NBER WORKING PAPERS SERIES

AUTOS AND THE NATIONAL INDUSTRIAL RECOVERY ACT: EVIDENCE ON INDUSTRY COMPLEMENTARITIES

Russell Cooper

John Haltiwanger

Working Paper No. 4100

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 1992

NBER Working Paper #4100
June 1992

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ABSTRACT

This paper investigates the motivations for, and implications of, the Automobile Industry code under the National Industrial Recovery Act. The amended code contained a provision calling for automobile producers to alter the timing of new model introductions and the annual automobile show as a means of regularizing employment in the industry. After documenting key features of the automobile industry during the 1920s and 1930s and outlining the provisions of the automobile code, we analyze two models of the annual automobile cycle to explain the observations. In one model, the NIRA code simply codified a change in industry behavior that would have taken place anyway due to a change in fundamentals in the economy during the early 1930s. The competing model introduces a coordination problem into the determination of the equilibrium timing of new model introductions. Our analysis of this period provides evidence against the hypothesis that changes in fundamentals led to the dramatic changes in the seasonal patten of production and sales starting in 1935. Instead, it appears that the National Industrial Recovery Act succeeded in coordinating activity on an alternative equilibrium.

Correspondence to:

Professor Russell Cooper
Department of Economics
Boston University
Boston, MA 02215
and NBER

John Haltiwanger
Department of Economics
University of Maryland
College Park, MD 20742

Autos and the National Industrial Recovery Act: Evidence on Industry Complementarities

I. Introduction

On January 31, 1935 President Franklin D. Roosevelt signed Amendment 5 to the Code of Fair Competition for the Automobile Manufacturing Industry. Section 3 of the amendment contained the following provision:

> "The members of the Industry are requested and authorized to enter into agreements with one another with respect to Fall announcements of new models of passenger automobiles and the holding of automobile shows in the Fall of the year, as a means of facilitating regularization of employment in the industry."

Relative to current standards, this level of government intervention seems quite extraordinary. In fact, this amendment was part of the President's program, under the National Industrial Recovery Act (NIRA), to regularize employment in the economy. Implementation of this program involved the negotiation of over 500 quite specific codes of competition regulating conditions of employment and compensation. The automobile industry code was a key element of the President's program due, in part, to the large fluctuations in employment and hours in that industry. The point of the section of the amendment quoted above was to promote the regularization of production by altering key factors in the seasonality of automobile production: the timing of new model introductions and the annual automobile show.

Simply stated, the goal of this paper is to understand the basis and the implications of this amendment. What was the argument for this intervention in the automobile industry? Why were the changes under this amendment so important in the program of regularizing production and employment? Finally, why did the changes endorsed by this amendment persist despite the fact that the NIRA was ruled unconstitutional in May 1935, only six months after the amendment?

To address these questions, the paper begins with a review of the NIRA and the automobile industry in the 1920s and 1930s. Our purpose here is to place the automobile code within the broader context of the NIRA and to provide insights into the role of this code during this period. We also produce evidence on the seasonal pattern of employment, output and sales and document the magnitude of fluctuations in the automobile industry during the 1920s and 1930s. Looking at the seasonal patterns of production, sales and employment both before and after the NIRA code period, it is quite clear that after 1935 there was a permanent change in the seasonal timing of production and sales in the automobile industry.

The third section of the paper models the annual cycle of production, sales and new model introduction for the industry. In the basic model, which extends our previous work on machine replacement, Cooper-Haltiwanger [1992], a single decision-maker chooses the frequency of new model introductions given the presence of a fixed cost to switching models.

Using this model, we investigate the factors that determine the optimal timing of new model introductions. For this economy, permanent changes in the fundamentals (preferences and technology) in the mid-1930s can "explain" the observed changes in the timing of new model introduction, sales and production found in the data. From the perspective of this model, the NIRA per se had no real effects; it simply codified a change in behavior that would have taken place anyway.

We develop a competing model in which multiple producers decide independently on the timing of new model introductions. In this economy, there is a strategic complementarity associated with the fixed cost of introducing new models. In particular, we assume that new model introductions are less expensive if other producers are introducing models simultaneously. Our goal is to capture, in a simple fashion, the economies of scale associated with the introduction of new models through the automobile show.

With this model, the change in the timing of new models and the automobile show can be a consequence of a coordination failure. That is, prior to the NIRA code, the automobile producers were in a Pareto-inferior Nash equilibrium in which new models were introduced early in the calendar year, followed by the automobile show and, soon thereafter, a period of high sales and production. In this equilibrium, producers were unable to smooth production over the model year. Yet, as long as the complementarities through the automobile show were sufficiently strong, unilateral deviations to a smoother production program were not profitable. Through Amendment 5 of the automobile code, producers were able to coordinate on a preferred equilibrium which facilitated production smoothing.[1] Once at this preferred equilibrium, the fact that the NIRA was ruled unconstitutional was inconsequential.

The final section of the paper provides evidence on the competing models. Here we argue that there is little evidence to support the argument that fundamental changes in the industry, in terms of either the seasonal pattern of tastes, the production process or storage costs, led to the change in the seasonal pattern of production observed after 1935.

II. Background

This section of the paper provides a historical review of the automobile industry in the 1920s and 1930s and of the NIRA, with particular emphasis on the automobile code. In both cases, our focus is on Amendment 5 of the code. Hence we concentrate on factors within the automobile industry concerning the timing of new models, the seasonal pattern of fluctuations in sales, output, employment and hours and the role of the automobile show.

[1] As discussed further below, due to spillovers to upstream producers, the timing of the introduction of new models was also important to firms and workers in many other sectors. To the extent that these effects were not internalized by the automobile producers, there is the possibility of further social gains to the regularization of the automobile cycle.

The first two parts of the background section provide an overview of the automobile industry and the NIRA codes. The final part provides empirical evidence on industry behavior.

A. Automobile Industry in the 1920s and 1930s

By the mid-1930s there were four basic features of the automobile industry that are critical for understanding the NIRA automobile code.

-- The model year began in January and ended with a shutdown period for retooling in November and December.

-- The major annual auto shows were held in January of each year.

-- There was a burst of sales each Spring and low sales prior to the introduction of new models.

-- Production followed the pattern of sales. Following the shutdown period, production was high through the end of the Spring burst and then generally fell through the rest of the calendar year.

The basic storyline underlying this pattern of activity is relatively simple. There were two important factors influencing the pattern of demand: the introduction of new models and a Spring burst of demand associated with the beginning of good weather.[2] The automobile show was set for mid-January in order to provide a forum to display the new cars that would be sold

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[2] The burst in Spring demand reflected the advent of good driving conditions associated with warmer weather. In a study for the automobile industry, DuBrul [1935] estimated that the introduction of new models increased sales by 43% the first month and by 37% in the second month. In the month prior to the new models, demand was lower by about 33%.

during the Spring. During the period between the auto show and the Spring sales burst, production of finished products, as well as inputs into the automobile production process, would rise sharply. In the months before the automobile show, most producers had a retooling period in which the adjustments in plant and equipment would occur in preparation for new model production.[3]

Support for these basic features of the seasonal automobile cycle is provided in Figures 1 and 2 and in Tables 1 and 2. Figure 1 plots monthly automobile production over the 1923:1-1941:12 period.[4] From 1928 through 1935, production peaks during the Spring and falls to a trough near the end of the calendar year. These fluctuations in the volume of production were quite large as indicated in Table 1. During this period, production during the low month was often less than 25% of production in the highest month. In contrast, the trough to peak ratio of industrial production for total manufacturing (including autos) ranged from .61 in 1933 to .8 in 1932. Clearly the seasonal fluctuations in automobile manufacturing were excessive relative to manufacturing overall. Note too that the trough/peak ratio is lower after 1929 than in the 1925-28 period reflecting greater volatility in the

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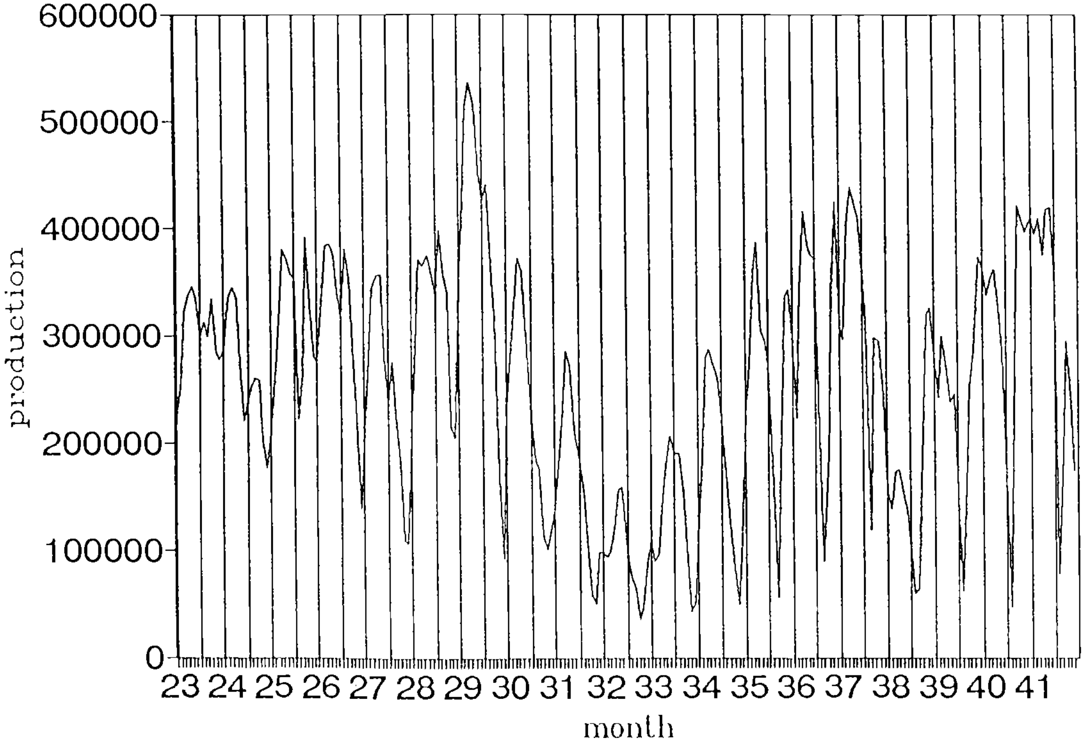
[3] This process of retooling for process and production innovations is described in Automobile Manufacturers Association [1940] and Fine [1963].

[4] The production data are for U.S. automobile plants reported in Ward's Automotive Year Book [1938 and 1944] and Automobile Facts and Figures [1930].

FIGURE 1

Automobile Production

1923:1 to 1941:12

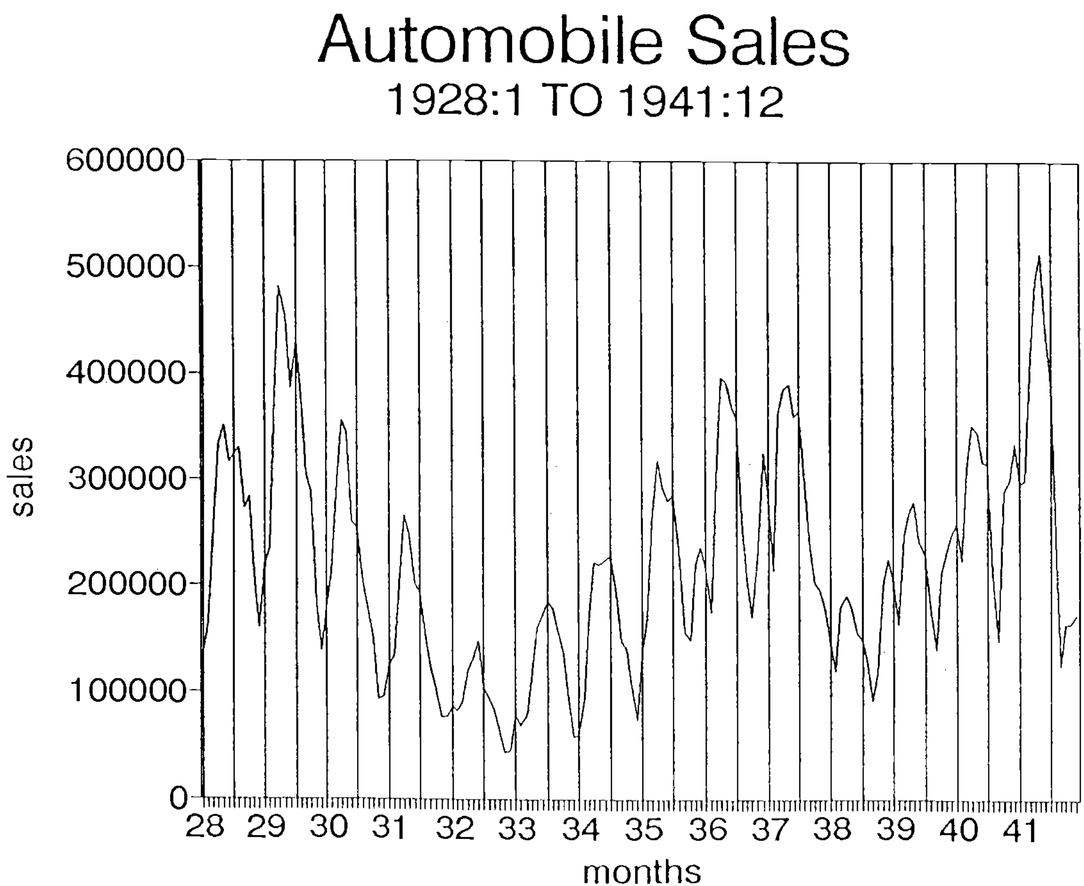


Automobile Annual Production and Sales Volatility: 1925-1940*		
Year	Sales: Trough/Peak	Production: Trough/Peak
1925	na	.54
1926	na	.36
1927	na	.30
1928	.39	.51
1929	.29	.17
1930	.26	.27
1931	.28	.17
1932	.30	.22
1933	.32	.20
1934	.27	.17
1935	.48	.14
1936	.43	.21
1937	.46	.27
1938	.41	.18
1939	.50	.16
1940	.42	.11

* Data are from the same sources as used in Figures 1 and 2.

Table 1

FIGURE 2


Automobile Sales
1928:1 TO 1941:12
600000
500000
400000
300000
200000
100000
0
sales
28
29
30
31
32
33
34
35
36
37
38
39
40
41
months

production process during the time of low economic activity. After 1935, the seasonal pattern of production appears to change; in particular, there is a second peak during the calendar year and a new trough in early Fall.

Figure 2 plots sales over the 1928:1-1941:12 period.[5] As was the case with production, during the 1928-35 period, there is a noticeable peak in sales during the Spring and a tendency for sales to fall during the remainder of the calendar year. After 1935, a new peak in sales emerges near the end of the calendar year. Table 1 indicates that, like production, sales was quite volatile over the year.

The importance of weather considerations for the seasonal pattern of sales can be better understood from sales data that is disaggregated by region. Henderson [1935, Exhibit 6] provides tables and charts which illustrate the fact that the seasonal pattern in sales was much more pronounced in the Northwest and Northeast parts of the U.S. than in the South and Pacific Coast regions. We present related evidence below.

A measure of employment volatility comes from data on separations in automobiles relative to other manufacturing industries. Byer-Anker [1937] provide a detailed analysis of labor turnover for manufacturing and 16

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[5] The data is car registrations provided by the R.L. Polk & Co. reported in various issues of Automotive Industries. As described by Kashyap-Wilcox [1992], General Motors commissioned Polk to assemble the data to provide information for GM's attempt at production smoothing. Ely [1935] documents many of the problems in inferring sales from registrations, particularly in June and December when buyers could profitably postpone the registration of cars.

industries over the 1930-36 period. From Table 1 of that paper, the automobile and bodies industry and the automobile parts industries had separation and accession rates close to twice those for manufacturing overall. To get some indication of the amount of turbulence in the Automobiles and Bodies Industry, Byer-Anker report that, per 100 employees, the total separation rate in 1933 was 96.96 and in 1934 reached 117.3 while the accession rate was 116.59 in 1933 and 144.23 in 1934.[6] In contrast the separation rates in manufacturing were 45.38 and 49.17 and accession rates were 65.2 and 56.91 for 1933 and 1934.

As for the annual automobile show, starting in 1900, the industry held major shows each year. From 1920 until 1935, shows were held in January in both New York and Chicago.[7] In 1935, following the amendment to the code, there was a show in January for the 1935 models and a second one in November for the 1936 models. After 1936 the show was held in the Fall, either in October or November. These shows were generally a time in which new models were shown for the first time to dealers and customers. Key product innovations during the 1920s, such as balloon tires, closed cars and four-wheel brakes, were the "highlights" of the respective shows.

The importance of these shows is illustrated by the following quotes

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[6] The total separation rate includes lay-offs, discharges and quits.

[7] There were also shows in other cities. Automotive Industries, November 15, 1930, provides a list of shows across the U.S. which were held in January and February of 1931.

from a November 15, 1930 article in Automotive Industries:

> "The industry needs the national and local auto shows as never before. We need the concentration of public interest in our products; we need new motor cars figuring as news; we can use a large quantity of generated enthusiasm."
>
> "Nearly a dozen dealer associations, state and city, have gone on record in the last year or so favoring the announcement of all new models around the first of the year, one of the reasons for this desire being a strengthening of public interest in the shows."

The timing of the automobile show had implications for the introduction of new models over the calendar year. Table 2 provides evidence on the timing of new model introduction from Ely [1935].[8] The second column reports, by month, the percentage of announcements that occurred in that month. Clearly, the pattern was to introduce new models between November and January, just prior to the automobile show. Using these raw data, 70% of the new models were introduced during this period. In fact, this figure understates the importance of new model introductions in the November-January period since it was quite often the small producers (such as Nash and Essex-Terraplane) who introduced new models in other times of

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[8] This table comes from material reported in Ely [1935] which summarized the stabilization of employment in the automobile industry. In the memo, Ely analyzed the implications of the DuBrul report's calculations of the effects of new models on sales. The study included over 50 examples of new model announcements by the 10 leading car producers (including Ford) from 1927 to 1934.

Distribution of New Model Announcements by Month for 10 large automobile manufacturers from 1927 to 1934	
Month	Raw Percentages
Jan.	.49
Feb.	.02
March	.06
April	.02
May	.03
June	.04
July	.05
August	.0
Sept.	.0
Oct.	.07
Nov.	.06
Dec.	.15

TABLE 2

the year. In particular, General Motors (GM) was a large producer of automobiles and usually introduced new models during December and January. Buick was an exception with new model announcements in July between 1927 and 1930.

This pattern of seasonal production in automobiles had significant implications for industries that provided the machines and the parts for automobiles, such as the tool and die industry which produced the machinery and tools that were needed in the automobile production process. During the annual retooling, these machines and tools had to be produced to allow the manufacturers to begin production of the new models after the automobile show. As discussed in the Henderson report [1935,p.27], production of these materials prior to retooling was quite difficult as the nature of the new models themselves was often in flux late into the calendar year. As a consequence, the tool and die manufacturers, as well as the automobile parts producers, had significant fluctuations in their employment and output. Byer-Anker [1937] report that the excessive accession and separation rates for the automobile and body producers were also prevalent in the automobile parts industry.

Overall, the automobile industry was a significant purchaser of a large number of inputs. As reported in Automobile Facts and Figures [1935], in 1934 the automobile industry used 21% of all steel produced, 75% of the rubber produced, 57% of the iron produced, 70% of the plate glass produced and so forth. These strong factor demand linkages are relevant for understanding changes in the seasonal pattern of production in these industries after the 1935 automobile code amendment.

The automobile producers were certainly well aware of the nature of these fluctuations and their potential costs. As a case in point, Kashyap-Wilcox [1992] document the efforts by GM to stabilize output over the year by adopting a policy to "production smooth." Kashyap-Wilcox argue that the data indicate the success of this program, particularly from 1925 to 1932. Excluding the shutdown months, they find that the variance of production exceeds the variance of sales in only 4 of these 16 years, 3 of them in the post 1935 period. Once they include shutdown months, however, Kashyap-Wilcox find that the variance of production exceeds that of sales for all but the first 3 years of the 1925 to 1940 period. This points to the important role of the shutdown period prior to the introduction of new models for understanding output and employment fluctuations in the automobile sector.

Note too that GM's action to regularize employment in 1924 did not extend to changes in the timing of new model introductions.[9] Kashyap-Wilcox report (see note 1 of their Table 2) that the GM shutdowns from 1925 to 1934 occurred in November or December in all but 4 instances, and these

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[9] However, GM management was certainly aware of the role of the timing of the annual shutdown. Sloan [1963] describes a GM board meeting in 1925 in which both the concept of annual model changeovers and the timing of new model introductions was debated. Sloan [1963, pg. 167] states that "General Motors in fact had annual models in the twenties, every year after 1923, and has had them ever since, but as the discussion above shows, we had not in 1925 formulated the concept in the way it is known today. When we did formulate it I cannot say. It was a matter of evolution."

exceptions involved October shutdowns. Starting in 1935 and continuing through 1940, GM's shutdowns occurred in August and September, with one exception occurring in July 1939.[10]

In November 1934, GM announced that it would unilaterally begin the staggered introduction of its new models. In announcing this change, Alfred Sloan, President of GM, argued that this policy would be an important step toward the regularization of employment. This proposal by GM was never acted upon due to actions, described below, taken under the NIRA.

The timing of new model years and their implications for the seasonal pattern of production and employment was also debated by industry leaders. The September 4, 1924 issue of Automotive Industries contained an article entitled "Are Yearly Models on the Way Out?" which summarized the debate at that time. The benefits of new models were that they stimulated demand while the main costs were the scrapping of the obsolete cars and the parts used in production of earlier models. As reported in Automotive Industries, January 17, 1931, the National Automobile Chamber of Commerce (NACC) recommended the synchronized introduction of new models in November or December of the calendar year. The main argument in favor of the synchronization concerned the problems of retailing cars when new models are being presented throughout the calendar year. This is an issue that we return

[10] For some years, Kashyap-Wilcox find multiple shutdowns. Presumable this reflects some staggering across GM divisions.

to below.

Overall, as indicated by our figures, the basic pattern of retooling prior to the automobile show in January and then producing at a high volume to meet the Spring burst was the underlying characteristic of the industry from 1926 to 1935. While the costs of the pattern were apparently recognized by industry leaders, the large seasonal fluctuations in production and employment remained an important industry characteristic.

These large seasonal fluctuations were not only a concern for automobile producers. In 1933, the National Industrial Recovery Act was passed with, among other goals, a charge to reduce employment fluctuations and to create more jobs. We now turn to that legislation and its implications for the automobile sector.

B. The Automobile Industry Under the NIRA

The NIRA was passed in June 1933 and was the centerpiece of the Roosevelt New Deal legislation. It gave sweeping powers to the Federal Government to attain a number of important economic goals, including: the stabilization of hours of work, the promotion of employment and the expansion of the purchasing power of workers.[11] To attain these lofty goals, the

[11] The National Industrial Recovery Act had many dimensions beyond the sections devoted to regularization of employment. Other important sections of the Act dealt with minimum wages and the right of workers to organize and collectively bargain.

Administration created the National Recovery Administration (NRA) to negotiate industry codes. A prime element in these codes were hours provisions restricting the maximum number of hours per week and average hours worked over longer periods. Through these constraints, the NIRA hoped to promote the reemployment of the nation's workforce. In effect, this was an attempt to spread work which would, it was argued, expand demand and thus support a higher level of economic activity. Most industry codes were in effect by February 1934.

The automobile code received special attention within the Roosevelt Administration. This was partly due to the automobile sector's overall size in the economy (in the mid-1930's automobile production was about 5% of total industrial production) and its significance as a purchaser of goods produced in other sectors. Further, as documented in the previous section, the fluctuations in the automobile sector were considerably larger than in other sectors. Thus, in an attempt to regularize employment, the automobile sector was a prime candidate for intervention. Finally, there was apparently strong Presidential interest in the automobile sector, perhaps stemming from the relationship between Roosevelt and Henry Ford.[12]

Despite the excessive volatility of employment in the industry, the

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[12] Ford was a supporter of Hoover in 1932 and a critic of many features of the NIRA codes. In fact, Ford did not sign the automobile code though the company did adhere to the hours restrictions.

automobile code, approved on August 26, 1933 was fairly standard in most respects. The automobile parts producers, the tool and die manufacturers and the automobile dealers had separate codes.[13] The expiration date of the code was set for June 16, 1935. The code acknowledged

> "substantial fluctuations in the rate of factory production throughout each year, due mainly to the concentration of a large part of the annual demand for cars within a few months, and also to the slowing down of employment in connection with changes in models and other causes beyond the Industry's control."

Key provisions of the code included:

> "For this purpose [spreading work] it is made a provision of this Code that employers shall so operate their plants that the average employment of *each* factory employee (with exceptions stated below) shall not exceed *forty* hours per week for the period from the effective date to the expiration date.
>
> In order to give employees such average of *forty* hours per week, it will be necessary at times to operate for substantially longer hours, but no employee shall be employed for more than six days or 48 hours in any one week, and all such peaks shall be absorbed in such average."

Omitted from this initial code were any provisions concerning changes in the timing of new model introduction. Still, this was recognized as an important issue. The code called on the industry to

> ".. make a further study of this problem in an effort to

[13] For a complete discussion of these codes, see Myrick [1935].

develop any further practical measures which can be taken to provide more stable and continuous employment and to reduce to a minimum the portion of employees temporarily employed and to submit a report thereon to the Administrator by December 1, 1933."

A report by the National Automobile Chamber of Commerce (NACC), entitled "Measures to Provide More Stable and Continuous Employment in the Automobile Manufacturing Industry" was presented to the NRA at the end of 1933. The report stressed the importance of model changeover for the continued success of the industry. The report, pg. 5, notes the implications of this practice for production smoothing:

> "The majority of manufacturers however, have changed models about the first of the year. This practice largely precludes production of parts or completed cars for stock to meet the peak customer demand in the spring months because following the new model introduction a high rate of production is required for some time in order to give dealers the necessary stocks for display purposes and to keep them adequately supplied with cars for meeting the increased consumer demand."

For our purposes, the most important aspect of the report concerned the timing of the new models. In the report, the industry group stated that

> ".. more stable and continuous employment could be provided in the Industry if manufacturers would be able and willing to announce to the public the change in their models for the following year at some time in the late summer and early fall."

To support this view, the NACC report included charts of the seasonal patterns of sales and employment for the majority of producers who announced new models in January and for the minority of producers who had deviated from the pattern and introduced new products in the Fall. The charts indicated the gains of regularized employment from Fall announcements.[14]

Further steps to reduce employment fluctuations were begun in November 1934 and culminated in Amendment 5 to the Automobile Manufacturing Code. These additional steps reflected the lack of success in regularizing employment under the original code. In particular, enforcement of the averaging clauses was viewed as quite difficult due to problems monitoring hours worked.

An important element leading to Amendment 5 is the Henderson report [1935], a document entitled "Preliminary Report on Study of Regularization of Employment and Improvement of Labor Conditions in the Automobile Industry" prepared by the NRA at the request of President Roosevelt. In the transmittal letter to Roosevelt, the NRA stated that "..the report makes a strong prime facie case for fall announcement of new models and a fall date for the automobile show that the Board wishes to express its willingness to cooperate with and support the industry in formulating and effectuating an appropriate amendment to the code for this purpose."

The Henderson report noted that the first NRA code for the

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[14] It is quite interesting to compare these calculations from 1933 with our own estimates of the seasonal pattern of production and sales before and after the NIRA code amendment. In particular, our analysis includes the effect of changing the automobile show while the NACC analysis was for deviant producers given that the automobile show was held in January in each of the years under their study. It appears that their forecasts actually overstated the amount of regularization that would arise from Fall introduction of new models.

automobile industry had not succeeded in regularizing employment through the restrictions on hours. The summary of the report, pg. 10, stated that

> "Regularization is not only possible, and actively desired by the industry, but it will provide for a large group of workers the income and security necessary to dissipate considerable unrest. Regularization can be substantially achieved by fall announcement of new models and a fall date for the automobile show. The Administration should take steps immediately to assist the industry of the new plan."

The gains to regularization, according to the Henderson Report, stemmed from excessive overhead, high labor turnover costs, high training costs and the need to employ less efficient workers during periods of peak production. There was also a brief discussion of staggering the new models, perhaps those within a given price class, as a means of stabilizing employment. But the report argues (pg. 13) that this is not practical due, in part, to the effect of staggering on retailing.[15]

It is noteworthy that the recommendation of the Henderson report included a change in both the model year and the timing of the automobile show. In part, this was a consequence of the fact that without a change in the auto show, manufacturers would have an incentive to delay the introduction of new models to learn the nature of competitors' products. The Henderson report also argued, pg. 13, that ".. it quickly becomes apparent that the

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[15] Some of these same points were raised in a January 17, 1931 Automotive Industries article referenced earlier. A letter from S.M. Heimlich, a Dodge-Plymouth dealer, to President Roosevelt, Heimlich [1934], outlines the case of the dealers against the staggering of new model introductions.

present custom of having models ready for an automobile show the first week in January is largely the result of habit and the fact that the show has long been scheduled for that date."

The response of the Industry was quite positive, in part because the Henderson report and the new code amendment put into law a provision first proposed by the industry in NACC [1933]. The views of the Industry were summarized in a Automobile Manufacturer's Association (AMA) document of February 1935 which summarized a members' meeting of December 1934. During that meeting, the members of the AMA agreed to the Fall introduction of new models beginning in 1935.[16] The AMA proposal also contained a call for a November auto show. In proposing these changes, the AMA argued that employment would be regularized by the creation of a Fall burst in sales and would allow manufacturers to build cars in advance of the Spring peak (despite the high storage costs) and to hold inventories of automobile parts. In addition, the AMA noted (pg. 4) that the necessary plant shutdowns would occur during the summer months when ".. the effect on the employee will be less burdensome then in the winter months as at present,.." As in the Henderson Report, the AMA argued that the staggered of new models was not a viable solution to the regularization problem due, in part, to retailing difficulties.

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[16] More precisely, October 1 was the target and manufacturers could announce new models 60 days before or after this target date.

The impact of the Henderson report and the subsequent code modification is captured in the following quote from Automotive Industries, September 28, 1935, pg. 405:

> "The opening of the New York Automobile Show Nov. 2 in Grand Central Palace, New York City, will signalize the start of an experiment in cooperative employment, an industrial planning project undertaken by private capital and management at the request of the President of the United States with a view to leveling off the peaks and valleys of employment in a seasonal industry, according to the Automobile Manufacturers Association."

Besides influencing the automobile producing industry, the change in the timing of new model introduction was viewed as having effects throughout the economy. Charles Roos ([1937], p.468), who was the Director of Research at the Cowles Commission and formerly the Director of Research for the National Recovery Administration, said:

> "Late in 1934 automobile manufacturers reached an agreement to introduce the 1935 new models in October instead of December so as to separate the new-model and spring demand and make possible steadier operation. Simple as the plan is, its effects should be tremendous -- regularization of employment in the automobile industry and to a lesser extent in steel, lumber and allied industries, and, as may readily be verified by existing statistics, intensification of seasonal demand for transportation. Moreover, without any additional capital outlay, productive capacities of the automobile and steel industries will be increased, demand for housing in Detroit, Flint and other automobile-manufacturing towns will be regularized and bank deposits throughout the country be changed seasonally. Also, farm workers, who have been accustomed to finding winter employment in the automobile industry, will have to look elsewhere. But despite all these economic changes, the net effect on the national economy should be beneficial."

C. Evidence

Against this historical background, it is important to evaluate the effects of the NIRA on the seasonal pattern of output, sales, employment and average hours. Figures 1 and 2 provide some insights into the question of whether Amendment 5 of the Automobile Code influenced the seasonal pattern of production and sales. After 1935, note that a new peak in sales and production appears near the end of the calendar year. Further, this year-end peak in sales and production is preceded by a reduction in sales and production near the beginning of the second half of the year. Relative to the pre-1935 period, the NIRA appears to have created a second peak in sales and production and a new trough in the seasonal cycle. This conforms with the NRA (see the Henderson report) and the Automobile Manufacturers Association [1935] predictions of the effect of changing the introduction of new models.

These impressions are confirmed by testing for a change in seasonal patterns of production and sales starting in January 1935. Figures 3a and 3b present the monthly coefficient estimates from a regression on seasonal dummies and seasonal dummies interacted with an NIRA dummy variable (set to 1 post 1935:1). The coefficients are presented for the logs of sales and production detrended with the Hodrick-Prescott filter. The null hypothesis that all of the coefficients on the monthly/NIRA dummies are zero is rejected at the 0.001 level for production and sales, respectively. Simply put, we find a

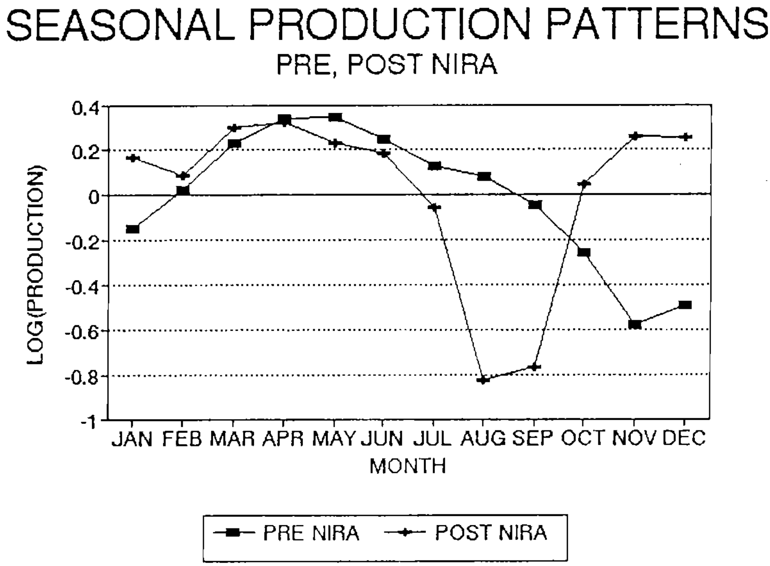

Figure 3a

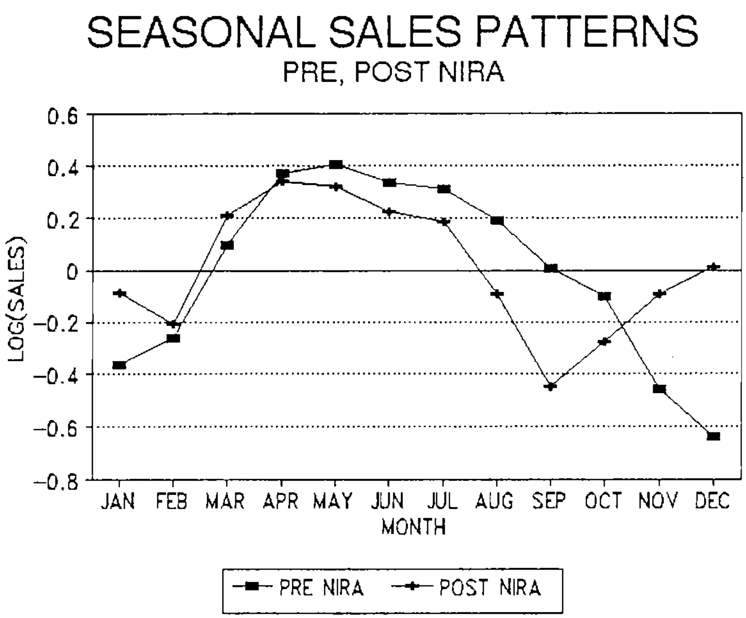

Figure 3b

striking and significant change in the monthly pattern of production and sales after the 1935 Amendment to the Automobile Code.[17]

These changes represent the predicted response of consumers and producers to the change in the timing of the new model introductions. The post-1935 production pattern indicates higher production levels in November and December, after the new model introductions, and lower production levels prior to the end of the model year, in August and September. There is a significant increase in sales in the last two months of the calendar year and a falloff in sales just prior to the introduction of new models.

As mentioned earlier, these sales patterns are evident at the regional level as well. Figures 4a and 4b present the monthly coefficient estimates for the log of detrended sales in the Northeast and the Pacific Coast for the pre- and post-NIRA periods.[18] Note that the sales pattern changed abruptly in both regions after 1935, reflecting the change in the timing of new model introductions. In both sub-periods, there is a noticeable burst of sales in the

[17] The conclusion of a break in the monthly pattern of production and sales also appears using the raw series, a series detrended using linear and quadratic time trends, the series of growth rates, and a series of production and sales as percentages of 12-month moving averages. For production, individual months with statistically significant changes at the 5% level include January, and August through December. For sales, individual months with statistically significant changes at the 5% level include January, August, September, November and December.

[18] Following Henderson [1935], the Pacific Coast includes Washington, Oregon, California and Idaho while the Northeast includes Connecticut, Delaware, Washington DC, Illinois, Indiana, Kentucky, Maine, Maryland, Mass., Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia and Wisconsin.

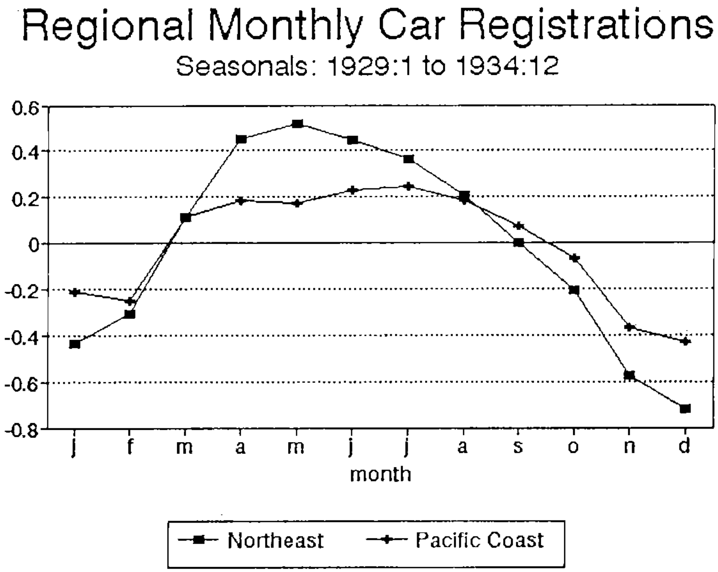

Figure 4a

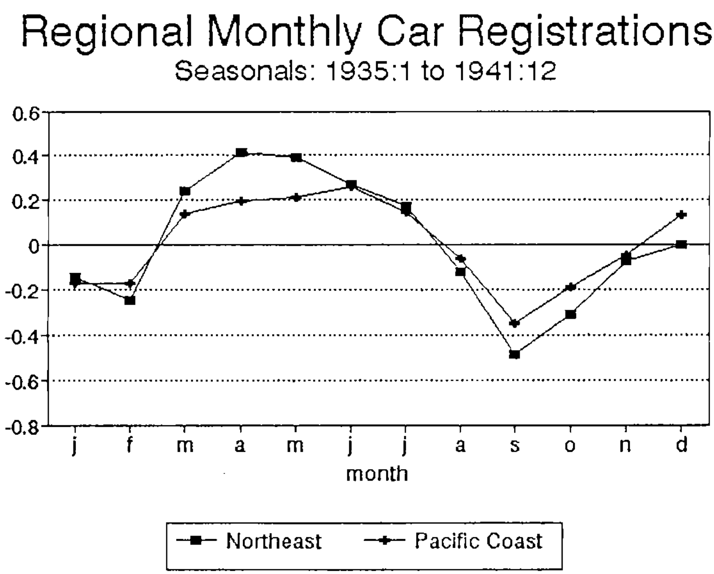

Figure 4b

Spring for each of the regions. The Spring sales surge is certainly much stronger in the Northeast: this is evidence of the impact of weather conditions on sales .

Comparing the variability of sales to production, there is no evidence of production smoothing over the model year. Table 3 computes the variance of production and sales for the pre and post-NIRA sub-samples. These are computed as variances of the estimates of the monthly coefficients reported for the series in Figures 3a and 3b for the two sub-samples. The first part of the table reports these variances for all months while the second part excludes retooling months. Using the coefficients for all months, the pre-1934 sample indicates that the variance of production was slightly less than that of sales. In the post-NIRA period, both sales and production were more volatile and the variance of production exceeds that of sales over the seasonal cycle. However, once the retooling months are excluded, the ratio of the variance of production to that of sales is lower in the post-NIRA period. The importance of this result is discussed in Section IV.

III. Optimal and Equilibrium Model Introductions

The previous sections have provided a historical background and a statistical analysis of the automobile industry during the 1920s and 1930s. The key aspect of that background was the action under the NIRA to alter the timing of new model introductions and the automobile show.

Variances of Production and Sales in Automobile Manufacturing			
Period	Production	Sales	Prod./Sales Ratio
All Months			
28:1-34:12	3.19	3.42	.93
35:1-41:12	4.99	3.6	1.39
Excluding Retoolings[2]			
28:1-34:12	1.72	2.44	.7
35:1-41:12	.88	3.12	.29

[1] The series used here are the same as those from Figures 1 and 2 except that the production series here is started in 1928. The reported variances are in millions.

[2] For the 28:1-34:12 period, November and December were excluded while for the 35:1 to 41:12 period, August and September were excluded.

TABLE 3

The goal of this section of the paper is to propose a framework for understanding the timing of new model introductions. There are a number of important factors that influence the optimal time for new models, including the storability of the product, the seasonal pattern of the value of leisure and the seasonal pattern of the value of a new car. All of these factors influence the fundamentals of the problem; i.e. these are factors which concern tastes and technology.

In addition, there are strategic factors that warrant attention. First, there is a public goods aspect to the automobile show in that it provided a forum for a large number of prospective customers, including dealers, to evaluate the new products. Automobile producers could show their products individually, but at a higher cost. Thus, the costs of new model introductions depend on the number of other producers introducing models at the same time.

Second, producers fiercely competed for consumers through product design. As noted in the Henderson report [1935, pg. 15], ." the highly competitive conditions of the industry have led manufacturers to wait until the last possible moment to make final design changes on their product.." This describes a "race" in which producers find it advantageous to wait until just prior to the Spring burst of demand to bring forth new products.

Both of these strategic features of the industry are important to understanding the timing of the introduction of new models and the automobile show. To distinguish fundamentals from strategic interactions, we begin with a simple model of the automobile cycle in which these strategic interactions are absent and then introduce them into the analysis.

A. Single Producer/Consumer

Suppose that there is a single producer of a storable, durable good. This producer receives a flow of utility from durable purchases, incurs disutility of work from production and also bears a cost of changing the "model" of the produced good. For simplicity, we do not characterize a decentralized equilibrium with durable goods and model years. Instead we analyze the problem of a representative agent who produces and consumes the good to better understand the factors that influence the efficient timing of new model introductions.

The optimization problem for the single agent is given by:

$$\max_{\{n_t, I_t, s_t\}} \sum_{t=0}^{\infty} \beta^t \left[u(\alpha_t s_t \theta_t) - g(n_t) - z_t k \right]$$

$$s.t. \tag{1}$$

$$I_{t+1} + s_t = I_t(1-\delta) + n_t$$

$$\theta_t = \begin{cases} \rho\theta_{t-1} \text{ if } z_t=0 \\ \hat{\theta} \text{ if } z_t=1. \end{cases}$$

In this problem, s_t is the total period t sales (purchases) of the durable good. Goods purchased in period t yield a flow of θ_t per unit. Assume $\alpha_t=1$ for t even and that $\alpha_t=\alpha>1$ for t odd. These variations in α_t proxy for deterministic variations in the marginal rate of substitution between consumption and leisure, as in periods of high marginal utility of cars (Spring) or high disutility of work (Summer).

As this is a durable good, interpret $u(\alpha_t s_t \theta_t)$ as the discounted utility flow over the life of the product evaluated in the period of purchase. In the absence of seasonal taste variations, $u(s\theta)=\sum\beta^t V((1-\kappa)^t s\theta)$ where β is the agent's discount rate, κ is the depreciation rate of the stock of durables, $s\theta$, and $V(\cdot)$ represents the utility flow from the stock in a given period. If $V(\cdot)$ is strictly increasing and concave in $s\theta$, then so will be $u(\cdot)$. Deterministic seasonals influence the flow of utility from the stock of durables in each period so that the value of the stock is indexed by the period of purchase: i.e. $u_t(s\theta)$. Assuming depreciation of the stock ($\kappa>0$) and discounting ($\beta<1$), at a given cost, durable demand will be higher in periods where service flows are more highly valued. Our model is a simple representation of this: $u_t(s_t\theta_t)=u(\alpha_t s_t \theta_t)$ and we term $\alpha_t s_t \theta_t$ period t consumption. This captures, in a tractable fashion, a seasonal component in the demand for durables.

In any period, the single agent receives a flow of utility from the stocks from purchases in other periods. Assuming that preferences are separable across these durable goods, those flows would appear as constants in (1) and are therefore not relevant for the decisions in that period.

Employment in period t is given by n_t which, we assume, is equal to output. Assume that cu'(c) is increasing in c and that g(•), a function representing the disutility of effort, is strictly increasing and strictly convex. With these restrictions, the agent will elect to work more in periods of high marginal utility.

The variable z_t indicates whether or not a new model will appear in period t. The agent incurs a cost of k in period t to produce a new model in that period. Note that the cost of producing a new model is modeled here simply as a utility loss, rather than a reduction in labor productivity as in Cooper-Haltiwanger [1992]. Further, in our earlier paper, there was a lag in the process of machine replacement which is absent here to further simplify the analysis. Since we are analyzing a model in which there are only 2 periods in a year, the lags in the retooling process, as well as possible congestion effects during retooling, are not included.

The first constraint is the inventory equation linking the stock of goods at the beginning of period to the stock of period t and the excess of production over sales in that period, n_t-s_t. These are finished goods inventories of the current model only. The variable δ is a measure of the physical depreciation of goods held in inventory.

The key to the model is the time path of θ_t, a measure of the "quality" of period t goods. From the last constraint, if there is no new model introduction, $\theta_t = \rho\theta_{t-1}$. Assume that $\rho < 1$ to reflect obsolescence in the quality of the product. Once a new model is introduced, θ is set to $\hat{\theta}$ and the utility flow from purchases of old models goes to 0. In this way, we generate a desire for new models. Thus the producer weighs the cost of replacement (k) against the gains of having a new model. In what follows, we normalize so that $\hat{\theta} = 1$.

One interpretation of this aspect of the model is that, through technological progress, the quality of goods is increasing over time. However, in order to produce better goods, the agent must replace existing machines with new ones, capable of producing the more desired product. Over time, a gap emerges between the quality of goods being produced and the quality that could be produced if new machines were installed. Given k, there will be an optimal time to stop production of the old goods and start producing the new ones. In our formulation of the model, we capture the essence of this potentially non-stationary problem through the assumption that $\rho < 1$ which creates a gap between the quality of existing goods and new models.

Implicit in the formulation of the problem are implications for the overlap of model years: In any period, the same durable good is produced and purchased. The introduction of a "new model" implies that the production of the old model drops to zero. This is a consequence of the fact that new models are no more expensive to produce and yield, due to $\rho < 1$, a higher flow of utility. Further, once new products are introduced we assume the complete obsolescence of old models that have not yet been purchased. Thus at the end of a "model year", the existing inventories of the good are purchased by the single agent.[19] This also implies that we need not keep track of stocks of different models since inventories will not be held over model years.

In this problem, there are two important dynamics: the frequency of new model introductions and the pattern of inventory holdings. As noted in our discussion of the historical experience in automobiles, the key issue was the timing of the introduction of new models over the calendar year and not the frequency of new model introductions.[20] With this in mind, the analysis of the model focuses on the timing of model introductions. To do so, we assume that new models are introduced every other period. This allows us to characterize the optimal timing of the new model introductions. Cooper-Haltiwanger [1992], in contrast, addresses the question of the optimal time

[19] If there was not complete obsolescence of old models, then the agent would have an incentive to mix purchases of older models with purchases of new ones. Of course, if preferences were separable across models as well as time, then the possibility of holding inventories of multiple vintages would not interfere with the solution to the problem of the timing of new model introductions. In a decentralized environment, modelling the holding of multiple vintages would require us to model both the choices of automobile dealers and the used car market which would take us too far astray.

[20] A very important exception to this statement was Ford Motor Company. In contrast to General Motors, Ford did not engage in the annual introduction of new models in the 1920s and early 1930s. In fact, the Model T was under mass production from 1913 through 1927. At that point, Ford underwent an extensive period of retooling (see Kuhn [1985] for estimates of the cost of this retooling and the related discussion in Nivens [1957]) to produce the Model A. Again, Ford stuck with this model until 1932 when another massive retooling was necessary. Still, even during the 1920s Ford did have plant shutdowns for the purpose of "inventory adjustment" and for the installation of new machines.

between new models in an environment with full depreciation of inventories.

With new models emerging every other period, there are two stationary configurations of new model introductions: in even or odd periods. In the following discussion, we refer to even periods as the Fall and odd periods as the Spring.[21] This corresponds to the automobile industry where there was a burst of demand (high α) in the Spring. It could also capture a high value of leisure in the Fall relative to the Spring. Since the introduction of new models generally took only a few months, it is reasonable to assume no lag in the process of model introduction.

In determining the timing of new model introductions, we will compare the values over the two seasons from Fall and Spring introductions. To avoid having results hinge on whether the first period is Spring or Fall, we assume that $\beta=1$ throughout the analysis.

Since α_t is high in the Spring, there are gains to introducing new models in that season as the full value of the new model is obtained when α occurs. As we shall see, under this strategy sales will be lower in the Fall when $\alpha_t=1$ so that gains to production smoothing are not possible. This is a cost of Spring model introductions. The model is consistent with fact that the Spring burst of sales prior to 1935 reflected both a new model and a Spring

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[21] Other seasons will be introduced later in the discussion. In the notation that follows, variables with "^" represent decisions under Spring model introductions and variables without hats are from Fall introductions. The subscripts denote the season for these flows.

demand affect.

The alternative strategy of introducing a new model in the Fall, may facilitate production smoothing since inventories can be held for Spring purchase. However, there is a cost of Fall model introductions due to $\rho < 1$: by the Spring, when demand is strong, models are somewhat obsolete.

Thus a simple tradeoff emerges between production smoothing and having new models available when the marginal utility of service flow is high. With this in mind, we turn to an evaluation of the optimal timing of new model introductions.

Formally, let V^S be the utility over the two periods between model introductions when the new model appears during Spring, at the time of high α,

$$V^S = \max \; u(\alpha \hat{n}_S) - g(\hat{n}_S) + [u(\hat{n}_F \rho) - g(\hat{n}_F)] \tag{2}$$

The first order conditions for this problem are

$$\begin{aligned} \alpha u'(\alpha \hat{n}_S) &= g'(\hat{n}_S) \text{ and} \\ \rho u'(\rho \hat{n}_F) &= g'(\hat{n}_F). \end{aligned} \tag{3}$$

Note that inventory holdings are zero in this problem. Since inventories can only be held from the Spring to the Fall and <u>not</u> across model years, inventories will not be held if $\alpha u'(\alpha n_S) > \rho(1-\delta) u'(n_F)$. This inequality means that the cost of holding a unit of inventory is greater than the benefit from increased consumption in the following period. From the first-order conditions defining V^S, it is straightforward to see that this inequality holds.[22]

V^F, the utility flow from introducing new models in the Fall, is given by

$$V^F = \max\ u(c_F) - g(n_F) + [u(\alpha\rho[n_S + (n_F - c_F)(1-\delta)]) - g(n_S)] \tag{4}$$

In this problem, it is feasible for inventories to be held from the Fall to the Spring, thus facilitating some production smoothing in the model year. The first order conditions are given by

$$\begin{aligned} \alpha\rho u'(c_S) &= g'(n_S), \\ u'(c_F) &= g'(n_F) \text{ and} \\ u'(c_F) &\geq \alpha\rho(1-\delta)u'(c_S). \end{aligned} \tag{5}$$

The last condition holds as an equality holds iff $n_F > c_F$. In these conditions, the Spring consumption flow is given by $c_S = \alpha\rho[n_S + (n_F - c_F)(1-\delta)] = \alpha\rho s_S$ where s_S denotes Spring sales. Under this timing of new model introductions, Fall sales and Fall consumption are equal.

Throughout this analysis, we assume $\alpha\rho > 1$. This implies that, in the event of Fall new model introduction, Spring is a period of higher marginal

---

[22] We argue below that Spring employment will exceed Fall employment when new models are introduced in the Spring. That fact, along with $\rho(1-\delta) < 1$, implies that inventories will not be held from the Spring to the Fall.

utility than the Fall, for a given level of consumption. Without this assumption, the introduction of cars in the Fall would imply higher sales in the Fall than Spring. As this is inconsistent with the evidence on sales presented earlier, we focus attention on the case of $\alpha\rho > 1$. Further, without this condition $V^S > V^F$, making it impossible to rationalize the change in the timing of the introduction of new cars from January to the Fall.[23]

The optimal timing of the introduction of new models will reflect the rate of depreciation (δ), the rate of technological obsolescence (ρ) and the magnitude of the Spring demand burst (α). The closer is δ to 0, the bigger will be the gains to retooling in the Fall so that a stock of new models can be built up for the period of high marginal utility in the Spring. The cost of this is influenced by ρ: if ρ is large these production smoothing gains are reduced by the reduction in the value of the new model.

<u>Proposition 1</u>: If $\alpha\rho > 1$, then $\hat{n}_S > n_S > n_F > \hat{n}_F$. Further, $\hat{s}_S > \hat{s}_F$ and $s_S > s_F$.

Proof: To see that $\hat{n}_S > n_S$, use (3) and (5) to obtain $\alpha u'(\alpha\hat{n}_S)/g'(\hat{n}_S) = \alpha\rho u'(c_S)/g'(n_S) \leq \alpha\rho u'(\alpha\rho n_S)/g'(n_S)$, where the last inequality comes from $c_S \geq \alpha\rho n_S$. Since $cu'(c)$ is an increasing function of c, $\alpha u'(\alpha\hat{n}_S)/g'(\hat{n}_S) < \alpha u'(\alpha n_S)/g'(n_S)$. This implies that $\hat{n}_S > n_S$ since $u(\cdot)$ is strictly concave and $g(\cdot)$ is strictly convex.

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[23] Formally, one can show that if $\alpha\rho < 1$, then no inventories will be held when new models are introduced in the Fall and, following the arguments of Proposition 2, $V^S > V^F$.

To see that $n_F > \hat{n}_F$, note that $n_F \geq c_F$. As cu'(c) is increasing in c, $u'(n_F)/g'(n_F) \leq 1 < u'(\hat{n}_F)/g'(\hat{n}_F)$ so that $n_F > \hat{n}_F$.

Finally, to see that $n_S > n_F$. consider two cases depending on whether inventories are held or not. First, if $n_F > c_F$, then (5) implies $(1-\delta)g'(n_S) = g'(n_F)$ so that $n_S > n_F$ as $g(\cdot)$ is convex. Second, if inventories are not held, $n_F = c_F$ and $n_S = c_S$ implies that $g'(n_S) = \alpha\rho u'(\alpha\rho n_S) > u'(n_S)$ since $\alpha\rho > 1$ while $g'(n_F) = u'(n_F)$ implying that $n_S > n_F$.

Since no inventories are held with Spring introductions, $\hat{s}_S > \hat{s}_F$ follows from $\hat{n}_S > \hat{n}_F$. The fact that inventories may be held with Fall introductions implies that $s_S \geq n_S > n_F \geq s_F$. QED.

The proposition illustrates the role of production smoothing in this environment. If new models are first produced in the Spring, then no inventories will be held over the model year. The high value of α in the Spring will lead to higher production and consumption relative to the Fall. In contrast, if new models are introduced in the Fall, then the employment pattern over the year is smoother than under Spring introduction. This reflects the separation of new model and high marginal utility effects when new models are introduced in the Fall. Even without the holding of inventories, the marginal utility of cars in the Spring is lower since $\rho < 1$ leading to smoother production. If inventories are held, then production is smoother than sales since $s_S > n_S$ while $s_F < n_F$.

Note that the proposition <u>does not</u> indicate that sales under Fall introduction will necessarily be smoother than under Spring introduction. This will be true if inventories are not held since then employment and sales will be equal so, from Proposition 1, $\hat{s}_S > s_S > s_F > \hat{s}_F$. This smoothing of sales through Fall introductions again reflects the separation of the stimulus to demand from new cars from the increase in marginal utility associated with Spring purchases. However, once there are positive inventory holdings under Fall model introduction, the process of smoothing production will raise Fall production and hence marginal cost in that season. As a consequence, Fall sales will be lower than in the allocation without inventory holding. Similarly, holding inventories permits higher Spring sales without incurring higher Spring production costs. It is possible that a consequence of these effects will be for sales to be <u>more</u> volatile under Fall introduction, i.e. for $s_F < \hat{s}_F$ and $s_S > \hat{s}_S$.

<u>Proposition 2</u>: If $\rho < 1$ and $\alpha\rho(1-\delta) \leq 1$, then $V^S > V^F$.

Proof: From Proposition 1, $n_S > n_F$ so that $u'(n_S) < u'(n_F)$. Then, $\alpha\rho(1-\delta) \leq 1$ and $\alpha\rho > 1$ imply that $\alpha\rho(1-\delta)u'(\alpha\rho n_S) < u'(n_F)$. Thus at zero inventories, the marginal cost of holding a unit in inventory exceeds the benefit. So, if $\alpha\rho(1-\delta) \leq 1$, then no inventories will be held if new models are introduced in the Fall.

Since there are no inventory holdings regardless of when new models are introduced, both V^S and V^F are the sum of two static problems. Let

$W(\alpha,\rho)$ be the payoff in a period for a given value of α and ρ. That is, $W(\alpha,\rho) = \max_n \{u(\alpha\rho n) - g(n)\}$ and note that cu'(c) increasing in c implies $W_{12} > 0$. Then $V^S = W(\alpha,1) + W(1,\rho)$ and $V^F = W(1,1) + W(\alpha,\rho)$. To see that $V^S > V^F$, note that $V^S - V^F = W(\alpha,1) - W(1,1) + [W(1,\rho) - W(\alpha,\rho)]$ implying

$$V^S > V^F \ \mathit{iff} \qquad (6)$$
$$\int_1^{\alpha} W_1(x,1)\,dx > \int_1^{\alpha} W_1(x,\rho)\,dx .$$

Since $W_{12} > 0$ and $\rho < 1$, this last inequality holds. QED.

The point of this proposition is that if the return on holding inventories of goods over two periods, $\alpha\rho(1-\delta)$, is less than 1, then inventories will not be held even with Fall new model introduction. In that case, there are no gains to introducing new models in the Fall since these become less desirable goods in the Spring, a period of high marginal utility. Interestingly enough, the proposition implies that the key to the desirability of Fall new models does not necessarily lie in a low value of α. If α is too low, inventories will not be held so that Fall model announcements will be dominated by Spring model introductions. That is, the gains to production smoothing are outweighed by the costs associated with discounting and obsolescence.

It is not, of course, the case that Fall new model introductions are never desirable. In the extreme where inventories do not depreciate and obsolescence is low, the benefits of production smoothing through Fall model introduction will be obtained.

Proposition 3: If δ near 0 and ρ near 1, then $V^F > V^S$.

Proof: Suppose that $\delta = 0$ and $\rho = 1$. Then, $V^S = W(\alpha,1) + W(1,1)$. Though inventories can be costlessly held, there will be no inventory holdings if the new product is introduced at the same time that α occurs. This is because $n_S > n_F$ in the determination of V^S.

V^F is given by the solution to (4). At $\delta=0$, $\rho=1$, the allocation is determined by

$$
\begin{aligned}
g'(n_S) &= \alpha u'(c_S) \\
g'(n_F) &= u'(c_F) \text{ and} \\
\alpha u'(c_S) &= u'(c_F).
\end{aligned}
\qquad (7)
$$

As $\alpha > 1$, these conditions imply that $c_S > n_S = n_F > c_F$. If, to the contrary, $c_F = n_F$, then $c_S > n_S = n_F = c_F$ and $\alpha u'(c_S) = u'(c_F)$ could not hold. So, production smoothing occurs with positive inventory holdings from the Fall until the Spring.

To see that $V^F > V^S$, consider the allocation in the problem determining V^S, $(\hat{c}_F, \hat{c}_S)$. Suppose that retooling occurs so that the new model is available in Fall, contrary to the V^S allocation, but that the consumption profile is the same as in that allocation. Since $\rho=1$, this new allocation yields the same utility flow as V^S. Now, as in the V^F allocation, set employment to a constant in the two periods, leaving consumption unchanged. By the convexity of $g(\cdot)$, this will increase utility over the two periods. The resulting allocation, which dominates V^S, can not be worse than V^F since it was feasible when V^F was determined.

Thus $V^F > V^S$ when $\delta=0$ and $\rho=1$. By continuity, this is true for δ near 0 and ρ near 1. QED.

Note too when $\rho=1$ and $\delta=0$, sales in the Fall (Spring) will be lower (higher) under Fall model introduction than under Spring model introduction. To see this, from Proposition 1 we know $\hat{n}_S > n > \hat{n}_F$ where n is the seasonally independent level of employment under Fall introduction with these parameter restrictions. This ordering of the employment levels implies that $s_S > \hat{s}_S$ and $\hat{s}_F > s_F$. So, in this extreme case, and for parameter values close by, $V^F > V^S$ but sales will not be smoother under Fall model introduction, though production will be constant.

Proposition 2 is informative about the conditions under which V^F is definitely less than V^S as there are no gains to production smoothing. Proposition 3, in contrast, argues that there are some extreme parameter values such that Fall new models is desirable. To characterize some of the intermediate cases, let

$$\Delta(\delta,\rho) \equiv V^S(\delta,\rho) - V^F(\delta,\rho).$$

Here $V^S(\delta,\rho)$ and $V^F(\delta,\rho)$ are given by (2) and (4) respectively with dependence on (δ,ρ) shown explicitly.

Proposition 4: $\Delta_\rho(\delta,\rho)<0$ and $\Delta_\delta(\delta,\rho)\geq 0$ with $\Delta_\delta(\delta,\rho)>0$ if $n_F>c_F$.

Proof: By definition, $\Delta_\rho = 1/\rho[\hat{c}_F u'(\hat{c}_F) - c_S u'(c_S)]$. Using $\alpha\rho>1$ and $cu'(c)$ is increasing in c, $c_S>n_S>\hat{n}_F=\hat{c}_F$ so that $\Delta_\rho<0$. By definition, $\Delta_\delta=\alpha u'(c_S)(n_F-c_F)$ since V^S is independent of δ. This is clearly positive if $n_F>c_F$ and zero when no inventories are held. QED.

Based on these propositions, the mapping from (δ,ρ) into the optimal timing of new model introductions is shown in Figure 5, for a given value of α. Combinations of (δ,ρ) such that $\rho\alpha(1-\delta)=1$ are given in the figure. On and below this curve, we know from Proposition 2 that $V^S>V^F$. In this region, there are no gains to early model introductions as there is no production smoothing desired. For combinations of (δ,ρ) in the neighborhood of (0,1), inventories will be held and, from Proposition 3, $V^F>V^S$. By continuity, there is a curve that lies above the $\rho\alpha(1-\delta)=1$ curve such that $V^F=V^S$, as shown in the diagram.

As suggested by the original intuition about this problem, the optimal timing of new model introductions reflects the costs of inventory holdings and the rate of obsolescence. If technological progress is fast and inventories are

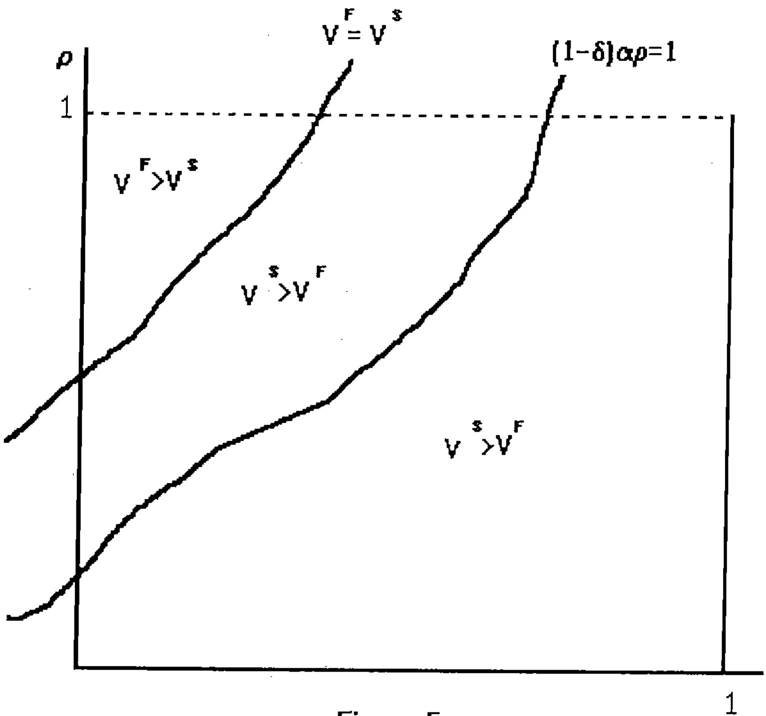

Figure 5

costly to hold, then the Spring introduction of new models is desirable. On the other hand, the gains to production smoothing are obtainable if inventory holding costs and the rate of obsolescence are low.

A final factor influencing the timing of new model introductions are seasonal taste variations. In the model, the effect of changes in α are ambiguous. On one hand, an increase in α will lead to an increase in Spring production relative to the Fall and thus a desire to take advantage of production smoothing through Fall model introductions. On the other hand, an increase in α makes it even more desirable to have new models in the Spring to avoid obsolescence, associated with $\rho<1$. To illustrate, $\rho=1$ and $\delta=0$, if $\alpha=1$, there is no difference at all between Spring and Fall introductions. Yet, for α slightly above 1, Fall introductions dominate to obtain the gains for production smoothing. At the other extreme, where $\rho<1$ and $\delta=1$ and $\alpha=1$ there is again indifference in the timing of new model introductions. However, a slight increase in α above 1 implies that Spring introductions are desired to avoid obsolescence.

As noted earlier, it is necessary that α be <u>high</u> enough that $\alpha\rho(1\text{-}\delta)>1$ so that inventories will be held from Fall to Spring under Fall new model introductions. Without these inventory holdings, $V^S > V^F$ as in Proposition 2. At the other extreme, if α falls below 1, then the seasons are simply reversed and Fall becomes the period of high marginal utility. In this case, Fall model introductions are best when ρ is low and δ is high. Short of this extreme, one could consider the importance of changes in the disutility of work in addition to the variations in marginal utility of sales stressed thus far. One could then argue that reductions in the marginal disutility of work in the Fall could, independently of variations in the Spring taste parameter, lead to $V^F > V^S$.

In order to explain the change in the timing of the new model introductions in 1935, this model requires that during that year or preceding years (allowing for costs associated with changing the timing of the model year to generate some lag in the response), there were changes in the automobile industry that either reduced inventory holding costs, reduced the rate of technological obsolescence or changed the seasonal pattern of preferences. Each of these possible changes leads, in turn, to predictions for the seasonal pattern of sales and output post 1935. If following Figure 5, there was an increase in ρ or a reduction in δ, then once Fall introduction of new models began, production would be smoother than previously. Further, there would be a new model effect on sales arising in the Fall and a reduction in the magnitude of the Spring sales peak. As noted earlier though, these effects could be muted by the holding of inventories from Fall to Spring. Alternatively, if there was a reversal of the relative seasonal taste parameters ($\alpha < 1$ in the extreme), then Fall sales and production would exceed Spring's, post 1935.

B. Multiple Producers

The presence of multiple producers introduces some interesting strategic considerations into the model. First, there may be economies of scale associated with multiple producers showing their products at a national show. This was one of the important features of the national automobile shows that were held starting in 1900. Formally, one could envision a model in which there is search by consumers to locate and view products. A national show is a consequence of the gains from temporal agglomeration due to economies of scale in the marketing of new models.[24]

In the model which follows, this interaction across agents is modeled through a modification of the retooling cost. We assume that the cost of introducing a new model, including the costs of retooling and marketing are a decreasing function of the number of other producers undertaking new model introductions at the same time. This is a simple means of modelling the economies of scale associated with the automobile show. This assumption introduces a complementarity into the problem of new model introductions. As in our previous work, Cooper-Haltiwanger [1990a,1992], this leads to the synchronization of discrete activities. This is consistent with the fact that producers tended to bunch the introduction of new models throughout this period.

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[24] Howitt [1985] provides a formal model in which selling costs depend inversely on the level of market activity. That model could be amended to provide a microeconomic foundation for our assumption, made explicit below, that new model introductions are less costly when they are bunched by producers.

Suppose that producers are involved in a simultaneous games in which, at the start of time, they decide whether to introduce new models in the Spring or the Fall. Taking the timing decisions of others as given, a single agent solves

$$\max_{\{n_t, I_t, s_t\}} \sum_{t=0}^{\infty} \beta^t \left[u(\alpha_t s_t \theta_t) - g(n_t) - z_t K(N_t) \right]$$

$$s.t. \tag{8}$$

$$I_{t+1} + s_t = I_t(1-\delta) + n_t$$

$$\theta_t = \begin{cases} \rho\theta_{t-1} \text{ if } z_t = 0 \\ \hat{\theta} \text{ if } z_t = 1. \end{cases}$$

This is essentially the same formulation as (1) except that here the costs of introducing new models in period t depends on N_t, the number of producers introducing new models in that period. There are two components to K(N). One which reflects the cost of retooling, k, and a second which represents marketing costs, M(N). Assume that M'(N), and therefore K'(N), is negative. This is the only source of strategic interactions we allow at this point. The next section considers strategic interactions arising from interrelated demands.

The importance of the strategic interactions can then be easily seen. Suppose that there are N producers. Further, suppose that the efficient time for the introduction of new models is the Fall.[25] Since, by assumption, K(N) < K(1), producers introducing new models in the Fall is a Nash equilibrium of the game in which producers decide on either Spring or Fall introductions.[26] A deviant strategy of introducing new models in the Spring would be unprofitable because retooling costs increase and because production smoothing does not occur. Is there another equilibrium?

Proposition 6: Suppose $V^F > V^S$. If K(1) is sufficiently larger than K(N), then a Nash equilibrium exists in which all producers introduce new models in the Spring.

Proof: Suppose that all producers introduce new models in the Spring. V^S is given by (2). A deviant firm could introduce new models in the Fall, thus benefiting from production smoothing with payoffs given by V^F. Let K(1)-K(N) exceed V^F-V^S. Then a deviation to Fall model introduction is not profitable. QED.

The existence of an inefficient Nash equilibrium with Spring introductions thus rests on the presence of large enough economies to scale in

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[25] A symmetric argument can be made that the efficient time for new models could be in the Spring but that an equilibrium exists with Fall introductions.

[26] As in the single agent problem, we focus on history independent equilibria where the strategy set for each player is {Fall, Spring}. The choice of Fall (Spring) implies that the player will introduce new products every Fall (Spring) regardless of the play of others. Any equilibrium of the "one-shot" game will also be a Nash equilibrium of the infinitely repeated game.

the process of introducing new models.[27] When K(1) is sufficiently large, there is the possibility of a coordination failure in the timing of new model introductions: Spring model introductions can occur even though a Pareto-superior equilibrium exists. As suggested by the Henderson Report [1935, pg. 13], ".. it quickly became apparent that the present custom of having models ready for an automobile show the first week of January is largely the result of habit and the fact that the show has long been scheduled for that date." In this case, collective action was needed to coordinate new model introductions in the Fall. From the perspective of the coordination model, this was the point of Amendment 5 of the NIRA automobile code.

In terms of sales and production, the impact of the NIRA is characterized by Proposition 1. The seasonal pattern of employment and output would be smoother post 1935. The effect of the change on sales is not

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[27] There is another, potentially profitable, strategy that is not feasible in our model: the production of new models in the Fall, the introduction of these models in the Spring and sale of new models in the Spring and subsequent Fall. Relative to a candidate equilibrium of Spring introductions, this strategy would allow some production smoothing without incurring the costs of new model introductions by a single agent. This strategy, strictly speaking, is not feasible in our model as it decouples new model production from introductions. We have assumed that once a new model is produced the previous model becomes totally obsolete, i.e. $\rho=0$ for the previous model. This restriction is consistent with observed behavior by automobile producers: when new models were produced they were immediately available for sale to the public.

If we allow this alternative strategy, one can show that for some parameter values, this type of deviation will not be profitable relative to a candidate Nash equilibrium with Spring models. The strategy outlined above entails two periods of obsolescence and two periods of inventory holdings since production starts in the Fall and that model is consumed in the Spring and the following Fall. Thus for δ sufficiently high and ρ sufficiently low, this alternative strategy will not be a profitable deviation from Spring introduction even when $V^F > V^S$.

clear for reasons explained earlier. However, one would expect to see a stimulus to Fall sales due to the new models and a reduction in Spring sales due to the obsolescence effect.

C. Seasonal Innovation Races

A second source of strategic interaction concerns the nature of the demand for a firm's product.[28] One possibility is that producers who bring forth models before others may be imitated, thus losing the gains from model introduction. As a consequence, it may be optimal for producers to synchronize the introduction of new models in the Spring, when demand is high.

To be more specific, suppose that there are two producers whose products differ in terms of both variety (e.g. Ford vs. GM) and in the quality of the product. Consumers are located uniformly along the [0,1] interval as in the Hotelling model and the firms are located at the endpoints. Thus the interval serves as a model of product variety where consumers bear a utility loss from "moving" along the interval. Consumers purchase at most a single unit of the product and have preferences over both variety and quality.[29]

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[28] We are grateful to Michael Manove for persuading us to pursue these ideas.

[29] If a consumer located at point i purchases a product from producer j, then the utility is θ_j - p_j - $\gamma x_{i,j}$ where θ_j is the quality of firm j's product, p_j is the price charged by j and $\gamma x_{i,j}$ is the transportation cost born by consumer i from purchasing from firm j.

At each point in time, firms select prices to maximize profits given the current quality of their product. In addition, there is a dynamic aspect of the game associated with the choice of quality at each point in time. As in the models presented already, suppose that there is a cost of introducing a higher quality product. To understand the incentives for synchronization, which is the point of the discussion, assume that new products are introduced by the firms every other period.

If the utility of a consumer is linear in the quality of the product and the "cost" from moving along the variety interval, then there will be a symmetric Nash equilibrium with a staggered introduction of new products. Along the equilibrium path, producers will obtain more than one-half the market when introducing new products. This staggering arises from the fact that the game between producers is characterized by strategic substitutability.[30] In order to obtain synchronization, as was observed in the automobile industry, it is necessary to introduce a seasonal variation in demand. Suppose then that the number of buyers is higher in odd (Spring) than in even (Fall) periods. If this seasonal is large enough, an equilibrium with product introductions in the Spring will occur.

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[30] To be a bit more precise, consider the payoffs of the producers in the static Nash equilibrium of the price setting game for given product quality levels. These reduced-form payoffs will satisfy strategic substitutability. From Cooper-Haltiwanger [1990a, 1992], strategic substitutability implies the staggering of discrete decisions, including the introduction of new products, in the absence of aggregate shocks.

While this model is consistent with Spring introductions, as in the pre-1935 period, multiple equilibria do not arise.[31] Instead, for the race model to be consistent with the observed facts, there would have to be fundamental changes such that the equilibrium timing of new model introductions changed from Fall to Spring. That is, one could add a production smoothing motive to this model and thus, assuming enough convexity, obtain the prediction that Fall introductions could arise in equilibrium. Since this model also rests on fundamentals, we have treated it informally and consider the main contrast between the two extreme models given in the previous sections.

D. A seasonal model and other extensions

The above models simplify the environment by assuming that high values of α occur every other period. This enabled us to provide some insights into the tradeoff between production smoothing through Fall new models and the gains from Spring models through the synchronization of high marginal utility and new products.

An alternative model with four seasons would expand upon this logic and allow one to introduce an increased value of leisure during the Summer, distinct from the higher marginal utility of consumption in the Spring. It

[31] To be more precise, looking at the choice of Spring vs. Fall model introductions as the strategy variables in the one-shot game, multiple equilibria do not exist. As suggested to us by Richard McLean, if one considers the infinitely repeated game, other equilibria will exist.

would also enable us to introduce, as in Cooper-Haltiwanger [1992], a lag in the retooling process and a congestion effect such that the marginal product of labor in the production of cars falls during the retooling period. In this case, the Fall announcement of new models would have the added advantage of a shutdown in the Summer when the value of leisure was high.[32] So, in this model, even if $\alpha=1$, implying no particular seasonal pattern in marginal utility, there would be a strict incentive for Fall model introductions due to the higher value of leisure in the Summer. Finally, the model would be a bit closer to the monthly observations in our data.

While the richness of this model is apparent, so is its complexity since one would have to evaluate a larger number of alternative timing configurations. We chose the two season model to illuminate the tradeoff between production smoothing and model obsolescence; a tradeoff that would carry over to a setting with four or even twelve periods in a model year.

A final important extension of the model would be to incorporate the rich upstream and downstream linkages between the producers of parts, tools and die and the retailers. As noted earlier, the timing of new model introductions had important effects on the seasonal pattern of upstream production and downstream retailers. To the extent that automobile producers did not internalize the effects of their new model introductions on these other

[32] This is of course captured in the current model to some extent since $\alpha > 1$ implies a higher marginal rate of substitution between consumption and leisure in the Fall than in the Spring.

agents, additional social gains (including the welfare of upstream producers) are possible in moving from Spring introductions of new models. However, these spillovers alone cannot account for the multiplicity of Nash equilibria since the timing decisions by the producers would not generally reflect the payoffs of upstream producers and downstream retailers.

IV. Evaluation of the Competing Models

Both the fundamental's model and the coordination model are consistent with the observations described in Section II. In particular, the change in the timing of new models and the automobile show could arise either due to a change in fundamentals or from the elimination of a coordination problem.

Further, the observed changes in the seasonal pattern of production and sales following the change in the model year is consistent with either model. From Proposition 1, the change in the introduction of new models should yield increased production in the Fall relative to the Spring.[33] When new models are introduced in the Fall rather than the Spring, Fall sales will be increased due to the new model effect. This new model effect is reflected in the estimates reported in Figure 3b as significant increases in sales in

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[33] The comparisons in Proposition 1 hold for the coordination model in that these comparisons hold fundamentals fixed. If the change to Fall introductions reflected a change in fundamentals (ρ increases or δ falls), then similar comparisons would hold.

November and December after 1935. Further, Figure 3b indicates a reduction in sales in August through October, relative to the pre 1935 period, as consumers anticipated the introduction of new models. As our formal model has only two seasons, it is not capable of reproducing these richer observations concerning the emergence of additional peaks and troughs after 1935 in sales and production. Those affects are present in the model but are time aggregated.

To distinguish the competing models, we make the following identifying assumption. Changes induced by fundamentals (changes in tastes, technology) should be evident in observed changes in the seasonal pattern of production or sales in the years leading up to 1935. That is, it is our sense that changes in fundamentals are likely to have occurred systematically and gradually over time, instead of abruptly in 1935.

What types of actual changes could have occurred over this period that may have prompted a change in the optimal time for model year introduction? One argument is that the utility flow from automobile use in the late Fall and early Winter was increasing during this period. From various issues of Automotive Industries over this period, there were reports of improvement in reliability, roads and tires and cars were increasingly closed, thus providing better protection from the weather.[34]

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[34] The start of widespread production of closed cars dates to the mid 1920s.

To understand this identifying assumption, consider the implications of a change in fundamentals. According to the model, a gradual and systematic increase in the relative demand for autos in the Fall, say due to a lower rate of obsolescence, could induce an increase in Fall sales relative to Spring sales with associated implications for seasonal production. Ultimately, an accumulation of such demand changes that are sufficiently large could induce a discrete change to Fall model year introductions. Under this scenario, we should observe a gradual increase in Fall sales relative to Spring sales until a critical year is reached in which there should be a discrete change to Fall introductions with associated discrete changes in the seasonal pattern of sales and production. Note that gradual changes in inventory holding costs (δ) could yield similar dynamics. If δ falls, so that the storability of cars increases, then one should observe smoother production during the model year.[35]

The general point is that gradual changes in any one of these fundamentals could ultimately trigger a change from an equilibrium with Spring model introductions to one with new models in the Fall. This identifying assumption suggests empirical exercises designed to detect changes

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[35] Strictly speaking this is not a prediction of our model since, with Spring introductions, no inventories are held. In a more general setting with more than 2 seasons, inventories could be held even with Spring introductions and some production smoothing may occur over the model year. It was certainly the case that inventories were held from Winter to Spring by automobile producers in the pre-1935 period.

in the seasonal patterns of sales and production prior to 1935. To begin this investigation, Figure 6a plots the seasonal residuals for auto sales and output for the period 1928:1 to 1934:12 and Figure 6b plots the seasonal residuals for the period 1935:1 to 1941:12. These residuals are generated from regressions of the Hodrick-Prescott filtered series (in logs) on seasonal dummies.[36] While there are undoubtedly large residuals, there are no striking systematic changes in the seasonal patterns of production and sales prior to 1935. Many of the large residuals are associated with particular identifiable events that cannot be interpreted as systematic changes in fundamentals. For example, in August and September in both 1928 and 1929 we observe positive and quite large residuals in production and sales. This is coincident with the deviant timing of new model introductions by Buick and Chevrolet in those two years.[37] Large residuals are also observed stemming from the sharp decline in activity at the end of 1929 and the sharp rise in activity in 1933. These effects are arguably the consequence of the dramatic economy-wide changes occurring at these times rather than evidence of a systematic change in the

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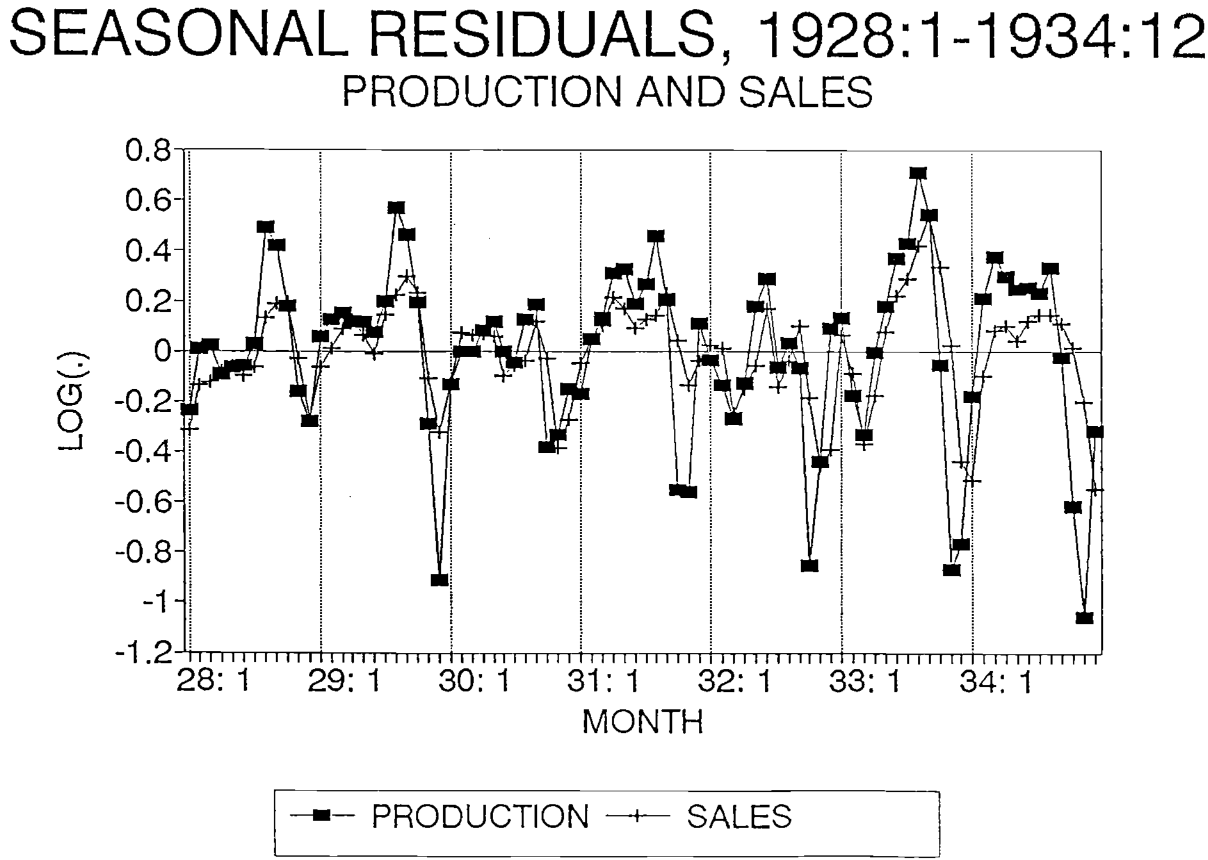
[36] The regressions were estimated over the entire period for which data are available for each series (23:1-41:12 for output and 28:1-41:12 for sales). For the exercises in this section, we also considered alternative detrending methods. In particular, rather than using the HP-filtered series, a specification with calendar year dummies was used instead. The residual plots corresponding to Figures 6a and 6b and the coefficient plots corresponding to Figures 7a and 7b were essentially identical to those depicted here.

[37] See the August 4, 1928, the July 27, 1929 and the August 3 1929 issues of Automotive Industries for a discussion of the introduction of new models by Buick and Chrysler in 1928 and 1929.



SEASONAL RESIDUALS, 1928:1-1934:12
PRODUCTION AND SALES
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
LOG(.)
28: 1
29: 1
30: 1
31: 1
32: 1
33: 1
34: 1
MONTH
PRODUCTION
SALES

Figure 6a

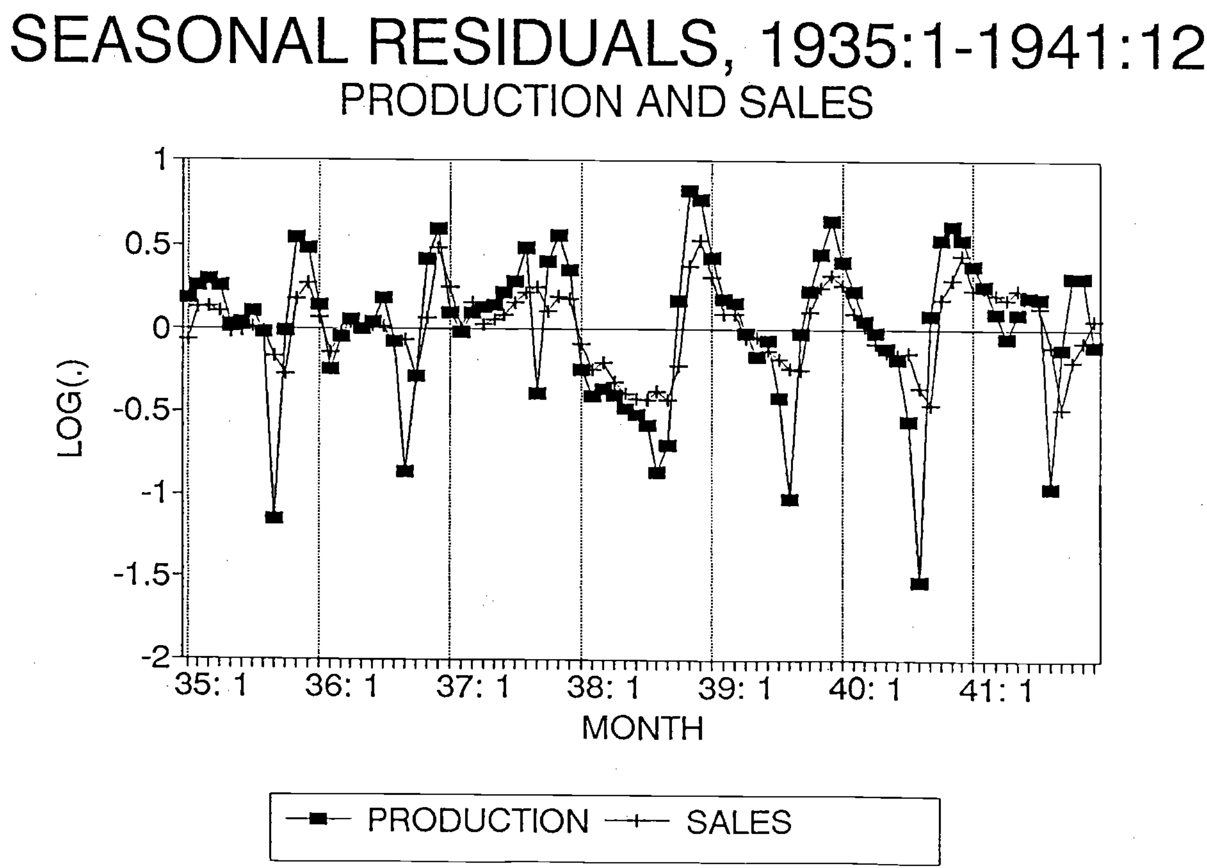

SEASONAL RESIDUALS, 1935:1-1941:12
PRODUCTION AND SALES
1
0.5
0
-0.5
-1
-1.5
-2
LOG(.)
35: 1
36: 1
37: 1
38: 1
39: 1
40: 1
41: 1
MONTH
PRODUCTION
SALES

Figure 6b

seasonal pattern of sales and production in autos.

In contrast, Figure 6b clearly depicts a systematic change in the production and sales residuals starting in 1935 consistent with the change of the model year. That is, there is a sharp decline in production and sales in the early Fall and a sharp increase in production and sales in late Fall and Winter.

To confirm this visual impression, we estimated OLS regressions of the Hodrick-Prescott filtered log output and log sales series on seasonal dummies, seasonal dummies interacted with a NIRA dummy (defined in section II), and seasonal dummies interacted with a linear time trend. This specification nests systematic and continuous changes in the seasonal patterns of sales and production with discrete changes associated with the NRA code. We interpret the interaction of the seasonal dummies and the trend as capturing any gradual changes in fundamentals occurring over the period. The impact of the NIRA is captured by the interaction of the seasonal dummies and the NIRA dummy.

If the NIRA did change the seasonal pattern of production and sales, contrary to the fundamentals argument, then exclusion of the NIRA interaction dummies would create a spurious time trend in the seasonal coefficients. The NIRA dummy is not further interacted with the interaction of the trend and the seasonal dummies. This constrains the trend interaction coefficients to be the same over the entire 1928-41 period. The inclusion of the trend interaction terms is intended to capture low frequency changes in the seasonal pattern of sales and production induced by changes in the fundamentals, i.e. tastes and technology. Presumably, changes in fundamentals occurred both pre- and post-1935. Further, it is not obvious that 1935 should represent any discrete change in the time path of these fundamentals. In addition, given the relatively short sample period, breaking the trend in 1935 makes it more likely that large seasonal outliers, not reflecting a change in fundamentals, dominate the trend interaction coefficients. We know, for example, that Buick and Chevrolet introduced new models in July and August in 1928 and 1929 (see the discussion above). The effect of these deviant introductions is evident in the residuals reported in Figures 6a and 6b. Taken together, these arguments motivate the specification and results reported here. Note, however, we have considered the alternative specification with a break in the trend interaction in 1935. The results using this latter specification are quite similar to those reported here.

The predicted seasonal patterns in production and sales from the estimated coefficients are plotted in Figures 7a and 7b for selected years. Figure 7a reveals that the basic seasonal pattern of production changed relatively little between 1928 and 1934. That is, production peaks in the Spring and decreases for the remainder of the calendar year. There is a noticeable and significant decrease in production in the last few months of 1934 relative to 1928 -- the null hypothesis that the trend interaction

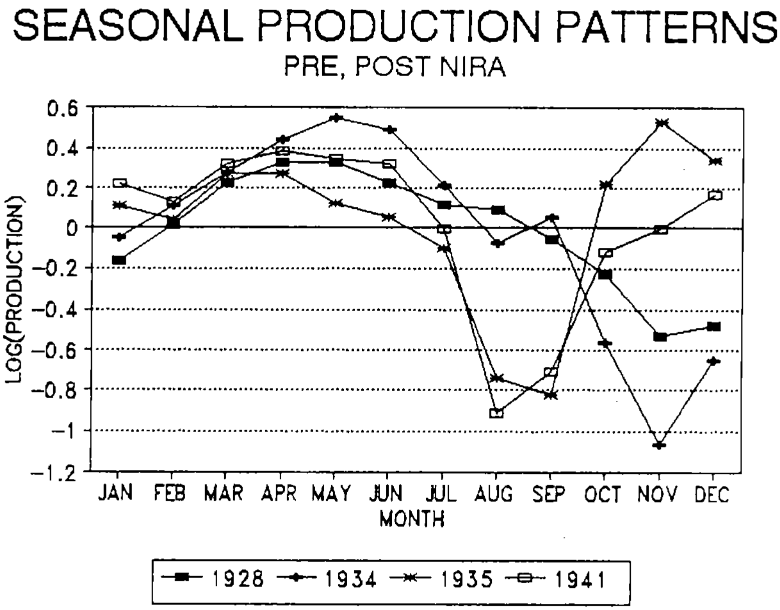


Figure 7a

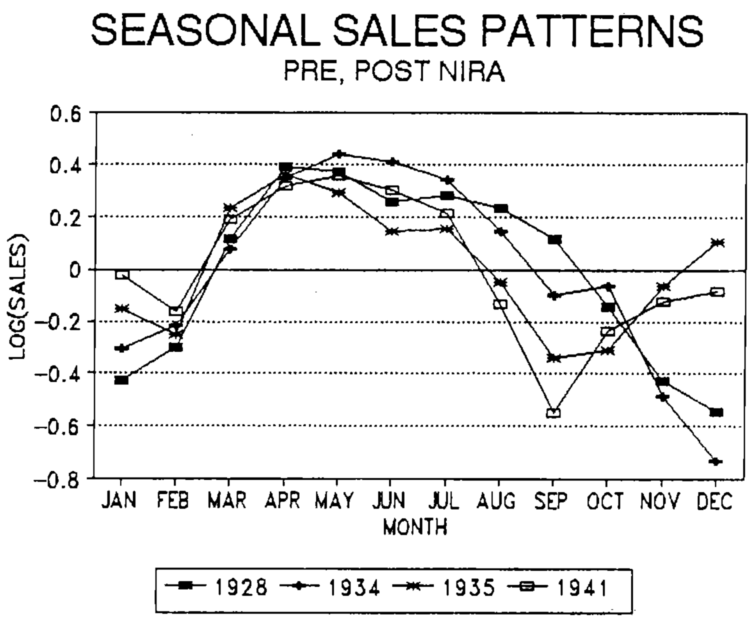


Figure 7b

coefficients is zero is rejected at the 1% level. This does not represent a qualitative change, but rather a reinforcement of the large differences between production in the first and second halves of the year. In 1935 we see again the striking decrease in production in the early Fall and subsequent increase in the late Fall and early Winter -- the null hypothesis that the NIRA interaction coefficients are zero is rejected at the 1% level. This new pattern persists through 1941. There is some evidence that the model changeover downturn in production changes slightly from 1935 to 1941. In 1935, the predicted trough is September while, by 1941, the predicted trough is August.

Figure 7b indicates only modest changes in the predicted seasonal pattern of sales between 1928 and 1934. The null hypothesis that the trend interaction coefficients are zero cannot be rejected at the 10% level. In 1935, there is a shift in the predicted pattern of sales associated with the changed timing of new model introductions. The null hypothesis that the NIRA interaction coefficients are zero is rejected at the 1% level. In particular, we observe a noticeable decrease in October sales and a sharp increase in November and December sales. This new pattern persists and becomes more pronounced by 1941, perhaps reflecting a delayed consumer response to the change in the model year.

What inferences can be drawn from Figures 7a and 7b? Clearly, the change in the timing of model introductions initiated by the NIRA had a dramatic impact on the seasonal pattern of production and sales. The question is whether we observe changes in the patterns prior to 1935 that would indicate it was a change in fundamentals that induced the change in the model year in 1935. For sales, there is no significant change. This is strong evidence against the fundamentals hypothesis since a leading candidate for changes in fundamentals was a change in seasonal patterns of demand. Despite this, there is a significant change in the seasonal pattern of production between 1928 and 1935 -- Spring production increases, late Fall production decreases. This is, as noted above, a reinforcement of the strong seasonal patterns of production that were already present. Since sales did not change significantly, this change in the seasonal pattern of production could have been induced by a change in fundamentals only if the change affected production and not sales. In terms of the model, this might be a change in δ. However, if δ had fallen (i.e., it became cheaper to store cars), we should observe greater production after the introduction of new models to build inventories for the Spring surge in demand. This is not what we observe pre-1935. Hence, the change in the pattern of production does not appear to support the hypothesis of underlying changes in fundamentals that would provide incentives for a switch to Fall model introductions.

Our reading of the accounts from this period suggests that the more pronounced seasonality in production reflected the greater synchronization of model year changes over this period of time. In commenting on the abnormally large decline in production and sales in late 1934, the November

3, 1934 issue of Automotive Industries states:

> "In large measure this is due to the practically simultaneous announcement of new models which important manufacturers are expected to make in December or January, resulting in coincidental shutdowns for necessary model changes."

There are a number of factors that led to this increased synchronization. First, the market share of GM and Chrysler grew over this period and they were the auto producers that had institutionalized annual model changeovers in the 1920s. Second, the NACC recommendation of January 31 referred to in Section II above had urged manufacturers to concentrate new model introductions late in the calendar year. Thus, our interpretation of the change in production patterns between 1928 and 1934 is that it reflects an intensification of the synchronization of the introduction of new models. Under this interpretation, the benefit from intervention in terms of remedying the hypothesized coordination problem increased over this period.

Our interpretation of Figures 7a and 7b is that they provide strong evidence against the hypothesis that the change in the timing of new models was induced by changes in fundamentals. Of course, we cannot use this evidence to rule out the possibility that there was a discrete change in fundamentals in 1935. We believe this latter explanation is implausible since it would requires a coincidence of a discrete changes in fundamentals with the known intervention through the NIRA. Examination of the nature of technological improvements over this period reveals no coincident discrete technological changes and there are no reports of discrete changes in the seasonal demand for cars coincident with 1935.[38]

One possible concern about our methodology thus far is that there may have been other exogenous events that led to the discrete structural change in the seasonal patterns of production and sales. We have argued that there were no other obvious such events in 1935. However, it is possible that some other event occurred in a year other than 1935 that led to a discrete change in the seasonal pattern of production and sales and our NIRA dummy is simply capturing that effect. In other words, we may have misdated the discrete change and inadvertently captured the impact of some other event. Two arguments suggest otherwise. First, examination of the residual plots Figures 6a and 6b clearly points to 1935 as the date of the structural change. Second, we use the method suggested by Quandt [1958, 1960] to date the structural change.[39] Using the simple linear model relating monthly production (and sales) to seasonal dummies with an unknown breakpoint, this procedure involves maximizing the implied likelihood function for each set of potential breakpoints. The breakpoint with the maximum value of the likelihood function is the maximum likelihood estimate of the breakpoint.

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[38] A description of technological changes each year is provided in the periodical Automotive Industries.

[39] Recent papers employing this method of dating a structural break include Huizinga and Mishkin [1986] and Mankiw, Miron and Weil [1987].

We report the results of the procedure in Table 4. Specifically, for each set of potential breakpoints, we calculate minus twice the log of the Quandt likelihood ratio, i.e., the maximized likelihood assuming there are no breaks divided by the maximized likelihood conditional on that set of breakpoints. The year that this statistic reaches a maximum represents the breakpoint that maximizes the likelihood function. The results in Table 4 are striking. The maximized value of the Quandt statistic is clearly 1935 for production and sales.[40] Further, the likelihood function is not very flat in the neighborhood of 1935.

A different perspective on changes in fundamentals is to search for changes in seasonal patterns of economic activity in other sectors. It may be that there were significant economy-wide changes in seasonal consumption or leisure demand, such as an increased value of summer vacations. Such economy-wide changes in fundamentals could have induced a shift in the timing of production and sales in all sectors including autos. There are identification problems with this approach as well. As emphasized by Long and Plosser [1987] and Cooper and Haltiwanger [1990b], it is difficult to

[40] While the Quandt procedure provides a method for selecting a breakpoint, it does not provide a formal statistical test for the breakpoint. Quandt [1958] suggested that this test statistic was approximately chi-squared but his [1960] paper makes clear through Monte Carlo simulations that the distribution of this statistic has fatter tails than the chi-squared distribution. Recently, there has been renewed focus on testing for unknown breakpoints and developing appropriate test statistics. One related test statistic proposed by Andrews [1990] is a max Chow test. Using the critical values generated by Andrews (Table T-1), we can reject the null hypothesis of no structural break at the 1% level for both the seasonal patterns of production and sales. Note further that the maximum Chow statistic dates to 1935 for both production and sales.

Dating of Breakpoints in Seasonal Patterns of Production and Sales Minus Twice the Log of the Quandt Likelihood Ratio		
Breakpoint	Production	Sales
1931	188.74	98.89
1932	185.68	120.86
1933	177.88	120.28
1934	215.75	141.28
1935	265.12	206.46
1936	198.25	158.12
1937	174.57	121.62
1938	206.72	141.58
1939	172.55	98.00

TABLE 4

distinguish between positive co-movement across sectors induced by common shocks and positive co-movement induced by factor demand or final goods demand complementarities across sectors. With these limitations in mind, we proceed with the empirical exercise.

We investigate the role of economy-wide changes in fundamentals by examining changes in the seasonal patterns of production for components of the industrial production index for this period. We estimated regressions of the Hodrick-Prescott filtered industrial production series on seasonal dummies and seasonal dummies interacted with the NIRA dummy for the period 23:1 to 40:1. The panels of Figure 8 display the estimated seasonal coefficients for each of the sectors pre and post 1935.[41]

Several interesting patterns are observed in Figure 8. There is a modest change in the seasonal pattern of Total industrial production that is qualitatively consistent with the change in Transportation Equipment (note: Auto production is about 80% of Transportation Equipment and about 5% of Total industrial production). Similarly, total manufacturing and its two aggregate components (durables and nondurables) exhibit modest changes that are qualitatively consistent with the change in Transportation Equipment.

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[41] The null hypothesis that all the NIRA interaction coefficients are zero is rejected at the 1% level for: Total Industrial Production, Total Manufacturing, Durable Manufacturing, Transportation Equipment, Rubber, Leather Products, Chemicals, and Petroleum. This hypothesis is rejected at the 5% level for: Nondurables, Iron and Steel, Fuels, and Tobacco. While there is evidence of widespread statistically significant changes in seasonal patterns, as shown in Figure 8, these changes are not generally consistent with the changes in autos in either a quantitative or qualitative manner.

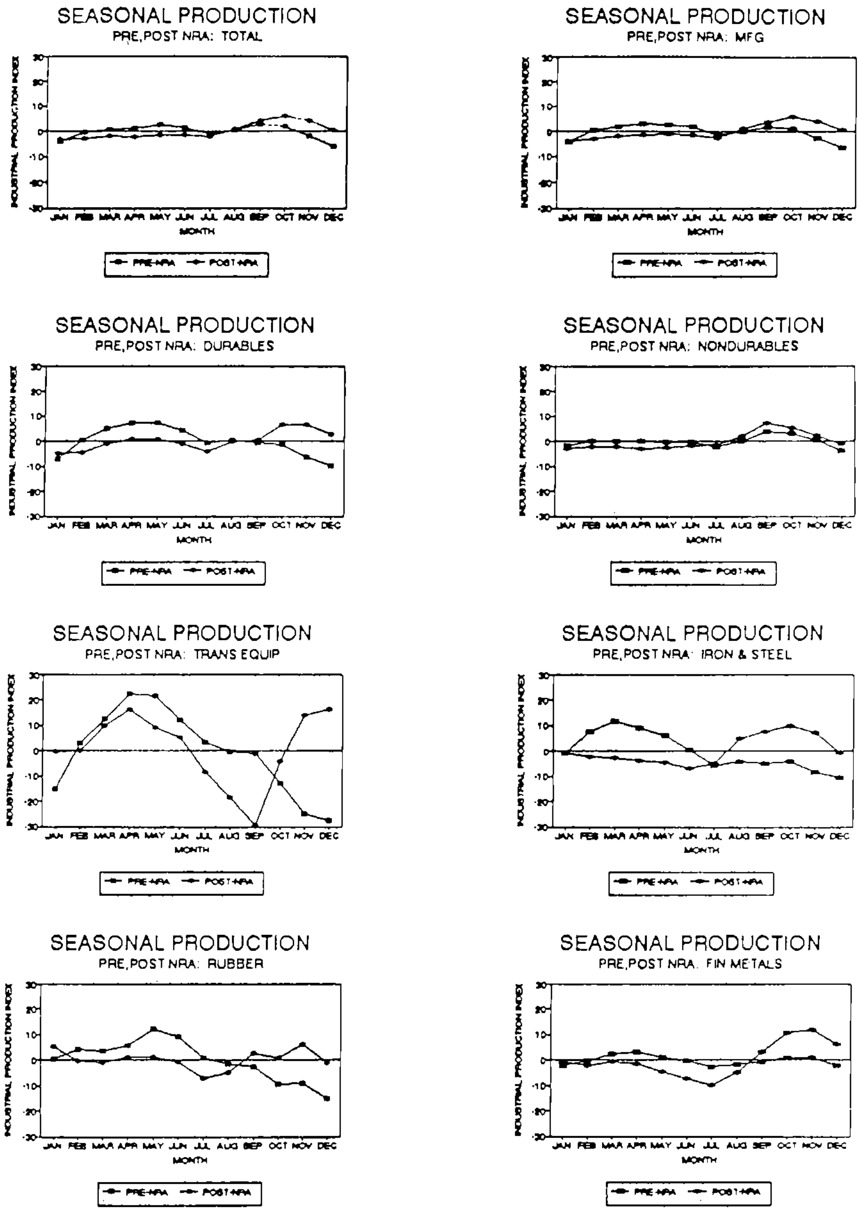

SEASONAL PRODUCTION
PRE,POST NRA: TOTAL
SEASONAL PRODUCTION
PRE,POST NRA: MFG
SEASONAL PRODUCTION
PRE,POST NRA: DURABLES
SEASONAL PRODUCTION
PRE,POST NRA: NONDURABLES
SEASONAL PRODUCTION
PRE,POST NRA: TRANS EQUIP
SEASONAL PRODUCTION
PRE,POST NRA: IRON & STEEL
SEASONAL PRODUCTION
PRE,POST NRA: RUBBER
SEASONAL PRODUCTION
PRE,POST NRA: FIN METALS
INDUSTRIAL PRODUCTION INDEX
MONTH
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
PRE-NRA
POST-NRA

Figure 8

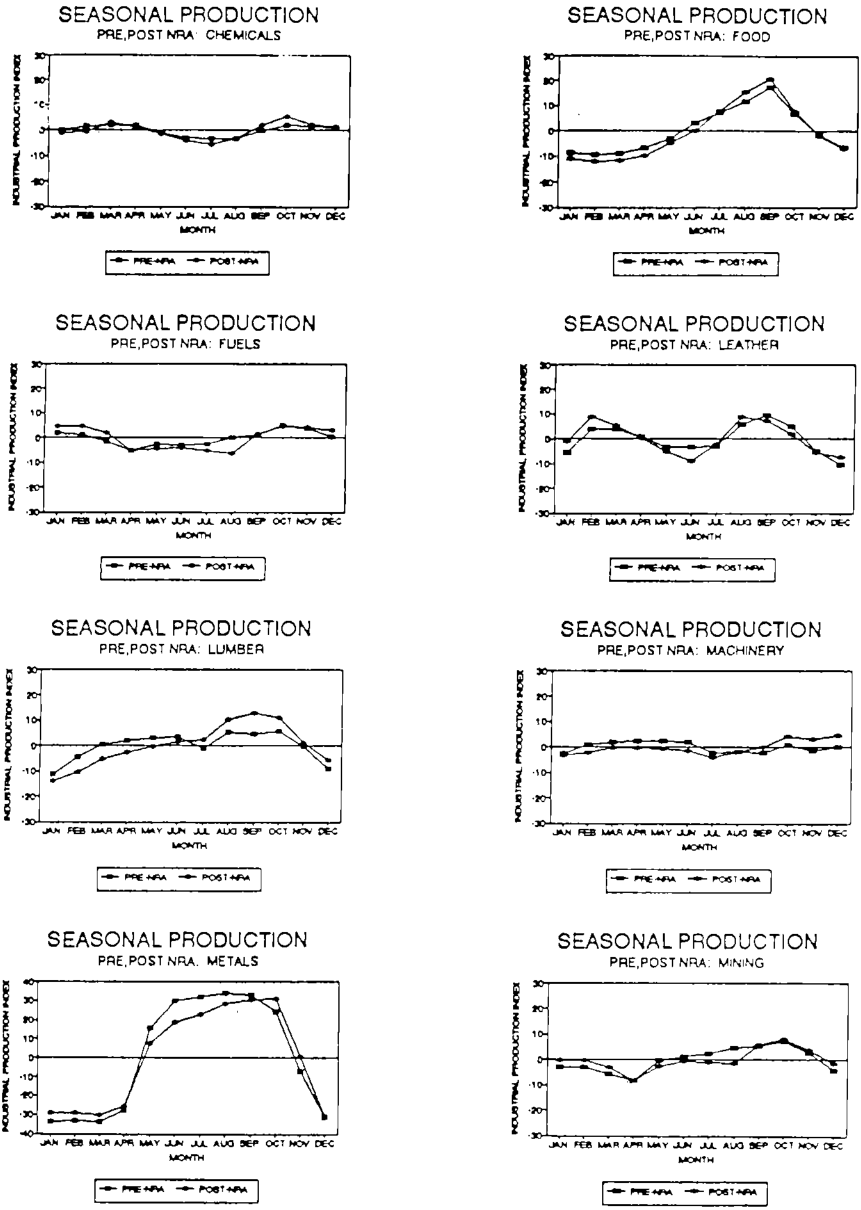
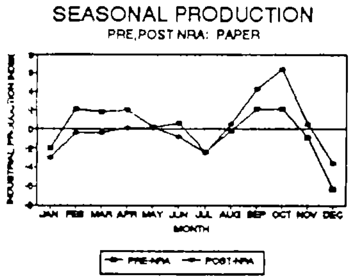
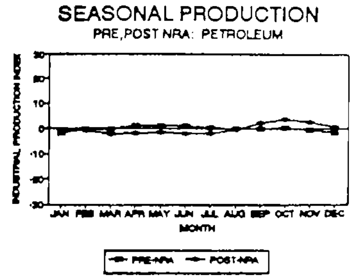
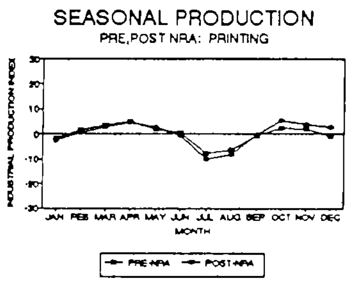
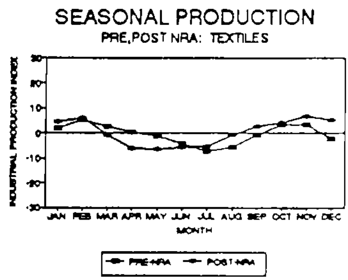

SEASONAL PRODUCTION
PRE,POST NRA: CHEMICALS
SEASONAL PRODUCTION
PRE,POST NRA: FOOD
SEASONAL PRODUCTION
PRE,POST NRA: FUELS
SEASONAL PRODUCTION
PRE,POST NRA: LEATHER
SEASONAL PRODUCTION
PRE,POST NRA: LUMBER
SEASONAL PRODUCTION
PRE,POST NRA: MACHINERY
SEASONAL PRODUCTION
PRE,POST NRA. METALS
SEASONAL PRODUCTION
PRE,POST NRA: MINING
INDUSTRIAL PRODUCTION INDEX
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH
PRE-NRA
POST-NRA

FIGURE 8


SEASONAL PRODUCTION
PRE,POST NRA: PAPER
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH
PRE-NRA
POST-NRA


SEASONAL PRODUCTION
PRE,POST NRA: PETROLEUM
INDUSTRIAL PRODUCTION INDEX
MONTH
PRE-NRA
POST-NRA


SEASONAL PRODUCTION
PRE,POST NRA: PRINTING
INDUSTRIAL PRODUCTION INDEX
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH
PRE-NRA
POST-NRA


SEASONAL PRODUCTION
PRE,POST NRA: TEXTILES
INDUSTRIAL PRODUCTION INDEX
MONTH
PRE-NRA
POST-NRA

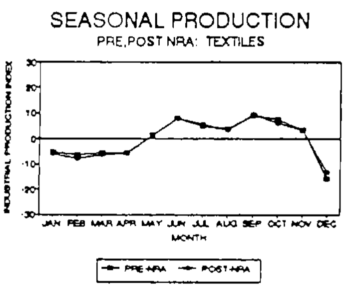

SEASONAL PRODUCTION
PRE,POST NRA: TEXTILES
INDUSTRIAL PRODUCTION INDEX
MONTH
PRE-NRA
POST-NRA

Figure 8

However, the changes are trivial in magnitude relative to the change in Transportation Equipment. The difference in magnitudes raises doubts that economy-wide changes in fundamentals generated the change in Transportation Equipment.

Examination of the disaggregated components of industrial production is also revealing. Substantial changes in the seasonal pattern of iron and steel, rubber, and finished metals consistent with the changes in Transportation Equipment are observed. In contrast, while there are some modest changes in the seasonal patterns of sectors such as textiles, food, tobacco, leather goods, the pattern of changes are neither quantitatively or qualitatively similar to the changes in Transportation Equipment. These findings suggest that the changes in Transportation Equipment had significant upstream effects but there is little evidence economy-wide changes in fundamentals induced the dramatic shift in the seasonal pattern in Transportation Equipment.[42]

From this evidence, we are led to the conclusion that there is little support for the argument that there were fundamental changes in tastes and technology that could explain the abrupt shift in the seasonal pattern of activity beginning in 1935. In particular, there is no evidence of these effects in the automobile industry and no support for the hypothesis that aggregate changes in fundamentals led to an economy-wide shift in the seasonal pattern of

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[42] It is worth noting as well that these results suggest that the changes in Transportation Equipment did not induce large economy-wide changes in seasonal patterns of economic activity.

activity. While there are other sectors of activity exhibiting changes in their seasonal pattern of activity in a manner similar to the automobile industry, these observations are easily explained through the existence of factor demand linkages with automobiles.

The absence of evidence on changes in fundamentals lends support to the competing hypothesis that coordination problems explained the effects of the NIRA code amendment. More direct evidence for this argument emerges from noting that producers understood the gains from production smoothing and some attempted to deviate from the January new model year introductions in the years prior to 1935. Despite these efforts, it was not until the 1935 amendment that the change actually took place. Further, it is important to note that there is no evidence of producers introducing new models in times other than the early Fall in the years after 1935. In particular, in our a review of Automotive Industries for 1936 and 1937, we did not find evidence that producers had either delayed introduction past the Fall or redesigned a new model after the Fall introductions. The suggested change in 1935, while never enforced by the government, succeeded in coordinating model introductions in the Fall.

One piece of evidence that initially seems difficult to reconcile with either the fundamentals model or the coordination model is that, as presented in Table 3, the variance of production actually exceeded the variance of sales after 1935. This appears to be inconsistent with the argument that Fall model introductions would succeed in production smoothing.

Note though from Figure 7a that the production trough due to retooling is deeper in the post-NIRA period, perhaps reflecting both increased sophistication of machinery and greater synchronization of retooling (including Ford) in the post-NIRA period. Our model concerns the smoothing of production over the model year and is silent with regard to the relative size of the output loss due to retooling. With that in mind, in comparing Figures 7a and 7b, the increase in production in November and December in the post-NIRA exceeds the increase in sales by a considerable amount. Further, note from Figure 3a that post-1935 there is very little seasonal variation in the production after the beginning of the calendar year: following the Fall retoolings, there is a buildup of production for a few months and then level production till the end of the model year.

Stevens [1947] argues that this reflects the buildup of inventories during the end of the calendar year as producers sought to stabilize production over the model year. This view is supported by Table 3 which indicates that once the retooling periods are excluded, the variance of production relative to the variance of sales is lower in the post-NIRA period.

V. Conclusions

The goal of this paper is to provide an understanding of the dramatic changes in the seasonal pattern of production and sales in the automobile industry beginning in 1935. The change in the timing of new model introductions and the annual automobile show led to the creation of new peaks in production and sales in the Fall.

One interpretation of this experience rests on changes in tastes and technology that would alter the optimal timing of new model introductions. We have argued that there is little persuasive evidence that fundamentals changed in a slow, persistent manner that would rationalize the abrupt change in seasonals observed in 1935. Further, while one can never formally reject this alternative, the argument that a fundamental change occurred simultaneously with the amendment of the automobile code under the NIRA is not very compelling.

An alternative view is that the automobile producers, due to historical experience, were in an inefficient Nash equilibrium in which new products were introduced in the January, following the annual automobile show. The NIRA amendment to the code provided an opportunity (a form of pre-play communication) for the producers to coordinate on an alternative, presumably more profitable equilibrium, where new products were introduced in the Fall. The fact that the NIRA was subsequently ruled unconstitutional was not important once a new equilibrium timing of model introductions was achieved.

ACKNOWLEDGEMENTS

We are grateful to Joanna Barnish and Laura Power for outstanding research assistance, to William Creech of the National Archives for assistance in locating material for this study and the National Science Foundation for financial support. Olivier Blanchard, Jeff Miron and Anil Kashyap provided numerous helpful comments and suggestions throughout this research. Comments from seminar participants at Boston University, Cornell University, Harvard University, the NBER Macroeconomic Complementarities group meeting in July 1991, the NBER Macroeconomics History Meeting in April 1992, New York University, the University of Michigan, Rutgers University and the University of Windsor were appreciated. Cooper thanks the Institute for Empirical Macroeconomics at the Federal Reserve Bank of Minneapolis for support during the preparation of this manuscript.

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