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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, Euler equation residuals identify a series of unusually large negative demand shocks that appeared to have hit the U. S. economy during the 1930s. Measured demand shocks are applied to a dynamic general equilibrium model. Size and sequence of shocks can generate a pattern of the model economy that is not unlike data. The artificial economy 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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"We feel that, so far as industrial activity is concerned, the worse will be over in the next six weeks." [*Business Week*, December 14, 1929, p. 3]

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 about twenty-five percent below trend in 1939. Put alternatively, the recovery phase lasted seven years – four times the average post-war recovery period.

The current paper identifies atemporal demand shocks as chiefly culpable for the Great Depression. In particular, I examine a modification of the real business cycle model with stochastic preferences. Phrased precisely, the essay applies equilibrium analysis to identify how much of the decline can be accounted for by demand shocks. I find that such an optimizing model, driven only by estimated demand shocks, can explain fittingly a number of central features of Great Depression era. In particular, the artificial economy can account for the lion's share of the decline in economic activity from 1929 to 1933, it can replicate the subsequent lukewarm recovery throughout the rest of the decade as well as the 1937-1938 recession.

In contrast, 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 about 1935. 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 grew at spectacular growth rates 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 held the economy off track must have been at work throughout most of the 1930s.

This all suggests that important nonmonetary, domestic forces kept the economy off track. Correspondingly, Bordo et al. (2000) and Cole and Ohanian (2000) shift attention to New Deal labor policy that facilitated inflating real wages. Still, Cole and Ohanian's (2000) technology-driven cartel-model closes the reported gap between the perfect markets real business cycle model and U.S. output by only a half. Perhaps even more important, it appears to miss the 1937-1938 recession – the third largest recession in American history in terms of output loss – altogether.

Here, I look towards shocks to demand as an alternative explanation for the entire Depression era. The point of departure is Temin's (1976) insistence that the Great Depression was brought on by a collapse of aggregate demand.[1] What evidence does Temin muster to support his proposition? The centerpiece of his argument rests on the pattern of both nondurable and durable consumption which bears no resemblance to that of other episodes of recession. 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 also stresses investment's 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 the uncertainty led to delaying the expenditures on durable goods.

Temin's original formulation remains in the confines of the superannuated 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.

The 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 shell of dynamic optimization. Baxter and King (1991) construct a dynamic general equilibrium model that furthered

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

Hall's original idea 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. Similarly, Hall (1997) stresses the leading role of atemporal shocks – those that are found in the current paper – in explaining post-war recessions. By generating a series of demand innovations that I find to best reflect the behavior of preferences during the Depression, I am able to show that the model economy takes a path that is strikingly similar to historical data. In particular, the 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 the artificial economy goes through a recession in 1937-1938.

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 I 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, i, these participants are assumed to solve

$$\max_{\{c_{i,t},l_{i,t},u_{i,t},x_{i,t}\}} E\sum_{t=0}^{\infty}\beta^t(1+n)^t\left[(1-\eta)\log(c_{i,t}-\Delta_t)+\eta\log(1-l_{i,t})\right]$$

$$\text{s.t. } c_{i,t}+x_{i,t}=y_{i,t}=A_t^{\gamma}(u_{i,t}k_{i,t})^{\alpha}l_{i,t}^{1-\alpha}$$

$$A_t=(u_tk_t)^{\alpha}l_t^{1-\alpha}$$

$$(1+g)^{\frac{(1-\alpha)(1+\gamma)}{1-\alpha(1+\gamma)}}(1+n)k_{i,t+1}=(1-\delta_{i,t})k_{i,t}+x_{i,t}$$

$$\delta_{i,t}=\frac{1}{\theta}u_{i,t}^{\theta}$$

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 omitting the agent index, i, denotes 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 I consider symmetric equilibria only.

I will next describe the parametric specification of the model and assign parameter values. Calibration is now routine in a wide range of macroeconomic areas. Table 1 represents a typical calibration. 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, I set the increasing returns to scale parameter to zero for the time being. In fact, one needs 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. The 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). Finally, the steady state consumption share of output amounts to 72 percent. This is close to the U.S. consumption share in 1929.

Table 1: Calibration

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

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

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

[3]Bresnahan 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.

[4]See 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

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

where $\mathbf{M}$ is a 3×3 matrix (the Appendix presents the complete solution of the model). An equilibrium is defined as a sequence $\{\widehat{k}_{t+1}, \widehat{\Delta}_t\}_{t=0}^{\infty}$ that solves (1) subject to initial conditions as well as the transversality condition. The next section 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 the 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. Note that the intratemporal optimality condition for consumption implies that

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

Hence, 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. Therefore, Hall (1997) classifies these shocks as atemporal effects as opposed to intertemporal effects.

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

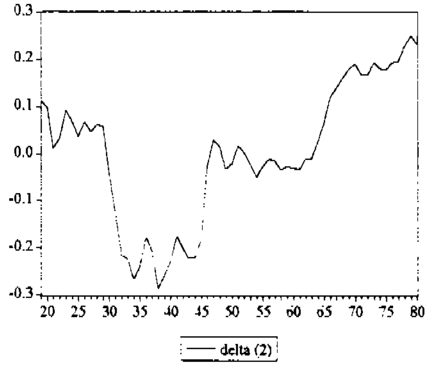

Figure 1: Preference shifter (computed as in equation 2)

After Taylor-approximating it, the household's two intratemporal optimality conditions becomes[6]

$$\widehat{\Delta}_t \simeq \widehat{c}_t - \widehat{w}_t + \frac{l}{1-l}\widehat{l}_t. \tag{2}$$

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. 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, I 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), I employ BLS data on hourly wages directly – chained into Hanes's data. 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, $\widehat{\Delta}_t$, over the 1919 to 1980 period. The series centers around zero which mimics the

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

[7]The 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.

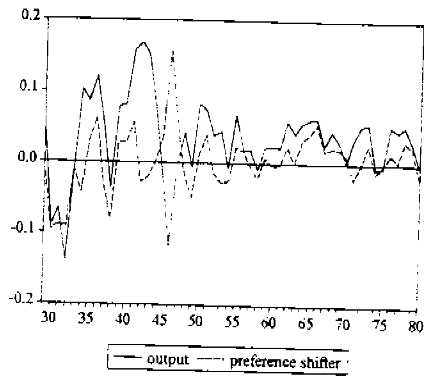

Figure 2: U.S. output vs. preference shifts

construction of preferences in the 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. Furthermore, we note two upward swings, the first one setting in with the end of World-War-II which brought the preference shifter to its pre-Depression level and another one during the first half of the 1960s. Figure 2 plots the time series of the change in the preference variable and U.S. output growth. One sees 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 the years 1929 to 1939, the correlation becomes 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.

In a related exercise, Temin (1976, Appendix) reports significant residuals from consumption functions that employ wealth and permanent income estimates occurring 1929 to 1930. In fact, he finds even larger unexplained variations of consumption than when consumption functions that current income had been used and negative residuals appear for 1937 to 1938 as well.

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 I 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 (AR) including a constant and trend provides a good fit for the evolution of the preference state. I experimented with a number of possible low-order processes – various AR processes and random walk specifications. The findings can be summarized as follows. When the dynamic process is of first-order, the process displays clear evidence of serial correlations of residuals. This is no longer the case when I assume that preferences are described by a second-order autoregressive process. On the other hand, additional lags were not found to contribute significantly. I conclude that a second-order autoregressive process including constant and trend provides a good description of the evolution of preferences (t-statistics in parenthesis):[8]

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

The reported shock volatility appears large. This is the result of the 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 the 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 is the only period in which I measure negative shocks of that magnitude and the volatility of demand shocks becomes remarkably smaller in the post-war period. We also see that the absolute volatililty decreases significantly after 1950; one can trace from Figure 3 that the two upward shifts in preferences that occurred during the 1940s and the 1960s did not yield excessive sequences of demand shocks: with the exception of the year 1946 in which preferences returned to their pre-Depression level. This corresponds to the findings reported in DeLong and Summers (1986) that demand shocks were either less

[8] The Schwarz criterion leads to the same lag-choice.

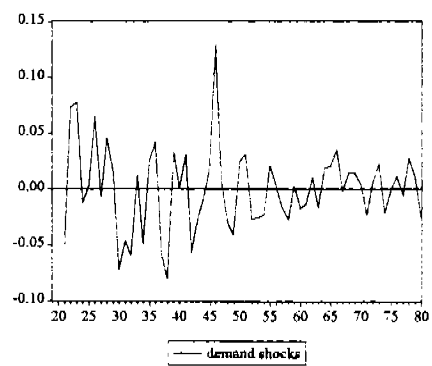

Figure 3: Demand Shocks

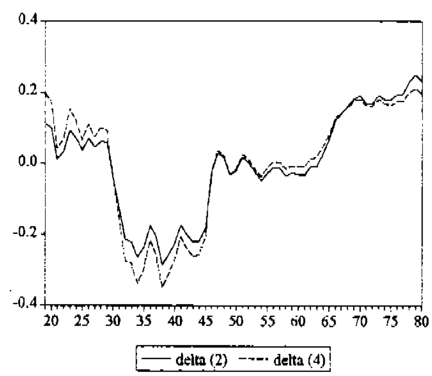

Figure 4: Preference shifters

important or smaller in the postwar period or were partially neutralized by active fiscal and monetary policies. However, DeLong and Summers arrive at their conclusion by using a considerably different methodology. In the following, alternative formulations for the preference process were tried to see if the results were sensitive to the choice of data and method of detrending.

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

Alternatively, relationship (2) could be transformed to

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

where the tildes denote that variables were trend adjusted. Here, the variables were rendered stationary by deflating each variable by its long run (sample) trend growth.[9] Figure 4 graphs the resulting behavior of the preference 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. 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. Thus, I decided to simply use formulation (2) in the following section.[10]

Next, one may object that the choice of manufacturing wages distorts the results. However, manufacturing real wages and aggregate real wages moved 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). Hence, 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. In any case, I repeated the calculation of (2) by using aggregate measures. In particular, I use Kendrick's (1961) measure of total hours and the total economy real wage (see Cole and Ohanian, 1999, for construction).[11] 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. Independently of the sectors, we observe an economy-wide shift in preferences.[12] In fact, the decline in demand, and therefore the size of measured demand shocks, is even larger when using aggregate wage and employment data. In the end, I have decided in favor of using manufacturing wage data mainly because of its higher quality and since it is consistently available over a long time span.

Finally, we must check if demand shocks are not caused by other fundamentals that is I test the hypothesis of no-Granger causality from a number of fundamentals like output, money and interest rates to the preference shifter, $\widehat{\Delta}_t$. If $\widehat{\Delta}_t$ reflects variations in preferences, we should not reject the exogeneity hypothesis, thus, demand shocks should be orthogonal to past patterns of fundamentals. I will begin by checking the effect of output on demand shocks. Our sample period is 1929-1939 (Table 2) and 1929-1980

[9] We 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.

[10] Preferences are suspiciously nonstationary. Indeed, Dickey-Fuller tests indicate that in levels the series fails to accept stationarity. I will return to the possibility of random walk preferences in the Appendix.

[11] Steady state values are sample means.

[12] One 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.

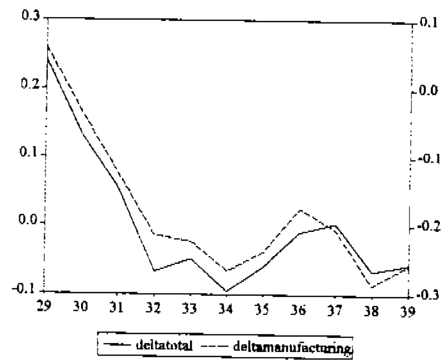

Figure 5: Total wages vs. manufacturing wages

(Table 3) using lag length of one year.[13] The Tables display F-statistics and implied probability levels for the hypotheses that real output growth does not Granger cause $\widehat{\Delta}_t$ ($H_0^{y\Delta}$) and that $\widehat{\Delta}_t$ causes output ($H_0^{\Delta y}$). We see that the $H_0^{y\Delta}$-null of no-Granger causality cannot be rejected at conventional significance levels. In fact, if at all the results suggest that indeed demand shocks cause output: when the test is limited to the Great Depression era, then we can establish Granger causality running from measured preference shocks to output (see Table 2, $H_0^{\Delta y}$).

Table 2: Granger causality tests

	F-Statistic	Probability
$H_0^{y\Delta}$	0.68	0.44
$H_0^{\Delta y}$	10.30	0.01

Pairwise Granger causality tests: sample 1929-1939; $H_0^{y\Delta}$: output growth (y) does not Granger cause $\widehat{\Delta}_t$; $H_0^{\Delta y}$: $\widehat{\Delta}_t$ does not Granger cause output growth.

Table 3: Granger causality tests

	F-Statistic	Probability
$H_0^{y\Delta}$	0.12	0.73
$H_0^{\Delta y}$	1.85	0.18

Pairwise Granger causality tests: sample 1929-1980.

[13] Adding lags does not alter the main results.

Table 4 reports the effect of money (nominal and real M1) and interest rates (annual prime commercial paper rate) on $\widehat{\Delta}_t$; given the objective of the exercise to examine the impact of demand shocks during the Great Depression, I present only results from the 1929 to 1939 subsample. Again, we find that monetary variables do not Granger-cause the preference shifter. However, there appears to be an effect from $\widehat{\Delta}_t$ to money which accordingly may contain some endogenous components.[14]

Table 4: Granger causality tests		
	F-Statistic	Probability
$H_0^{M/P\Delta}$	0.00	0.99
$H_0^{\Delta M/P}$	4.20	0.08
$H_0^{M\Delta}$	0.02	0.90
$H_0^{\Delta M}$	8.47	0.02
$H_0^{cp\Delta}$	0.59	0.47
$H_0^{\Delta cp}$	1.92	0.21

Pairwise Granger causality tests: sample 1929-1939; M denotes $M1$, M/P denotes $M1$ divided by the GNP-deflator, cp is the annual prime commercial paper rate. Therefore, $H_0^{M/P\Delta}$ means "real money does not Granger cause $\widehat{\Delta}_t$" *et cetera.*

To sum up, the section suggests a sequence of negative demand shocks that started to slam the U.S. economy in 1930. In the following section, I will use the result and confront the identified demand innovations with the theoretical model. It is only then that one 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.

4 The model and the Great Depression

In this section I use the measured series of demand shocks and generate the model time series of relevant variables. This constitutes an important test for the relevance of the shocks that have been identified in the previous section. I will discuss the model economy having (i) constant returns to scale in production and (ii) modest increasing returns in production.

The procedure of obtaining model series is as follows. I use the autoregressive process (3) to compute a shock series $\{d_t\}_{1930}^{1939}$. The disturbances are fed then into the artificial economy and start shocking the model (1) which

[14] Joines (1981) finds that income tax rates on capital and labor changed little during the 1929 to 1933 period. Thus, it is unlikely, that fiscal shocks were operating in some reduced-form way through preferences.

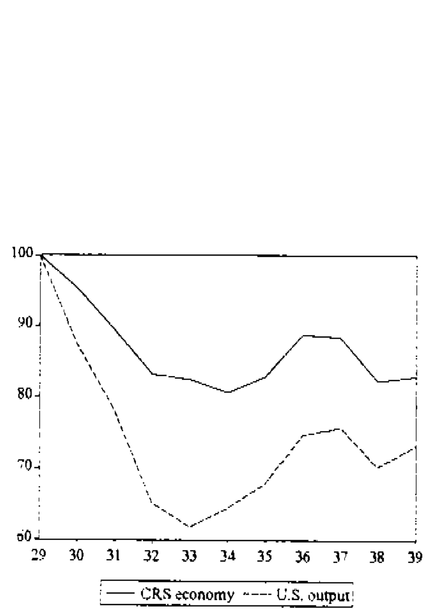

Figure 6: Constant returns demand model

by assumption 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 in 1929 the U.S. economy was near trend. Cole and Ohanian (1999) work on a similar premise.[15] Figure 6 contains the plots of annual real U.S. GNP and of the model with constant returns given the realizations of demand shocks that have been derived in the previous section. Both artificial 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 about 20 percent below trend. This is not quite as deep as the U.S. recession – in 1933 the economy hovered 38 percent below trend. The constant returns model can account for only about 50 percent of the decline in real GNP. [16] 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.[17]

[15]There may be good reasoning, however, to assume that by the late twenties the economy was above trend given a number of innovations that came into effect during that period. It should be noted that if we would have assumed that scenario and start above the steady state, the workings of the endogenous propagation mechanism grant demand shocks an even larger role.

[16]In contrast, the perfect markets real business cycle model predicts a decline of 15 percent (see Cole and Ohanian, 1999). The real business cycle model is above trend during the second half of the 1930s. Note that the large measured decline in factor productivity has become a conundrum for the real business cycle strategy, since it is unlikely the result of technological regress (Ohanian, 2001).

[17]Given that the demand model does predict the complete decline, the theory could be

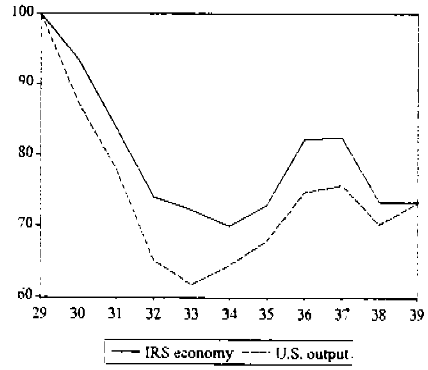

Figure 7: Increasing returns demand model

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 the 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 economic collapse 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 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, 1997), scale economies are thought to be small. Bernanke and Parkinson (1993) conclude that data suggests significant increasing returns in the 1920s and 1930s.[18] Burns (1933) also points to some evidence for increasing returns. I set $\gamma = 0.15$ which is not empirically implausible but on the upper end of acceptable calibrations.

Figure 7 presents that the upshot from considering increasing returns is that now output takes an even deeper dive. At its trough, model output is 31 percent below trend which almost matches data; the model explains around 82 percent of the overall decline. Yet, the downward pressure arising from the demand side appears to become most crucial during the second half of the thirties since the recovery remains weak. By 1939, the artificial economy and US output have converged – the model is at 27 percent below trend. It appears that increasing returns have the effect of providing a

reconciled with empirical cross-country analysis that finds countries that remained in the Gold Block were most harshly hit during the Depression.

[18] See also Bordo and Evans (1995).

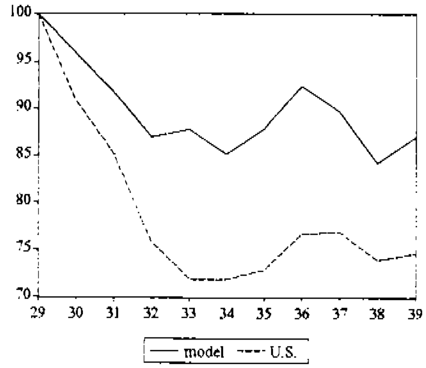

Figure 8: Consumption

stronger propagation mechanism of the pernicious consumption shocks. I 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, I 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. As per U.S. data, consumption is expenditures on nondurables and services; investment is measured 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.[19] 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 I did not capture here.Lastly, let us confront the model with the finding that total factor productivity fell by about 14 percent in the United States between 1929 and 1933. Given the increasing returns in the present model, we should be able to produce a countercyclical pattern of productivity. To see this, suppose the artificial economy is examined under the assumption of constant returns – Cole and Ohanian's (1999) prior when looking at the U.S. economy. Applying a Solow decomposition on artificial data would deliver a

[19]See also Benhabib and Wen (2000).

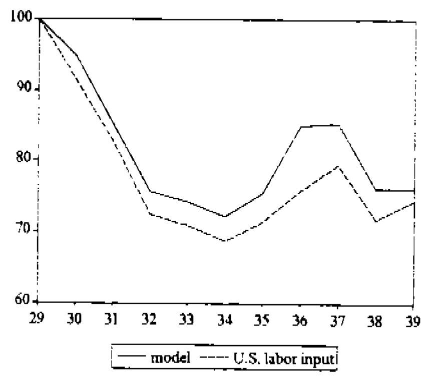

Figure 9: Labor input

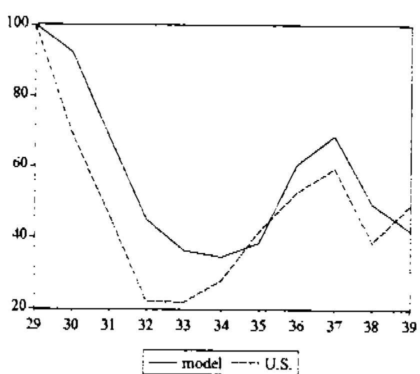

Figure 10: Investment

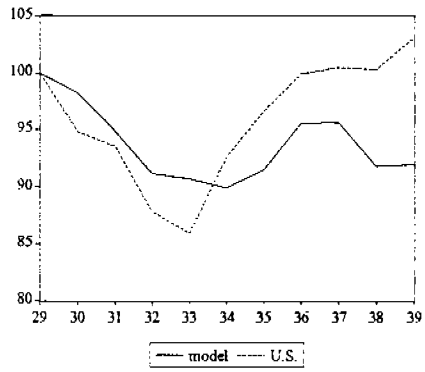

Figure 11: "Total factor productivity"

measure of total factor productivity which in effect arises from externalities. Figure 11 plots the Solow residuals for both the model and U.S. data and one sees that over 70 percent of the measured technological decline can be explained by the presence of increasing returns: by 1933 model "total factor productivity" has fallen by about 10 percent.

Finally, the 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, I will apply a test that discriminates between model performances during that period. I follow Fair and Shiller (1990) who check the forecasting ability by evaluating the information content of endogenous model output through the lens of a regression. To this end, I apply a test in which one can 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 technology-driven cartel model can account for a large portion of the tepid recovery.[20] 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)

$$y_t^{US} = \underset{(-2.68)}{-38.63} + \underset{(0.90)}{0.66} y_t^{COMP} - \underset{(-0.15)}{0.12}\, y_t^{CARTEL} + \underset{(3.74)}{0.67} y_t^{\Delta,CRS}$$

$$y_t^{US} = \underset{(-1.20)}{-14.68} + \underset{(1.09)}{0.89} y_t^{COMP} - \underset{(-0.44)}{0.40}\, y_t^{CARTEL} + \underset{(3.40)}{0.45} y_t^{\Delta,IRS}$$

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

One can 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, I 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:

$$y_t^{US} = \underset{(-2.64)}{-32.67} + \underset{(4.41)}{0.59} y_t^{CARTEL} + \underset{(3.76)}{0.65} y_t^{\Delta,CRS}$$

$$y_t^{US} = \underset{(-0.73)}{-7.95} + \underset{(3.52)}{0.57} y_t^{CARTEL} + \underset{(3.13)}{0.41} y_t^{\Delta,IRS}.$$

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. The findings again suggest that shocks to demand were not unimportant factors during the 1930s.

Finally, I extended 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 12 shows model and data growth rates of output. First, the volatility of both economies declines significantly after World-War-II; the upward shift of $\widehat{\Delta}_t$ that can be seen in Figure 4 for example, does not trigger any excessive sequence of positive demand shocks that translate in two high of output growth rates. Second, the model volatility is 88 percent that of U.S. output growth's volatility suggesting that much, but not all, of the variation in output is accounted for by demand shocks. Third, the correlation of both series is 0.26 for 1930 to 1980 which questions the model's ability to explain for most of the U.S. business cycle. However, when the World-War-II years are excepted, the comovement figure improves considerably. The series' correlation rises to 0.84 for the 1930s and to 0.49 for the 1950 to 1980 subperiod. Thus, when excluding the extraordinary 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 my argument is correct, disturbances on the demand side may have played a central role during the Great Depression. Indeed one can identify from Euler equation residuals a number of unusually large negative demand shocks

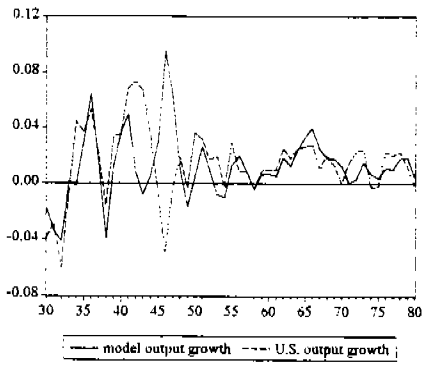

Figure 12: Output growth model vs. U.S.

bunched in the 1930s. These appear to have derailed the U.S. economy for a whole decade. These findings echoes the view originally promoted by Temin (1976) and they support his theory that consumption declined in a atypical manner for cycles during the that period. I apply these measured demand shocks to a dynamic equilibrium model and find that size and sequence of shocks can produces 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. Thus, the essay pushes equilibrium analysis to single out the fraction of the economic downturn that can be explained by consumption shocks alone. Granted, other real and nominal factors contributed to the Depression, and adding them to the model may likely enhance the match to data even further. I 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 I have interpreted shifts of Δ_t plainly as exogenous consumption shocks. In a sense, this follows the traditional Keynesian argument of sudden attacks of thriftiness or agent's animal spirits that cause erratic movements of aggregate demand. The latter interpretation may however turn into a potential pitfall since measured shocks 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 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.[21] 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 the fall beforehand - the surge of stock prices prior to 1929 with subsequent low returns. Even though the 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.[22] In particular, Prescott argues that the fall in hours worked in Japan during the 1990s reflects agents' desire to substitute in favor of enjoying more leisure. Therefore, the preference shift that was identified in the current paper may simply parallel the hypothesis laid out by Prescott: following the buoyant 1920s the 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). Similarly, Hall (1997) stresses the leading role of atemporal shocks – those that are found in the current paper – in explaining post-war recessions. He writes

> "A recession is indeed a time when people spend fewer hours in paid work and consume a lower volume of market goods and services. We need a much more intensive examination of the uses of time other than in paid work." (Hall, 1997, p. S249)

Thus, it appears that more work should be done in identifying the economics behind the preference shifts and I plan to pursue this in future re-

[21] I would like to thank Harald Uhlig for pointing this out to me.

[22] Note, however, that any changes in market institutions and industrial policies did not come into effect until the second half of the 1930s.

search.[23]

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 the 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, if the assumption of a distortion-free economy with constant returns to scale is correct then the present paper suggests that 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 the characterization. Moreover, this straightforward conclusion no longer holds in second-best environments with increasing returns. This points to externalities in production not only acting as the magnifying channel that produces a large slump from initially perhaps smaller scale disturbances. Production complementarities also represent an essential source of coordination failure that allow the interpretation of the Great Depression as a nonoptimal event.

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[23] On this isssue see also Mulligan (2000) and – indirectly – Chari, Kehoe and McGrattan (2002).

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6 Appendix

6.1 The model

In the symmetric equilibrium, 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 I attain

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

I 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

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

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

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

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

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

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

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

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

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

where $\omega_{t+1} \equiv E_t \widehat{x}_{t+1} - \widehat{x}_{t+1}$ is the expectations error. Given that I do not consider cases of indeterminacy, one eigenvalue of $\mathbf{M}$ will be outside the unit circle. I apply Farmer's (1993, chapter 7) method to solve for the unique solution. I 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,

$$\begin{bmatrix} z^1_{t+1} \\ z^2_{t+1} \\ z^3_{t+1} \\ z^4_{t+1} \end{bmatrix} = \begin{bmatrix} \lambda_1 & 0 & 0 & 0 \\ 0 & \lambda_2 & 0 & 0 \\ 0 & 0 & \lambda_3 & 0 \\ 0 & 0 & 0 & \lambda_4 \end{bmatrix} \begin{bmatrix} z^1_t \\ z^2_t \\ z^3_t \\ z^4_t \end{bmatrix} + \begin{bmatrix} v^1_{t+1} \\ v^2_{t+1} \\ v^3_{t+1} \\ v^4_{t+1} \end{bmatrix}$$

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

$$z^1_t = 0$$

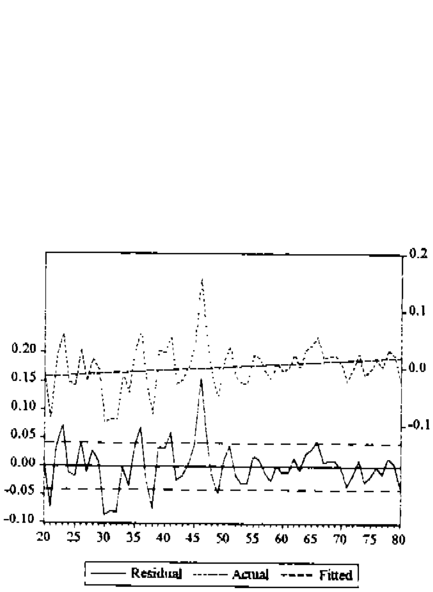

Figure 13: Demand shocks (random walk)

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 by

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

which is equation (1) in the main text.

6.2 Alternative driving process

Here I will demonstrate the robustness of the results. First, I will consider an alternative specification of the shock process. Then I 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, I close the presentation by assuming an alternative driving process of the preference shifter. I consider the following random walk process to describe demand shocks

$$\widehat{\Delta}_t - \widehat{\Delta}_{t-1} = \underset{(-1.45)}{-0.0154} + \underset{(1.87)}{0.0006}t + d_t$$

$$R^2 = 0.06, \quad SE = 0.041, \quad DW = 1.40.$$

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. I find large

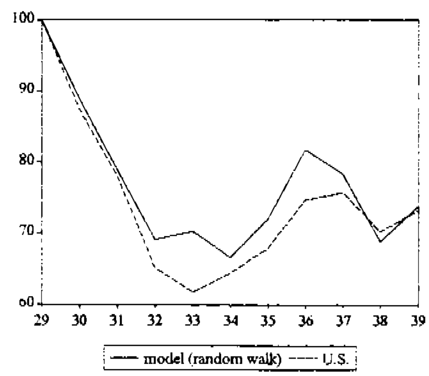

Figure 14: Output

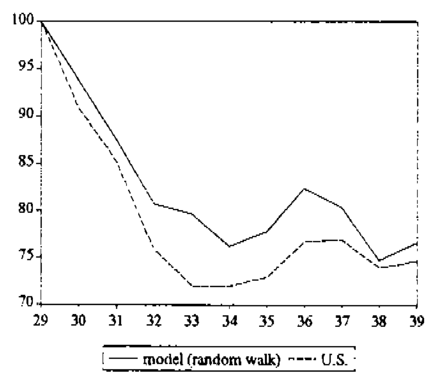

Figure 15: Consumption

negative demand shocks for the 1930s whose magnitude is not observable in the postwar period. This chimes with the results from the other shock 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 which results from the driving process' nonstationarity: 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.