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ECONOMICS, SUPPLY CHAIN SHIFTS, AND THE ROLE OF AUTOMOTIVE TPOs

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Presented by:

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ABSTRACT

The volatile global and U.S. macroeconomic situations have become key factors affecting the N. American auto industry, the associated plastics supply chain, and automotive TPOs.

This paper will examine the implications for automotive TPOs, olefinic thermoplastic vulcanizates (o-TPVs), and PP compounds of:

- Changes in vehicle demand, fleet mix, and fuel economy legislation in N. America
- New TPO materials and fabrication technologies that are adapting to the challenges and opportunities of the automotive marketplace
- An autoplastics supply chain structure being driven by rapid paradigm shifts, U.S. marketplace economics, dollar devaluation, penetration by non-domestic suppliers and globality. (Ref. 1)

ECONOMIC IMPACTS

Some of the key economic factors affecting the autoplastics supply chain and TPOs are shown in Exhibit 1 and include:

U.S. and Global Real GDP Growth – U.S. GDP growth has declined since 2004 (Exhibit 2). The spread of GDP slowdown to other global regions starting in mid-2008 is creating further headwinds for the U.S. economy. U.S. GDP growth is also affected by the export of $700BN petrodollars/yr. to oil-rich regions.

Dollar Deflation – The dollar has been in a long-term decline against a trade-weighted basket of currencies (Exhibit 3). This decline, in addition to global demand increases and supply limitations, is partly responsible for the increase in petroleum costs. Deflation of the U.S. dollar is also encouraging non-U.S. automotive OEMs and Tier 1s to invest in N. American production facilities. The mid-2008 slight rebound of the U.S. dollar, resulting from the spillover of the U.S. credit crisis to other global regions, is accelerating investment in U.S. production facilities by offshore OEMs and Tier 1s in the hopes of offsetting import losses and being in place before a potential reversal of the dollar's decline. (Ref. 2)

Credit Crunch – The convulsions in the U.S. home mortgage market have contributed to the difficulty of obtaining credit and eroded consumer purchasing power. The decline in residual value of poor fuel economy leased vehicles has led to a sharp reduction in leasing offerings by the 3 domestic OEMs and this has further contributed to vehicle sales declines.

Inflationary Pressures – In the first half of 2008, U.S. inflation was at an unexpectedly high 3.1%, and this has also impacted vehicle sales. Inflationary pressures have spread to other global regions.

Wage Gap – In contrast to the Euro zone, where unions are stronger and there is an upward wage-price spiral, U.S. wages have not kept up with inflation as shown in Exhibit 4. This erosion of earning power in combination with a U.S. vehicle offering mix not suited to current and likely continued high fuel costs (crude oil at $90-150/barrel for the foreseeable future) has further contributed to the decline of vehicle sales in N. America. Exhibits 5 and 5-A show the relationship between GDP growth and N. American vehicle production.

Rising Fuel Costs/Fuel Efficiency – The combination of the steep rise in fuel costs throughout 2007 and 2008 and the low fuel efficiency of N. American vehicles (Exhibits 6, 7, 7A) as compared to European and Japanese vehicles have resulted in a major shift in both vehicle sales and mix of the N. American sales fleet toward smaller, more fuel efficient vehicles as shown in Exhibit 8.

Corporate Average Fuel Economy (CAFE) – The belated 40% increase in U.S. fuel economy requirement (to 35 mpg by 2020) legislated in the U.S. in May 2008:

- Is modest compared to existing fleet fuel economy performance in other global regions
- Is likely to be exceeded by high fuel prices driving consumer demand for even better fuel economy than mandated
- Can be met via a variety of low cost automotive alternatives (e.g., smaller vehicles, continuously variable transmissions [CVTs], tire design, hybrids)
- Will increase the value of weight savings ($/lb. saved) and the use of TPOs and PP compounds in easily achieved weight saving applications (e.g., substitution for steel in crosscar beams, down-gauging wall thickness) rather than more expensive, longer-term developments such as plug-in vehicles based on lithium ion battery technology. (Eventually the lithium ion battery will stimulate demand for impact copolymer polypropylene to be used in the battery casing.)

THE AUTOMOTIVE MARKET

Global Vehicle Sales History and Outlook (Exhibit 9) – Global vehicle sales since 1990 have grown at a rate of about 2.6%/year, relatively unaffected by a variety of global crises (wars, recessions, financial crashes). The growth of purchasing power in the BRIC countries (Brazil, Russia, India, China) had been expected to continue to boost global vehicle sales at a somewhat higher rate in the next few years despite market stagnation in N. America and W. Europe, but even these high growth regions have seen demand slowdown in 2008. This will cause a slowing of global vehicle sales growth.

Regional Auto Production Shifts – The shift in global vehicle production towards Asia (with China in the lead [Exhibits 10, 11]) has shifted autoplastics investment and R&D focus towards Asia (particularly China) to reflect the regional production shift. Unfavorable demographics (an aging population) as well as market saturation are favoring this vehicle demand shift away from the U.S. and Western Europe.

Auto Assembly Plants – N. American auto assembly plants were designed during a previous paradigm of relatively low raw material costs and high vehicle sales (16-17MM units/year). These single-vehicle plants are less flexible than European and Japanese assembly plants. As a result, the conversion of vehicle assembly plants to accommodate new fleet mix and fuel economy performance is relatively slow in N. America but is becoming a near-term focus of auto OEM investment.

Role of Non-U.S. Vehicle Designs – High fuel prices and taxation policies in Europe and Japan (see Exhibit 7) have resulted in more efficient vehicle designs in these regions. These designs are relatively polypropylene (PP) and TPO intensive (Exhibit 12) driven partly by the European End-of-Life Vehicle (ELV) legislation. Among the consequences of these more efficient vehicle designs will be:

- Increased vehicle imports to N. America (despite a devalued but very slightly recovering U.S. dollar)

- Investment by European and Asian OEMs, Tier 1s, and resin suppliers encouraged by the devalued dollar. (BMW, Mercedes, Hyundai, VW are examples.)

- Development of N. American vehicles based on European designs and associated shifts in materials usage (e.g., Ford will import six European vehicle designs)

- A rush by automotive OEMs to seek government subsidized loans to overhaul and retool assembly plants towards more fuel-efficient vehicle designs (many of which will emanate from Europe and Asia)

- Reduced vehicle profitability as fleet mix downshifts to smaller vehicles

- Accelerated growth of global platforms and multiple global manufacturing sites for the same vehicle (e.g., GM's Cruze made in Lordstown, OH; St. Petersburg, Russia; and Korea.)

- Development of global approvals and materials specifications (being pursued by the Detroit 3 OEMs)

AUTOPLASTICS DYNAMICS AND SUPPLY CHAIN RESPONSES

Raw Material Price Increases – Prices for all automotive raw materials (steel, plastic, rubber, glass) spiked sharply in 2008. One estimate (Ref. 1) is that the spike will be equivalent to $600-900/vehicle sold in N. America. The rapid increase in polyolefin-based resin costs (due primarily to monomer cost increases) shifted some resin production to Middle East locations, and:

- Sharply increased the costs of automotive TPOs
- Decreased the profitability of resin companies and Tier 1 and Tier 2 molders unable to pass on costs
- Caused legal disputes between OEMs and Tier 1s unable to meet contractual terms developed under a previous raw material cost scenario

Resin suppliers have been forced to seek resin price increases to offset monomer cost increases. Some purchasing contracts are now indexed to monomer costs, but other costs (e.g., energy transportation) have also increased, and the differential between monomer costs and resin selling prices continues to erode the profitability of TPO and PP resin suppliers.

Supply Chain Restructuring – Manufacturing inefficiencies that were acceptable in an earlier paradigm, in combination with macroeconomic pressures, are resulting in major restructuring of the automotive plastics supply chain (Exhibit 13), which will:

- Change the path to market for TPOs
- Stimulate TPO substitution
- Encourage the use of new resin and compound technologies
- Encourage the use of new fabrication technologies (Exhibit 15)

OEM Responses – OEMs have a broad range of potential responses to this challenging economic environment and the structural demand shift in the U.S. auto market. Among these are:

Trans-global Partnering: The globality (Ref. 1) of the auto market, increasing commonality of vehicle design, economic pressures, and technology differences between regions will result in an increase in trans-global joint ventures by OEMs (a possible Chrysler/Nissan J/V, for example) and increased investment in non-N. American production. This will result in increased transfer of autoplastics technology between regions and a further internationalization of the TPO supplier base. The import of kit cars is one possible partnering result that pressures the supply chain.

Loan Relief: Funding for retooling the N. American auto assembly base during a period of intense financial stress will be difficult. The energy bill passed by the U.S. Congress in December 2007 provided for low cost loans for retooling to produce more fuel-efficient vehicles (fuel efficient small cars [probably based on European/Japanese designs], hybrids, electric vehicles). The Detroit 3 are petitioning Congress to appropriate the funds (up to $50BN) under the Advanced Technology Vehicle Manufacturing Incentive Program. The funds would be available (at reduced interest rates) to all OEMs and parts suppliers with U.S. operations, but the Detroit 3 would be the major beneficiaries.

Pressuring the Supply Chain: OEMs are seeking further cost reductions from the supply chain via automotive solutions (reduced vehicle complexity, predictable production schedules, higher volume platforms) as well as seeking to benefit from improved manufacturing efficiencies from the autoplastics portion of the supply chain. Chrysler, for example, is seeking a 25% reduction in supply chain costs in the next three years.

Staff Reductions: N. American OEMs have made reductions in white collar staffing. These reductions, in combination with reductions in technical service and applications development by resin suppliers, compounders, and Tier 1s, raise the question of whether sufficient human resources remain to implement an adequate response to the new automotive market paradigm.

Upgrading Interiors and Paying for Weight Savings: OEMs have demonstrated willingness to pay for upgraded interiors. (The Malibu interior costs $35 extra, per Bob Lutz.) Paying more for weight savings to gain fuel efficiency is a likely next step.

Tier 1 Responses – Some typical responses by Tier 1s to the autoplastics supply chain shift include:

- Seeking Chapter 11 protection and exiting the market
- Unloading unprofitable, underutilized facilities
- Massive restructuring and layoffs (raises the question of whether sufficient technical and engineering depth remains to take on the coming challenge)
- Increasing globality (Ref. 1) in their manufacturing footprint to reduce costs, meet demands for global supply capabilities, and optimize sourcing
- In-house compounding
- Plant consolidation
- Shorter term, real time, indexed raw material purchase contracts
- Invest in automated assembly
- Increased use of process analysis before building tooling

Small Car Effects – The structural shift of the N. American fleet mix to smaller, more globally competitive vehicle designs will impact TPO and PP compound profitability and sales volume (Exhibit 14). Decreased TPO part size will impact resin sales volume (e.g., bumper fascia, instrument panels), but this will be partially offset by other factors that could potentially enhance profitability.

The China Price – “The China price" has been a bargaining tactic by OEMs in negotiations with the autoplastics supply chain. Manufacturing in China remains advantageous (Refs. 6, 7, 8, 13), but these advantages have been weakened recently by:

- Strengthening of the renminbi vs. the U.S. dollar (6.5% in 2008) from the former low levels set by the Chinese to encourage exports
- Increased labor costs in China (by 65% in the last 4 years [Ref. 1])
- Higher shipping costs (driven by container shortage, higher fuel costs)
- Slower ship speeds (to conserve fuel), which can add 20% to a formerly typical 4-week shipping time

One consequence of higher production and shipping costs from China has been a strengthening of interest in autoplastics manufacturing in Mexico and renewed interest in supplier parks similar to those found in Europe (most notably at VW and Ford).

AUTOPLASTICS TECHNOLOGY RESPONSES

The previous inefficiencies of the autoplastics supply chain can be partially offset by a combination of resin and fabrication technologies. Some examples of technology shifts in auto interiors are shown in Exhibit 15.

Two-shot Molding – Current methods for making instrument panels and door trim panels are inefficient with respect to:

- Multiple step process
- Use of multi-materials rather than a single material
- Difficulty of recycling
- High scrap rate
- High labor content
- Use of coatings

Multi-shot molding for small parts (e.g., toothbrushes, tools, small soft-touch parts for auto interiors) is well established to produce a:

- 3-layer vertical multilayer (e.g., skin/foam/substrate)
- 2-layer vertical multilayer (e.g., skin/substrate)
- Side-by-side hard/soft combination (e.g., fan shrouds and cowl vent seals)

Two-shot molding entered the large automotive parts market via door trim panels (e.g., Dodge Caliber 2007). The technology now is likely to enter the instrument panel sector and, as shown in Exhibit 16, has the capability to overcome many of the disadvantages of the incumbent processes. Flexible TPO formulations will play a key role in the surface layers and high stiffness TPOs or PP copolymers will be used in substrate compounds.

The use of 2-shot molding is an example of a combination of materials and fabrication process technologies to make the supply chain more efficient. Combining the skin and foam in one of the injection shots also opens the opportunity for the use of relatively high value multi-functional concentrates that combine foaming capability with other functions (e.g., color, surface properties, etc.).

In-line Compounding – is now used for making long-glass fiber reinforced thermoplastics (LGF-RTPs) directly at the injection press. The process relies upon a 2-stage machine combination – stage 1 for incorporating glass, stage 2 for injection molding. In-line compounding for either modifying TPOs or adding fillers reduces costs associated with conventional compounding operations.

In-house compounding by Tier 1s also offers material cost savings.

Increased Use of Reactor TPOs – Resin polymerization technology is becoming more sophisticated in its ability to tailor molecular architecture and provide a TPO directly from the reactor thereby avoiding a subsequent compounding step. The use of reactor TPOs in combination with molded-in color can provide cost savings, even for critical applications such as airbag doors and energy management applications. Reactor TPOs, after targeting perhaps premature applications, have, thus far, not made broad penetration into major target applications (e.g., bumper fascia) in N. America despite their widespread use in Europe.

Down Gauging of Average Wall Thickness in TPO Bumper Fascia – The volume of TPO used for bumper fascia will decline from current levels due to the reduced vehicle sales in N. America (Exhibits 5, 5A) and reduced part size on smaller vehicles. TPO demand will be further reduced by the strong drive to reduce bumper fascia thickness toward 2.5 mm from the current level of 2.8-3 mm. This reduction depends on both more sophisticated TPO formulations and more precise control during molding operations. Thicker moldings hide bosses and defects better than thin moldings.

Body Seal/Glazing Systems Substitution – The move toward systems has been underway for several years as a manufacturing cost saving strategy. The introduction of o-TPVs as a substitute for incumbent EPDM and the ability to co-extrude with rigid PP compounds offer the capability of producing an all-polyolefin system at a net cost, weight (replacing both metal and rubber), and energy savings, with recycling benefits.

Increased Use of Micro-talc in TPO and PP Formulations – The introduction of micro-talcs offers the capability of achieving substantially improved stiffness/impact balance and obtaining target properties at a lower talc concentration (Refs. 3, 5). The impact improvement at a given concentration is directly related to the particle size of the talc. In addition, improved surface quality is possible, allowing the production of exterior panels. The introduction of talc/TPO formulations for exterior panels is likely to be the next major growth spurt in exterior automotive TPO, particularly on smaller vehicles with relatively small fenders and an increased share of hatchback doors.

Growth of Injection Molded Foams – The technology for injection molding of TPO foams (both rigid and flexible) has advanced relatively slowly but is likely to be stimulated by the:

- Drive for weight savings
- Cost savings associated with process step reduction via 2-shot or other processes
- Development of more sophisticated multifunctional masterbatches
- Improved control of the pressure cycle during injection

Interior Semi-structural Substitutions – Elimination of the metal instrument panel crosscar beam via substitution of an LGF-PP integrated into the instrument panel structure is an example of the continued substitution potential of polyolefins.

“Green” Pressures – Pressures for reduced carbon footprint have shifted somewhat from materials selection to fuel economy. European materials and process selection have generally been more responsive to legislated environmental requirements (for example, European End-of-Life Vehicle [ELV] legislation), which will accompany the transfer of European vehicle designs to N. America.

SUMMARY

The N. American vehicle fleet mix and the associated supply chain evolved in response to favorable domestic conditions in profitable isolation from global trends and reached a market saturation point (close to one vehicle/eligible driver [Ref. 4]). Some of the supply/demand effects are summarized in Exhibit 17.

Global macroeconomics (crude oil prices, inflation, regional sales trends, raw materials prices) and U.S. domestic factors (inflation/wage gap, housing/financial crisis, credit crunch, dollar deflation) have resulted in steep vehicle sales declines and a paradigm shift in fleet mix requirements to serve a more fuel economy conscious market for which N. American OEMs and their supply chain were unprepared.

Recovery will require substantial investment, a shift in vehicle manufacturing infrastructure, and a shift toward globally competitive, fuel-efficient vehicles. The autoplastics supply chain is restructuring itself to survive in the new paradigm.

Automotive TPO sales volumes and profitability in N. America have declined and will be affected by the fleet mix shift. TPOs, o-TPVs, and PP compounds remain cost effective, easily recycled, lightweight systems solutions that can meet the requirements of the new paradigm. Their full potential has not been realized to date. Full realization of their potential will require:

- Capitalizing on the ability of TPOs/o-TPVs and PP resins to be tailored to meet functional requirements and be combined in 2- or 3-step processes into recyclable parts
- Further consolidation of an inefficient supply chain
- Reduction in the number of unit operations to produce plastics assemblies
- Further penetration of thermoset rubber applications
- Implementation of recently developed resin and compound technologies
- Investment in cost saving fabrication technologies
- Ability to operate on a global scale to gain the benefits of high volume, global platforms

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AUTHORS' BIOs

ROBERT ELLER is President of Robert Eller Associates LLC (REA), a firm specializing in consulting to management of the plastics and rubber industries. His company has offices in Akron, Ohio (U.S.), France and China.

Automotive plastics is one of the consulting specialties of REA. Bob and his associates have carried out numerous technology, strategy, and manufacturing analyses, pricing forecasts, product positioning analyses, and market analyses in the autoplastics fabrication industry in N. America, Europe, Japan and China. His firm has completed a global technical, economic, and market multiclient analysis of the TPE sector in N. America/Europe and China as well as multiclient studies of automotive interiors and advanced technology nonwovens in automotive applications. Other specialties include compounding, engineering thermoplastics, thermoplastic elastomers and polyolefins in the broad range of markets. His languages include French, Spanish and Hungarian.

Mr. Eller is a graduate of M.I.T. (Chemical Engineering) and has an M.S. from Brooklyn Polytechnic in Polymer Science and Chemical Engineering. Employment experience includes ExxonMobil, A.D. Little (1966-1981), Phillip Townsend Associates, Charles River Associates (Vice President), Multibase (a French/U.S. compounding company [General Manager]) and Robert Eller Associates LLC (President, 1991 – Present).

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CHRISSTINA WARDELL is an REA research associate. She has contributed to REA analyses of PP markets, property positioning of PP resins, TPOs, TPEs in China, and the analysis of macroeconomic effects on the autoplastics supply chain. In addition to English, Ms. Wardell is fluent in Spanish, and liaisons with REA's operations in France and Spain. She has a B.S. degree in International Business from The University of Akron.

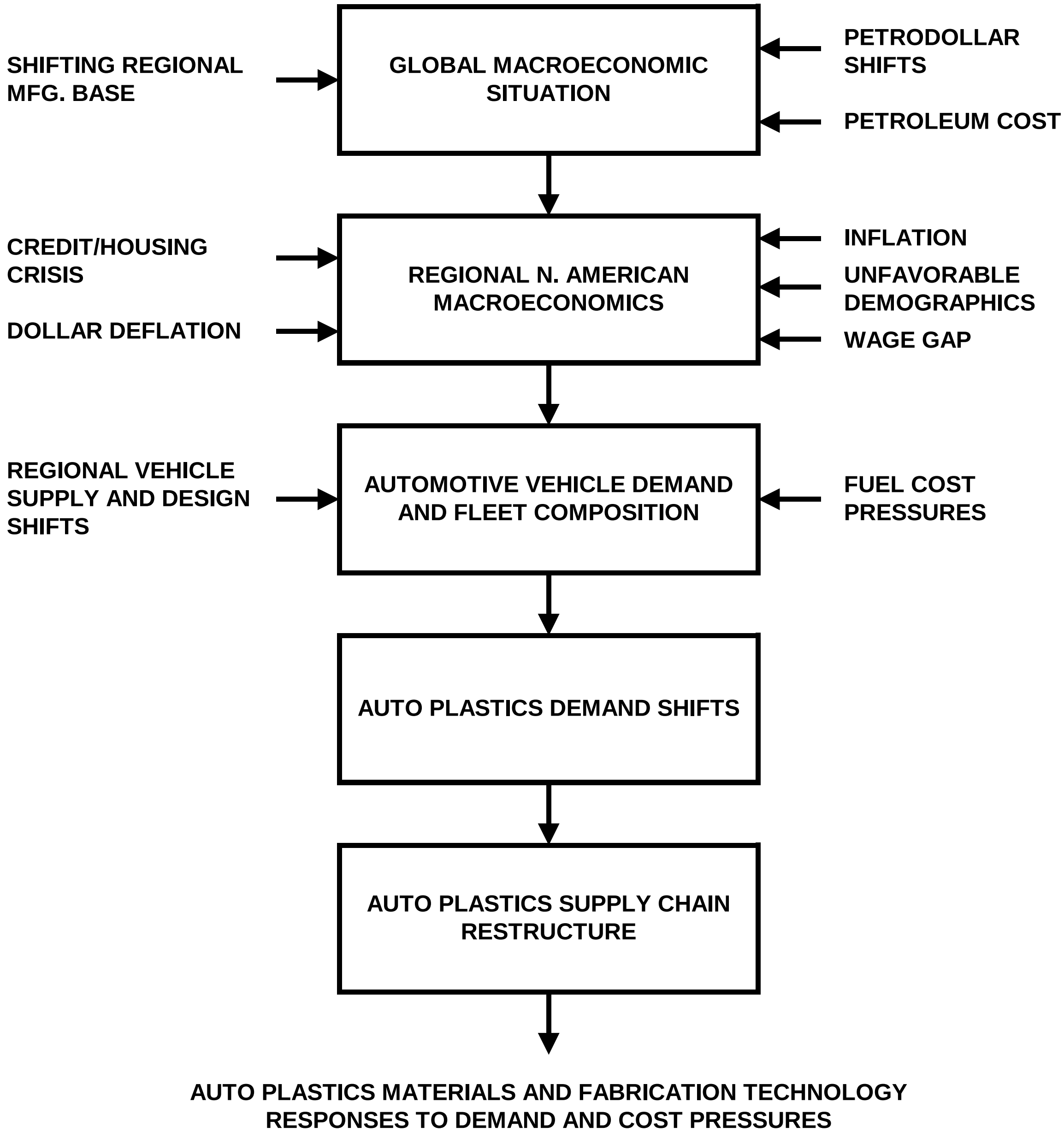
APPENDIX A

ABBREVIATIONS USED IN THIS PAPER

BRIC	–	Brazil, Russia, India, China
c-TPO	–	compounded TPO
CAFE	–	Corporate Average Fuel Economy (U.S.)
CAGR	–	compound annual growth rate
CVT	–	continuously variable transmission
ELV	–	End-of-Life Vehicle legislation (in Europe)
GDP	–	gross domestic product
LGF-PP	–	long-glass fiber polypropylene
LGF-RTP	–	long-glass fiber reactor thermoplastic
o-TPV	–	olefinic TPV
PP	–	polypropylene
r-TPO	–	reactor TPO
TPO	–	thermoplastic polyolefin

EXHIBIT 1

INTERACTION BETWEEN GLOBAL MACROECONOMICS, N. AMERICAN AUTOMOTIVE DEMAND, AND PLASTICS TECHNOLOGY RESPONSE



SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008

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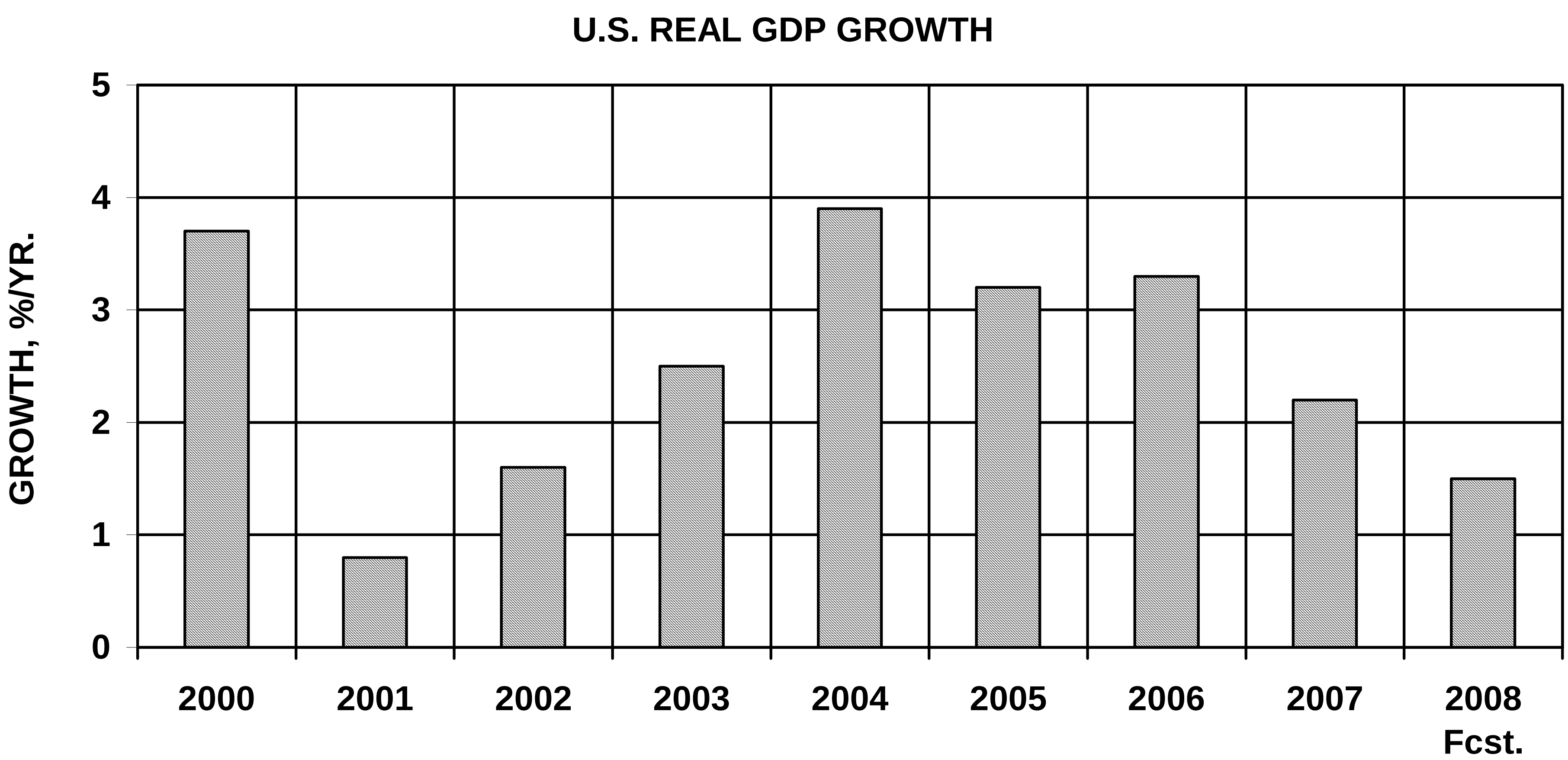
EXHIBIT 2



SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008

b/mydox/Auto Industry/US Vehicle Sales.xls

EXHIBIT 3

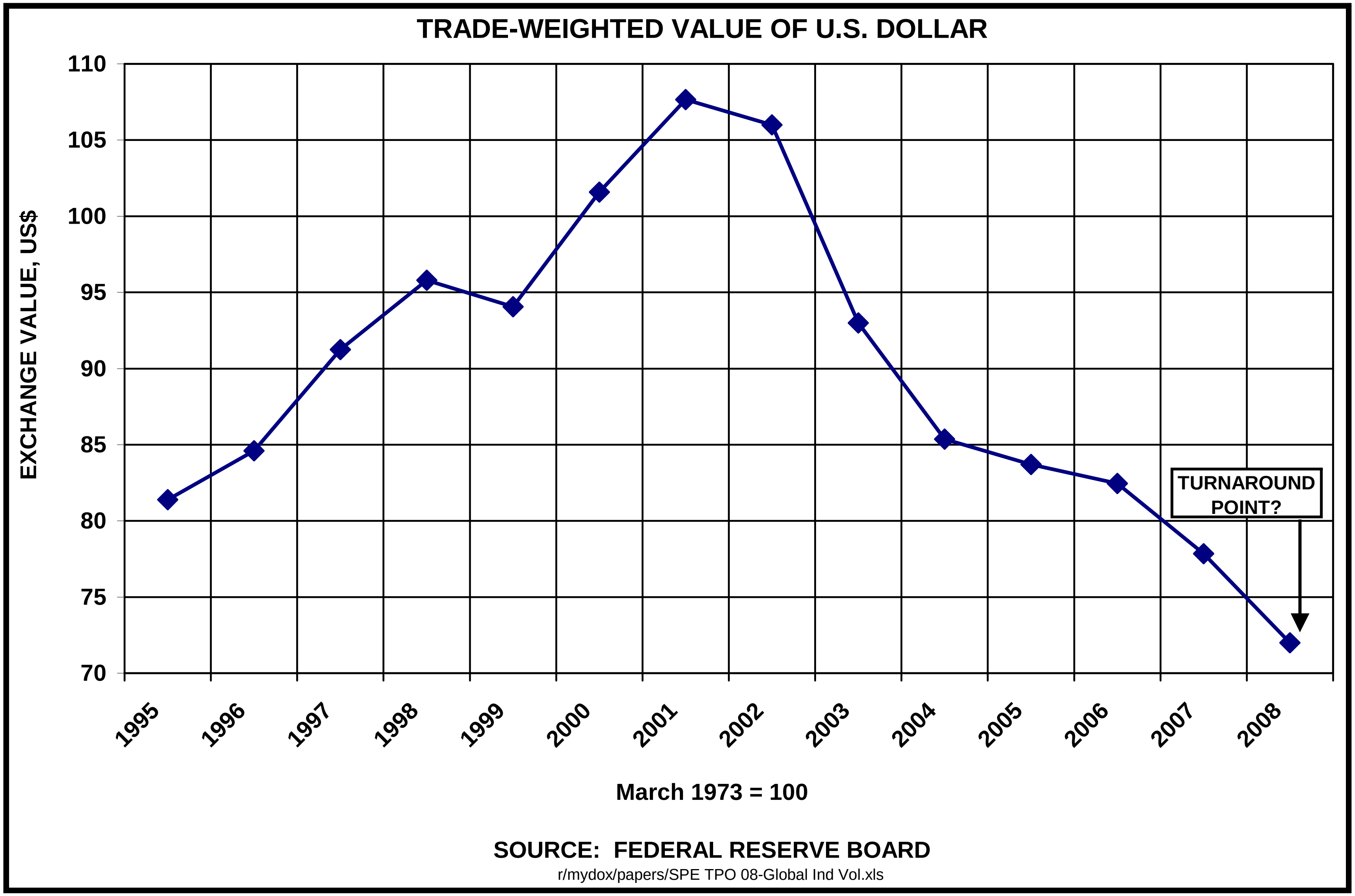

TRADE-WEIGHTED VALUE OF U.S. DOLLAR
EXCHANGE VALUE, US$
110
105
100
95
90
85
80
75
70
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
TURNAROUND POINT?
March 1973 = 100
SOURCE: FEDERAL RESERVE BOARD
r/mydox/papers/SPE TPO 08-Global Ind Vol.xls

EXHIBIT 4

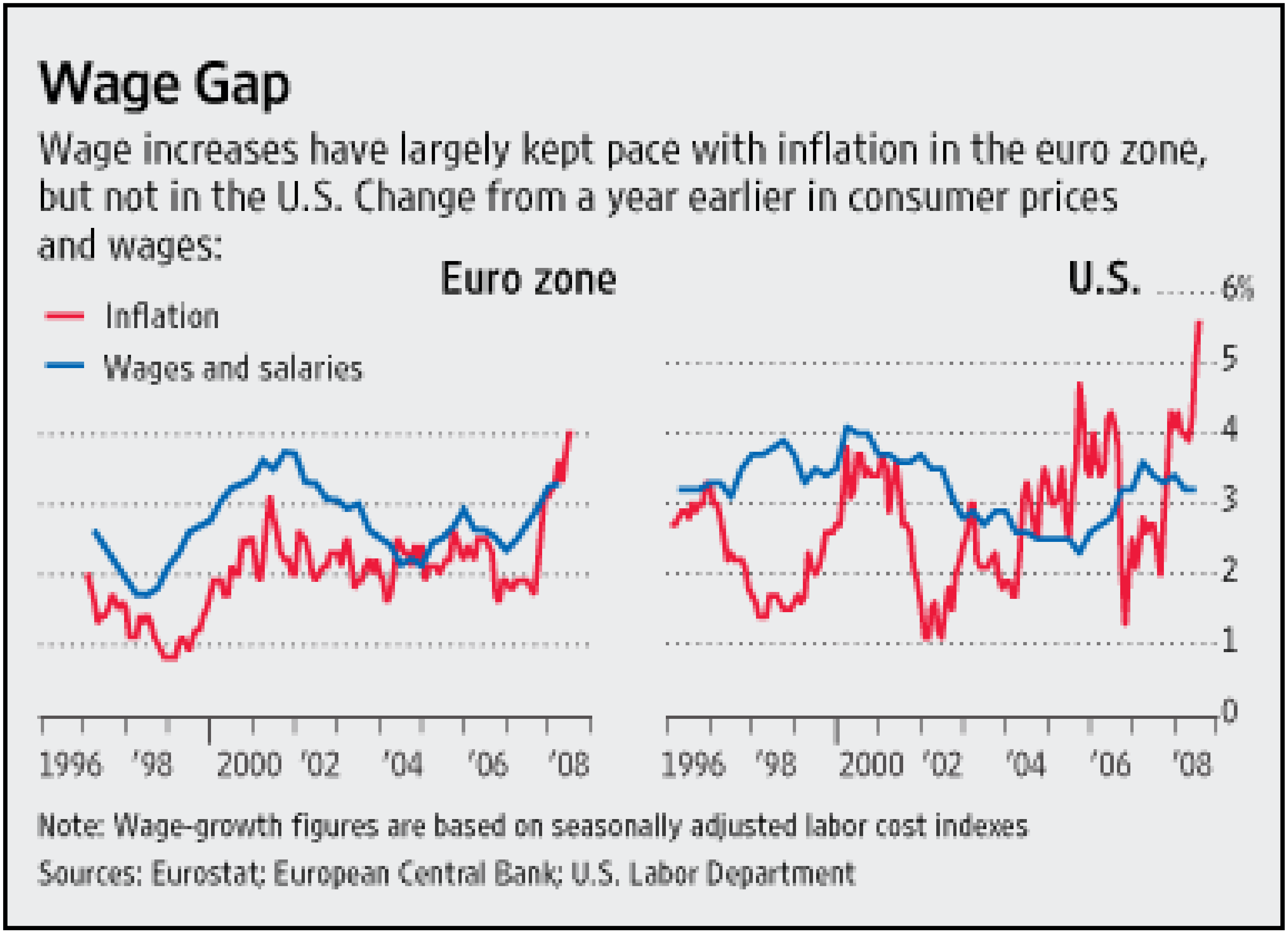

Wage Gap
Wage increases have largely kept pace with inflation in the euro zone, but not in the U.S. Change from a year earlier in consumer prices and wages:
Euro zone
U.S.
Inflation
Wages and salaries
6%
5
4
3
2
1
0
1996
'98
2000
'02
'04
'06
'08
1996
'98
2000
'02
'04
'06
'08
Note: Wage-growth figures are based on seasonally adjusted labor cost indexes
Sources: Eurostat; European Central Bank; U.S. Labor Department

EXHIBIT 5
U.S. GDP GROWTH RATE AND VEHICLE PRODUCTION

YEAR	GDP GROWTH RATE, %	N. AMERICAN VEHICLE PROD'N., MM UNITS	Y/Y PROD'N. DECLINE/GAIN, %	NOTE/EXAMPLE
2001	0.8			9/11 attack
2002	1.7			
2003	2.4	16.3	41.2	
2004	3.7	16.3	0.0	
2005	3.1	16.4	0.6	Profitability decline
2006	2.9	15.9	-3.0	Profitability decline, bailouts, consolidation
2007	2.2	15.5	-2.5	Profitability decline, bailouts, consolidation
2008	1.5	13.6	-12.0	Profitability decline, credit difficult to obtain, further acquisitions of distressed suppliers
2012		15.6		

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008
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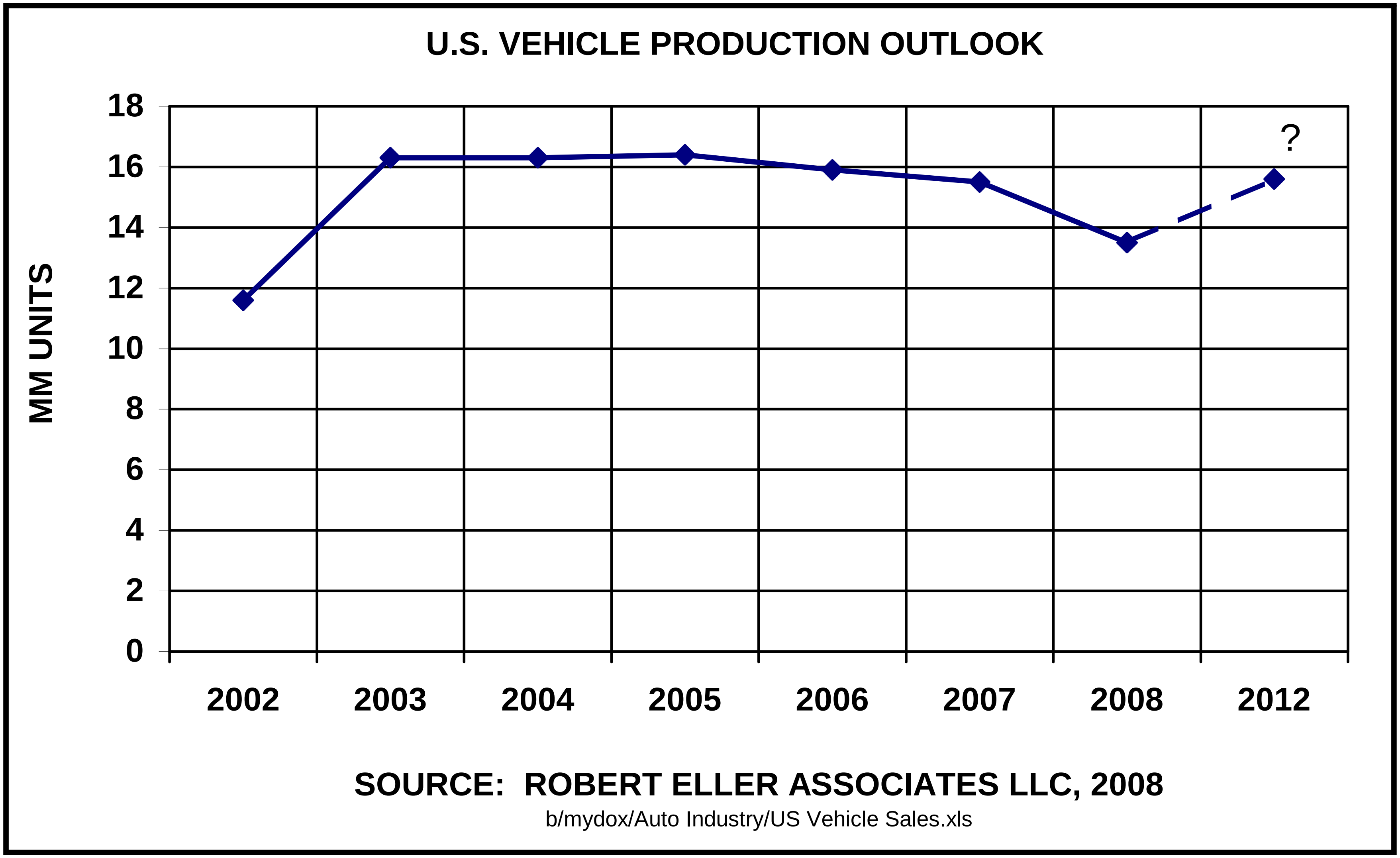
EXHIBIT 5A



U.S. VEHICLE PRODUCTION OUTLOOK
MM UNITS
18
16
14
12
10
8
6
4
2
0
?
2002
2003
2004
2005
2006
2007
2008
2012
SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008
b/mydox/Auto Industry/US Vehicle Sales.xls

EXHIBIT 6

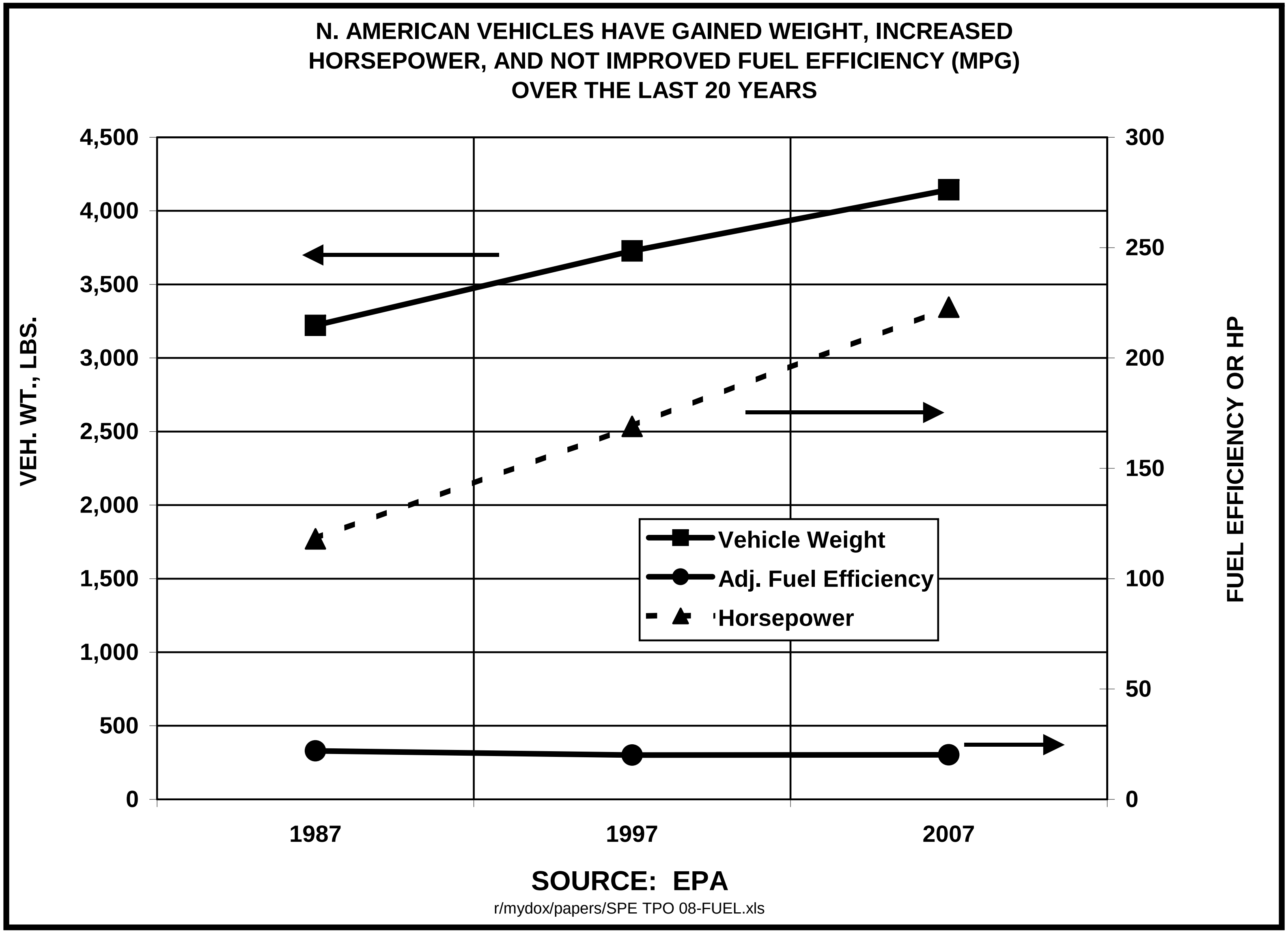

N. AMERICAN VEHICLES HAVE GAINED WEIGHT, INCREASED HORSEPOWER, AND NOT IMPROVED FUEL EFFICIENCY (MPG) OVER THE LAST 20 YEARS
VEH. WT., LBS.
FUEL EFFICIENCY OR HP
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
300
250
200
150
100
50
0
1987
1997
2007
Vehicle Weight
Adj. Fuel Efficiency
Horsepower
SOURCE: EPA
r/mydox/papers/SPE TPO 08-FUEL.xls

EXHIBIT 7

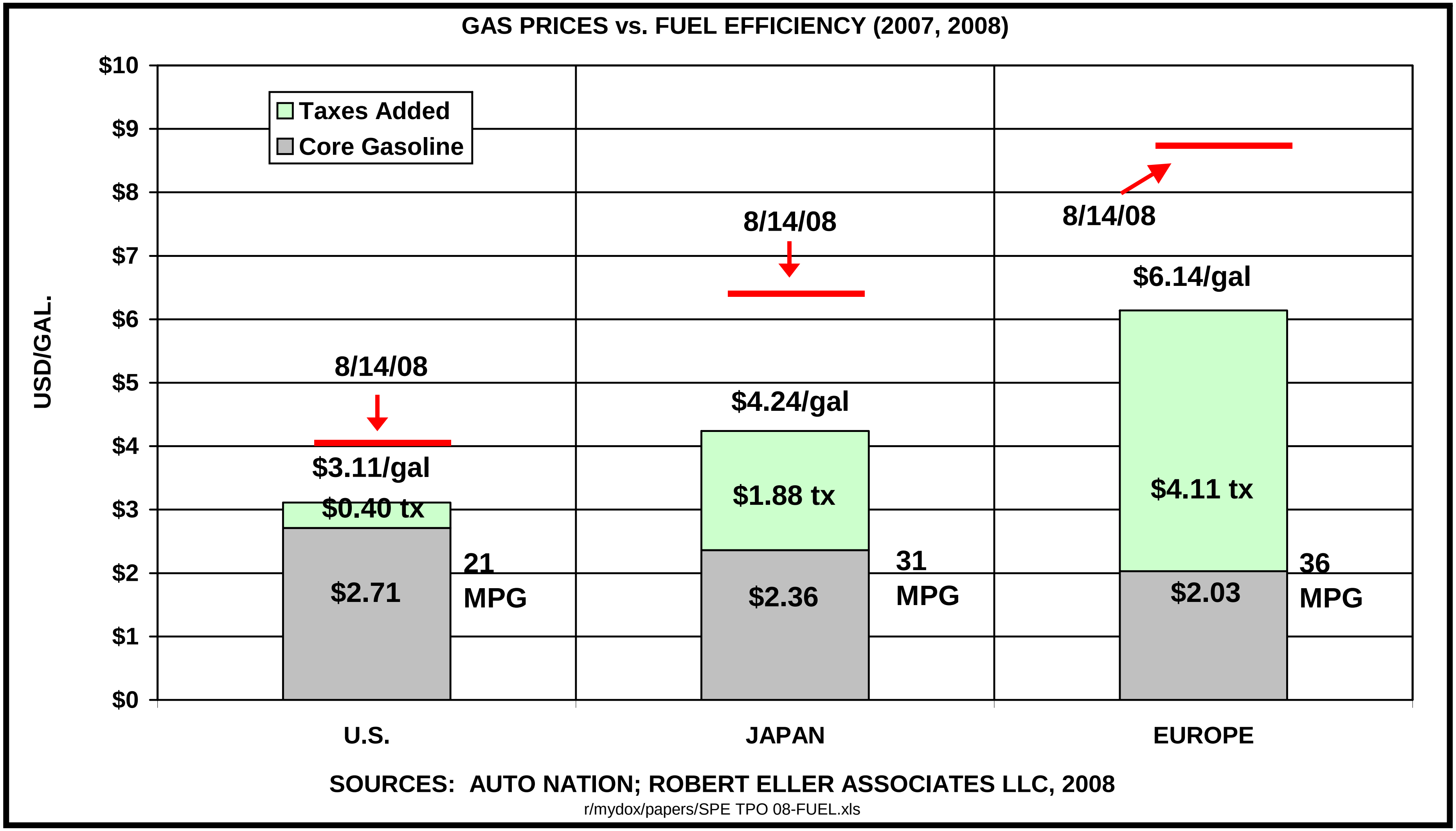

GAS PRICES vs. FUEL EFFICIENCY (2007, 2008)
USD/GAL.
$10
$9
$8
$7
$6
$5
$4
$3
$2
$1
$0
Taxes Added
Core Gasoline
8/14/08
$3.11/gal
$0.40 tx
$2.71
21
MPG
8/14/08
$4.24/gal
$1.88 tx
$2.36
31
MPG
8/14/08
$6.14/gal
$4.11 tx
$2.03
36
MPG
U.S.
JAPAN
EUROPE
SOURCES: AUTO NATION; ROBERT ELLER ASSOCIATES LLC, 2008
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EXHIBIT 7A

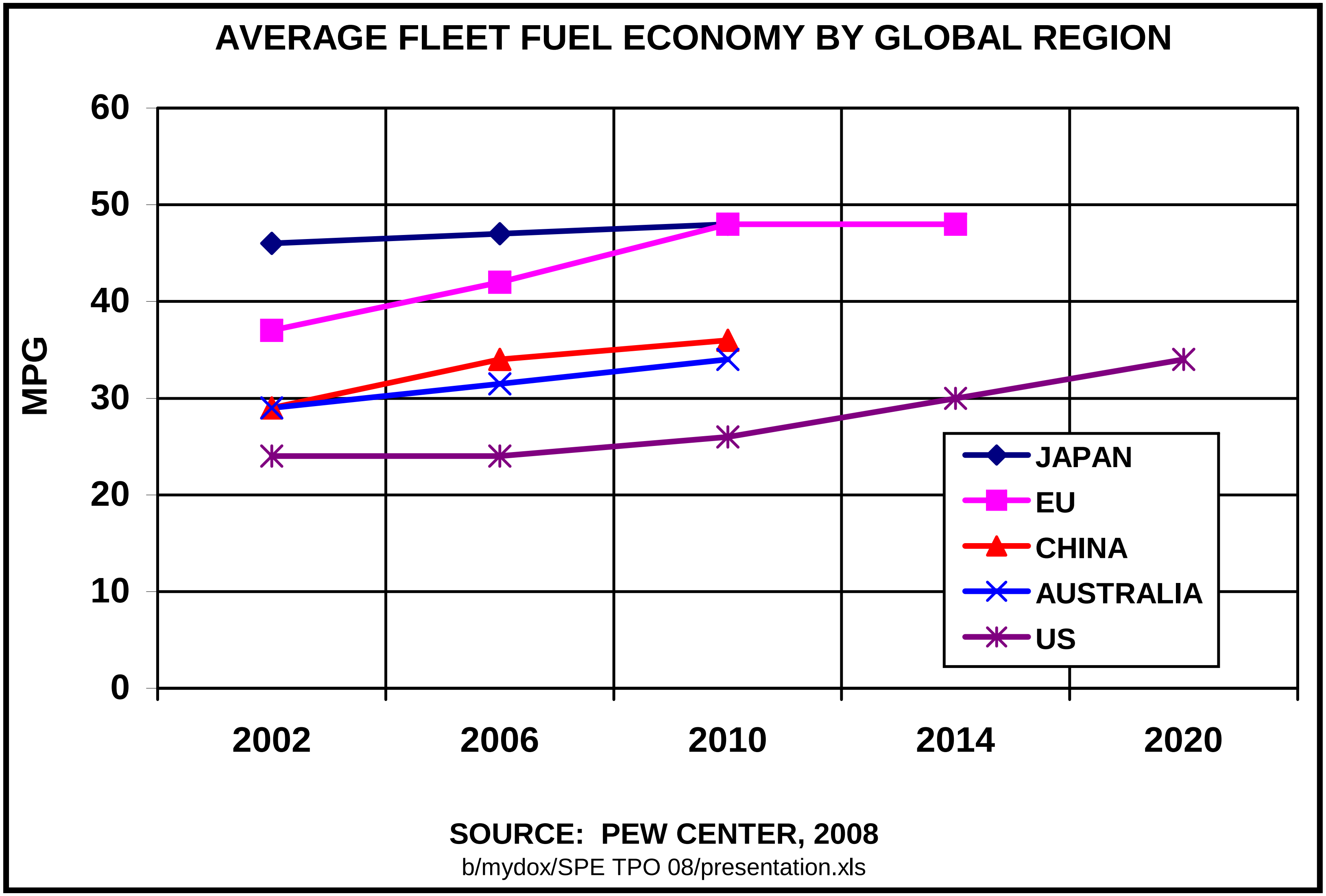
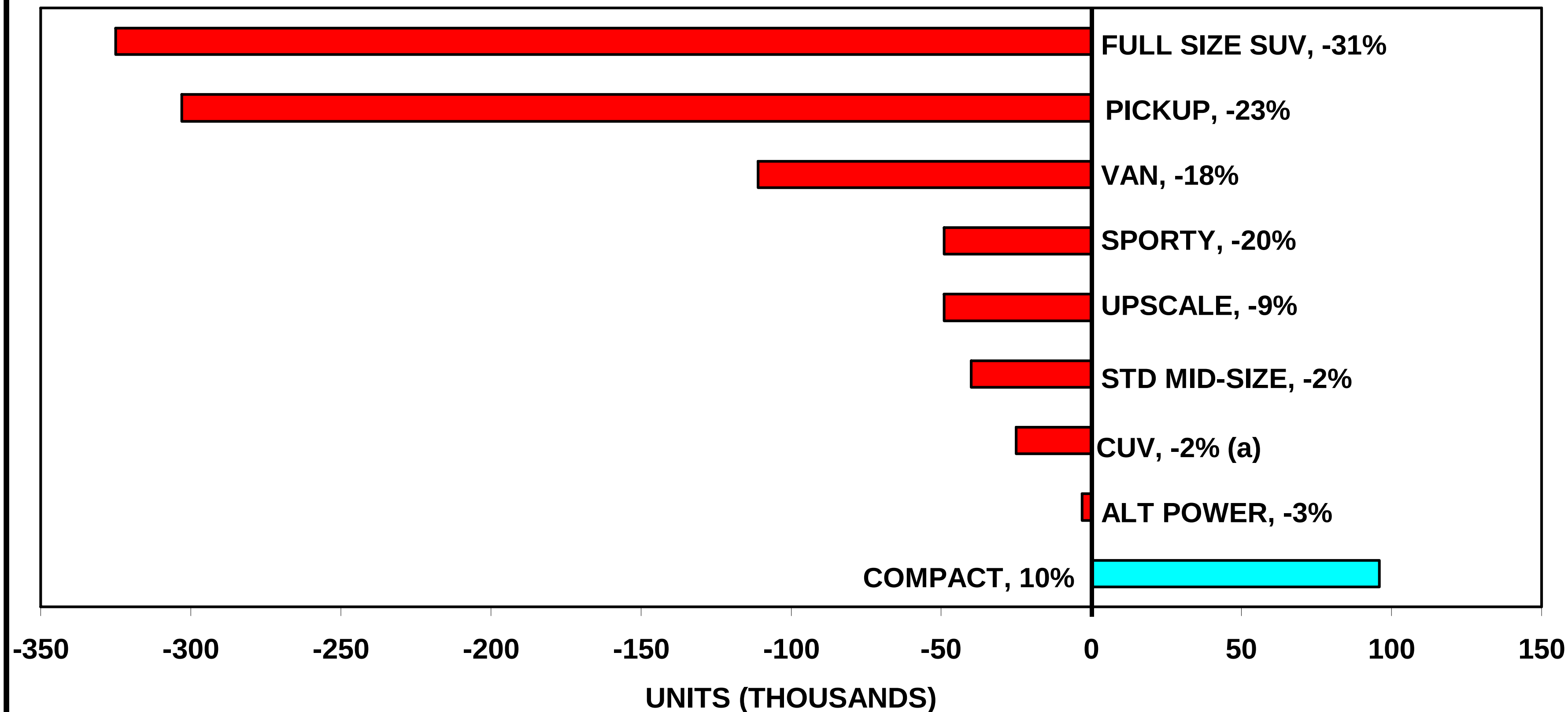

AVERAGE FLEET FUEL ECONOMY BY GLOBAL REGION
MPG
60
50
40
30
20
10
0
2002
2006
2010
2014
2020
JAPAN
EU
CHINA
AUSTRALIA
US
SOURCE: PEW CENTER, 2008
b/mydox/SPE TPO 08/presentation.xls

EXHIBIT 8

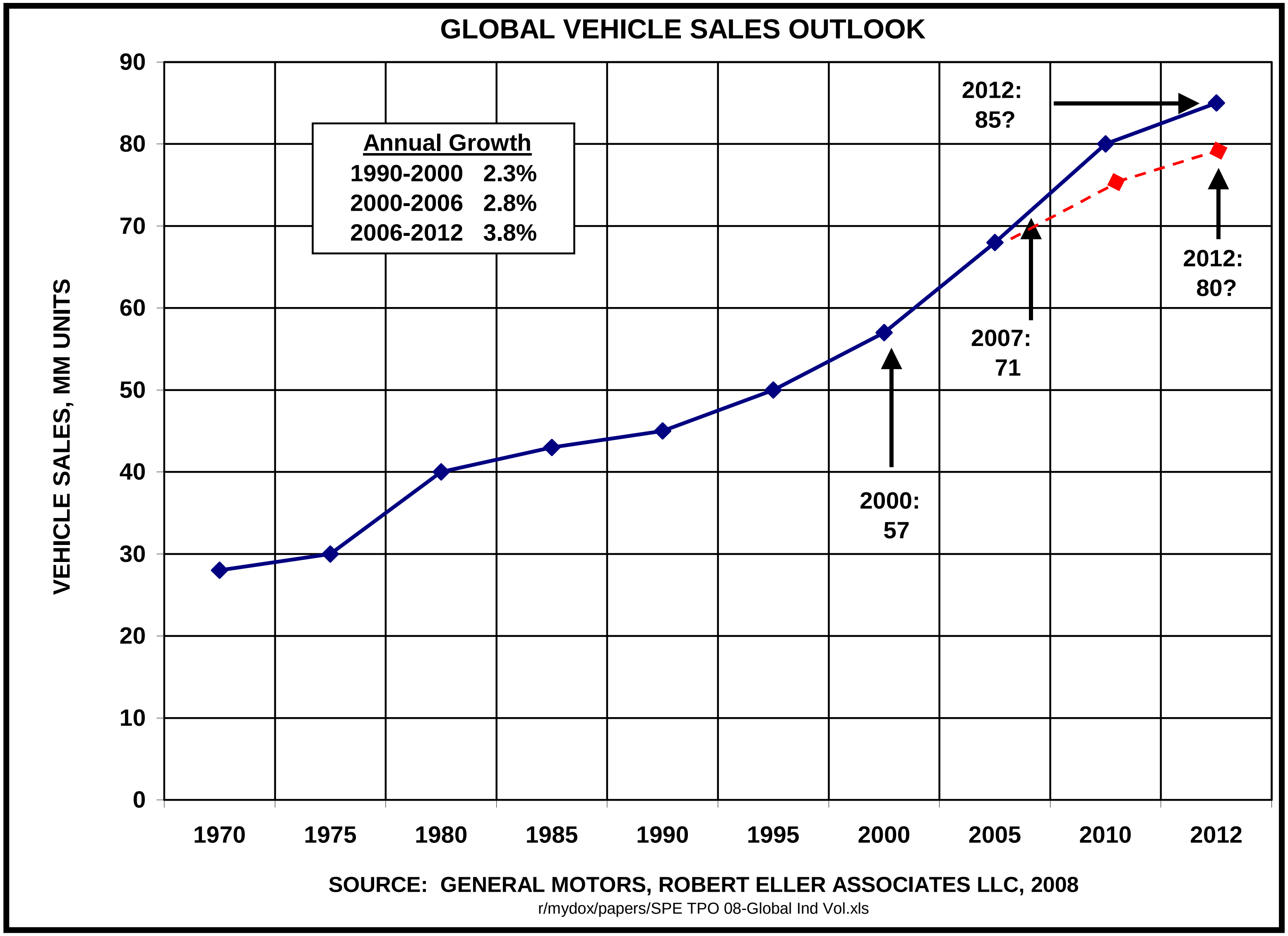
CHANGE IN U.S. VEHICLE SALES COMPOSITION, 2007-2008



NOTE: (a) Entry level CUVs gained 5.6% offset my midrange and premium CUV losses.

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008 b/mydox/Auto Industry/US Vehicle Sales.xls

EXHIBIT 9



GLOBAL VEHICLE SALES OUTLOOK
VEHICLE SALES, MM UNITS
0
10
20
30
40
50
60
70
80
90
1970
1975
1980
1985
1990
1995
2000
2005
2010
2012
Annual Growth
1990-2000 2.3%
2000-2006 2.8%
2006-2012 3.8%
2012: 85?
2012: 80?
2007: 71
2000: 57
SOURCE: GENERAL MOTORS, ROBERT ELLER ASSOCIATES LLC, 2008
r/mydox/papers/SPE TPO 08-Global Ind Vol.xls

EXHIBIT 10

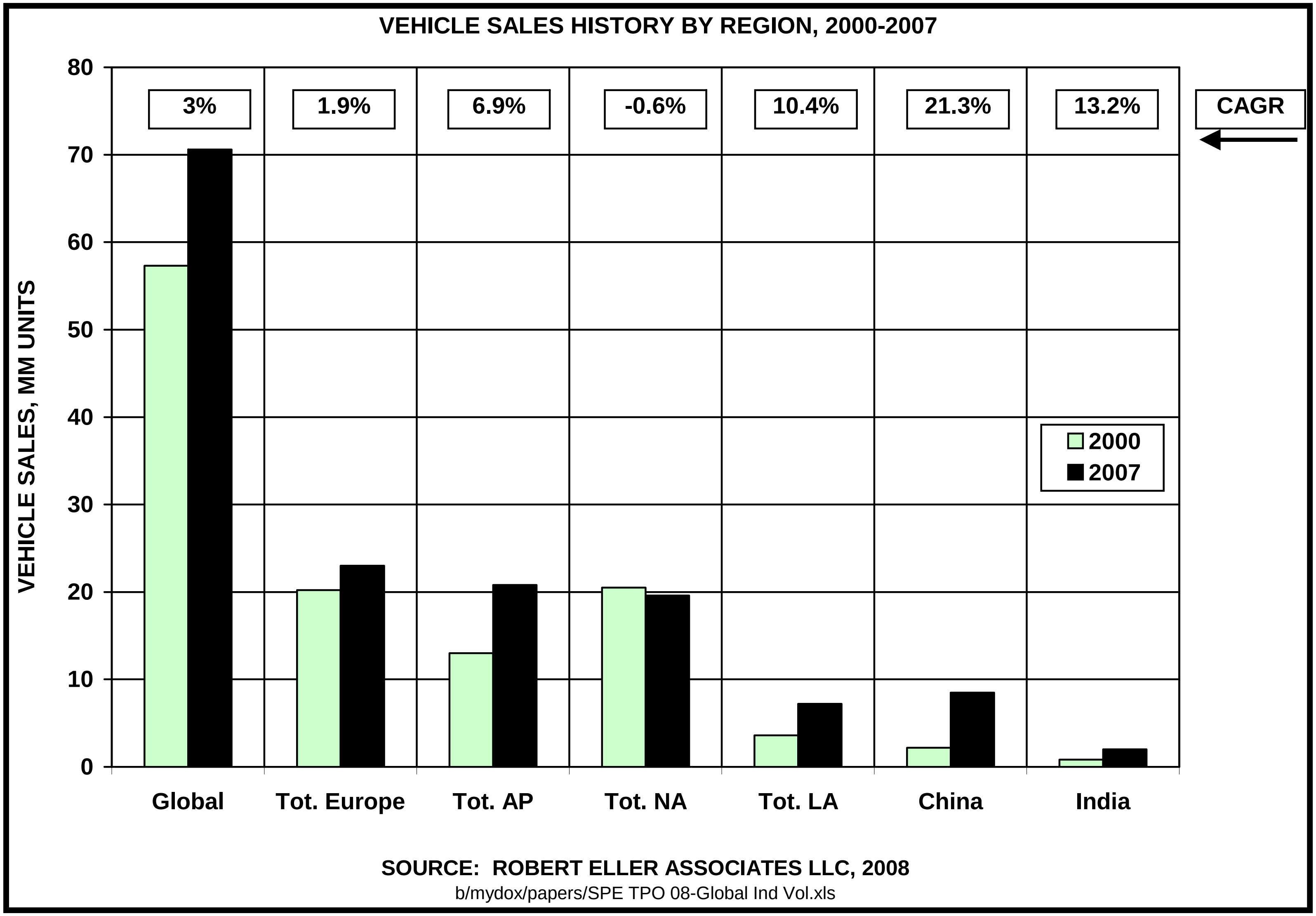
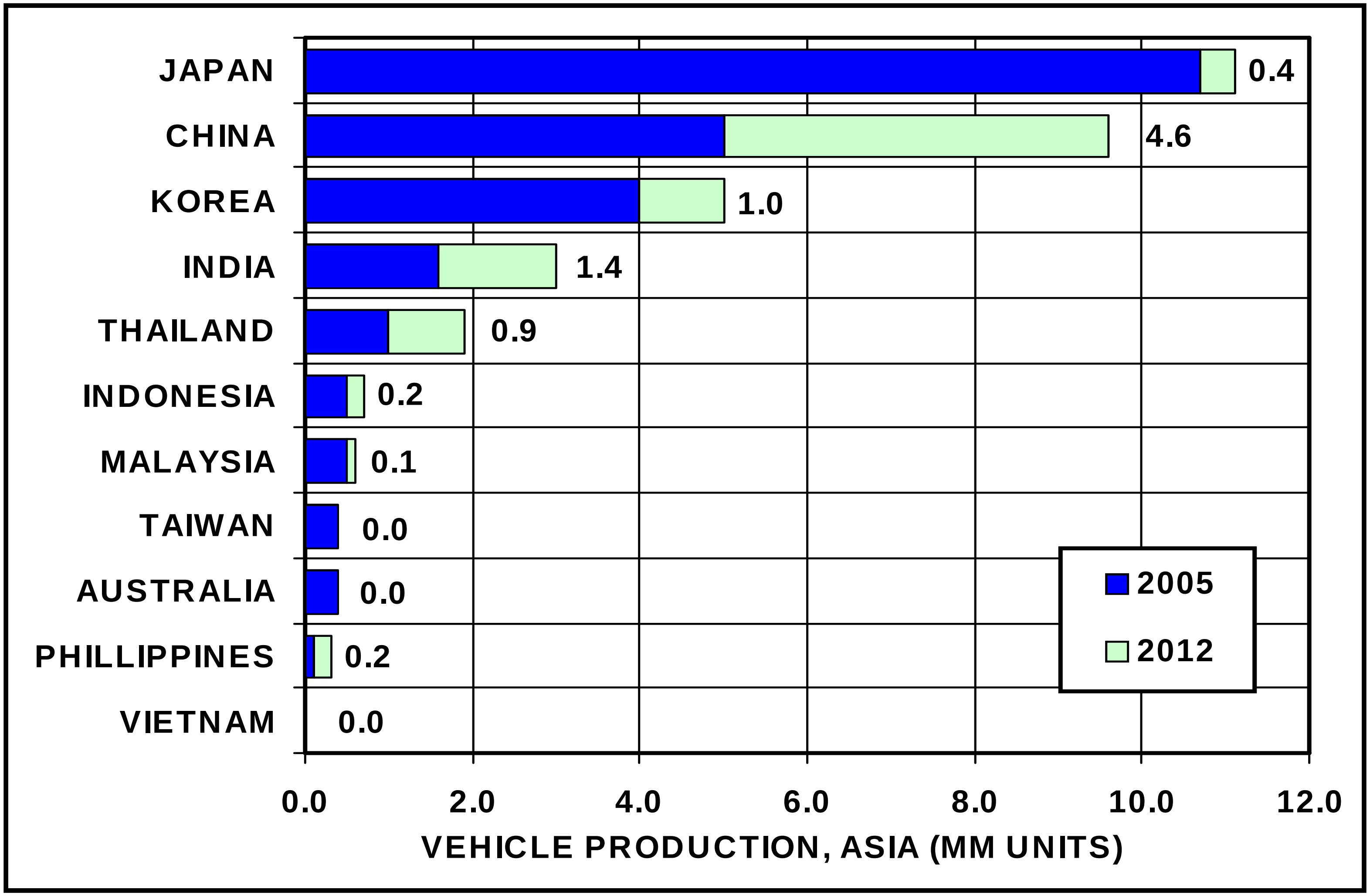

VEHICLE SALES HISTORY BY REGION, 2000-2007
VEHICLE SALES, MM UNITS
80
70
60
50
40
30
20
10
0
3%
1.9%
6.9%
-0.6%
10.4%
21.3%
13.2%
CAGR
2000
2007
Global
Tot. Europe
Tot. AP
Tot. NA
Tot. LA
China
India
SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008
b/mydox/papers/SPE TPO 08-Global Ind Vol.xls

EXHIBIT 11
PROJECTED AUTO PRODUCTION IN ASIA: 2005-2012



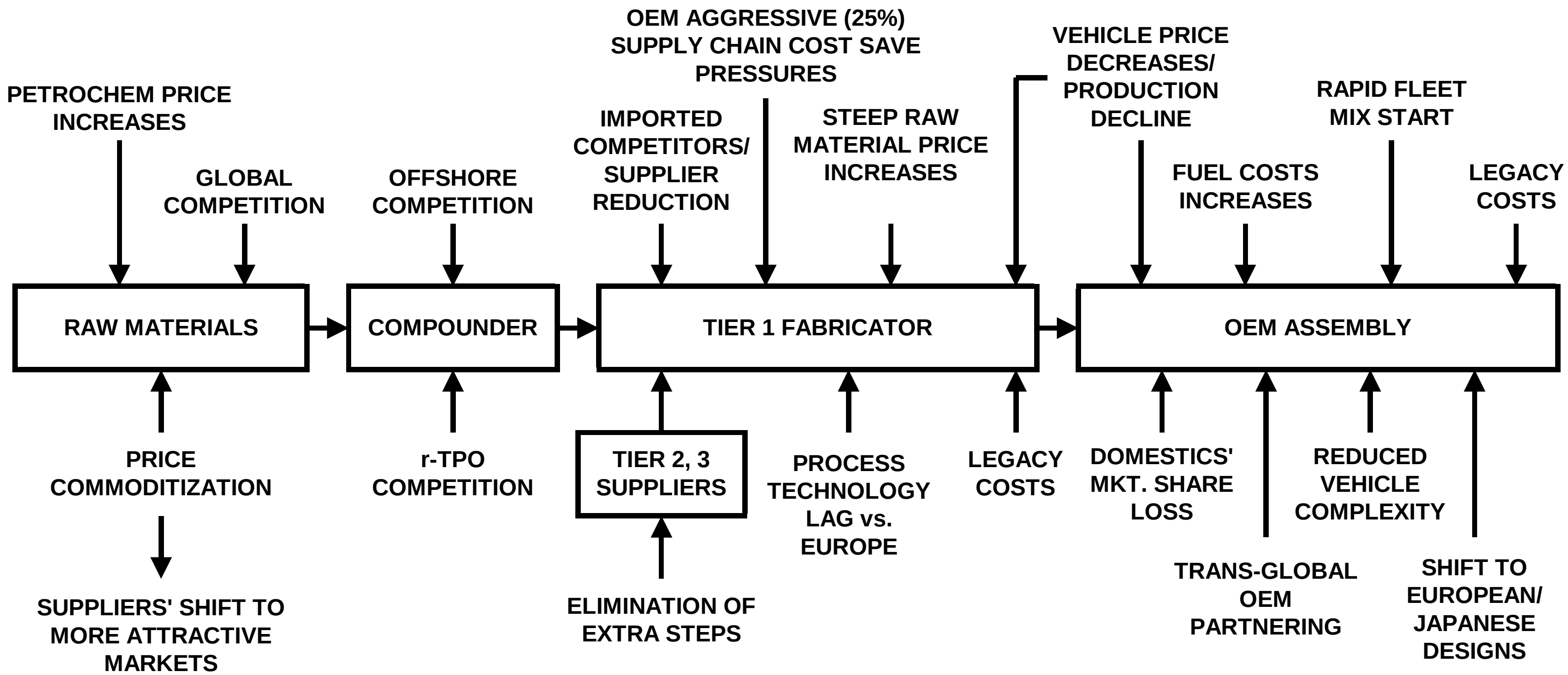
SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008
b/mydox/papers/SPE TPO 08.doc

EXHIBIT 12
EUROPEAN SMALL CARS ARE PP INTENSIVE

VEHICLE	PP (kg)	PP/PLASTICS (%)
Citroen C4	90	56
Toyota Aygo	47	52
Toyota Auris	71	51
Toyota Yaris	64	47
Opel Corsa	65	44
Ford Mondeo	72	41
Fiat 500	60	49
Mercedes C-Class	72	34

SOURCE: Mavel
b/mydox/papers/SPE TPO 08.doc

EXHIBIT 13
AUTOPLASTIC SUPPLY CHAIN RESTRUCTURE PRESSURES



<u>PRESSURES PASSED DOWN THE SUPPLY CHAIN</u>

- ← PRICING PRESSURES
- ← SUPPLY CHAIN "MANAGEMENT"
- ← VEHICLE DEMAND SLOWDOWN
- ← REVISED SPECIFICATIONS
- ← GLOBALIZATION PRESSURES
- ← INCREASED EUROPEAN/ JAPANESE INFLUENCE

<u>ELIMINATE/REDUCE THE INEFFICIENCIES</u>:
- MULTIPLE STEPS
- EXCESSIVE LOGISTICS
- SCRAP GENERATION
- INEFFICIENT PROCESS TECHNOLOGIES
- SALES/MARKETING COSTS
- EXCESS LABOR COSTS
- OVER-GLOBALIZATION?

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008

r/mydox/papers/SPE TPO 08-Implosion0808.vsd // lg/myfiles/Visio/SPE TPO 08-Implosion0808.vsd

EXHIBIT 14

EFFECTS OF SHIFT TO SMALLER, GLOBAL VEHICLE DESIGNS ON AUTOMOTIVE TPOs IN N. AMERICA

PARAMETER	EFFECT ON AUTO TPO/PP DEMAND OR PROFITABILITY	
	INCREASE	DECREASE
Average part weight		-Lower part weight decreases TPO demand
OEM Profit/Vehicle	Lower OEM profit increases incentive to use TPOs	-Increases pricing pressure on TPOs
PP/TPO penetration	Higher	
r-TPO(b) vs. c-TPO	Increased OEM pressure to use r-TPO to reduce costs	
Parts integration	Increased systems designs increase profit potential	
Rubber substitution	Higher (increases o-TPV use)(a)	
Higher quality requirements	Increase demand	-Willing to pay for quality?
Increased global platforms	Global sales potential	-Non-global resin suppliers/ compounders/ molders lose position -Global purchasing pressures from OEMs
Technology proliferation	Better materials/fabrication technology via imports leads to increased profit potential	-Increased competition from transplant suppliers

Notes:
(a) Increased o-TPV substitution for thermoset rubbers saves weight, fabrication cost, and systems costs
(b) Reactor TPOs have yet to satisfy their full potential.

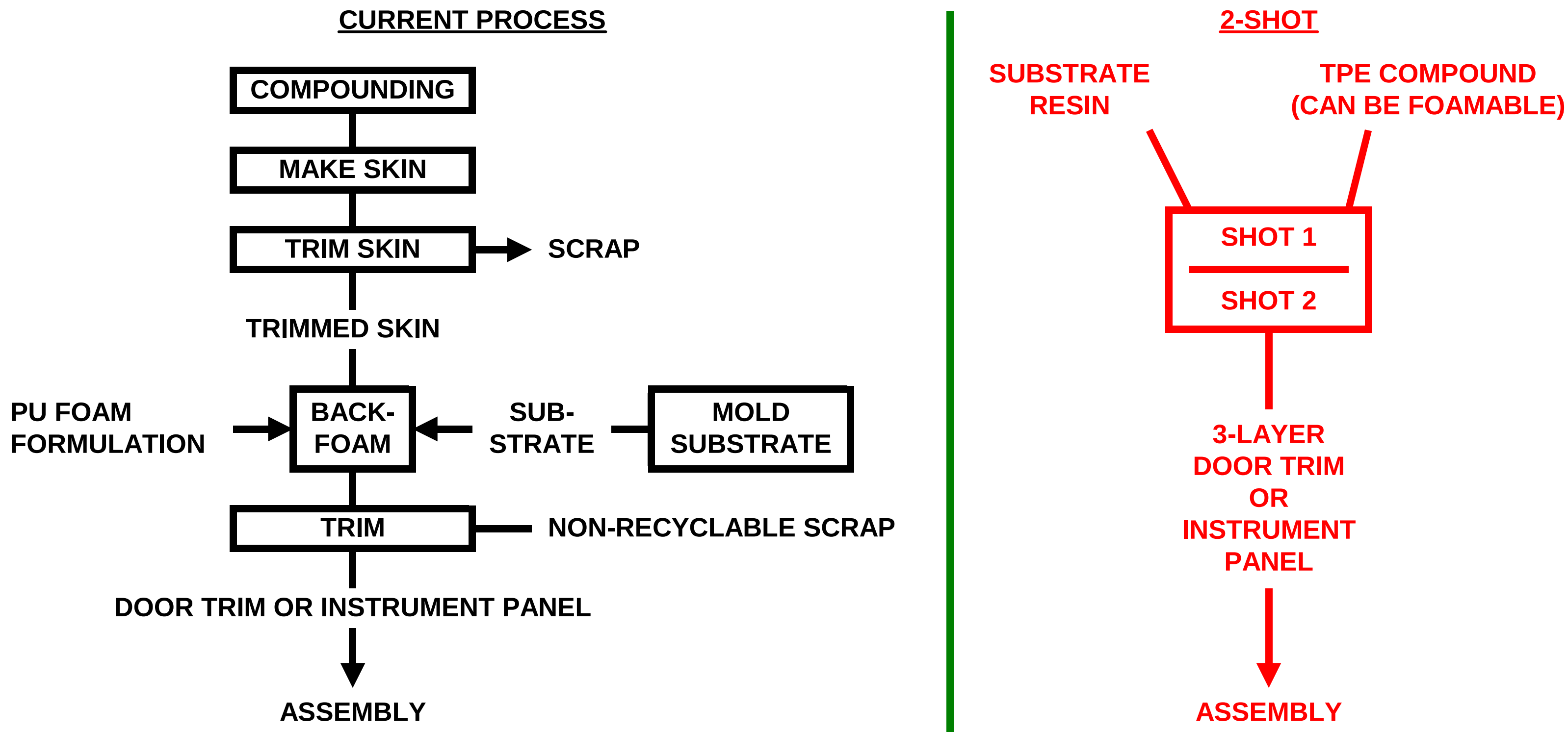
SOURCE: ROBERT ELLER ASSOCIATES LLC 2008

EXHIBIT 15
EXAMPLES OF TPO AND PP TECHNOLOGY RESPONSES TO AUTOMOTIVE MARKETPLACE PARADIGM SHIFTS

- 2-shot molding
- In-line compounding
- In-house compounding (by molders)
- Interior semi-structural substitutions (e.g., elimination of the instrument panel crosscar beam)
- Increased use of reactor TPOs
- Down gauging of average wall thickness
- Body seal systems substitution using o-TPV
- Growth of injection molded foams
- Increased use of multifunctional masterbatches
- Increased use of single compound for multiple interior and exterior components
- Increased use of micro-talc in TPO and PP formulations
- Increased use of molded-in color
- Elimination of coating on molded parts

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008

EXHIBIT 16
NEW HIGH GROWTH TPE FABRICATION TECHNOLOGY: LARGE-PART, 2-SHOT MOLDING



Current process:

- LABOR INTENSIVE
- HIGH SCRAP
- MULTI STEP
- MULTI MATERIAL
- NON-RECYCLABLE
- DIFFICULT CRAFTSMANSHIP

2-shot:

- LOW LABOR
- LOW SCRAP
- SINGLE STEP
- 1-2 CLOSELY RELATED MATERIAL FAMILIES
- EASILY RECYCLED
- HIGH CRAFTSMANSHIP

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008

r/mydox/papers/ACS08-LgPt2Shot08.vsd // lg/myfiles/Visio/ACS08-LgPt2Shot08.vsd

EXHIBIT 17

GLOBAL ECONOMIC SUPPLY/DEMAND FACTORS AFFECTING THE AUTOPLASTICS SUPPLY CHAIN AND TPO SUBSTITUTIONS

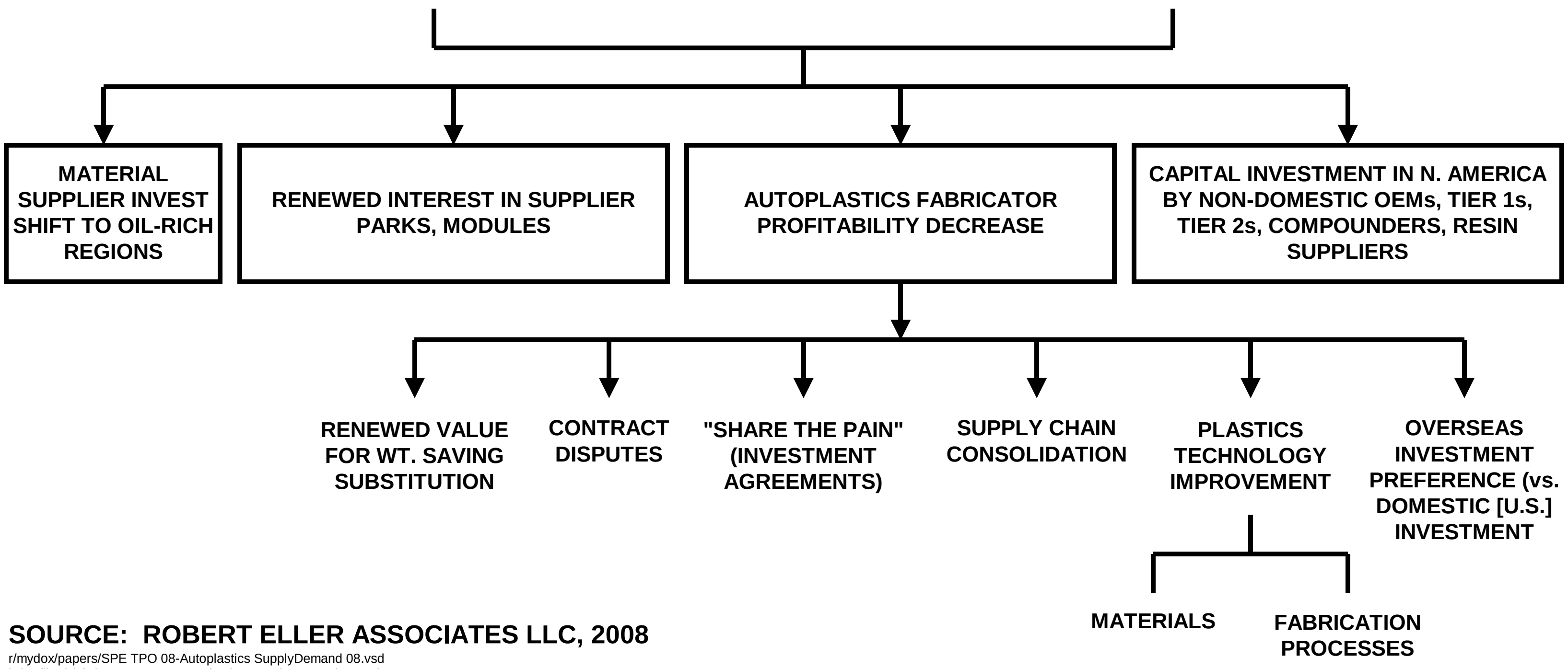
DEMAND

N. AMERICAN MARKET DOWNTURN:

- CREDIT CRUNCH
- INFLATION
- FUEL COST EFFECT ON FLEET COMPOSITION
- HOUSING IMPLOSION
- FLEET COMPOSITION SHIFT
- DOLLAR DEFLATION
- UNFAVORABLE DEMOGRAPHICS

SUPPLY (MARKET)

- FUEL COST INCREASE
- RAW MATERIAL INCREASE
- INEFFICIENT PRODUCTION
- INFLEXIBLE AUTO PLANTS
- TRANSPORTATION COST
- PRESSURE FOR GLOBAL FABRICATOR AND RESIN SUPPLY CAPABILITY
- INTERNAL CORPORATE INVESTMENT COMPETITION
  - N. AMERICA vs. NON-N. AMERICA



SOURCE: ROBERT ELLER ASSOCIATES LLC, 2008

r/mydox/papers/SPE TPO 08-Autoplastics SupplyDemand 08.vsd
lg/myfiles/visio/SPE TPO 08-Autoplastics SupplyDemand 08.vsd