# Re-Examining the Role of Sticky Wages in the U.S. Great Contraction: A Multi-sector Approach

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# Re-Examining the Role of Sticky Wages in the U.S. Great Contraction: A Multi-sector Approach*

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**Abstract**

We quantify the role of contractionary monetary shocks and nominal wage rigidities in the U.S. Great Contraction. In contrast to conventional wisdom, we find that the average economy-wide real wage varied little over 1929-33, although real wages rose significantly in some industries. Using a two-sector model with intermediates and nominal wage rigidities in one sector, we find that contractionary monetary shocks can account for only a quarter of the fall in GDP, and as little as a fifth at the trough. Intermediate linkages play a key role, as the output decline in our benchmark is roughly half as large as in a two-sector model without intermediates.

JEL Classification: E20, E30, E50.

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# 1 Introduction

A long-standing view is that deflationary monetary policy and rigid nominal wages led to high real wages that were a key contributor to the fall in employment and output in the U.S. "Great Contraction" of 1929-33 (e.g., Bernanke (1995), Bordo, Erceg, and Evans (2000), and Eichengreen (1995)). Despite the debated conclusion of Cole and Ohanian (2001) that the rise in real wages was a minor contributor to the contraction, recent work by Hatton and Thomas (2010) and Ohanian (2009) continues to point to high real product wages (i.e., wages divided by sectoral output price) as a key contributor.

This leads us to re-examine the quantitative contribution of nominal wage rigidities and deflationary monetary shocks to the U.S. Great Contraction. Our analysis relies on two key elements: sectoral (industry) differences in the degree of wage rigidity and intermediate inputs. When we incorporate these features into a standard two-sector model calibrated to the interwar U.S. economy, we find that contractionary monetary shocks can account for less than a quarter of the decline in output during this period. Intermediate linkages play a key role, as the predicted decline in output roughly doubles when we drop intermediates from our model.

Our focus on sectoral heterogeneity in wage rigidity and intermediates is motivated by two empirical observations. First, real wage changes varied across sectors, with wages rising significantly in some sectors and falling rapidly in others (see Table 1). Moreover, in contrast to the conventional view, we find that the economy-wide real wage, constructed using compensation and hours for all workers, was relatively flat over 1929-33. Key to this finding is the inclusion of the earnings and hours worked of self-employed (see Figure 1.A) who accounted for roughly a quarter of the workforce and were concentrated in industries (especially agriculture) where wages fell dramatically.

The second observation is that the shifts in relative wages were accompanied by large shifts in relative prices, with large declines in the price of less processed goods used as intermediate inputs. This is important, since many papers point to a rise in the real product wage (the nominal wage deflated by the industry output price) in manufacturing industries as evidence of high real wages during the U.S. Great Contraction.[1] When we examine several manufacturing industries for which data on gross output and intermediates are available, we find that the pass-through of lower intermediate prices accounts for a significant share

[1]See, for examples, Bernanke (1995) and Bernanke and Carey (1996).

of the fall in final gross output prices. As a result, the real value-added product wage for manufacturing (computed using the implied value-added deflator) closely resembles our economy-wide real wage, remaining roughly constant over the downturn. This contrasts with the established view that manufacturing real product wages (deflated by wholesale prices) rose sharply during the early 1930s. This also suggests that modeling intermediates may be important in assessing the impact of high real wages, since a fall in the price of intermediates pushes up a firm's labor demand schedule.

These facts lead us to develop a two-sector model where sectors differ in the degree of wage rigidity and in their use of intermediates. In the *flexible* sector, wages adjust to equate labor demand and supply, while in the *sticky* sector, nominal wages adjust slowly. To facilitate comparisons with the literature, we follow Bordo, Erceg, and Evans (2000) and assume that sticky-sector wages are determined by Taylor nominal wage contracts, so that hours worked depend on the firm's real product wage. Each of the sectoral goods is produced using capital, labor, and a sector-specific intermediate good comprised of both sectoral goods. The final consumption/investment good is produced using the two-sectoral goods.

To quantify the contribution of wage rigidities to the Great Contraction, we input estimated money supply growth shocks from 1929:4 to 1936:4 into our calibrated model economy. Contrary to the established view, we find that deflation and wage rigidity account for less than a quarter of the fall in output during the Great Contraction. By design, our calibration delivers a larger rise in the aggregate real wage than observed in the data over 1929-33. This suggests that, if anything, our experiment *overestimates* the fall in output due to high real wages.

The model features two mechanisms that mitigate the impact of high sectoral real wages. First, the flexible-wage sector offers final goods producers a channel to substitute away from the relatively more expensive sticky-sector good. Second, since the sectoral intermediate bundle includes both flexible and sticky goods, a contractionary monetary shock results in a lower price of intermediates relative to the sticky-sector wage. This allows sticky-sector firms to substitute intermediates for relatively more expensive labor. As a result, changes in relative prices drive a wedge between real product wages and real value-added wages.

Intermediate linkages across sectors play the crucial role in mitigating the effects of high real wages in the sticky sector. Compared to a two-sector model without intermediates calibrated to deliver the same sticky-sector real wage, our benchmark generates a fall in output roughly half as large. The key mechanism is that the fall in the (relative) price of flexible-sector intermediates partially offsets the effect of higher sticky-sector wages, and leads to a smaller rise in the relative price of the sticky good. This allows the model with intermediates to match the same sticky-sector real wage as in the two-sector model without intermediates with a smaller degree of wage rigidity.

In contrast, we find that sectoral heterogeneity in wage rigidity by itself does not significantly mitigate the distortionary effects of high sectoral real wages. Comparing the two-sector model without intermediates to a one-sector version calibrated to match the same economy-wide real wage, we find similar predictions for aggregate output and employment. This is because of offsetting mechanisms. While the flexible sector provides a channel to substitute away from the sticky good, this also lowers the real consumption wage in the flexible sector. As a result, a larger rise in the sticky-sector real wage (i.e. a "larger" friction) is required to match the same aggregate real wage as in the one-sector environment.

Incorporating intermediates also helps address the concern that a multi-sector model with asymmetric wage rigidities is inconsistent with the data. In an insightful discussion, Bordo, Erceg, and Evans (2001) take manufacturing as a proxy for the sticky sector and point out that the wholesale price index (WPI) of manufactures declined by more than the GNP deflator over 1929-1933. In contrast, in a multi-sector model without intermediates, a contractionary monetary shock results in a smaller fall in the sticky-sector price than in the aggregate price. Intermediates help account for this critique. In Section 2.3, we construct an implied value-added price deflator for manufacturing and find that it falls by less than the GNP deflator, similarly to what happens in the model. This is due to the pass-through of lower intermediate prices into the manufacturing gross output price, highlighting the importance of accounting for input-output relationships during periods of large relative price shifts.

There is a large literature debating the contribution of deflation and wage rigidity to the Great Contraction.[2] Our paper is most closely related to Bordo, Erceg, and Evans (2000) and Cole and Ohanian (2001), who reach very different conclusions.[3] While we share with

[2]This is part of a broader literature debating the contribution of monetary factors to the Great Contraction that dates back to Friedman and Schwartz (1963). The papers in Kehoe and Prescott (2007) examine the experiences of a number of countries.

[3]Christiano, Motto, and Rostagno (2003) also conclude that real wages were not an important factor, although as we discuss in Section 2.1 this follows from the estimate of real wages they construct. Dighe (1997) argues that real product wages in manufacturing in the 1921 recession were similar to those observed

Cole and Ohanian (2001) the view that sectoral heterogeneity in wages was an important factor in the Great Contraction, we differ both in incorporating intermediate linkages and in explicitly modeling nominal rigidities in a two-sector general equilibrium model. In contrast to Bordo, Erceg, and Evans (2000) – whose one-sector framework is nested as a limiting case of our model – our results suggest that high real wages were not the predominant factor in accounting for the large fall in output during the Great Contraction. We also show that the key reason Cole and Ohanian (2001) find a smaller role for high real wages than Bordo, Erceg, and Evans (2000) is not the multi-sector structure of their model, but rather their calibration to a smaller increase in the aggregate real wage.

Motivated by President Hoover's efforts to jawbone large manufacturing firms into not cutting nominal wages or employment in 1930, Ohanian (2009) examines a two-sector model where real wages in one sector are above their steady state-level. Unlike our paper, Ohanian (2009) concludes that wage rigidity in manufacturing combined with a fall in hours worked per worker can account for a large fraction of the fall in output during the Great Contraction.[4] Our paper shows that accounting for intermediate linkages significantly reduces the impact of high real product wages in manufacturing on output and employment.

In recent work, Cole, Ohanian, and Leung (2005) revisit the conclusions of Eichengreen and Sachs (1985) and Bernanke and Carey (1996), that differences in the timing according to which countries abandoned the gold standard account for the observed cross-country deflation and output declines. Their findings support a link between the gold standard and deflation experiences, but they find that deflation accounts for a small share of output declines. While our work has similar implications for the contribution of contractionary monetary shocks to the fall in prices and output during the Great Contraction, we focus on the U.S. and show that intermediate linkages mitigate the high real wages in some sectors. This paper is also related to early work on international linkages in the Great Depression by Crucini and Kahn (1996). They adopt a multi-sector model and show that a rise in tariffs on intermediate goods can have sizable effects on output. Although our paper shares an interest in the impact of intermediate prices, our work highlights the implications of the fall in raw material prices for the impact of high real wages in manufacturing.

Our work is also related to a large literature on cyclical movements in relative prices.

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in the Great Contraction.

[4] Ohanian (2009) also argues that manufacturing firms cooperated with President Hoover request due to the threat of unionization in manufacturing.

Means (1966) highlighted the large shifts in relative prices across industries during the Great Depression, while Neal (1942) examined whether movements in relative prices across manufacturing industries could be accounted for by shifts in input prices. Our paper differs from these studies in its quantitative theory emphasis and focus on real wages. More recent work has found that prices of intermediate goods, relative to both final goods and average wages, move procyclically in the post-war period (Murphy, Shleifer, and Vishny, 1989), and that monetary contractions lower the relative price of less processed to more processed goods (Clark, 1999). While we find similar effects from monetary shocks over 1929-33, we differ in our focus on the quantitative contribution of wage rigidities to the Great Contraction.[5]

The remainder of this paper is organized as follows. Section 2 documents several key facts on aggregate and sectoral wages and hours and on the impact of shifts in the price of intermediates on U.S. manufacturing wholesale prices. Section 3 outlines our baseline two-sector model with intermediates. Section 4 quantifies the impact of contractionary monetary shocks in our model. The final section offers a brief conclusion.

## 2 Data

While the labor market figures prominently in many explanations of the Great Depression, surprisingly little work has explored the extent and implications of heterogeneity in wages and hours worked across industries.[6] Indeed, with a few exceptions, the most common approach in the literature has been to use the average manufacturing wage as a proxy for the economy wide wage[7] As we argue in this section, this provides a misleading picture of real wages during the Great Contraction due to large shifts in relative wages and prices across industries in the early 1930s.

Since direct measures of hourly wages exist for only a few industries, we use estimates of hours worked and total labor income to construct aggregate and sectoral hourly wages during the Great Contraction. We find substantial sectoral shifts in relative wages across

[5] Bouakez, Cardia, and Ruge-Murcia (2009) find that sectoral heterogeneity in price rigidities and intermediate linkages can help account for the transmission of monetary shocks. Huang, Liu, and Phaneuf (2004) argue that shifts in the level of intermediate usage can account for changes in the cyclicality of real wages.

[6] This reflects the limited data on wages and hours worked outside of manufacturing and agriculture. Cole and Ohanian (2001) document the fall in agricultural wages relative to manufacturing, while Cole and Ohanian (2004) focus on New Deal policy induced heterogeneity over 1934-1939.

[7] See, for examples, Margo (1993) and Bernanke (1995).

industries, which coincided with large shifts in relative prices over 1929-1933. In contrast to conventional wisdom, we find that the average real wage for all workers over 1929-1933 barely rose. This is mainly due to our inclusion of the self-employed, whose income fell dramatically during this period. These facts are related, as the self-employed were concentrated in sectors where real wages declined. In contrast, self-employed workers were a small fraction of the workforce in industries where real wages rose. Consistent with differential degrees of wage rigidity, hours worked tended to decline more in industries where relative wages rose. These sectoral differences lead us to develop a multi-sector environment in Section 3 to quantify the role of real wage rigidities in the Great Contraction.

## 2.1 Average Real (Consumption) Wage

We construct an estimate of the average wage by dividing a measure of total labor income by total hours worked. Our measure of total hours worked is the product of persons engaged in production (full-time equivalent (FTE) employees plus sole-proprietors) and average hours worked per FTE worker.[8] Since our hours measure includes sole-proprietors, we define total labor income as total employee compensation plus 60 percent of sole-proprietors' income.[9] To construct the real *consumption* wage, we deflate our nominal wage estimate using the Balke and Gordon (1986) GNP deflator.[10]

Our estimate of average real consumption wages (*All-workers* in Figure 1.A) exhibits little increase during the downturn, rising only after the introduction of New Deal policies in the mid-1930s. As we discuss in Section 2.2, although there was little change in the average real wage, there were large shifts in relative wages across industries. Since self-employed workers were mostly concentrated in agriculture and retail trade (where wages fell), the inclusion of self-employed workers has a large impact on our estimated wage. This can be seen by comparing our average wage series with that of employees only, which rises by roughly 12 percent over 1929 to 1932 (see Figure 1.A).[11]

Other papers that construct an estimate of the aggregate real wage have taken dif-

[8] We use the Denison (1962) economy-wide average hours estimates for comparability with Bordo, Erceg, and Evans (2000). This series is similar to that of Kendrick (1961) over 1929-39.

[9] Changes in real wages are not very sensitive to reasonable (constant) values for the labor share.

[10] We refer to this as the real *consumption* wage to distinguish it from industry level real *product* wages, computed using industry deflators, which we examine in Section 2.3.

[11] Average real wage for employed workers (*Employees*) is total compensation of employees per hour, where hours worked are the product of full time equivalent employees and average hours worked.

ferent approaches to self-employed workers. Bordo, Erceg, and Evans (2000) ignore the self-employed, and use the average wage of employees as their measure of the average real wage. This yields a substantial rise in real wages during the Great Contraction, as Figure 1.A shows. Christiano, Motto, and Rostagno (2003) follow Bordo, Erceg, and Evans (2000) in using total compensation of employees as their estimate of earnings, but include hours worked by sole-proprietors in total hours. Since hours fell by less in industries with a large share of self-employed workers (as we discuss below), this approach yields an aggregate real wage series that declines during the Great Contraction.

Given the large impact that self-employed workers have on the average wage, are our findings robust to alternative estimates of average self-employed hourly earnings? One check is to replace our measure of self-employed earnings with the hourly earnings of (employed) agricultural workers.[12] This is a reasonable proxy for the opportunity cost of sole-proprietors since over half of self-employed workers were in agriculture.[13] As Figure 1.A illustrates, this exercise yields an economy-wide real wage estimate (*All-workers* $w_{ag}$ *proxy*) similar to our benchmark. This suggests that excluding the self-employed from the calculation of average wages effectively under-weights industries where wages fell during the Great Contraction.

A more general question is whether the self-employed should be taken into account when computing average economy-wide real wages? Standard theory suggests they should, as the workhorse stochastic growth model treats hours worked by employees and self-employed symmetrically. A more practical argument for inclusion is that the self-employed accounted for over a fifth of the workforce in 1929. Moreover, informed contemporaneous observers reported that many self-employed closely resembled comparable wage workers. For example, a BLS report stated that: "...there is a basis in the economic status of many farm operators for classifying them with wage earners." (pg. 66, Bureau of Labor Statistics (1939)).

The view that many of the self-employed resembled employed workers is supported by the frequent transitions between employee and self-employed status. In 1930, roughly 40 percent of farms were tenant run (i.e., the farmer rented the land), and nearly 30 percent of tenants were sharecroppers, who received a fraction of the crop they produced (Black and

[12]Specifically, we divide the Alston and Hatton (1991) estimate of monthly earnings of agricultural workers by an estimate of hours worked in agriculture (total hours from Kendrick (1961) divided by Persons Engaged in Farms from the BEA). The average wage is the weighted average of the employee average wage series and the agricultural wage, where the weights are the fraction of FTE Persons Engaged (i.e., FTE Employees/FTE Persons Engaged and FTE Sole-Proprietors/FTE Persons Engaged).

[13]Johnson (1953) used the 1940 Census and found that the wages of workers who migrated from farms to urban areas was close to that of urban workers of the same age and sex.

Allen (1937)). There was substantial career mobility both up and down the "agricultural ladder" from employed farm-hand, to sharecropper, to tenant farmer and to farm owner.[14]

While there is little direct evidence on retail sector employee-operator transitions, data from the Census of Retail Distribution in 1929 and 1933 indicate that most retail operations were small. In 1933, over two-thirds of retail establishments had annual gross sales of less than \$10,000 and were mainly run by proprietors, as they averaged only 0.4 full-time employees per store.[15] Given that retail gross margins were roughly 25 percent, the income of small store proprietors was modest (e.g., a store with \$5,000 in sales would net \$1250 before operating expenses), and comparable to the annual average earnings of full-time retail employees: just under \$1000 in 1933 (see Bureau of the Census (1935)). This points to an economic environment where most self-employed were not entrepreneurs running large companies, but were small tenant farmers (including sharecroppers) or operators of small retail stores and establishments.

One concern is that our wage estimate is impacted by composition bias due to a changing mix of workers within and across industries. The cross industry bias arises from the lower average wage of the industries we classify as flexible, compared to those we characterize as sticky. Since our estimate of total hours in the flexible industries rises from roughly 44 percent in 1929 to just over 50 percent in 1933, this labor shift towards lower wage industries biases the average wage downwards. To approximately estimate the magnitude of this bias, we compute an average wage series where we weight the average wage of the flexible and inflexible industries by their share of total hours in 1929. This implies a slightly higher real wage series then our benchmark, roughly 3 percentage points higher over 1931 to 1933.

Working in the opposite direction is a shift towards relatively more productive workers within each industry. Margo (1993) and Ohanian (2001) cite work by Lebergott, who found that many manufacturing firms reduced the hours of their least productive workers, which resulted in a 10 percent increase in the average quality of workers. This effect may also have been at work in agriculture, as Alston and Hatton (2005) find that relatively more productive agricultural workers were more likely to transition up the agricultural ladder from farm hand to self-employed.[16] Since the Lebergott estimate of the within-industry compositional shift

[14]There is a large literature studying career mobility in agriculture that starts in the interwar period and continues to the present day (e.g., Barlowe and Timmons (1950), Alston and Hatton (2005)).

[15]See table 4c in Bureau of the Census (1935)

[16]Alston and Hatton (2005) report that average income for sharecroppers was only slightly higher than that of wage earners, but that tenants income was on average 50 percent higher than share croppers.

more than offsets the bias of the cross-industry shift in worker composition, this suggests our estimate provides an upper bound on the aggregate real consumption wage.

Our real consumption wage estimate suggests two key take-aways. First, there is little evidence that the average real wage for the entire economy rose. However, as we explore in more detail in the next section, there is evidence that real wages did rise in several industries. Second, measurement issues (including possible composition biases and estimates of self-employed wages) associated with limited data suggest we should view our average real consumption wage estimate with caution. Consequently, we do not use it as a calibration target in our numerical exercises in Section 4. Instead, we choose as a calibration target the path of real wages in the sticky-sector, which had few self-employed workers.

## 2.2 Industry Level Estimates of Wages and Hours

While the large decline in agricultural wages relative to manufacturing (over 40 percent) over 1929-33 is well known, the lack of wage data for other industries has led to debate over whether shifts in relative wages occurred across other sectors. To address this, we construct estimates of wages and hours worked for construction, wholesale trade, retail trade, transportation and public utilities, finance, insurance, and real estate (FIRE), services, and government, in addition to agriculture and manufacturing.

To compute industry wages, we divide total labor income by hours worked. Our measure of total labor income is labor compensation plus 60 percent of sole-proprietors' income with inventory and Capital Cost Allowance (CCA) adjustments. We use Kendrick (1961) hours worked estimates for agriculture, government, manufacturing, mining, and transportation plus public utilities.[17] For the remaining private non-farm industries, total hours are based on Kendrick's estimate of private non-farm hours less hours worked in the aforementioned non-farm industries. Lacking better information, we apportion these hours to each industry using the number of persons engaged in production. All wages are deflated using the GNP deflator, and quantities are per working-age person.

We begin by comparing our estimates of agriculture and manufacturing wages with direct

[17] If we construct hours worked using persons engaged in production and average hours from Denison (1962), we obtain similar hours worked (and hence wages) in agriculture, and slightly smaller declines in hours worked in manufacturing (and hence larger wage declines). This estimate of the manufacturing wage closely tracks the Bureau of Labor Statistics (1939) series for entry wages in manufacturing.

(survey) estimates of wages.[18] Panel B in Figure 1 plots our imputed real wage series as well as commonly cited real wage series for each sector. Our estimate of the manufacturing wage tracks the National Industrial Conference Board's (NICB) average manufacturing wage series closely. Compared to the Alston and Hatton (1991) farm laborer wage series, our agricultural real wage initially declines faster, before rebounding over 1932-1935. This larger fall is not surprising, as most (roughly two-thirds) of the workforce in agriculture were sole-proprietors and there were large swings in farm income during the Depression. Our wage estimates thus imply a slightly larger decline in agricultural wages relative to manufacturing than other estimates. Consistent with the shift in relative wages, manufacturing hours declined by over 40 percent, while hours worked in agriculture declined very little over 1929-32 (see Table 1).

The estimates for the other industries, also shown in Table 1, provide further evidence of large shifts in relative wages during the downturn. They were flat or declined in agriculture, construction, retail trade and FIRE. The workforce in these industries included a significant number of sole-proprietors, and together accounted for more than four-fifths of all self-employed workers (see the last row of Table 1). In the remaining sectors, real wages increased over 1929-33, with larger increases in transportation and government than manufacturing.

While we lack the data to construct industry-specific price deflators, the Cost of Living Index (COLI) data presented in Table 2 shows that the shifts in relative prices largely coincide with those in sectoral wages. Agriculture (Food) and FIRE (Rent), two of the industries where real wages fell, experienced the largest price declines, while Utilities (Fuel) and Services (Miscellaneous), industries where real wages rose, had the smallest.[19]

This heterogeneity in real wages across sectors motivates the two-sector model we construct in Section 3, where the degree of wage rigidity varies by sector. For simplicity, we refer to the sectors as *sticky* and *flexible*. As a simple guide to map the data into the model framework, we allocate industries where real wages rose to the sticky sector (i.e., manufacturing, transportation and communications, government, mining, services, and wholesale trade) and industries where real wages fell (i.e., agriculture, construction, retail trade and FIRE) to the flexible sector. The flexible industries accounted for roughly 41 percent of GDP in 1929.

Panels C and D in Figure 1 plot our sectoral estimates of real wages (computed using the

[18] In 1929, these industries each accounted for roughly 20 percent of employment and over a third of GDP. value-added in agriculture was slightly less than half that of manufacturing.

[19] One issue is that consumption prices are a weighted average of the gross output prices of the sectoral good (e.g., food items) and retail and wholesale services. In the Web Appendix we show that breaking out the distribution component strengthens our conclusion on relative price movements.

GNP deflator) and hours per adult as log-deviations from their third quarter of 1929 values. We use the relative share of hours worked in each industry in 1929 as weights in computing these series. Consistent with a story of sectoral heterogeneity in wage rigidities, real wages rose more, and hours fell more, in the sticky than in the flexible sector.

## 2.3 Real Product Wages, Intermediates and Sectoral Prices

The most commonly adopted proxy for real wages during the Great Depression is the manufacturing wage deflated by some measure of wholesale prices (e.g., see Margo (1993)).[20] The rise in this measure of real product wages accompanied by a decline in hours and output in manufacturing is often cited as evidence for how the deflation of the early 1930s led to a large fall in GDP (e.g., Bernanke (1995), Eichengreen (1995), Eichengreen and Sachs (1985) and Bernanke and Carey (1996)). This is based on the rational that the firms demand for labor is a function of the nominal wage and the output price.

Our analysis challenges this interpretation of the data. Our critique is based on the large fall in the price of less processed goods used as intermediates, relative to final goods, during the early 1930s (see Figure 1.E). This relative price change impacts measured real product wages since sectoral price indexes such as the manufacturing WPI are *gross output* prices. By construction, gross output prices are a weighted average of an implied value-added deflator (i.e. the weighted average of wages and capital costs) and the price of intermediates. Since the share of intermediates in manufacturing production costs exceeded 50 percent, the pass-through of lower intermediate costs significantly reduced the gross output price (i.e. the WPI for manufactured goods).[21] This implies an upward bias in the conventionally measured real product wage.

To examine the quantitative importance of this intermediate channel, we construct implicit value-added deflators for the manufacturing sector as well as for seven frequently studied manufacturing industries, over 1929-33. For these industries, we assemble data on quantities and prices of intermediates and gross output. We employ a sectoral CES produc-

[20] Eichengreen and Hatton (1988) argue that the manufacturing WPI – a sub-index of the WPI – is the appropriate deflator, since the WPI includes both manufactured goods and commodities. We show that use of the manufacturing WPI is not sufficient to control for the large decline in unprocessed good prices due to the pass-through of lower intermediate prices into manufacturing prices.

[21] Recent work finds that factor prices changes pass through into output prices (e.g. Bils and Chang (2000)).

tion function to back out the implied value-added deflator:

$$Y_i = \left[\alpha_i \left(VA_i\right)^{\rho_i} + (1-\alpha_i) Q_i^{\rho_i}\right]^{\frac{1}{\rho_i}},$$

where $VA_i$ denotes the value-added components (a mix of labor and capital), $Q_i$ denotes intermediate goods, and $Y_i$ is gross output in industry $i$. If firms are price takers, the value-added prices, $p_{i,VA}$, the intermediates' prices, $p_{i,Q}$, and gross output prices, $p_i$, satisfy:

$$p_i = \left[\left(\frac{p_{i,VA}}{a_i}\right)^{r_i} + \left(\frac{p_{i,Q}}{1-a_i}\right)^{r_i}\right]^{\frac{1}{r_i}}, \tag{1}$$

where $r_i = \frac{\rho_i}{\rho_i - 1}$, and $a_i = \alpha_i^{\frac{1}{\rho_i}}$.

To back out the value-added deflator, $p_{i,VA}$, implied by gross output and intermediate prices we first parameterize the production function. We set $\rho_i = -.45$, implying an elasticity of substitution between value-added and intermediates of 0.69, the mean estimate of Rotemberg and Woodford (1996) for U.S. manufacturing. We set $\alpha_i$ to match an intermediates' share of expenditure in manufacturing during the interwar period of roughly 55 percent.[22] The manufacturing WPI is our gross output price measure, $p_i$, and the WPI for semi-manufactured goods proxies for the price of intermediates, $p_{i,Q}$ (see the last row in Table 3).[23]

Figure 1.F plots our estimate of the manufacturing valued-added deflator, as well as the manufacturing WPI and the GNP deflator. Taking the pass-through of lower intermediate prices into account, the implied manufacturing value-added deflator falls by less than the GNP deflator. As a result, we find that controlling for the fall in intermediate prices (by using our imputed value-added deflators to compute real product wages) has a large impact on real product wages. While the ratio of nominal wages to the manufacturing WPI increased over 1929 to 1933, real product wages adjusted for intermediate prices were roughly constant over 1929-33, as the fall in nominal wages in manufacturing roughly equaled the fall in our implied value-added deflator (see the last row in Table 4).

As a robustness check, we examine seven manufacturing industries for which data on input and output prices (WPI), intermediates shares and average hourly wages are available.[24] The

[22]The intermediate share is the ratio of intermediates to gross output from the Census of Manufactures.

[23]This understates the pass-through of intermediate prices since raw material prices declined by more.

[24]These industries were examined in Bernanke (1986), as well as Bernanke and Parkinson (1991) and

intermediate share of gross output for these industries in 1929 varied from roughly 54 percent in Iron and Steel to nearly 87 percent in meat-packing. As Table 3 shows, industries with larger declines in intermediate prices tended to have larger declines in their output prices. This effect was larger for industries with relatively less processed intermediates such as meat-packing, leather, and wool, which had larger price declines than those using relatively more processed goods.[25] With the exception of iron and steel (whose measured input prices were flat), the implied value-added deflator for each industry (constructed in the same way as for manufacturing as a whole) fell by more than the corresponding industry's WPI.[26] As a result, in six of the seven industries, real product wages measured using our implied value-added deflator are 7 to 80 percent below the WPI-deflated measure, and actually decline through 1933 (see Table 4). This industry-level pattern is consistent with the manufacturing average, which shows relatively small movements in real wages over 1929-1933.

This leads us to two conclusions. First, the pass-through of intermediate prices has a significant impact on the interpretation of manufacturing price changes, and challenges the standard view that real product wages in manufacturing rose significantly during the downturn. Second, our estimates of real product wages constructed using value-added price deflators increase by less than the real consumption wage (the nominal wage deflated by the GNP deflator).[27]

This shift in real consumption relative to real product wages means that explicitly modeling intermediates may affect the way monetary shocks are transmitted in the context of a two-sector model where the degree of wage stickiness differs across sectors. This motivates our analysis in the following sections, where we use a model with intermediate linkages across industries and sectoral differences in wage rigidity to quantify the contribution of wage rigidities to the U.S. Great Contraction.

Bordo and Evans (1995) who replace meat-packing with petroleum and include the rubber industry. These were all relatively large industries, with meat-packing, iron and steel and automotives each accounting for over 5 percent of total manufacturing gross output.

[25]The one industry which faced flat input prices was iron and steel, as iron ore and coke had very small price declines. Interestingly, iron and steel featured a significant degree of vertical integration, as a large fraction of iron ore production was owned by steel producers (Hines (1951)).

[26]See the Web Appendix for the industry deflators.

[27]Our manufacturing deflator also implies a smaller fall in measured manufacturing output and (thus) TFP than measures of Ohanian (2001) and Amaral and MacGee (2002) who use the GNP defaltor to deflate value added in manufacturing.

# 3 A Two-sector Model with Intermediates

Motivated by our empirical observations, we incorporate intermediates into a standard two-sector closed economy. Both sectors use capital, labor, and intermediate goods as inputs. Since the input-output table for 1929 constructed by Leontief (1951) sees most industries being an important source of their own intermediates, we model the sectoral intermediate bundle as an aggregate of the two sectoral goods. The intermediates bundles used by each industry can differ both in their share of industry gross output as well as in the relative mix of the two goods.

Given our interest in quantifying the impact of heterogeneity in real wages across industries, we assume that our sectors differ in how wages adjust and the labor markets clear. The flexible wage sector has a competitive labor market where wages adjust each period to equate labor demand and supply. The sticky wage sector builds on Bordo, Erceg, and Evans (2000) and features Taylor nominal wage contracting. In this sector, the firm (the short side of the market) decides how much to hire given the (real) product wage. The two-sectoral goods are used to produce the final consumption and/or investment good. To facilitate comparability with the literature, we also follow Bordo, Erceg, and Evans (2000) and introduce a role for money via a standard specification of money in the utility function.

A key issue in any sectoral environment is how to model reallocation. We allow capital to move freely across sectors, but assume workers cannot switch sectors. Hours worked in the sticky sector are determined by firms and do not enter the household's utility function. This amplifies the effect of wage rigidities in our framework, and thus biases our analysis in favour of finding that high real wages were a significant factor in accounting for the downturn.

## 3.1 Environment

### Households

The economy is populated by an infinitely-lived stand-in household with preferences defined over streams of consumption of the final good, $\{C_t\}_{t=0}^{\infty}$, hours of work in the flexible wage sector (sector 1), $\{L_{1,t}\}_{t=0}^{\infty}$ and real money balances, $\left\{\frac{M_t}{P_t}\right\}_{t=0}^{\infty}$, where $P_t$ is the price of the final good. The household chooses consumption, hours of work in the flexible sector, nominal bond holdings, $B_t$, money holdings, $M_t$, capital in each sector, $K_{i,t+1}$, holdings of intermediate goods $Q_{i,t}$, and sales of intermediate goods (bought last period) to firms, $Q_{ij,t}$, so as to solve:

$$
\begin{aligned}
\max \quad & \sum_{t=0}^{\infty} \beta^t \left[ \log C_t - \frac{\mu_L}{1-\sigma_L} L_{1,t}^{1-\sigma_L} + \mu_M \log \left( \frac{M_t}{P_t} \right) \right] && (2) \\
s.t. \quad & B_t = (1+R_{t-1})B_{t-1} + \sum_{i=1}^{2} (J_{i,t}K_{i,t} + W_{i,t}L_{i,t}) + \sum_{i=1}^{2} \pi_{i,t} + X_t \\
& + \sum_{i=1}^{2} \sum_{j=1}^{2} P_{i,t}^s Q_{ij,t} - \left( M_t - M_{t-1} + P_t C_t + P_t \sum_{i=1}^{2} I_{i,t} + \sum_{i=1}^{2} P_{i,t} Q_{i,t} \right), && (3) \\
& K_{i,t+1} = (1-\delta_i)K_{i,t} + I_{i,t}, \qquad i = 1,2, && (4) \\
& Q_{i,t-1} = Q_{ii,t} + Q_{ij,t}, \qquad i = 1,2; j = 1,2, && (5)
\end{aligned}
$$

where $R$ is the nominal interest rate on bonds, $X$ is a lump-sum cash transfer from the government, and $J_i$, $W_i$, $I_i$, $L_i$, $\delta_i$, and $\pi_i$ are sectoral variables: the rental rate of capital, the nominal wage, investment, hours worked, the depreciation rate of capital and sectoral nominal profits, respectively. $Q_{ij}$ denotes intermediates produced by sector $i$ and used in sector $j$. Our timing has the household purchasing period $t-1$ intermediate goods from both sectors, $Q_{i,t-1}$, at prices $P_{i,t-1}$. At the beginning of period $t$ the household sells its holdings of intermediates at price $P_{i,t}^s$. Intermediate goods are akin to investment with this timing.

**Firms**

Sectoral output is produced using a CES production function:

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

where the two intermediates inputs are perfect complements. Firms take sectoral prices, $P_{i,t}$, factor prices and intermediates prices as given when making production decisions to maximize static profits:

$$\max \pi_{i,t} = P_{i,t}Y_{i,t} - \sum_{j=1}^{2} P_{j,t}^s Q_{ji,t} - K_{i,t}J_{i,t} - W_{i,t}L_{i,t}, \tag{6}$$

where $Q_{ji}$ are intermediates produced in sector $j$ and used in sector $i$.

Final output producers buy sectoral goods, $Y_{i,t}^n$, and take sectoral prices and the final good price as given when maximizing profits:

$$\max P_t \left(\eta \left(Y_{1,t}^n\right)^\rho + (1-\eta)\left(Y_{2,t}^n\right)^\rho\right)^{1/\rho} - \sum_{i=1}^{2} P_{i,t} Y_{i,t}^n, \tag{7}$$

where $\rho < 1$ and the elasticity of substitution is $\sigma = \frac{1}{1-\rho}$. The sum of intermediate goods bought by households and final output producers has to equal the total amount of sectoral goods produced: $Y_{i,t} = Y_{i,t}^n + Q_{i,t}$, $i = 1, 2$.

The final good, $Y_t = \left(\eta \left(Y_{1,t}^n\right)^\rho + (1-\eta)\left(Y_{2,t}^n\right)^\rho\right)^{1/\rho}$, can be transformed into consumption or allocated to investment in either sector:

$$Y_t = C_t + \sum_{i=1}^{2} I_{i,t}. \tag{8}$$

**Wage Setting**

While wages adjust freely in sector 1, they are subject to Taylor-type contracts in sector 2.[28] Labor is divided into four equally-sized cohorts. Each period, the contract wages of one cohort are adjusted. The nominal wage the firm pays is a geometric average of the cohort contract wages:

$$W_{2,t} = x_t^{\phi_0} x_{t-1}^{\phi_1} x_{t-2}^{\phi_2} x_{t-3}^{\phi_3}, \tag{9}$$

where $\phi_i$ are cohort weights that sum to 1.

The contract wage in period $t$, $x_t$, depends on the current and future expected nominal wages and labor gaps relative to steady-state, so that:

$$\begin{aligned} \log x_t \quad = \quad & \phi_0 \log W_{2,t} + \gamma(L_{2,t} - \bar{L}_2) + E_t\Big\{\phi_1 \log W_{2,t+1} + \gamma(L_{2,t+1} - \bar{L}_2) \\ + \quad & \phi_2 \log W_{2,t+2} + \gamma(L_{2,t+2} - \bar{L}_2) + \phi_3 \log W_{2,t+3} + \gamma(L_{2,t+3} - \bar{L}_2)\Big\}, \end{aligned} \tag{10}$$

where $\gamma$ is a labor-gap adjustment parameter to be estimated.

Setting cohort weights to be the same, $\phi_i = 0.25$, repeated substitution of (9) into (10) yields the current contract wage as a function of past and expected future contract wages

[28] The Taylor contract assumption makes our results comparable to Bordo, Erceg, and Evans (2000).

and the current and expected labor gaps:

$$\begin{aligned}\log x_t &= \frac{1}{12}\log x_{t-3} + \frac{1}{6}\log x_{t-2} + \frac{1}{4}\log x_{t-1} + \gamma\left(L_{2,t} - \bar{L}_2\right) \\ &+ E_t\Big\{\frac{1}{4}\log x_{t+1} + \frac{1}{6}\log x_{t+2}\frac{1}{12}\log x_{t+3} + \sum_{k=1}^{3}\gamma\left(L_{2,t+k} - \bar{L}_2\right)\Big\}.\end{aligned} \tag{11}$$

**Money**

The growth rate of the stock of money follows an exogenous AR(1) process:

$$g_t = \log M_t - \log M_{t-1}, \tag{12}$$

$$g_{t+1} = g + \rho_m g_t + \epsilon_{t+1}, \tag{13}$$

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

**Equilibrium**

Given the law of motion for the growth rate of money, the nominal variables are non-stationary, therefore we rescale them by the stock of money. Let $\tilde{P}_t = \frac{P_t}{M_t}$, $\tilde{B}_t = \frac{B_t}{M_t}$, $\tilde{P}_{it} = \frac{P_{it}}{M_t}$, $\tilde{P}^s_{it} = \frac{P^s_{it}}{M_t}$, $\tilde{J}_{it} = \frac{J_{it}}{M_t}$, $\tilde{W}_{it} = \frac{W_{it}}{M_t}$, $\tilde{X}_{it} = \frac{X_{it}}{M_t}$, and $\tilde{x}_t = \frac{x_t}{M_t}$.

Given $g_0$, $M_0$, $K_{i,0}$, and the laws of motion (12) and (13), an equilibrium is quantities $\left\{\tilde{B}_t, C_t, K_{i,t}, Q_{i,t}, Y_{i,t}, Y^n_{i,t}, L_{i,t}, \tilde{X}_t, \pi_{i,t}\right\}_{t=0}^{\infty}$, and prices $\left\{\tilde{J}_t, \tilde{P}_t, \tilde{P}_{i,t}, \tilde{P}^s_{i,t}, R_t, \tilde{W}_{i,t}, \tilde{x}_t\right\}_{t=0}^{\infty}$, such that households, firms in each sector and final good producers solve the problems described above subject to market clearing conditions. In equilibrium, $\tilde{B}_t = 0$, as there is one representative household; $\tilde{\pi}_{i,t} = 0$, 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 household's and firms' first-order conditions, together with the wage setting equations (9), and (10) and the market clearing conditions for the final and sectoral goods constitute the set of necessary conditions. We solve the model by log-linearizing around the non-stochastic steady-state and applying the techniques described in Uhlig (1999).

## 3.2 Parameterization and Calibration

We adopt a mixture of parameterization and calibration to select reasonable parameter values for our model economy. A summary of parameter values and targets appears in Table 5.

We assume that each period in the model lasts one quarter. We set $\beta = 0.99$, which implies an annual risk-free return of roughly 4%. The quarterly depreciation rate of capital for both sectors is 0.025. We choose $\sigma_L = -0.5$ so that the Frisch elasticity is 2, and given this, we set $\mu_L$ so that steady-state total market time, $\bar{L}_1 + \bar{L}_2$, is one third. Since $\mu_M$ has no effect on the dynamics of the system we follow Bordo, Erceg, and Evans (2000) in setting it.

We allocate industries to the flexible or the sticky sector based on whether the industry real wage increased or decreased during the Great Contraction.[29] To compute the labor share in each sector, we follow the convention that ambiguous income sources (such as proprietors' income) breakdown between capital and labor income in the same proportion as unambiguous income sources. Since our model abstracts from a government sector and residential housing, we follow Gomme and Rupert (2007) in excluding income from these sources. Unambiguous labor income is total compensation of private employees less housing compensation of employees, while unambiguous capital income is rental income plus net interest income plus corporate profits plus capital consumption for private, nonresidential capital less housing rental income, housing net interest income and housing corporate profits.[30] The average labor share in 1929 is roughly 0.7 in both sectors, which leads us to set $\theta_1 = \theta_2 = 0.3$ (i.e. the capital share of value-added is 30 %).

The targets for sectoral production parameters ($\alpha_i$, $\rho_i$, and $\chi_i$) are: (i) the gross output share of intermediates in the flexible (sticky) sector is 32% (38%); (ii) the share of flexible intermediates in total intermediates is 39% (31%) in the flexible (sticky) sector; and (iii) the elasticity of substitution between value-added and intermediates in both sectors is 0.69.

Our sectoral estimates are based on the weighted average of industry level data. For manufacturing and transportation we use the 1929 input-output table of Leontief (1951) and the Statistical Abstract of the U.S. to estimate value-added shares (0.45 and 0.66, respectively) and a share of intermediates coming from the flexible sector of 0.35 and 0.26, respectively.[31] In mining, our value-added estimate is 0.83, which is the average value across

[29] This allocation rule is consistent with the question our experiment in Section 4 seeks to answer: whether high real wages in some sectors contributed to the Great Contraction. In the Web Appendix we conduct a robustness check by shifting FIRE from the flexible to inflexible sector, and reach similar conclusions to those presented in Section 4.

[30] Our measure of private sector CCA excludes sole-proprietors' income. Although this is not significant for the economy-wide average, it does matter for the labor share at the industry level.

[31] Since Leontief (1951) does not distinguish between investment and consumption goods, we assume that flows from iron and steel manufacturers to other industries are investment, which we assign to final output.

1919 and 1954 (Table Db1-11, Historical Statistics of the United States). Given the limited input-output data for service sector industries, we use 2002 Census data on business expenses in trade, which lumps wholesale and retail together. This implies a value-added share of 77% and a share of flexible intermediates of 25%. We assume that the numbers for services, communications and government are the same as for trade. Turning to the flexible sector, the value-added share in gross output in agriculture in 1929 was 0.49, with a share of flexible intermediates of 0.69 (Leontief (1951)). The 1930 Census data for construction implies a value-added share of 0.57. Construction uses very little flexible-sector inputs, so we make the educated guess that their share is 10% (we use the same number for mining). We assume that the numbers for FIRE are the same as those in trade.

To convert these values into sector averages, we weight each of these industry shares by their value-added share in their respective sector. This implies an intermediate share in the flexible sector of $1 - \alpha_1 = 0.316$, 39% of which is allocated to flexible intermediates. For the sticky sector, the intermediate share is $1 - \alpha_2 = 0.384$, with 31 % being allocated to flexible intermediates. The elasticity of substitution between value-added and intermediates is set to 0.69, which is the mean value estimated by Rotemberg and Woodford (1996) for U.S. manufacturing industries. To complete the sectoral part of our calibration, we assume intermediates are perfect complements.[32]

The elasticity of substitution between sectoral goods in the final good aggregator, $\frac{1}{1-\rho}$, and the share of flexible goods in final good production, $\eta$, are jointly calibrated to match the flexible-sector share of GDP in 1929 (0.42 according to our sectoral breakdown) and to minimize the squared distance between model and data, in this same share, over 1930-33.

Similarly, in calibrating $\gamma$, the crucial parameter regulating nominal wage adjustment in the sticky sector, we minimize the squared distance between this sector's real consumption wage, $\frac{W_2}{P}$, in the model and the data over 1929-33.

Our raw money supply measure is M1 from Friedman and Schwartz (1963)(Table A-1). Consistent with our model, we use M1 per adult when estimating the parameters in the money growth rate's law of motion, equation (13), from the second quarter of 1922 to the last quarter of 1928. The estimates we obtain are $\hat{g} = 0.0015$ and $\hat{\rho}_m = 0.44$.

[32]In section 4.1.1 we relax this assumption and conduct some sensitivity analysis.

# 4 Real Wage Rigidities and the Great Contraction

We use our calibrated model to quantity the contribution of wage rigidities to the Great Contraction. Our strategy follows that of Bordo, Erceg, and Evans (2000), as we input the estimated money supply growth shocks from 1929:4 to 1936:4 into our calibrated model economy.[33] To evaluate the role of intermediates, we replicate our baseline experiment in a version of our model without intermediate linkages.

Our experiments yield two main insights. First, contrary to the established view, we find that deflation and wage rigidity account for less than a quarter of the fall in output during the Great Contraction. Second, we find that it is intermediates rather than a two-sector model *per se* that is key to our results. The impact of sectoral wage rigidities on GDP is nearly twice as large in a model economy without intermediates than in our benchmark (see Figure 6.A). Moreover, we show that a one-sector version of the model delivers the same aggregate fall in output as the two-sector model without intermediates – provided the real wage rigidity is calibrated so that the real consumption wage in the two environments are the same.

## 4.1 Impact of Contractionary Monetary Shocks

Figures 2 and 3 show the key aggregate and sectoral variables (along with their data counterparts) that result from inputting the estimated money supply growth shocks from 1929:4 to 1936:4 into our calibrated model economy.

We find that wage rigidities can account for only a fifth of the fall in GDP at the trough (Figure 2.A). This is an upper bound estimate, as the aggregate real wage in the model (averaging across the flexible and sticky sectors) is higher than that observed from 1929 to 1934 (Figure 2.C). Despite the higher real wage, the fall in hours in the model is less than half of that observed in the data (Figure 2.D). The aggregate price of the final consumption/investment good closely tracks the GNP deflator until 1935 (Figure 2.B).

Behind the aggregate numbers are large shifts in relative sectoral wages and prices due to the sectoral asymmetries in wage rigidity. These shifts, in turn, result in changes in sectoral *real product wages* and *real consumption wages*, which interact with intermediate linkages to shape the sectoral responses to a contractionary monetary shock (see Figure 3).

[33] We assume that the economy was at its steady-state in the third quarter of 1929. In the Web Appendix we present an experiment where we relax this assumption.

While prices and nominal wages decline in both sectors, they fall by less in the sticky sector, where staggered wage contracts cause nominal wages to decline slower than prices following a contractionary monetary shock. This means that the aggregate price level declines by more than the sticky-sector price, but by less than the flexible-sector price (Figure 3.C and D). It also means that the sticky real consumption wage rises by more than the sticky real product wage.

Our calibration strategy chooses the wage rigidity parameter, $\gamma$, so as to match the real consumption wage in the sticky sector during the contraction (Figure 3.H). Since the model generates a larger decline in the sticky-sector price than in the data (Figure 3.D), the sticky real product wage increases more than in the data. As hours in the sticky sector are determined by the firm's labor demand schedule, they are decreasing in the real product wage. This biases our calibration strategy towards finding a larger decline in output.

Intermediates mitigate the impact of high real wages in the sticky sector. The price of the sticky-sector intermediate bundle falls relative to the cost of labor, since it is a weighted average of the sectoral goods prices (see Figure 3.I). This induces a substitution of intermediates for sticky-sector labor, which increases the ratio of intermediates to hours (notice how intermediates usage in Figure 3.J fall less than hours in Figure 3.F). In effect, this enables the sticky firm to substitute flexible-sector labor (embodied in the intermediates) for more expensive sticky labor. Indirectly, this further offsets the impact of high sticky wages by pushing up the marginal product of labor.

In the flexible sector, hours depend on labor supply and demand. The (nominal) labor supply schedule falls, despite a negative wealth effect, because the aggregate price falls. The labor demand schedule is lowered by the fall in the relative price of the flexible good, as well as by the relative increase in the cost of intermediates. This results in a decline in both flexible hours and the flexible real consumption wage, while the real product wage remains roughly constant, as sectoral prices and wages fall by similar amounts. As a consequence, the sticky real consumption wage rises by more than the economy-wide real consumption wage (as the flexible real consumption wage falls).

#### 4.1.1 Sensitivity analysis

To assess the sensitivity of our quantitative conclusions, we repeat our experiment for several alternative values of the elasticity of substitution both at the sectoral level as well as in final good production. In these experiments we adjust the elasticity of substitution in final good production, $\rho$, the share of each sector in final production $\eta$, and the wage rigidity parameter, $\gamma$, to match our aggregate calibration targets.

Figure 4 compares our benchmark economy with intermediates to two alternatives: one where the elasticity of substitution between value-added and intermediates is 1 (labeled "Sectoral C-D"), and another where the sectoral intermediate aggregator is Cobb-Douglas (labeled "Intermediates C-D") instead of Leontief.[34] In both cases, GDP falls by more than in the benchmark (panel A). In the absence of sectoral differences in wage rigidity, a monetary shock would not impact *relative* sectoral prices. Thus, the larger change in the relative price of sticky to flexible goods (see panel B) indicates the sectoral wage rigidity is more distortionary than in the benchmark. Why does the sticky good become relatively more expensive compared to the benchmark? In the "Sectoral C-D" case, flexible-sector firms substitute away from intermediates and into (cheaper) labor, while sticky-sector firms substitute away from expensive labor and into intermediates. Since flexible labor is relatively cheaper than intermediates, the flexible good becomes relatively cheaper. In the "Intermediates C-D" case, firms in both sectors substitute away from sticky intermediates and into flexible ones. This causes a relative increase in the sticky-sector price for 2 reasons: (i) sticky intermediates have a larger share in sticky production than in flexible production, and (ii) while the sticky sector's real consumption wage path is the same as in the benchmark, it is lower in the flexible sector, which induces substitution towards (relatively) cheaper labor.

This leads to a larger output decline than in the benchmark for two reasons. First, the aggregate price level declines by less (recall the sticky sector accounts for nearly 60% of value-added output). Since our calibration targets the same real sticky consumption wage, this results in a larger wage rigidity parameter. This parameter change accounts for nearly one-third of the larger output decline. Second, the shift in prices impacts sectoral labor demand and output. In the flexible sector, the larger fall in prices and lower intermediate usage pushes down labor demand and output. In the sticky sector, the reduced use of intermediates acts like a negative productivity shock, which is only partially offset by the relatively higher price of the sticky good. As a result, output falls by more in both sectors than in the benchmark.

Finally, the aggregate results are not sensitive to (local) variation in the elasticity of

[34] See the supplementary appendix we report the results if we set the the elasticity of substitution between value-added and intermediates to 0.5 or 0.9.

substitution between sectoral goods in final good production. In our benchmark, $\rho$ is chosen to match the observed path of sectoral value-added shares. Figure 5 shows that varying the elasticity of substitution up to 1 ($\rho = 0$) and down to one third ($\rho = -2$) does not substantially change aggregate GDP (panel A).[35] However, moving away from our benchmark towards Cobb-Douglas ($\rho = 0$) is inconsistent with the observed fall in the flexible sector's share of GDP (panel B), as it generates a much smaller shift in relative prices.

While the first two sensitivity experiments suggest a larger role for wage rigidities during the Great Contraction, they carry important counterfactual implications. The "Sectoral C-D" case, unlike our benchmark specification, is inconsistent with the fact that the intermediate share of gross output in manufacturing (agriculture) fell (rose) over 1929-33.[36] Regarding the elasticity of substitution between different types of intermediates, which we set to one in the "Intermediates C-D" case and assume is zero in the benchmark, it seems reasonable to think that the substitutability between fairly granular inputs (e.g. substituting steel for wood in automobiles) at such a short horizon should be low.

A possible concern is that our calibration overestimates the share of efficiency-weighted labor accounted for by the flexible sector. Our benchmark calibration assumes hours supplied in both sectors are equally productive and targets the sectoral value added shares of GDP, which implies that 41 percent of hours in 1929 were supplied to the flexible sector. While this is below our data estimate of total hours worked in that sector (44 percent), our estimate of average hourly wages in the flexible sector is only 57 percent of that in the sticky sector. Using this measure of relative productivity, we find that the share of efficiency units of labour accounted for by the flexible sector in 1929 was only 31 percent.[37]

To check whether this has a large quantitative impact on our estimates, we scale down the productivity of hours worked in the flexible sector by a factor of 0.65 so that the implied share of efficiency hours worked is equal to the data.[38] When we replicate our benchmark experiment from Section 4.1, recalibrating the parameters so as to match the same targets, aggregate output falls by only 2 percentage points more at the trough than in our benchmark.

[35] When we vary $\rho$, the other parameters are chosen to continue to match the targets in Table 5.

[36] An elasticity of one between between value-added and intermediates is well above our benchmark (0.69), which is already at the higher end of the estimates in the literature. Rotemberg and Woodford (1999) cite estimates roughly half as large as the one we use, which would lead to even smaller decreases in GDP.

[37] Specifically, we normalize the efficiency units of an hour of inflexible worker in 1929 to one, and then use the wage ratio and the respective hours shares to obtain $\frac{.57(.44)}{.57(.44)+.56} \simeq .31$.

[38] This factor is chosen so that the scale factor times our benchmark model hours yields a share of efficiency weighted hours equal to roughly 31 percent: $\frac{.65(0.41)}{.65(0.41)+.59} \simeq .31$.

Finally, a word on adjustment costs. We do not run an experiment with a specification where there are adjustment costs on capital and/or labor. We chose this course of action not only because we want to allow the model the best chance of accounting for the fall in output, but also for empirical reasons. Indeed, as Bordo, Erceg, and Evans (2000) show, allowing for labor adjustment costs results in a shallower downturn. Moreover, the model's predictions for the behaviour of hours in our benchmark without adjustment costs already fall short of the data (see panels E and F in Figure 3). The capital dynamics implied by the model are relatively modest, with the model's predicted total capital stock falling by roughly 7 percent in 1933, which is in line with what we found in Amaral and MacGee (2002).[39]

## 4.2 Are Intermediates Quantitatively Important?

To quantify the effect of intermediates, we drop them from the model economy and repeat our experiment. We leave the other features of the model economy, as well as the aggregate calibration targets, unchanged.[40]

While the outcomes are qualitatively similar to those of the benchmark economy, the quantitative impact of wage rigidities is much larger. In the economy without intermediates, the fall in output is almost twice as large as in our benchmark, accounting for nearly 40% of the fall in GDP from 1929 to 1933 (Figure 6.A). This is driven by a larger decline in hours worked (Figure 6.D). Importantly, this larger fall in hours occurs despite a smaller increase in the average real wage for all workers (Figure 6.C) than in the economy with intermediates.

The sectoral variables follow a similar pattern, with output and hours falling by more in the model without intermediates, despite lower real product wages in both sectors. In the flexible sector, this is driven mainly by lower wages, as the flexible-sector price follows similar paths with and without intermediates (see Figure 7.I). In the sticky sector, the smaller rise in the real product wage is mainly due to a smaller decline in the sticky-sector price (relative to the final good) in the economy without intermediates (compare Figure 6.B to Figure 7.J).

If the sticky real product wage is higher and sticky hours are determined by the firms' labor demand schedule, how can hours fall by less in the benchmark economy? The key reason is that the intermediate bundle uses both sectoral goods. Since the flexible-sector

[39]The largest quarterly declines in sectoral capital stocks implied by the model are always less than depreciation, which also points to a small potential role for capital adjustment frictions.

[40]The parameter values that change in the no-intermediates economy are reported in Table 5, under "No-intermediates version".

price falls relative to the sticky good, the price of the intermediate bundle sticky-sector firms buy falls relative to the price of labor. This relative price drop acts as a positive shift in the marginal product of labor schedule by increasing the ratio of intermediates to labor, which partially offsets the effect of higher real wages:

$$\frac{w_i}{p_i} = (1-\theta_i)\alpha_i \frac{\left(K_{i,t}^{\theta_i} L_{i,t}^{1-\theta_i}\right)^{\rho_i}}{L_{i,t}} \left[\alpha_i \left(K_{i,t}^{\theta_i} L_{i,t}^{1-\theta_i}\right)^{\rho_i} + (1-\alpha_i)\left[Q_{i,t}\right]^{\rho_i}\right]^{\frac{1}{\rho_i}-1}.$$

As a result, in the no-intermediates economy, sticky hours fall by more despite a lower real product wage.

There is a second, more subtle, reason why output decreases by less under the presence of intermediates. Holding the wage adjustment parameter, $\gamma$, fixed, the aggregate price level falls by more in the economy with intermediates. This follows from the quantity equation: since output falls by less with intermediates, the price level must fall by more in response to the fall in money supply. In turn, this implies that the intermediates economy requires less "rigid" wages (i.e. a higher value of $\gamma$, see Table 5) to match the same increase in the sticky-sector real consumption wage (Figure 7.F). The smaller distortion, in turn, lessens the impact of a contractionary monetary shock on hours and output.

Intermediates also dampen the impact of monetary shocks on flexible-sector output (Figure 7.A). Intuitively, the larger fall in the price of the final good results in a smaller fall in the flexible sector real consumption wage, and thus a movement along the labor supply schedule. The flexible labor demand schedule falls more in the economy with no intermediates, where capital falls by 17% at the trough, than in the economy with intermediates, where capital and intermediates fall by roughly 12%. These forces combine to result in a smaller fall in flexible hours and output in the economy with intermediates. Because of the smaller decline in the flexible-sector real consumption wage, the average (economy-wide) real wage is higher in the economy with intermediates than in the no-intermediate case.

An alternative way to show that it is intermediate linkages, rather than sectoral differences in wage rigidities alone, that are key to our quantitative findings, is to compare our two-sector environments (with and without intermediates) to a one-sector version based on the sticky sector. To allow for a direct comparison, we calibrate the wage rigidity parameter in the one-sector model so that it generates the same economy-wide real wage over 1929 to to 1933 as the one produced by each of the two-sector economies (with and without intermediates).[41]

We find that the one-sector economy and the two-sector economy without intermediates generate a nearly identical fall in output (compare "No-intermediates" to "One-sector" in Figure 8.A). However, when we compare the one-sector model to our benchmark economy with intermediates, we find very different implications. As Figure 9.A shows, output declines substantially less in the economy with intermediates than in its one-sector counterpart.

We take two key messages from these experiments. First, sectoral heterogeneity in wage rigidity alone does not imply materially different predictions for the impact of a contractionary monetary shock than an appropriately calibrated one-sector model. Second, incorporating intermediate linkages with sectoral heterogeneity in wage rigidity reduces the quantitative contribution of high real wages to the Great Contraction.

### 4.2.1 Discussion: Wage Rigidity, Intermediates and the Great Contraction

While our focus on intermediates is novel, we contribute to a debate over the quantitative importance of nominal wage rigidity in the U.S. Great Contraction. In this section, we briefly outline the insights that our work brings to this debate.

In a well cited paper, Bordo, Erceg, and Evans (2000) conclude that wage rigidities account for roughly 70% of the output decline over 1929 to 1933. In contrast, Cole and Ohanian (2001) employ a two-sector model to evaluate the impact of high real wages, and conclude that sticky wages account for less than a sixth of the fall in output. However, Gertler (2001) and Bordo, Erceg, and Evans (2001) argue that both the data and the model approach raise questions as to the robustness of Cole and Ohanian (2001) findings.

Our quantitative analysis in Section 4.2 indicates that Bordo, Erceg, and Evans (2000) and Cole and Ohanian (2001) reach different conclusions primarily as a result of targeting different aggregate real wage series. When we reproduce the one-sector model of Bordo, Erceg, and Evans (2000) but calibrate the wage rigidity parameter, $\gamma$, to match the economy-wide real wage in our two-sector model without intermediates, we find a nearly identical output decline (compare "No-intermediates" to "One-sector" in Figure 8).[42] In other words, the two-sector (without intermediates) and one-sector models have similar aggregate predictions when the wage rigidity parameter is calibrated to match the same economy-wide average

[41] We choose the other parameters to continue to match the common targets in Table 5.

[42] The $\gamma$ required to match the same economy-wide real wage varies with model structure.

real wage.[43] Explicitly modeling intermediates breaks this equivalence, as our model with intermediates delivers an output decline half as large as that of a one-sector model calibrated to match the same aggregate real wage.

Although our benchmark experiment yields a slightly larger quantitative contribution of high real wages to the Great Contraction than Cole and Ohanian (2001), our overall conclusion is similar. However, our framework addresses the key technical criticisms raised by Gertler (2001) and Bordo, Erceg, and Evans (2001) of the Cole and Ohanian (2001) exercise. First, our calibration results in a sticky-wage sector roughly twice as large as in Cole and Ohanian (2001). Second, we explicitly incorporate nominal rigidities in our sectoral model by "nesting" the one-sector framework of Bordo, Erceg, and Evans (2000). Finally, we abstract from productivity growth which offsets the impact of wage rigidities. Indeed, our finding is arguably an upper bound estimate of the contribution of high real wages, since our benchmark real wage is higher than our data estimate of the economy-wide real wage.[44]

By modeling intermediates, we address a key critique of the "sectoral hetereogeneity in wage rigidity" mechanism. In the two-sector model, a contractionary monetary shock increases the sticky-sector good price relative to the flexible-sector one. This results in a larger rise in the sticky-sector real consumption wage than in the real product wage. The question of whether this is consistent with the data is controversial. A common view, cogently outlined by Bordo, Erceg, and Evans (2001) is that since the wholesale price of manufactures fell by more the GNP deflator (or the COLI), manufacturing real product wages (a proxy for the sticky sector) increased relative to manufacturing real consumption wages during the Great Contraction. As they point out, while a two-sector model with sectoral heterogeneity in wage rigidities is consistent with the divergence in relative nominal wages across industries, it is seemingly at odds with the fact that manufacturing real product wages (deflated by the manufacturing WPI) increase by more than real consumption wages over 1929-33.

Our work suggests that accounting for intermediate prices largely resolves this critique. The calculations in Section 2.3 show that when one uses the implied value-added deflator to compute manufacturing's real product wages, these go up by at most 4% (see Table 4), while manufacturing's real consumption wages go up by over 10% (Figure 1.B), which is consistent

[43] Herrendorf, Rogerson, and Valentinyi (2011) come to a similar conclusion when they compare one- and two-sector models for the purpose of explaining differences in cross-country growth.

[44] Our model generates a lower real economy-wide wage than that targeted by Bordo, Erceg, and Evans (2000). Their finding of a larger decline in output, shown in Figure 8 as "BEE", results from targeting a real wage series close to our sticky-sector estimate, rather than our economy-wide real wage.

with the predictions of our two-sector model with intermediates. This is due to the implied manufacturing value-added deflator rising by less than the GNP deflator.

This highlights the distinction between gross output and value-added prices with intermediates. Unlike sectoral prices in "standard" value-added models, a sectoral gross output price is a weighted average of the value-added deflator (itself a weighted average of the input prices) and the cost of the intermediate bundle. Because this last component is a weighted average of the sticky and flexible prices, the price of the sticky intermediate bundle (the dashed line in Figure 3.I) declines relative to its value-added price (the dotted line in Figure 7.H). As we show, this distinction is important during periods of large relative price shifts.

One dimension along which the two-sector model with intermediates cannot match the data concerns the relationship between the sticky-sector's gross output price and the GNP deflator. In the data, the WPI for manufactured goods declines by more than the GNP deflator due in part to the pass-through of large declines in intermediate prices. In the model, as we increase the flexible share of intermediate goods in the sticky sector, we find that the gross output price of the sticky-sector good declines more. However, in a two-sector model, the price of final output is a weighted average of the two-sectoral goods. As a result, the sticky sector's gross output price must decline by less than the price of the final good.

In an environment with three or more sectors, one can construct input-output structures where the gross output price of at least one sticky-wage sector declines by more than the price of final output. For example, if one were to divide the sticky sector into two sub-sectors, with one sector having a large intermediate share of flexible sector goods and the other a small share, one could easily generate a case where the gross output price in the former sector would fall by more than the average price of the final good.[45]

Our finding of a small contribution of high real wages to the U.S. Great Contraction is seemingly at odds with Ohanian (2009), who argues that President Hoover's public request of major manufactures not to cut (nominal) wages or employment was a key contributor to the Great Contraction. Although Ohanian (2009) does not explicitly model rigid wages, our papers share a two sector structure where real wages in one sector are calibrated to sectors such as manufacturing while wages in the other sector are free to adjust. Our benchmark experiment captures any effect that Hoover may have had on manufacturing wages, since this is included in the sticky sector real wage we target. However, as our discussion in Section

[45]This parametrization is consistent with the data, as manufacturing had a much higher intermediate share than the sticky-sector average.

2.3 as well as our model results illustrate, taking intermediates into account significantly reduces the impact of high real wages on manufacturing employment and output.[46]

In addition to intermediates, the Ohanian (2009) production structure differs from this paper in that a reduction in average hours worked per worker effectively acts to reduce sectoral productivity.[47] He argues that by publicly encouraging firms to adopt a policy of work sharing to avoid lay-offs, President Hoover contributed to a fall in the average hours worked in manufacturing. In his experiments, Ohanian (2009) takes the observed fall in average hours per worker as an exogenous input. This plays a key role in amplifying the effect of high real wages in the "sticky wage" sector, and thus in delivering a fall in output. However, this also implies an even larger rise in the sticky sector price relative to the average price level in the economy. As a result, this mechanism (a fall in hours per worker) is subject to the Bordo, Erceg, and Evans (2001) critique that it implies a shift in relative prices not observed in the data.

This points to the questions of what impact would productivity shocks have in our model? To examine how TFP shocks impact our quantitative findings, we repeat our benchmark experiment (Section 4.1) with sectoral TFP shocks together with contractionary monetary shocks. Lacking direct measures of sectoral TFP, we calibrate the sectoral productivity shocks to match the trough in each sector. As a result of this calibration, the model exactly matches the decline in sectoral output, as well as the corresponding aggregate decline, shown in panel A of Figure 10. Since (negative) productivity shocks lower the marginal product of labor schedule, this calibration implies a larger fall in hours (panel C) and a smaller fall in measured TFP than in the data (panel D).[48] Because of the drop in efficiency, the aggregate price level is now counterfactually higher, as shown in panel B of Figure 10, dropping by less than half relative to the data, at the trough.

When we decompose the contribution of TFP shocks and contractionary monetary shocks to the fall in output, we find that TFP accounts for roughly two-thirds, with the contractionary monetary shocks accounting for a third.[49] We also find that real wages do little to

[46] Rose (2010) argues that the Hoover intervention to discourage wage cuts had little impact, as there is little evidence that firms which attended the conferences organized by Hoover were slower to cut wages than firms that did not attend.

[47] Specifically, Ohanian (2009) assumes a sectoral production function $y = he_s^{\gamma}k_s^{1-\gamma}$, where $h$ is hours per worker and $e$ is the number of workers.

[48] We use measured aggregate TFP from Amaral and MacGee (2002). See the Web Appendix for more details on this experiment.

[49] This decomposition is broadly consistent with Cole, Ohanian, and Leung (2005), who examine cross-

amplify the effect of productivity, as the fall in output when the two shocks operate together is roughly equal to the sum of what we find when we input the shocks separately. Overall, this leads us to conclude that productivity shocks are not a promising mechanism to overturn our conclusion that nominal wage rigidities were a modest contributor to the Great Contraction.

## 5 Conclusion

Our results yield two important messages for the debate over the quantitative role of wage rigidities during the Great Contraction. First, contractionary monetary shocks coupled with nominal wage rigidities played a modest role in the downturn. In our benchmark model with intermediates, we find that wage rigidities account for less than a fifth of the output decline. This is likely an upper bound, as the economy-wide real wage in the model exceeds our estimate for the U.S.

Second, we find that the input-output structure of the economy is quantitatively important for the debate over the role of sectoral heterogeneity in wage rigidity in this period. Our comparison of the two-sector model (without intermediates) with a one-sector version suggests that the Bordo, Erceg, and Evans (2000) and Cole and Ohanian (2001) debate is largely about different views on aggregate real wages during the Great Contraction, as we find nearly identical declines in output when one targets the same aggregate real wage. Importantly, however, the introduction of intermediates breaks this link, as our model with intermediates delivers half as large an output decline compared with a one-sector model calibrated to match the same aggregate real wage.

While we focus on the U.S. experience, nominal wage rigidities are also cited as a key factor in accounting for the cross-country nature of the Great Depression, with Eichengreen and Sachs (1985) and Bernanke and Carey (1996) arguing that deflation experiences are correlated with cross-country variation in measured real product wages. Our results suggest that a closer examination of the empirical work on cross-country real wage data and economic performance during the Great Depression is warranted. Several authors (e.g., Eichengreen and Hatton (1988)) have argued that using the WPI for manufactured goods, instead of the WPI itself, corrects for the large fall in the price of unprocessed intermediates. Our findings

country data on real wages and output through the lens of a a Lucas (1972)-type misperception model.

suggest that this approach likely overstates the rise in real product wages, and that using manufacturing real product wages as a proxy for the real wage may be misleading.

Finally, our findings also suggest that while the multi-sectoral linkages we examine are important in accounting for the sectoral disparities observed during the Great Contraction, they must have interacted with other price shocks, as contractionary monetary shocks on their own fail to generate enough action in output. We conjecture that modeling international trade, particularly in commodities, where price changes were very significant in this period, might be a fruitful avenue to pursue in future research regarding the cross-country spread of the Great Depression.

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Table 1: **Sectoral labor market statistics (per adult, 1929=100)**

Hours Worked

| Year | Agric. | Constr. | Retail | FIRE | Flex. | Manuf. | Transp. | Gov. | Min. | Serv. | Wholesale | Sticky | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1929 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 1930 | 97.6 | 91.3 | 92.6 | 94.9 | 95.0 | 83.5 | 89.9 | 101.3 | 83.3 | 93.9 | 93.1 | 89.6 | 91.9 |
| 1931 | 98.0 | 80.7 | 85.0 | 88.6 | 91.0 | 67.2 | 75.3 | 100.8 | 64.3 | 85.8 | 82.4 | 77.5 | 83.5 |
| 1932 | 93.4 | 64.5 | 75.3 | 81.8 | 83.1 | 53.0 | 60.8 | 96.6 | 49.0 | 76.0 | 72.4 | 65.5 | 73.4 |
| 1933 | 92.0 | 53.5 | 73.9 | 77.7 | 80.3 | 56.1 | 56.3 | 113.7 | 51.4 | 72.5 | 71.2 | 66.4 | 72.6 |

Real Wages

| Year | Agric. | Constr. | Retail | FIRE | Flex. | Manuf. | Transp. | Gov. | Min. | Serv. | Wholesale | Sticky | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1929 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 1930 | 78.2 | 92.3 | 99.6 | 95.4 | 91.1 | 104.0 | 103.8 | 104.5 | 106.2 | 102.5 | 103.7 | 104.4 | 98.9 |
| 1931 | 65.4 | 80.6 | 99.9 | 97.4 | 84.2 | 109.1 | 112.4 | 116.3 | 109.0 | 106.6 | 107.4 | 111.1 | 99.6 |
| 1932 | 49.5 | 59.3 | 91.6 | 98.9 | 72.6 | 108.7 | 116.8 | 127.9 | 111.30 | 107.4 | 103.5 | 113.5 | 96.3 |
| 1933 | 55.7 | 53.3 | 85.1 | 98.0 | 70.5 | 106.0 | 115.2 | 113.3 | 106.3 | 101.8 | 92.7 | 111.5 | 94.2 |

% Self-Employed

| Year | Agric. | Constr. | Retail | FIRE | Flex. | Manuf. | Transp. | Gov. | Min. | Serv. | Wholesale | Sticky | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1929 | 66 | 36 | 31 | 10 | - | 1 | 4 | 0 | 2 | 21 | 6 | - | 23 |

Source: Hours data from Kendrick (1961). Hours are per working-age person.
Note: Transp. is Transportation, Communications and Public Utilities.

Table 2: **Price Indices (1929=100)**

| | | | | COLI | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | GNP Defl. | WPI (Man.) | VA Defl. (Man.) | All | Food | Cloth | Rent | Fuel | H. Furn. | Misc. |
| 1929 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 1930 | 96.9 | 93.1 | 100.8 | 97.5 | 95.1 | 97.7 | 97.2 | 99.0 | 97.5 | 100.5 |
| 1931 | 88.1 | 81.5 | 92.1 | 88.7 | 78.4 | 89.0 | 92.1 | 96.8 | 87.7 | 99.5 |
| 1932 | 78.4 | 74.4 | 89.9 | 79.7 | 65.3 | 78.8 | 82.7 | 91.9 | 76.5 | 97.2 |
| 1933 | 76.7 | 74.6 | 81.2 | 75.4 | 63.5 | 76.2 | 71.2 | 88.9 | 75.4 | 94.1 |

Source: GNP deflator is from Balke and Gordon (1986).
COLI data is from Table 5 in *Cost of Living in 1941*, BLS Bulletin No. 710.

Table 3: **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 | 89.8 | 87.9 | 84.4 | 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 | 95.1 | 85.8 | 74.5 | 60.9 |
| 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 |
| Manufacturing | 100 | 93.1 | 81.5 | 74.4 | 74.6 | 100 | 87.1 | 73.5 | 63.2 | 69.5 |

Source: See the Web Appendix. The input price indices are based on the main input for each industry. For manufacturing, the input price index is for semi-manufactured goods (the values for the index of raw materials are 100, 86.5, 67.3, 56.5, 57.9).

Table 4: **Real Product Wages (1929=100)**

| | *VA Deflator (CES)* | | | | | *WPI Deflator* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Industry | 1929 | 1930 | 1931 | 1932 | 1933 | 1929 | 1930 | 1931 | 1932 | 1933 |
| Automobile | 100 | 105.9 | 105.8 | 90.7 | 96.5 | 100 | 106.5 | 109.2 | 99.7 | 103.9 |
| Boots and Shoes | 100 | 90.9 | 84.1 | 70.3 | 79.0 | 100 | 98.3 | 98.6 | 99.9 | 107.5 |
| Iron and Steel | 100 | 118.1 | 131.1 | 105.5 | 119.5 | 100 | 107.7 | 110.8 | 97.1 | 96.7 |
| Meat-Packing | 100 | 75.0 | 66.2 | 65.4 | 96.0 | 100 | 113.7 | 142.5 | 156.7 | 182.8 |
| Paper and Pulp | 100 | 100.7 | 97.6 | 84.4 | 59.9 | 100 | 103.5 | 107.4 | 101.7 | 94.8 |
| Leather | 100 | 83.3 | 54.0 | 47.0 | 88.3 | 100 | 112.5 | 126.31 | 152.3 | 135.8 |
| Wool Man | 100 | 84.9 | 79.1 | 65.0 | 75.1 | 100 | 113.8 | 126.3 | 121.9 | 105.7 |
| Manufacturing | 100 | 99.1 | 103.9 | 93.8 | 102.7 | 100 | 107.3 | 117.4 | 113.4 | 111.5 |

Source: Wage data is from the NICB and the industry wholesale price deflators are from various issues of *Wholesale Prices*. The manufacturing input price series is semi-finished materials.

Table 5: **Calibration**

| Parameter | Value | Target |
|---|---|---|
| $\beta$ | 0.99 | Annual risk-free rate 4% |
| $\delta$ | 0.025 | Annual depreciation rate 10% |
| $\sigma_L$ | -0.5 | Frisch elasticity of 2 |
| $\eta$ | 0.36 | Flexible sector's share of GDP in 1929: 41% |
| $g$ | 0.0015 | Estimated from M1 data |
| $\gamma$ | 0.05 | Sticky sector's real consumption wage path (1929-1933) |
| $\mu_L$ | 7.3345 | Total market time of 1/3 |
| $\mu_M$ | 0.013 | BEE (2000) |
| $\phi_i$ | 0.25 | Quarterly contracts |
| $\rho_m$ | 0.44 | Estimated from M1 data |
| $\rho$ | -1.96 | Path of Flexible sector's share of GDP (1929-1933) |
| $\theta_1$ | 0.3 | Capital income share of 30% |
| $\theta_2$ | 0.3 | Capital income share of 30% |
| $\alpha_1$ | 0.8750 | Intermediates' share (Flexible sector): 32% |
| $\alpha_2$ | 0.8410 | Intermediates' share (Sticky sector): 38% |
| $\rho_1$ | -0.4493 | Elasticity of substitution between value-added and intermediates: 0.69 |
| $\rho_2$ | -0.4493 | Elasticity of substitution between value-added and intermediates: 0.69 |
| $\chi_1$ | 0.7888 | Flexible intermediates' share (flexible sector): 39% |
| $\chi_2$ | 0.5545 | Flexible intermediates' share (sticky sector): 31% |

**No-intermediates version**

| Parameter | Value | Target |
|---|---|---|
| $\eta$ | 0.34 | Flexible sector's share of GDP in steady-state: 41% |
| $\gamma$ | 0.02 | Sticky sector's real consumption wage path (1929-1933) |
| $\rho$ | -0.82 | Path of flexible sector's share of GDP (1929-1933) |

**One-sector versions**

| Parameter | Value | Target |
|---|---|---|
| $\gamma$ | 0.0087 | Real manufacturing wage (1929-1933) from Bordo, Erceg, and Evans (2000) |
| $\gamma$ | 0.0822 | Economy-wide real wage (1929-1933) from no-intermediates model |
| $\gamma$ | 0.0232 | Economy-wide real wage (1929-1933) from benchmark |

Figure 1: **Data estimates**

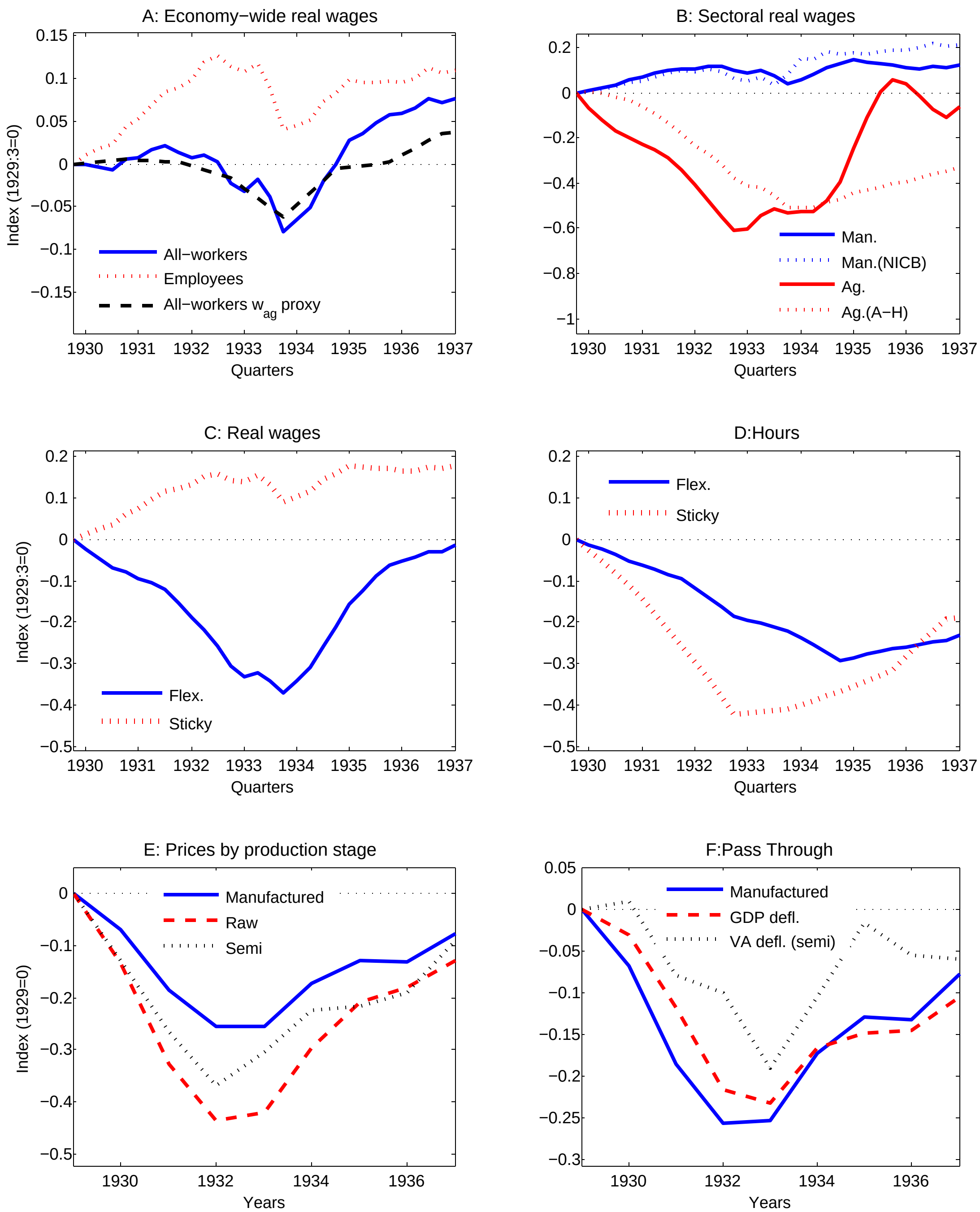

Figure 2: **Benchmark with intermediates: aggregate variables**

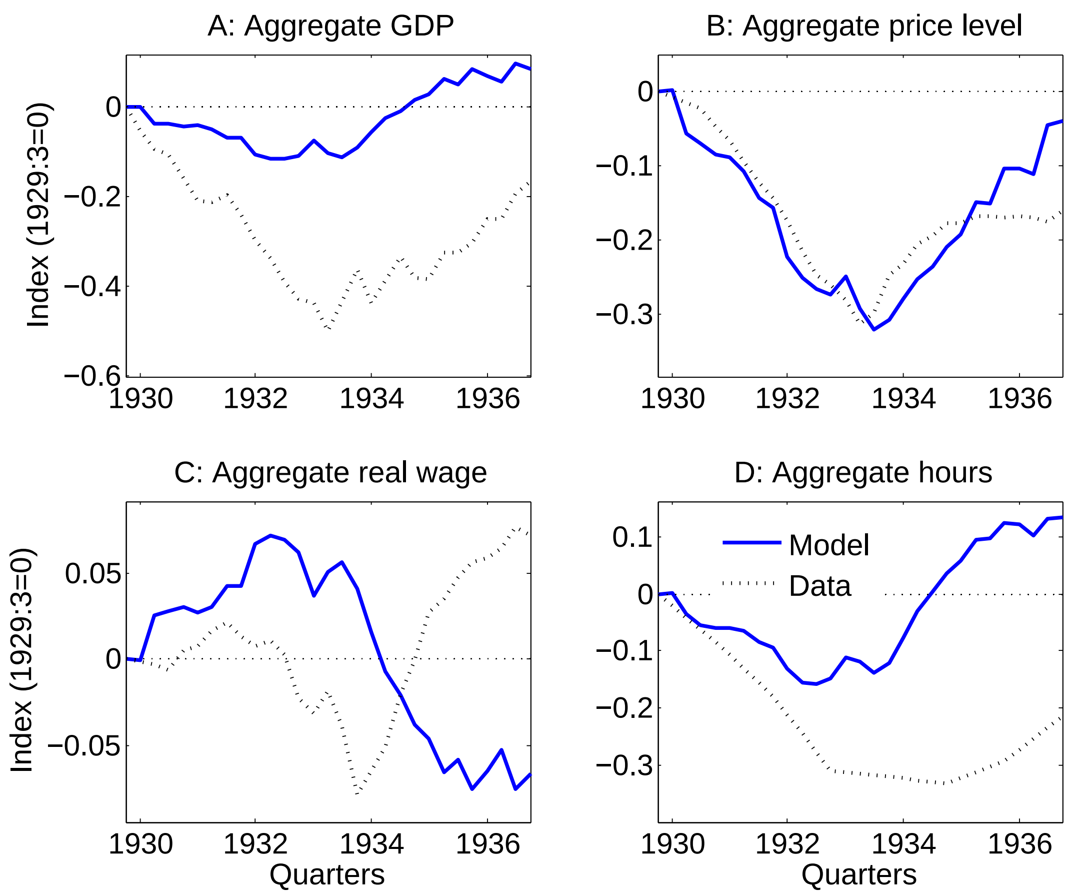

Figure 3: **Benchmark with intermediates: sectoral variables**

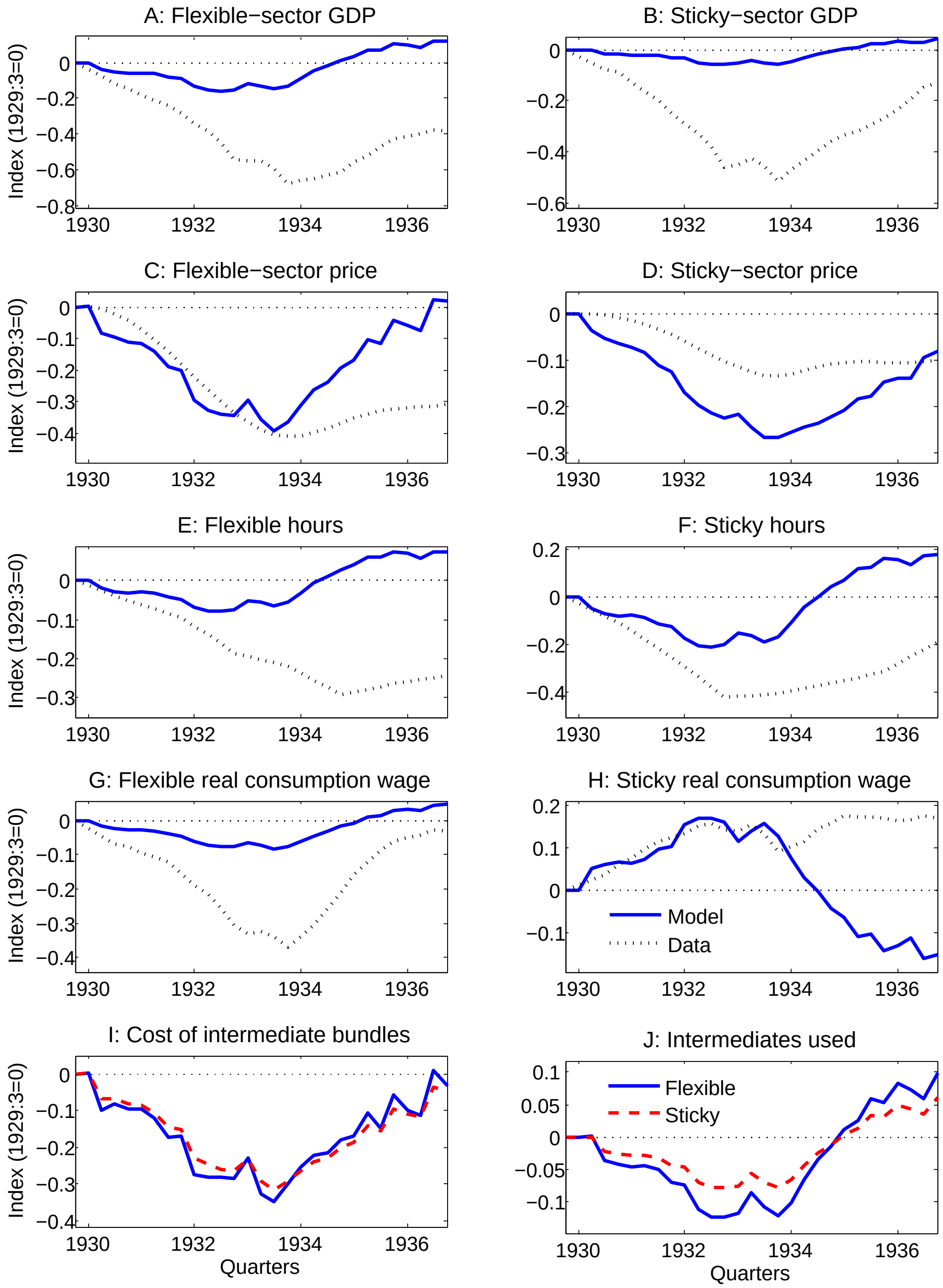

Figure 4: **Sensitivity analysis: sectoral good production substitutability**

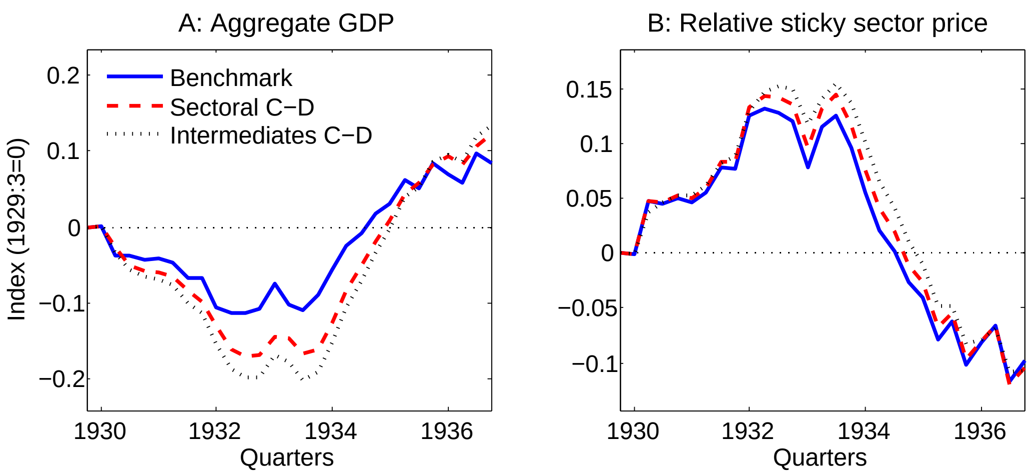


Figure 5: **Sensitivity analysis: final good production substitutability**

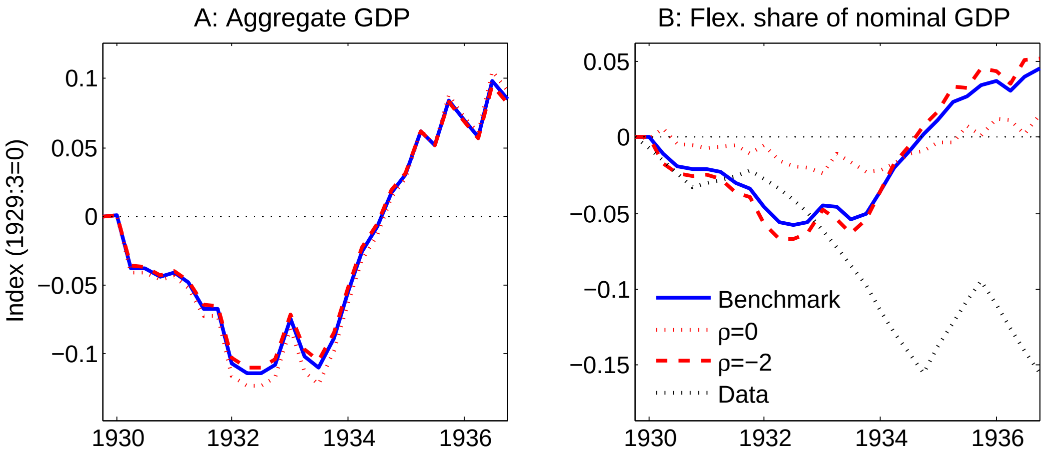

Figure 6: **No intermediates: aggregate variables**

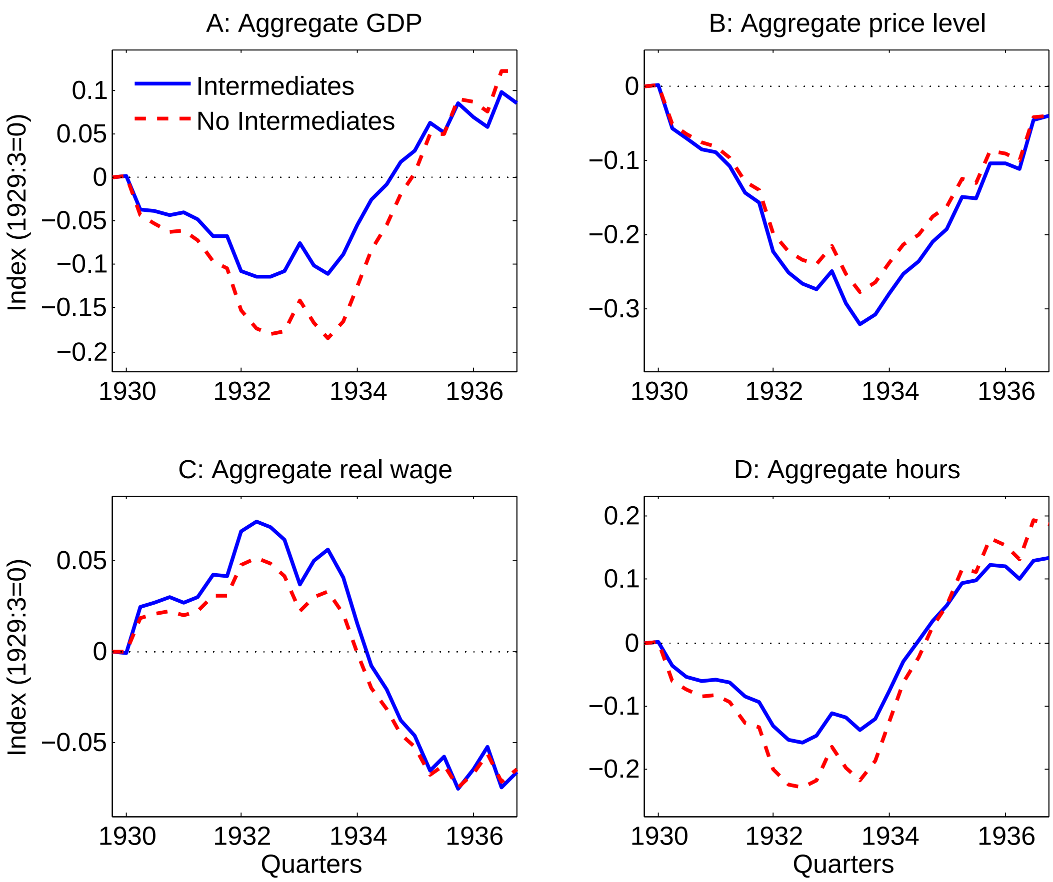

Figure 7: **No intermediates: sectoral variables**

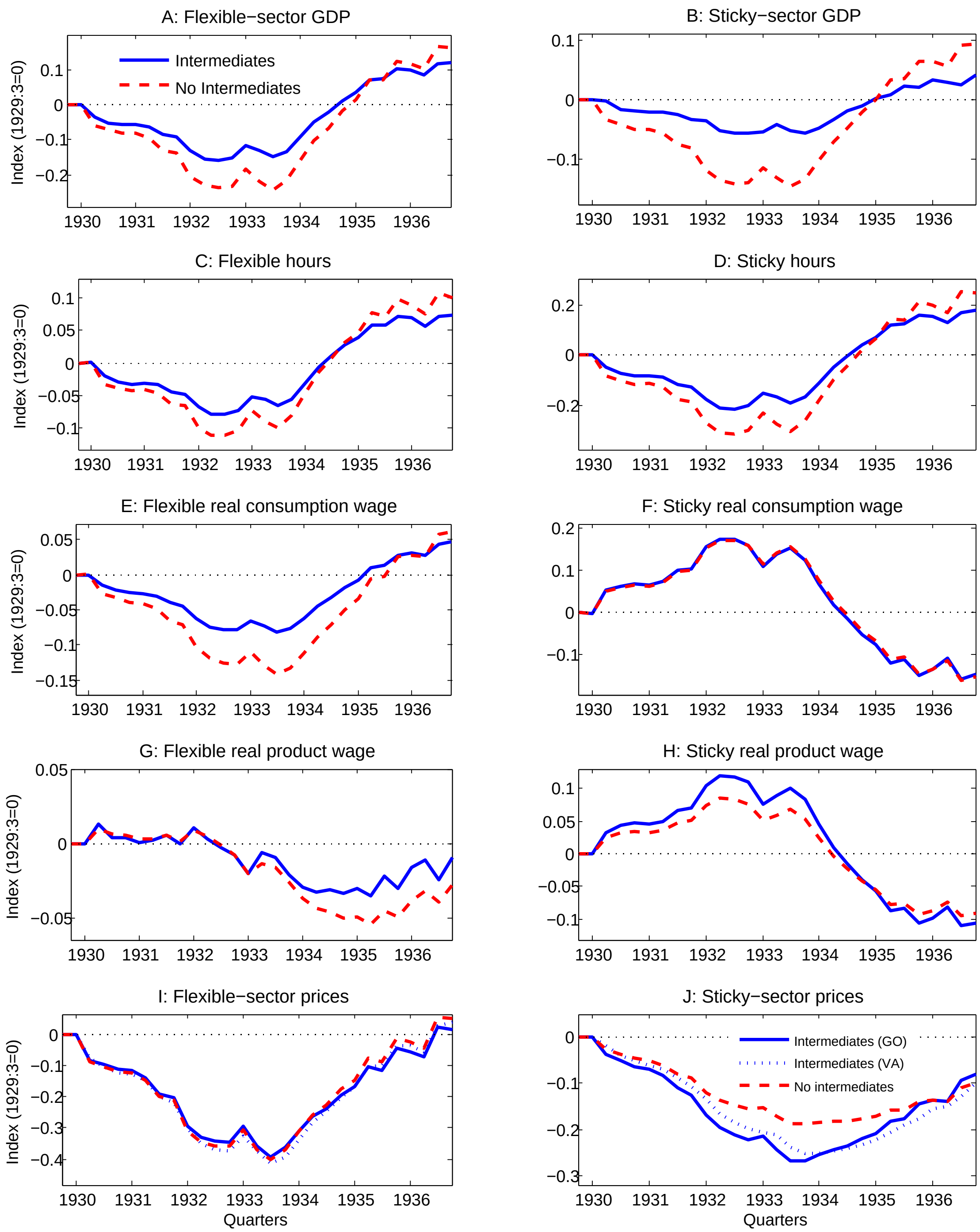

Figure 8: **Comparison: no-intermediates vs. one-sector**

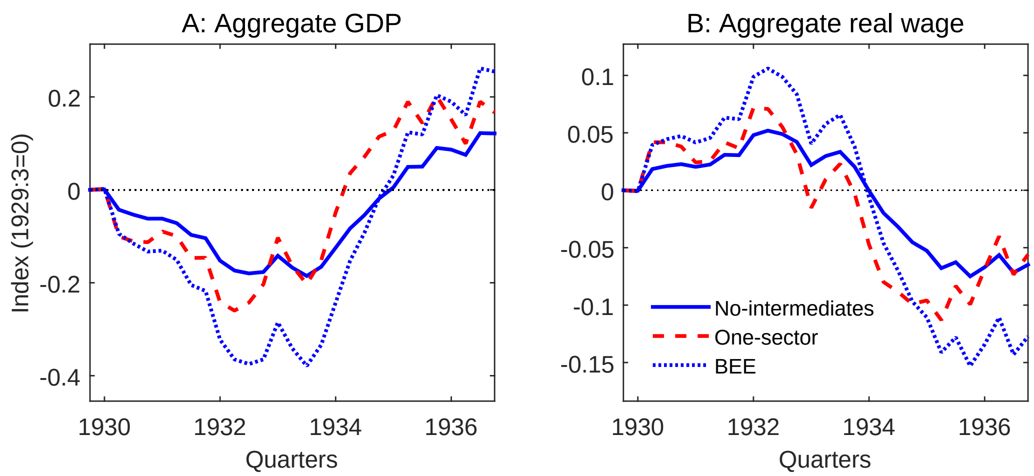


Figure 9: **Comparison: intermediates vs. one-sector**

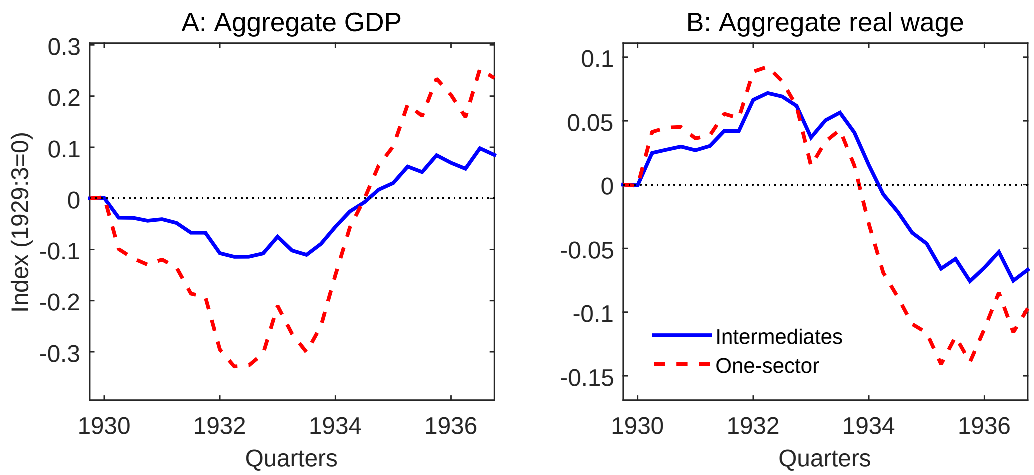

Figure 10: **Drop in TFP: aggregate variables**