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A Multi-Sectoral Approach to the U.S. Great Depression

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We document sectoral differences in changes in output, hours worked, prices, and nominal wages in the United States during the Great Depression. We explore whether contractionary monetary shocks combined with different degrees of nominal wage frictions across sectors are consistent with both sectoral as well as 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 that in turn 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 monetary shocks estimated from the data. 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 the one implied by a one-sector model. Alternatively, if wages are set using Calvo-type contracts, the decline in output is even smaller.

Key words: Great Depression, sectoral models, sticky wages.

JEL code: E20, E30, E50

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1 Introduction

This paper explores the importance of sectoral heterogeneity in evaluating the contribution of 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.[1] 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 using a multi-sector model to evaluate the implications of the inflexible nominal wages story for both aggregate and sectoral outputs, wages, prices as well as labor inputs.

Our paper is motivated by the recent debate over the contribution of high real wages to the Great Depression. In an important recent paper, Bordo, Erceg, and Evans (2000) employ a one-sector model with staggered (Taylor) wage contracts, and find that the U.S. deflation of 1929-33 combined with inflexible nominal wages can account for roughly 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. Bordo, Erceg, and Evans (2001) find this analysis unconvincing for several reasons. First, they argue that Cole and Ohanian (2001) overestimate the size of the flexible sector at between 50 and 72 percent. Second, they argue that the real wage used significantly understates the real wages observed in the data. Finally, they argue that if one assumes that productivity grew at 2% during the decline, like Cole and Ohanian (2001)do, the finding that real wages had a small impact on aggregate output is not surprising.

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 fact, we examine data on nominal wages, intermediate and final good prices, as well as the share of materials in 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 wage setting in one sector while assuming

[1] See, for examples, Bernanke (1995), Eichengreen (1992), Eichengreen (1995), Friedman and Schwartz (1963), and Temin (1993).

that wages are free to adjust in the other sector. Since (as documented 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 thus requires capital, 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 we have attempted to incorporate the main criticisms Bordo, Erceg, and Evans (2001) extend to 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, allowing us to compare the real wages predicted by the model to those from the data. Finally, we abstract from underlying productivity growth.

We find that the contractionary monetary shocks (starting in 1929) generate a decline in GDP of roughly 12% over 1929-1933, which is about a third of the observed decline. While this decline is three times as large as that found by Cole and Ohanian (2001), it is less than half 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 decline in aggregate output as consumers partially substitute towards the relatively cheaper flexible good. Secondly, the input-output structure of the model stymies 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 than the decline in output in the one-sector model.

There is a large literature exploring the possible causes of the Great Depression. Most of the quantitative model-based macroeconomic analyses involve one-sector models.[2] Most closely

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

related to this paper are Bordo, Erceg, and Evans (2000) and Cole and Ohanian (2001). Our paper differs in several key respects from the latter. 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 for a better evaluation of the interaction across sectors. Moreover, we expand the sectoral comparison beyond 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 their benchmark experiment.

Relative to Bordo, Erceg, and Evans (2000), our sectoral framework allows us to compare the results of the exercise to a more detailed set of data, but more importantly, highlighting the roll sectoral asymmetries played during the contraction period of the Great Depression. Moreover, by introducing inflexible ways in different ways we show that their modeling choice is not innocuous.

The sectoral focus of our paper is also related to a number of older studies which emphasized the role of relative prices changes. Neal (1942) examined whether movements in relative prices across manufacturing industries were correlated with industrial concentration or could be largely accounted for by differences in input price movements across industries.[3] Means (1966) paid particular attention to shifts in relative prices across industries. Our paper differs from these earlier studies both in its quantitative theory emphasis as well as in its focus on real product wages. Finally, this paper is also related to more recent work exploring the impact of monetary policy on changes in 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, which is precisely what we find foe the 1929-33 period.

The remainder of this paper is organized as follows. Section 2 documents several facts on sectoral wages, prices and output. Section 3 presents the model environment and section 4 presents the different numerical experiments.

2 Data

We begin by documenting several facts on sectoral wages, hours, output and prices. A quick summary: first, nominal agricultural wages fell compared to manufacturing wages; secondly,

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

while agricultural hours remained more or less stable until 1932 and there was little reallocation of labor away from it, manufacturing hours fell by almost half; thirdly, in terms of real production, agricultural gross output remained stable until the "Dust Bowl" years, while manufacturing gross output plummeted; finally, in terms of prices, while all broad measures of prices fell, the price of manufactured goods prices fell by less than the price of commodities, while the price of goods declined relative to that of services.

We go on to gauge the importance of these relative price movements in computing real wages by backing out implicit value-added deflators that account for the "pass-through" effect from changes in the price of intermediates. These effects are large, highlighting the need for modeling intermediate usage explicitly, which we go on to do next section.

2.1 Nominal Wages and Hours by Sector

The labor market plays prominently in many explanations of the Great Depression, but surprisingly little attention has been paid to the considerable heterogeneity in both wages and employment across industries.[4] In this section we present evidence supporting two facts: (i) large movements in nominal wages across industries, which in turn led to large changes in relative wages across industries; and (ii) this industry difference was large compared to post-war business cycles.

We focus on agriculture and manufacturing wages as hourly wages are largely unavailable for other sectors. In 1929, value added in agriculture was roughly 10 percent of GDP, while manufacturing accounted for about 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.[5]

Hours worked show the opposite pattern. As figure 2 shows, 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

[4] 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.

[5] 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.

decline in any of these industries except for agriculture.

2.2 Real Output

There are 2 alternative measures of real sectoral output: gross output and value added. Figure 3 plots an index of real gross output in manufacturing and agriculture. While manufacturing output was practically halved, total agricultural output declined very little during the initial years of the Great Depression, with the effects of the "Dust Bowl" appearing only after 1932. The picture for agricultural real GDP looks very different. Figure 4 plots real sectoral GDP in agriculture and manufacturing. This figure suggests an even larger decline in real sectoral GDP than the gross output measures, with an especially pronounced difference in agriculture. A key reason for the difference is that sectoral GNP deflators do not exist, so nominal sectoral GDP is deflated by the aggregate GNP deflator. Given this was a period of significant movements in relative prices, as documented below, the use of different deflators matters a great deal for sectoral measures of real output.

2.3 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 that of manufactured goods. Figure 5 plots the wholesale prices for raw materials versus the wholesale price for manufactured goods.[6] While raw materials' prices declined by roughly 40 % over 1929-1933, manufactured goods' prices declined by only half as much.

The data also suggests that the price of goods declined relative to that of services, as Figure 6 shows. These measures of consumer prices are from the Cost of Living index. We combine the Cost of Living indices for food and clothing into a commodity intensive group, while for services we compute the (weighted) average of shelter, household operations and sundries/miscelaneous goods.[7]

[6]The Wholesale Price Index (WPI) is also shown in the figure. This 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.

[7]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 %.

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, is necessarily abstracted from by authors that deflate nominal wages using value added deflators, such as Bordo, Erceg, and Evans (2000), while even those that consider the real product wage in manufacturing – the ratio of nominal manufacturing wages to wholesale prices, such as Dighe (1997), largely fail to explore its implications by not explicitly modeling intermediates. To assess the potential quantitative importance of relative price movements, we compare a value added production function with a gross output production function. In organizing our thoughts, we use a Cobb-Douglas specification:

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

where K_i is capital and L_i is labor used to produce good i. A natural way of introducing a gross output measure is to extend this to a version with intermediates:

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

where Q_i denotes intermediate goods and Y_i is gross output in industry i.

To derive the linkage between input and output prices we need to make an additional assumption regarding the nature of the different product markets. Here we assume that firms are competitive price takers in both input and output markets. In this case, the relationship between the output and input prices follows from a standard cost minimization problem:

$$\begin{aligned} p_{i,VA} &= \left(\frac{r}{\theta_i}\right)^{\theta_i} \left(\frac{w}{1-\theta_i}\right)^{1-\theta_i}, \\ p_{i,GO} &= \left(\frac{r}{\alpha_i \theta_i}\right)^{\alpha_i \theta_i} \left(\frac{w}{(1-\theta_i)\alpha_i}\right)^{(1-\theta_i)\alpha_i} \left(\frac{p_Q}{1-\alpha_i}\right)^{1-\alpha_i} = \left(\frac{1}{\alpha_i}\right)^{\alpha_i} p_{i,VA}^{\alpha_i} \left(\frac{p_Q}{1-\alpha_i}\right)^{1-\alpha_i}. \end{aligned} \tag{3}$$

Equation (3) highlights the potential implication of changes in the relative prices of final versus intermediates goods (see Figure 5) on wholesale prices. In this Cobb-Douglas example, each percent decline in the price of intermediates leads to a $(1-\alpha)$ percent decline in the wholesale price level. 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

Table 1: **Intermediate Share of Gross Output (%)**

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

Source: Census of Manufacturing,
Statistical Abstract of the United States.

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 about 30 percent in agriculture.[8]

To explore the quantitative importance of this channel, we examine data on manufacturing wages and prices.[9] In practice, we have data on gross output prices and many inputs (especially materials) from the WPI. Using (3) we can back out the implicit price index for value added:

$$WPI_{VA} = \alpha_i(1-\alpha_1)^{\frac{1-\alpha_i}{\alpha_1}} \left(\frac{WPI_{\text{finished}}}{WPI_{\text{intermediates}}^{1-\alpha_i}} \right)^{1/\alpha_i}. \tag{4}$$

As a proxy for nominal wages we use the nominal wage series for all of manufacturing from the National Industrial Conference Board (NICB).[10] 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 as given by equation (4). Both adjustments assume an intermediate share of 50 percent. As a proxy for the price of intermediates we use the price index for raw materials in one series and the price index for semi-manufactured in the other.

[8]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)).

[9]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.

[10]This is also the series Bordo, Erceg, and Evans (2000) use for manufacturing.

This allows us to to "strip out" the change due to pass-through of lower intermediate costs.

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 roughly constant over 1929-31, and decline by between 10 and 20 percent over 1931-33. This picture reflects two driving forces. 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 led to a reduction in the ratio of nominal wages to the implied value added deflator. Because the price of intermediates fell by more than the price of gross output, manufacturing firms substituted away from labor and capital and into intermediates. This is exactly the point illustrated by the two-sector model we introduce in section 3.

The 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 by the same measure of hours. As the figure illustrates, during most of the Great Depression period gross output labor productivity was well above value added labor productivity in manufacturing. Moreover, while from 1929 to 1933 gross output labor productivity increased, value added labor productivity decreased.

2.4.1 Industry Level Data: 8 Manufacturing Industries

In order to explore the impact of intermediate prices on the implied real product wage in more detail, we now turn to the eight manufacturing industries used in Bernanke (1986) and closely related to those studied in Bernanke and Parkinson (1991) and Bordo and Evans (1995).[11] The reason for focusing on these industries is that data from the NICB 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.[12]

Table 2 reports the intermediate share of gross output for these eight industries as well as

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

[12] 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 of Gross Output: Manufacturing industries (%)**

Industry	1927	1929	1931	1933	1935
Automobile	62.9	63.3	61.9	65.0	71.5
Boots and Shoes	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	67.2	70.1	63.7	58.3	64.7
Wool Man	57.3	57.0	52.8	52.6	54.8
Lumber	40.4	32.9	36.2	35.4	40.3
Manufacturing	56.4	55.0	53.3	54.2	57.7

Source: Census of Manufacturing, Statistical Abstract of the United States.

for manufacturing. The intermediate share varied considerably across these industries, ranging from roughly 40 percent in Lumber to over 80 percent in Meat Packing.[13]

We begin by reporting two measures of real wages at the industry level during the Great Contraction. The first measure reported in Table 3 deflates this nominal wage using the GNP deflator. The second does it using a wholesale price index for output at the industry level. The two series show a generally similar upward trend, consistent with the view that real wages rose during the Great Contraction. 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 using the GDP deflator. These differences are primarily due to shifts in relative prices across industries.

The different movements in industry output prices seem to be closely related to shifts in the relative prices of intermediate inputs. Table 4 reports industry level wholesale prices for output and main inputs. The pattern of prices largely lines up with the observation that the prices of the more processed commodities declined less than those of 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

[13]In the case of Iron and Steel and Automobiles, the classifications changed slightly in 1931. The intermediate share was very similar for both classifications.

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

	GNP Deflator					*WPI*				
Industry	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
Boots and Shoes	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 NICB. The GNP deflator is from Balke and Gordon (1986). The industry wholesale price deflators are from various issues of *Wholesale Prices*.

considerable weight on iron ore and coke, which had very small price declines.[14]

Using these data on prices, 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 measured using our implied VA deflator are significantly below the measure using the industry's WPI as a deflator, and actually show decreases through 1932. This industry level pattern is consistent with the average for all manufacturing, which shows relatively small 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 address this question in the context of a fully specified model.

[14]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. On this see Hines (1951).

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

	WPI (GO)					*WPI (Main Input)*				
Industry	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
Boots and Shoes	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 indices are based on the main input for each industry: Automobile: Iron and Steel, Boots and Shoes: 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; Manufacturing: index of raw materials (the values for the index of semi-manufactured goods are 100, 87.1, 73.5, 63.2, 69.5).

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

	VA Deflator (C-D)					*WPI*				
Industry	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
Boots and Shoes	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 NICB. The industry wholesale price deflators are from various issues of *Wholesale Prices*. The implied VA deflators are computed using the industry WPI and the main input price deflators described in Table 4. The manufacturing input price series used here is the one for semi-finished materials.

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. This 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, resulting in unemployment.

3.1 Environment

3.1.1 Households

The economy is populated by a stand-in household with preferences over streams of consumption of the final good, $\{C_t\}_{t=0}^{\infty}$, and real money balances, $\left\{\frac{M_t}{P_t}\right\}_{t=0}^{\infty}$, where P_t is the price level associated with one unit of the final good. The household chooses consumption, nominal bond holdings B_t, money holdings, M_t, and capital K_{t+1} so as to solve:

$$\max \quad \sum_{t=0}^{\infty} \beta^t \left[\mu \log C_t + (1-\mu)\log\left(\frac{M_t}{P_t}\right)\right] \tag{5}$$

$$\begin{aligned} s.t. \quad & B_t = (1+R_{t-1})B_{t-1} + \sum_{i=1}^{2}(J_{i,t}K_{i,t} + W_{i,t}L_{i,t}) + \sum_{i=1}^{2}\pi_{i,t} + X_t + \sum_{i=1}^{2} P^b_{i,t}Q^b_{i,t} \\ & - \left(M_t - M_{t-1} + P_tC_t + P_t\sum_{i=1}^{2} I_{i,t} + \sum_{i=1}^{2} P_{i,t}Q_{i,t}\right), \quad (6) \\ & K_{i,t+1} = (1-\delta_i)K_{i,t} + I_{i,t}, \qquad i = 1,2, \quad (7) \\ & Q_{i,t-1} = Q_{ii,t-1} + Q_{ij,t-1}, \qquad i = 1,2, \quad (8) \\ & Q^b_{i,t} = \min\left\{Q_{1i,t}, \xi_1 Q_{2i,t}\right\}, \qquad i = 1,2, \quad (9) \end{aligned}$$

where R is the nominal interest rate on bonds, J_i is the rental rate of capital in sector i, 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 are 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.

This problem assumes the following timing structure: the household purchases intermediate goods from both sectors, Q_1 and Q_2, at prices P_1 and P_2, respectively. In the next period it decides how much of the intermediates bought from each sector will be allocated to each sector (Q_{ij} denotes intermediates produced by sector i and to be used in sector j) subject to the feasibility constraints $Q_{i,t-1} = Q_{ii,t} + Q_{ij,t}$. The intermediates are then "bundled" according to a Leontieff technology $Q^b_{i,t} = \min\{Q_{1i,t}, \xi_1 Q_{2i,t}\}$ and sold to firms at prices $P^b_{1,t}$ and $P^b_{2,t}$.

3.1.2 Firms

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

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

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.[15] Labor is divided into equally-sized cohorts, and in 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:

$$W_{2,t} = x_t^{\phi_0} x_{t-1}^{\phi_1} x_{t-2}^{\phi_2} x_{t-3}^{\phi_3}. \tag{10}$$

where ϕ_i are cohort weights that sum to 1.

In turn, the contract wage, x_t, depends on the average wage, $W_{2,t}$, as well as on the distance between current hours and steady-state labor, $\bar{L}_2$, in the following way:

$$\begin{aligned} \log x_t &= \phi_0 \log W_{2,t} + \gamma(L_{2,t} - \bar{L}_2) + E_t \Big\{ \phi_1 \log W_{2,t+1} + \gamma(L_{2,t+1} - \bar{L}_2) \\ &+ \phi_2 \log W_{2,t+2} + \gamma(L_{2,t+2} - \bar{L}_2) + \phi_3 \log W_{2,t+3} + \gamma(L_{2,t+3} - \bar{L}_2) \Big\}, \end{aligned} \tag{11}$$

where γ is a labor-gap adjustment parameter to be estimated.

Setting cohort weights to be the same, $\phi_i = 0.25$, repeated substitution of (10) into (11) yields:

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

[15] The Taylor contract environment makes our results directly comparable to those of Bordo, Erceg, and Evans (2000). In section 4.2 we explore whether the results are robust to the introduction of Calvo-type wage contracts.

3.1.3 Aggregate economy

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

$$Y_t = \left(\eta(Y_{1,t} - Q_{1,t})^{\rho} + (1-\eta)(Y_{2,t} - Q_{2,t})^{\rho}\right)^{1/\rho}, \tag{13}$$

where $\rho < 1$ and the elasticity of substitution is $\sigma = \frac{1}{1-\rho}$.

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

$$Y_t = C_t + I_{1,t} + I_{2,t}, \tag{14}$$

and the laws of motion for capital are subject to a common depreciation rate: $K_{i,t+1} = (1-\delta)K_{i,t} + I_{i,t}$ for $i = 1, 2$.

The problem of the final good producer can be written as

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

and the FOC are:

$$\tilde{P}_{i,t} = \tilde{P}_t Y_t^{1-\rho} \eta (Y_{i,t} - Q_{i,t})^{\rho-1}, \qquad i = 1, 2. \tag{15}$$

3.1.4 Money

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

$$g_t = \log M_t - \log M_{t-1}, \tag{16}$$

$$g_{t+1} = g_0 + \rho_m g_t + \epsilon_{t+1}, \tag{17}$$

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

3.2 Equilibrium

Given the law of motion for 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 $K_{i,0}$, an equilibrium is quantities

$$\left\{B_t, C_t, K_{i,t}, L_{i,t}, M_t, Q_{i,t}, Q^b_{i,t}, Q_{ij,t}, X_t, \pi_t\right\}_{t=0}^{\infty},$$

and prices

$$\left\{\tilde{J}_t, \tilde{P}_t, \tilde{P}_{i,t}, \tilde{P}^b_{i,t}, R_t, \tilde{W}_{i,t}, \tilde{x}_t\right\}_{t=0}^{\infty},$$

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; $\pi_{i,t} = 0$, as the sectoral technologies are 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:

$$\tilde{P}_t C_t = \frac{\mu}{1-\mu}\frac{R_t}{1+R_t}, \quad (18)$$

$$\tilde{P}_t C_t = \frac{1}{\beta} E_t\left[\frac{\tilde{P}_{t+1}C_{t+1}}{1+R_t}\right], \quad (19)$$

$$\left(\tilde{P}_{1,t} + \frac{\tilde{P}_{2,t}}{\xi_1}\right)(1+R_t) = E_t\left[\tilde{P}^b_{1,t+1}(1+g_{t+1})\right], \quad (20)$$

$$\left(\tilde{P}_{1,t} + \frac{\tilde{P}_{2,t}}{\xi_2}\right)(1+R_t) = E_t\left[\tilde{P}^b_{2,t+1}(1+g_{t+1})\right], \quad (21)$$

$$\frac{1}{C_t} = \beta E_t\left[\frac{1}{C_{t+1}}\left(\frac{\tilde{J}_{1,t+1}}{\tilde{P}_{t+1}} + 1 - \delta\right)\right], \quad (22)$$

$$\frac{1}{C_t} = \beta E_t\left[\frac{1}{C_{t+1}}\left(\frac{\tilde{J}_{2,t+1}}{\tilde{P}_{t+1}} + 1 - \delta\right)\right]. \quad (23)$$

From the firm's problem in sector $i = 1, 2$:

$$\tilde{W}_{i,t} = \tilde{P}_{i,t}(1-\theta_i)\alpha_i L_{i,t}^{-1}\left(K_{i,t}^{\theta_i}L_{i,t}^{1-\theta_i}\right)^{\alpha_i}\left(Q^b_{i,t}\right)^{1-\alpha_i}, \quad (24)$$

$$\tilde{J}_{i,t} = \tilde{P}_{i,t}\theta_i\alpha_i K_{i,t}^{-1}\left(K_{i,t}^{\theta_i}L_{i,t}^{1-\theta_i}\right)^{\alpha_i}\left(Q^b_{i,t}\right)^{1-\alpha_i}, \quad (25)$$

$$\tilde{P}^b_{i,t} = \tilde{P}_{i,t}(1-\alpha_i)\left(K_{i,t}^{\theta_i}L_{i,t}^{1-\theta_i}\right)^{\alpha_i}\left(Q^b_{i,t}\right)^{-\alpha_i}. \quad (26)$$

The final producer's first-order conditions (15), the wage setting equations (10), and (11), the growth rate of money equation (17) and the feasibility and market clearing conditions for goods and intermediates complete the set of necessary conditions. We solve the model by log-linearizing these conditions around the non-stochastic steady-state and then applying the techniques described in Uhlig (1999).

3.3 Parameterization

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 in calibrating common parameters.

We assume that each of the four contract periods lasts for one quarter. 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 approximate 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 (17), from the first quarter of 1923 to the last quarter 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 to react to it during 1922, a year that exhibits unusually high monthly growth rates of the money supply. The estimates we obtain are $\hat{g_0} = 0.0035$ and $\hat{\rho_m} = 0.39$. Although this is not used anywhere in the model, the standard deviation of the residuals was $\hat{\sigma_\epsilon} = 0.0111$.

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 real-economy production structures feature multiple horizontal and vertical production stages, the mapping of industries into our environment is not immediately clear.[16] 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

[16] To illustrate this, consider an industry such as Boots and Shoes. On the one hand, essentially all of the intermediate goods used in Boots and Shoes are from manufacturing. However, over half of the value of these inputs is for materials (hides) used in leather tanning.

Table 6: **Sectoral statistics**

Sectors	Share in GDP	Share of VA	Share of Sector 1 Int.
Agriculture	0.098	0.49	0.69
Construction	0.044	0.57	0.10
Trade	0.155	0.77	0.25
FIRE	0.148	0.77	0.25
Services	0.101	0.77	0.25
Manufacturing	0.252	0.45	0.35
Transportation	0.076	0.66	0.26
Communications	0.032	0.77	0.25
Government	0.059	0.77	0.25
Mining	0.024	0.83	0.10

Source: See text.

roughly 42% of (value-added) GDP. We assign Manufacturing, Transportation and Communications, 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 because of its well documented wage behavior. Construction, Trade, (retail and wholesale), FIRE and Services are more ambiguous. One especially important feature these industries share with agriculture, and the reason they are included in the flexible sector, is the large share of employment accounted for by self-employed agents.[17]

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 the 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 flexible sector intermedi-

[17] In section 4.1.2 we show that our results are not very sensitive to the size of the flexible and inflexible sectors.

ates, with another 16% being accounted for by other intermediates (Leontief (1951)).[18] Based on this, we set the share of value added in gross output in agriculture to $(1-0.35-0.16) = 0.49$, and the share of intermediates of sector 1 in total intermediates to $\frac{0.35}{0.35+0.16} = 0.69$.

The 1930 Census data for Construction implies a value added share of 0.57. Construction uses very little flexible sector inputs. We make the educated guess that their share is 10% (we use the same number for mining). For trade, using Census data for 2002 on business expenses, we get a value added share of 77% and a share of flexible intermediates of 25%, and make the assumption that these shares are fairly constant over time. We assume that the numbers for FIRE, Services, Communications and Government are the same as for trade.

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).[19] Finally, we use the average share of value added in mining in 1919 and 1954 (Table Db1-11, Historical Statistics of the United States), which was 0.83.

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 $1 - \alpha_1 = 0.316$, 39% of which is allocated to sector 1 intermediates. For sector 2, the intermediate share is $1 - \alpha_2 = 0.384$, with 31 % being allocated to sector 1 intermediates. Finally, the value of η is chosen so that the value added share of sector 1 in GDP is equal to 0.42.

In terms of substitutability between sectoral goods in the final good aggregator, we start with the benchmark case of $\rho = -1$, which implies an elasticity of substitution of $\sigma = \frac{1}{1-\rho} = 0.5$, and go on to do some sensitivity analysis.

Finally, γ is the crucial parameter regulating how sluggishly nominal wages in the inflexible sector adjust. We follow Bordo, Erceg, and Evans (2000)'s strategy of estimating it so as to minimize the distance between the real wages in the model's inflexible sector and the real wages in manufacturing from 1929 to 1933.

A summary of all the parameter values appears in table 7.

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

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

4 Results

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 and intermediates are fixed on impact, this leads to a decrease in sector 2 labor. Overall, this leads to a fall in sector 2 gross output. More importantly, because labor is relatively more expensive than intermediates, distorted firms substitute away from it and into intermediates (as labor decreases by three times as much as intermediate usage, Q_2^b).

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, while the subsequent decline in sector 1's output can be attributed to two channels. First, the sharp decrease in sector 1's price causes the real product rental rate of capital to rise, lowering investment in sector 1. Second, the increase in the relative price of sector 2 goods increases the price of sector 1's intermediate bundle. This leads to lower intermediate usage (see Figure 10), which acts as a negative productivity shock in Sector 1. Note, in particular, how sector 1's use of intermediates, Q_1^b, declines much more than that of sector 2.

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 is qualitatively consistent with the one observed during the Great Contraction.

Figure 11 compares the impulse response functions for the multi-sector and the one-sector models in terms of aggregates.[20] Notice that in the one-sector model, output falls by around three times as much as in the multi-sector model. The two main channels at play are: (i) while in the one-sector model the whole economy is distorted, in the multi-sector model resources can be directed to the non-distorted sector. The amount of resources that get redirected depends not only on the substitutability at the final good level but also on factor mobility across sectors. In trying to give the monetary shock story as much of a chance as possible, we do not allow labor to move from the distorted sector to the undistorted one (in fact there is no evidence that it did); and (ii) while in the one-sector world firms cannot substitute away from

[20] The calibration for the one-sector model keeps the common parameters and reestimates γ. It is shown in table 8.

the more expensive labor into intermediates, that channel is open in the multi-sector world. Again, the extent to which such channel is used depends not only the elasticity of substitution between intermediates and the value added component, but also on the elasticity of substitution between the types of intermediates themselves (recall from the price panel in figure 9 that the price of undistorted goods falls by more than that of distorted ones). While the Cobb-Douglas structure we have between intermediates and value added in sectoral production allows for a fair degree of substitution and is consistent with the little movement in shares we see in table 1, we will relax that assumption below and allow for less substitutability.

4.1 Simulation

The main experiment involves simulating both the one- and two-sector models. The inputs are the money supply growth shocks starting in the third quarter of 1929. We assume that the economy was at its steady-state in the second quarter of 1929. As can be seen from figure 12, the one-sector model does a very good job of accounting for the fall in output. 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.[21]

The multi-sector model offers a slightly different view of the role of monetary shocks. Specifically, we highlight two key findings. On one hand, as in Cole and Ohanian (2001), monetary shocks have a much smaller impact on output in the multi-sector world, and can account for only about a third of the decline in output, from peak to trough, but on the other hand, when combined with differential nominal wage rigidities across sectors, contractionary monetary shocks are qualitatively consistent with the pattern of relative prices, output and wages observed in the data. The two findings together suggest that while the nominal wage rigidity mechanism may have played a significant role in this period, contractionary monetary shocks cannot account for the entire story.

Why is the decline in output smaller than in the one-sector world? As highlighted in our description of the impulse response functions above, 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 in the distorted sector; it acts like an "escape valve" at the final good level provided some substitution is possible. This effect was highlighted in Cole and Ohanian (2001). The second channel is that the presence of intermediates partially offsets the effects of high real wages in sector 2, as the lower relative price of sector 1 goods

[21] The aggregate data is from Balke and Gordon (1986).

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 more intermediates. This is a novel effect, one that comes about because we explicitly incorporate an input-output structure.

Unlike the one-sector model, the multi-sector model can fully accounts for the decline in the nominal price of the final consumption/investment good. In a frictionless, one-sector world, the price level would fall by as much as the stock of money. When nominal wages are sluggish, output is comparatively more costly to produce as a result of a contractionary monetary shock, and the fall in the price level is smaller. In contrast, in a multi-sector world, the price level falls further because it is, loosely speaking, an average of the two sectoral prices, where one of the sectors is undistorted and therefore experiences larger price decreases.

The multi-sector model is also qualitatively consistent with the relative movements in prices, wages and output across sectors. Figure 13 compares the flexible sector simulation with data drawn from agriculture. The model is unable to match the initial increase in real output in the flexible sector, although it tracks the real product wage reasonably well over the 1929-1933 period. The model accounts for roughly half of the decline in the price of the flexible good.

Figure 14 reports the simulation results for sector 2 (the inflexible wage sector) and compares it to manufacturing data. The model accounts for roughly a fifth of the decline in gross output and a third of the decline in labor. The smaller declines in sectoral output and labor than the ones observed in the one-sector model follow because while the output price declines, it does so by less than the price of the sector 1 good. As a result, both the relative price of capital as well as the price of the intermediate bundle (relative to the price of the sector 2 good) decline as the two bottom panels in figure 15 show, so sector 2 firms's capital decreases by less than it does in the one-sector world and the use of intermediates decreases by less than the use of labor. This partially offsets the decline in labor, thus increasing the marginal product of labor by more than what happens in the one-sector model. As a result, the model does a good job of matching the real product wage with a much smaller decline in labor.[22]

4.1.1 The importance of substitutability

In going from a one-sector world to a two-sector one with intermediates we are adding two substitutability margins. One is at the final good production level, the other at the sectoral level, when firms decide between using more "value added" inputs (capital and labor) or more

[22]In the benchmark experiment of Bordo, Erceg, and Evans (2000) labor falls by more than in the data.

of the intermediate bundle. There is a further margin we are shutting down: the substitution between different types of intermediates follows a Leontieff-type technology.[23]

To gauge the relative importance of these two margins we build a two-sector economy with no intermediates that is identical to our benchmark economy in everything else. In the top-left panel of figure 16 we see that the all-important margin is the possibility of substituting at the final good level, as output declines by almost as much with and without intermediates.

This result is predicated on the calibration we have, though. As we make it harder to substitute at the final good level, by setting $\rho = -3$ and therefore halving the elasticity of substitution, the top-left panel of figure 17 shows that the importance of explicitly including intermediates increases substantially.

4.1.2 Sensitivity analysis

We have opted for modeling the usage of sectoral intermediates in fixed proportions because we think the higher the level of disaggregation, everything else being the same, the smaller the elasticity of substitution. Moreover, because we are looking at a relatively short period of time (1929-1933), it is unlikely that large adjustments in the mix of intermediates could take place. Nonetheless, to make sure this assumption does not drive our results we computed the same experiment with a Cobb-Douglas technology at the level of intermediates so that production of sectoral good i is given by

$$Y_{i,t} = \left(K_{i,t}^{\theta_i} L_{i,t}^{1-\theta_i}\right)^{\alpha_i} \left(Q_{ii,t}^{\omega_i} Q_{ij,t}^{\omega_i - 1}\right)^{1-\alpha_i} \qquad \text{for } i = 1, 2, \tag{27}$$

where we calibrate the parameters ω_i to obtain the same income shares of intermediates shown in table 7.

As the top left panel in figure 19 shows, the difference from the benchmark economy in terms of output is small. Any elasticity of substitution that is lower than one would, of course, lie in between the two lines shown in the figure.

We also conduct sensitivity analyses with respect to the other parameters in the model. These results are in the various panels of figure 19. Of particular importance is the elasticity of substitution at the final good level as the top-left panel shows. While, from a partial equilibrium perspective, one might think that decreasing the elasticity of substitution between sectors at the final good level would lead to a larger decrease in aggregate GDP as final good producers are less able to substitute toward the relatively cheaper flexible good, this is not

[23] Section 4.1.2 shows that our results are not very sensitive to this assumption.

what happens. General equilibrium effects change relative prices so that the flexible good price falls by less, while the inflexible good price falls by more, the end result being that aggregate output actually falls by more.

The two bottom panels also deserve a closer look. They report the results of relaxing the Cobb-Douglas structure between value added components and intermediates. The sectoral production functions are generalized to:

$$Y_i = \left[\alpha_i \left(K_{i,t}^{\theta_i} L_{i,t}^{1-\theta_i}\right)^{\rho_i} + (1-\alpha_i)\left(Q_{i,t}^b\right)^{\rho_i}\right]^{\frac{1}{\rho_i}}, \qquad i = 1, 2,$$

and we conduct sensitivity analysis with respect to ρ_i, with $\rho_i = 0$ being our benchmark. If we restrict the degree of substitutability in each of the sectors, if anything, we get even less action in GDP.

4.2 Calvo-style wage setting

The Taylor contract equation (11) is arguably an ad-hoc way of determining wages and lacks any sort of micro-foundation. We use it here to be able to compare our results to those of Bordo, Erceg, and Evans (2000). An alternative to this approach that has both gained traction in the literature and is micro-founded, is Calvo-style wage setting as in Erceg, Henderson, and Levin (2000).

We modify our economy to introduce infinitely many households (indexed by h on the unit interval) that supply differentiated labor services to the sticky sector (sector 2). Firms in sector 2 regard each household's labor services $L_{2,t}(h)$, $h \in [0,1]$ as imperfect substitutes.

Households derive utility from streams of the final good, leisure, and real balances. Every period, households choose consumption, $C_t(h)$, hours in sector 2, $L_{2,t}(h)$, nominal bond holdings $B_t(h)$, money holdings, $M_t(h)$, and capital $K_{t+1}(h)$ so as to solve:

$$
\begin{aligned}
\max \quad & \sum_{t=0}^{\infty} \beta^t U\left(C_t(h), L_{2,t}(h), \frac{M_t(h)}{P_t}\right) && (28)\\
s.t. \quad & B_t(h) = (1+R_{t-1})B_{t-1}(h) + W_{1,t}\bar{L}_1 + (1+\tau_2^w)W_{2,t}(h)L_{2,t}(h) && (29)\\
& + \sum_{i=1}^{2}(J_{i,t}K_{i,t}(h) + P_{i,t}^s Q_{i,t-1}(h) + \pi_{i,t}) + X_t \\
& - \left(M_t(h) - M_{t-1}(h) + P_t C_t(h) + \sum_{i=1}^{2}(P_t I_{i,t}(h) + P_{i,t}Q_{i,t}(h))\right), && (30)\\
& K_{i,t+1}(h) = (1-\delta_i)K_{i,t}(h) + I_{i,t}(h), \qquad i = 1,2, && (31)
\end{aligned}
$$

where the notation is the same as before. Households supply $\bar{L}_1$ units of sector 1 hours inelastically, but they are competitive monopolists in supplying sector 2 hours. Labor in sector 2 is subsidized at rate τ_2^w so that in steady-state, the tax exactly offsets the monopolistic distortion associated with the markup in sector 2 wages.

Every period a given household will be able to reset its wage with probability $(1-\theta_w)$, making the duration of each wage contract randomly determined. For households that do not adjust, their nominal wage grows at the unconditional mean rate of gross inflation $1+\bar{g}$. Letting $W_{2,t}(h)$ denote the nominal wage for an household of type h, this means the nominal wage of a household whose wage has not been adjusted in j periods since period t is $W_{2,t+j}(h) = W_{2,t}(h)\Pi^j$. The contract adjusting probability is independent of the number of periods that have gone by without adjustment, and of the state vector. This implies a constant fraction $(1-\theta_w)$ of households adjusts their contracts at any point in time.

We need to assume full consumption (but not leisure) risk sharing across households so that consumption is the same across all households $C_t(h) = C_t$. Moreover, all households resetting their wage in a given period will choose the same wage rate.

The production function for sector 2 firms is the same as before, but they now hire a "lump" of labor given by:

$$
L_{2,t} = \left[\int_0^1 L_{2,t}(h)^{\frac{\epsilon_w - 1}{\epsilon_w}} dh\right]^{\frac{\epsilon_w}{\epsilon_w - 1}}. \tag{32}
$$

Cost minimization by sector 2 firms implies demand schedules for each type of labor given by:

$$
L_{2,t}(h) = \left(\frac{W_{2,t}(h)}{W_{2,t}}\right)^{-\epsilon_w} L_{2,t}, \tag{33}
$$

where the implied wage rate is:

$$W_{2,t} = \left[\int_0^1 W_{2,t}(h)^{1-\epsilon_w} dh \right]^{\frac{1}{1-\epsilon_w}}. \tag{34}$$

Assuming separable utility in all 3 arguments, from the households' problem:

$$\begin{aligned} 0 &= \beta^t U_C(C_t) - \lambda_t P_t, & (35)\\ 0 &= U_M\left(\frac{M_t}{P_t}\right) - \lambda_t + E_t\lambda_{t+1}, & (36)\\ 0 &= -\lambda_t + E_t\lambda_{t+1}(1+R_t). & (37) \end{aligned}$$

An household h that is able to reset its contract wage, maximizes utility with respect to $W_{2,t}(h)$. This maximization is subject to the budget constraint as well as the demand for labor (33) and implies the following FOC:

$$\begin{aligned} \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\theta_w)^j \Big[& U_L\left(L_{2,t+j}(h)\right)(-\epsilon_w)\left(W_{2,t}(h)(1+\bar{g}^j)\right)^{-\epsilon_w - 1} W_{2,t+j}^{\epsilon_w} L_{2,t+j} \\ & + \lambda_{t+j}(h)(1+\tau_2^w)(1-\epsilon_w)\left(W_{2,t}(h)(1+\bar{g})^j\right)^{-\epsilon_w} W_{2,t+j}^{\epsilon_w} L_{2,t+j} \Big] = 0, \end{aligned} \tag{38}$$

where $\lambda_{t+j}(h)$ are the multipliers associated with the budget constraint and the labor demand condition has been substituted in. Using (35), (33), letting $(1+\tau_2^w) = \frac{\epsilon_w}{\epsilon_w - 1}$ and $\text{MRS}_{t+j}(h) = -\frac{U_L(L_{2,t+j}(h))}{U_C(C_{t+j})}$ yields, after some algebra and log-linearization (small caps):

$$\tilde{w}_{2,t}(h) = (1-\beta\theta_w)\mathbb{E}_t \sum_{j=0}^{\infty} (\beta\theta_w)^j \left[\text{mrs}_{t+j}(h) + \tilde{p}_{t+j} + \bar{g} \sum_{k=1}^{j} \hat{g}_{t+k} \right], \tag{39}$$

where we are using the convention that for $j = 0$, $\bar{g}\sum_{k=1}^{j} \hat{g}_{t+k} = 0$.

At this point it will be convenient to put some structure on the utility function, therefore assume that:

$$U\left(C_t(h), L_{2,t}(h), \frac{M_t(h)}{P_t}\right) = \frac{C_t^{1-\sigma_C}(h)}{1-\sigma_C} + \frac{\left(1 - \bar{L}_1 - L_{2,t}(h)\right)^{1-\sigma_L}}{1-\sigma_L} + \frac{\mu_0}{1-\sigma_M}\left(\frac{M_t(h)}{P_t}\right)^{1-\sigma_M}. \tag{40}$$

Recalling that because of our insurability assumption $C_{t+j}(h) = C_{t+j}$, we can write the percentage deviations in the marginal rate of substitution in period $t+j$ for a household that last updated its wage in period t as $\text{mrs}_{t+j}(h) = \sigma_c c_{t+j} - \sigma_L l_{2,t+j}(h)$. On the other hand, let the economy's average marginal rate of substitution be given by $\text{mrs}_{t+j} = \sigma_c c_{t+j} - \sigma_L l_{2,t+j}$. Then, log-linearizing (33) in period $t+j$, we get $l_{2,t+j}(h) - l_{2,t+j} = -\epsilon_w \left(\tilde{w}_{2,t}(h) - \tilde{w}_{2,t+j} - \bar{g} \sum_{k=1}^{j} \hat{g}_{t+k} \right)$. This allows us to write:

$$\begin{aligned}
\text{mrs}_{t+j}(h) &= \text{mrs}_{t+j} - \sigma_L \left(l_{2,t+j}(h) - l_{2,t+j} \right) \\
&= \text{mrs}_{t+j} + \sigma_L \epsilon_w \left(\tilde{w}_{2,t}(h) - \tilde{w}_{2,t+j} - \bar{g} \sum_{k=1}^{j} \hat{g}_{t+k} \right). \qquad (41)
\end{aligned}$$

Plugging this in (39):

$$\tilde{w}_{2,t}(h) = \frac{1-\beta\theta_w}{1-\sigma_L\epsilon_w} \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\theta_w)^j \left[\text{mrs}_{t+j} - \sigma_L \epsilon_w \tilde{w}_{2,t+j} + \tilde{p}_{t+j} + (1-\sigma_L\epsilon_w)\bar{g} \sum_{k=1}^{j} \hat{g}_{t+k} \right].$$

Recalling the wage mark-up is zero in steady-state, define the percentage deviation in the mark-up as $\mu^w_{t+j} \equiv \tilde{w}_{2,t+j} - \tilde{p}_{t+j} - \text{mrs}_{t+j}$. Using the law of iterated expectations and the definition of $\tilde{w}_{2,t+1}(h)$, we get

$$\tilde{w}_{2,t}(h) = (1-\beta\theta_w) \left(\tilde{w}_{2,t} + \beta\theta_w \bar{g} \mathbb{E}_t \hat{g}_{t+1} - \frac{\mu^w_t}{1-\sigma_L\epsilon_w} \right) + \beta\theta_w \frac{1-\beta\theta_w}{1-\sigma_L\epsilon_w} \mathbb{E}_t \tilde{w}_{2,t+1}(h), \qquad (42)$$

or, in terms of the original variables:

$$\tilde{w}_{2,t}(h) = (1-\beta\theta_w) \left(\tilde{w}_{2,t} + \beta\theta_w \bar{g} \mathbb{E}_t \hat{g}_{t+1} - \frac{\tilde{w}_{2,t} - \tilde{p}_t - \sigma_c c_t + \sigma_L l_{2,t}}{1-\sigma_L\epsilon_w} \right) + \beta\theta_w \frac{1-\beta\theta_w}{1-\sigma_L\epsilon_w} \mathbb{E}_t \tilde{w}_{2,t+1}(h). \qquad (43)$$

From (34), the average wage in sector 2 is:

$$W_{2,t} = \left[\theta_w \left(W_{2,t-1}(1+\bar{g}) \right)^{1-\epsilon_w} + (1-\theta_w) W_{2,t}^{1-\epsilon_w}(h) \right]^{\frac{1}{1-\epsilon_w}}. \qquad (44)$$

With this utility specification, the consumption Euler equation becomes:

$$C_t^{-\sigma_C} = \beta \mathbb{E}_t \left[(1+R_t) \frac{P_t}{P_{t+1}} C_{t+1}^{-\sigma_C} \right], \qquad (45)$$

and replaces (19), while the new version of the money demand equation (18) is:

$$\frac{M_t}{P_t} = \left[\frac{C_t^{-\sigma_C}}{\mu_0} \left(\frac{1+R_t}{R_t} \right) \right]^{-\frac{1}{\sigma_M}}. \tag{46}$$

We calibrate this economy so that its steady-state coincides with the one in our benchmark economy. This means that all common parameters are unchanged and we set $\sigma_c = 1$ and $\sigma_m = 1$ so as to have log preferences in consumption and real money balances like before. We set σ_l such as to get total market hours to be one third.[24] We set $\theta_w = 0.6$ so that average contract duration is $\frac{1+\theta_w}{1-\theta_w} = 4$ quarters.[25] Finally, we set $\epsilon_w = 4$ so that the wage mark-up factor is $\frac{\epsilon_w}{\epsilon_w - 1} = \frac{4}{3}$.

As can be seen from figure 20 the model is unable to deliver a sizable output decrease as a result of the observed monetary contraction. This happens because real wages in the distorted sector of this Calvo economy are not increasing by as much as they were in our benchmark economy (see figure 14). In fact, to match the same real wage increase we need to set the parameter regulating the fraction of households that get to adjust their wages (or equivalently the duration of the wage contracts) to the implausibly high level of $\theta_w = 0.99$, implying only 1% of households adjust their wages each quarter and contracts last for 199 quarters. Even then, as figure 21 shows, output falls by less than half as much as in the data.

We conclude from this experiment that much of the action in output we see in the benchmark economy hinges on the Taylor-contract specification. This is unfortunate because there is little or no motivation to favor such a ad-hoc specification over the Calvo setting.

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 argue that the pass-through effect from changes in the prices of intermediates is quantitatively meaningful and therefore one should use a multi-sector model with intermediates to understand any changes operating through a real wage-type channel. To do this we use the data to discipline a multi-sector model that helps us understand whether monetary contractions coupled with slow adjusting wages in one of the sectors, can account for the observed fall in aggregate (value added) output. We conclude

[24] This yields $\sigma_l = 2.46$.

[25] See Dixon and Kara (2006) for a discussion on how to compare contract duration between Taylor and Calvo worlds.

such an explanation falls short because the substitution margins a two-sector model introduces (both at the final good level as well as at the inputs level) are important and do away with most of the fall in output a one-sector model predicts. Nonetheless, the model can qualitatively address most the observed heterogeneity in the data.

We also examine whether the results obtained from the one-sector model are robust to different specifications of the wage setting mechanism. We find that they are not. While a Taylor-type wage setting mechanism results in losses in output that are close to the ones observed in the data, as in Bordo, Erceg, and Evans (2000), a Calvo-type wage setting mechanism parameterized to yield the same contract duration delivers no such result.

We take these results to mean that future work, whether focusing on finding an alternative, plausible, amplification mechanism for the contractionary monetary shocks, or studying a new underlying change, should take the sector heterogeneity that is the focus of this paper seriously.

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Table 7: **Calibration: common parameters**

Parameter	Value	Moment matched
β	0.99	Annual risk-free rate 4%
δ	0.025	Annual depreciation rate 10%
ϕ_i	0.25	Quarterly contracts
g_0	0.0035	Estimated
μ	0.987	BEE(2000)
ρ_m	0.39	Estimated
ρ	-1	
α_1	0.684	Intermediates share in GO 32%
α_2	0.616	Intermediates share in GO 38%
η	0.426	Sector 1 share in GDP 42%
ξ_1	0.86	Sector 1 share of intermediates 39%
ξ_2	0.61	Sector 1 share of intermediates 31%
γ	0.0031	Estimated
θ_1	0.3	Capital income share of VA 30%
θ_2	0.3	Capital income share of VA 30%

Table 8: **Calibration: one sector model**

Parameter	Value	Moment matched
γ	0.0037	Estimated
θ	0.3	Capital income share of VA 30%

Figure 1: **Relative agricultural wage**

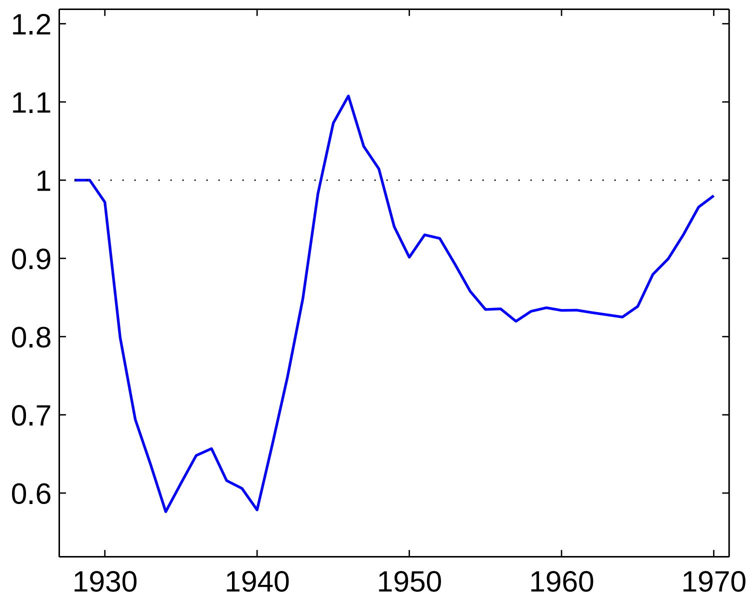


Figure 2: **Hours worked**

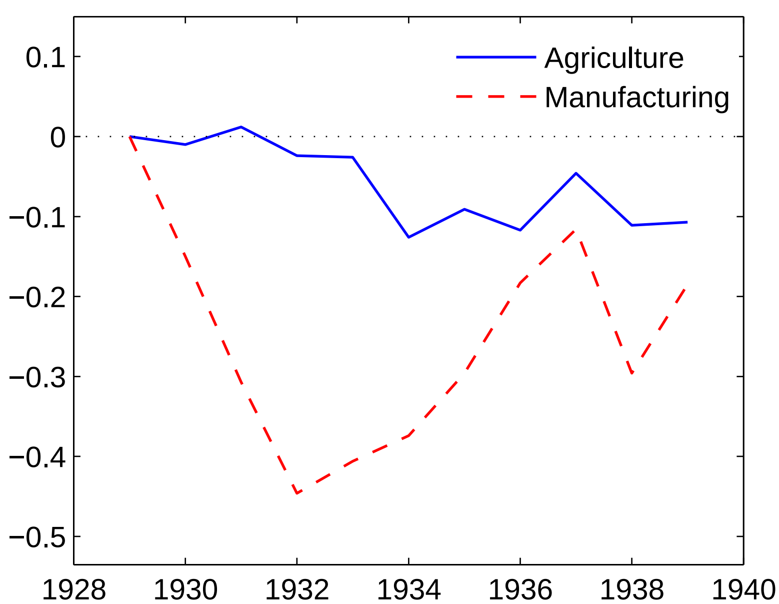


Figure 3: **Sectoral gross output**

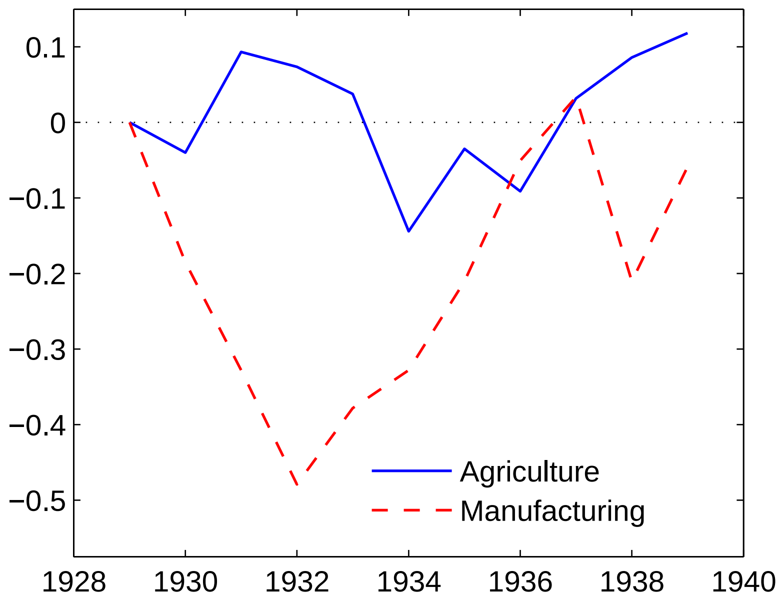


Figure 4: **Sectoral value added**

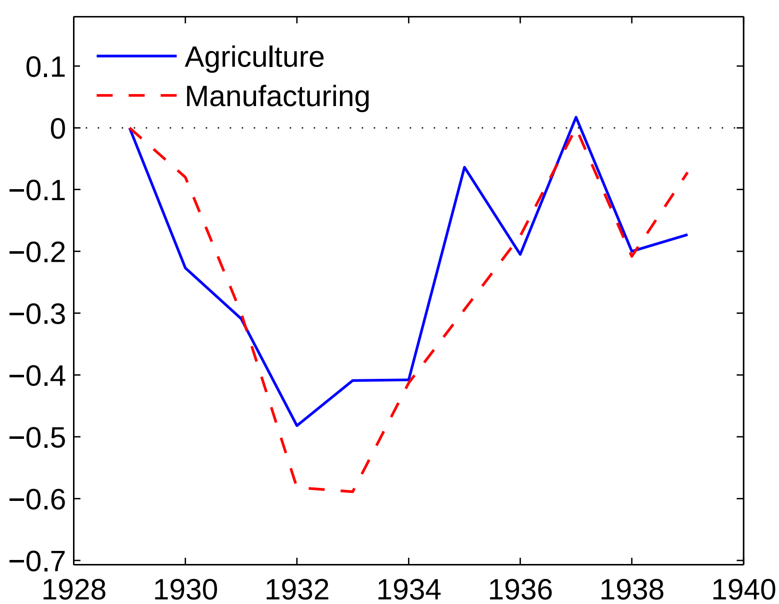


Figure 5: **Prices by processing stage**

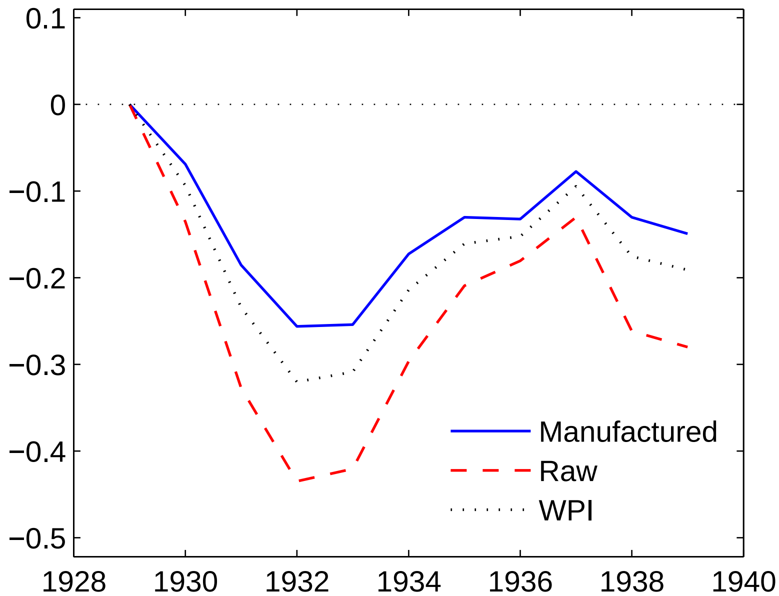


Figure 6: **Prices**

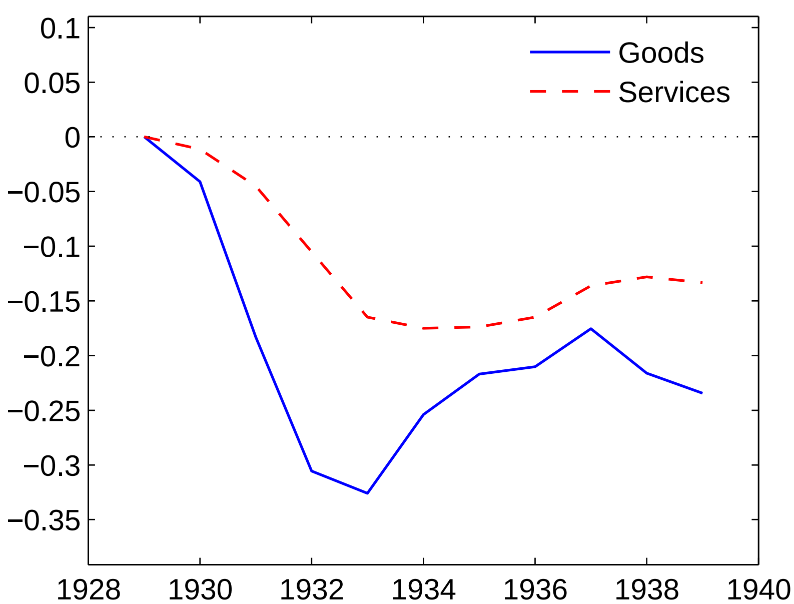


Figure 7: **Real product wage**

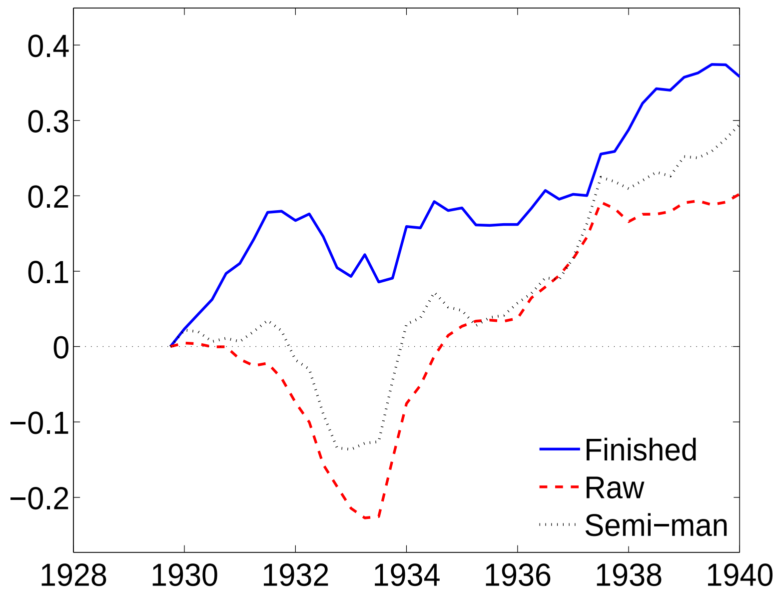


Figure 8: **Labor productivity: manufacturing**

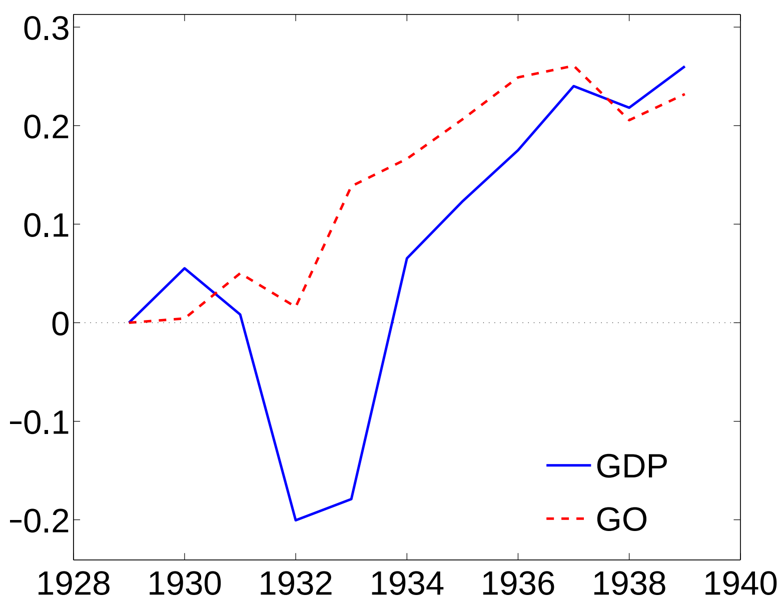


Figure 9: **Impulse response: sectoral**

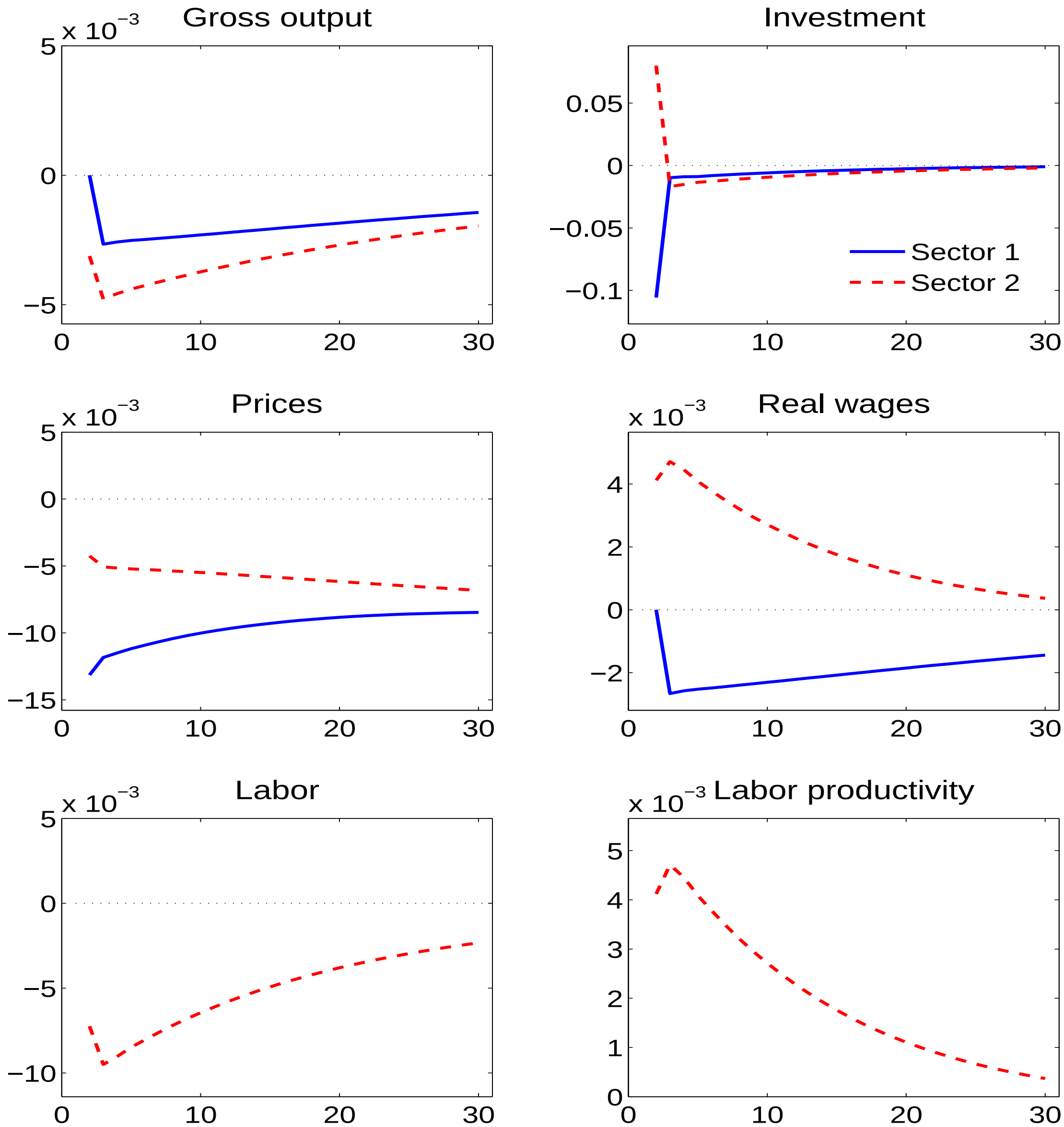


Figure 10: **Impulse response: intermediates**

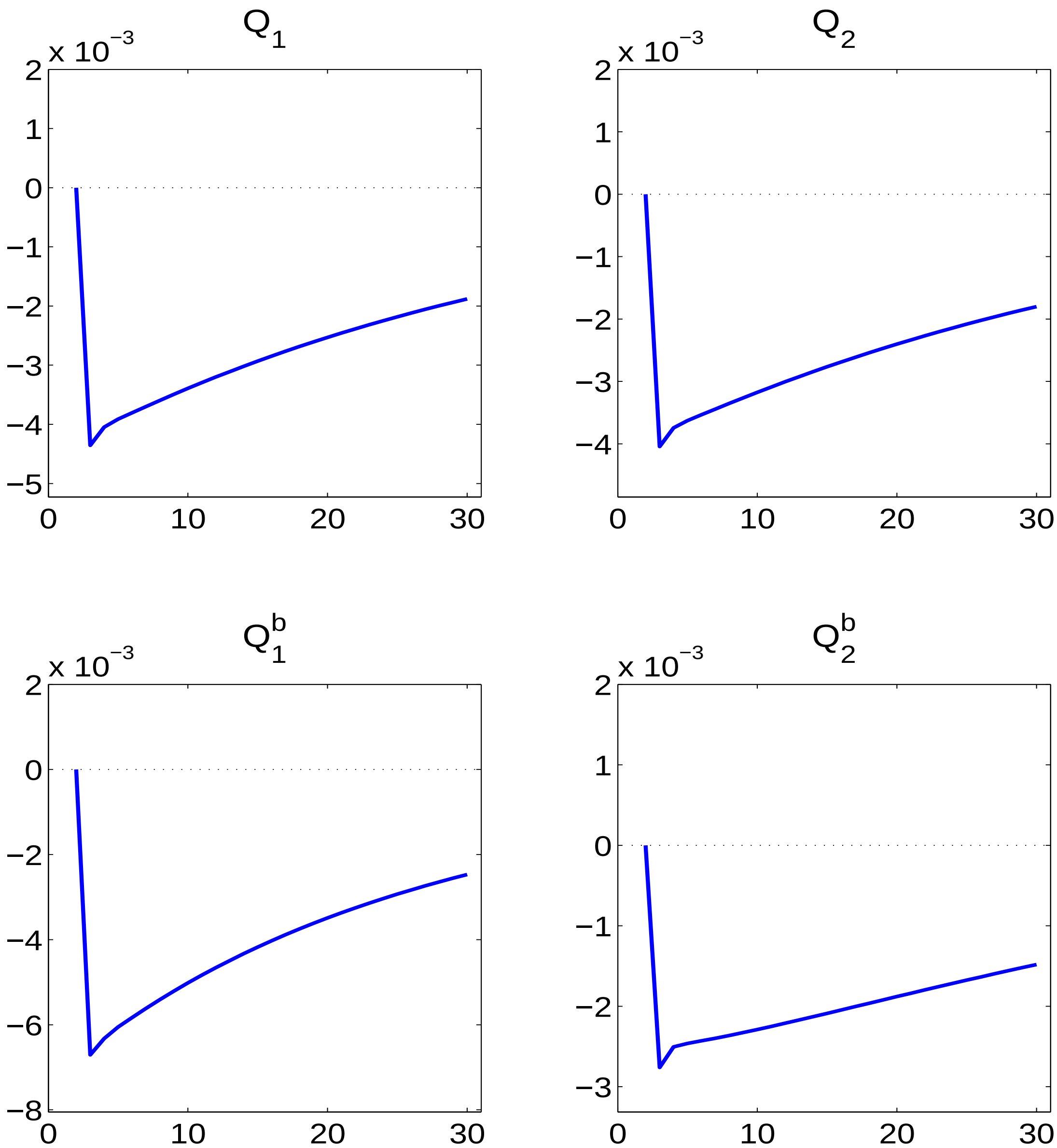


Figure 11: **Impulse response: aggregate**

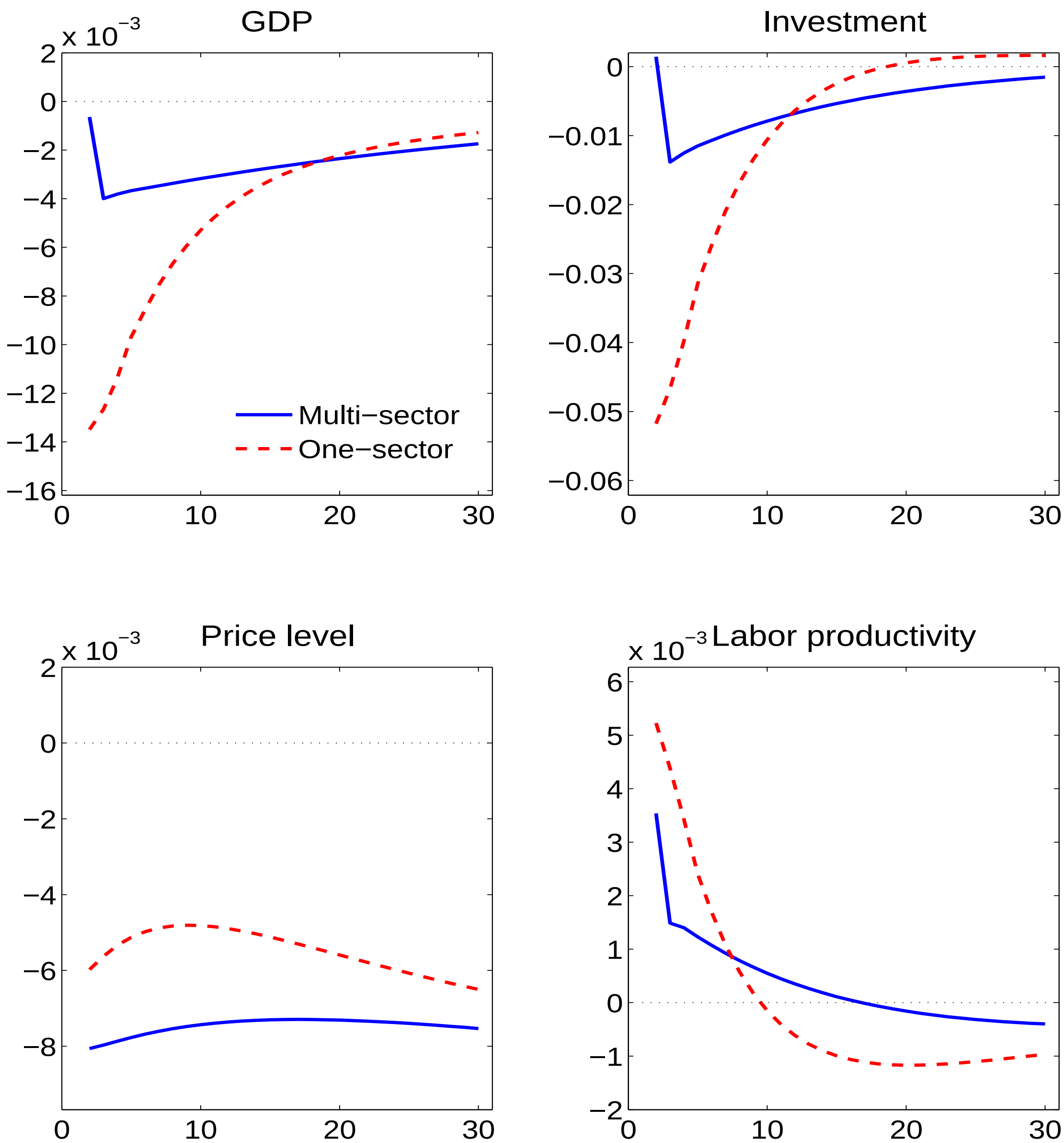


Figure 12: **One-sector vs. Two-sectors**

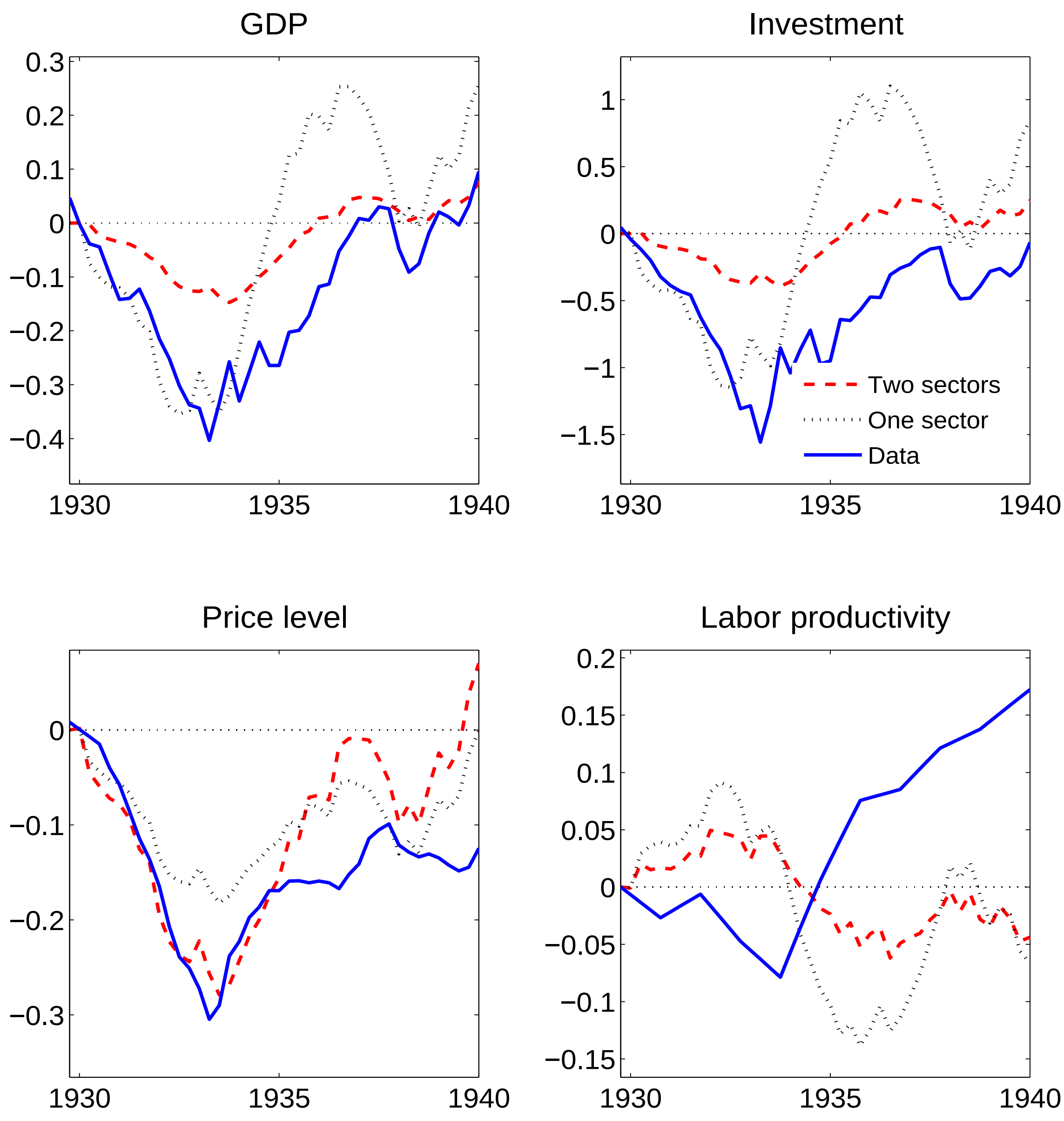


Figure 13: **Flexible sector**

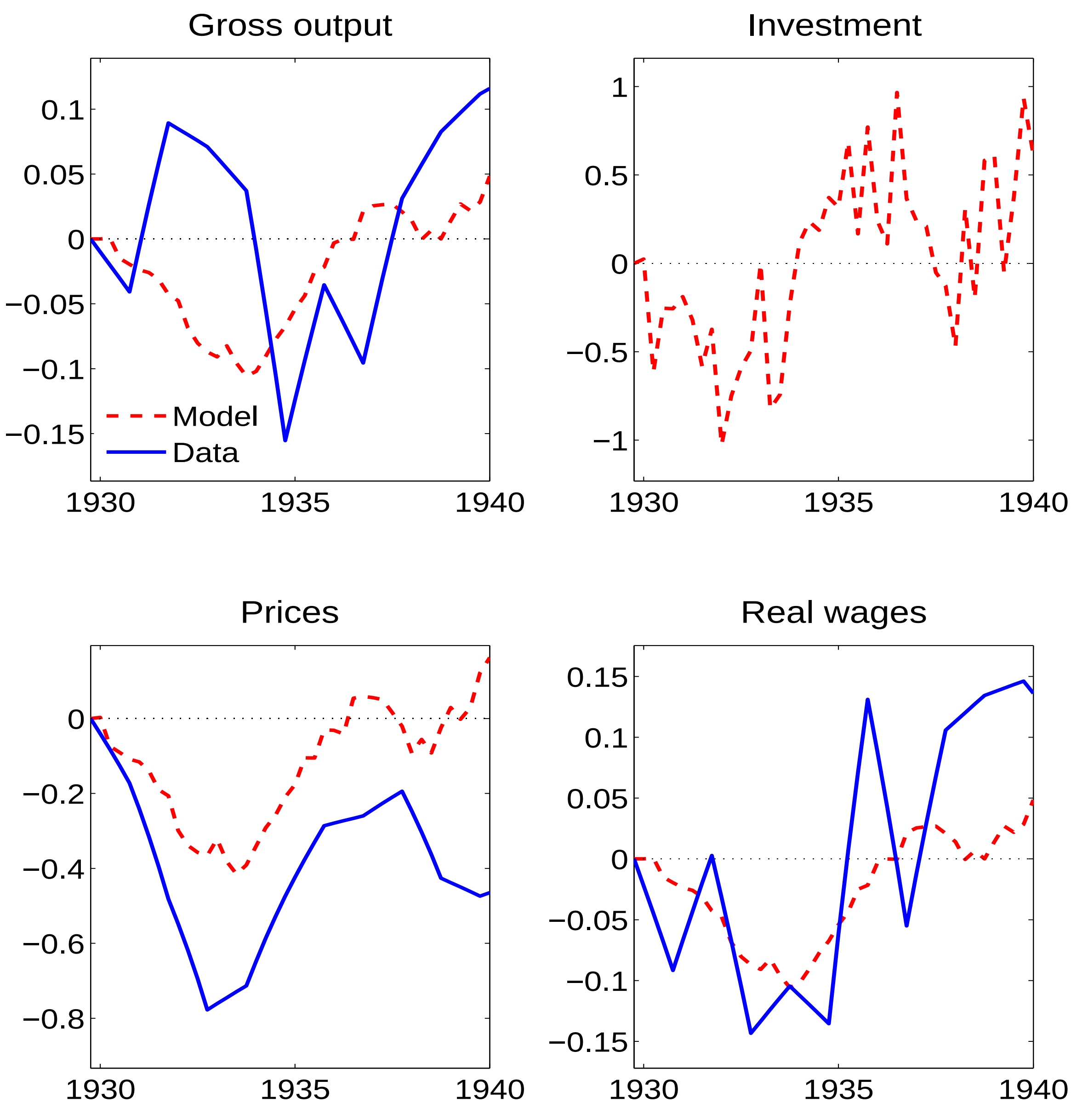


Figure 14: **Distorted sector**

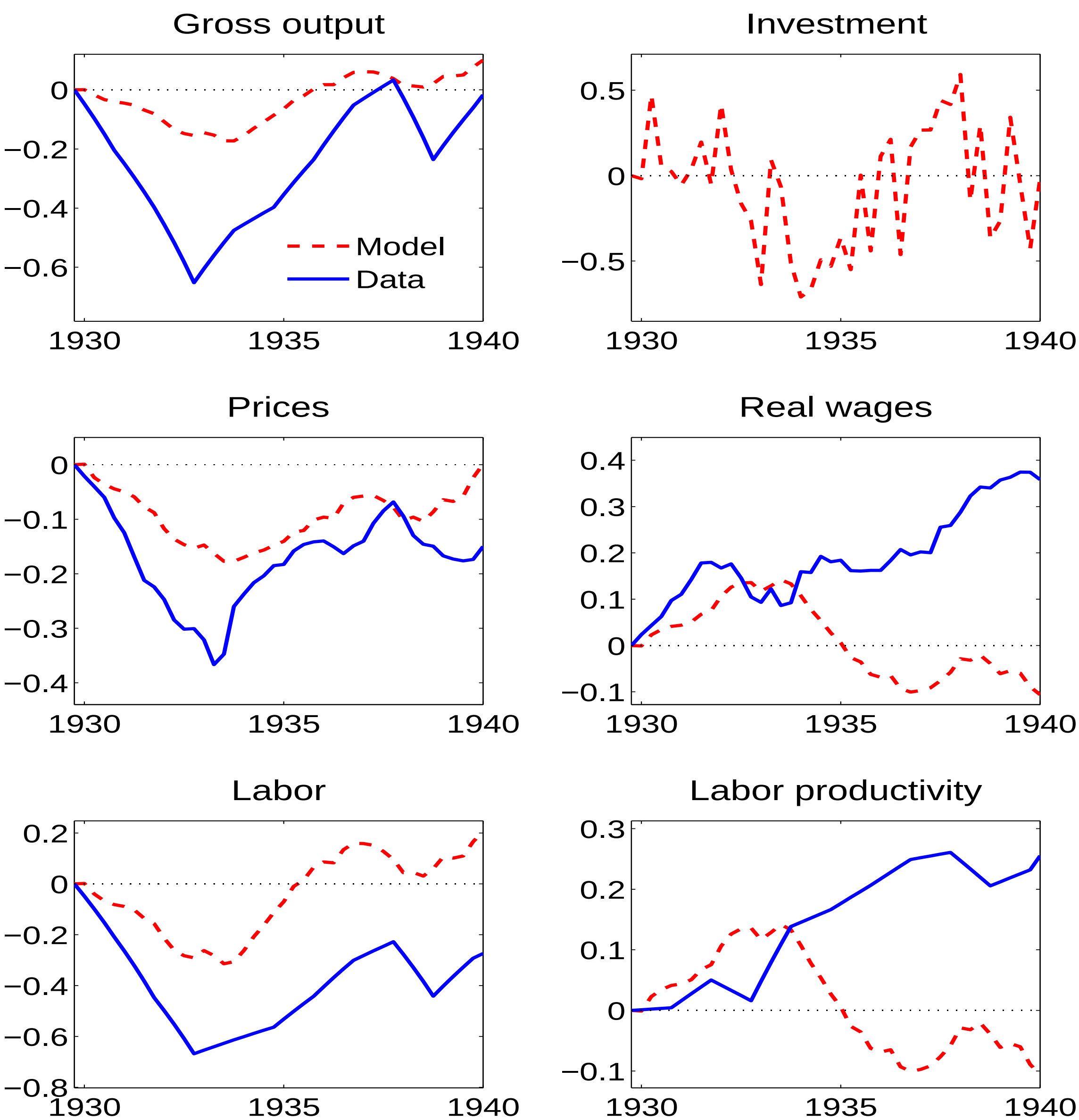


Figure 15: **Product and input prices**

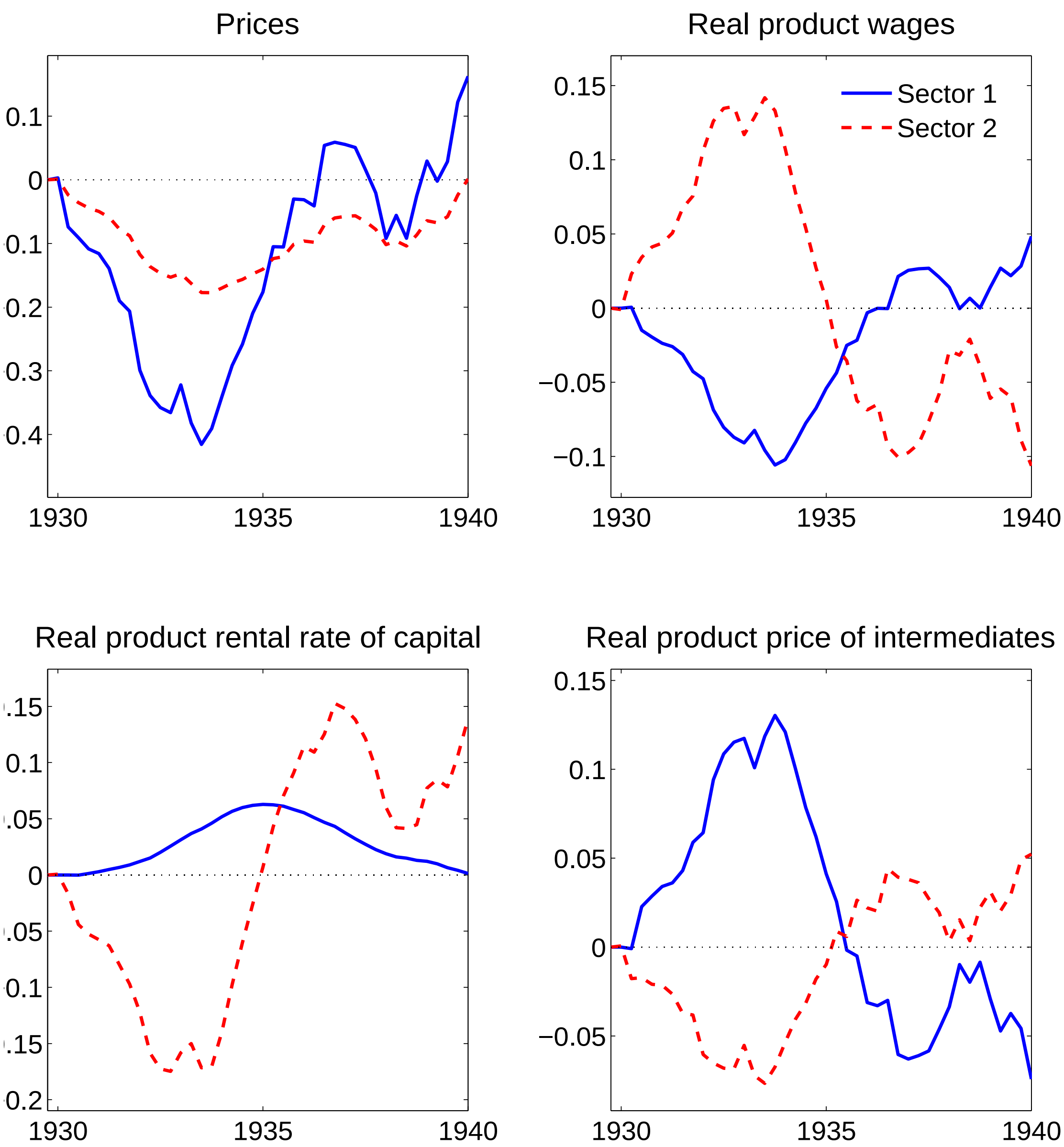


Figure 16: **The importance of substitutability**

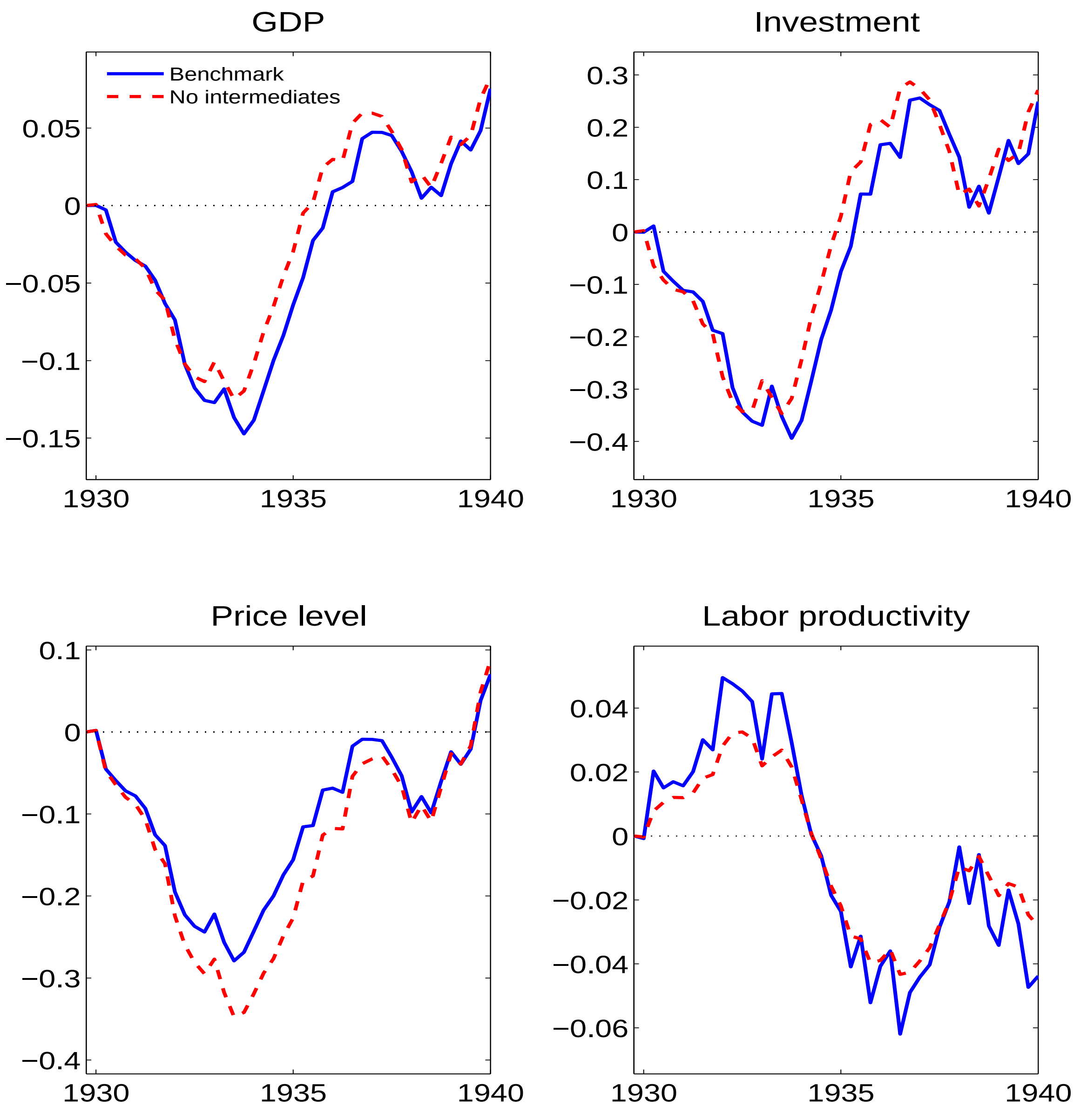


Figure 17: **The importance of substitutability (low elasticity)**

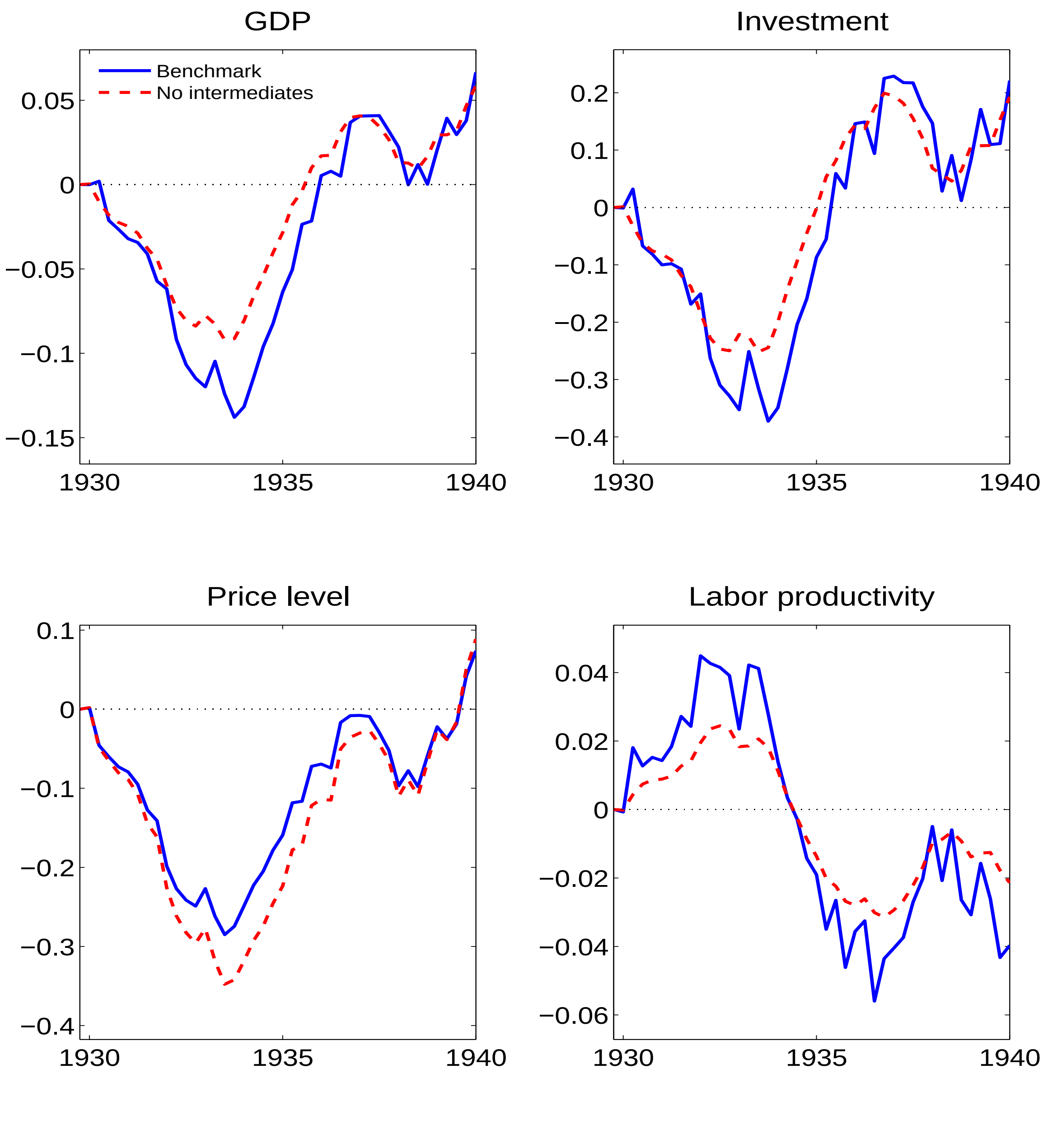


Figure 18: **High substitutability between intermediates**

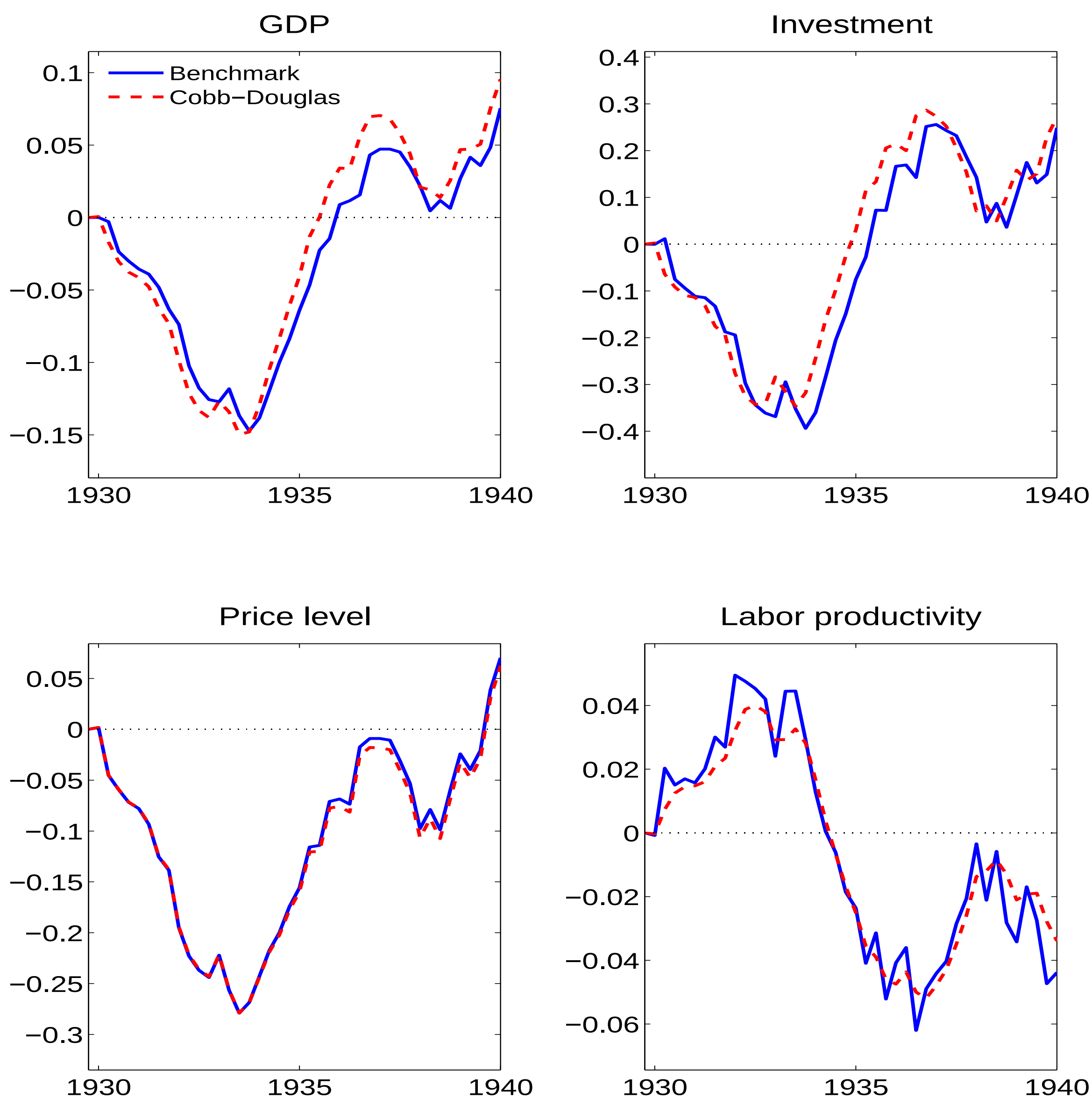


Figure 19: **Sensitivity analysis (GDP in y-axis)**

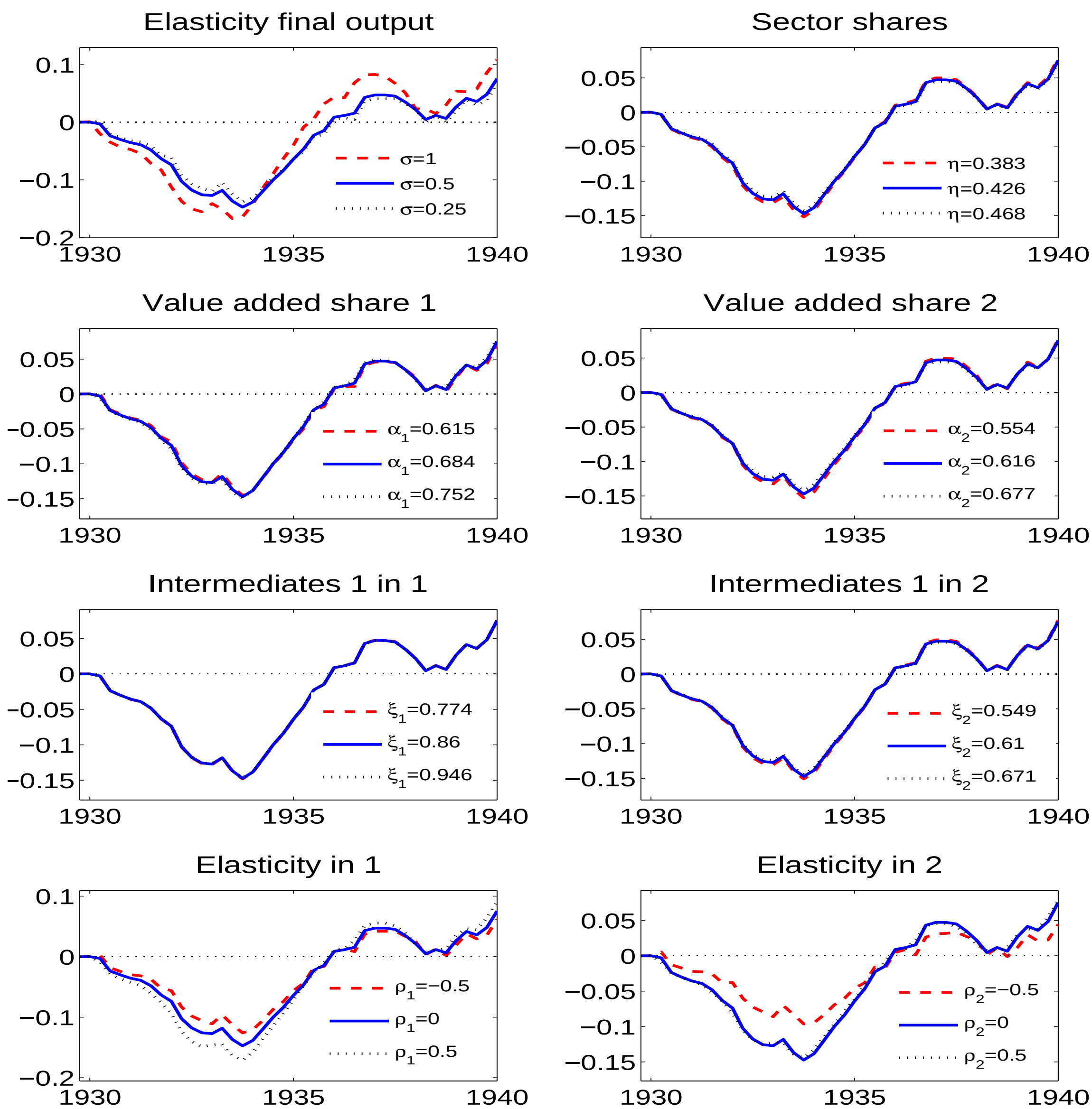


Figure 20: **Calvo-type wages**

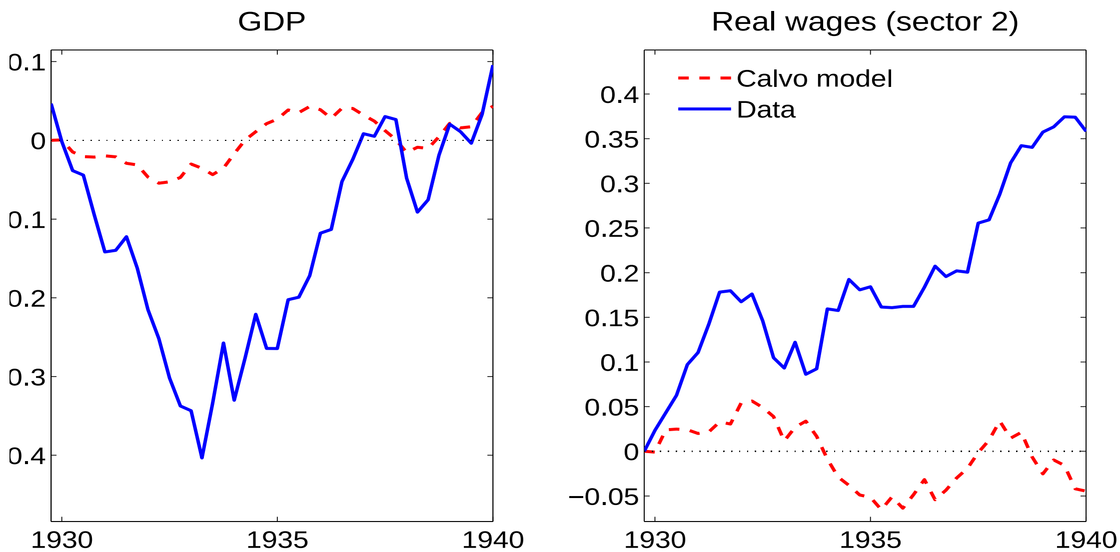
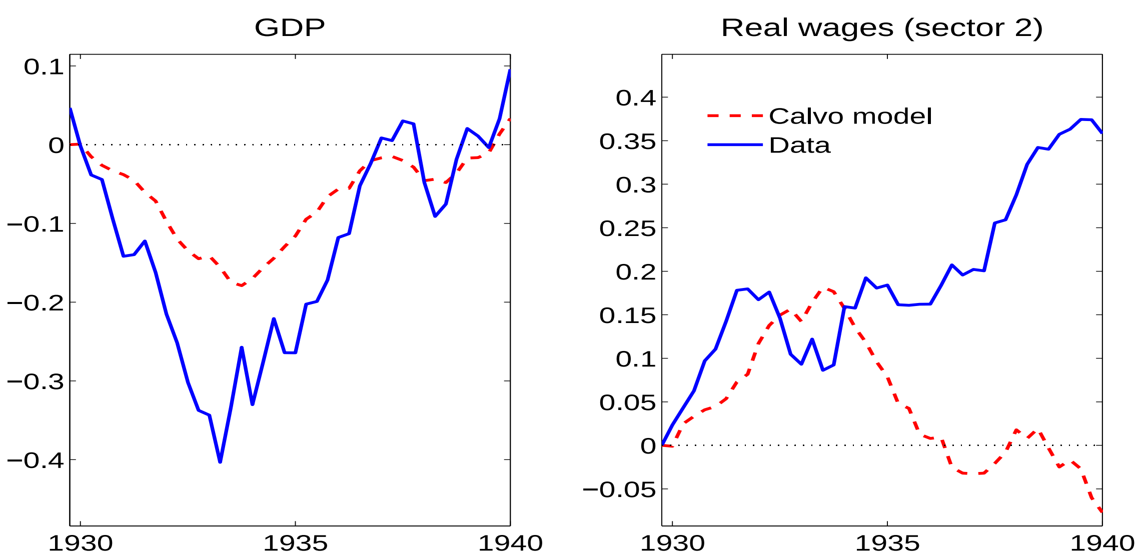


Figure 21: **Calvo-type wages** ($\theta_w = 0.99$)



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.[26] 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.

Hours data: 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.

Industry data: The eight industries' data reported in Tables 2, 3 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 large fraction of the iron ore production was 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 the 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

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

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.[27] 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 and 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%).

Boots and Shoes: 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.*

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

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

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.