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Determinants of Automobile Production:
An Empirical study



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By

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I hereby recognize and pledge to fulfill my responsibilities as defined by the Honor Code to maintain the integrity of both myself and the college as a whole.

Kyle Adams

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Abstract

Motor vehicles have been produced to move materials and people from one place to another since the 1800's. As automobile ownership past from being a fad to a necessity in the United States, many people saw their chance to live the "American Dream." The car was a symbol of freedom; you could simply go anywhere you wanted. This initial fad of individualism caused demand for the automobile to increase. To fulfill this demand, the first assembly line to mass-produce cars was launched by Henry Ford in the early 1900's with the introduction of the Model-T. To present day US automakers still use Ford's idea of an assembly line, with a few advances in technology. Annually the automobile industry continues to contribute to GDP and the supply of jobs to citizens. The industry as a whole has seen its ups and its downs in production since its inauguration. In this study I use different economic indicators to measure revenues, costs, technological change, impact of substitutes, and the state of the economy in the United States to measure the value gained due to the Automobile industry.

Chapter 1: Introduction

The purpose of this study is to understand the determinants of production in the United States Automobile industry, in order to seek ways to improve the performance of the industry over the business cycles. Before we can clearly understand the determinants of production, we first want to form a solid foundation of what the automobile industry consists of and why it matters to people and our society. Second it will be important to understand the goals of the firms and how manufacturers operate within the monopolistically competitive market place. Lastly, by researching key economic values gathered by various organizations I hope to shed light on the determinants of production for the Automobile industry. To begin in this chapter we will determine what the automobile industry consists of and why it is important to individuals and our economy.

1.1 What is the Automobile Industry?

The automobile industry has seen drastic changes in its purpose and structure since the first car was produced. Whether you are a car enthusiast like myself, an average Joe looking for the best-valued car, or someone against cars in general, believe it or not we all are affected by the decisions that automobile companies make. Changes in technology and personal tastes have driven automobile manufactures to integrate cars into our everyday lives, as we use them as a means of transportations, for hauling materials, and leisure.

According to the North American Industry Classification System (NAICS) (which was developed jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada , and Mexico's Instituto Nacional de Estadística y Geografía , to allow for a high level of comparability in business statistics among the North American countries) automobiles are categorized under industries within the Transportation Equipment Manufacturing

subsector, which produce equipment for transporting people and goods. According to the NAICS transportation equipment is a type of machinery. The NAICS recognizes an entire subsector devoted to this activity because of the significance of its economic size in all three North American countries.

The NAICS's description of the automobile sector notes that establishments in this subsector utilize production processes similar to those of other machinery manufacturing establishments - bending, forming, welding, machining, and assembling metal or plastic parts into components and finished products. However, the assembly of components and subassemblies and their further assembly into finished vehicles tend to be a more common production process in this subsector than in the Machinery Manufacturing subsector.

NAICS has industry groups for the manufacture of equipment for each mode of transport - road, rail, air and water. Parts for motor vehicles warrant a separate industry group because of their importance and because parts manufacture requires less assembly, and the establishments that manufacture only parts are not as vertically integrated as those that make complete vehicles.

Land use motor vehicle equipment not designed for highway operation (e.g., agricultural equipment, construction equipment, and materials handling equipment) is classified in the appropriate NAICS subsector based on the type and use of the equipment and is not considered to be a part of the Transportation Equipment Manufacturing subsector (NAICS 336: Transportation Equipment Manufacturing).

1.2 Why our Auto Industry Matters:

The Transportation Equipment Manufacturing subsector is a significant contributor to the United States economy directly through employment, wages paid, and good

produced. This industry warrants special attention due to the direct effect it has on the residents of the United States over the business cycles.

Zarnowitz and Moore describe business cycles as recurrent sequences of persistent and pervasive expansions and contractions in economic activities. In these expansion and contractions we see the effect on output and employment. Zarnowitz and Moore quote Burns saying business cycles are a product of culture, found only in modern nations where economic activities are organized mainly through business enterprises and where individuals enjoy considerable freedom in producing, pricing, trading, and saving or investing. It is important to note changes in business cycles are a result of changes in the structure of production, markets, institutions, and policies (1984 Zarnowitz: 520-521).

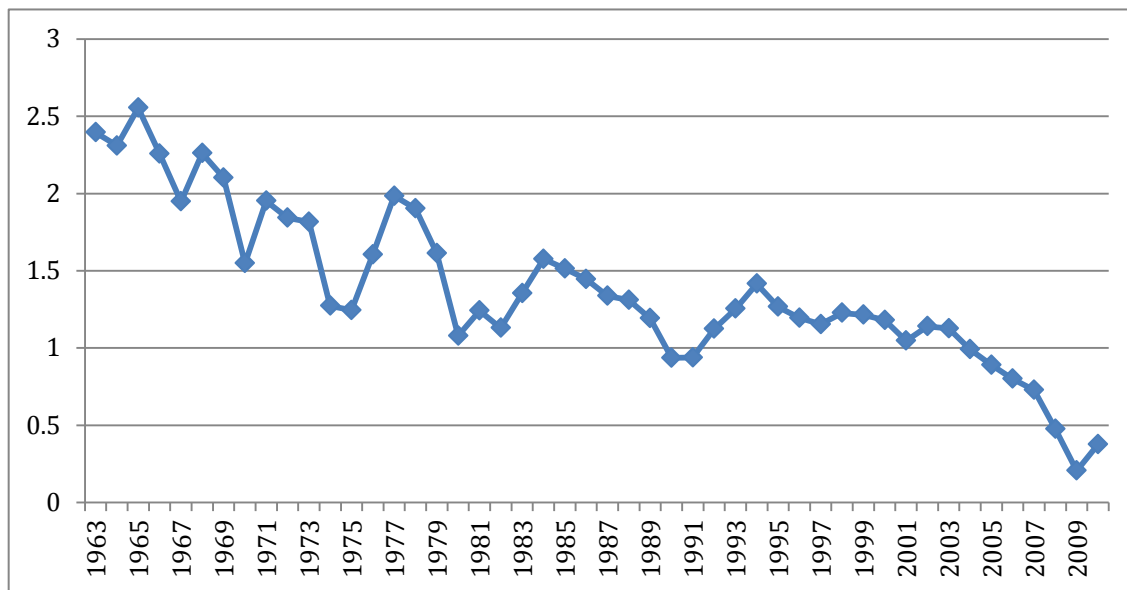
1.2.1 Percent of GDP related to Automobile Production

To represent how much the auto industry has contributed to total GDP for the United States in Graph 1.1 I have formed the ratio value added to GDP. This graph shows the volatility of the industry; during recessions the total contribution of the industry to GDP is significantly lower, than it is during booms.

Graph 1.1 also shows that the automobile industry makes a far smaller contribution to the United States GDP today than in the early part of the 1960's. Some of this can be related to the United States GDP, because advances in other fields cause GDP to rise faster than automobile production, we will expect it to contribute less to total GDP. The other part can be explained by the increased share of imports into the domestic market Ramrattan an economist at UC Berkley quoted R. L. Polk & Co., an agency located in Detroit Michigan responsible for reporting on nearly 197 million motor vehicles, showing that the share of imports climbed from 14.53 percent in 1972, to 32.09 percent in 1987. The

increase was steady between 1978-1982, and between 1982-1987. In reaction domestic firms retaliated by making smaller cars, cutting wages, closing plants, improving efficiency, and adopting measures to reduce government regulations (1988, p. 32). In either case this is relevant because cuts in production are directly related to cuts in employment and wages paid.

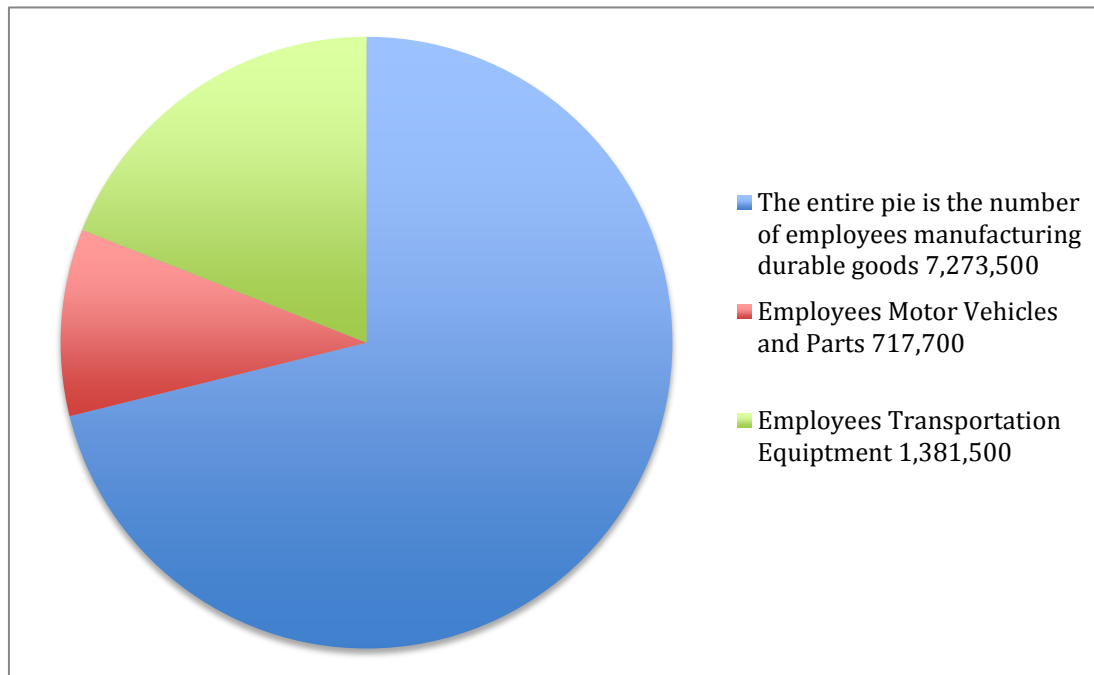
Graph 1.1 Value Added as a percent of GDP



1.2.2 Manufacturing Labor Market

Automobile manufacturers both directly and indirectly create a large number of jobs. According to data gathered by the Bureau of Labor Statistics, in 2011 transportation equipment and motor vehicles and parts accounted for more than twenty five percent of the jobs in manufacturing durable goods. Graph 1.2 shows employees who find work manufacturing durable goods. Motor vehicles and parts employ 9.9% of people working to manufacture durable goods. Transportation equipment accounts for 19% of people working to manufacture durable goods.

Graph 1.2 Employees Manufacturing Durable Goods Related to Automobiles in 2011



In recent years, the economy has been in a recession, with a very slow recovery. A recession in most cases cause financial stress for many people. As consumers, people have little money available to consume luxury goods, and so fewer new goods will need to be produced. For workers in automobile manufacturing, this means no work or relatively limited work is available. Employment is directly related to wages paid to employees; with limited wages employees have limited funds to support their needs.

In the most recent recession, the United States motor vehicle and parts employment hit a low of 664 thousand employees in 2009 just as the recession was coming to an end. This caused nearly half of the work force to be laid off since the economic boom in 2000 when employment was nearly at full capacity to fill necessary demand (BLS 2013).

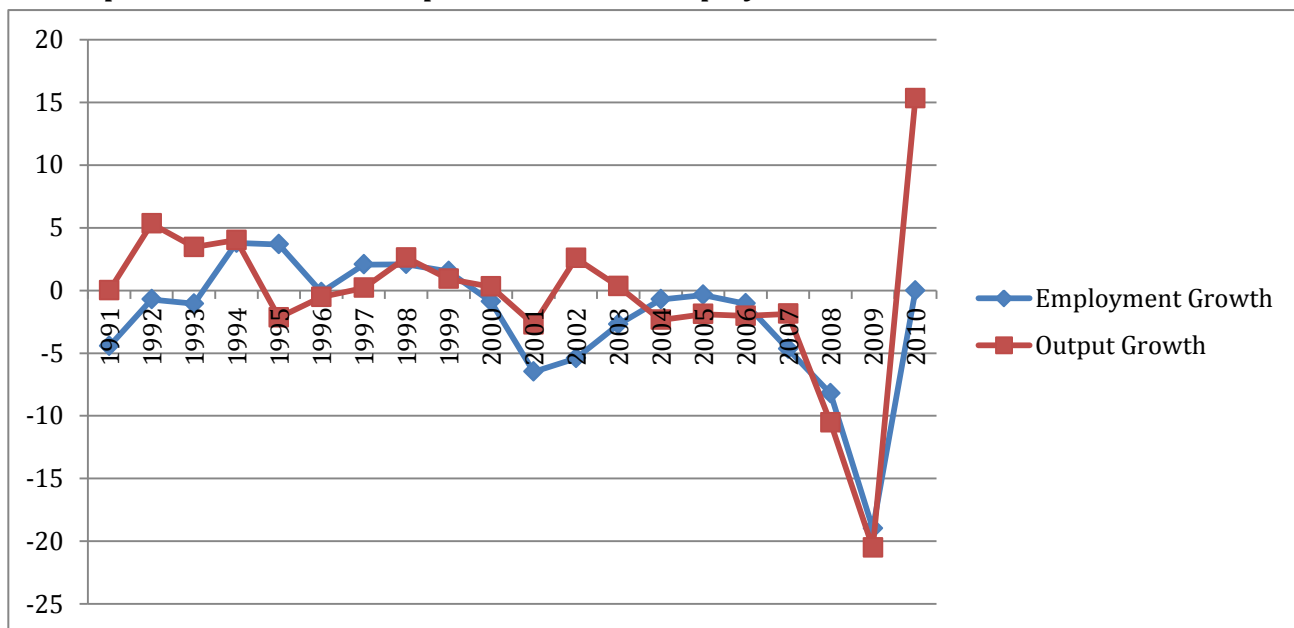
The automobile can also be linked to the production and continued work on roadways and interstates. That part of the construction industry dedicated to roadwork continues to keep roads up to date for the cars that have already been purchased and need

to travel the road daily. A recession can also impact this industry; in times of a recession tax revenues may not be adequate to take on a project so it may be held off until a later date. This Industry is only one example of the trickle down effect that is caused by the auto industry giving people jobs and wages paid.

1.2.3 Automobile Output Growth and Employment Growth

The Bureau of Labor Statistics (BLS) has employment records for motor vehicles and parts and transportation equipment since 1990. I gathered these data, changing employment into a growth rate, along with output growth of the automobile industry and placed them in Graph 1.3.

Graph 1.3 Automobile Output Growth and Employment Growth



Graph 1.3 shows that both employment growth and automobile output growth are procyclical. That is, during times of a boom, employment and output increase and, in times of a recession, employment and output decrease. Graph 1.3 also shows that both employment growth and automobile output growth could be leading indicators for the

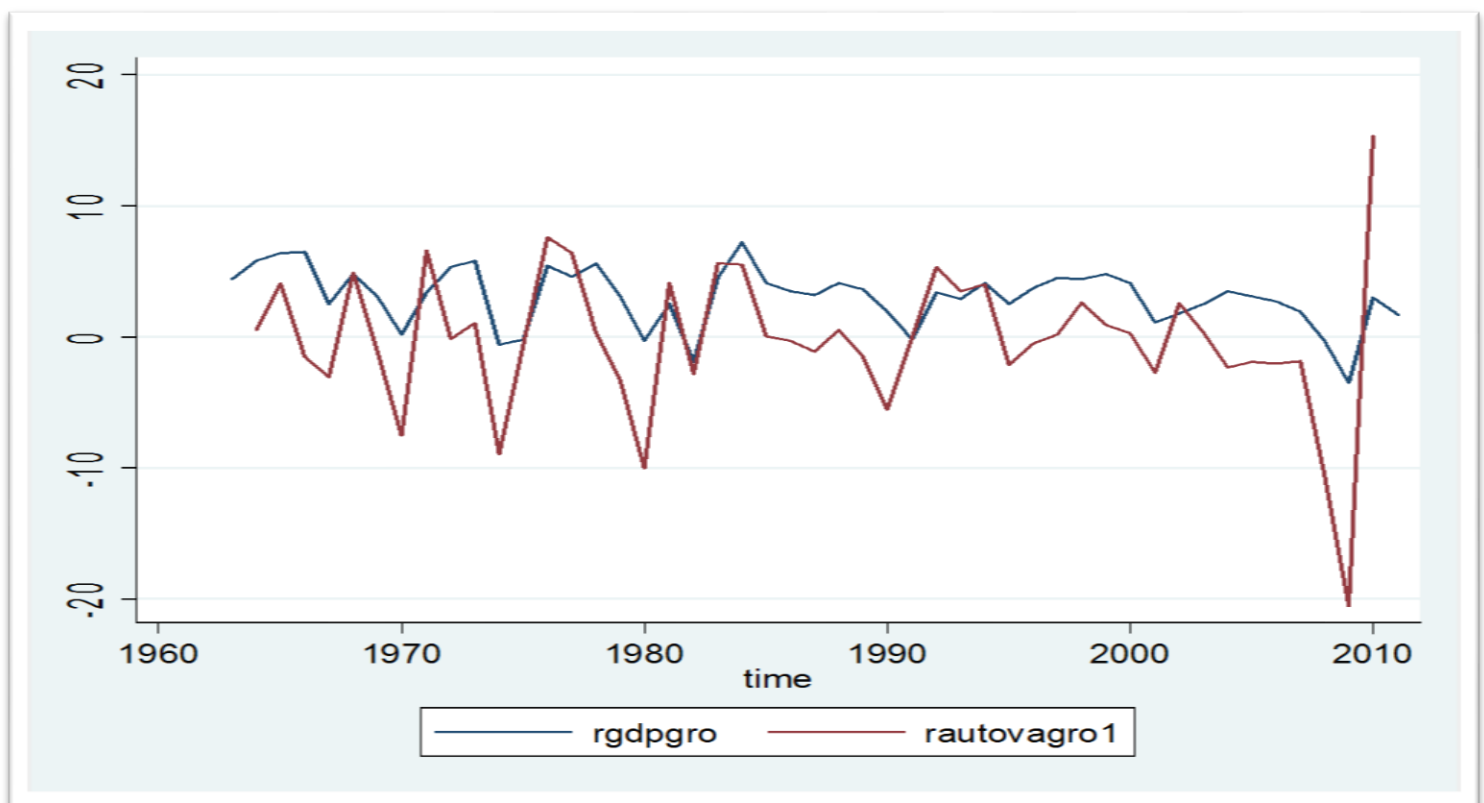
overall state of the economy. That is, employment growth and output growth will increase or decrease before the economy, i.e., GDP.

1.2.4 Real Value Added Growth VS Real GDP Growth

To get a better feel for auto production, Graph 1.4 shows the change in real value added growth of the auto industry (**rautovagro1**) throughout time. I have also added the line for real GDP growth (**rgdpgro**) to compare how value added by the auto industry changes during times of booms and recessions in the American economy.

Graph 1.4 shows that the auto industry is procyclical. This means that value added growth of the auto industry is positively correlated with the overall state of the economy. In times of a boom, value added growth increases along with GDP growth, while in times of a recession value added decrease.

Graph 1.4 Real GDP Growth and Real Value Added Growth of the Auto Industry



Taking a closer look at Graph 1.4, you can see that when real GDP growth decreases real value added growth of the auto industry decreases by more. This indicates that the real value added by the auto industry is more volatile than real GDP growth. The volatility in value added growth of the auto industry reflects that it is prone to recessions, that the value added growth of the auto industry declines when the overall state of the economy is in a recession.

The auto manufacturing companies are now almost too big to fail, as was seen with the recent government bail out of General Motors and Chrysler. The companies' employ enough Americans that the state of our economy as a whole can be predicted by the direction the auto industry is heading. To reinforce this idea, Graph 1.4 shows how value added growth by the auto industry often is a leading indicator of GDP. The values for real value added growth tend to rise or drop before real GDP growth does. This is valuable information in predicting the growth of GDP for our economy.

1.3 Relevance of the Automobile Industry

In the first chapter we learned automobiles are categorized under industries within the Transportation Equipment Manufacturing subsector, which produce equipment for transporting people and goods. The automobile industry today contributes far less to overall GDP in the United States than it has in years since 1960. This can be related to the United States GDP, and the increased share of imports into the market place.

As of 2011 transportation equipment and motor vehicles and parts accounted for nearly 28% of all jobs relating to manufacturing durable goods. This is important since

value added by the auto industry is also more volatile than GDP, insinuating the industry is prone to recession and can have an impact on these employees.

Automobile Industry employment growth, output growth, and value added growths are all procyclical and leading indicators for our economy. They increase and decrease in times of booms and recessions and in many cases tend to react before the state of the economy changes.

Towards the end of this study we want to understand the determinants of production in the United States Automobile industry, in order to seek ways to improve the performance of the industry over the business cycles. To continue our study, chapter two will explore economic concepts that play a role in explaining how auto industry output is determined and how the firm will act to maximize profits in a monopolistically competitive market. Once we understand how the firms in the Automobile Industry make decisions in chapter three we will explore an empirical study of the Automobile Industry based on indicators reporting revenues, costs, and technological changes to see the impact each will have on the production of transportation vehicles. To finish up our study chapter four will be a summary of the paper paying particular attention to the specific factors that influence Automobile production in the United States.

Chapter 2: Profit Maximization in Monopolistic Competition

The purpose of this study is to shed light on basic economic concepts that play a role in explaining how auto industry output is determined. To provide a theoretical context for this analysis, this chapter describes how the sector operates in a monopolistically competitive market. In the sections that follow I will provide basic definitions of costs and revenues, describe a monopolistically competitive industry, profit maximization in the market place, and factors that can change demand for the product and average cost to fall. Before we continue further, note this study is based on a model of profit maximization. The graphs, tables, and data in this chapter are based on Samuelson and Nordhaus's *Microeconomics* textbook.

2.1 Profit Maximization: Basic Definitions

Auto industry manufacturers like GM, Ford, and Chrysler want to produce a quantity of output, denoted by q , which will maximize the profits for the firm. This quantity in most cases can be produced according to a production function, accounting for capital, labor, and other inputs. To produce this given quantity of output the company must purchase inputs and pay for labor and factory costs. In addition, the company must be able to sell its product and cover liable costs to continue operating effectively.

Firms operating in a monopolistically competitive market want to maximize their profits. Before we are able to understand how the firm makes output decisions to maximize profits, it is important to understand costs that the firm incurs as well as the revenue it retains from selling a good.

2.1.1 Minimizing Costs to Earn Profits

A company's total costs of operation can be grouped into fixed and variable costs. In almost every case, firms strive to minimize costs, which can lead to larger profits.

Samuelson and Nordhaus refer to fixed costs (FC) as a company's overhead. These costs are considered to be items that have contractual payments. Building and equipment rentals, interest payments on debts, and salaries of long-term employees are all examples of a fixed cost to the firm. Fixed costs must be paid no matter the quantity produced by the firm (pg 167-68). Graph 2.1 shows that fixed costs are constant no matter the quantity of output that is being produced. If the company would choose not to produce any goods it would still be responsible for the fixed cost.

Graph 2.1 Total, Fixed and Variable Cost

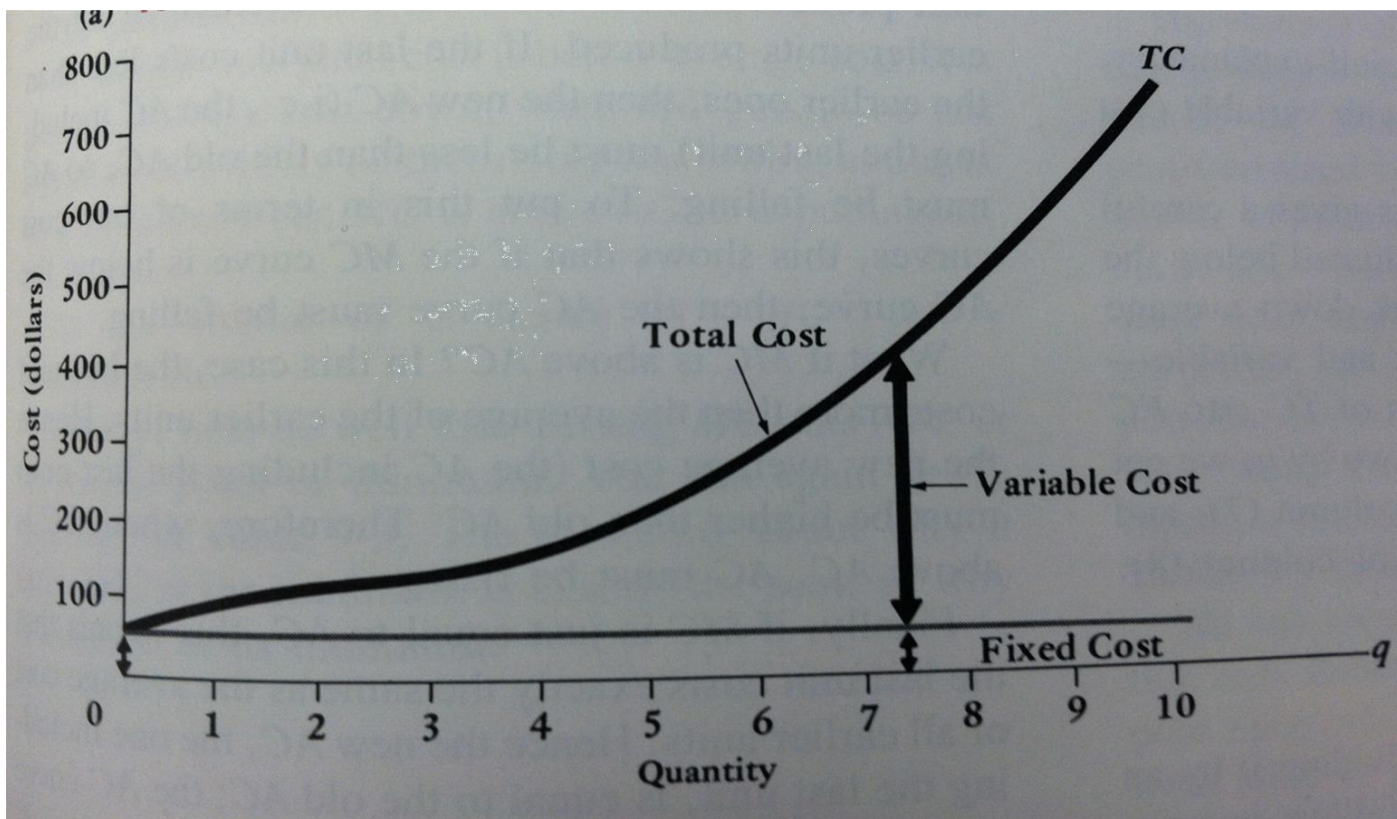


Image courtesy of Samuelson and Nordhaus (1989 pg 171)

Samuelson and Nordhaus define variable costs (VC) as the costs that vary with the quantity produced by the firm. Examples of such costs include materials required to produce output (such as steel to produce automobiles); workers to staff the production lines; fuel, light, and power to operate the factories; and the like (pg 168). Graph 2.1 shows variable cost as quantity produced changes. As you can see, at a quantity of zero the variable cost to the company is zero. The variable cost will increase as the output of the firm increases.

By combining fixed and variable costs we get total cost (TC) representing the lowest dollar amount necessary to produce a given quantity. By definition,

$$TC = FC + VC.$$

Table 2.1 provides an example of how total cost is calculated with respect to fixed and variable costs. Total cost incurred by the firm varies based on input prices and the state of technology. As a company integrates technology and new techniques they are able to produce more goods at a lower total cost. With lower costs to the firm they are able to charge a lower price. This lower price adds value by giving consumers more money to spend on other luxury goods in addition to the one they already purchase. It is important to note that a company should be ethical and moral when trying to minimize total costs and should not break laws established by local or national officials to minimize costs

Table 2.1 Total, Variable, & Fixed Costs

(1) QUANTITY <i>q</i>	(2) FIXED COST <i>FC</i>	(3) VARIABLE COST <i>VC</i>	(4) TOTAL COST <i>TC</i>
0	55	0	55
1	55	30	85
2	55	55	110
3	55	75	130
4	55	105	160
5	55	155	210
6	55	225	280

Image courtesy of Samuelson & Nordhaus (1989, pg 167)

Marginal Costs

As described by Samuelson, the key to understanding how much a firm will want to produce and sell is the marginal cost of producing goods and services. Marginal cost (MC) denotes the extra or additional cost of producing 1 extra unit of output. Table 2.2 presents an example of the determination of marginal cost. In Table 2.2 to calculate the marginal cost of the third unit, we subtract the total cost of the second unit from the total cost of the third unit, i.e.,

$$\begin{aligned}
 MC_3 &= TC_3 - TC_2 \\
 &= \$130 - \$110 \\
 &= 20.
 \end{aligned}$$

Nordhaus said we can also measure marginal cost, by applying this concept to variable costs (1989, pg 168). Because variable cost always grows exactly with

Table 2.2 Solving Marginal Cost

(1) OUTPUT <i>q</i>	(2) TOTAL COST <i>TC</i>	(3) MARGINAL COST <i>MC</i>
0	\$ 55	
1	85	\$30
2	110	25
3	130	20
4	160	30
5	210	50

Samuelson & Nordhaus (1989, pg169)

total cost, the only difference is that variable cost must--by definition--start out from 0 rather than from the constant fixed cost level. For example, looking at Table 2.3, solving for the marginal cost of the third unit using variable cost, we subtract the variable cost of the second unit from the variable cost of the third unit, i.e,

$$\begin{aligned} MC_3 &= VC_3 - VC_2 \\ &= \$75 - \$55 \\ &= \$20. \end{aligned}$$

As we found before the marginal cost of producing the third unit is 20\$.

Table 2.3 Important Cost Concepts

(1) QUANTITY q	(2) FIXED COST FC	(3) VARIABLE COST VC	(4) TOTAL COST $TC = FC + VC$	(5) MARGINAL COST PER UNIT MC	(6) AVERAGE COST PER UNIT $AC = \frac{TC}{q}$
0	55	0	55	33	Infinity
1	55	30	85	30	85
2	55	55	110	27	55
3	55	75	130	25	43 $\frac{1}{3}$
4*	55	105	160	22	40*
5	55	155	210	20	42
6	55	225	280	30	46 $\frac{2}{3}$
7	55	—	370	21	52 $\frac{2}{3}$
8	55	—	480	30	60
9	55	555	610	50	67 $\frac{2}{3}$
10	55	705	760	60	76

Image courtesy of Samuelson & Nordhaus (1989 pg 170)

Average Costs

According to Samuelson, another important cost concept is average cost, which, when compared with price or average revenue, allows a business to determine whether or

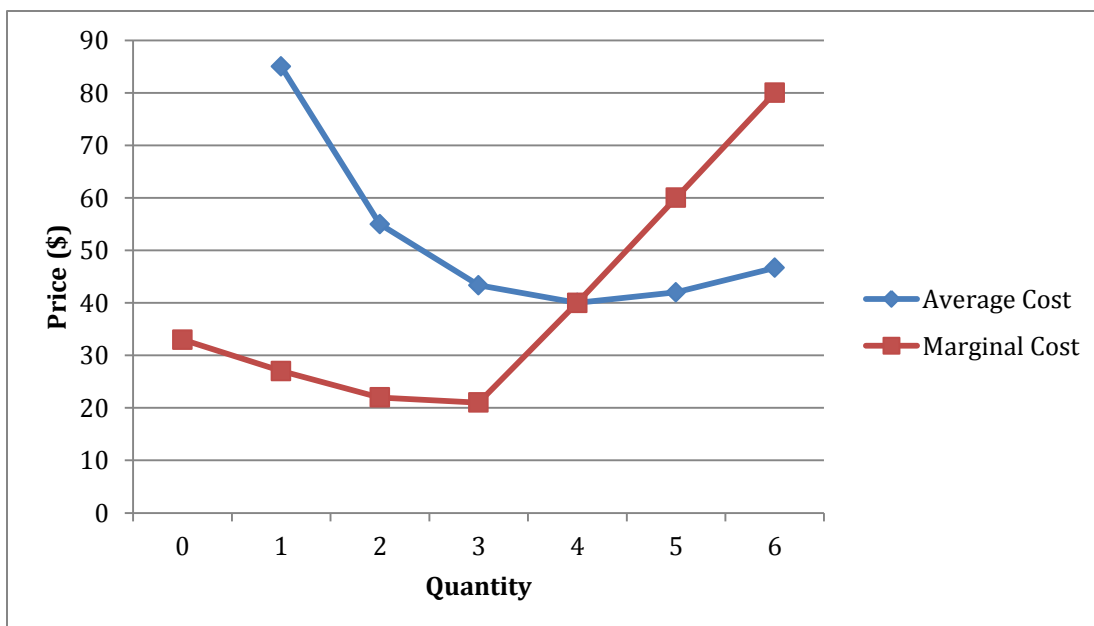
not it is making a profit (pg 170). Average Cost (AC) is total cost (TC) divided by the number of units produced (q). In Table 2.3, you can see how average cost is estimated if you would produce a quantity of 4. That is,

$$\begin{aligned} \text{Average cost}_4 &= \frac{TC_4}{q_4} = AC_4 \\ &= \$160 / 4 \\ &= \$40 \end{aligned}$$

Average and Marginal Cost Combined

Average cost and marginal cost are displayed in Graph 2.4 using numbers from Table 2.3. Samuelson noted that MC intersects AC at its minimum. This key fact is not a coincidence, but is due to the important relationship between marginal and average costs (1989, pg 171). By combining these two lines we form a crucial economic diagram helping to explain how many units of output should be produced, so that the company would be able to operate at the minimum average cost per unit of output.

Graph 2.2 Average vs. Marginal Cost

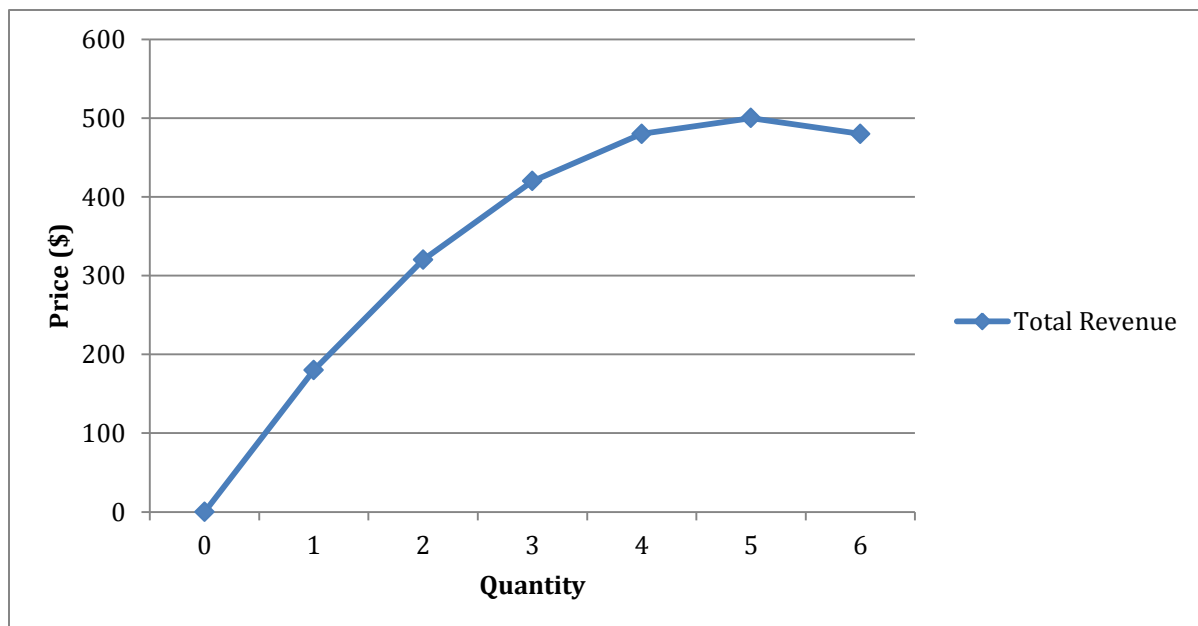


The basic point to see is that if marginal cost is below average cost, then average cost must be falling and vice versa. Referring to Table 2.3 and Graph 2.2 note that for the first 3 units, MC is below AC; AC is thus declining. At exactly 4 units AC equals MC. Above 4 units, MC is above AC and pulling AC up steadily (1989 pg 172). By minimizing average cost per unit of output, the firm has taken the first steps in maximizing the profit.

2.1.2 Maximize Revenue to Earn Profits

Having discussed the costs of the firm it is important to understand the other side of business activity, the revenue made from a sales transaction. In order for a business to operate it must have a stream of revenue it earns by performing the actions of the business. In the case of the automobile industry, by selling a vehicle to a consumer revenue is earned.

Graph 2.3 Total Revenue



This stream of revenue enables the company to pay its costs so the business can continue to produce goods and add value to our economy as a whole. Samuelson defines total

revenue as equal to price times quantity, by definition

$$TR = P \times q.$$

Graph 2.3 shows the relationship. The level of output sold, in the total revenue formula, is largely affected by prices, people's tastes, needs, and income.

Average Revenue

Similar to average cost, Average Revenue is simply the price that the quantity of goods will be sold at. In Graph 2.3, total revenue from selling two goods is \$320. The average revenue is simply $\$320/2 = \$160$ or the price at which the goods were sold. Table 2.4 shows an example of the relationship between price, total revenue, and average revenue.

Table 2.4 Total and Marginal Revenue

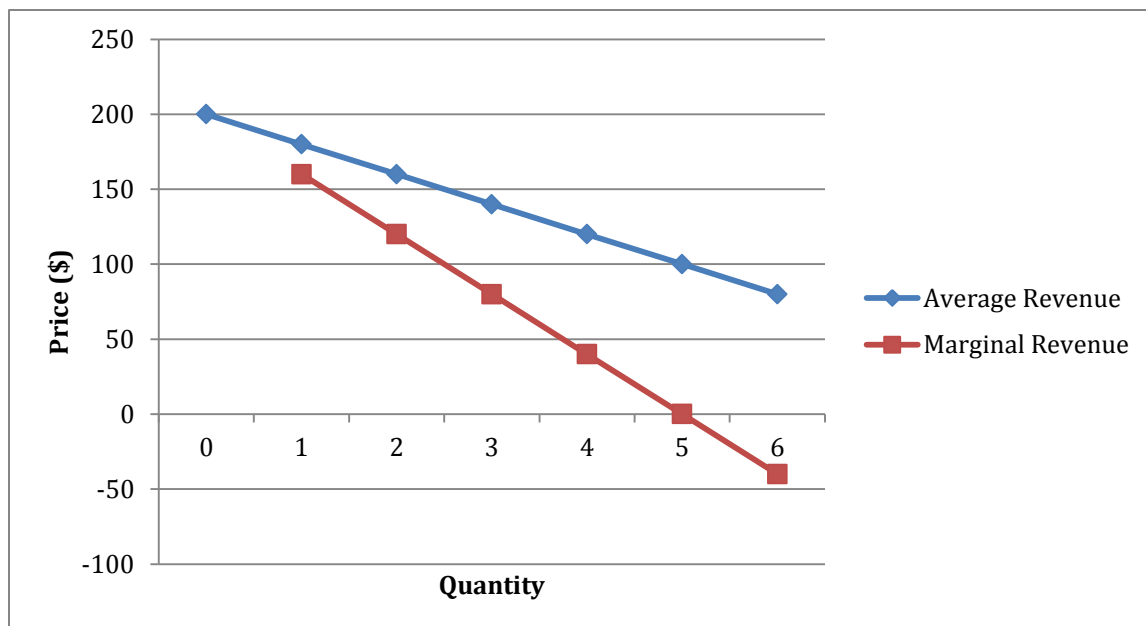
(1) QUANTITY q	(2) PRICE $P = AR = TR/q$	(3) TOTAL REVENUE $TR = P \times q$	(4) MARGINAL REVENUE MR
0	\$200	\$ 0	÷\$200
1	180	180	+180
2	160	320	+160
3	140	420	+140
4	120	480	+120
5	100	500	+100
6	80	480	+80
7	60	—	—
8	40	320	+40
9	—	180	+20
10	0	0	0
			-20
			-40
			-60
			-80
			-100
			-140
			-160
			-180

Image courtesy of Samuelson & Nordhaus (1989, pg 230)

Marginal Revenue

As described by Samuelson, Marginal Revenue is the increment in total revenue (plus or minus) that comes when output increases by 1 unit. Table 2.4 shows the marginal revenue for each increase in output. Graph 2.4 shows the relationship between average and marginal revenues. The negative slopes of the AR and MR reflect the Law of Demand: when the price decreases, sales will increase but since MR and AR decrease the firm's revenues will also decrease.

Graph 2.4 Average vs. Marginal Revenue



2.2 Monopolistic Competition

It is assumed that auto manufacturers seek to maximize profits and that they operate in a monopolistically competitive market. According to Edgar and Jacqueline Browning economics professors at Texas A&M, monopolistic competition contains elements of both competitive and monopoly markets, much like that of the auto industry. Like the competitive model, it includes a large number of independent sellers, and entry

into and exit from the industry is unrestricted. However, the firms produce differentiated products, meaning that consumers do not view the product of one firm as identical to the product of another firm. When firms make a product that is different from, but still similar to, that of other firms, they will have a small degree of monopoly power (1986 pg400). For example only Chevrolet can sell a corvette. Unlike a monopoly product, however, a Corvette has fairly close substitutes, which limits Chevrolet's' control over price. Customers may have a yen for a Corvette when the price of a Corvette and a Mustang are about the same.

In order to better analyze monopolistically competitive industries, Edward Chamberlin a professor of economics at Harvard University and the first to analyze the subject assumed the following: (1) the product has close substitutes; (2) a large number of firms produce the product (which is differentiated), and entry into the industry is unrestricted; (3) the number of firms in the product group is sufficiently large so that each firm expects its action to be ignored by its rivals; and (4) the cost and demand conditions are the same for all firms in the product group (1962, pg 68-69).

Browning and Browning say the first step in analyzing monopolistic competition is to understand the demand curve for a single firm. Since each firm's product differs slightly from that of other firms in ways that appeal to its customers, quantity sold is unlikely to fall to zero if the individual firm charges slightly higher prices than a competitor. However, because all the products are similar (close substitutes), sales will fall sharply as price increases because customers will shift to other brands. This means firms in this market type have a downward sloping demand curve that is highly elastic (1986, pg401).

Browning and Browning go on to say each monopolistically competitive firm has some limited control over the price it can charge, seen in various prices for cars by different manufacturers. The negative slope of its demand curve as seen in Graph 2.4 reflects this fact. Since the demand curve is downward sloping, marginal revenue is less than price that means the revenue made from the last car produced is less than the price the firm charges for the car.

As we see in the next section, for an auto manufacturer to maximize profits the firm must operate where marginal revenue is equal to marginal cost. Browning made a point to note that this long-run equilibrium position is similar to the competitive and monopolistic equilibria. As is true in the competitive case, each firm's demand curve is tangent to its long-run average cost curve, so zero economic profit is made. Like monopoly, the demand curve is downward sloping, so price is greater than marginal cost at the equilibrium (1986 pg 401-403).

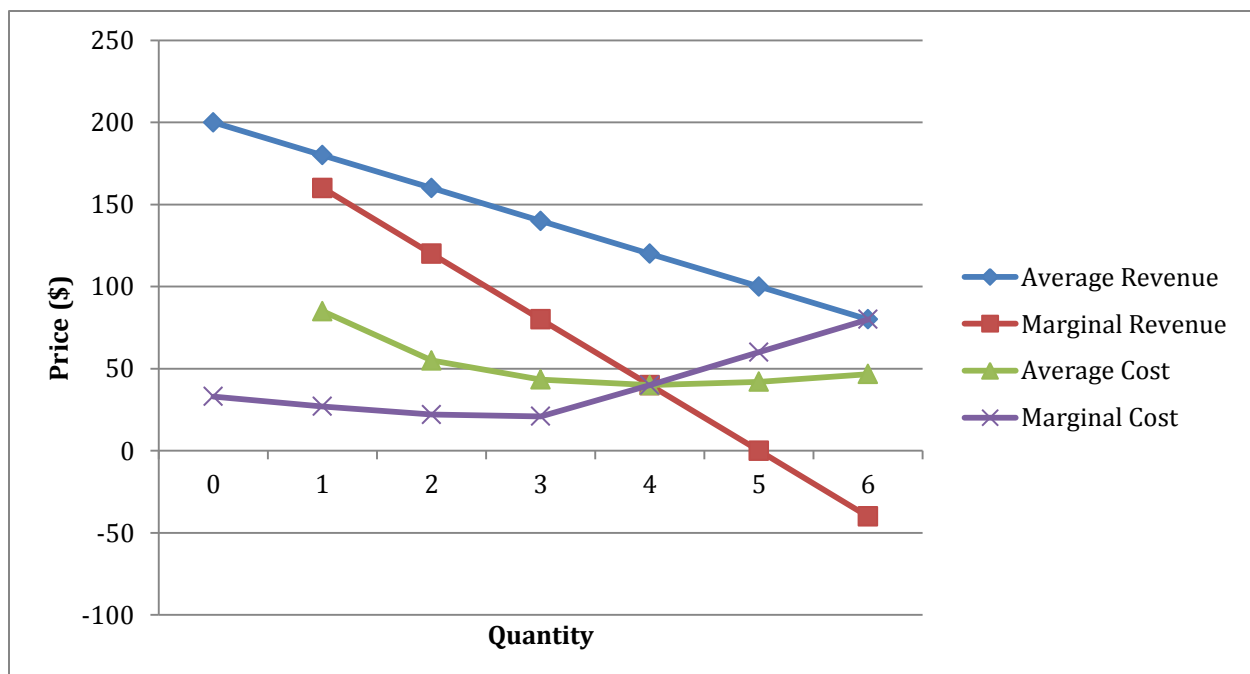
2.3 Profit Maximization

In this section we focus on the individual firm's output decision to maximize profit. Many people assume that a business enterprise will attempt to make as much money as possible; yet, many observers have taken issue with the assumption that profits are the single, overriding goal of the firm. Nevertheless, as was noted before for this study of the auto sector we assume that the goal of the firm and its management team is to indeed maximize profits. Since there is a separation of ownership and control in the many large businesses and corporations in monopolistically competitive markets, it is important that manager's goals are aligned with that of the stockholders so that the profits of the owners are maximized.

To maximize profits in a monopolistically competitive market, Browning and Browning point out that the firm would need to produce a quantity of goods where the marginal revenue equals marginal cost; that is $MR=MC$. This enables the firm to maximize its profits in a monopolistically competitive market place as seen in Graph 2.5 (data was gathered from Tables 2.3 & 2.4). For this case in order to maximize profit they must produce at a quantity of 4 and sell them at a price of \$120. At this intersection the additional cost of producing the last product is equal to the additional revenue received for the sale of said good.

If MR is greater than MC the extra revenue from selling the last good earned the firm extra revenue, leading to a profit; however the firm could be doing better and maximize their profit. If MC is greater than MR the firm is not earning enough revenue to cover the extra costs incurred for producing that given quantity and are operating at a loss. In either case it is not efficient and in the long run the firm should seek to operate where $MR=MC$.

Graph 2.5 Profit Maximization



2.4 Shifts in Demand and Cost

The quantity found at the intersection of marginal revenue and marginal cost will depend on multiple factors; the cost of operations, demand for the product being sold, and the overall state of the economy. As firms operate they have to continually adapt to the competitive nature in the market place. In this section we hope to understand different factors based on theory that affect revenue's and operating costs of a firm. This will be useful so we can compare theory's expectations in this chapter to the empirical study in chapter three to see how the Automobile Industry is currently reacting to these different indicators.

2.4.1 Demand Shock

We will start by looking at a shock in the demand for the product. Holding costs constant, if there is a shock in demand due to a change in the price of related goods (both substitutes and complements), income, population, expectations, or any event that changes a consumers mind, the demand for the product will most likely change. The change in demand will affect the selling price and give the firm a new marginal revenue line. The shock to demand will affect the optimal level that the firm needs to produce to maximize profits due to a change in the marginal revenue curve. The rest of this section will explore different rates that will have this type of shock in demand. Based on theory we will describe what is expected to happen to productivity of a firm based on real GDP growth, and automobile import growth.

Real GDP Growth is a measure of revenues of firms operating in the United States. During the business cycles we will expect Value Added by the Automobile industry to be

directly correlated to Real GDP Growth. Real GDP growth is an indicator of the economy and a standard of living for many Americans, as the economy booms employees earn wages. In return, employees being consumers have more available funds to purchase luxury goods like cars. Based on theory we expect the automobile industry to increase production to fill the new demand.

Real automobile import growth is a measure of revenues in the United States of firms manufacturing outside the United States. Automobile imports are considered to be a substitute to any car manufactured in the United States. Since these firms operate in a monopolistically competitive market each firm's product is slightly differentiated so we know from early in this section that the quantity sold will most likely never drop to zero, and each firm will not be concerned with the actions of their competitor. With that being said as more substitutes enter the market place we would expect sales to drop for domestic manufacturers due to the availability of substitutes for relatively equal prices.

2.4.2 Cost Shock

In this section we will be examining a firm's costs and shocks that can affect these costs. By holding demand constant if there is a shock in the cost due to price of inputs, or the state of technology changing it will either result in savings or costs to the firm. The change in costs of inputs will affect the total cost incurred by the firm at each level of quantity produced, giving them a new marginal cost line. The shock in cost will affect the optimal quantity level that the firm needs to produce so profits are maximized, due to a change in the marginal cost curve. Based on theory we will see what is expected to happen to production for a firm based on the real wage, real price of capital goods, and productivity growth.

Real wage is a measure of costs. Samuelson and Nordhaus express the real wage in terms of purchasing power of an hour's work (1989 pg 332). Based on theory and the demand for labor as the real wage increases we expect firms to lower their demand for employment and cut back in supply of labor there for reducing production. On the other hand if the real wage decreases we expect a firms demand for employment to increase, and we will expect the firm to increase their supply of labor, which leads to increased production. In chapter three we will see how the real wage of automobile workers affects employment and output.

Real price of capital is another measure of costs. This measures the cost of investing in capital goods used in the operation activity of a firm. Examples of capital goods are a building, factory, equipment, or machinery that is used to make a consumer good. Based on theory if the real price of capital were to increase, we would expect the production of the firm to be cut back. If the real price of capital were to decrease, we would expect the production of the firm to increase. In chapter three we will examine the real price of capital and how it affects the value added by the automobile industry.

Productivity Growth is a measure of technological change in the economy. Changes in technology- invention of new products, improvements in old products, or changes in the processes for producing goods and services is what Samuelson and Nordhaus describe as technological change. They continue by adding technological change occurs when new or improved engineering and technical knowledge allows more output to be produced from the same inputs, or when the same output can be produced with fewer inputs (1989, pg 160). So based on theory, productivity growth is a measure of technological change, as more techniques evolve we expect firms production and value added to increase.

2.4.3 Shock to the Economy

Dummy Variables are used to represent different states of the economy that can affect costs and revenues. These dummy variables respectively represent recessions, the great moderation, and the great recession. For each cycle of the economy theory expects production to react differently. During a recession and most recently the great recession theory expects production to be cut, as funds are limited for many people in the society. During the great moderation in which our country structurally changed theory expects production to increase as the economy is evolving to more manufacturing jobs.

2.5 Firms goals

In summary the chapter explored automobile manufacturers in a monopolistically competitive market place. We examined important cost and revenue curves that play a role in determining output for a firm. Chamberlin described a monopolistically competitive market saying the product has close substitutes; a large number of firms produce the product (which is differentiated), and entry into the industry is unrestricted; the number of firms in the product group is sufficiently large so that each firm expects its action to be ignored by its rivals; and the cost and demand conditions are the same for all firms in the product group. Firms operating in a monopolistically competitive market place want to maximize profits, we found based on theory that the firm will seek to operate where $MR = MC$. This given quantity of output is altered by shocks to demand, costs, and the economy changing where the firm will want to operate to maximize profits.

Based on the predicted impacts of the variables discussed in this chapter, in chapter three we will construct a multiple regression to see how those variables actually are affecting the value added by the automobile industry in the United States. By the end of

chapter three we will have presented the relevant variables impacting production in the automobile industry. In chapter four we will review the study depicting the key areas manufacturers of automobiles need to focus on to improve their performance in the market place.

Chapter 3: Determinants of Auto Production: Empirical Analysis

To continue our mission in discovering what influences domestic automobile production in this chapter I report on results from a multiple regression. The purpose of this study is to specifically understand how different economic variables in the United States affect auto production. In the sections that follow I will explain what a multiple regression model is, and present the fundamental equation used to explain that model. In addition we will define terms that explain the models' relevance which include R^2 , the t-test, and F test. Lastly I will interpret the results of the regression for value added in the automobile industry based on model indicators and compare these to what is expected in theory. By the end of the chapter I hope to provide enough information to understand how different economic indicators affect automobile production in the United States.

3.1 The Explanatory Power of a Multiple Regression Model

Newbold states that a multiple regression model uses independent variables to explain changes in a dependent variable; in this case the real value added growth of the auto industry, *rautovagro1* (2010, pg 497). In this particular model we express *rautovagro1* as a function of economic conditions *L1*, *rgdpgro*, *prodgro*, *rwagegro*, *rcappricgro*, *rautoimpgro*, *dumrec*, *strucdum*, and *grecdum*. That is

$$\begin{aligned} \text{rautovagro1} = & _cons + b_1L1 + b_2rgdpgro + b_3prodgro + b_4rwagegrow + \\ & b_5rcappricgro + b_6rautoimpgro + b_7dumrec + b_8strucdum + b_9grecdum \end{aligned}$$

where *rautovagro1* is the dependent variable, real value added growth of the auto industry, measured as a percent; *_cons* is the model's intercept, the value added growth of the auto industry when all other independent variables equal zero; *L1* is the lagged value of car sales, representing an increase in the previous years sales by one percent; *rgdpgro* is real

GDP growth, measured as a percent; prodgro is productivity growth, measured as a percent; rwagegro is real wage growth, measured as a percent; rcappriro is real price of capital growth, measured as a percent; rautoimpgro is real import growth of automobiles, measured as a percent; dumrec is a dummy variable for recessions; strucdum is a dummy variable for structural change; and grecdum is the great recession dummy variable.

3.2 Defining R² Variation in a Model

As Newbold said earlier a multiple regression uses independent variables to explain the behavior of the dependent variable. He also says that the variability in the dependent variable could, in part, be explained by a linear function of the independent variables. In this section we develop a measure, R², which is the proportion of variability in the dependent variable from its mean that can be explained by the multiple regression model (2010, pg 497). R² is referred to as the coefficient of determination. Before we can solve for this value we first have to decompose the sum of squares.

3.2.1 Sum of Squares Decomposition and the Coefficient of Determination

For simplicity I have used Newbold's constructed equations to explain how the Sum of Squares is decomposed; these equations can be found in his text *Statistics for Business and Economics* (2010, pg 499). We begin with the multiple regression model fitted by least squares

$$y_i = b_0 + b_1x_{1i} + b_2x_{2i} + \dots + b_kx_{Ki} + e_i = \hat{y}_i + e_i$$

where the b_i terms are the least squares estimates of the coefficients of the population regression model and the e terms are the residuals from the estimated regression model.

The model variability can be partitioned into the components

$$SST = SSR + SSE$$

Where these components are defined as follows:

Total sum of squares,

$$SST = \sum_{i=1}^n (y_i - \bar{y})^2,$$

which is the foundation for the sample variance of y.

Error sum of squares, which shows

$$SSE = \sum_{i=1}^n (y_i - \hat{y}_i)^2 = \sum_{i=1}^n e_i^2$$

Regression sum of squares, which shows

$$SSR = \sum_{i=1}^n (\hat{y}_i - \bar{y})^2.$$

It can be shown that

$$SST = SSR + SSE$$

or

Total Sample Variability = Explained Variability + Unexplained Variability.

The coefficient of determination, R^2 , of the fitted regression is defined as the proportion of the total sample variability explained by the regression that is

$$R^2 = \frac{SSR}{SST} = 1 - \frac{SSE}{SST}$$

and it follows that

$$0 \leq R^2 \leq 1.$$

R^2 will fall between the values 0 and 1. This decimal is directly related to the total sample variability from its mean that is explained by the regression. Values closer to 0 represent less variability of the dependent variable from its mean that is explained by the regression, where as values closer to 1 represent more variability of the dependent variable from its mean that is explained by the regression.

3.3 Testing Significance

In this section I provide details for testing the significance of a single variable and the significance of all explanatory variables. Respectively for this case the t-test is used on a single variable and F-test is used to analyze the significance of all explanatory variables.

3.3.1 T-test: Single Variable Significance

When focusing on whether or not an independent variable has an effect on the dependent variable Newbold explains, we test for its significance. To get started it is important to specify an appropriate null and alternative hypothesis, denoted beta β , these are mutually exclusive so you can determine what exactly you want to determine.

$$\text{Null Hypothesis} = \beta = 0$$

$$\text{Alternative Hypothesis} = \beta \neq 0$$

Based on theory we can find that the null hypothesis states the independent variable has no explanatory power on the dependent variable. The alternative states that we reject the null hypothesis that the variable has no explanatory power on the dependent variable.

To determine if the null hypothesis is retained or rejected we must see if the test statistic, t , falls within the critical or rejection region. In our case, to construct these regions we look for a 90% confidence interval with 43 degrees of freedom on a normal t distribution table. To get the boundaries of this interval we used the student t -distribution table which is available online, this gives us a lower boundary of -1.679 and an upper boundary of 1.679. If the test statistic falls within the boundary we do not retain the null hypothesis if it falls outside the boundary we do retain the null hypothesis if the test statistic falls within the boundary limits.

To solve for the test statistic in our regression model, Casler described the use of the equation:

$$t_{n-2} = \frac{b - \beta}{Sb}$$

Where b is the coefficient and Sb is the standard error associated with the variable, and β reflects our null hypothesis is equal to 0. By plugging an independent variable's values into this equation we can solve for the test statistic, to see whether the variable has explanatory power or not.

3.3.2 F-test Significance of all Explanatory Variables

To begin the F test is used to test the significance of all explanatory variables. Consider the model

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \dots + \beta_m x_{mi} + \varepsilon_i$$

We begin by considering the null hypothesis that all of the coefficients are simultaneously equal to zero:

$$H_0 = \beta_1 = \beta_2 = \dots = \beta_m = 0$$

Newbold says retaining this hypothesis leads us to conclude that none of the predictor variables in the regression model are statistically significant and, thus, that they provide no useful information. If this were to occur, then we would need to go back to the model specification process and develop a new set of predictor variables. Fortunately, in most applied regression situations, this hypothesis is rejected because the specification process usually leads to identification of at least one significant predictor variable (2010, pg 516). That is, we find the alternative hypothesis to be true where at least one variable has explanatory power on the model

$$H_i = \beta_i \neq 0$$

To test the previous hypothesis, we can use the partitioning of variability developed in the previous section 3.2:

$$SST = SSR + SSE$$

From this we find that a suitable test statistic is

$$F_{m,n-m-1} = \frac{SSR/m}{SSE/n-m-1}$$

Alternately we can write

$$= \frac{SSR}{SSE} * \frac{n-m-1}{m} = \frac{SSR}{SST-SSR} * \frac{n-m-1}{m}$$

where

$$= \frac{SSR/SST}{SST-SSR/SSR} * \frac{n-m-1}{m}$$

This can be simplified further to

$$= \frac{R^2}{1-R^2} * \frac{n-m-1}{m}.$$

This final equation represents the value of the F statistic found for the regression model.

When solving for the F test, we will have to find where the critical region lies on the distribution to see if we will retain or reject the null hypothesis. This value varies based on the number of degrees of freedom found for the numerator and denominator. This is represented by $F_{m,n-m-1}$, where m is the degrees of freedom in the numerator and n-m-1 is the degrees of freedom in the denominator; n is the number of observations, and m is the number of independent variables found in the regression model.

In class Casler explained if we find H_1 to be true, then the model has explanatory power. In that case R^2 is “Big” and $(1-R^2)$ is “small.” Therefore, the critical region is located in the right tail of the F distribution, and we would reject the null hypothesis (2012, Casler).

3.4 Independent Variable Analysis

Table 3.1 is the regression model that was generated with data collected from the *Economic Report of the President*, and *Bureau of Economic Analysis*. Data was gathered from 1963-2011 for each of the variables in the model. In the following paragraphs I will interpret the results for each independent variable, determine whether it is significant to the model based on the t test and, at the end of the section, decide if the model is significant as a whole based on the R^2 and F test.

Table 3.1 Determinants of Auto Production Regression Model

Source	SS	df	MS	Number of obs = 45		
Model	866.849845	9	96.3166494	F(9, 35) =	6.19	
Residual	544.693767	35	15.562679	Prob > F =	0.0000	
				R-squared =	0.6141	
				Adj R-squared =	0.5149	
Total	1411.54361	44	32.0805366	Root MSE =	3.945	

rautovagro1	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
rautovagro						
L1.	-.072015	.0420927	-1.71	0.096	-.1574677	.0134377
rgdpgro	.9748105	.7297285	1.34	0.190	-.5066172	2.456238
prodgro	.4232305	.5429556	0.78	0.441	-.679028	1.525489
rwagegro	.6285591	.8087832	0.78	0.442	-1.013358	2.270476
rcapprigro	-.8070972	.5993037	-1.35	0.187	-2.023748	.4095539
rautoimpgro	.0268441	.0608615	0.44	0.662	-.0967113	.1503994
dumrec	-1.658645	2.206803	-0.75	0.457	-6.138693	2.821403
grecdum	-7.434488	3.657602	-2.03	0.050	-14.85981	-.0091615
strucdum	.6779734	3.0696	0.22	0.826	-5.553646	6.909592
_cons	-7.215838	4.344718	-1.66	0.106	-16.03609	1.604409

3.4.1 Real Value Added Growth of the Automobile Industry (rautovagro1)

The real value added growth of the automobile industry is my dependent variable. These values were obtained from the *Bureau of Economic Analysis* under Annual Industry Accounts looking at GDP by industry under motor vehicles, bodies and trailers, and parts. The goal is to see how this value is affected by the variables in the regression model

These data for value added by motor vehicles, bodies and trailers, and parts were then made real by dividing by the price index and then made into a growth rate and divided by the average of values t and $t-1$.

Intercept (_cons)

The intercept term `_cons` can be interpreted as the real value added growth of the auto industry when all independent variables are equal to zero. In the regression model real value added growth of the auto industry will be negative .072% on average.

This relates to, Graph 1.1 in Chapter 1, showing that the auto industry's total contribution to GDP has been declining since the 1960's. However, looking at the t statistic we can see that this term does not have explanatory power and that it is not relevant in explaining output in the future.

3.4.2 Real Automobile Value Added Growth Lagged(L1.)

The term `L1` represents a lagged value of cars sales. This value is obtained by lagging the real value added growth of the automobile industry one time period. The purpose is to represent an increase in sales of cars in the previous year. If the Industry as a whole experienced a 1% increase in sales from the previous year, you can expect real value added of the auto industry to decrease the following year by .07%, on average.

3.4.3 Real GDP Growth (rgdpgro)

Real GDP Growth numbers were obtained from the *Economic Report of the President*; Table B-4, column 2, Gross Domestic Product. Table 3.1 shows that a 1 % increase in real GDP (rgdpgro), will cause real value added of the auto industry to rise by .97%, on average.

Real GDP Growth is a measure of total revenue growth from the model. The model followed theory in which as GDP grows the real value added by the automobile industry is also expected to expand.

3.4.4 Productivity Growth (prodgro)

Productivity values were also obtained from the *Economic Report of the President*, Table B-50, column 2, Output per hour of all persons, business sector. Table 3.1 shows that a 1% increase in productivity (prodgro), will cause real value added of the auto industry to rise by .42%, on average.

The model follows theory that as productivity growth increases due to technological change the real value added growth of the auto industry will increase. Improved engineering and technical knowledge allow more output to be produced from the same inputs, or when the same output can be produced with fewer inputs. This relates directly to decreased costs, as less is needed to produce the output necessary. By reducing costs with new techniques firms are able to increase profits.

3.4.5 Real Wage Growth (rwagegrow)

Values for real wage growth were obtained from the *Economic Report of the President*; Table B-47, column 10, percent change from year earlier in current dollar

amounts. Table 3.1 shows that a 1% increase in real wages (rwagegrow), will cause real value added of the auto industry to rise by .63%, on average.

It is important to understand the direct correlation between real wage growth and real value added growth of the Automobile Industry. In this case, real value added is influenced by real wage growth. This relationship can be reversed in that real wage growth could be influenced by the real value added growth in the automobile industry. Simply meaning that better and more productive work can lead to increases in the real wage.

The model for real wage growth does not follow theory for the Automobile Industry that when wages grow employers will desire fewer workers and cut back in production. This can be related to contracts the autoworkers have with unions, in that when unions were at their peak, wages are high and productivity is high. This phenomenon could explain why the value is positive rather than negative.

3.4.6 Real Price of Capital

The investment price index was obtained from the Economic Report of the President; Table B-3, column 3, Gross Domestic Product chain-type price index. This index was then converted into a real rate then into a growth rate. Table 3.1 shows that a 1% increase in the real price of capital (rcapprgro), will cause real value added of the auto industry to fall by .81%, on average.

This coefficient follows theory showing that as costs increase the firm will produce less because the cost of doing business has increased. With cuts in production less supply of labor will be desired meaning individuals will be out of work.

3.4.7 Real Import Growth for Automobiles (rautoimpgro)

Information and data on real import growth for automobiles were obtained from the economic report of the President, table B-104, column 14, non-petroleum imports specifically automotive. Based on Table 3.1 a 1% increase in the real import growth for automobiles (rautoimpgro), will cause real value added of the auto industry to increase by .03%, on average.

The model does not follow theory because as substitutes enter the market from a foreign country people will try other products and less would be willing to purchase a domestic vehicle. However, the value is nearly 0 due to the substitution effect for imported and exported vehicles.

3.4.8 Recession Dummy Variable (dumrec)

Referring to Table 3.1 the recession dummy variable (dumrec) shows, when our economy is in an economic downturn real value added of the auto industry will fall by 2.27%, on average. Dumrec was constructed using a 0 to represent years the economy was not in a recession and a 1 in years that our economy was in a recession since 1963. We placed a 1 in the following years 1969-70, 1974-75, 1980-82, 1990-91, and 2001, as you will see the most recent recession the “great recession” has its own dummy variable due to its significance.

The Recession Dummy Variable followed theory showing production will be scaled back when the economy is in a downturn.

3.4.9 Great Moderation Dummy Variable (strucdum)

Based on Table 3.1 the structural change dummy variable (strucdum) shows that while our economy was in the great moderation and structural change, real value added of the auto industry increased by .87%, on average. Strucdum was constructed using a 0 to

represent years before the structural change and for years during the great recession. In total the years from 1984-2006 represent the great moderation, in those boxes we placed a 1.

The great moderation dummy variable followed theory, indicating production will increase as technology and infrastructure improve.

3.4.10 Great Recession Dummy Variable (grecdum)

Based on Table 3.1 the great recession dummy variable (grecdum) shows that while our economy was in the great recession we will experience a decrease in real value added of the auto industry by 5.21%, on average. Grecdum was constructed using a 0 to represent years prior to the great recession and a 1 to represent years we have been in the recession. We placed a 1 in 2007, 2008, and 2009.

The great recession dummy variable followed theory showing production will be slowed during this recovery period.

3.5 Variability in the Model

As discussed earlier R^2 is the proportion of variability in the dependent variable from its mean that can be explained by the multiple regression model. R^2 for this model is

$$\begin{aligned} R^2 &= \frac{SSR}{SST} \\ &= \frac{866.85}{1411.54} \\ &=.61 \text{ or } 61\% \end{aligned}$$

That is 61% of the variance in real value added growth of the auto industry from its mean is explained within the model we have constructed. The fit of the model is not perfect; it

leaves room to explore different economic indicators so we can improve the overall fit and explanatory power for the regression.

3.6 Significance of Independent Variables t & F tests

T-test

In the regression model the t- statistic values are under t in Table 3.1. Based on theory if we are testing with a 90% confident interval the test statistic t value needs to fall between -1.679 and 1.679 to retain the null hypothesis and if the value falls outside we reject the null hypothesis.

In our case we have two independent variables that reject the null hypothesis real automobile value added growth lagged one time period, and the great recession dummy variable, the rest are not retained and are accepted as not being significant. That is we reject the null hypothesis that real automobile value added growth lagged one time period and the great recession have no impact on the real value added growth of the auto industry.

To clarify how to solve for the t statistic we will look at, values for the real automobile value added growth lagged one time period (L1.). Solving for the t statistic we use

$$\begin{aligned}t_{n-1} &= \frac{b - B}{Sb} \\&= \frac{-.072 - 0}{.042} \\&= -1.71\end{aligned}$$

Just to reiterate what was said before this value falls in the rejection region, which means we reject the null hypothesis that real automobile value added growth has no impact on the real value added of the auto industry.

F-test

In this model, to conduct the F test we need to first discover the rejection region, which is determined by the number of degrees of freedom and comparing these to the F-distribution table. In this case the numerator is, m, the number of independent variables and the denominator is, n-m-1, the number of observations minus independent variables minus 1. We find the Numerator to be 9 and the denominator to be 35 for this case. Which gives us a rejection region equal to 2.16.

Solving for the F statistic

$$\begin{aligned} f_{m,n-m-1} &= \frac{R^2}{(1-R^2)} * \frac{n-m-1}{m} \\ &= \frac{.61}{(1-.61)} * \frac{35}{9} \\ &= 6.08 \end{aligned}$$

This means that the F statistic falls in the rejection region that is we reject the null hypothesis that the model has no explanatory power. Since we found H_1 to be true, then the model has explanatory power. As was described earlier for this case R^2 is “Big and $(1-R^2)$ is “small.” Therefore, the critical region is located in the right tail of the F distribution and we would reject the null hypothesis that the model has no explanatory power.

3.7 Economic Variables Influencing Production

The purpose of this chapter was to examine the motor vehicle industry through a multiple regression model to see how value added of the automobile industry is affected by economic variables in the United States during the business cycles. To accomplish this we first covered the explanatory power of a multiple regression, in addition we discussed important tools that aid in checking the models reliability and significance.

In the case of the Automobile industry we were able to construct a useful tool indicating two significant factors that influence production. We found that real automobile value added growth lagged one time period and the economy being in the great recession as being influential determinants in value added by the automobile Industry. In chapter four we will review what the automobile industry is, why it is important to our society, how it acts in a monopolistically competitive market place in order to maximize profits, and what economic variables automobile manufacturers need to keep an eye on in order to improve their performance.

Chapter 4: Automobile Industry

The automobile industry is categorized within the Transportation Equipment Manufacturing subsector, which produces equipment for transporting people and goods. The automobile industry is important to our society due to the direct effect it has on the residents of the United States over the business cycle. The automobile industry makes significant contributions to the United States economy directly through employment, wages paid, and goods produced. Today, we see that the automobile industry contributes far less to overall GDP in the United States than it has since the early 1960's. As a result employees for automobile manufacturers suffer due to no work or relatively limited work. Employment relates directly to wages paid to employees; with limited wages employees have limited funds to support their needs. It is for this reason that we seek to improve the performance of the industry over the business cycles.

Automobile Manufacturing firms operate in a monopolistically competitive market place. This means that cars have close substitutes; a large number of firms produce cars (which are differentiated), and entry into the industry is unrestricted; the number of firms in the product group is sufficiently large so that each firm expects its action to be ignored by its rivals; and the cost and demand conditions are the same for all firms in the product group. Firms, like those in the Automobile Industry competing in a monopolistically

competitive market have some limited control over the price they can charge, seen in various prices for cars by different manufacturers. However, because all the products are similar (close substitutes), sales will fall sharply as price increases because customers will shift to other brands. This translates to firms in this market type having a downward sloping demand curve that is highly elastic.

As firms operate in the monopolistically competitive market place they wish to maximize their profits. Since there is a separation of ownership and control for Automobile Manufacturers, it is important that manager's goals are aligned with that of the stockholders so that the profits of the owners are maximized. As for operating efficiently to maximize profits we pointed out that firms must operate where marginal revenue is equal to marginal cost. In either case, if marginal revenue is greater than marginal cost or if marginal cost is greater than marginal revenue the firm is not operating as efficiently as possible and in the long run should seek to operate where marginal revenue is equal to marginal cost.

Shifts in demand and cost directly affect the marginal revenue and cost for automobile manufacturers, therefore changing the output the firm should produce. A shock in the price of related goods, income, population, expectations, or any event that changes a consumers mind, will likely cause the demand for the product to change. A shock in the cost of doing business due to price of inputs, or the state of technology changing will either result in savings or costs to the firm. The change in costs of inputs will affect the total cost incurred by the firm at each level of quantity produced, giving them a new marginal cost line.

We saw that real GDP growth and real automobile import growth can impact production patterns for Automobile Manufacturers. Real GDP growth is an indicator of the economy and a standard of living for many Americans, as the economy booms employees earn wages. In return, employees being consumers have more available funds to purchase luxury goods like cars. Based on theory we expect the automobile industry to increase production to return to equilibrium because the marginal revenue curve shifted outward. Real automobile import growth measures the change in the number of imports sold domestically. Based on theory as more substitutes enter the market place, i.e. import cars; we would expect sales to drop for domestic manufacturers due to the availability of substitutes for cheaper or relatively equal prices. This would lead to cuts in production.

Real wage growth, the real price of capital growth, and productivity growth were shocks to costs that we examined. Real wage growth measures the change in costs to the firm for labor. Based on theory when a higher wage is demanded firms are less likely to hire because of the increased cost, because of this we expect production to be cut back to accommodate for the outward shift in the marginal cost curve. The real price of capital growth measures the cost of investing in capital goods used to make commodity products. Based on theory we expect firms to decrease production as the price of purchasing capital goods increases due to as outward shift of the marginal cost curve. Productivity growth is a measure of technological change. Technological change occurs when new or improved engineering and technical knowledge allows more output to be produced from the same inputs, or when the same output can be produced with fewer inputs. Based on theory productivity growth will decrease the operating cost of the firm so we should expect the firm to increase production to accommodate the inward shift of the marginal cost curve.

Variables measuring different revenues and costs are not the only factors impacting production patterns for automobile manufacturers. Different states of the economy can also have a strong influence on production. Based on theory in times of a recession theory expects firms to cut production since the economy is stagnant and not many products are being sold. The great moderation and structural change also impact production as costs decrease for the firm we expect production to increase

We ran a multiple regression to see if theory held up for the factors influencing value added of the automobile industry. From the model we found real GDP growth, productivity growth, and the dummy variables all to follow theory. Real wage growth and real automobile import growth both did not follow theory. Real wage growth acts in reverse of what theory expected. As the real wage increases productivity also increases. This can be related to contracts the autoworkers have with unions, in that when unions were at their peak, wages are high and productivity is high. Real automobile import growth also goes against theory. An increase of imported cars actually increases the productivity in the automobile industry. This can be related to the substitution effect between imports and output.

The regression model narrowed down what variables were significant in explaining automobile production. Of all the shift factors explored in the model only two variables have explanatory power on the value added by the Automobile Industry. The great recession dummy variable and the real automobile value added lagged on time period were the two variables found to be significant in explaining the model. That is 61% of the variability in valued added growth in the automobile industry from its mean is explained by those two variables.

The state of the economy is an important indicator used to predict production output. By understanding the market place and business cycles, auto manufactures can produce more when consumers have money for luxury goods, and can scale back production when funds are tight. I believe in order to invigorate the automobile industry we must increase spending, through lowered interest rates and direct spending by the government to get the economy out of this very slow recovery. Increased spending leads to the production of goods that need labor to be produced. This labor relates directly to wages paid, as more goods are needed, labor is needed and so employees earn wages to pay for their needs. It is in any event necessary as a student studying the economy to stay informed on the activities of the Automobile Industry due to the massive influence it has on people living in the United States over the business cycles.

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