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The great demand depression

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The Great Demand Depression

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Abstract

This paper entertains the notion that disturbances on the demand side play a central role in our understanding of the Great Depression. In fact, from Euler equation residuals we are able to identify a series of unusually large negative demand shocks that appeared to have hit the U. S. economy during the 1930s. This echoes the view originally promoted by Temin (1976). We apply these measured demand shocks to a dynamic general equilibrium model and find that size and sequence of shocks can generate a pattern of the model economy that is not unlike data. The model is able to account for the lion's share of the decline in economic activity and is able to exaggerate realistic persistence.

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”A clear distinction between the patterns of pre-and-post-World War II data is the larger size of aggregate demand shocks during the earlier period.” (Bradford DeLong and Lawrence Summers, 1986, p. 680)

1 Introduction

The Great Depression in the United States, in all its many dimensions, stands unparalleled. Real output cumulatively declined by about 30 percent between 1929-1933 which dwarfs any post-war business cycle and the rate of unemployment elevated to unique heights by reaching 25 percent. Yet, perhaps the most perplexing aspect of the Great Depression is that the economy remained depressed for so long. It did not return to full employment until after the outbreak of World War II and for a long time staggered at levels that seem too low to square with the normal mechanisms of business cycles. Specifically, real GNP did not reach its pre-Depression value until 1936 and per capita output still remained twenty-five percent below trend in 1939. The recovery phase lasted seven years – four times the average post-war recovery period.

Recent work in dynamic general equilibrium shows that the tepid recovery remains a conundrum for a wide range of models such as the perfect markets Real Business Cycle approach as well as for sticky price monetary models. In particular, measured total factor productivity reverted to trend by 1936. Thus, by putting the Real Business Cycle model into action, theory predicts an end of the Depression by the mid-thirties (Cole and Ohanian, 1999). Likewise, the Federal Reserve followed an expansionary policy starting in 1933. Money supply – measured as M1 – grew at spectacular growth rates of ten percent per year between 1933 and 1937. Again, theory predicts a strong and comparatively rapid recovery (Bordo, Erceg and Evans, 2000). These findings are related to the often stressed viewpoint that the United States’ adherence to the Gold Standard was a crucial element of the economic decline (Eichengreen, 1992): countries that abandoned the Gold Standard early, such as the Scandinavians, experienced the Great Depression through little more than ordinary recessions and returned to normal levels of economic activity by the mid-1930s. However, the U.S. administration only suspended its commitment to gold in January 1932 – the Glass-Steagall Act which meant that the gold above a statutory minimum was now entirely ”free”; the United States imposed a full embargo on gold exports in the Spring of that following year. This all suggests that important nonmonetary, domestic forces which kept the economy off track must have been at work throughout most of the 1930s.

Accordingly, research founded in dynamic general equilibrium shifted its focus to changes in the institutional framework as being predominantly responsible for the persistence of the Depression (Cole and Ohanian, 2000,

as well as Bordo, Erceg and Evans, 2000). Particular emphasis is thereby placed on New Deal cartelization policies and bargaining processes. These institutional factors inflated real wages in large parts of the economy. This distortion, it is argued, emerges as an essential piece in the puzzle of the sluggish recovery in the 1930s. Still, Cole and Ohanian's (2000, see their Table 13) model, which takes into account the institutional changes, closes the gap between the perfect market Real Business Cycle model and U.S. output by only a half and misses the 1937-1938 recession – the third largest recession in American history in terms of output loss – altogether.

The current paper approaches the Great Depression from a disparate perspective. Our point of departure is Temin's (1976) insistence on contractions of aggregate *demand* distinctly during the first stage of the Great Depression.¹ What evidence does Temin muster to support his proposition? The centerpiece of his argument rests on an episodic pattern of consumption which bears no resemblance to that of other recessions. Temin reports that consumption fell by 5.4 percent from 1929 to 1930. This is unique behavior when compared to other economic downturns. For example, Temin reports that during the 1920-1921 recession, consumption had *increased* by 6.4 percent. He identifies large residuals from estimated Keynesian consumption functions for the onset of the Great Depression. He stresses that investment took similar sudden hits. In an old-fashioned interpretation, Temin classifies these shocks as the collapse of *autonomous spending*. Romer (1990) picks up on this observation and cites an increasing state of uncertainty following the October 1929 stock market crash. Indeed, she finds that this uncertainty led to delaying the expenditures on durable goods.

Temin's original formulation remains in the confines of the old Keynesian apparatus. In contrast, the present model is framed within methodological standards that are set and met by the Real Business Cycle approach. It applies Temin's interpretation to a fully articulated dynamic general equilibrium framework in which demand shocks drive economic fluctuations. If the Great Depression was such an equilibrium, the model should be able to replicate the behavior of key macroeconomic aggregates during that time.

Our strategy of estimating demand shocks from data stems from Hall's (1986) analysis of the role of consumption in the U.S. business cycle. His work was first to propose a framework that allows demand shocks to be computed readily within the framework of dynamic optimization. Baxter and King (1991) construct a dynamic general equilibrium model that furthered Hall's original concept by introducing stochastic household preferences. Their framework allows the coherent estimation of demand shifts from the Euler equations. Any residual of the law of motion of preferences can then be interpreted as demand shocks. By generating a series of demand innovations that we find to best reflect the behavior of preferences

¹For a critique on Temin's methodology see Mayer (1980).

during the Depression, we are able to show that the model economy takes a path that is strikingly similar to historical data. In particular, our model correctly predicts a recession setting in after 1929, it can account for more than half of the decline in real GNP, most notably it generates a persistent depression that lasts well over ten years and it goes through a recession in 1937-1938.

The remainder of this paper is organized as follows. The next section will set out the model. In Section 3, demand shocks will be estimated. Then, we apply these shocks to the fully specified model and compare results to the empirical observation on key macroeconomic variables during the Great Depression. Section 5 concludes.

2 The environment

The model is based on Baxter and King (1991) and Greenwood, Hercowitz and Huffman (1988). Essentially, it is a standard one-sector Dynamic General Equilibrium model with variable capital utilization augmented by stochastic preferences. The economy that we examine is populated with a large number of identical consumer-workers households, each of which will live and grow forever and each with identical preferences and technologies. Let us start with the problem faced by a representative consumer-worker household, these participants are assumed to solve

$$\max_{\{c_t, l_t, x_t\}} E \sum_{t=0}^{\infty} \beta^t (1+n)^t [(1-\eta) \log(c_t - \Delta_t) + \eta \log(1-l_t)]$$

$$\text{s.t. } c_t + x_t = y_t = A_t^\gamma (u_t k_t)^\alpha l_t^{1-\alpha}$$

$$A_t = (\bar{u}_t \bar{k}_t)^\alpha \bar{l}_t^{1-\alpha}$$

$$(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}} (1+n)k_{t+1} = (1-\delta_t)k_t + x_t$$

$$\delta_t = \frac{1}{\theta} u_t^\theta$$

inclusive of the usual initial and transversality conditions. Here, $0 < \alpha < 1$, $0 < \beta < 1$, $0 < \eta < 1$, and $\theta > 1$. c_t , l_t , x_t , k_t , u_t and β denote consumption, labor, investment, capital, capital utilization rate and the discount factor respectively. All variables are in detrended per capita terms. Δ_t is a random variable that affects the subsistence level of consumption; it is zero in the stationary state. A positive shock to Δ_t generates an urge to consume in the

sense of an exogenous demand shock to consumption. Preference dynamics are described by an autoregressive process of maximal order two.² The parameter n is the deterministic rate of population growth and g designates the deterministic rate of labor augmenting technical progress. The product $u_t k_t$ denotes the flow of capital services. As in most studies of variable capital utilization, the rate of depreciation, δ_t , is an increasing function of the utilization rate.³ The economy as a whole is affected by organizational synergies that cause the output of an individual firm to be higher if all other firms in the economy are producing more. A_t stands for these aggregate externalities where bars over variables denote average economy-wide levels. The production complementarities are taken as given for the individual optimizer and they cannot be priced or traded. Increasing returns to scale in production are measured by γ . All markets are perfectly competitive and we consider symmetric equilibria only.

We will next describe the parametric specification of the model and assign parameter values. Calibration is now routine in a wide range of macroeconomic areas. The following Table represents a typical calibration (essentially Christiano and Harrison's, 1999). The fundamental period in the model is one year. The capital share is a third and the annual rate of depreciation is eight percent. The discount factor is set so that the steady state net return to capital is three percent. The labor force grows at a rate of one percent per year and labor augmenting technology expands at an annual 1.9 percent. These numbers were taken from Cole and Ohanian (1999) and conform to Maddison (1991). Lastly, we set the increasing returns to scale parameter to zero for the time being. In fact, we need limiting $\gamma < 0.4$ to rule out indeterminacy of rational expectations.⁴ The calibration implies that, on an annual basis, capital is 2.57 times that of output. This value agrees with the findings in Maddison (1991) who reports ratios of gross non-residential capital stock to GDP at 2.91 (for 1913) and at 2.26 (for 1950). The steady state consumption share of output amounts to 72 percent.

Table 1: Calibration					
α	β	γ	δ	g	n
1/3	0.97	0	0.08	0.019	0.01

Let us denote $\hat{k}_t \equiv (k_t - k)/k$ and $\hat{\Delta}_t \equiv (\Delta_t - c)/c$ where omitting time indices on variables indicates steady state values (the preference shifter is

²This gives way to some empirical results in the next section. There we show that a second order process indeed describes best the evolution of the preference shifter.

³Bresnahan and Raff (1991) suggest that at least twenty percent of the aggregate capital stock was idled between 1929 and 1933. Thus, variable capital utilization may be an important factor for any model of the Great Depression.

⁴See Harrison and Weder (2001) for a sunspot based interpretation of the Great Depression.

zero in the stationary state). Then, the model can be approximated and reduced to the stochastic matrix difference equation

$$\begin{bmatrix} \hat{k}_{t+1} \\ \hat{\Delta}_{t+1} \\ \hat{\Delta}_t \end{bmatrix} = \mathbf{M} \begin{bmatrix} \hat{k}_t \\ \hat{\Delta}_t \\ \hat{\Delta}_{t-1} \end{bmatrix} + \begin{bmatrix} 0 \\ d_{t+1} \\ 0 \end{bmatrix} \quad (1)$$

where $\mathbf{M}$ is a 3×3 matrix (the Appendix presents the complete solution of the model). An equilibrium is defined as a sequence $\{\hat{k}_{t+1}, \hat{\Delta}_t\}_{t=0}^{\infty}$ that solves (1) subject to initial conditions as well as the transversality condition. In the next section we will discuss the computation of demand shocks $\{d_t\}$ which will then be used to shock the dynamical system (1) and to derive output realizations for the artificial economy.

3 Will the real demand shock please stand up?

Technology shocks are customarily estimated as residuals from a Solow decomposition. Put another way, these shocks are not directly observable and measurement takes place within a particular model – a production function. Hall (1986, 1997), Parkin (1988), Bencivenga (1992) and especially Baxter and King (1991) apply this methodology to measure demand shocks as well. Their idea adapts from the findings that representative agent Euler equations perform poorly. *Inter alia*, this suggests the notion of stochastic preferences playing a potential role.⁵ In particular, the above authors use the intratemporal first-order conditions to derive a sequence of demand shocks. To that avail, note that the intratemporal optimality condition for consumption implies that

$$c_t = \frac{1 - \eta}{\lambda_t} + \Delta_t.$$

Thus, a positive innovation to Δ_t represents a positive demand shock to consumption for a given shadow value of wealth, λ_t . In another interpretation, one may think of Δ_t affecting the marginal rate of substitution between goods and work. The intratemporal first-order condition is given by

$$\frac{\eta}{1 - \eta} \frac{c_t - \Delta_t}{1 - l_t} = w_t.$$

A fall in Δ_t will require a decline of labor supply at given levels of consumption and of the remuneration of labor.

⁵See for example Eichenbaum, Hansen and Singleton's (1988) Euler equation investigation.

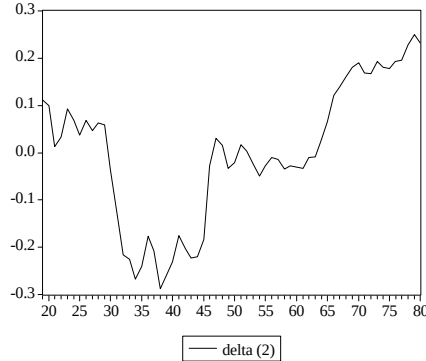


Figure 1: Preference shifter

We Taylor-approximate the household's two intratemporal optimality conditions as⁶

$$\hat{\Delta}_t \simeq \hat{c}_t - \hat{w}_t + \frac{l}{1-l} \hat{l}_t. \quad (2)$$

In the following computation, steady state values for labor, l , are sample means. Formulation (2) allows estimation results to be fed directly into the linearized model. Given information on consumption, wage and labor input allows us to estimate demand shocks. Our annual data on real consumption expenditures on nondurables and services in 1972 dollars for 1919-1980 are from Balke and Gordon (1986) and the national income and product accounts. Data were divided by the working-age population (16 years and older). Wage data are average hourly earnings.⁷ Unfortunately, earnings data are not available for all sectors in the beginning decades of the sample. To maintain continuity of overall series, let us use wages in the manufacturing sector only. In particular, we use Hanes' (1996) compilation of National Industrial Conference Board and Bureau of Labor Statistics (BLS) data. For missing years (1919 to 1922 and World-War II years), we employ BLS data on hourly wages directly – chained into Hanes's data. We use the GNP deflator to deflate the series. Lastly, labor input is measured as hours (in manufacturing) times total nonfarm employment per capita (basic source of data: www.bls.gov). The data-measured labor input was adjusted to match a steady state equal to $l = 0.20$.

Figure 1 displays the computed series of the state of preferences, $\hat{\Delta}_t$, over the 1919 to 1980 period. The series centers around zero which mimics the

⁶The presence of preference shocks precludes estimating Euler equations with GMM and therefore to compute the sequence of Δ_t from the intratemporal equations directly.

⁷Our sample ends in 1980 because afterwards manufacturing wages divert from their previous trend which is likely the consequence of structural changes within the economy and the decline of unions.

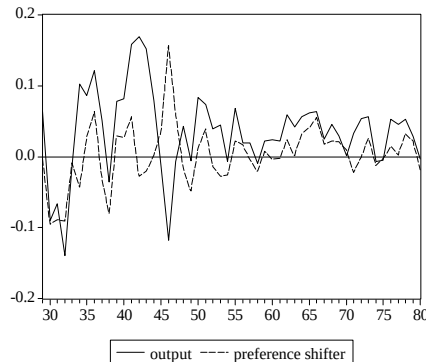


Figure 2: U.S. output vs. preference shifts

construction of preferences in our model. Its mean is -0.0038 . One readily notices a striking plunge that distinguishes the early years of the Great Depression. This gives cue to Temin’s (1976) proposition of a plummeting consumption demand that derailed the economy. Furthermore, around 1937-1938 the economy appears to have taken yet another smaller demand side jolt. Figure 2 plots the time series of the change in the preference variable and U.S. output growth. We see from this Figure that both series observe high volatility before 1945. The preference variable covaries positively with output for most of the time. The correlation of both series is 0.27 when the whole time span is considered. For 1929 to 1939 we compute a correlation of 0.84; for 1950 to 1980 the correlation is 0.63. Notable exceptions of positive comovements were the 1940s. During World War II, output exhibited excessive growth rates that were not matched by positive demand innovations – this most likely reflects the dramatic increase of war-related government expenditures. The second half of that decade (the Reconversion-period after 1945 to 1947 which is associated with a dramatic increase of measured Δ_t and the 1949-recession) is characterized by the opposite picture.

The current paper does not touch upon the question if the observed preference drop after 1930 may reflect a regime change or a structural break. In fact, the strategy that we will take on in the following exercise circumvents such ideas and contrastingly interprets the detected decline of preferences as an unfavorable sequence of large negative shocks. This conforms to a general definition of the Great Depression as being different from other downturns – Prescott (1999) classifies the Great Depression as a magnitude larger than the phenomenon that we normally coin “the business cycle” – but does not rely on assuming structural changes which were not operating during other episodes.

There has been little work done on the way the dynamic process of preferences should realistically be modelled, notably for the interwar period.

This differs from routinely assuming a simple first-order process for technology which has become the widely agreed upon specification within the Real Business Cycle approach. For the postwar period, Baxter and King (1991) find that a first-order autoregressive process including a constant and trend provides a good fit. We experimented with a number of possible low-order processes – various first-order to third-order AR processes and random walk specifications. Our findings can be summarized as follows. When the dynamic process is of first-order, the process displays evidence of serial correlations of residuals. This is no longer the case when we assume that preferences are described by a second-order autoregressive process. On the other hand, considering even higher order process does not deliver additional statistically significant coefficients. We find that a second-order autoregressive process including constant and trend provides a good description of the evolution of preferences (t -statistics in parenthesis):

$$\begin{aligned}\widehat{\Delta}_t &= \underset{(-2.05)}{-0.0251} + \underset{(2.35)}{0.0008t} + \underset{(9.67)}{1.2212} \widehat{\Delta}_{t-1} - \underset{(-2.60)}{0.3209} \widehat{\Delta}_{t-2} + d_t \\ R^2 &= 0.94, \quad SE = 0.039, \quad DW = 1.77.\end{aligned}\quad (3)$$

The reported shock volatility appears large. This is the result of massive shocks during the 1930s. In fact, when only the post-war period is considered, then the variance of shocks settles down to the ballpark of Baxter and King's (1993) number. Figure 3 plots the computed shocks for this process. Not surprisingly, it yields large negative demand shifts in the early thirties. In fact, from 1930 to essentially 1934, the economy is subject to unremitting contractions striking from the demand side. Moreover, the 1930s are the only period in which we measure negative shocks of that magnitude and the volatility of demand shocks becomes remarkably smaller in the post-war period. This corresponds to the findings reported in DeLong and Summers (1986) who, however, arrive at their conclusion by using a considerably different methodology. In the following, we will check for robustness of these results.

To begin with, we excluded the 1940s from the sample such to keep out the effects of World-War-II. This does not change results significantly. In particular, we again find dramatic negative demand shocks during the 1930s.

Alternatively, relationship (2) could be transformed to

$$\widetilde{\Delta}_t \simeq \widetilde{c}_t - \widetilde{w}_t + \frac{l}{1-l} \widetilde{l}_t \quad (4)$$

where the tildes denote that variables were trend adjusted. The variables were rendered stationary by deflating each variable by its long run (sample) trend growth.⁸ Figure 4 graphs the resulting behavior of the preference

⁸We detrend real wages at a 1.87 percent annual rate. The constructed labor input grows by half a percent per year. Per capita consumption was deflated by the annual growth rate of 1.65 percent.

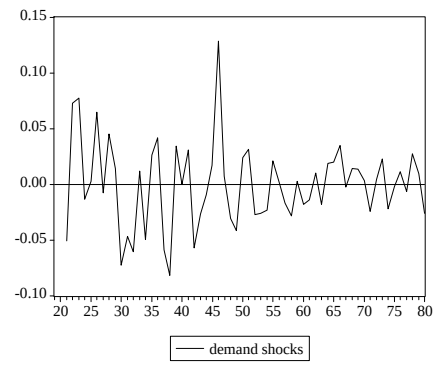


Figure 3: Demand Shocks

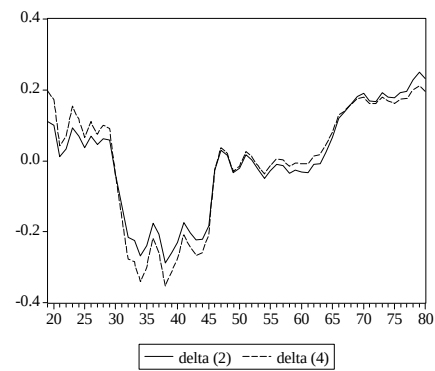


Figure 4: Preference shifters

shifter *vis-a-vis* the shifter derived from equation (2). When the series is computed from the trend-adjusted equation (4), the mean is -0.0057 . Thus, regardless of which measure is used, the conclusion appears that the 1930s are characterized by a sharp decline in Δ_t . Both computed series virtually overlap. The correlation of both series is 0.98 and it is 0.9989 for the 1929 to 1939 subperiod. We decided to simply use formulation (2) in the following section.⁹

Lastly, one may object that the choice of manufacturing wages distorts the results. However, manufacturing real wages and aggregate real wages moved very parallel during the whole depression except for the year 1933 in which manufacturing real wages diverged upwards (see for example Bordo, Ecreg and Evans, 2000, Figure 1). Thus, using a constructed aggregate wage measure instead would most likely have yielded the same preference plunge for most of the Great Depression's downturn phase and a similar pattern for the entire recovery. We repeat the calculation of (2) by using aggregate measures. In particular, we use Kendrick's (1961) measure of total hours and the total economy real wage (see Cole and Ohanian, 1999, for construction).¹⁰ The derived series has mean 0.002. Figure 5 displays the patterns of the preference shifter given the two alternative labor market measures. Both sequences move uniformly through the 1930s. The correlation of both series is 0.98.¹¹ Thus, independently of the sectors we observe an economy-wide shift in preferences.¹² In the end, I have decided in favor of using manufacturing wage data because of its higher quality and since it is consistently available over a longer time span.

To sum up, this section suggests that a sequence of negative demand shocks that started to slam the U.S. economy in 1930. In the following section, we will use this result and confront the identified demand innovations with the theoretical model. It is only then that we can make any reasonable judgements on the importance of these shocks along the dimensions deepness and persistence of the Great Depression in the United States.

⁹Preferences are suspiciously nonstationary. Indeed, Dickey-Fuller tests indicate that in levels the series fails to accept stationarity. We will return to the possibility of random walk preferences in the next section. Yet, the general pictures remains largely the same for other specifications of the driving process – they are available from the author upon request.

¹⁰Steady state values are sample means.

¹¹In fact, when we take out the "consumption-component" of the preference shifter (thus computing $-\hat{w}_t + \frac{L}{1-L}\hat{l}_t$) both series still are highly correlated ($\rho = 0.96$).

¹²One may interpret our findings as saying that wage distortion do not affect the (estimated) demand shocks since agents are still free to chose consumption and leisure such to follow optimality conditions.

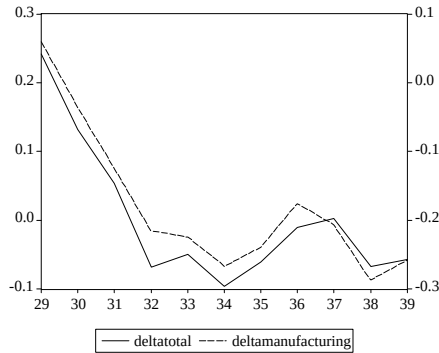


Figure 5: Total wages vs. manufacturing wages

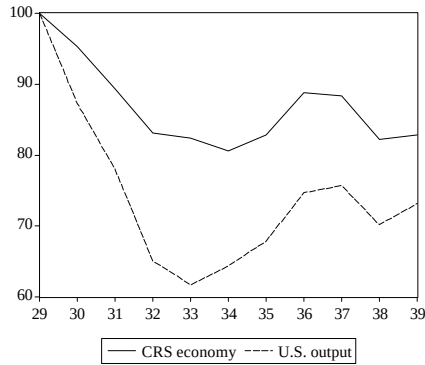


Figure 6: Constant returns demand model

4 The model and the Great Depression

In this section we use the measured series of demand shocks and generate model series of relevant variables. This constitutes an important test for the relevance of the shocks that have been identified in the previous section. We will at first assume that the preference shifter follows a second-order process. We will discuss the model economy having (i) constant returns to scale in production and (ii) modest increasing returns in production.

We use the autoregressive process (3) to compute a shock series $\{d_t\}_{1930}^{1939}$. Then we feed the disturbances into the model. We start shocking a model which in 1929 settles in a stationary state. Here we act upon Balke and Gordon's (1986) computation of trend output which reveals that in that year the U.S. economy was very near trend. Cole and Ohanian (1999) work on a similar premise. Figure 6 contains plots of annual real U.S. GNP and of the model with constant returns given the realizations of demand shocks that

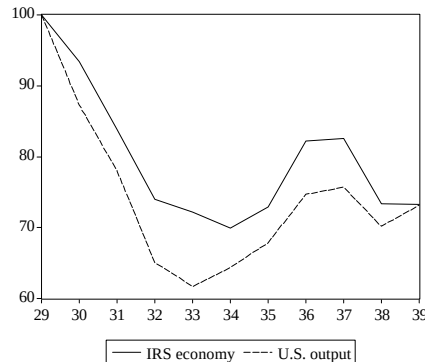


Figure 7: Increasing returns demand model

we have derived in the previous section. Both model and data series were set so that output in 1929 equals 100 and both series refer to detrended (per capita) figures. As for the U.S. series, this was done by dividing output by adult population and detrending by the average growth rate of real output per adult (1.9 percent per year).

The key finding is that the model economy predicts a drastic slowdown in economic activity after 1929. Not only does the timing of the depression match U.S. data, but the duration of the downturn appears to match as well. At its trough, the model is 20 percent below trend. This is not quite as deep as the U.S. recession – in 1933 the economy hovered 38 percent below trend. Thus, the constant returns model can account for only about 50 percent of the decline in real GNP. In contrast, the perfect markets Real Business Cycle model predicts a decline of 15 percent (see Cole and Ohanian, 1999).¹³ The second finding is that the model predicts a relatively slow recovery. In particular, by 1939 output is still 16 percent below trend as opposed to the 27 percent divergence to trend in the data (the Real Business Cycle model is above trend during the second half of the 1930s; see Cole and Ohanian, 1999). Lastly, the demand driven model predicts the 1937-1938 recession correctly in timing and deepness – the model replicates the two dips that we observe in 1930s data. There are some differences between the behavior of the model economy and the behavior of the U.S. economy during this episode. Most notably, the cycle's trough does not coincide with data. The model lags by about one year. Put in other words, the speed with which the collapse of production takes place is slower in the model. Overall, the model can capture the general pattern of the Great Depression, yet the model depression is not quite as deep and precipitous as found in data.

Let us now turn to the role of increasing returns in production and

¹³Ohanian (2001) questions the "standard" meaning of measured technology shocks.

inquire whether externalities can propagate the shocks in such a way as to help bring model and data even closer together. Reflecting on recent estimates for the U.S. economy (see for example Basu and Fernald, 2000, and references therein), scale economies are thought to be small. Bernanke and Parkinson (1993) conclude that data suggests significant increasing returns in the 1920s and 1930s.¹⁴ Burns (1933) also points to some evidence for increasing returns. We set $\gamma = 0.15$ which is not empirically implausible but on the upper end of acceptable calibrations. The upshot from considering increasing returns is that now output takes an even deeper dive (Figure 7). At its trough, the model output is 31 percent below trend which almost matches data. Yet, the downward pressure arising from the demand side appears to become most crucial during the second half of the thirties. By 1939, the artificial economy and US output have converged – the model is at 27 percent below trend. Increasing returns have the effect of providing a stronger propagation mechanism. We conclude that when we combine the measured demand shocks with a modest increasing returns to scale economy, then most of the decline in economic activity is accounted for.

Next, we look at the movements of GNP components and factor inputs. Figures 8 to 10 report the pattern of consumption, investment, and labor input *vis-a-vis* their data equivalents. Consumption is expenditures on non-durables and services. Investment is measure by business fixed investment. To make data comparable to the model, labor input in the data series is total hours worked. Once again, both the increasing returns model and data series were set such that variables in 1929 equal 100 and all series refer to detrended versions. First of all, each variable drops sharply coinciding with the pattern that we find for the U.S. economy. Particularly, investment and consumption move in the same direction at impact – when the 1930 demand shock hits. This would not have been the case would capital utilization be constant. Model hours track data closely. Investment tumbles to 70 percent below trend as opposed to 78 percent found in the data. On the other hand, consumption appears to be too smooth in the model. It falls by 16 percent whereas the U.S. economy displays a 28 percent decline. This suggests other forces (such as credit rationing) being at work that we did not capture here.¹⁵ ¹⁶

Finally, our results should be compared to the prediction of other models. As stressed in the introduction, a successful theory of the Great Depression should account for the slow recovery. In the following, we will apply a test that discriminates between model performances during that period. We follow Fair and Shiller (1990) who check the forecasting ability by evaluat-

¹⁴See also Bordo and Evans (1995).

¹⁵Labor productivity falls in the increasing returns model by three percent, thus, not to the extent of the observed 12 percent decline in U.S. data.

¹⁶The Appendix presents a discussion by considering an alternative formulation of the preference driving process. It is shown that reported results carry over.

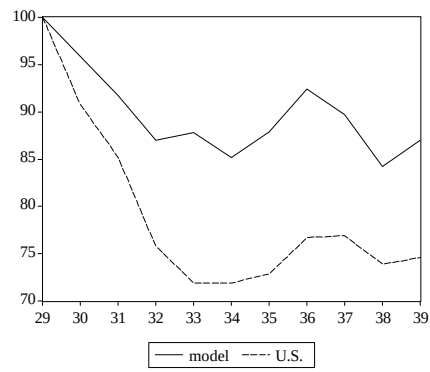


Figure 8: Consumption

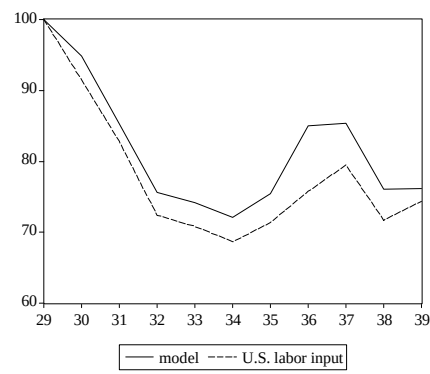


Figure 9: Labor input

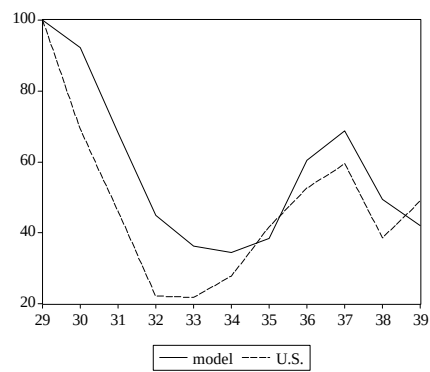


Figure 10: Investment

ing the information content of endogenous model output through the lens of a regression. To this end, we apply a test in which we assess the information contained in the constant returns and in the increasing returns demand-driven model's forecasts compared to that in two supply driven Real Business Cycle models. Those are Cole and Ohanian's (2000, Tables 12 and 13) competitive model, y_t^{COMP} , and their cartel model, y_t^{CARTEL} , which incorporates important elements of New Deal labor and industrial policies. Cole and Ohanian claim that their cartel model can account for a large portion of the tepid recovery.¹⁷ Regression of annual U.S. output (detrended levels from 1934 to 1939) on the three models' output yields the following results (t -statistics in parentheses)

$$y_t^{US} = -38.63 + 0.66 y_t^{COMP} - 0.12 y_t^{CARTEL} + 0.67 y_t^{\Delta, CRS}$$

(-2.68)
(0.90)
(-0.15)
(3.74)

$$y_t^{US} = -14.68 + 0.89 y_t^{COMP} - 0.40 y_t^{CARTEL} + 0.45 y_t^{\Delta, IRS}$$

(-1.20)
(1.09)
(-0.44)
(3.40)

We understand from these three-way tests that the demand driven model, y_t^{Δ} , provides statistically significant information for U.S. output while the two competitors do not. Phrased differently: once the demand model is included, the two other contestants appear to have no informational power. Moreover, we obtain negative coefficients for the cartel-model. That picture changes when only the cartel and the demand driven model contend in a two-way matchup:

$$y_t^{US} = -32.67 + 0.59 y_t^{CARTEL} + 0.65 y_t^{\Delta, CRS}$$

(-2.64)
(4.41)
(3.76)

$$y_t^{US} = -7.95 + 0.57 y_t^{CARTEL} + 0.41 y_t^{\Delta, IRS}$$

(-0.73)
(3.52)
(3.13)

Now, the cartel-model contributes significant information. Both models end up in a draw. Judging the overall performance, the demand-driven model fares at least as good as its considered contenders. Our findings suggest that shocks to demand were important factors during the 1930s.

Finally, we will extend the simulation past the year 1939. Demand shifts are represented by the second-order process (3) and the model starts in steady state in 1929. Figure 14 shows model and data growth rates of output. First, we observe that the volatility of both economy declines significantly after World-War-II. Second, the model volatility is 90 percent that of U.S. output growth's volatility. In terms of Prescott's (1986) original motivation of Real Business Cycle theory, the model can explain a material

¹⁷Their model starts out of steady state by assumption – the years before 1936 were not modelled.

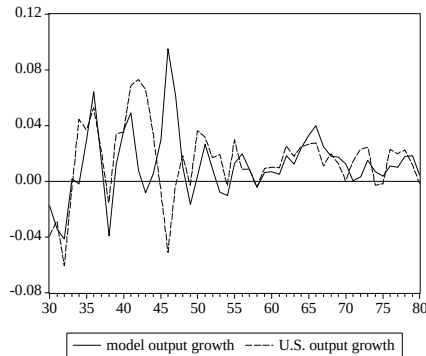


Figure 11: Output growth model vs. U.S.

fraction of observed economic fluctuations. Third, the correlation of both series is 0.26 for 1930 to 1980 which questions the model's ability to account for most of the U.S. business cycle and which suggest other, largely orthogonal, shocks. However, when the War years are excepted, the comovement improves. The series' correlation rises to 0.84 for the 1930s and to 0.49 for the 1950 to 1980 subperiod. Thus, when excluding the effects of World-War II, demand shocks may constitute the source of a weighty portion of the United States business cycle. Put differently, demand disturbances appear to have exercised an unusual toil during the Depression years. To a certain extend, they seem less important for the post-war period, yet, as also noted by Hall (1997), they represent an important factor for our understanding of the post-war cycle.

5 Concluding remarks

If our argument is correct, disturbances on the demand side may have played a central role during the Great Depression. Indeed we can identify from Euler equation residuals a number of unusually large negative demand shocks bunched in the 1930s. These appear to have derailed the U.S. economy. This echoes the view originally promoted by Temin (1976) and it supports his theory that consumption declined in a atypical manner for cycles during the that period. We apply these measured demand shocks to a dynamic general equilibrium model and find that size and sequence of shocks can generate a pattern of the model economy that is not unlike data. The model grants demand shocks a major role in both generating the economic downturn as well as exaggerating persistence. Noteworthy is the model's ability to account for the lion's share of the decline in economic activity – if we accept the presence of modest increasing returns to scale, then demand shocks

can account for almost all the deepness of the depression. Furthermore, the speeds of adjustment in the model parallel those in the Great Depression which were much slower than in other recessions. The demand-driven model performs particularly well between 1934 and 1939. Undoubtedly, other factors contributed to the Depression, and adding them to the model may likely enhance the match to data even further. We leave this to another project.

This being said, two final issues emerge: (i) what exactly are the demand shocks and (ii) was the Great Depression suboptimal after all? Until now we have interpreted shifts of Δ_t plainly as exogenous consumption shocks. This follows the traditional Keynesian argument of animal spirits or sunspots that cause erratic movements of aggregate demand. However, a potential pitfall of this interpretation is that the measured preference shifts are serially correlated. By drawing strictly on the indeterminacy literature (see Farmer, 1993), this would stand in conflict to the rational expectations assumption – besides the model does not display multiple equilibria of any sorts. Yet, one could also think that the shocks are a stand-in for something different. For example, Hansen and Prescott (1993) defend technology shocks as really being about government restrictions and in the present case a change of the preference shifter could represent exogenous factors somehow affecting the intratemporal rate of substitution between consumption and leisure. However, no candidate policy parameter (in particular distortionary taxation) appears to display any significant change: tax rates on capital and labor changed very little during the 1929 to 1933 period (see Joines, 1981). An alternative interpretation which stands closer to the "standard" demand side version relates to the artificial economy's asset pricing implications and would stress on exogenous changes in the aversion towards risk.¹⁸ In the model, high values of Δ_t mean high risk aversion which imply a high equity premium. Consequently, predicted asset returns are high and price-dividend ratios are low. As displayed in Figure 1, Δ_t falls dramatically at the onset of the Great Depression indicating a fall of risk aversion. Therefore, the interpretation evolves that agents perceived this fall beforehand - thus the surge of stock prices prior to 1929 with subsequent low returns. Even though this interpretation appears observationally equivalent to the case of "standard" demand shocks, it demonstrates that the correct asset pricing sequence is implied. Another interpretation follows Prescott (1999) who advances the view that labor market institutions and the "rules of the game" may be essential in explaining phenomena like the Great Depression in the United States, the current bust in Japan or high unemployment in Europe. In particular, Prescott argues that the fall in hours worked in Japan during the 1990s reflects agents' desire to substitute in favor of more leisure. Therefore, the preference shift that was identified in this paper may simply parallel the hypothesis laid out by Prescott: following the buoyant 1920s the

¹⁸I would like to thank Harald Uhlig for pointing this out to me.

United States chose to consume smaller volumes of goods, work less and correspondingly run down economic activity. The drop of Δ_t expresses a change of the marginal rate of substitution between consumption and leisure (note that in data and in the artificial economy the consumption share rises after 1929).¹⁹ It appears that more work should be done in identifying the economics behind the preference shift and we plan to pursue this in future research.

This leads us to the second issue. Since fiscal actions apparently did not induce the economic decline, the Depression as characterized throughout a large portion of our discussion, emerges as a voluntary phenomenon absent of any sort of market failures. In particular, if production is constant returns, then the estimated changes in preferences call upon a significant decline of output after 1929. Put alternatively, about half of the deepness of the decline can be interpreted as optimal response. Surely, this leaves open what caused the rest of the slump and to what extent those factors fit this characterization. Moreover, this straightforward conclusion no longer holds in second-best environments with increasing returns. This points to increasing returns not only acting as the magnifying channel that produces a large slump. Production complementarities also represent an essential source of coordination failure that allows the interpretation of the Great Depression as a nonoptimal event.

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¹⁹Note that any sort of market institutions and industrial policies did not come into effect until the last half of the 1930s.

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6 Appendix

6.1 The model in more detail

The first-order conditions entail

$$\frac{\eta}{1-\eta} \frac{l_t}{1-l_t} = \frac{(1-\alpha)y_t}{c_t - \Delta_t}$$

$$\delta_t = \frac{\alpha}{\theta} \frac{y_t}{k_t}$$

$$\frac{(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}}}{c_t - \Delta_t} = E_t \frac{\beta}{c_{t+1} - \Delta_{t+1}} \left[\alpha \frac{y_{t+1}}{k_{t+1}} + 1 - \delta_{t+1} \right]$$

$$(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}} (1+n)k_{t+1} = (1-\delta_t)k_t + x_t$$

$$\delta_t = \frac{1}{\theta} u_t^\theta$$

$$c_t + x_t = y_t = (u_t k_t)^{\alpha(1+\gamma)} l_t^{(1-\alpha)(1+\gamma)}$$

and a transversality condition.

The preference shifter Δ_t is zero in the steady state. In balanced growth, the Euler equation implies

$$\frac{(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}}}{\beta} = \alpha \frac{y}{k} + 1 - \delta$$

which allows to compute y/k . From the first order condition with respect to capital utilization together with the Euler equation we attain

$$\frac{(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}}}{\beta} = 1 - \delta(1 - \theta).$$

We obtain a value for θ . The law of motion of the capital stock in steady state gives

$$(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}}(1+n) - (1-\delta) = \frac{x}{k}$$

which yields the steady state investment share.

The linearized model is given by

$$\widehat{y}_t = \alpha(1+\gamma)\widehat{u}_t + \alpha(1+\gamma)\widehat{k}_t + (1-\alpha)(1+\gamma)\widehat{l}_t$$

$$\widehat{l}_t + \frac{l}{1-l}\widehat{l}_t = \widehat{y}_t - \widehat{c}_t + \widehat{\Delta}_t$$

$$\widehat{\delta}_t = \widehat{y}_t - \widehat{k}_t$$

$$\begin{aligned} & -(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}}(\widehat{c}_t - \widehat{\Delta}_t) \\ = & -\beta[\alpha\frac{y}{k} + 1 - \delta]E_t(\widehat{c}_{t+1} - \widehat{\Delta}_{t+1}) + \alpha\beta\frac{y}{k}\left[E_t\widehat{y}_{t+1} - \widehat{k}_{t+1}\right] - \beta\delta E_t\widehat{\delta}_{t+1} \end{aligned}$$

$$(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}}(1+n)\widehat{k}_{t+1} = (1-\delta)\widehat{k}_t - \delta\widehat{\delta}_t + \frac{x}{k}\widehat{x}_t$$

$$\widehat{\delta}_t = \theta\widehat{u}_t$$

$$\frac{c}{y}\widehat{c}_t + \frac{x}{y}\widehat{x}_t = \widehat{y}_t$$

and

$$\widehat{\Delta}_{t+1} = 1.221257\widehat{\Delta}_t - 0.320895\widehat{\Delta}_{t-1} + d_t$$

(or

$$\widehat{\Delta}_{t+1} = \widehat{\Delta}_t + d_t$$

with a random walk process).

The linear model can be reduced to

$$\begin{bmatrix} \widehat{y}_t \\ \widehat{c}_t \\ \widehat{l}_t \\ \widehat{u}_t \end{bmatrix} = \mathbf{R} \begin{bmatrix} \widehat{x}_t \\ \widehat{k}_t \\ \widehat{\Delta}_t \\ \widehat{\Delta}_{t-1} \end{bmatrix}.$$

and

$$\begin{bmatrix} \widehat{x}_{t+1} \\ \widehat{k}_{t+1} \\ \widehat{\Delta}_{t+1} \\ \widehat{\Delta}_t \end{bmatrix} = \mathbf{M} \begin{bmatrix} \widehat{x}_t \\ \widehat{k}_t \\ \widehat{\Delta}_t \\ \widehat{\Delta}_{t-1} \end{bmatrix} + \mathbf{L} \begin{bmatrix} \omega_{t+1} \\ 0 \\ d_{t+1} \\ 0 \end{bmatrix} \quad (5)$$

where $\omega_{t+1} \equiv E_t \widehat{x}_{t+1} - \widehat{x}_{t+1}$ is the expectations error. Given that we do not consider cases of indeterminacy, one eigenvalue of $\mathbf{M}$ will be outside the unit circle. We apply Farmer's (1993, chapter 7) method to solve for the unique solution. We premultiply (5) by $\mathbf{Q}^{-1}$, the inverse of the matrix of eigenvalues of $\mathbf{M}$. This gives a system of uncoupled equations in the transformed variables

$$z_t = \mathbf{Q}^{-1} \begin{bmatrix} \widehat{x}_t \\ \widehat{k}_t \\ \widehat{\Delta}_t \\ \widehat{\Delta}_{t-1} \end{bmatrix}$$

and

$$v_{t+1} = \mathbf{Q}^{-1} \begin{bmatrix} \omega_{t+1} \\ 0 \\ d_{t+1} \\ 0 \end{bmatrix}.$$

Now,

$$\begin{bmatrix} z_{t+1}^1 \\ z_{t+1}^2 \\ z_{t+1}^3 \\ z_{t+1}^4 \end{bmatrix} = \begin{bmatrix} \lambda_1 & 0 & 0 & 0 \\ 0 & \lambda_2 & 0 & 0 \\ 0 & 0 & \lambda_3 & 0 \\ 0 & 0 & 0 & \lambda_4 \end{bmatrix} \begin{bmatrix} z_t^1 \\ z_t^2 \\ z_t^3 \\ z_t^4 \end{bmatrix} + \begin{bmatrix} v_{t+1}^1 \\ v_{t+1}^2 \\ v_{t+1}^3 \\ v_{t+1}^4 \end{bmatrix}$$

Suppose that $\lambda_1 > 1$. From $E_t v_{t+1}^1 = 0$, this yields

$$z_t^1 = 0$$

thus a linear combination of $\widehat{x}_t$ with $\widehat{k}_t$, $\widehat{\Delta}_t$, and $\widehat{\Delta}_{t-1}$. This allows to eliminate the "investment equation" and the dynamics are then governed

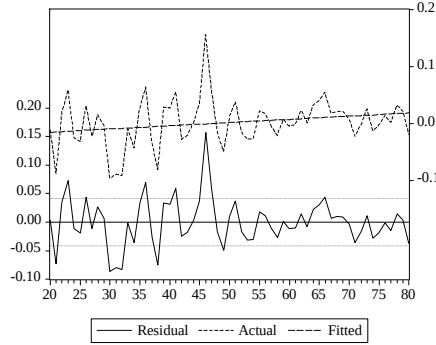


Figure 12: Demand shocks (random walk)

by

$$\begin{bmatrix} \hat{k}_{t+1} \\ \hat{\Delta}_{t+1} \\ \hat{\Delta}_t \end{bmatrix} = \widetilde{\mathbf{M}} \begin{bmatrix} \hat{k}_t \\ \hat{\Delta}_t \\ \hat{\Delta}_{t-1} \end{bmatrix} + \begin{bmatrix} 0 \\ d_{t+1} \\ 0 \end{bmatrix}$$

which is equation (1) in the main text.

6.2 Alternative driving process

Here we will demonstrate the robustness of our results. First, we will consider an alternative specification of the shock process. Then we will compute model output past the Great Depression era.

As mentioned in footnote 8, preferences are suspiciously nonstationary. Indeed, Dickey-Fuller tests indicate that in levels the series fails to accept stationarity. Thus, we close our presentation by assuming an alternative driving process of the preference shifter. We consider the following random walk process to describe demand shocks

$$\begin{aligned} \hat{\Delta}_t - \hat{\Delta}_{t-1} &= \underset{(-1.45)}{-0.0154} + \underset{(1.87)}{0.0006t} + d_t \\ R^2 &= 0.06, \quad SE = 0.041, \quad DW = 1.40. \end{aligned}$$

Compared to (3), the fit worsens which makes this formulation less appealing. The regressors are no longer statistically significant as was the case in the AR(2) specification. Furthermore, the shock volatility increases. Figure 11 plots the shock sequence that results from the regression. We find large negative demand shocks for the 1930s whose magnitude is not observable in the postwar period. This chimes with the results from our other shock

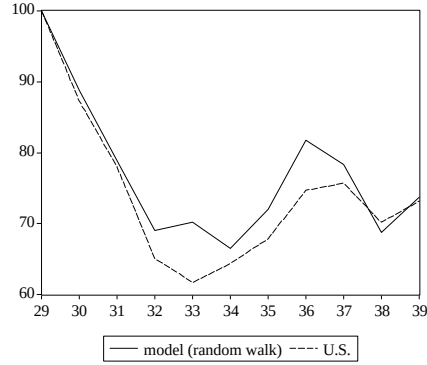


Figure 13: Output

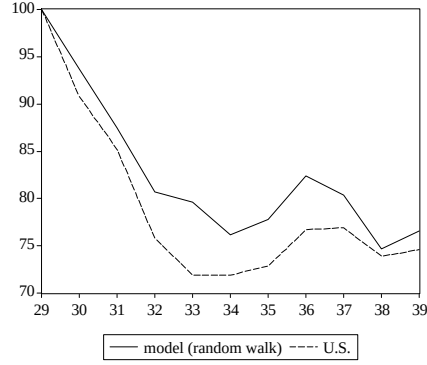


Figure 14: Consumption

specifications. Figure 12 and 13 display the behavior of the model and data output given the calibration of the constant returns economy. The deepness and persistence of the Great Depression are captured by this model: output is now 34 percent below trend at trough. Moreover, the model replicates the double dip that we observe in data. Consumption follows a less of a smooth pattern than with AR(2) shock process: it is 23 percent below trend at its trough which is not ill-matching the 25 percent of U.S. consumption. Thus, when allowing for the possibility of a random walk preference process, then departures from constant returns to scale are no longer needed to explain a substantial share of the Great Depression.