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

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Abstract

We quantify the role of contractionary monetary shocks and wage rigidities in the U.S. Great Contraction. While the average economy-wide real wage varied little over 1929-33, some industries experienced large increases while others experienced outright declines. We calibrate a two-sector model with intermediates to the 1929 U.S. economy where wages in one sector adjust slowly. We find that while the model qualitatively replicates key sectoral facts, it can account for only a fifth of the fall in GDP over 1929-33. Intermediate linkages are important, as removing them roughly doubles the output decline predicted by the model.

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1 Introduction

A common view is that deflationary monetary policy, combined with nominal wage rigidity, was a key contributor to the U.S. “Great Contraction” of 1929-33. Central to this view is the belief that real product wages – the nominal wage relative to the prices received by firms – rose significantly over 1929-33 (Bernanke (1995), Bordo, Erceg, and Evans (2000)). This rise in real product wages in turn, moved firms along their labor demand schedules, resulting in a fall in employment and output.

In this paper, we adopt a multi-sectoral approach and re-examine the quantitative contribution of high real product wages to the fall in output and employment during the U.S. Great Contraction. We adopt a multi-sectoral approach for two reasons. First, we find that the high real wage story is a sectoral rather than aggregate story. Using data on worker compensation and hours worked, we construct average wages at the aggregate and 1-digit SIC level over 1929-36. Our estimate of the economy-wide real wage (the aggregate nominal wage deflated by the GNP deflator) for all workers increases little, and eventually falls, over 1929-33 (see Figure 1). However, there were widespread differences in the behavior of wages across industries. While in government, mining, manufacturing, and transportation and utilities, real wages increased by over 10 percent, they declined precipitously in agriculture and construction, with more modest declines in retail trade and finance, insurance, and real estate.

The second reason we adopt an explicit multi-sectoral approach is that shifts in relative prices of goods matter for real product wages. The large shifts in relative wages over 1929-33 were accompanied by a fall in the price of less processed goods relative to final manufactured goods. If these lower input prices were passed through into the final gross output price of manufacturing goods, then the WPI for manufactured goods would be lower than the implied value added price deflators. Using wholesale price data, we construct approximate estimates of implicit value-added deflators for manufacturing and seven frequently studied manufacturing industries. We find that the value-added price deflators decline less than either the wholesale price deflators or the GNP deflator. As a result, the real product wage for manufacturing (using the value-added deflator we construct) now closely resembles our estimate of the economy wide real wage, and varies little over the Great Contraction.

This shift in relative prices of intermediates also has important implications for the debate

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2The lack of direct wage measures is why earlier work focused only on agriculture and manufacturing (e.g. Cole and Ohanian (2001), Ohanian (2009), and Amaral and MacGee (2002)).

3While this price shift is recognized to upwardly bias real product wages if one uses wholesale price indexes (WPI) as a proxy for manufacturing output prices, it is argued that using the WPI for manufactured goods or the GNP deflator can yield a reasonable measure of the real product wage (e.g. see Eichengreen and Hatton (1988)).
over whether sectoral differences are important for assessing the quantitative impact of real wages during the Great Contraction. As Cole and Ohanian (2001) point out, in a two-sector model where sectors differ in their degree of wage flexibility, shifts in relative prices play a key role in mitigating the impact of monetary shocks. In Section 3, we illustrate this in the context of a simple two-sector DSGE model, where (for simplicity) we assume that one sector, the flexible wage sector, has competitive labor markets where wages adjust each period so as to equate labor demand and supply, while the other, the sticky wage sector, features nominal rigidities. In this sector, the firm (the short side of the market) decides how much to hire given the real product wage it faces. The output of the two sectors is combined to produce a final consumption/investment good.

In this environment, contractionary monetary shocks lead to an increase in the sticky sector wage relative to the flexible sector’s. This results in a similar shift in the relative price of the two sectoral goods. Since the price of the final good is an average of the two sectoral good prices, it falls relative to the sticky sector price. As a result, the sticky sector’s real consumption wage (the nominal wage divided by the final good price) increases by more than the sticky real product wage (the nominal wage divided by the inflexible good price). This plays an important role in mitigating the impact of wage rigidities in this model, since the smaller increase in the sticky sector firms’ real product wage leads to a smaller decline in hours (and thus output).

A key critique of this simple sectoral story is that this shift in relative prices is counterfactual. Taking manufacturing as a proxy for the sticky wage sector, Bordo, Erceg, and Evans (2001) point out that, since the Wholesale Price Index (WPI) of manufactures declined by more than the GNP deflator (or the Cost of Living), the manufacturing real product wage increased by more than the real consumption wage over 1929-1933. This seemingly calls into question the key mechanism via which the two-sector model acts to reduce the effect of sectoral wage rigidity on output.

This critique, however, does not take into account the effect of intermediate linkages on gross output prices (i.e. the WPI). This leads us to incorporate intermediate linkages in our two-sector model. To calibrate the model economy, we allocate industries to each sector based on whether our estimated industry real consumption wages increased or decreased over 1929-1933. This results in roughly 60% of the U.S. economy being included in the sticky sector. Given this division, we use data on the input-output structure of the U.S. economy to parameterize the production parameters. A key component of our calibration strategy is the parameter governing wage rigidity, which we choose so as to minimize the distance between the sticky sector’s real consumption wage in the model and the data over 1929-1933.

We find that this sectoral view leads to a much smaller quantitative contribution of deflation and wage rigidity to the Great Contraction. When we feed the estimated (unanticipated) monetary shock into the model, the high real wage story can account for less than a fifth of the decline in
output during the Great Contraction. Since the aggregate real (consumption) wage for all workers in our model economy is above our estimate for the U.S. data, this is likely an upper-bound estimate. Thus, we conclude that while the impact of contractionary monetary shocks in our framework is qualitatively consistent with the shifts in relative wages and prices over 1929-1933, the rigid real wage channel does not appear to be the primary cause of the Great Contraction.

Both the sectoral structure and intermediate linkages play an important role in generating this relatively small output decline. To illustrate this, we compare our model with intermediates to a two-sector world without intermediates and to a one-sector version of our sticky wage sector. We find that removing intermediates results in nearly twice a decline in output, from 10% to 18% over 1929-1933, which is roughly a third of the observed fall. In contrast, a one-sector model where all workers are subject to sticky-wage contracts, calibrated to match the same real wage, can account for two-thirds of the decline in output.

The smaller output decline in the multi-sector framework reflects two key factors. First, the presence of the flexible sector allows final good producers to substitute away from the more expensive sticky sector good. The presence of intermediates accentuates this by providing an additional channel via which sticky sector producers can substitute away from more expensive labor. Second, and more importantly, sectoral heterogeneity in wage flexibility leads to a wedge between the real wages that are relevant for the firms’ and the consumers’ problems. Following a contractionary monetary shock, the sticky sector price increases relative to the flexible sector one. This drives a wedge between the workers’ real consumption wage (the nominal wage divided by the final good price) and the sticky sector firms’ real product wage (the nominal wage divided by the sectoral price), because the final good price is a weighted average of the sectoral goods. Again, intermediates amplify this effect by providing a channel via which a decline in the price of intermediates produced in the flexible sector can be passed through to the firms’ gross output price.

There is a large literature which examines the contribution of deflation and wage rigidity to the Great Depression. Most closely related to this paper are Bordo, Erceg, and Evans (2000) and Cole and Ohanian (2001), who reach different conclusions on the quantitative importance of wage rigidity in the U.S. Great Contraction. While we share with Cole and Ohanian (2001) the view that sectoral heterogeneity in wage rigidity is an essential feature, we differ both in incorporating intermediate linkages and by explicitly modeling nominal rigidities in a two-sector general equilibrium model, “nesting” the framework of Bordo, Erceg, and Evans (2000) as a limiting case. In addition, our calibration (based on our estimates of sectoral wages for the entire economy) features a much

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4The use of quantitative DSGE models to examine Great Depressions is relatively recent. The papers in Kehoe and Prescott (2007) examine the experiences of a number of countries, while Christiano, Motto, and Rostagno (2003) examines the U.S. depression.
larger sticky-wage sector, roughly twice as large as their benchmark.\textsuperscript{5} Despite these differences, our benchmark estimates of the decline in output are roughly a third as large as in Bordo, Erceg, and Evans (2000). Thus, similarly to Cole and Ohanian (2001), we also conclude that high real wages were not the main cause of the fall in output over 1929-33.

Several recent papers have also reexamined the contribution of high real wages to the Great Contraction. Dighe (1997) notes that real wages in manufacturing during the Great Depression resembled those observed in the shallower 1920-22 recession. In recent work, Cole, Ohanian, and Leung (2007) revisit the conclusions of Eichengreen and Sachs (1985) and Bernanke and Carey (1996) that contractionary monetary shocks combined with the difference in timing in abandoning the international gold standard can account for the observed cross-country deflations and output declines. They find evidence of the former, but not the latter causal relationship. Interestingly, Ohanian (2009) argues that the fact that the threat of unionization was high for manufacturing and low for agriculture, allowed President Hoover to convince manufacturing firms to keep their wages high while reducing the length of their workweek in exchange for protection from unions. Inputting the observed wages and workweek length in manufacturing and agriculture into a two-sector model, he is able to generate two-thirds of the fall in output by the end of 1931. Unlike these papers, we show that explicitly taking into account intermediates linkages significantly reduces the impact of high real product wages on the output decline during the Great Contraction.

Our work is also related to a large literature on cyclical movements in relative prices of different goods. Interestingly, an older literature also highlighted the large shifts in relative prices across industries during the Great Depression (e.g. Means (1966)). Neal (1942) examined whether movements in relative prices across manufacturing industries were correlated with industrial concentration or could be accounted for by differences in input price movements across industries. Our paper differs from these early studies both in its quantitative theory emphasis and focus on real product wages. More recent work has found that prices of intermediates goods relative to both final goods and average wages moves procyclically in the post war period (e.g. Murphy, Shleifer, and Vishny (1989)), and that monetary contractions lower the relative price of less processed to more processed goods (e.g. Clark (1999)). While we find similar effects of monetary shocks over 1929-33, we differ in our focus on the quantitative contribution of wage rigidities to the Great Contraction.\textsuperscript{6}

The remainder of this paper is organized as follows. Section 2 documents several key facts on aggregate and sectoral wages and hours. Section 3 examines the impact of contractionary

\textsuperscript{5}Since our model also abstracts from any underlying productivity growth, these differences address the key criticisms of Gertler (2001) and Bordo, Erceg, and Evans (2001) of Cole and Ohanian (2001).

\textsuperscript{6} 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 round-about intermediate use can help account for changes in the cyclicality of real wages.
monetary shocks in a two-sector environment without intermediates. Section 4 examines the role of intermediates on U.S. manufacturing wholesale prices and extends the model to include intermediate goods. The final section offers a brief conclusion.

2 Data

While the labor market figures prominently in many explanations of the Great Depression, surprisingly little attention has been paid to the considerable heterogeneity in both wages and hours worked across industries.\(^7\) In this section, we construct aggregate and sectoral measures of nominal wages and hours worked during the Great Contraction.

We find little increase in the economy-wide real wage for all workers over 1929-1933. While one might be tempted to conclude that this is compelling evidence against high real wages being an important cause of the Great Contraction, this conclusion is not warranted as there were large movements in relative wages across industries. While real wages rose in some sectors over 1929-1933, workers in other industries experienced large declines. These shifts in relative wages coincide with large shifts in relative prices across industries. Altogether, the sectoral differences suggest that an evaluation of the role of real wage rigidities in the Great Contraction requires a multi-sector environment. We pursue this in section 3.

2.1 Aggregate Estimates of Wages and Hours

Since direct measures of hourly wages exist for only a few industries, we use estimates of hours worked and total labor income to construct hourly wage series. Our guide in this exercise, the neoclassical growth model, does not distinguish between hours worked by employees and the self-employed, therefore our measure of the workforce is persons engaged in production (full-time equivalent employees plus sole-proprietors). Total hours worked is the product of total workers and average hours worked per full-time equivalent worker.\(^8\) Since hours worked includes sole-proprietors, we define total income as total employee compensation plus 60 percent of sole-proprietors income.\(^9\) The nominal wage is total labor income divided by total hours. We use the Balke and Gordon (1986) GNP deflator to compute real wages, and all measures are per working-age person.\(^10\)

\(^7\)A notable exception is Cole and Ohanian (2001), who highlight the large shift in agricultural wages relative to manufacturing. Cole and Ohanian (2004) focus on New Deal policy induced heterogeneity over 1934-1939.

\(^8\)We use the Denison (1962) average hour estimates so as to be comparable with Bordo, Erceg, and Evans (2000). Our industry estimates of hours are based on Kendrick (1961). Both total hour series are similar over 1929-39.

\(^9\)The change(s) in real wages are not very sensitive to reasonable (constant) values for the labor share of sole proprietors' income.

\(^10\)As pointed out by Hanes (1999), this seriously likely overweights the prices of less processed goods, which fell more than processed goods during the Great Contraction. As a result, this series likely overstates the decline in the
Our measure of the aggregate real wage (All-workers in figure 1.A) exhibits little increase during the Great Contraction, rising only after the introduction of New Deal policies. This contrasts with the conventional wisdom that real wages increased during the Great Contraction. The main reason for this difference is that our measure includes the self-employed, who comprised nearly 25% of the workforce in 1929. To illustrate this, we construct an aggregate real wage for employed workers only (Employees in figure 1.A), where labor income is total compensation of employees while hours worked is the product of full time equivalent employees and Denison’s average hours worked. This average real wage series increases significantly, rising roughly 12% between 1929 and 1932.

The finding that once one accounts for self-employment, aggregate real wages were basically flat until 1933 constitutes a challenge to any explanation of the Great Depression featuring high real wage mechanisms in the context of a one-sector economy.

2.2 Industry Estimates of Wages and Hours

While the large decline in agricultural wages relative to manufacturing (over 40%) in the 1929-33 period is well known, the lack of direct measures of wages in other industries has led to debate over whether the experiences of agriculture and manufacturing were representative of other sectors. To address this question, we construct estimates of real 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 industry measures of labor compensation from NIPA by hours worked. The hours worked estimates are based on Kendrick (1961), who reports hours worked for agriculture, government, manufacturing, mining, and transportation plus public utilities. For the remaining private non-farm industries, total hours are given by 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. For each industry, total labor compensation is labor compensation plus 60% of sole proprietor’s income (with inventory and CCA adjustments). Again, all wages are deflated using the GNP deflator, and quantities are per working-age person.

We begin our examination of sectoral wages and hours with agriculture and manufacturing. In 1929, each of these industries accounted for roughly 20% of employment, although value added in agriculture was roughly 10% of GDP versus 25% in manufacturing. Panel B in figure 1 plots average price level.

If we construct hours worked as the product of persons engaged in production and Denison’s average hours worked, we obtain very similar hours worked (and hence wages) in agriculture, and slightly smaller declines in hours worked in manufacturing (and hence larger wage declines). This alternative estimate of the manufacturing wage closely tracks the Bureau of Labor Statistics’ series for entrance wages in manufacturing during the Great Contraction.
our imputed real wage series for agriculture and manufacturing as well as a 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. Overall, the imputed wage series implies a slightly larger decline in agricultural wages relative to manufacturing than direct estimates of average wages. Consistent with the shift in relative wages, while hours worked in agriculture declined very little over 1929-1932, hours worked in manufacturing declined by over 40% from their 1929 level (see table 1).

The real wages we estimate for the remaining industries reinforce the view that there were large shifts in relative wages across industries during the Great Contraction. They were flat or declined in agriculture, construction, retail trade and FIRE. These industries all had large shares of sole-proprietors, and together accounted for more than four-fifths of all self-employed workers. In the remaining sectors, real wages increased over 1929-33, with transportation and government showing even larger increases than manufacturing.

It is this divide, between industries where real wages increased and those where they did not, that constitutes the basis for our mapping from the data to a two-sector model where one sector is subject to real wage rigidities and the other is not. For simplicity we refer to these sectors as Sticky and Flexible, respectively. We classify manufacturing, transportation and communications, government, mining, services, and wholesale trade as sticky, and agriculture, construction, retail trade and FIRE as flexible. The flexible industries accounted for roughly 41% of GDP in 1929.

Figure 2 plots our sectoral estimates of real wages, computed using the GNP deflator, and hours per adult as log-deviations from their 3rd quarter of 1929 values. As weights in computing these series, we use the relative share of hours worked in each industry in 1929. In constructing the sticky sector’s real wage we use the industries with the most reliable wage measures: manufacturing, transportation and communications and mining. Consistent with a story of sectoral heterogeneity in wage rigidities, the sticky wage sector had a larger increase in real wages and a larger decline in hours worked than the flexible wage sector.

While we lack the data to construct industry specific price deflators, the available Cost of Living Allowances (COLA) data reveal large shifts in relative prices over 1929-33 as shown in table 2. Goods related to Agriculture (food) and FIRE (rent) showed the largest price declines, while those related to Utilities (fuel) and Services (the better part of miscellaneous) had the smallest. Overall, the shifts in relative prices largely coincide with the sectoral real wage movements.

We draw two lessons from these data. First, there was considerable sectoral heterogeneity in
real wages and hours worked during the Great Contraction. Second, and consistent with differential
degrees of wage rigidity across sectors, hours worked tended to decline more in industries where
real wages rose than in industries where they increased. Motivated by this, in the next section, we
construct a multi-sector model where wage rigidities vary across sectors to quantitatively examine
this mechanism’s contribution to the Great Contraction. In section 4, we extend the model to
include intermediates, after establishing that gross output and value-added prices yield different
implications for the shift in relative prices across sectors during the Great Contraction.

3 A Two-sector Model

The model economy has two sectors that differ in their wage adjustment process. The flexible wage
sector has competitive labor markets where wages adjust each period so as to equate labor demand
and supply. The sticky wage sector is based on Bordo, Erceg, and Evans (2000) and features Taylor
nominal wage contracting. The firm (the short side of the market) decides how much to hire given
the real product wage it faces. Both sectors use capital and labor in production. The output of the
two sectors is used to produce the final good that can be used for consumption and/or investment.

A key issue in any sectoral model is how to model sectoral reallocation. We assume that capital
can be reallocated across sectors. In modeling the labor market, we implicitly assume that workers
cannot switch sectors. Hours worked in the inflexible sector are determined by firms, and do not
enter the household’s utility function. This assumption acts to amplify the impact of wage rigidities
in our framework, and thus gives the real wage story the best possible shot at accounting for the
downturn.\footnote{If hours worked enter the utility function, the qualitative results remain unchanged but the fall in GDP is smaller.} We return to this issue in section 3.3.

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,
hereafter dubbed sector 1 for convenience, $\{L_{1,t}\}_{t=0}^{\infty}$ and real money balances, $\left\{\frac{M_t}{P_t}\right\}_{t=0}^{\infty}$, where $P_t$
is the price level associated with one unit of the final good. The household chooses consumption,
hours of work in the flexible sector, nominal bond holdings, $B_t$, money holdings, $M_t$, and capital
in each sector, $K_{i,t+1}$, so as to solve:

$$\max \sum_{t=0}^{\infty} \beta^t \left[ \log C_t - \frac{\mu L}{1 - \sigma L} L_{1,t}^{1-\sigma L} + \mu M \log \left( \frac{M_t}{P_t} \right) \right]$$

s.t. \(B_t = (1 + R_{t-1}) B_{t-1} + \sum_{i=1}^{2} (J_i K_{i,t} + W_i L_{i,t}) + \sum_{i=1}^{2} \pi_{i,t} + X_t - \left( M_t - M_{t-1} + P_t C_t + P_t \sum_{i=1}^{2} I_{i,t} \right), \quad \text{(2)}\)

$$K_{i,t+1} = (1 - \delta_i) K_{i,t} + I_{i,t}, \quad i = 1, 2, \quad \text{(3)}$$

where $R$ is the nominal interest rate on bonds, $\delta_i$ is the depreciation rate of capital, $X$ is a lump-sum cash transfer from the government, and $J_i, W_i, I_i, L_i,$ and $\pi_i$ are sectoral variables: the rental rate of capital, the nominal wage, investment, hours worked and sectoral nominal profits, respectively.

**Firms**

Firms in both sectors seek to maximize static profits. They have access to a constant returns to scale production in capital and labor, $Y_{i,t} = K_{i,t}^{\theta_i} L_{i,t}^{1-\theta_i}$, which they rent from households, and take sectoral prices, $P_{i,t}$, and factor prices as given when making production decisions to solve:

$$\max P_{i,t} K_{i,t}^{\theta_i} L_{i,t}^{1-\theta_i} - W_{i,t} L_{i,t} - J_{i,t} K_{i,t}. \quad \text{(4)}$$

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

$$\max P_t \left( \eta Y_{1,t}^\rho + (1-\eta) Y_{2,t}^\rho \right)^{1/\rho} - \sum_{i=1}^{2} P_{i,t} Y_{i,t}, \quad \text{(4)}$$

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

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

$$Y_t = C_t + I_{1,t} + I_{2,t}. \quad \text{(5)}$$

**Wage Setting**

While wages are perfectly flexible in sector 1, they are subject to Taylor-type contracts in sector 2.\(^{13}\) Labor is divided into four equally-sized cohorts. Each period, the contract wages of one cohort

\(^{13}\)The Taylor contract environment makes our results directly comparable to Bordo, Erceg, and Evans (2000).
are adjusted. The nominal wage the firm pays is a geometric average of the cohort contract wages:

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

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

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

$$\log x_t = \phi_0 \log W_{2,t} + \gamma (L_{2,t} - \bar{L}_2) + \mathbb{E}_t \left\{ \phi_1 \log W_{2,t+1} + \gamma (L_{2,t+1} - \bar{L}_2) \right\} + \phi_2 \log W_{2,t+2} + \gamma (L_{2,t+2} - \bar{L}_2) + \phi_3 \log W_{2,t+3} + \gamma (L_{2,t+3} - \bar{L}_2),$$

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 (6) into (7) yields the current contract wage as a function of past and expected contract wages and the current and expected labor gaps:

$$\log x_t = \mathbb{E}_t \left\{ \frac{1}{12} \log x_{t-3} + \frac{1}{6} \log x_{t-2} + \frac{1}{4} \log x_{t-1} + \frac{1}{4} \log x_{t+1} + \frac{1}{6} \log x_{t+2} + \frac{1}{12} \log x_{t+3} + \sum_{k=0}^{3} \gamma (L_{2,t+k} - \bar{L}_2) \right\}.$$

**Money**

The stock of money is exogenously determined, and its growth rate follows an AR(1) process:

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

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

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 $\tilde{P}_t = \frac{P_t}{M_t}$, $\tilde{B}_t = \frac{B_t}{M_t}$, $\tilde{P}_{it} = \frac{P_{it}}{M_t}$, $\tilde{J}_{it} = \frac{J_{it}}{M_t}$, $\tilde{W}_{it} = \frac{W_{it}}{M_t}$, and $\tilde{x}_{it} = \frac{x_{it}}{M_t}$.

Given $g_0$, $M_0$, $K_{i,0}$, and the laws of motion (9) and (10), an equilibrium is quantities \(\{B_t, C_t, K_{i,t}, L_{i,t}, M_t, X_t, \pi_t\}_{t=0}^{\infty}\) and prices \(\{\tilde{J}_{it}, \tilde{P}_t, \tilde{P}_{it}, \tilde{P}_{it}^*, R_t, \tilde{W}_{it}, \tilde{x}_t\}_{t=0}^{\infty}\), such that households, firms in each sector and final good producers all solve the problems described above subject to market clearing conditions. In particular, in any equilibrium for this model specification, $B_t = 0$, $C_t = 0$, $K_{i,t} = 0$, $L_{i,t} = 0$, $M_t = 0$, $X_t = 0$, and $\pi_t = 0$. This implies that the economy is in a steady state.
as there is one representative household; \( \pi_{i,t} = 0 \), as the sectoral technologies are CRS; and the government transfer has to equal the newly printed money: \( X_t = M_t - M_{t-1} \).

The household’s, the sectoral firms’, and the final producer’s first-order conditions, together with the wage setting equations (6), and (7) and the market clearing conditions for the final and sectoral goods constitute the set of necessary conditions. We solve the model by log-linearizing these conditions around the non-stochastic steady-state and then applying the techniques described in Uhlig (1999).

3.2 Calibration

Each of the four contract periods lasts for one quarter. We set \( \beta = 0.99 \), which implies an annual risk-free return of roughly 4%. The depreciation rate of capital is set to 0.025 for both sectors, which implies an annual depreciation rate of 0.1. We choose \( \mu_L \) such that the steady-state total market time, \( \bar{L}_1 + \bar{L}_2 \), is one third. The parameter \( \mu_M \) has no effect on the dynamics of the system, and we follow Bordo, Erceg, and Evans (2000) in setting it.

The elasticity of substitution between sectoral goods in the final good aggregator, \( 1 - \rho \), and the share of flexible goods used in final good production, \( \eta \), are jointly calibrated to match the flexible sector share of GDP in 1929 and to minimize the distance between the model’s flexible sector share of GDP and its data counterpart over 1929-33. Similarly, in calibrating \( \gamma \), the crucial parameter regulating nominal wage adjustment in the sticky sector, we minimize the distance between the sticky sector real consumption wage in the model and the data over 1929-33.

As discussed in Section 2, we allocate industries to the flexible or the inflexible sector based on whether the industry real wage increased or decreased during the Great Contraction. 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 sources of income. Since our model abstracts from both 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.\(^{14}\) The average labor share in 1929 is roughly 0.7 in both the sticky and flexible wage sectors. This leads us to set the capital share of value added to 30% in both sectors, so \( \theta_1 = \theta_2 = 0.3 \).

Finally, our raw money supply measure is M1 from Friedman and Schwartz (1963)(table A-1).

\(^{14}\)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.
To be consistent with our model, we look at M1 per adult. We estimate the parameters in the money growth rate’s law of motion, equation (10), from the second quarter of 1922 to the last quarter of 1928. The estimates we obtain are \( \hat{\dot{g}} = 0.0015 \) and \( \hat{\rho}_m = 0.44 \). Although this is not used anywhere in the computation, the standard deviation of the residuals was \( \hat{\sigma}_e = 0.0104 \).

A summary of the parameter values appears in table 3.

### 3.3 Results

To evaluate the quantitative importance of nominal wage rigidities in the Great Contraction, we input the money supply growth shocks from the data from 1929:4 to 1936:4 into the model economy.\(^{15}\) This exercise yields two key insights. First, contractionary monetary shocks combined with nominal wage rigidities can only account for roughly a third of the decline in GDP during the Great Contraction in our two-sector environment. This is less than half the contribution estimated by Bordo, Erceg, and Evans (2000), who focused on a one-sector economy. Second, contractionary monetary shocks and asymmetric nominal wage rigidities across industries are qualitatively consistent with the pattern of relative prices, output, wages, and hours observed in the data. This leads us to conclude, that while important, contractionary monetary shocks are not the main cause of the Great Contraction.

Figure 3 plots aggregate output, hours worked, price level and real wages for the simulation and the data.\(^{16}\) In our benchmark, contractionary monetary shocks combined with wage rigidities can account for roughly one-third of the decline in aggregate output and nearly half of the decline in hours. This is an upper bound estimate, as the aggregate real wage in the model (averaging across the flexible and inflexible sectors) is higher than our data estimate over 1929 to 1934. The higher real wages predicted by the model are driven by a slower decline in nominal wages in the model compared to the data, as the model closely tracks the aggregate price level.

The sectoral results in figure 4 suggest that contractionary monetary shocks, combined with sectoral heterogeneity in nominal rigidities, are qualitatively consistent with movements in sectoral output, prices, hours, and wages in the Great Contraction.\(^{17}\) While prices and wages decline in both sectors, they fall by more in the flexible sector so that the flexible sector price (wage) fall relative to the inflexible sector price (wage). Consistent with the data, real wages increase in the inflexible sector and decrease in the flexible one, with hours and output declining in both. Nonetheless, the model fails to quantitatively capture the overall (and sectoral) output slump.

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\(^{15}\)We assume that the economy was at its steady-state in the third quarter of 1929.

\(^{16}\)The aggregate data is from Balke and Gordon (1986), and the real wage data is outlined section 2.

\(^{17}\)We deflate our sectoral nominal wages (see section 2) by the GNP deflator. Since we lack good sectoral price deflators for the data, we deflate sectoral nominal GDP in the data and model by the aggregate GNP price deflator. The sectoral price series in figure 4 are constructed using components of the COLA.
The shifts in relative wages and prices reflect sectoral differences in the degree of wage rigidity. In the inflexible sector, staggered wage contracts lead nominal wages to decline slower than prices in response to a contractionary monetary shock. This increases the real wage in the inflexible sector which reduces the firm’s demand for labor, resulting in a decline in hours worked and output.\textsuperscript{18} The output decline in the sticky sector pushes up the price of its good relative to the flexible sector’s. In the flexible sector, hours depends on both labor supply and demand, and the negative wealth effect partially offsets the substitution effect on labor supply, so that while hours decrease by roughly 10% at the trough, the nominal wage declines by more than the sectoral price, resulting in a decrease in the real wage.

The presence of the flexible sector offers two channels which can potentially mitigate the impact of sticky wages on aggregate output. First, the final output producer can substitute towards the flexible sector good. Second, the increase in the relative price of the inflexible good acts to partially offset the impact of higher nominal wages in this sector. Since hours are pinned down by the firm’s labor demand, a relatively higher price for the inflexible good acts to move the firm down its labor demand curve, thus leading to a smaller decline in hours.

This highlights the fact that in a multi-sector environment, a shift in relative prices across sectors can have a different impact on the the real product wage compared to the real consumption wage. From the point of view of the household, when deciding how many hours to work (in the flexible sector), what matters is the wage in terms of the final consumption good – which depends on how the nominal wage moves relative to the price of final output. In contrast, the firm’s real product wage depends on how the wage moves relative to the price of the sectoral good.

In our framework, this distinction turns out to be important. While the impact of sticky wages on inflexible sector output is muted by a smaller increase in the real product wage (relative to a one-sector model environment), the decline in hours worked in the flexible sector is amplified. The reason is that the relatively smaller decline in the inflexible sector’s price pushes up the price of final output relative to the flexible sector’s good. This lowers the real consumption wage. In addition, the larger decline in the flexible good’s price pushes up the real product wage, which lowers firm’s demand for labor.

The important role of relative price movements raises two potential concerns. First, since the shift in the relative price of flexible and inflexible goods is important, one might think that the results are sensitive to how substitutable sectoral goods are in final good production. To evaluate this, we consider both a higher ($\rho = 0$: Cobb-Douglas) and lower ($\rho = -2$) elasticity of substitution.\textsuperscript{18}

\begin{itemize}
  \item If hours worked in the sticky sector enter the utility function, but are not a decision variable for the household, flexible hours would fall by (slightly) less, and overall output would decline by roughly 16% instead of 18%. Again, the spirit of the exercise was to give the story the best shot at accounting for the fall in output.
\end{itemize}
As can be seen from figure 5, varying the elasticity of substitution results in very little change in the output decline predicted by the model. Indeed, making it harder to substitute away from the distorted sector actually leads to a smaller fall in output. The explanation for this seemingly counter-intuitive effect is that a lower elasticity of substitution implies a larger shift in the relative price for any shift in the relative real level of outputs. This means the price of the sticky-sector good falls by less, which in turn implies that real product wages in this sector increase by less, mitigating the fall in sticky-sector hours relative to the benchmark.

The second issue is that there are two different real wages that one can potentially use as targets when calibrating the wage rigidity parameter, $\gamma$. We choose to calibrate to the real consumption wage in the inflexible sector rather than to the real product wage. This implies that our calibration strategy is biased in favor of the contractionary monetary story. As figure 4 shows, the model actually overestimates the average real wage for the economy, and closely matches the GDP deflator and the real consumption wage in the sticky sector (by design). It follows that it does a good job of matching the path of the nominal wages in the sticky sector. More importantly, as panel D in figure 4 shows, our simulation generates a larger decline in the sticky sector price than in the data, which implies too large an increase in the real product wage. As a result, our approach gives an upper bound on the effect of nominal wage rigidities.

### 3.4 Discussion

The quantitative role of wage rigidities in the Great Contraction is much debated. Two heavily cited papers which represent opposite sides in this debate are Cole and Ohanian (2001) and Bordo, Erceg, and Evans (2000). Whereas Cole and Ohanian (2001) conclude that, in the context of a two-sector model, imperfectly flexible wages can account for less than a sixth of the fall in output, Bordo, Erceg, and Evans (2000) find that wage rigidities account for roughly 70% of the output decline over 1929 to 1933.

Our two sector framework differs from Cole and Ohanian (2001) in several key respects. First, our calibration (based on our estimates of sectoral wages) results in a much larger inflexible wage sector, roughly twice as large as their benchmark. Second, we explicitly incorporate nominal rigidities in our two-sector general equilibrium model by “nesting” the one-sector framework of Bordo, Erceg, and Evans (2000) as a limiting case. Finally, we abstract from assuming any underlying productivity growth which would offset the contribution of wage rigidities.\(^{19}\) While these differences result in a larger role for wage rigidities in accounting for the Great Contraction than in Cole and Ohanian (2001), we still find a much smaller impact than do Bordo, Erceg, and Evans (2000).

\(^{19}\)These differences address the key criticisms of Gertler (2001) and Bordo, Erceg, and Evans (2001) of Cole and Ohanian (2001).
The key reason we find a much smaller role for wage rigidities is that the different environments suggest different targets to calibrate the wage rigidity parameter, $\gamma$. Bordo, Erceg, and Evans (2000) choose to target the economy-wide real wage for employees (see figure 1.A), while we target the real wage for the inflexible sector (see figure 2.A). In a two-sector model, the asymmetry in the degree of wage rigidity drives a wedge between the price of flexible, $P_1$ and sticky goods, $P_2$, with the former declining more than the latter in response to a contractionary monetary shock. As a result, the final good price, $P$, declines by more than the sticky good price, which means that the two-sector model can match any given increase in the real consumption wage in the sticky sector, $\frac{W_2}{P_2}$, with a lower wage degree of wage rigidity (a higher $\gamma$).

Our benchmark thus generates a lower real economy-wide wage than that targeted by Bordo, Erceg, and Evans (2000), albeit above our estimate of the economy-wide real wage. When we run a version of their economy where we choose the wage rigidity parameter to match the economy-wide real wage in our benchmark simulation, we find a nearly identical decline in output to that predicted by our two-sector framework (see figure 6). Their larger decline in output thus results from their targeting a real consumption wage for all workers that closely resembles our estimate for the inflexible sector, rather than our estimate of the economy-wide real wage.

The shift in the relative price of flexible and inflexible goods also plays an essential role in our two-sector environment. The increase in the relative price of the inflexible sector good lowers its real product wage, thus reducing the impact of high real consumption wages on inflexible sector labor demand. We find that this shift in relative prices is consistent with the rough sectoral price estimates we construct using disaggregated components of the COLA. However, this mechanism – and more specifically, the shift in relative prices implied – is controversial. A common view, cogently outlined by Bordo, Erceg, and Evans (2001), is that manufacturing is a good proxy for the sticky wage sector. Since the wholesale price of manufactures declines more the GNP deflator (or the COLA), the manufacturing real product wage in the data seems to rise by more than the real consumption wage. Thus, this interpretation suggests that the relative sectoral price movements implied by our model are wrong.

This raises the question of how to reconcile these views. One possible solution lies in recognizing the potential differences between sectoral gross output and manufacturing price deflators. Since a considerable share of manufacturing inputs were commodities and semi-processed goods, the manufacturing wholesale price index (WPI) is heavily influenced by the relative price of commodities which declined significantly during the Great Contraction (figure 7.A). This raises the possibility that part of the observed decline in the WPI (a gross output price deflator) is driven by falling intermediate prices, rather than by a decline in the implicit value added price of manufacturing.

\footnote{Note that the $\gamma$ required to match the same economy-wide real wage varies significantly with model structure.}
output. We turn to the question of the quantitative importance of intermediates in the next section.

4 The Importance of Intermediate Linkages

A key feature of our two-sector model with asymmetric wage rigidities is that the price of the sticky-sector good increases relative its flexible sector counterpart following a contractionary monetary shock. This prediction is inconsistent with the common view that real product wages in inflexible wage industries increased by more than real consumption wages during the Great Contraction. The common view is based on a large literature which, due to data limitations, has largely used a wholesale price index (a gross output price) to construct the real product wage in manufacturing.\(^\text{21}\) Since wholesale prices decline by more than the GNP deflator (or COLA), this measure of the real product wage increases by more than the real consumption wage.

A potential concern about this approach is that the WPI for manufactured goods is a gross output price. As a result, it varies both with the relative prices of intermediate goods, as well as with prices of labor and capital (the value added component).\(^\text{22}\) This implies that declines in the relative price of manufacturing inputs (commodities and semi-finished goods) could have lowered the manufacturing WPI even if the implied value added deflator for manufacturing varied little.

To evaluate the quantitative plausibility of this mechanism, we construct implicit value-added deflators for manufacturing and seven frequently studied manufacturing industries. We find that the pass-through of lower intermediate goods prices has a significant impact on the final good’s (gross output) price, so that the constructed value-added price deflators decline by less than the wholesale price deflators and the GNP deflator. As a result, real product wages constructed using value-added price deflators increase by less than the real consumption wage.

This leads us to extend our two sector model to incorporate intermediate goods. When we calibrate this environment to the U.S. interwar economy, we find that this further reduces the quantitative contribution of real wages to the Great Depression. Interestingly, we also find an even more important role for the sectoral structure than when we abstract from intermediate linkages. Unlike what happens the environment without intermediate linkages, our calibrated two-sector framework with intermediates generates a much smaller decline in GDP than the one-sector model calibrated to the same economy-wide real wage.

\(^{21}\) See Bordo, Erceg, and Evans (2000) and Dighe (1997).

\(^{22}\) Recent work finds that factor prices changes are passed through into output prices (e.g. Bils and Chang (2000)).
4.1 Data

To assess the potential quantitative importance of relative price movements, we assemble data on intermediate and gross output prices, intermediate usage, gross output and wages for manufacturing as well as for seven frequently studied manufacturing industries during 1929-33.

We combine these data with basic theory to construct value-added price deflators. To guide our initial analysis, we extend the (value-added) Cobb-Douglas production function, \( y_i = K_i^{\theta_i} L_i^{1-\theta_i} \), specification from Section 3 to a gross output production function:

\[
Y_i = \left( K_i^{\theta_i} L_i^{1-\theta_i} \right)^{\alpha_i} Q_i^{1-\alpha_i},
\]

where \( Q_i \) denotes intermediate goods and \( Y_i \) is gross output in industry \( i \). If firms are competitive price takers, then the value added, \( p_{i,VA} \), and gross output prices, \( p_{i,GO} \), satisfy:

\[
p_{i,GO} = \left( \frac{r}{\alpha_i \theta_i} \right)^{\alpha_i} \left( \frac{w}{(1-\theta_i)\alpha_i} \right)^{(1-\theta_i)\alpha_i} \left( \frac{pQ}{1-\alpha_i} \right)^{1-\alpha_i} = \left( \frac{1}{\alpha_i} \right)^{\alpha_i} p_{i,VA} \left( \frac{pQ}{1-\alpha_i} \right)^{1-\alpha_i},
\]

(12)

where \( pQ \) denotes the price of intermediates.

For manufacturing, the intermediate expenditure share of gross output, \( 1 - \alpha \), during the interwar period was roughly 55 percent. Equation (12) thus implies that each percent decline in the price of intermediates lowers the gross output price deflator by 0.55 percent. Rearranging (12) the implicit value added price deflator is given by:

\[
WPI_{VA} = \alpha_i (1 - \alpha_1)^{1-\alpha_i} \left( \frac{WPI_{finished}}{WPI_{intermediates}^{1-\alpha_i}} \right)^{1/\alpha_i}.
\]

(13)

Panel B in figure 7 compares three real product wages, each of which uses a different price index to deflate the average hourly earnings of all wage earners for manufacturing from the NICB. The first is the usual measure which uses the WPI for finished goods as the output price. In the other measures, we use equation (13) to construct a value-added price deflator so as to strip-out the pass-through of lower intermediate costs. As a proxy for the intermediate price, we use either raw materials prices or semi-manufactured prices. Both adjustments assume an intermediate share of 50 percent.

As figure 7 illustrates, the decline in the relative price of intermediates has a large impact on the real product wage during the Great Contraction. While the ratio of nominal wages to the WPI for manufactured goods increased over 1929 to 1933, the real product wages adjusted for intermediate prices were roughly constant over 1929-31, and declined by between 10 and 20 percent.
over 1931-33. Over 1929-31, the decline in the WPI for finished goods can largely be accounted for by the decline in the proxy for intermediate goods prices. As a result, the implied value added price deflator remained roughly constant – which combined with flat nominal wages implies little movements in the real product wage. After 1931, a number of manufacturing firms moved to reduce nominal wages, which combined with a decline in the relative price of intermediates to final manufacturing goods led to a reduction in the ratio of nominal wages to the implied value added deflator.

**Industry Level Data: 7 Manufacturing Industries**

To further explore the impact of intermediate prices on real product wages, we examine seven manufacturing industries for which data on average hourly wages and total hours worked (NICB), input and output prices (WPI) as well as an index of gross output (Federal Reserve Bulletin) are available. The intermediate share varied considerably across these industries, from roughly 40 percent in lumber to over 80 percent in meat packing. As can be seen from table 4, industries with large declines in their wholesale output prices also had the largest decline in intermediate prices. Overall, industries with relatively less processing (meat packing, leather, and wool) had larger price declines than those producing relatively more more processed goods. The one industry which faced flat input prices was iron and steel, as iron ore and coke had very small price declines.

For each industry we compute a (Cobb-Douglas) value-added deflator using input and output prices and the average intermediate share over 1929-33. As table 5 illustrates, taking into account shifts in intermediate prices leads to very different real product wages. In five of the seven industries, real product wages measured using our implied VA deflator are significantly (10 to 80 percent) below the WPI measure, and actually decline through 1932. This industry-level pattern is consistent with the manufacturing average, which shows relatively small movements in real wages over 1929-1933.

This suggests that intermediate prices had a significant impact on real product wages during the Great Contraction. To quantify how intermediates interacted with the contractionary monetary shocks, the next section introduces intermediate into our two-sector model.

### 4.2 Environment with Intermediates

We extend the model outlined in Section 3 by assuming that both sectoral goods are used as intermediate inputs into their production. Our timing convention 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

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23These industries were examined in Bernanke (1986), and largely overlap with those studied in Bernanke and Parkinson (1991) and Bordo and Evans (1995) who replace meat packing with petroleum and include the rubber industry. See the supplementary data appendix on the authors website for details on the data series used.

24The iron and steel industry featured a significant degree of vertical integration, as a large fraction of the iron ore production was owned by steel producers (Hines (1951)).
the household sells its holdings of intermediate goods to each sector at price $P_{i,t}^{s}$. Intermediate goods are akin to investment under this timing convention. The household budget constraint is:

\[ B_t = (1 + R_{t-1})B_{t-1} + \sum_{i=1}^{2} (J_{i,t}K_{i,t} + W_{i,t}L_{i,t}) + \sum_{i=1}^{2} \pi_{i,t} + X_t + \sum_{i=1}^{2} \sum_{j=1}^{2} P_{i,t}^{s}Q_{ij,t} \]

\[ - \left( M_t - M_{t-1} + P_tC_t + P_t \sum_{i=1}^{2} I_{i,t} + \sum_{i=1}^{2} P_{i,t}Q_{i,t} \right), \]  

(14)

\[ K_{i,t+1} = (1 - \delta_i)K_{i,t} + I_{i,t}, \quad i = 1, 2, \]  

(15)

\[ Q_{i,t-1} = Q_{ii,t} + Q_{ij,t}, \quad i = 1, 2, \]  

(16)

where $Q_{ij}$ denotes intermediates produced by sector $i$ and used in sector $j$.

Firms in both sectors rent capital, labor services, as well as intermediate goods from the household. To keep things as general as possible we allow for a CES production structure at the sectoral level. We begin by assuming intermediates are perfect complements, and below we explore how sensitive the results are to this assumption. The problem of a firm in sector $i = 1, 2$ is:

\[ \max \pi_{i,t} = P_{i,t} \left[ \alpha_i \left( K_{i,t}^{\theta_i}L_{i,t}^{1-\theta_i} \right)^{\rho_{i}} + (1 - \alpha_i) \min \{ Q_{1i,t}, \chi_i Q_{2i,t} \}^{\rho_{i}} \right]^{\frac{1}{\rho_{i}}} \]

\[ - \sum_{j=1}^{2} P_{j,t}^{s}Q_{ji,t} - K_{i,t}J_{i,t} - W_{i,t}L_{i,t}, \]  

(17)

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

Final output production and the wage setting process remain the same as in section 3, with perfectly flexible wages in sector 1 and Taylor-type wage contracts in sector 2.

4.3 Calibration

The (aggregate) calibration targets for the household and money supply process remain the same. Given the modified production structure, we construct additional calibration targets for sectoral production parameters ($\alpha_i$, $\rho_{i}$, and $\chi_i$): (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. The complete calibration is shown in table 3.

We maintain the same division of industries into flexible and sticky wage sectors, and use a variety of data sources to construct sectoral estimates of value added and the composition of intermediate bundles. 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.25 In mining, our value added estimate is 0.83, which is the average value across 1919 and 1954 (table Db1-11, Historical Statistics of the United States). Given the limited input-output data for service sectors industries, we use Census data for 2002 on business expenses in trade, which lumps wholesale and retail together and imply 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 \( \frac{0.35}{0.35+0.16} = 0.69 \). (Leontief (1951)). The 1930 Census data for construction implies a value added share of 0.57. Construction uses very little flexible sector inputs. 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 value of \( \eta \) is chosen so that the value-added share of the flexible sector in GDP is equal to 0.42. 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. Finally, in our benchmark calibration, we assume that intermediates are perfect complements.

### 4.4 Results

We follow our earlier approach, and feed the estimated money supply growth shocks for 1929:4 to 1936:4 into the calibrated model economy. While intermediate linkages do not change the qualitative impact of a contractionary monetary shock, they do have a significant quantitative effect.

Incorporating intermediate linkages significantly reduces the estimated impact of high sectoral real wages, with GDP falling roughly half as much at the trough as in the no-intermediates benchmark (see figure 8.A). The smaller decline in GDP reflects a similar smaller decline in total hours (figure 8.D). This occurs despite a larger increase in the average real wage for all workers (figure 8.C) in the economy with intermediates. The larger increase in the aggregate real (consumption) wage is due to a smaller decline in the flexible sector real wage, since the model (by calibration) delivers the same increase in the sticky-sector’s real consumption wage (figure 9.D).

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25Since 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.
Intermediates also significantly affect the impact of the contractionary monetary shock on relative prices, as the price of the sticky good relative to the final good, $\frac{P_2}{P}$, increases by less than in the no-intermediates case. This is driven by the production structure. With intermediates, the gross output price of the sticky sector good is the weighted average of the value added and intermediate prices. Since the intermediate bundle is a weighted average of the inflexible and flexible price, the price of the sticky intermediate bundle declines relative to the sticky good value added price (compare 8.F to G). This means the measured real product wage sticky-sector firms face, $\frac{W_2}{P_2}$, is higher than in the no-intermediates case (our calibration delivers the same $\frac{W_2}{P_2}$, and $\frac{P_2}{P}$ falls less.)

If the sticky real product wage is higher at the trough in the intermediate economy, and sticky hours are determined by the firms’ labor demand schedule, how can hours fall by less? The key to this result is that the intermediate bundle is a mix of sector 1 and 2 goods. As a result, sticky-sector firms substitute away from relatively more expensive labor into relatively cheaper intermediates. This mechanism explains the relatively small decline in intermediates used in the sticky sector (figure 8.H). Compared to the no-intermediates economy, this acts like a positive shift in the marginal product of labor schedule. This allows sticky-sector firms to reduce their hours by 20%, versus 30% in the no-intermediates case, despite facing a higher real product wage.

There is a second, more subtle, reason why output decreases by less when we introduce intermediates. Holding the nominal wage distortion level, $\gamma$, fixed, the aggregate price level falls by more in the economy with intermediates since relatively cheaper intermediates make it easier to “undo” the wage rigidity. This allows the model with intermediates to match the increase in sticky sector real consumption wages, $\frac{W_2}{P}$, with a smaller rigidity (a higher $\gamma$, see table 3).

The fact that output declines less in the economy with intermediates despite a larger increase in the real average wage suggests that modeling intermediates is important for evaluating the high real wage story. Recall from section 3.4 and figure 6 that the two-sector model without intermediates and the one-sector model generate similar output decreases when targeting a common real aggregate wage. In figure 10 we compare our economy with intermediates with a one-sector economy where the distortion, $\gamma$, is chosen so as to minimize the distance between the real aggregate wage in the two economies from 1929:3 to 1933:4 (panel C). As panel A shows, output declines substantially less in the economy with intermediates, establishing the importance of carefully modeling the production structure and dispelling the notion that all that matters is the real wage one targets.

This finding is also consistent with our original motivation for introducing intermediate linkages. As discussed in section 4, the data suggests that there were important differences between gross-output and value-added measures of prices in manufacturing during the Great Contraction period. Panel F in figure 9 plots the model counterpart of these measures. The availability of the cheaper, flexible-sector, intermediates means the gross output price falls by more than the value-added price.
in the sticky-sector, a similar pattern to the one found in the data.

The bottom panels in figure 5 report some sensitivity analysis. In panel C, we consider the case of Cobb-Douglas sectoral production functions (so the elasticity of substitution between value-added and intermediates is 1), while matching the same calibration targets. In panel D, we allow the mix of intermediates to be Cobb-Douglas as opposed to the perfect complements assumption we had above, while matching all the same targets (including the share of flexible sector intermediates in total intermediates). In both cases the results are similar to our benchmark, with GDP falling more than in our intermediates benchmark and only slightly less than in the no-intermediate benchmark. This highlights the fact that once one allows for enough substitution anywhere in the production process, the intermediate channel loses much of its “bite”.

4.5 Discussion

Our examination of intermediates yields two important messages for the debate over the quantitative role of wage rigidities in the Great Contraction. First, we find that contractionary monetary shocks coupled with nominal wage rigidities played a modest role in the Great Contraction, as our model with intermediates can account for only a fifth of the output decline. It is worth emphasizing that 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 matters for both the debate over real product wages during the Great Contraction and for the impact of real wage rigidities on output.

Our results imply that sectoral heterogeneity in wage rigidity per se plays a relatively small role in assessing the quantitative importance of high real wages in the U.S. Great Contraction. Our comparison of the two-sector model (without intermediates) with a one-sector version shows that the Bordo, Erceg, and Evans (2000) and Cole and Ohanian (2001) debate reduces to one over the path of aggregate real wages in the economy during the Great Contraction, as we find nearly identical declines in output when one targets the same aggregate real consumption wage. Importantly, however, the introduction of intermediates breaks this link, as our model with intermediates can only deliver roughly half as large an output decline compared with a one-sector model calibrated to match the same aggregate real consumption wage. This suggests that recent work on the role of sectoral heterogeneity by Ohanian (2009), which abstracts from sectoral linkages, may overstate the quantitative contribution of real wages to the Great Contraction.

This also has important implications for the puzzle regarding the relationship between real con-

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26This elasticity is well above that of Rotemberg and Woodford (1996) (0.69) which we use in our calibration. It is worth noting that this estimate is at the higher end of the literature, as Rotemberg and Woodford (1999) cite estimates roughly half as large. In our model, this would lead to even smaller decreases in GDP.
sumption wages and real product wages in manufacturing highlighted by Bordo, Erceg, and Evans (2001). As they point out, while a two-sector model with sectoral heterogeneity in wage rigidity is consistent with the divergence in relative wages across industries, it is seemingly at odds with the fact that in the data, manufacturing real product wages (deflated by the manufacturing WPI) increase by more than manufacturing’s real consumption wages over 1929-33. Our work suggests that taking intermediates into account can resolve this puzzle. Our calculations for manufacturing in Section 4.1 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 5), while manufacturing’s real consumption wages go up by over 10% (panel B in figure 1.), which is consistent with the predictions of our two-sector model with intermediates.

One dimension along which the two-sector model cannot match the data is the relationship between the 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, the sticky sector’s gross output price always declines less than the price of the final good. This follows from model structure, as the price of final output is necessarily a weighted average of the two sectoral goods. It is worth noting that if we moved to an environment with three or more sectors, one would be able to construct input-output structures that could result in the gross output price of at least one inflexible wage sector declining by more than the price of final output.

While we focus on the U.S. experience, our environment also has implications for recent work by Cole, Ohanian, and Leung (2005). Building on Bernanke and Carey (1996) and Eichengreen and Sachs (1985), they use cross-country data on real wages and output to help identify the contribution of wage rigidities to the Great Contraction. Despite the fact that money enters differently in their model, through a Lucas (1972)-type misperception, they also conclude that contractionary monetary shocks are not the main cause of the decline in output over 1929 to 1933. Instead, they argue that real shocks are the driving force, as roughly two thirds of the fall in output can be accounted for by TFP. Similarly to Cole, Ohanian, and Leung (2005), when we introduce sectoral TFP shocks in our framework, we find that (with contractionary monetary shocks) our model can account for the decline in GDP and hours.27 However, we also find that TFP shocks have trouble matching key features of shifts in relative prices and quantities observed in the sectoral data. This suggests that an increased focus on sectoral data across countries might be a useful direction for future research.

27 We choose the shocks to match the decline in aggregate measured TFP. See the Web Appendix for more details.
5 Conclusion

Detailed sectoral data for the downturn period of the U.S. Great Depression provides clues to the model one should use as a lens in interpreting this episode. Two findings stand out as particularly important. The first is that the behavior of real wages differed substantially across sectors. While some exhibited increases consistent with a sticky wage framework, others saw their real wages stay constant or even fall. Secondly, we also find meaningful differences between gross output prices and the implied value-added prices in manufacturing industries.

These facts leads us to use a two-sectoral framework with intermediates to assess the quantitative contribution of wage rigidities to the Great Contraction. We find that contractionary monetary shocks fall quantitatively short, accounting for at most a fifth of the decline in GDP over 1929 to 1933. However, the model’s qualitative movements in the sectoral variables are consistent with the data’s, implying that at least in part, this mechanism seems to have been important.

Our findings suggest that while the multi-sectoral linkages we examine are important in accounting for the Great Contraction, they must have interacted with some exogenous price shocks, as contractionary monetary shocks on their own fail to generate enough action in output. Here, 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.
References


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

### Hours Worked

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### Real Wages

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Source: Hours data from Kendrick (1961).
Note: Transp. is Transportation, Communications and Public Utilities.

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

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<th>All</th>
<th>Food</th>
<th>Cloth</th>
<th>Rent</th>
<th>Fuel</th>
<th>H. Furn.</th>
<th>Misc.</th>
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Source: GNP deflator is from Balke and Gordon (1986). COLA data is from .

---

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### Table 3: Calibration

#### Benchmark

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<tr>
<th>Parameter</th>
<th>Value</th>
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<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>Annual risk-free rate 4%</td>
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<td>$\delta$</td>
<td>0.025</td>
<td>Annual depreciation rate 10%</td>
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<td>0.3398</td>
<td>Flexible sector’s share of GDP in SS: 41%</td>
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<td>$g$</td>
<td>0.0015</td>
<td>Estimated</td>
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<tr>
<td>$\gamma$</td>
<td>0.0328</td>
<td>Sticky sector’s real consumption wage path (1929-1933)</td>
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<tr>
<td>$\mu_L$</td>
<td>7.3345</td>
<td>Total market time of 1/3</td>
</tr>
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<td>$\mu_M$</td>
<td>0.013</td>
<td>BEE (2000)</td>
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<tr>
<td>$\phi_i$</td>
<td>0.25</td>
<td>Quarterly contracts</td>
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<td>Estimated</td>
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<td>$\rho$</td>
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<td>Path of Flex. sector’s share of GDP (1929-1933)</td>
</tr>
<tr>
<td>$\theta_1$</td>
<td>0.3</td>
<td>Capital income share of 30%</td>
</tr>
<tr>
<td>$\theta_2$</td>
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<td>Capital income share of 30%</td>
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#### Intermediates

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<tbody>
<tr>
<td>$\alpha_1$</td>
<td>0.8750</td>
<td>Intermediates’ share (Flex. sector): 32%</td>
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<tr>
<td>$\alpha_2$</td>
<td>0.8410</td>
<td>Intermediates’ share (Sticky sector): 38%</td>
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<td>Path of Flex. sector’s share of GDP (1929-1933)</td>
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<td>$\rho_1$</td>
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<td>Elast. of subst. between VA and intermediates: 0.69</td>
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<td>$\rho_2$</td>
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<td>Elast. of subst. between VA and intermediates: 0.69</td>
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<td>$\chi_1$</td>
<td>0.7888</td>
<td>Flex. intermediates’ share (Flex. sector): 39%</td>
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<td>$\chi_2$</td>
<td>0.5545</td>
<td>Flex. intermediates’ share (Sticky sector): 31%</td>
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### Table 4: Industry Wholesale Output and Main Input Price (1929=100)

<table>
<thead>
<tr>
<th>Industry</th>
<th>WPI (GO)</th>
<th>WPI (Main Input)</th>
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<td></td>
<td>1929</td>
<td>1930</td>
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<tr>
<td>Automobile</td>
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<td>94.2</td>
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<td>Boots and Shoes</td>
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<td>96.0</td>
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<td>Iron and Steel</td>
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<tr>
<td>Meat Packing</td>
<td>100</td>
<td>90.2</td>
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<tr>
<td>Paper and Pulp</td>
<td>100</td>
<td>96.9</td>
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<tr>
<td>Leather</td>
<td>100</td>
<td>89.5</td>
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<tr>
<td>Wool Man</td>
<td>100</td>
<td>89.5</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>100</td>
<td>93.1</td>
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</table>

Source: See the data appendix. The input price indices are based on the main input for each industry. For manufacturing, the input price index is for raw materials (the values for the index of semi-manufactured goods are 100, 87.1, 73.5, 63.2, 69.5).

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

<table>
<thead>
<tr>
<th>Industry</th>
<th>VA Deflator (C-D)</th>
<th>WPI Deflator</th>
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<td>Paper and Pulp</td>
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<tr>
<td>Manufacturing</td>
<td>100</td>
<td>99.1</td>
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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.
Figure 1: Labor market estimates

Figure 2: Sectoral real wages and hours
Figure 3: Simulation: aggregate variables

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A: Economywide GDP

B: Aggregate price level

C: Aggregate real wage

D: Hours
Figure 4: **Simulation: sectoral variables**

A: Flexible-sector GDP

B: Sticky-sector GDP

C: Flexible-sector price

D: Sticky-sector price

E: Flexible-sector hours

F: Sticky-sector hours

G: Flexible-sector real wage

H: Sticky-sector real wage
Figure 5: Sensitivity analysis
Figure 6: Comparison: aggregate variables

A: Economy-wide GDP

B: Aggregate price level

C: Aggregate real wage

D: Hours

Figure 7: Pass-through effect

A: Prices by production stage

B: Real product wages
Figure 8: Intermediates: aggregate variables
Figure 9: Intermediates: sectoral variables

A: Flexible-sector GDP

B: Sticky-sector GDP

C: Flexible real consumption wage

D: Sticky real consumption wage

E: Flexible-sector prices

F: Sticky-sector prices

G: Cost of intermediate bundles

H: Intermediates used

Indices (1929:3=0)
Figure 10: **Comparison: aggregate variables**

A: Economy-wide GDP

B: Aggregate price level

C: Aggregate real wage

D: Hours