<td>0.0737</td>
<td>0.0314</td>
<td>2.35</td>
</tr>
<tr>
<td>ΔRGDPO (t-2)</td>
<td>0.0304</td>
<td>0.0319</td>
<td>0.95</td>
</tr>
<tr>
<td>ΔRGDPO (t-3)</td>
<td>-0.0256</td>
<td>0.0322</td>
<td>-0.80</td>
</tr>
<tr>
<td>ΔRGDPO (t-4)</td>
<td>-0.0256</td>
<td>0.0314</td>
<td>-0.82</td>
</tr>
</tbody>
</table>

N = 165. Granger-causality Wald test Chi-sq. = 17.2; d.f. = 5; pr> chi-sq. = 0.004
Portmanteau test: cross correlation of residuals to lag 6 Chi. Sq. = 4.96, pr> chi-sq. = 0.29
AICC = 12.73: Cointegration rank test using trace = 25.3 vs.5% critical value of 15.3.

The implied affect of a sustained $1 increase in past RGDPO (the sum of the $\theta_i$ coefficients in Table 3) is only a $0.05 increase in current RMVO. In the case of past RGDPO, a sustained $1 increase is a $0.12 increase (the sum of $\delta_i$ coefficients in Table 2) in RGDPO in the current quarter. Over the four quarters, the sum of the short run direct and indirect effects of past RGDPO on current RGDPO is estimated to be about $0.17 compared to the approximately $1.10 effect associated with past RMVO.

The fact that the two series are cointegrated is supportive of a long-run linkage between the two series, consistent with the conceptual structure of an I/O model. Fig. 2 illustrates how closely the two series have moved in the long run. It also illustrates that
the RMVO series is far more volatile than the RGDPO series. Despite its small share of real GDP, the extreme volatility of the RMVO series, along with the estimated effects, appears to give it a disproportionate effect on aggregate changes in the overall economy.

**Sub-Period Analysis**

We separate the sample into two sub-periods to examine the stability of coefficients. The first period is up to 1988.2, which is the period prior to Hamilton’s introduction of the sectoral shifts hypothesis. The second is the “post-hypothesis” period. Results for the post-hypothesis period are shown in Table 4 and 5. For the pre-hypothesis period the results are shown in Tables 6 and 7.

For the post-hypothesis sub-period, we fail to reject the hypothesis of no cointegration. Consequentially, the estimation of a VAR model would be more appropriate for that period. For both periods, the Granger-causality tests indicate bi-directional causality. When we examine the quantitative implications of the estimated coefficients (the sum of effects of $\gamma_i$ and $\tau_i$ coefficients) we also find that the implied cumulative magnitude of the indirect effect of a sustained dollar change of past RMVO has a considerably larger estimated effect on current RGDPO ($1.59 per dollar over four quarters) than does a sustained dollar increase in past RGDPO (sum of $\delta_i$ and $\theta_i$ coefficients) have on current RGDPO ($0.17 per dollar over four quarters). The cumulative impact estimates are similar to the full sample results. However, the estimated RMVO effects are larger.


Fig. 2 Growth of Motor Vehicle Output, Other GDP, and Total GDP, 1967-2007, (2000$)
Table 4 Change in RGDPO caused by change in prior RMVO (1988.2 to 2008.1)

<table>
<thead>
<tr>
<th></th>
<th>Coefficients</th>
<th>Std Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
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<td>Intercept</td>
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<td>3.54</td>
<td>0.001</td>
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<td>RGDPO (t-1)</td>
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<td>0.0110</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>∆RGDPO (t-1)</td>
<td>0.0597</td>
<td>0.1118</td>
<td>0.53</td>
<td>0.595</td>
</tr>
<tr>
<td>∆RGDPO (t-2)</td>
<td>0.3137</td>
<td>0.1153</td>
<td>2.72</td>
<td>0.008</td>
</tr>
<tr>
<td>∆RGDPO (t-3)</td>
<td>-0.0348</td>
<td>0.1164</td>
<td>-0.30</td>
<td>0.766</td>
</tr>
<tr>
<td>∆RGDPO (t-4)</td>
<td>-0.1582</td>
<td>0.1200</td>
<td>-1.32</td>
<td>0.192</td>
</tr>
<tr>
<td>RMVO (t-1)</td>
<td>0.3809</td>
<td>0.2760</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>∆RMVO (t-1)</td>
<td>0.2022</td>
<td>0.3667</td>
<td>0.55</td>
<td>0.583</td>
</tr>
<tr>
<td>∆RMVO (t-2)</td>
<td>-0.0127</td>
<td>0.3450</td>
<td>-0.04</td>
<td>0.971</td>
</tr>
<tr>
<td>∆RMVO (t-3)</td>
<td>0.2620</td>
<td>0.3229</td>
<td>0.81</td>
<td>0.420</td>
</tr>
<tr>
<td>∆RMVO (t-4)</td>
<td>0.8130</td>
<td>0.3002</td>
<td>2.71</td>
<td>0.009</td>
</tr>
</tbody>
</table>

N = 80. Granger-causality Wald test Chi-sq. = 12.65; d.f. = 5; pr> chi-sq. = 0.0269
Portmanteau test: cross correlation of residuals to lag 6 Chi. Sq. = 7.65, pr> chi-sq. = 0.11
AICC = 12.82: Cointegration rank test using trace = 6.65 vs.5% critical value of 15.34.

Table 5 Change in RMVO caused by change in prior RGDPO (1988.2 to 2008.1)

<table>
<thead>
<tr>
<th></th>
<th>Coefficients</th>
<th>Std Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.8059</td>
<td>5.8126</td>
<td>-0.31</td>
<td>0.757</td>
</tr>
<tr>
<td>RMVO (t-1)</td>
<td>-0.1722</td>
<td>0.1042</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>∆RMVO (t-1)</td>
<td>-0.0975</td>
<td>0.1385</td>
<td>-0.70</td>
<td>0.484</td>
</tr>
<tr>
<td>∆RMVO (t-2)</td>
<td>0.1048</td>
<td>0.1303</td>
<td>0.80</td>
<td>0.424</td>
</tr>
<tr>
<td>∆RMVO (t-3)</td>
<td>0.0433</td>
<td>0.1220</td>
<td>0.36</td>
<td>0.724</td>
</tr>
<tr>
<td>∆RMVO (t-4)</td>
<td>0.2794</td>
<td>0.1134</td>
<td>2.46</td>
<td>0.016</td>
</tr>
<tr>
<td>RGDPO (t-1)</td>
<td>0.0068</td>
<td>0.0041</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>∆RGDPO (t-1)</td>
<td>0.0957</td>
<td>0.0422</td>
<td>2.27</td>
<td>0.027</td>
</tr>
<tr>
<td>∆RGDPO (t-2)</td>
<td>-0.0442</td>
<td>0.0436</td>
<td>-1.01</td>
<td>0.314</td>
</tr>
<tr>
<td>∆RGDPO (t-3)</td>
<td>-0.1066</td>
<td>0.0440</td>
<td>-2.43</td>
<td>0.018</td>
</tr>
<tr>
<td>∆RGDPO (t-4)</td>
<td>0.0486</td>
<td>0.0452</td>
<td>1.07</td>
<td>0.287</td>
</tr>
</tbody>
</table>

N = 80. Granger-causality Wald test Chi-sq. = 14.51; d.f. = 5; pr> chi-sq. = 0.013
Portmanteau test: cross correlation of residuals to lag 6 Chi. Sq. = 7.65, pr> chi-sq. = 0.11
AICC = 12.72: Cointegration rank test using trace = 6.65 vs.5% critical value of 15.34.

For the pre-hypothesis sub-period, the hypothesis of no cointegration is rejected. As in the post-hypothesis sub-period, the Granger-causality test indicates that there is bidirectional causality. When we examine the quantitative implications of the estimated coefficients (the sum of effects of $\gamma_i$ and $\tau_i$ coefficients) we also find that the implied cumulative effect of a sustained dollar increase in past RMVO has a considerably larger effect on current RGDPO ($1.41 per dollar over four quarters) than does a sustained dollar increase in past RGDPO (sum of $\delta_i$ and $\theta_i$ coefficients) on current RGDPO ($-0.11 per dollar over four quarters).
Table 6 Change in RGDPO caused by change in prior RMVO (1967.1 to 1988.1)

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Std Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>17.72</td>
<td>9.1757</td>
<td>1.93</td>
</tr>
<tr>
<td>RGDPO (t-1)</td>
<td>-0.0116</td>
<td>0.0068</td>
<td>N/A</td>
</tr>
<tr>
<td>ΔRGDPO (t-1)</td>
<td>0.0889</td>
<td>0.1235</td>
<td>0.72</td>
</tr>
<tr>
<td>ΔRGDPO (t-2)</td>
<td>0.0204</td>
<td>0.1256</td>
<td>0.16</td>
</tr>
<tr>
<td>ΔRGDPO (t-3)</td>
<td>-0.1211</td>
<td>0.1265</td>
<td>-0.96</td>
</tr>
<tr>
<td>ΔRGDPO (t-4)</td>
<td>-0.0895</td>
<td>0.1237</td>
<td>-0.72</td>
</tr>
<tr>
<td>RMVO (t-1)</td>
<td>0.4297</td>
<td>0.2516</td>
<td>N/A</td>
</tr>
<tr>
<td>ΔRMVO (t-1)</td>
<td>0.5918</td>
<td>0.3253</td>
<td>1.82</td>
</tr>
<tr>
<td>ΔRMVO (t-2)</td>
<td>0.2743</td>
<td>0.3291</td>
<td>0.83</td>
</tr>
<tr>
<td>ΔRMVO (t-3)</td>
<td>0.1474</td>
<td>0.3304</td>
<td>0.45</td>
</tr>
<tr>
<td>ΔRMVO (t-4)</td>
<td>0.4416</td>
<td>0.3253</td>
<td>1.36</td>
</tr>
</tbody>
</table>

N = 85. Granger-causality Wald test Chi-sq. = 12.4; d.f. = 5; pr> chi-sq. = 0.0299
Portmanteau test: cross correlation of residuals to lag 6 Chi. Sq. = 5.73, pr> chi-sq. = 0.22
AICC = 12.86: Cointegration rank test using trace = 16.45 vs.5% critical value of 15.34

Table 7 Change in RMVO caused by change in prior RGDPO (qtr 1967 I to 1988 II)

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Std Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>6.6131</td>
<td>3.2921</td>
<td>2.01</td>
</tr>
<tr>
<td>RMVO (t-1)</td>
<td>-0.2170</td>
<td>0.0903</td>
<td>N/A</td>
</tr>
<tr>
<td>ΔRMVO (t-1)</td>
<td>-0.0251</td>
<td>0.1167</td>
<td>-0.22</td>
</tr>
<tr>
<td>ΔRMVO (t-2)</td>
<td>-0.1585</td>
<td>0.1181</td>
<td>-1.34</td>
</tr>
<tr>
<td>ΔRMVO (t-3)</td>
<td>0.1273</td>
<td>0.1186</td>
<td>1.07</td>
</tr>
<tr>
<td>ΔRMVO (t-4)</td>
<td>0.0120</td>
<td>0.1167</td>
<td>0.10</td>
</tr>
<tr>
<td>RGDPO (t-1)</td>
<td>0.0059</td>
<td>0.0024</td>
<td>N/A</td>
</tr>
<tr>
<td>ΔRGDPO (t-1)</td>
<td>0.0542</td>
<td>0.0443</td>
<td>1.22</td>
</tr>
<tr>
<td>ΔRGDPO (t-2)</td>
<td>0.0781</td>
<td>0.0451</td>
<td>1.73</td>
</tr>
<tr>
<td>ΔRGDPO (t-3)</td>
<td>0.0476</td>
<td>0.0454</td>
<td>1.05</td>
</tr>
<tr>
<td>ΔRGDPO (t-4)</td>
<td>-0.0449</td>
<td>0.0444</td>
<td>-1.01</td>
</tr>
</tbody>
</table>

N = 85. Granger-causality Wald test Chi-sq. = 12.0; d.f. = 5; pr> chi-sq. = 0.0354
Portmanteau test: cross correlation of residuals to lag 6 Chi. Sq. = 5.73, pr> chi-sq. = 0.22
AICC = 12.86: Cointegration rank test using trace = 16.45 vs.5% critical value of 15.34

With respect to coefficient stability, with the exception of one value, the $\gamma_i$ coefficients are consistently positive. The fourth quarter coefficient is consistently the largest. The $\theta_i$ coefficients are consistently small, and have inconsistent signs at longer lags. The cumulative effects over four quarters are illustrated in Fig. 3.
Do changes in motor vehicle output cause recessions?

The statistical evidence from Table 2 does not itself prove that the estimated relationship is a cause of recessions. In order to determine whether this is the case, one needs to examine exactly when declines in motor vehicle output occur relative to recessions. Since there remains considerable unexplained variation in RGDPO, the pattern that establishes the statistical linkage could well be uncorrelated with the timing of recessions. Although we recognize that this question might be explored via use of multiplicative dummy variables to separate out time intervals immediately before and during the peak to trough decline and post trough recovery period, at this point we address this question graphically. This approach has advantages for communication purposes. Many readers unfamiliar with state-of-the-art statistics can grasp the implications of a graph, especially when the effect seems relatively clear. In our 2008 paper we discussed the patterns of movement of annual values of RMVO and RGDP for each recession, but we did not graphically separate out the recessions. Here we use quarterly data, and pull out the quarters around the six recessions since 1967.

We start the plot for each recession at five quarters before the quarter containing the peak month of the recession (National Bureau of Economic Research, 2006). In order to investigate whether recovery from a recession seems likely to result from recovery of motor vehicle output, we extend the time interval two quarters beyond the quarter containing the trough month of the recession. Of course we also include all quarters during the peak to trough period. To assure visual standardization, we index the output
values to a single base quarter for each recession. That base quarter is the quarter within the five quarters prior to the peak where the peak in RMVO occurs. As it turns out, RMVO always peaks before the peak in RGDPO, which is a pattern consistent with Granger causality (the past causes the present), and Table 1 results. Thus, for each of the series, the values plotted are the ratio of the current quarter value for the series to the base quarter value. All series have a value of 1.0 for the base quarter. Results are shown in Fig. 4.

In every case, for the quarter in which RMVO first begins to decline, RGDPO is increasing. In five of the six cases the value of RGDPO increased in the quarter just prior to the quarter in which RMVO began to decline. In every case, the value of RGDPO was increasing two quarters prior to the quarter in which RMVO began to decline. For the only exception, which was itself an unusually timed recession (1981-82), the sum of changes of RGDPO for the two quarters before the initial drop in RMVO were strongly positive. For recessions, this pattern is clearly inconsistent with the standard explanation that when income begins to decline consumers first and most significantly cut back on consumption of durable goods. Rather, declines in the output of motor vehicles (a particular kind of durable good) start without a decline in RGDPO. Fig. 4 shows that the pattern is for RMVO to decline first, often well in advance of the eventual peak month before the recession. RMVO also declines dramatically on a percentage basis, relative to RGDPO. In all six cases RMVO has reversed its sharp decline and increases dramatically in the two quarters after the recession trough.

Fig. 4 Index Values of Motor Vehicle Output, Other and Total GDP for Six Recessions
Since we have plotted only recessions in Fig. 4, we have not shown that the absence of recessions is associated with the absence of significant declines in motor vehicle output. Nevertheless, study of Fig. 2 vs. Fig. 4 will show that this is the case. A feature of Fig. 4 that is relatively clear is that the two recessions since 1988 should have been relatively mild, since the declines in RMVO for those recessions was considerably less dramatic than for the average recession prior to 1988. In fact, the 2001 recession is recognized as having been particularly mild. Inspection of the data on changes in RMVO suggests that persistent, cumulatively large declines of RMVO over multiple quarters cause recessions. As this paper is written, the value of RMVO for the second quarter of 2008 has just been published (U.S. Department of Commerce, Bureau of Economic Analysis, 2008b) RMVO had already declined for two consecutive quarters through the first quarter of 2008. The preliminary estimates indicate that the decline in 2008 II was more rapid than for the prior two quarters. Inspection of cumulative values for consecutive quarterly declines for prior recessions suggests that the resulting cumulative decline from 2007 quarter 4 through 2008 quarter 2 will put the economy into recession. This is graphically illustrated in Fig. 5. Here we have examined and plotted the cumulative percent change in value of RGDP over a period of three quarters caused respectively by RMVO, RGDPO, and RGDP.

The computation is:

\[
\begin{align*}
\text{RGDP}_M & = 100 \times \frac{\text{RMVO}_t - \text{RMVO}_{t-3}}{\text{RGDP}_{t-3}} \\
\text{RGDP}_O & = 100 \times \frac{\text{RGDPO}_t - \text{RGDPO}_{t-3}}{\text{RGDP}_{t-3}} \\
\text{RGDP} & = 100 \times \frac{\text{RGDP}_t - \text{RGDP}_{t-3}}{\text{RGDP}_{t-3}}
\end{align*}
\]

Where:

\[
\begin{align*}
\text{RGDP}_M & = 3 \text{ quarter change in real GDP due to change in Motor vehicle output} \\
\text{RGDP}_O & = 3 \text{ quarter change in real GDP due to GDP change Other than motor vehicles} \\
\text{RGDP} & = 3 \text{ quarter change in real GDP}
\end{align*}
\]

Presented in this fashion, it is clear that the direct contribution of changes in RMVO to GDP is much smaller in total than from changes in the rest of the economy. Our vector error correction estimates do indicate a relatively large short term effect of RMVO “errors” from cointegrated trend on the rest of the economy. The statistical tests presented are a relatively straightforward linear first estimate.

Functional form experiments testing for the presence or absence of effect of oil prices on the economy have been done repeatedly since Hamilton’s original findings in 1983. Examination of theoretically logical alternative formulations (nonlinear, different time intervals, multi-variate tests) might actually increase the strength and/or certainty of
the estimated effect\(^2\). For example, Santini (1987) found that energy and money together reinforced the incremental explanatory power associated with the prior univariate tests for each separately.

If fluctuations in RMVO are indeed the primary cause of recessions, the plot in Fig. 5 suggests that the U.S. had not reached a recession inducing drop in RMVO as of 2008 quarter 1. For the weakest of the six recessions (2001), the cumulative decline of RMVO for a three quarter total was larger than had taken place by 2008 quarter 1. Fig. 5 clearly shows that there were no cumulative 3 quarter declines in RMVO as large as (or larger than) for the 2001 recession, aside from other recessions. The relatively low values of \( \text{RGDP}_{\Delta M} \) since about 2003 are consistent with the weak performance of the economy in that period compared to the 1990s. These low values during this period were actually indications of temporary success in the face of rising gasoline prices.

When statistical tests of the effect of oil and/or gasoline prices on RMVO are completed, the period from 2002 to 2005 may be an anomaly that could worsen an estimated univariate fit. Real gasoline prices did increase steadily from 2002, with cumulative increases greater than the two year increases preceding the 1990-91 and 2001 recessions (Energy Information Administration, 2008). During this time, auto manufacturers both took advantage of very low interest rates set by the Fed, and also accepted lower profits per large vehicle. McManus (2005) argued that, by taking these steps, manufacturers of cars and light trucks probably only temporarily forestalled and dampened the now apparently inevitable consequences of rising gasoline prices. In light of the gasoline price increases in this interval, McManus’ analysis may prove to provide an important explanation of an anomaly in apparent (lack of) reaction of consumers to gasoline price increases. McManus closed his paper by suggesting that “suppliers with technologies or products that can improve fuel economy should be able to gain sales and profits as concern about higher gasoline prices continues to influence consumers.” The implication that the problem of rising gasoline prices would continue was prescient, as was the call for motor vehicle manufacturers to prepare products with greater fuel efficiency.

\(^2\) Many economists may prefer to construct models using logarithmic transforms of RMVO and RGDPO, particularly those who normally do analyses in terms of elasticities. As Kouparitsas (2005) points out, “economists generally do not work with the level of GDP, but instead prefer to work with the log of GDP (log GDP)”. On the other hand, the logarithmic form may be regarded as less interpretable for conveying information for economists who generally use input-output analysis. The form used in this paper would facilitate comparison to input/output multipliers. Similarly, for public policy analysts, the form used here allows one to present to a legislator an estimate of the dollar benefits of a dollar of funds injected into the economy. Such a form of presentation is likely to be more broadly comprehensible than an elasticity estimate. Finally, forecasters may simply evaluate alternative functional forms in terms of expected accuracy of the forecast (see, for example, Lacivita and Seaks, 1988). We have done one test of a full period model with logarithmic transforms of RMVO and RGDPO and find no reason to alter the broad interpretations of the statistical, graphical and deductive findings in the paper. One difference we noted that may be of later interest is an estimate that it is certain that RMVO is weakly exogenous using the logarithmic transform, while this conclusion is not supported using the levels form of the model in the paper.
These closing comments on the 2002 to 2005 time interval highlight the fact that we do not anticipate that construction of a univariate vector error correction model of Granger causality of crude oil and gasoline on RMVO will be as successful as our tests of causality of RMVO on RGDPO. We have argued that the causes of the observed RMVO shocks to the economy are likely complex. We anticipate that multivariate models including gasoline cost, interest rates, technology shocks, strikes, and marketing strategies would be desirable, if not necessary, to understand how and why RMVO shocks are initiated, or avoided.

Summary and Conclusions

The modified sectoral shifts hypothesis, as partially tested here, is supported by the results. Past changes in the real dollar value of motor vehicle output (RMVO) were estimated to statistically significantly have a positive relationship with subsequent values of real GDP other than that of motor vehicles (RGDPO), for VAR models from one to five quarters (not presented). However, consistent with arguments made by Engle and Granger (1987), a vector error correction regression, with four lags, was chosen for presentation here. The concept of cointegration, adapted from Engle and Granger, was discussed. This is a tendency for two variables to have an equilibrium relationship that will be returned to aftershocks to the system. The possibility of an equilibrium share of RMVO within RGDP was examined in Fig. 1. The RMVO and RGDPO series were
estimated to be cointegrated over the full period. The 40 year pattern was illustrated in Fig. 2.

Unlike our prior results, where the evidence for Granger causality from RMVO to RGDPO was weak, the tests conducted here indicated that RMVO Granger causes RGDPO, with a very high degree of certainty for the full period, and with a normally used degree of certainty for two sub-periods.

The estimated coefficients of RMVO on RGDPO appeared relatively stable across two sub-periods (Tables 4 and 6, Fig. 3). Thus, there is no evidence of change of the tested part (second step in the chain of cause) of the sectoral shifts relationship since it was originally proposed by Hamilton. If there was any notable change, it was that the estimated strength of the relationship slightly increased.

Since the statistical model alone cannot prove that RMVO is a cause of recessions, we constructed a graphical investigation only of the six recessions within our study period, starting with five quarters prior to the peak quarter before the recession, as determined by the National Bureau of Economic Research (Fig. 4). Examination of the pattern of RMVO vs. RGDPO and RGDP led to the intuitive deduction that it is very probable that changes in RMVO cause recessions. By investigation of quarters prior to the start of declines in RMVO, we deduced that changes in RGDPO prior to recessions have not initiated the declines in RMVO that clearly did precede (and very probably caused) recessions.

It was noted that the statistical investigation of the relationship of motor vehicle output to other GDP is in its infancy. While the straightforward initial models were very supportive of the hypothesis that there is a causal link, it is nevertheless possible that the most properly specified link is different than implied by these initial tests. For example the time periods over which the effects occur do not necessarily have to be estimated for quarters or for years. Investigation of half year, or three quarter intervals may more accurately reveal the true relationship. Effects may be nonlinear. They may differ for decreases in RMVO vs. increases.

Examining one of the many possibilities, we constructed a graph (Fig. 5) of cumulative changes in RGDP over three quarters, as caused by changes in RMVO (RGDPΔM) and RGDPO (RGDPΔO) respectively. Evaluation of the patterns of change of this graph suggested that the magnitude of RGDPΔM up to the first quarter of 2008 was not sufficient to induce a recession. However, recent BEA estimates of the change of RMVO in 2008 quarter 2 appear to put our intuitive RMVO cumulative change indicator into the recession inducing range. The pattern of RGDPΔM values was consistent with weak, but positive RGDPΔO from about 2003 through 2007. We noted that the period from 2002 to 2005 experienced gasoline price increases that should otherwise have put the U.S. into recession in about 2005 or 2006. However, as noted by McManus, this was a time interval when a combination of unusually low interest rates and other motor vehicle manufacturer incentives was successful in keeping RMVO from a multi quarter cumulative decline such as that observed over the last three quarters.
This paper does not complete the test of Hamilton’s hypothesis. In order to do so, it will be necessary to show that oil prices rapidly cause changes in real motor vehicle output (i.e. within a few quarters). The time frame of the estimates here, four quarters, does allow for the possibility that the effect of oil prices on motor vehicle output can occur within the four quarter time window necessary for Hamilton to be correct. With regard to Santini’s hypothesis that motor vehicle output is a more important cause of GDP fluctuations than just prices of fuel used by motor vehicles, it would be necessary for the explanatory power of the effect of motor vehicle output on other GDP to be greater than the explanatory power of oil prices (or changes in gasoline expenditure shares) on other GDP.

When intuitively investigating behavior specific to recessions, the theory that changes in RGDPO are positively related to changes in RMVO was rejected. Statistically, results implied that if there is a positive short term effect of a positive shock to RGDPO on RMVO, it is weak and unreliable (Tables 3, 5 and 7). Thus, since the evidence here is that motor vehicle output is causally related to recessions, it is implied that a generic stimulus package not specifically directed toward motor vehicles will be considerably less effective in eliminating a recession than one designed to increase motor vehicle output. A paper by Walter McManus covering the period ~ 2002 to 2005 raised the issue of design of a stimulus package specific to motor vehicle manufacturers — whether a short term escape of a recession without necessary long-term adaptation would be (or was) desirable.

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**References**


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3 Our initial investigation with the logarithmic transformation of RMVO and RGDPO provides a second possible change of implications (in addition to the evidence for weak exogeneity of RMVO mentioned in the prior footnote). The full period $\theta_t$ coefficients are positive in the first three lags, and statistically significant in the first two. Such a result – that past RGDPO should have some positive effect on present RMVO – is consistent with economic theory and logic. Nevertheless, the quantitative effects on RMVO remain quite small and do not imply any change to overall findings. We have not yet completed subperiod tests.


23