A Multi-sectoral Approach to the U.S. Great Depression*

Pedro S. Amaral
Southern Methodist University

James C. MacGee
University of Western Ontario
Federal Reserve Bank of Cleveland

April 29, 2009

Preliminary and Incomplete

Abstract

We document sectoral differences in changes in nominal wages, prices, hours worked and output in the US during the Great Depression. We explore whether monetary shocks combined with different degrees of nominal wage frictions across sectors is consistent with the sectoral and aggregate facts. To do so, we construct a two sector model where goods from each sector are used as intermediates to produce the sectoral goods and to produce final output. One sector is assumed to have flexible nominal wages, while nominal wages in the other sector are set using Taylor contracts. We calibrate the model to the U.S. economy in 1929, and then feed in a monetary shock. We find that while the model can qualitatively replicate the key sectoral facts, it can account for less than a third of the decline in aggregate output. This decline in output is roughly half as large as that implied by a one sector model.

JEL Classification:

Keywords: Great Depression, Sectoral decomposition.

*Corresponding Author: Jim MacGee, Department of Economics, University of Western Ontario, Social Science Centre, London, Ontario, N6A 5C2, fax: (519) 661 3666, e-mail: jmacgee@uwo.ca. This research was supported by the Social Science and Humanities Research Council of Canada grant "Trade, Relative Prices and the Great Depression". The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Cleveland or the Federal Reserve System.

1 Introduction

This paper explores the implications of sectoral heterogeneity for the contribution of downwardly inflexible nominal wages to the Great Depression, particularly during the "Great Contraction" of 1929-33. A common view is that deflationary monetary policy combined with nominal wage rigidity was a key contributing factor to the onset of the Great Depression (Bernanke (1995), Eichengreen (1992), Eichengreen (1995), Friedman and Schwartz (1963), Temin (1993)). However, relatively little work has explored whether this story is consistent with the large shifts in relative prices and wages observed during the Great Depression. This paper seeks to fill this gap, and uses a multi-sector model to evaluate the implications of the downwardly inflexible nominal wages story for both aggregate and sectoral wages and prices as well as labor inputs and outputs.

Our paper is also motivated by recent debate over the contribution of high real wages to the Great Depression. In an important paper, Bordo, Erceg, and Evans (2000) employ a one sector with staggered wage setting, and find that the U.S. deflation of 1929-33 combined with inflexible nominal wages can account for 50 to 70 % of the decline in U.S. GDP over 1929-1933. This conclusion has been challenged by Cole and Ohanian (2001), who document large differences in nominal wage movements between agriculture and manufacturing during the Great Depression. Using a simple two sector model, they conclude that the degree of wage rigidity observed in the inflexible share of the U.S. economy can account for less than a 4 percent decline in real GDP. In turn, this finding has been challenged by Bordo, Erceg, and Evans (2001) and others on the grounds that the Cole and Ohanian (2001) exercise overestimates the size of the flexible sector at between 50 and 72 percent and does not explicitly examine a model with nominal wage rigidities and contractionary monetary shocks.

This paper contributes to this debate in two ways. First, we argue that the significant relative price movements observed between intermediate and final goods complicates the interpretation of manufacturing real product wages since "cheaper" intermediates should lead to lower sectoral gross output prices. To illustrate the potential importance of this, we examine data on nominal wages, intermediate and final good prices as well as the material share of

gross output for the manufacturing sector and several manufacturing industries. Second, we construct and simulate a two sector model with intermediate inputs. Given our interest in evaluating the role of asymmetries in "sticky wages" across sectors, we follow Bordo, Erceg, and Evans (2000) and introduce staggered (Taylor) wage setting in one sector while assuming that wages are free to adjust in the other sector. Since (as we document below) the Great Depression featured large changes in the relative prices of materials and manufactured goods, we adopt an input-output structure. This is an important feature for a model exploring the implications of high real wages since from the point of view of firms, the relevant real wage should be given by the ratio of the nominal wage to the (sectoral) gross output deflator. This leads us to assume that each of the sectoral goods is used as an intermediate good in the production of sectoral goods. The production of each sectoral good requires capital and labor, as well as intermediates produced in the two sectors. The final output good, which can be consumed or invested, is produced using goods from both sectors.

To evaluate the quantitative contribution of deflation and wage rigidity to the Great Depression, we follow the methodology of Bordo, Erceg, and Evans (2000) and feed the estimated monetary policy shock into a version of our model calibrated to the U.S. economy in 1929. In our benchmark calibration, the flexible wage sector accounts for roughly 42 percent of GDP. It is worth emphasizing that in our calibration we have attempted to incorporate the main criticisms of Bordo, Erceg, and Evans (2001) of the Cole and Ohanian (2001) exercise. First, the inflexible wage sector is relatively large, accounting for 58 percent of GDP. Second, the changes in real wages are endogenously caused by changes to the money supply's growth rates, which allows us to compare the real wages predicted by the model with those from the data. Finally, in our model we abstract from underlying productivity growth during the Great Depression period.

We find that the contractionary monetary shocks (starting in 1929) generate a decline in GDP of roughly 12% over 1929-1933, which is roughly a third of the observed decline. While this decline is roughly three times as large as that found by Cole and Ohanian (2001), it is about a third of the decline in GDP generated by a one-sector version of our model. There are

two key reasons why the two-sector model implies a significantly smaller decline in GDP. First, as noted by Cole and Ohanian (2001), the presence of a flexible wage sector partially mitigates the inflexible wage sector, as output in the flexible wage sector does not decline very much as a result of the monetary contraction. The second effect is that the input-output structure of the model mitigates the impact of inflexible wages in the model. The reason is that the relatively lower price of intermediates from the flexible wage sector acts similarly to a positive productivity shock. This implies that the decline in output in the inflexible sector is smaller in magnitude than the decline in output in the one sector model.

The input-output structure of our model also facilitates the comparison of the model with the available data. The natural mapping between the industry price in our model is to wholesale prices. We use the wholesale price index for manufactured goods as a proxy for the inflexible wage sector and the wholesale price index for farm products as the price of farm products. We use these prices to deflate agricultural and nominal wages in the data. Our experiments do a good job of matching the real wage in the inflexible sector during the downturn phase.

There is a large literature exploring possible causes of the Great Depression. Most of the quantitative model-based macroeconomic studies of the Great Depression (1929-33) involve one-sector models.[1] Most closely related to this paper are Cole and Ohanian (2001) and Bordo, Erceg, and Evans (2000). Our paper differs in several key respects from Cole and Ohanian (2001). First, we follow Bordo, Erceg, and Evans (2000) and explicitly model staggered wage setting in the presence of a monetary shock instead of inputting an exogenously given sequence of real wages into the model. Second, our model has an explicit input-output structure in the production of sectoral goods, which allows a better evaluation of the interaction across sectors. Moreover, we expand the sectoral comparison from nominal wages and compare the predictions of our model for sectoral prices, inputs, and outputs to the data. Third, our calibration strategy means that the inflexible wage sector in our experiments is over twice as large as in the Cole and Ohanian benchmark experiment.

The sectoral focus of our paper is also related to a number of older studies which emphasized

[1] Notable exceptions are Cole and Ohanian (2001), Crucini and Kahn (1996), Perri and Quadrini (2002), and Christiano, Motto, and Rostagno (2003).

the role of relative prices changes. The work of Means (i.e. Means (1966)) and others during the 1930s paid particular attention to shifts in relative prices across industries. This motivated Neal (1942) to examine whether movements in relative prices across manufacturing industries was correlated with industrial concentration or could be largely accounted for by differences in input price movements across industries.[2] Our paper differs from these earlier studies both in its quantitative theory emphasis and the focus on real product wages. This paper is also related to more recent work which explores the impact of monetary policy on relative prices of goods at different stages of production. Clark (1999) interprets the impact of monetary shocks using VARs, and finds that monetary contractions lead to declines in the relative price of less processed to more processed goods.

The remainder of this paper is organized as follows. Section 2 documents several facts on sectoral wages, prices and output. The following section presents the model environment. Section 4 presents the numerical experiments. The final section concludes.

2 Data

We begin by documenting several facts on sectoral wages, prices and output. First, there were large changes in *relative prices* and *wages*. In particular, the price of commodities fell relative to manufactured goods. In addition, the price of goods declined relative to services. Despite the significant decline in the relative price of agricultural commodities, there was little re-allocation of labor away from agriculture.

2.1 Nominal Wages and Employment by Sector

The labor market plays figures prominently in many explanations of the Great Depression. Surprisingly little attention has been paid to the considerable heterogeneity in both wages and employment across industries.[3] In this section, we document large movements in nominal

[2] Lewis (1949) also highlighted the role of relative price shifts, especially on developing economies.

[3] One recent exception to this is work by Cole and Ohanian (2001), who note that there was substantial differences in relative wages across sectors during the Great Depression.

wages and in hours worked across industries.

Most of the literature on relative wages in the Great Depression has focused on wages of workers in the agriculture and manufacturing sectors. In 1929, value added in agriculture was roughly 10 percent of GDP, while manufacturing accounted for roughly 25 percent of GDP. However, the level of employment in each sector was similar. As Figure 1 illustrates, nominal wages in agriculture declined by roughly 40 % more than nominal wages in manufacturing in two years.[4]

Hours worked shows the opposite pattern to nominal wages. While there was little decline in hours worked in agriculture over 1929-1932, hours worked in manufacturing declined by roughly 40 % from their 1929 level. Kendricks (1961) reports estimates of hours worked for agriculture (including forestry and fishing), manufacturing, mining, transportation and communications (including public utilities) during the interwar period. There is evidence that wages did not decline in all of these industries except agriculture. As can be seem from Figure 2, all of these sectors (except agriculture) experienced rapid and comparable declines in hours worked over 1929-1933.

2.2 Sectoral Prices

It is well known that the Great Depression coincided with a substantial deflation period (1929-33). What has received less attention (at least in the recent literature) is that this deflation was accompanied by large changes in *relative* prices. These relative price movements resemble the pattern of relative wages, as the price of commodities fell relative to manufactured goods. Figure 3 plots the wholesale prices for raw materials versus the wholesale prices for manufactured goods.[5] As can be seen, while raw materials prices decline by roughly 40 %

[4]The agricultural wage is series K-177 from Historical Statistics of the United States, which is a composite farm wage index. This series includes the value of room and board received by agricultural workers. The manufacturing wage data is series Ba4361 from Historical Statistics of the United States, and is an hourly wage index of production and non-supervisory workers in manufacturing. These figures may slightly understate the relative decline, as the wage data reported by Alston and Hatton (1991) suggest an even larger decline.

[5]The Wholesale Price Index (WPI) is an index of the prices of a variety of raw and processed materials, semi-finished goods and fully manufactured products. While most of the prices were for large transactions, not all occurred at the "wholesale" level, although the prices are generally for transactions below the retail level.

over 1929-1933, manufactured goods prices declined by roughly half as much. As a result, the wholesale price index declined by roughly the average of the raw materials and manufactured goods.

The data also suggests that the price of goods declined relative to services. One measure of this can be seen from looking at consumer price data for components of the Cost of Living index. We combine the Cost of Living Index indexes for food and clothing into a commodity intensive goods, and group (the weighted) average of shelter, household operations and sundries/Miscelaneous goods.[6] As can be seen from Figure 4, the price of consumption goods declined relative to services.

2.3 Real Output

We finally briefly turn to real output measures. There are 2 alternative measures of real sectoral output: gross output and value added. Figure 5 plots an index of real gross output in manufacturing and agriculture. This shows that total agricultural output declined very little during the initial years of the Great Depression, although the effects of the "Dust Bowl" begin to appear after 1932. The picture for real GDP looks very different. Figure 6 plots real sectoral GDP in agriculture and manufacturing, where nominal sectoral GDP is deflated using the GNP deflator. This suggests an even larger decline in real sectoral GDP than the gross output measures, with an especially pronounced difference in agriculture. This figure highlights the important role of relative prices movements during the interwar period.

2.4 Relative Prices and Intermediate Goods: Implications for Measured Real Wages and Labor Productivity

The large relative price changes during the Great Depression suggest that movements in gross output prices could be partially accounted for by changes in input prices. This possibility, however, has been largely abstracted from by papers which examine the real product wage in

[6]The weights of these components in the aggregate Cost of Living index is Food 31.6 %, Clothing 14.1 %, Fuel, Electricity, and ice 6 %, House-furnishings 4.8 %, Miscellaneous 23.7 % and Rent 19.8 %.

manufacturing – the ratio of wholesale prices (a gross output deflator) to nominal manufacturing wages (such as Bordo, Erceg, and Evans (2000) or Dighe (1997)). To explore the potential quantitative importance of relative price movements, we compare a standard value added production function with a gross output production function. In organizing our thoughts, we use a standard (value-added) production function of the form:

$$y_i = K_i^{\theta_i} L_i^{1-\theta_i} \tag{1}$$

where K_i is capital and L_i is labor used to produce good i. A natural starting point is to extend this to a Cobb-Douglas version with intermediates:

$$y_{i,GO} = \left(K_i^{\theta_i} L_i^{1-\theta_i}\right)^{\alpha_i} Q_i^{1-\alpha_i} \tag{2}$$

where Q_i denotes intermediate goods and $y_{i,GO}$ is gross output of industry i.[7] To derive the linkage between input and output prices requires an additional assumption on the nature of product markets. Here we assume that firms are competitive prices takers in both input and output markets. In this case, the relationship between the output and input prices follow from

[7]Following Rotemberg and Woodford (1999), we are assuming that the gross output production function is weakly separable in value added and materials. We could generalize the example to a CES function with a different degree of elasticity between value added and materials:

$$Y_{it} = \left(\psi_i \left(K_{it}^{\theta_i} L_{it}^{1-\theta_i}\right)^{\frac{\sigma_i - 1}{\sigma_i}} + (1-\psi_i)\left(Q_{i,t}\right)^{\frac{\sigma_i - 1}{\sigma_i}}\right)^{\frac{\sigma_i}{\sigma_i - 1}} \tag{3}$$

where σ_i is the elasticity of substitution between value added and materials in the production function. The minimum cost of producing a unit of the final good given $p_{VA,t}(w_t, r_t)$ and p_M is

$$p_{i,GO} = [\psi_i p_{i,VA}^{1-\sigma_i} + (1-\psi_i) p_Q^{1-\sigma_i}]^{\frac{1}{1-\sigma_i}} \tag{4}$$

In the Leontief case, this collapses to: $y_i = \min\{\left[\xi_v K_{it}^{\theta_1} L_{it}^{1-\theta_i}\right], \xi_m Q_{ii,t}^{\omega_i} Q_{ji,t}^{1-\omega_i}\}$, where the price index is: $p_{i,GO2} = \xi_v \left(\left(\frac{r}{\theta_i}\right)^{\theta_i} \left(\frac{w}{(1-\theta_i)\alpha_i}\right)^{(1-\theta_i)\alpha_i}\right) + \xi_m p_Q$.

the standard cost minimization problem:

$$p_{i,VA} = \left(\frac{r}{\theta_i}\right)^{\theta_i} \left(\frac{w}{1-\theta_i}\right)^{1-\theta_i} \tag{5}$$

$$p_{i,GO} = \left(\frac{r}{\alpha_i\theta_i}\right)^{\alpha_i\theta_i} \left(\frac{w}{(1-\theta_i)\alpha_i}\right)^{(1-\theta_i)\alpha_i} \left(\frac{p_Q}{1-\alpha_i}\right)^{1-\alpha_i} = \left(\frac{1}{\alpha_i}\right)^{\alpha_i} p_{i,VA}^{\alpha_i} \left(\frac{p_Q}{1-\alpha_i}\right)^{1-\alpha_i} \tag{6}$$

Examining the gross output productions price index highlights the potential role of a shift in the relative prices of final versus intermediates goods varies (see Figure 3) on wholesale prices. For the gross output production functions (in this Cobb-Douglas example), each percent decline in the price of intermediates leads to a $1-\alpha$ decline the price of the intermediate good. As a result, if the intermediate share is large, declines in the relative price of intermediates could lead one to conclude that real product wages in an industry were high. As can be seen from Table 1, the intermediate share of gross output was significant during the interwar period, averaging roughly 55 percent of gross output in manufacturing and roughly 30 percent in agriculture.

Table 1: Intermediate Share of Gross Ouptput

Year	Manufacturing	Agriculture
1927	56.3%	–
1929	55.0%	30.1%
1931	53.3%	29.3%
1933	54.2	32.2%
1935	57.7%	29.0%

The manufacturing data is from the (biannual) Census of Manufacturing. The manufacturing numbers slightly underestimate the material share prior to 1935 as contract work was counted as final output and not as an intermediate input (see Van Swearington (1939)).

To explore the quantitative importance of this channel, we examine data on manufacturing wages and prices.[8] In practice, we have data on gross output prices and many inputs (especially materials) from the WPI. Using the simple theory outlined above, we can back out a price

[8] Aside from data availability issues, this is an informative industry on which to focus since manufacturing closely tracks the overall fall and slow recovery of output, and most of the literature on real wages in the Great Depression have focused on manufacturing wages.

index for value added by defining $WPI_{VA} = \left(\frac{WPI_{finished}}{WPI_{Intermediates}^{1-\alpha_i}}\right)^{1/\alpha_i}$.

We begin by examining data for the overall manufacturing sector. As a proxy for nominal wages we use the nominal wage series for all manufacturing from the National Industrial Conference Board.[9] In Figure 7 we plot the series for the average hourly earnings of all wage earners divided by the wholesale price index of finished goods. We also plot two product real wages using a value added price deflator adjusted for the impact of intermediate prices ($WPI_{VA} = \left(\frac{WPI_{finished}}{WPI_{intermediates}^{1-\alpha}}\right)^{1/\alpha}$). Both adjustments assume an intermediate share of 50 percent. The first adjustment uses the price index of raw materials while the second uses semi-manufactured as a proxy for intermediate costs. This allows us to "strip out" the change due to pass-through of lower intermediate costs. One caveat worth noting, however is that both of these proxies for intermediates are biased towards less processed goods, so they are likely to provide an upper bound on the impact of falling intermediate prices.

As Figure 7 illustrates, the decline in the relative price of intermediates has a large impact on the real product wage during the Great Contraction. While the ratio of nominal wages to the WPI for manufactured goods increases over 1929 to 1933, the real product wage adjusted for intermediate prices are roughly constant over 1929-31, and decline by between 10 and 20 percent over 1931-33. This picture reflects two driving forces. First, as pointed out by Bordo, Erceg, and Evans (2000) (and others), there were few nominal wage reductions before 1931. However, the decline in the WPI for finished goods over 1929-1931 is largely accounted for by a decline in intermediates. After 1931, a number of manufacturing firms moved to reduce nominal wages, which combined with a decline in the relative price of intermediates to final manufacturing goods leads to a reduction in the ratio of nominal wages to the implied value added deflator.

This distinction between value added and gross output measures also matters for measured labor productivity. To illustrate this, we plot two alternative measures of labor productivity in manufacturing in Figure 8. The first measure is real manufacturing GDP (value added) divided by an index of hours worked. The second plots an index of real gross output divided

[9] This is the same series used by manufacturing used by Bordo, Erceg, and Evans (2000).

by labor hours. As can be seen from Figure 8, during most of the Great Depression period gross output labor productivity was above value added labor productivity in manufacturing.

2.4.1 Industry Level Data: 8 Manufacturing Industries

We now turn to eight manufacturing industries to further explore the impact of intermediate prices on the implied real product wage. These eight industries are the same as those used in Bernanke (1986) and closely related to those studied in Bernanke and Parkinson (1991) and Bordo and Evans (1995).[10] The reason for focusing on these industries is that data from the NCIB on average hourly wages and total hours worked as well as an output based index of gross output from the Federal Reserve Bulletin are available for these industries.[11]

Table 2 reports the intermediate share of gross output for these eight industries as well as for manufacturing. The intermediate share varied considerably across these industries, ranging from roughly 40 percent in Lumber to over 80 percent in meat packing. Most industries also featured a small decline in the intermediate share during the Great Contraction.

We begin by reporting two measures of real wages at the industry level during the Great Contraction. The nominal wage data is from the NCIB, and is the average hourly wage for all workers. The first measure reported in Table 5 deflates the nominal wage by the GNP deflator. The second is a measure of the real product wage by industry and uses a wholesale price index for output at the industry level as a wage deflator. The two different wage series show a generally similar upward trend, consistent with the view that real wages rose during the Great Contraction (Bordo, Erceg, and Evans (2001)). A closer look suggests some differences, as the real product wages for wool, meat packing and lumber all exhibit much larger movements than those deflated by the GDP deflator. These differences are primarily due to shifts in relative prices across industries.

The different movements of industry output prices seems to be closely related to shifts in the relative prices of intermediate inputs. Table 4 reports industry level wholesale prices

[10] Bernanke and Parkinson (1991) and Bordo and Evans (1995) and replace meat packing with petroleum and include the rubber industry.

[11] Many of the industry level indexes of (gross) output are based on hours worked, rather than on direct measures of output.

Table 2: **Intermediate Share Gross Output (%)**

Industry	1927	1929	1931	1933	1935
Automobile	62.9	63.3	61.9	65.0	71.5
Boot and Shoe	52.3	53.3	51.6	51.7	51.8
Iron and Steel	57.3	54.1	55.1	55.0	54.7
Meat Packing	87.1	86.5	84.3	80.7	86.0
Paper and Pulp	63.6	60.0	58.1	56.6	60.0
Leather Tanning and Finishing	67.2	70.1	63.7	58.3	64.7
Wool Man	57.3	57.0	52.8	52.6	54.8
Lumber and Millwork	40.4	32.9	36.2	35.4	40.3
Manufacturing	56.4	55.0	53.3	54.2	57.7

Source: Census of Manufactures. In the case of Iron and Steel and Automobiles, the classifications changed slightly in 1931. The intermediate share was very similar for both classifications, with the share (for the 1933 and 1935 grouping) being 54.7 (62.1) instead of 55.1 (61.9).

Table 3: **Real Wages: 1929 = 100**

Industry	GNP Deflator					Industry WPI				
	1929	1930	1931	1932	1933	1929	1930	1931	1932	1933
Automobile	100	103.5	111.2	111.8	114.4	100	106.5	109.9	98.5	99.8
Boot and Shoe	100	97.3	98.7	103.2	119.0	100	98.3	98.6	99.9	107.5
Iron and Steel	100	104.3	110.4	103.7	104.4	100	107.7	110.8	97.1	96.7
Meat Packing	100	105.8	111.7	106.7	109.2	100	113.7	142.5	156.7	182.8
Paper and Pulp	100	103.4	111.6	110.3	106.5	100	103.5	107.4	101.7	94.8
Leather	100	103.9	109.1	111.8	111.6	100	104.9	109.1	108.1	100.9
Wool Man	100	105.0	110.7	101.7	108.2	100	113.8	126.3	121.9	105.7
Lumber	100	100.4	101.3	90.6	94.4	100	106.4	120.5	113.8	96.1
Manufacturing	100	103.1	108.5	107.7	108.5	100	107.3	117.4	113.4	111.5

Source: The wage data is from the NCIB. The GNP deflator is the Balke-Gordon, while the industry wholesale deflators are from various issues of *Wholesale Prices*.

Table 4: **Industry Wholesale Output and Main Input Price: 1929=100**

Industry	WPI (GO)					WPI Main Input				
	1929	1930	1931	1932	1933	1929	1930	1931	1932	1933
Automobile	100	94.2	89.2	88.9	87.9	100	93.9	87.8	83.7	82.8
Boot and Shoe	100	96.0	88.1	81.0	84.9	100	89.5	76.1	57.5	63.1
Iron and Steel	100	93.9	87.8	83.7	82.8	100	101.3	100.6	100.4	98.1
Meat Packing	100	90.2	69.1	53.3	45.8	100	84.1	60.2	45.4	40.9
Paper and Pulp	100	96.9	91.6	84.9	86.2	100	94.1	83.6	70.2	56.3
Leather	100	89.5	76.1	57.5	63.1	100	80.7	53.4	37.3	59.5
Wool Man	100	89.5	77.2	65.3	78.5	100	70.4	51.5	36.9	59.1
Lumber	100	91.5	74.1	62.4	75.4					
Manufacturing	100	93.1	81.5	74.4	74.6	100	86.5	67.3	56.5	57.9

Source: The WPI for each industry is given in the appendix. The input price indexes are based on the main input for each industry: Automobile: Iron and Steel, Boot and Shoe: Leather, Iron and Steel: weighted average of iron ore, coke, electricity, coal, natural gas; Meat Packing: Livestock and poultry, Paper and Pulp: average price of pulpwood (fob pulp mill), Leather: Hides and Skins price index, Wool: (computed) index of raw wool prices using 1929 WPI weights, Lumber ?, Manufacturing: index of raw materials (the value for the index of semi-manufactured goods is (100, 87.1, 73.5, 63.2, 69.5).

(output) and (mainly primary) intermediate goods prices. The pattern of prices largely lines up with the observation that the prices of more processed commodities declined less than primary goods. The largest price declines are in meat packing, leather, wool and lumber. The one industry which faced flat input prices was iron and steel. This reflects the fact that the input price series places considerable weight on iron ore and coke, which had very small price declines.[12]

Using this price data, we repeat our earlier exercise and compute a value added deflator which we use to compute industry level real product wages. For each industry we use the average intermediate share over 1929-33. As can be seen from Table 5, taking into account intermediate prices matters for real wage movements. In five of the seven industries, real product wages decline instead of increasing over the great contraction. This industry level pattern is consistent with the average for all manufacturing, which shows relatively small

[12]It is also worth noting that the iron and steel industry featured a significant degree of vertical integration. A large fraction of the iron ore production were owned by final steel producers (see Hines (1951)).

Table 5: **Real Product Wages: 1929 = 100**

Industry	Industry VA Deflator (C-D)					Industry WPI				
	1929	1930	1931	1932	1933	1929	1930	1931	1932	1933
Automobile	100	105.8	107.0	88.8	90.1	100	106.5	109.9	98.5	99.8
Boot and Shoe	100	91.1	84.0	68.7	77.8	100	98.3	98.6	99.9	107.5
Iron and Steel	100	112.5	119.9	107.8	106.5	100	107.7	110.8	97.1	96.7
Meat Packing	100	78.9	69.7	68.1	101.3	100	113.7	142.5	156.7	182.8
Paper and Pulp	100	99.4	94.6	78.0	52.4	100	103.5	107.4	101.7	94.8
Leather	100	103.9	109.1	111.8	111.6	100	104.9	109.1	108.1	100.9
Wool Man	100	93.7	67.2	70.6	122.4	100	113.8	126.3	121.9	105.7
Manufacturing	100	99.1	103.9	93.5	102.8	100	107.3	117.4	113.4	111.5

Source: The wage data is from the NCIB. The industry wholesale deflators are from various issues of *Wholesale Prices*. The implied VA deflators are computed using the industry WPI and the main input prices deflators described in Table 4. The manufacturing input price series used here is that for semi-finished materials.

movements in real wages over 1929-1933.

Our interpretation of the data is that much of the increase in measured real wages in manufacturing is a result of a decline in the relative price of intermediates. This suggests that monetary stories of the great contraction which stress the role of nominal wage rigidities should be consistent with these sectoral movements in relative prices. In the next section we turn to this question.

3 A Two-sector Model

There are two sectors in the economy that differ in the way their wages adjust. As we make clear below, sector 1 has flexible wages, while sector 2 has "sticky" wages. To facilitate the comparison of our results with the literature, the structure of the sticky wage sector draws heavily upon Bordo, Erceg, and Evans (2000).

Both sectors use capital and labor as well as intermediate goods (produced by both sectors) in production. The output of the two sectors is then combined into aggregate output that can be used as consumption and/or investment.

A key issue in any sectoral model is the question of how to model sectoral reallocation. We assume that labor cannot move across sectors. As we argue later, this also is consistent with the low reallocation of labor across sectors during the 1930s. Households supply one unit of labor inelastically, this means that while in sector 1 the wage rate adjusts to clear the market, in sector 2 the labor market fails to clear.

3.1 Environment

3.1.1 Households

The economy is populated by a stand-in household who has preferences over consumption of the final good, C_t, and real money balances, $\frac{M_t}{P_t}$, where P_t is the price level associated with one unit of the final good. The households chooses consumption, nominal bond holdings B_t, money holdings, M_t, and capital K_{t+1} so as to solve:

$$\max \quad \sum_{t=0}^{\infty} \beta^t \left[\mu \log C_t + (1-\mu) \log \left(\frac{M_t}{P_t} \right) \right] \tag{7}$$

$$s.t. \quad B_t = (1+R_{t-1})B_{t-1} + \sum_{i=1}^{2} (J_{i,t}K_{i,t} + W_{i,t}L_{i,t}) + \sum_{i=1}^{2} \pi_{i,t} + X_t + P^s_{1,t}Q_{1,t-1} + P^s_{2,t}Q_{2,t-1}$$

$$- \left(M_t - M_{t-1} + P_t C_t + P_t(I^1_t + I^2_t) + P_{1,t}Q_{1,t} + P_{2,t}Q_{2,t} \right), \tag{8}$$

$$K_{1,t+1} = (1-\delta_1)K_{1,t} + I_{1,t}, \tag{9}$$

$$K_{2,t+1} = (1-\delta_2)K_{2,t} + I_{2,t}, \tag{10}$$

where R is the nominal interest rate on bonds, J is the rental price of capital, I_i is investment in sector i, W_i is the nominal wage rate in sector i, L_i is hours worked in sector i, π_i is nominal profits from sector i, and X is a lump-sum cash transfer from the government.

The household owns the capital stock, and chooses its level one period in advance. In addition, the household purchases intermediate goods from both sectors, Q_1 and Q_2, at prices P_1 and P_2, and sells them to firms one period later at prices P^S_1 and P^S_2, respectively. The stock of intermediate goods $Q_{i,t-1}$ are allocated between industries 1 and 2 each period.

3.1.2 Firms

Firms in both sectors rent capital and labor services, as well as intermediate goods. The problem of a firm in sector $i = 1, 2$ is to solve:

$$\begin{aligned} \max \pi_{it} &= P_{it} \left(K_{it}^{\theta_1} L_{it}^{1-\theta_i}\right)^{\alpha_i} \left(Q_{i,t}^b\right)^{1-\alpha_i} - \\ & \quad P_{i,t}^s Q_{i,t}^b - K_{i,t} J_{i,t} - W_{i,t} L_{i,t} \end{aligned}$$

where Q_i^b is the "bundle" of intermediate goods used in sector i.

While wages are perfectly flexible in sector 1, they are subject to Taylor-type contracts in sector 2. Labor is divided into equally-sized cohorts, and each period, only the wages of a particular cohort are adjusted. The nominal wage the firm pays is a geometric average of the cohort wages:

$$W_{2,t} = x_t^{\phi_0} x_{t-1}^{\phi_1} x_{t-2}^{\phi_2} x_{t-3}^{\phi_3}. \tag{11}$$

In turn, the contract wage, x_t, depends on the geometric average wage $W_{2,t}$ of all the cohorts as well as on the distance between current hours and a household time invariant target $\bar{L}_2$:

$$\begin{aligned} \log x_t &= \phi_0 \log W_{2,t} + \gamma(L_{2,t} - \bar{L}_2) + E_t \Big\{ \phi_1 \log W_{2,t+1} + \gamma(L_{2,t+1} - \bar{L}_2) \\ &+ \phi_2 \log W_{2,t+2} + \gamma(L_{2,t+2} - \bar{L}_2) + \phi_3 \log W_{2,t+3} + \gamma(L_{2,t+3} - \bar{L}_2) \Big\}. \end{aligned} \tag{12}$$

Setting cohort weights to be the same, $\phi_i = 0.25$, repeated substitution of (11) into (12) yields:

$$\begin{aligned} \log x_t &= E_t \Big\{ \frac{1}{12} \log x_{t-3} + \frac{1}{6} \log x_{t-2} + \frac{1}{4} \log x_{t-1} + \frac{1}{4} \log x_{t+1} + \frac{1}{6} \log x_{t+2} \\ &+ \frac{1}{12} \log x_{t+3} + \sum_{k=0}^{3} \gamma \left(L_{2,t+k} - \bar{L}_2\right) \Big\}. \end{aligned} \tag{13}$$

Final output is produced by combining the two sectoral goods according to the following

production function:

$$Y_t = \left(\eta(Y_{1,t} - Q_{1,t})^{1/\rho} + (1-\eta)(Y_{2,t} - Q_{2,t})^{1/\rho}\right)^{\rho} \tag{14}$$

In the unit elasticity case, this collapses to:

$$Y_t = (Y_{1,t} - Q_{1,t})^{\eta}(Y_{2,t} - Q_{2,t})^{1-\eta} \tag{15}$$

The final good can be transformed into consumption or allocated to investment in either sector.

$$Y_t = C_t + I_{1,t} + I_{2,t} \tag{16}$$

The problem of the final good producer can be written as

$$\max \pi_t \quad = \quad P_t(Y_{1,t} - Q_{1,t})^{\eta}(Y_{2,t} - Q_{2,t})^{1-\eta} - P_{1,t}Q_{1,t} - P_{2,t}Q_{2,t},$$

where in equilibrium, the usage of intermediate goods must be equal to the amount held by households:

$$Q_{1,t-1} = Q_{11,t} + Q_{12,t}, \tag{17}$$

$$Q_{2,t-1} = Q_{21,t} + Q_{22,t}. \tag{18}$$

We consider two alternative specifications for intermediate bundles. The first assumes that intermediate bundles for each industry are produced using a fixed coefficient technology with the intermediate goods from the two sectors.

$$Q^b_{1,t} = \min\left\{Q_{11,t-1}, \xi_1 Q_{21,t-1}\right\} \tag{19}$$

$$Q^b_{2,t} = \min\left\{Q_{12,t-1}, \xi_1 Q_{22,t-1}\right\} \tag{20}$$

The second specification we consider assumes unit elasticity in the production of the industry

intermediate good.

3.1.3 Money

The stock of money is exogenously determined. The growth rate of the stock of money is assumed to follow an AR(1):

$$g_{t+1} = g_0 + \rho g_t + \epsilon_{t+1}, \tag{21}$$

$$g_t = \log M_t - \log M_{t-1}, \tag{22}$$

where the innovation ϵ_{t+1} is iid $N(0, \sigma_g^2)$.

3.2 Equilibrium

Given the law of motion in the growth rate of money, the nominal variables are non-stationary. With that in mind, we rescale them by the stock of money. Let $\tilde{P}_t = \frac{P_t}{M_t}$, $\tilde{B}_t = \frac{B_t}{M_t}$, $\tilde{P}_{it} = \frac{P_{it}}{M_t}$, $\tilde{J}_{it} = \frac{J_{it}}{M_t}$, $\tilde{W}_{it} = \frac{W_{it}}{M_t}$, and $\tilde{x_{it}} = \frac{x_{it}}{M_t}$.

Given g_t, g_{t-1}, and K_{i0}, an equilibrium is quantities $\{B_t, C_t, K_{it}, L_{it}, M_t, Q_{it}, Q_{ijt}, X_t, \pi_t\}_{t=1}^{\infty}$ and prices $\left\{\tilde{J}_t, \tilde{P}_t, \tilde{P}_{it}, \tilde{P}_{it}^S, R_t, \tilde{W}_{it}, \tilde{x}_t\right\}_{t=1}^{\infty}$ such that households, firms in each sector and final good producers all solve the problems described above subject to market clearing conditions. In particular, in any equilibrium for this model specification, $B_t = 0$, as there is one representative household, $\pi_t = 0$, as the technology is CRS, and the government transfer has to equal the newly printed money: $X_t = M_t - M_{t-1}$.

The following conditions characterize the equilibrium. From the household's problem:

$$\tilde{P}_t C_t = \frac{\mu}{1-\mu}\frac{R_t}{1+R_t}, \tag{23}$$

$$\tilde{P}_t C_t = \frac{1}{\beta} E_t \left[\frac{\tilde{P}_{t+1} C_{t+1}}{1+R_t} \right], \tag{24}$$

$$\tilde{P}_{1t}(1+R_t) = E_t \left[\tilde{P}^S_{1t+1}(1+g_{t+1}) \right], \tag{25}$$

$$\tilde{P}_{2t}(1+R_t) = E_t \left[\tilde{P}^S_{2t+1}(1+g_{t+1}) \right], \tag{26}$$

$$\frac{1}{C_t} = \beta E_t \left[\frac{1}{C_{t+1}} \left(\frac{\tilde{J}_{1,t}}{\tilde{P}_t} + 1 - \delta \right) \right], \tag{27}$$

$$\frac{1}{C_t} = \beta E_t \left[\frac{1}{C_{t+1}} \left(\frac{\tilde{J}_{2,t}}{\tilde{P}_t} + 1 - \delta \right) \right]. \tag{28}$$

From the firm's problem in sector i:

$$\tilde{W}_{i,t} = \tilde{P}_{i,t}(1-\theta_i)\alpha_i L^{-1}_{i,t} \left(K^{\theta_i}_{i,t} L^{1-\theta_i}_{i,t} \right)^{\alpha_i} \left(Q^{\omega_1}_{ii,t} Q^{1-\omega_1}_{ji,t} \right)^{1-\alpha_i} \tag{29}$$

$$\tilde{J}_{i,t} = \tilde{P}_{i,t}\theta_i\alpha_i K^{-1}_{i,t} \left(K^{\theta_i}_{i,t} L^{1-\theta_i}_{i,t} \right)^{\alpha_i} \left(Q^{\omega_1}_{ii,t} Q^{1-\omega_i}_{ji,t} \right)^{1-\alpha_i} \tag{30}$$

$$\tilde{P}^s_{i,t} = \tilde{P}_{i,t}\omega_i(1-\alpha_i) Q^{-1}_{ii,t} \left(K^{\theta_i}_{i,t} L^{1-\theta_i}_{i,t} \right)^{\alpha_i} \left(Q^{\omega_i}_{ii,t} Q^{1-\omega_i}_{ji,t} \right)^{1-\alpha_i} \tag{31}$$

$$\tilde{P}^s_{j,t} = \tilde{P}_{i,t}(1-\omega_i)(1-\alpha_1) Q^{-1}_{ji,t} \left(K^{\theta_i}_{i,t} L^{1-\theta_i}_{i,t} \right)^{\alpha_i} \left(Q^{\omega_1}_{ii,t} Q^{1-\omega_i}_{ji,t} \right)^{1-\alpha_i} \tag{32}$$

From the final good producers problem:

$$\tilde{P}_{1,t} = \tilde{P}_t \eta (Y_{1,t} - Q_{1,t})^{\eta-1} (Y_{2,t} - Q_{2,t})^{1-\eta}, \tag{33}$$

$$\tilde{P}_{2,t} = \tilde{P}_t (1-\eta)(Y_{1,t} - Q_{1,t})^{\eta} (Y_{2,t} - Q_{2,t})^{-\eta}, \tag{34}$$

In addition, the wage setting equations 12 and 11, the growth rate of money equation 21 and the feasibility and market clearing conditions all hold.

We solve the model by log-linearizing the necessary conditions around the non-stochastic steady-state.

3.3 Parametrization

Since one of our goals is to compare the quantitative implications of the multi-sector model with the one-sector model of Bordo, Erceg, and Evans (2001), we follow their approach to calibrating common parameters.

We assume that each of the four contract periods lasts for three months. We set $\beta = 0.99$, which implies an annual risk-free return of roughly 4%. The depreciation rate of capital is set to 0.025, which implies an annual depreciation rate of 0.1. We assume that both sectors in the economy have the same capital share of value added of 30%, and set $\theta_1 = \theta_2 = 0.3$.

Our raw money supply measure of M1 is from Friedman and Schwartz (1963) (Table A-1). We proceed in two steps: first we estimate the parameters in the money growth rate's law of motion, equation **??** from the first semester of 1923 to the last semester of 1928. The reason we do not go back further is that the period from 1920 to 1922 was also one of unusually depressed economic activity, which caused the Federal Reserve Bank reacted to it during 1922, that exhibits unusually high monthly growth rates of the money supply. The estimates we obtain are $\hat{g}_0 = 0.0072$ and $\hat{\rho} = 0.38$. Although this is not used anywhere in the model, the standard deviation of the residuals was $\hat{\sigma}_\epsilon = 0.0194$.

Mapping the input-output production structure to the data is challenging due to data limitations. One obvious issue is how to allocate industries between the flexible and inflexible sector given the limited data on sectoral wages and prices. In addition, since our the production structure features multiple stages of both horizontal and vertical stages of production, the mapping of industries into our environment is not immediately clear.[13] Given the uncertainty raised by these issues, our approach is to choose parameter values in our benchmark calibration where we err on the side of giving the inflexible wage channel the best chance of having a large quantitative effect.

We assume that agriculture, construction, trade and half of Finance, Insurance and Real Estate (FIRE) and services are flexible price sectors. In 1929, these sectors accounted for

[13] To illustrate this, consider an industry such as boots and shoes. On the one hand, essentially all of the intermediate good used in boots and shoe is from manufacturing. However, over half of the value of these inputs is for material (hides) used in leather tanning.

roughly 42 % of (value-added) GDP. We assign manufacturing, transportation and communication, government, mining, and half of FIRE and services to the inflexible wage sector, thus accounting for the remaining 58 % of GDP. Agriculture is a relatively natural choice for the flexible sector. Trade (retail and wholesale) and Finance, Insurance and Real Estate (FIRE) and services are more ambiguous. One especially important issue (which these industries share agriculture) is the large share of employment accounted for by self-employed agents.

Given our input structure, we also have to assign values to the sectoral contributions of gross-output. To do so, we use data from the 1929 input-output table for the U.S. economy reported by Leontief (1951) as well as sectoral data from Historical Statistics of the United States and Statistical Abstracts of the United States. Since Leontief (1951) does not distinguish between investment and consumption goods, we assume that flows from steel works and rolling mills and other iron and steel electric manufacturers to other industries represents the flow in investment goods, which we assign to final output.

For the flexible sector, the most detailed data available is for agriculture. In 1929, roughly 35% of the value of gross output for agriculture was accounted for by agriculture intermediates, with another 13% being accounted for by manufacturing intermediates (Leontief (1951)).[14] Based on this, we set $\alpha_{1,ag} = 0.7$, and set $\omega_{1,ag} = \frac{0.3}{0.3+0.13} = 0.7$. We assume that construction has the same intermediate share as agriculture. For trade, FIRE, Services and Government we assume that the value added share is 90 % as these industries sell directly to final output.[15] For each of these sectors we assume that the share of intermediates is equal to the value added share of sector 1 and 2 in GDP. For manufacturing and transportation we use data reported in Leontief (1951) and the Statistical Abstract of the U.S. to estimate their value added shares (0.45 and 0.66, respectively) and their share of sector 1 intermediates (0.35 and 0.26, respectively).[16] We use the average share of value added in mining (0.78) in 1919 and

[14] We exclude manufacturing flows from the iron and steel industry, since these are most likely to represent capital goods.

[15] An alternative would be to model trade as using intermediates to sell directly to consumers. Retail mark-ups of 30 % and a wholesale markup of 12 % are roughly typical. If wholesalers sell directly to retailers, this would imply a trade sector mark-up is $0.3 + 0.12 * 0.7$.

[16] We exclude manufacturing flows from the iron and steel industry, since these are most likely to represent capital goods.

1954 (Table Db1-11, Historical Statistics of the United States). To convert these values into sector averages, we weigh each of these industry shares by the value added share for that sector. This implies an intermediate share in sector 1 of $1 - \alpha_1 = 0.23$, 51% of which is allocated to sector 1 intermediates. For sector 2, the intermediate share is $1 - \alpha_2 = 0.35$, with 36 % (64 %) is spent on sector 1 (2) intermediate goods. Finally, the value of η is chosen so that the value added share of sector 1 (2) in GDP is equal to 0.42 (0.58).

The final parameters deal with the substitutability between goods. We consider two alternative cases. The first assumes that intermediate goods cannot be substituted (i.e. Leontief), and an elasticity of substitution between good 1 and 2 in final good production of 0.5. The second case assumes a unit elasticity of substitution between sector 1 and 2 goods in both final good and intermediates.

A summary of the parameter values appears in table 6.

3.4 Impulse Responses

To illustrate the mechanics of the model, we begin by looking at the impulse response functions. Figures 9, 10, and 11 depict the response of sectoral values, intermediates, and aggregate variables, respectively, to a one percent decrease in the growth rate of money. On impact, the nominal wages in sector 2 cannot fully adjust, therefore the real product wage (the ratio of the nominal wage to the sectoral output price) in sector 2 increase by almost as much as the fall in sector 2's price. As capital is fixed on impact, this leads to a decrease in sector 2 labor. In response to the change in relative prices, investment in sector 2 initially jumps up, before declining. Overall, this leads to a fall in sector 2 gross output on impact. In sector 1, in contrast, prices fully adjust to the decrease in the growth rate of money supply, since labor is fixed in this sector, on impact, nothing happens. Since the labor input is fixed in sector 1, the resulting decline in sector 1's output can be attributed to two channels. First, the sharp decrease in sector 1's price leads to a lower investment in sector 1. Second, the increase in the relative price of sector 2 goods increases the price of the sector 1 intermediate bundle. This leads to lower intermediate usage (see Figure 10), which acts as a negative productivity shock

in Sector 1.

The implications for sectoral prices and real wages are worth noting. Prices in the flexible sector fall more than those in the distorted sector; real wages in the distorted sector go up on impact and then fall, while in the flexible sector they go down and then up back to steady-state. This pattern of relative prices and wages are qualitatively consistent with those observed during the Great Contraction.

Figure 12 presents the same impulse response functions for a one-sector model with the same parameters as those of Bordo, Erceg, and Evans (2000) (see table 7).[17] Notice that in the one sector model, output falls by around three times as much as in the multi-sector model, while the price level declines by roughly a third as much. This reflects the fact that in the one-sector model the whole economy is distorted, while that is not the case in the multi-sector world. This highlights the importance of taking into account different degrees of wage flexibility across sectors.

4 Results

The main experiment involves simulating both the one and two sector models and comparing the model results with the historical data. The simulations inputs the money supply growth shocks estimated from equation 21 starting in the second quarter of 1929. We assume that the economy was at its steady-state in the second quarter of 1929.

The simulations for the one-sector model are the same as those of Bordo, Erceg, and Evans (2000).[18] As can be seen from Figure 13, the one sector model does a very good job of accounting for the fall in output, capturing almost all of it relative to the trough. This leads Bordo, Erceg, and Evans (2000) to conclude that the contractionary monetary shock can account for the majority of the output decline observed over 1929-1933.

The multi-sector model offers a slightly different view of the role of monetary shocks. Specifically, we highlight two key findings. First, monetary shocks have a much smaller impact

[17] This corresponds to the no adjustment cost benchmark calibration in Bordo, Erceg, and Evans (2000).
[18] The aggregate data is from Balke and Gordon (1986).

on output in the multi-sector model, and can account for less than a third of the decline in output in the benchmark. This finding is qualitatively consistent with that of Cole and Ohanian (2001). The second finding is that contractionary monetary shocks and differential nominal wage rigidities across sectors are qualitatively consistent with the pattern of relative prices, output and wages observed in the data. However, the model is unable to fully account for the magnitude of relative price shocks. Overall, we interpret this as supporting the view that while contractionary monetary shocks may have played a significant role in the Great Contraction, the nominal wage rigidity channel cannot account for the entire story.

Figure 13 compares the model simulations with the main macro aggregates. The multi-sector model predicts a decline in gross domestic product (value added output) and investment that is roughly one-third as large as in the one sector model. This reflects the fact that the multi-sector model offers two channels which reduce the impact of nominal wage rigidity. First, the presence of a flexible wage sector attenuates the effect of the increase in real wages happening in the distorted sector, as output in the flexible wage sector does not decline very much as a result of the monetary contraction. This effect was highlighted in Cole and Ohanian (2001). The second channel is that intermediates partially offset high real wages in sector 2, as the lower relative price of sector 1 goods reduces the price of the intermediate bundle relative to the output price. This acts similarly to a positive productivity shock. Firms in the distorted sector can partially substitute away from more expensive labor by using intermediates. The intermediate bundle is a composite of the distorted and undistorted sector goods, and as result its price declines relative to that of labor in sector 2. This is a novel effect, one that comes about because we explicitly incorporate an input-output structure.

The bottom two plots in Figure 13 reveal two dimensions along which the multi-sector model pushes the monetary shock story closer to the data. First, the multi-sector model can largely account for the movements in the nominal price of the final consumption/investment good. Second, the two-sector model predicts a smaller increase in labor productivity than the one sector model. However, it is worth noting that the model prediction remains counterfactual, as aggregate labor productivity declined during the Great Contraction.

The multi-sector model is also qualitatively consistent with the relative movements in prices, wages and output across sectors. Figure 14 compares the flexible sector simulation with data drawn from agriculture. The model (by construction) is unable to match the initial increase in real output in the flexible sector, although it tracks the real product wage reasonably well during the 1929-1933 period. The model accounts for roughly half of the decline in the nominal price of the flexible good.

Figure 15 reports the simulation results for sector 2 (the inflexible wage sector). The model accounts for roughly a fifth of the decline in gross output and a third of the decline in labor. The smaller decline in sectoral output and labor than the one observed in the one sector model follows from two forces. First, while the gross output price declines, it does so by less than the price of the sector 1 good. As a result, both the price of capital and the price of the intermediate bundle declines relative to the price of the sector 2 good. This partially offsets the decline in labor, thus increasing the marginal product of labor by more than that observed in the one sector model. As a result, the model can do a good job of matching the real product wage with a much smaller decline in labor. The sectoral results however, partially address the labor productivity critique of the high real wage story. The bottom right panel of Figure 15 plots a gross output measure of labor productivity in the model versus manufacturing data. While the model predicts a larger increase in labor productivity than the data, the direction of the change is qualitatively consistent with that observed in the data over 1929-1933.

Finally, figure 17 plots the relative sectoral nominal wage. The multi-sector model accounts for more than half of the decline in the relative wages.

5 Conclusion

In this paper we document sectoral asymmetries regarding nominal wages, prices, hours worked and output in the US during the Great Depression. We go on to explore whether one of the most widely accepted explanations for the output contraction during this period, monetary contractions coupled with slow adjusting wages, can, in the context of a multi-sector model, account for the observed fall in aggregate (value added) output, and to what extent it can

address the observed heterogeneity. We conclude such an explanation falls short.

The model we present is very sparse. In future research we plan to add features that can possibly give this story a better chance to work. For example, decreasing the degree of substitutability in the output aggregator should, everything else the same, make for a larger fall in output as it will be harder to substitute out of distorted sector goods. By the same token, decreasing the substitutability (in the gross output production function of the distorted sector) between intermediates from the flexible sector and labor (or own intermediates) should also help. This requires more data work in order to understand whether such changes in elasticities are warranted or not.

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Table 6: **Calibration: Common Parameters Across Models**

Parameter	Value	Moment matched
β	0.99	
δ	0.025	
ϕ_i	0.25	
g_0	0.0078	
μ	0.987	
ρ_m	0.1	

Table 7: **Calibration: one sector model)**

Parameter	Value	Moment matched
γ	0.0037	
θ	0.3	

Table 8: **Calibration: multi-sector model: Leontief Intermediate Composite**

Parameter	Value	Moment matched
Leontief Intermediate Composite: Bench		
ρ	-1	
α_1	0.77	
α_2	0.65	
η	0.34	
ξ_1	1.61	
ξ_2	0.86	
γ	0.0048	
θ_1	0.3	
θ_2	0.3	
Leontief Intermediate Composite: Ag-Man		
ρ	-1	
α_1	0.	
α_2	0.	
η	0.	
ξ_1	0.	
ξ_2	0.	
γ	0.0037	

Figure 1: **Relative agricultural wage**

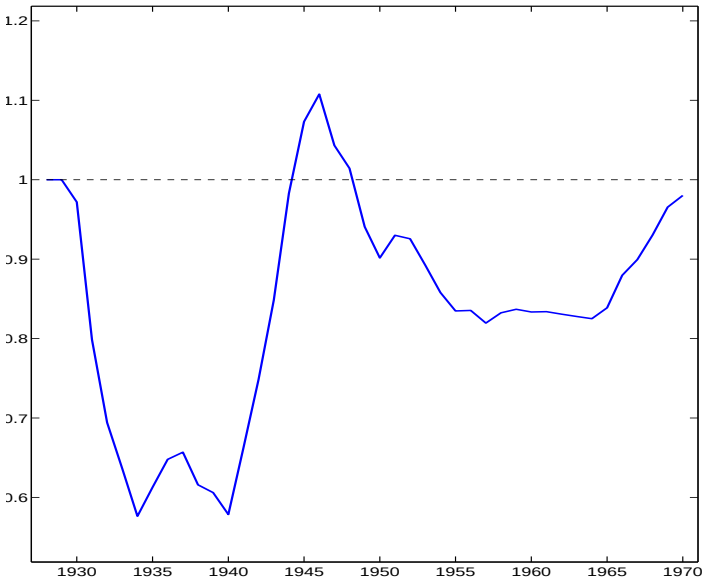


Figure 2: **Hours worked**

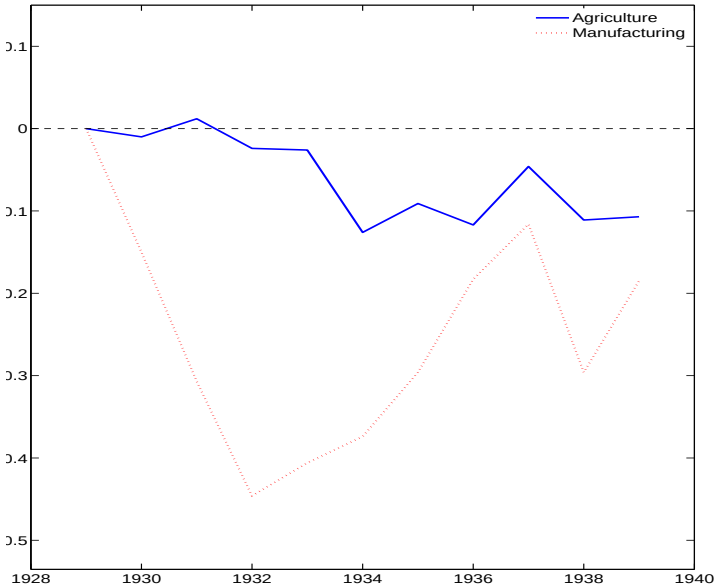


Figure 3: **Prices by processing stage**

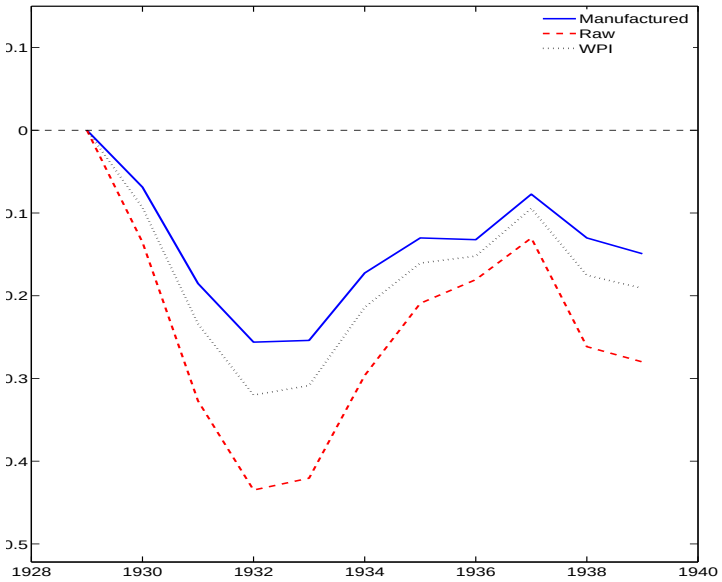


Figure 4: **Prices**

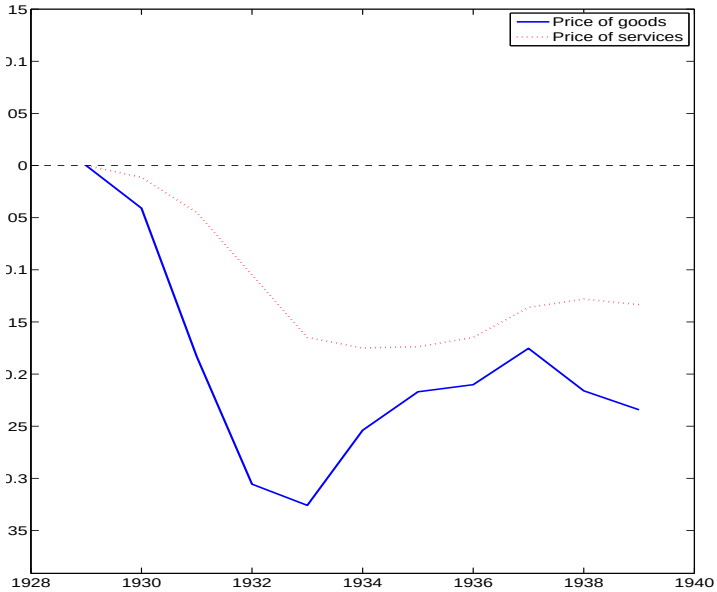


Figure 5: **Sectoral gross output**

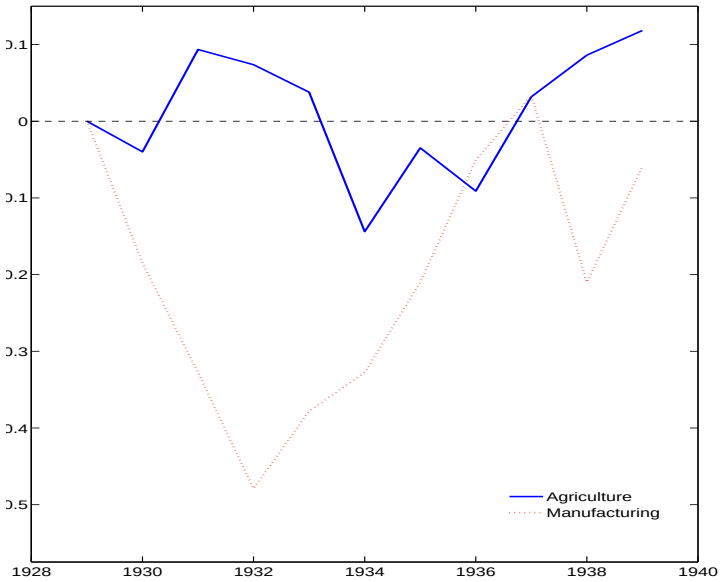


Figure 6: **Sectoral value added**

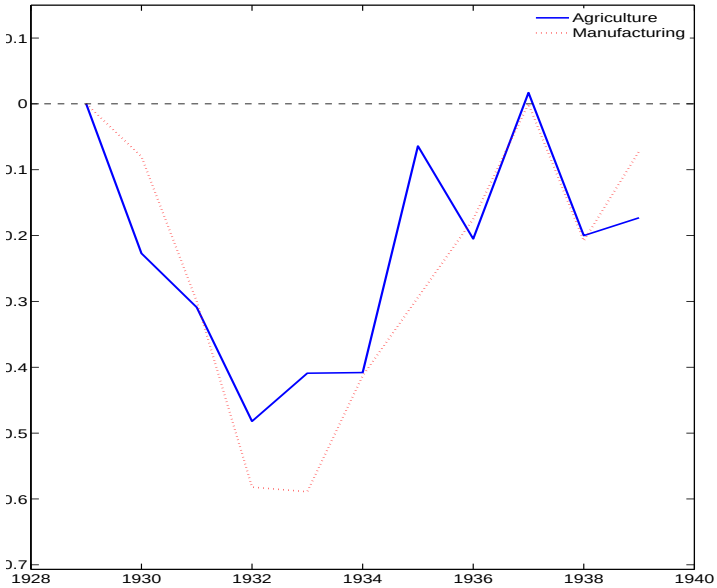


Figure 7: **Real Product Wage**

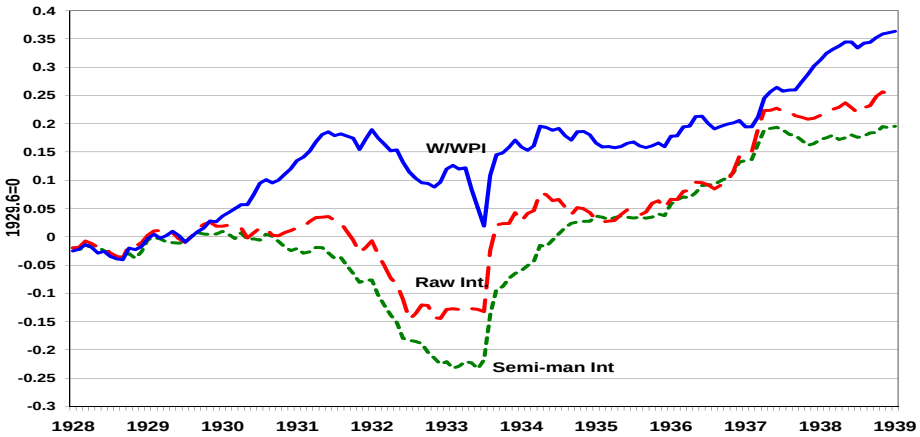


Figure 8: **Labor Productivity: Manufacturing**

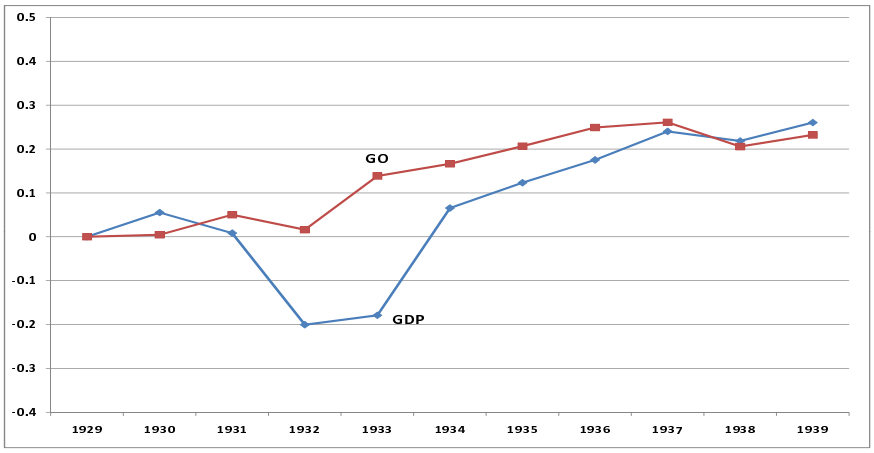


Figure 9: **Impulse response: money innovation on sectoral variables**

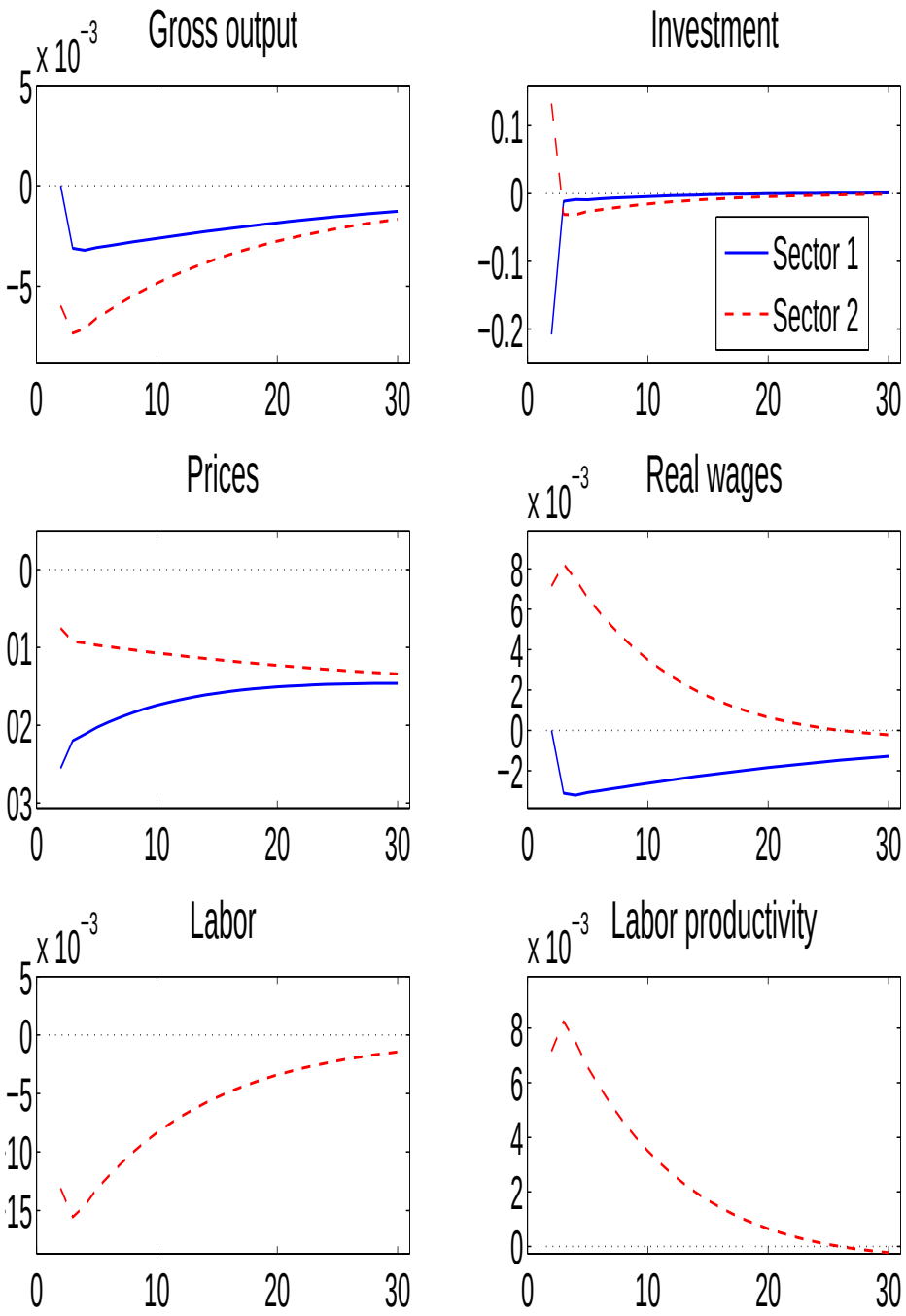


Figure 10: **Impulse response: money innovation on intermediates**

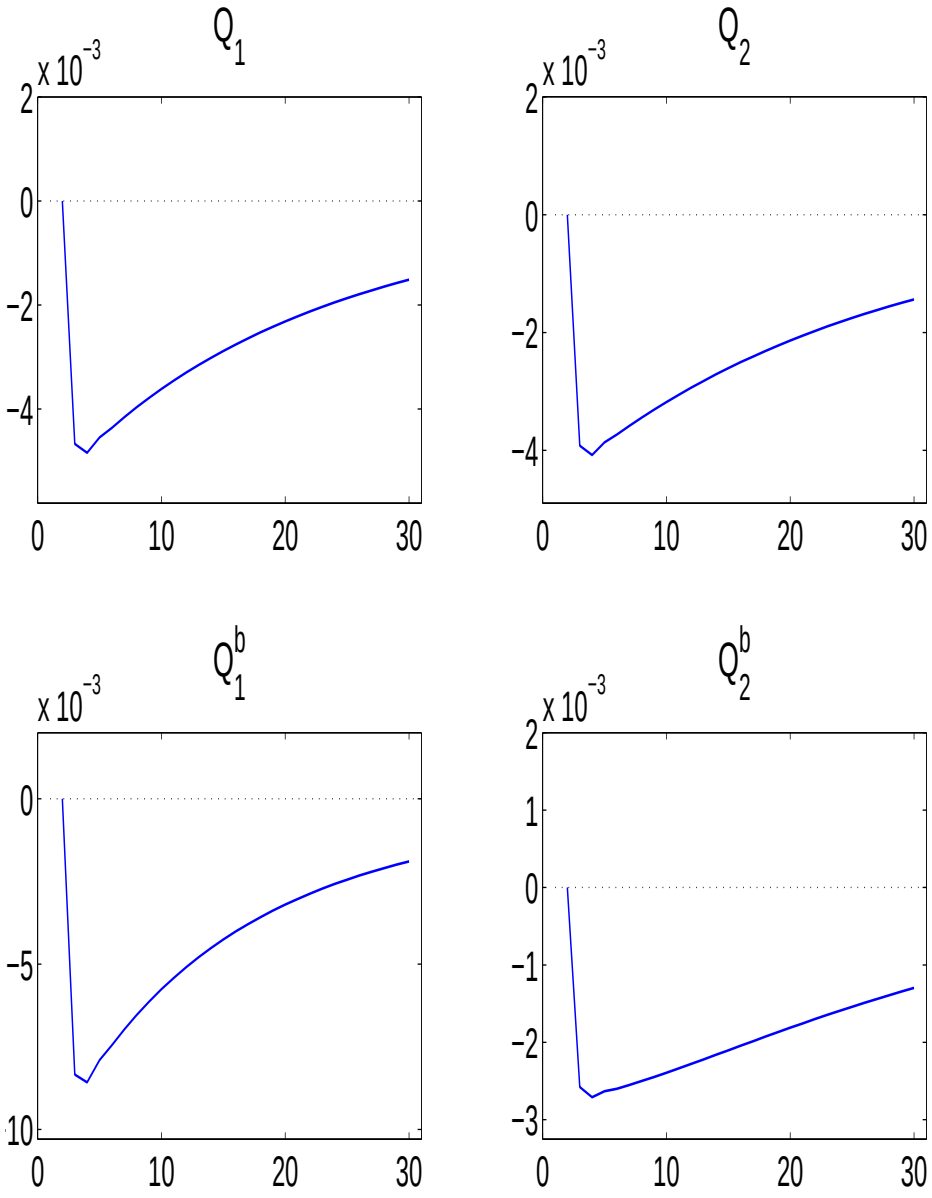


Figure 11: **Impulse response: money innovation on aggregate variables**

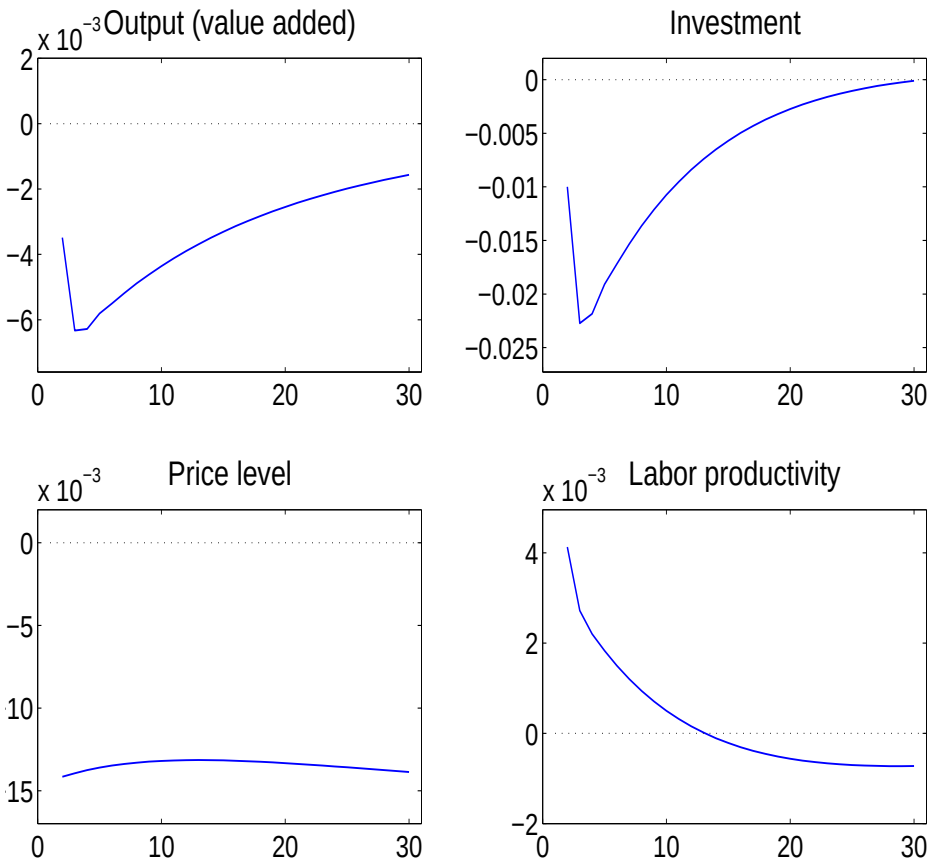


Figure 12: **One sector impulse response: money innovation**

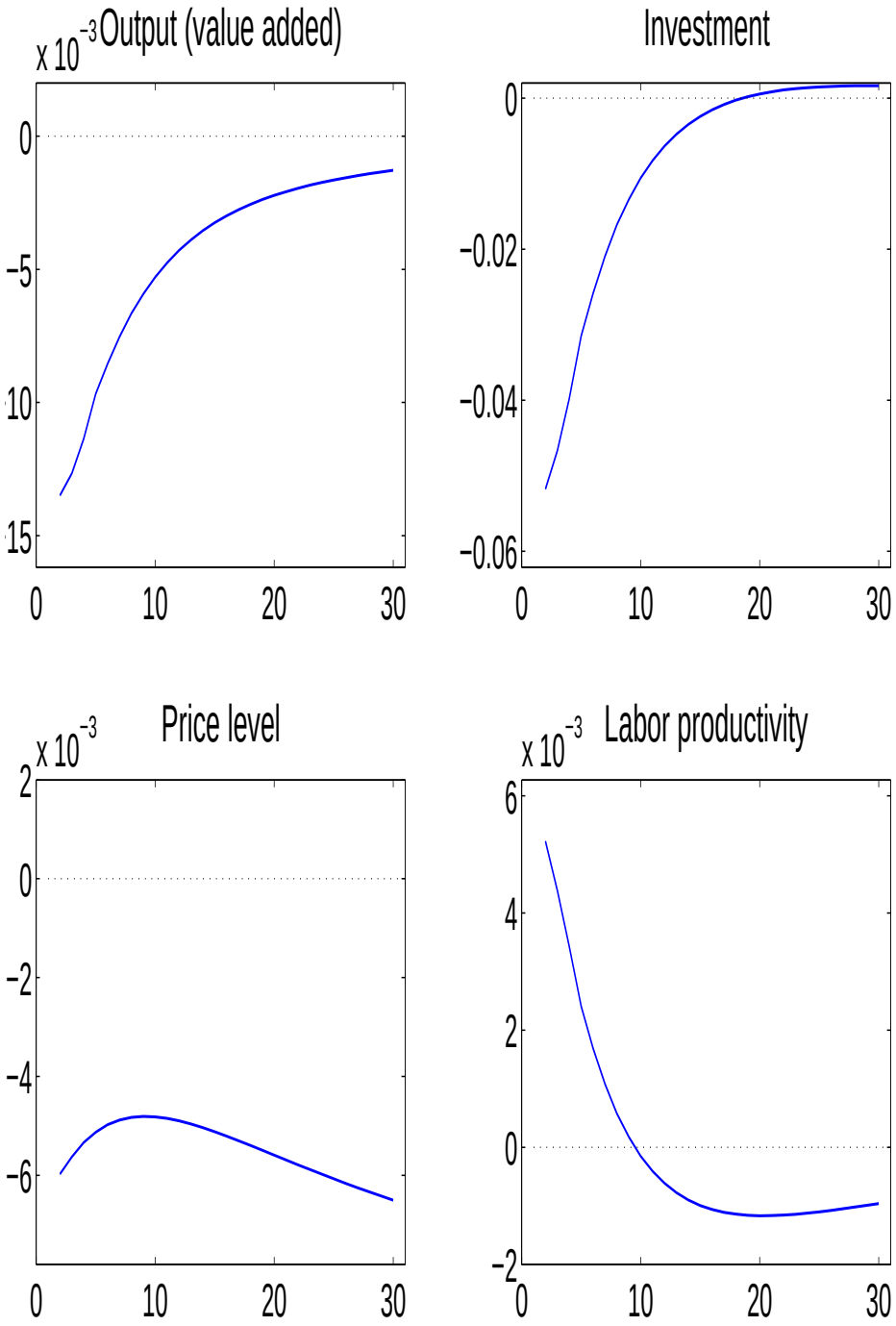


Figure 13: **Simulation money innovation One Sector vs Multi-Sector**

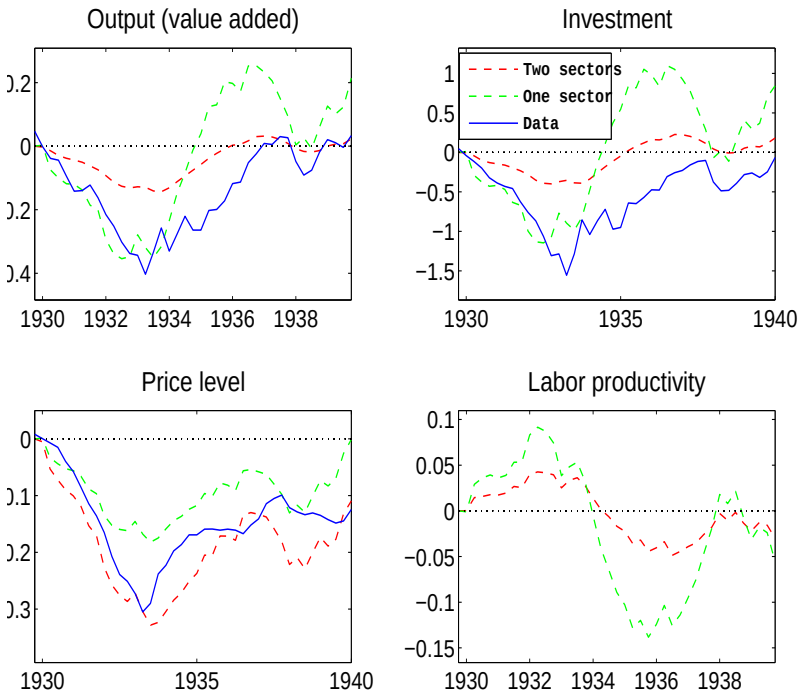


Figure 14: **Simulation: money innovation on agriculture**

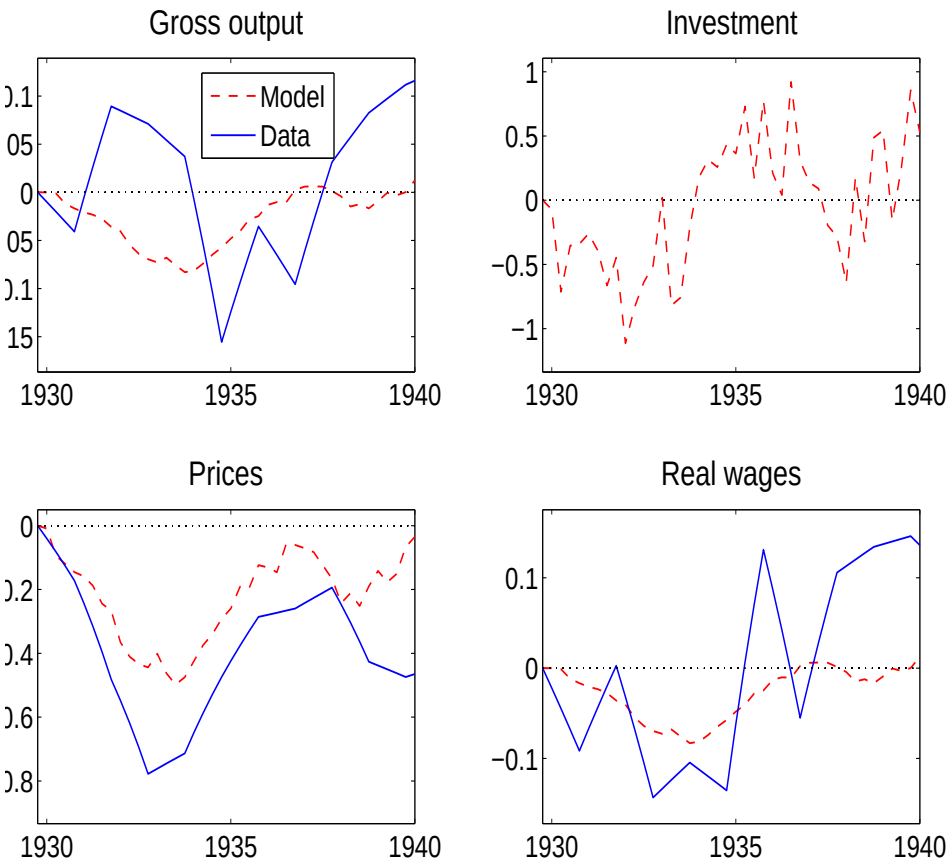


Figure 15: **Simulation: money innovation on manufacturing**

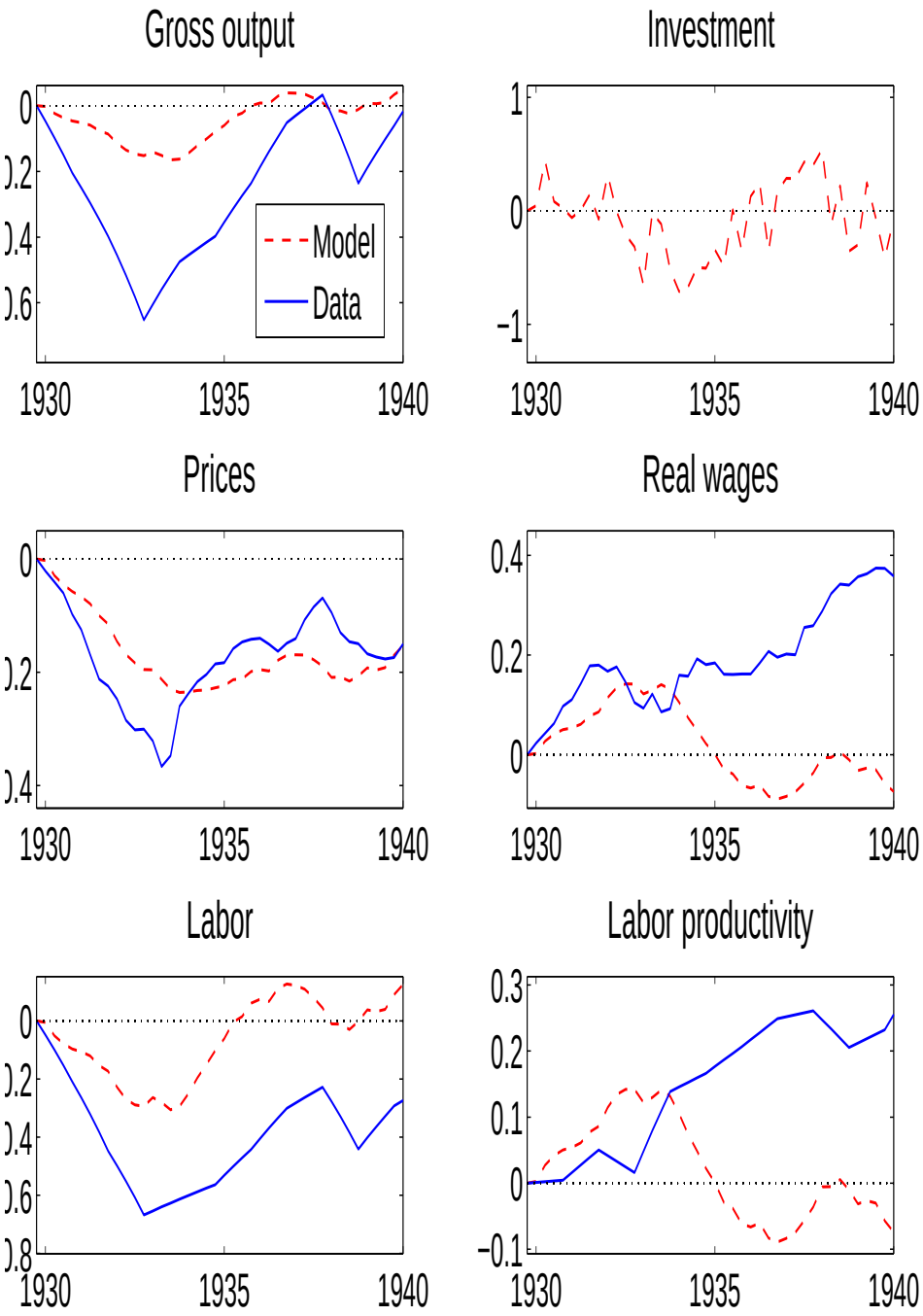


Figure 16: **Simulation: money innovation on intermediates**

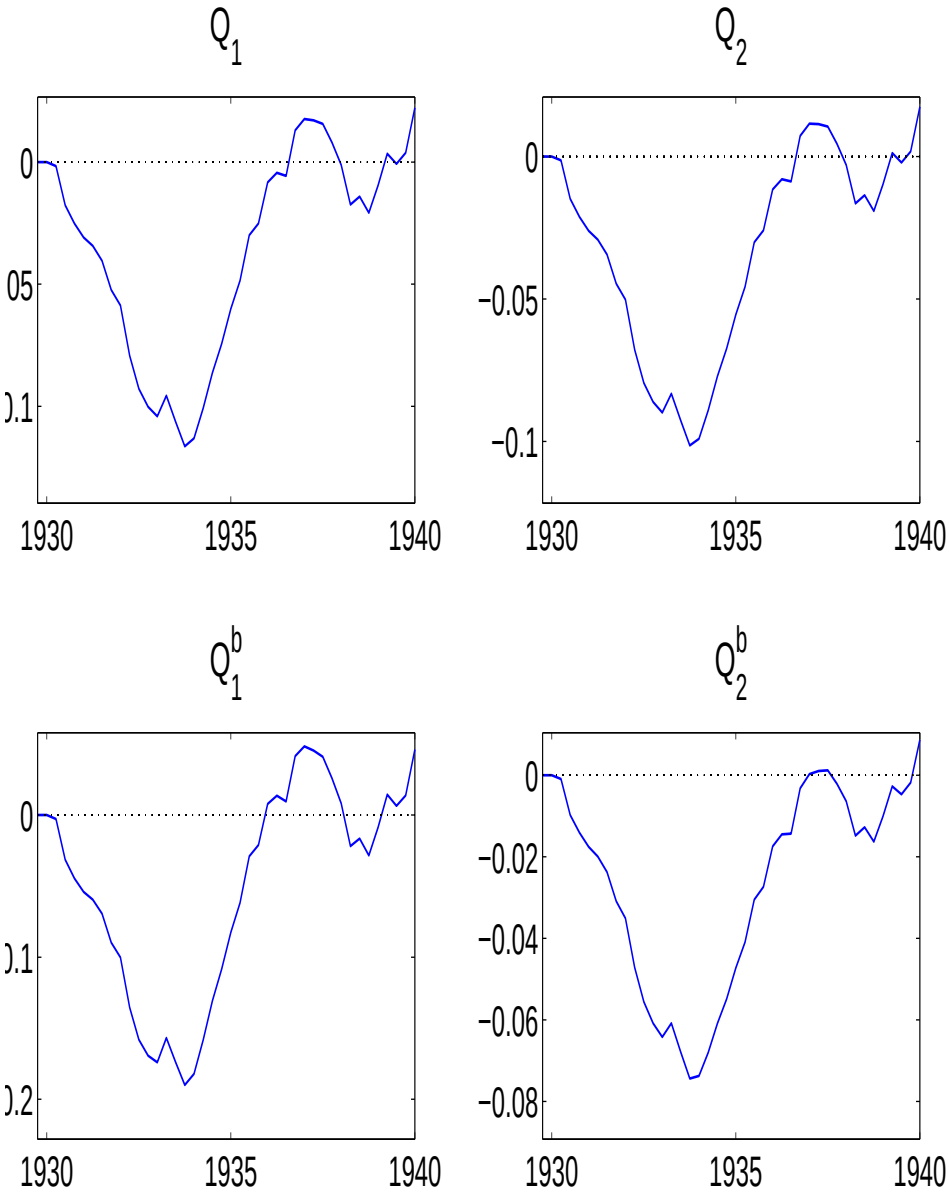
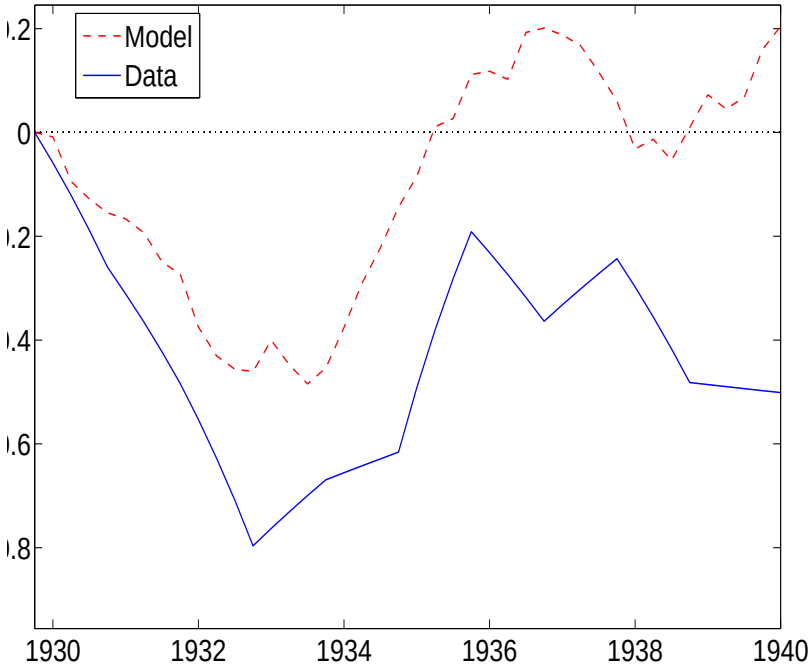


Figure 17: **Simulation: money innovation on relative wages**



6 Data Appendix

Wage Data: The agricultural wage data is a weighted average of the wage of agricultural employees and an estimate of the average wages of self-employed farmers. Taking into account the earnings of self-employed in agriculture is important since self-employed workers accounted for between 66 and 72 percent of the full-time equivalent workers in agriculture during the Great Depression.[19] Moveover, agriculture had a large share of self-employed compared to the rest of the economy, as over half of all self-employed workers during the 1930s were in the agricultural sector.

To construct the hours series for farm proprietors we use the product of average hours worked in agriculture per week in 1929 and 1937 times an index of average hours multiplied by total employment. The average wage of the self-employed is the ratio of proprietors income in agriculture (from NIPA) divided by the constructed hours series. The real product wage for agriculture is the weighted average of the wage paid to agricultural workers and imputed average wage of proprietors divided by the index of farm output prices.

Table 1: The manufacturing data are from *Statistical Abstract of the United States*.

The eight industry data reported in Tables 2, 5 and 4 are from several different sources. Industrial output is from the Federal Reserve Board, while data on value added, gross output and intermediates is from the Census of Manufacturing (as reported in various issues of *Statistical Abstract of the United States*). The price data is primarily from various issues of *Wholesale Prices*.

We briefly summarize the data sources for each industry.

Automobiles: The Federal Reserve gross output index for automobiles was based on production data for a selected list of models. The weight in the overall index was 4.79.

Data on the major input sources were obtained from Leontief (1951). The largest source of intermediates was the automobile sector (25 % of gross output), followed by iron and steel (16 %) and other industries (15 %). As a rough proxy, we use the price index of iron and its products as the input price index.

Iron and Steel: The Federal Reserve gross output index for iron and steel products was comprised of pig iron production ($\frac{0.87}{11}$) and steel ingot production ($\frac{10.13}{11}$).

The wholesale price index for iron and steel includes the price of iron ore (see *Wholesale Prices 1931*). This is unfortunate, since pig iron is produced using iron ore and energy inputs. In turn, pig iron (and scrap iron) are key inputs into the production of steel. It is also worth noting that the iron and steel industry featured a significant degree of vertical integration. A

[19] This value may be an underestimate, since unpaid family members are excluded from this calculation.

large fraction of the iron ore production were owned by final steel producers (see Hines (1951)).

The price index for intermediates is a weighted average of price indexes for iron ore (0.29), Coke (0.276) Electricity (0.166), Gas (0.154) and Coal, bituminous (0.112). The weights are based on data from Canadian iron and steel industry for 1933.

Leather Tanning and Finishing: The *Federal Reserve* gross output index for leather and products was comprised of leather tanning and shoe production indices. The leather index used here is the Leather Tanning. This index was the weighted average of three sub-indexes: (i) production of cattle hide leathers; (ii) production of calf and kip leathers; and (iii) production of goat and kid leathers. The weights for each component were: $(\frac{0.54}{0.92}, \frac{0.16}{0.92}, \frac{0.22}{0.92})$.

Mack (1956) discusses the production structure of the leather industry. She reports that hides and skins accounted for the majority of material costs in leather tanning (nearly 90%). Based on this, it seems reasonable to use the price index of hides and skins as a measure of material costs in leather tanning and the price index for leather as the gross output price.[20] We use these as weights for the construction of a price index based on The source of these price indexes are various issues of the *monthly Labor Review* (in the articles on "Wholesale Prices") as well as various issues of the *Bureau of Labor Statistics* annual (bulletins) publication *Wholesale Prices*.

Data on leather & hide tanning & finishing is also available for recent census years. Interestingly, in 1997, the values are quite similar to the interwar values. The material share of gross output was roughly 69%, and hides and skins accounted for $1,4487,834 of the $2,325,541 spent on materials (roughly 65%).

Boot and Shoe: The *Federal Reserve* gross output index for shoe production was a component of the leather and products index (with weight $(\frac{1.36}{2.28})$.)

We use the gross output data from the Manufacturing Census for *Boots and shoes, other than rubber*. The data is from various issues of Statistical Abstracts of the United States during the interwar years. The output price index is the Shoe index (referred to as Boot and Shoe index in some early years of BLS publications). This index is a subcomponent of the leather products group. Mack (1956) discusses the production structure of the leather industry. She reports that tanned leather accounts for the majority of material costs in (leather) shoe making. Based on this, it seems reasonable to use the price index for leather as the gross input price. The source of these price indexes are various issues of the *monthly Labor Review* (in the articles on "Wholesale Prices") as well as various issues of the *Bureau of Labor Statistics* annual (bulletins) publication *Wholesale Prices*.

Data on leather & hide tanning & finishing is also available for recent census years. In-

[20] An alternative would be to construct an index using reported prices and the wights from the Federal Reserve output index.

terestingly, in 1997, the values are quite similar to the interwar values. The material share of gross output was roughly 69%, and hides and skins accounted for $1,4487,834 of the $2,325,541 spent on materials (roughly 65%).

Lumber : The Federal Reserve gross output index for lumber production had a weight in the overall index of 2.90.

We use as an output price index that of *Lumber*. This index was based on milled wood products, mainly intended for building.

Meat Packing: The *Federal Reserve* gross output index for meat packing is comprised of pork and lard production ($\frac{0.58}{1.15}$), beef production ($\frac{0.43}{1.15}$), veal production ($\frac{0.06}{1.15}$), and lamb and mutton production ($\frac{0.08}{1.15}$).

Mack (1956) notes that meat packers were the source of just over half of the hides used by leather tanners. These hides accounted for roughly 10 - 12 % of the value of a typical carcass, and were the most valuable by-product of meat packers.

Paper and Pulp: The *Federal Reserve* gross output index for paper and pulp was broken out into sub-indices for pulp (which in turn had 4 subindices: groundwood pulp ($\frac{0.05}{0.33}$), sulphate pulp ($\frac{0.10}{0.33}$), Sulphite pulp ($\frac{0.15}{0.33}$), and Soda pulp ($\frac{0.03}{0.33}$),) and paper products (which in turn had 5 subindices: paperboard production ($\frac{0.72}{2.16}$), fine paper production ($\frac{0.24}{2.16}$), printing paper production ($\frac{0.44}{2.16}$), tissue and absorbent paper production ($\frac{0.21}{2.16}$), and newsprint ($\frac{0.09}{2.16}$),).

Many mills produced both pulp and paper (especially newspaper). Intermediates were heavily biased towards wood pulp and energy.

Woolen: The *Federal Reserve* gross output index for Wool textiles was broken out into sub-indices for carpet wool production ($\frac{0.29}{3.38}$), apparel wool production ($\frac{0.16}{3.38}$), woolen yard production ($\frac{0.45}{3.38}$), worsted yard production ($\frac{0.32}{3.38}$),and woolen and worsted cloth production ($\frac{2.16}{3.38}$).

Prices of (raw) wool were used to construct an input price index. The weights were those reported in *Wholesale Prices 1929* (page 74) for nine grades of wool. The original prices for these goods were take from various issues of *Wholesale Prices*.

One rough measure of the usage of raw (scoured) wool is from Hyson (1947) who reports the usage of scoured wool at mills for apparel.

Manufacturing

The price index for manufacturing is Manufactured articles (Cc112, Index 1926 = 100) from Table Cc109-112: Wholesale price indexes, by stage of processing: 1913-1951 [Bureau of Labor Statistics], Historical Statistics of the United States.