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Deflation, Real Wages, and the International Great Depression: A Productivity Puzzle

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ABSTRACT

The high real wage story is one of the leading hypotheses for how deflation caused the International Great Depression. The story is that world-wide deflation, combined with incomplete nominal wage adjustment, raised real wages in a number of countries, and these higher real wages reduced employment as firms moved up their labor demand curves. This story implies a strong negative correlation between output deviations and real wage deviations, while this correlation in the data is positive. This positive correlation implies the need for another shock that works as a labor demand shifter. We take that other shock to be one that worked through productivity, and evaluated the relative contributions of productivity shocks, and of money shocks (operating through high real wages) to output changes for 17 countries between 1930-33. We estimate that about 2/3 of output changes in the international cross section is accounted for by a productivity or productivity-like shock which is orthogonal to deflation, and about 1/3 of output changes is accounted for by money shocks.

1. Introduction

A number of countries experienced depressions and deflations between 1930 and 1933.[1] Many economists argue that deflation caused the International Depression. The *high real wage hypothesis* is one of the leading stories for how deflation caused the International Depression (see Eichengreen and Sachs (1985) Bernanke and Carey (1994), and Bernanke (1995)). A simple version of this story is that world-wide decreases in the money supply led to worldwide deflation, which in turn raised real wages across countries through incomplete nominal wage adjustment. The second part of the story is that higher real wages then reduced employment as firms moved up their labor demand curves to equate the higher real wage with a higher marginal product of labor.

Bordo, Erceg and Evans (2000) provide some evidence in favor of this story for the U.S. between 1930-33 using a dynamic general equilibrium model with nominally predetermined wages. There is, however, no systematic study of this hypothesis for the international cross-section using dynamic, general equilibrium models. This paper conducts this type of analysis for a cross-section of 17 countries between 1930-33. We focus on this period for two reasons. One reason is that 1930-33 is the major worldwide deflation period. Specifically, the price level fell significantly in many countries during this period, and then began rising in most countries afterwards. The other reason we focus on 1930-33 is that other important factors began affecting real wages in these economies after 1933, including a variety of government policies across countries (see Cole and Ohanian (2001) for an analysis of labor and industrial policies and their effect on wages in the U.S., and Fisher and Hornstein (2002) for an analysis of wages and Nazi policies towards labor unions in Germany). Thus, any cross-country study of the effects of monetary policy on real wages after 1933 must tackle the difficult problem of modeling and distinguishing the effects of these other important factors on real wages.

Our analysis uses two standard models in which unanticipated deflation raises real wages and reduces output; a model with predetermined nominal wages, along the lines of Blanchard and Kiyotaki (1987), and a model in which households have imperfect information

[1] The reason why so many countries simultaneously had deflations is the gold standard. Our analysis deduces the macroeconomic implications of this worldwide deflation, treating the source of the deflation as exogenous. Eichengreen (1995) presents a detailed account of the gold standard.

about the price level, along the lines of Lucas (1972). The only substantive difference between the models is that the response of output to a money shock is bigger in the predetermined wage model.

We begin our analysis by showing cross-country scatterplots of real wages and output for each year and calculating the correlation between these variables. The simple high wage story implies that these variables should be highly negatively correlated and that they should lie on a downward sloping line. In contrast, the actual data are positively correlated, and deviate substantially from the line implied by the theory. This positive real wage-output correlation in the data suggests that the International Depression is not just a story about firms moving up their labor demand curves in response to high real wages. Instead, this correlation suggests that a big part of the Great Depression is a shock that differentially shifts labor demand curves across countries.

We therefore include both productivity shocks as well as money shocks in our models. We add productivity shocks because these shocks shift labor demand, and because there are large, systematic differences in labor productivity for the 4 countries for which we have economy-wide labor productivity data. Specifically, the countries with the biggest output decreases have large decreases in labor productivity, and the countries with small output decreases have small changes in labor productivity. Since we only have total factor productivity measures for two countries, we conduct an experiment in which we construct productivity shocks and monetary shocks such that the misperceptions model replicates output and the price level in each country and in each year.

We then decompose output changes into the fractions accounted for by productivity shocks and monetary shocks. We find that productivity shocks account for between 48 and 86 percent of the sum of squared output deviations, depending on the orthogonalization of the two shocks. Our preferred orthogonalization decomposes productivity into two components, one of which is orthogonal to deflation. For this decomposition, we find that orthogonal productivity shocks account for 68 percent of the sum of squared output deviations across countries.

We next compare the constructed productivity shocks in the model to the data. We do this two ways. We calculate labor productivity in the model, and compare it to actual labor productivity in the 4 countries for which we have economy-wide labor productivity. We find that labor productivity in the model is very similar to actual labor productivity in these 4 countries. We then go beyond the 4 countries for which we have economy-wide labor productivity data, and compare labor productivity in the model to manufacturing labor productivity in the data, which we have for 15 countries. We find that the correlation between labor productivity in the model and actual manufacturing labor productivity is around 0.7. We conclude from this evidence that accounting for the bulk of the International Depression within this class of models requires a quantitatively important, country specific factor that shifts labor demand and that acts and looks a lot like a productivity shock.

The paper is organized as follows. Section 2 presents the two monetary models we use in the analysis. Section 3 presents the basic parameterization of the models. Section 4 presents an analysis of the hypothesis for the U.S. along the lines of Bordo, Erceg and Evans as a warm-up exercise to the international analysis. Section 5 describes the international data and presents the scatterplots and correlations. Section 6 discusses details about how we add the labor demand shifter (productivity) to the basic high wage model. Section 7 assesses the relative contributions of productivity and monetary shocks to the Depression. Section 8 evaluates whether the productivity shocks might be proxying for some other factors. Section 9 presents our conclusions and plans for future work that aim at developing a deeper understanding of what these productivity-like shocks might be. The Appendix describes technical details about the models and presents some additional tables.

2. The High Wage Theory and Two Monetary Models

The basic high real wage hypothesis is a simple one. Before we describe the models in detail, we summarize the basic elements of the hypothesis, which in fact are very robust across all models that have a downward sloping labor demand curve.

The key ingredient in the story is a neoclassical production function and profit maximization. This gives rise to a downward sloping labor demand curve that shows - in the absence of a shift in the marginal product of labor - a negative relationship between real wages and the quantity of labor demanded. Combining the labor demand curve and the production function yields a negative relationship between the real wage and output similar to that between the real wage and labor. This real wage-output relationship captures the essence of the high wage theory.

This means that an increase in the real wage, ceteris parabus, reduces labor input and output *in any model* with a neoclassical production function and a diminishing marginal product of labor. The models we describe below have neoclassical production functions, and thus capture this part of the high wage story.

The remaining part of the high wage theory is a story for how the real wage increased. The theory states that real wages rose through deflation and incomplete nominal wage adjustment. Our models have mechanisms which capture this part of the story as well. The models only differ in the quantitative impact of a money shock on output. Given this simple sketch of the high wage story, we now turn to the two model economies.

The first model is a Lucas-type misperceptions model. In this model, negative monetary shocks raise real wages through incomplete information. Households choose their labor supply knowing the nominal wage rate, but before they know the realizations of the money or technology shocks. A negative monetary shock reduces the nominal wage, which is misperceived by households as a decrease in the real wage. This leads to a negative shift in labor supply and thus an increase in the market clearing real wage. The second model is a sticky wage model. In this model, households set their nominal wage before knowing either of the shocks. A negative monetary shock reduces the price level, which in turn raises the real wage, since the nominal wage is fixed.

As we show below, the only difference between these models is in the response of real wages to a money shock, when then affects output. The misperceptions model displays a range of responses, depending on the value of a signal extraction parameter that is a function of the relative variances of the technology and monetary shocks. All of the output responses in this model are smaller than the response in the predetermined wage model. The responses of output in the misperceptions model range from 0 at one extreme value for the signal extraction parameter, to a response that is about 40 percent smaller than the response in the predetermined wage model at the other extreme value of the signal extraction parameter. Hereafter, we will refer to this signal extraction parameter as η.

We now turn to the details of the models. Both models share the same basic infinitely lived, representative agent monetary model with cash and credit goods. We first describe this basic environment that serves as the foundation of each model, and then specify each model in turn by modifying this basic environment.

A. Basic Environment

Preferences

There is a large number of households who have identical preferences over sequences of a cash good, a credit good, and leisure. We normalize the size of the population to one. Households are indexed by the type of labor they supply. We include differentiated labor in the model because this facilitates developing the sticky wage model. Despite this heterogeneity in labor services, our model retains the representative agent construct because all households have identical preferences and because each household's labor enters production symmetrically. (The production side of the model is described later in this section).

Preferences for a type "i" household are given by

$$(1)\quad E\sum_{t=0}^{\infty}\beta^t\left\{\log([\alpha C_{1t}(i)^\sigma+(1-\alpha)C_{2t}(i)^\sigma]^{1/\sigma})+B\log(1-N_t(i))\right\},$$

where C_1 is the cash good, C_2 is the credit good, and $1-N$ is non-market time. The type "i" household maximizes (1) subject to the following wealth constraint and CIA constraints:

$$\begin{aligned}&M_t(i)+W_t(i)N_t(i)+R_tK_t(i)+(T_t-1)M_{t-1}\\ \geq\ &M_{t+1}(i)/T_t+P_t\left[C_{1t}(i)+C_{2t}(i)+K_{t+1}(i)-(1-\delta)K_t(i)\right],\end{aligned}$$

$$P_tC_1(i)\leq M_t(i)+(T_t-1)M_t,$$

The household's wealth is the sum of its beginning-of-period cash holdings $M_t(i)$, its labor income $W_t(i)N_t(i)$, the gross return on its capital stock $R_tK_t(i)$, where R is the gross return on capital, and a lump-sum monetary transfer from the government $(T_t-1)M_{t-1}$,where T_t is the gross growth rate of the money stock. The household's wealth must be sufficient to finance the sum of the cash the household carries into the following period $M_{t+1}(i)/T_t$, plus its purchases of cash goods, credit goods, and investment $P_t[C_{1t}(i)+C_{2t}(i)+K_{t+1}(i)$ $-(1-\delta)K_t(i)]$.

There are two features to note about this wealth constraint. First, the money balances that the household carries over to the following period are divided by the gross growth rate of money, T_t. This formulation preserves stationarity in the model by keeping the aggregate money stock constant over time.[2] Second, both consumption goods and investment all sell for the same nominal price, which we denote as P. This follows from our specification of the technology for producing goods, which we describe later in this section.

The CIA constraint is standard, and requires that the stock of cash carried over by the household from the previous period, plus the lump-sum monetary transfer it receives from the government, is sufficient to pay for cash goods $P_t C_{2t}(i)$.

Technology

Output is produced from a constant returns to scale technology using capital K_t and aggregate labor N_t, which is a constant elasticity of substitution (CES) aggregate over individual household labor:

$$N_t = \left[\int_0^1 N_t(i)^\theta di \right]^{1/\theta}.$$

The technology for producing goods is Cobb-Douglas:

$$Y_t = Z_t K_t^\gamma N_t^{1-\gamma},$$

where Z is a technology shock that follows a first order lognormal autoregressive process:

$$Z_t = e^{z_t},\ z_t = \rho_z z_{t-1} + \varepsilon_{zt}, \varepsilon_{zt} \sim N(0, \sigma_z^2)$$

Output is used for either consumption or investment. One unit of output can be costlessly transformed into one unit of either of the consumption goods or investment. The resource constraint is thus given by:

$$C_{1t} + C_{2t} + X_t \leq Y_t.$$

[2] This general approach of retaining stationarity is standard in monetary models (e.g. Cooley and Hansen, 1989).

This one-to-one transformation between output and cash consumption, credit consumption, and investment implies that all goods will sell for the same price. The transition rule for capital is given by:

$$K_{t+1} = (1 - \delta)K_t + X_t$$

Monetary Policy

Monetary policy is given by changes in the gross growth rate of money, which follows a first-order lognormal autoregressive process:

$$T_t = \bar{\tau} e^{\tau_t}, \text{ where } \tau_t = \rho_\tau \tau_{t-1} + \varepsilon_{\tau t}, \varepsilon_{\tau t} \sim N(0, \sigma_\tau^2)$$

The change in the money stock at the beginning of the period is thus equal to $(T_t - 1)M_t$, and the total money stock at the beginning of the period is given by:

$$M_{t+1} = T_t M_t$$

As noted above, money holdings are taxed at the gross rate of T_t at the end of the period to keep the money supply constant over time.

Information and the Timing of Transactions

We now specify the timing of information and the timing of activities within a period. To do this, we first need to define the state of the economy, which we denote as $S_t = (K_t, z_{t-1}, \tau_{t-1}, \varepsilon_t^z, \varepsilon_t^\tau)$. Note that we include the lagged values of the shocks and their current innovations separately in the state vector. This specification facilitates constructing both the misperceptions model and the wage setting model because both of these models require that households make their labor market choices before they observe $(\varepsilon_t^z, \varepsilon_t^\tau)$.

The timing of information is as follows. At the start of a period, the households knows its own state $(K_t(i), M_t(i))$, knows a subset of the state vector: $\bar{S}_t = (K_t, \tau_{t-1}, z_{t-1})$, and knows the nominal wage. We assume that the representative firm knows the full state vector, which means that they know the state of technology and the nominal price of their good.[3]

[3] These assumptions about the household's information set and the firm's information set are natural to

In the wage setting model, the household chooses its nominal wage given $\bar{S}_t$, and firms determine the quantity of labor hired at that wage. In the misperceptions model, the household chooses its labor supply schedule given $\bar{S}_t$. The intersection of labor supply and labor demand then determines the market clearing wage and the quantity of labor that is hired.

After the household makes its labor market choices in both of the models, the full aggregate state $S_t = (K_t, z_{t-1}, \tau_{t-1}, \varepsilon_t^z, \varepsilon_t^\tau)$ is revealed, and households receive their monetary transfer from the government. The household then supplies labor and capital in production, and acquires cash consumption goods, credit consumption goods, and investment goods. At the end of the period, firms and labor settle their remaining transactions, with firms paying households for their labor and capital services, and households paying firms for credit consumption goods and investment goods.

B. Misperceptions Model

We now specify a recursive formulation of the misperceptions model. For notation, we index individual choice variables by i. Aggregate variables are not indexed. We denote the law of motion for aggregate capital by $H(S_t)$. We normalize the aggregate money stock to one.

Household's problem

The representative household has a two-stage maximization problem in this model.

make in this environment, given that we are using this simply environment to stand in for a richer environment in a multi-sectors model producing heterogeneous consumer goods. In such an environment, the firm only cares about four variables in the model: their product price, the state of their technology, and the rental prices of labor and capital. It seems plausible that the firm would know a lot about these variables just prior to production. The households in such an environment would care about many more variables than a firm does. In particular, the household would care about the entire distribution of prices in the economy. It seems plausible that households would have only imperfect information about the entire distribution at the start of the period. To match the larger informational frictions faced by households within our simple model, we assume that firms know the full state vector, which implies they know their technology and the prices, while households do not know the current shocks.

The Bellman equation for the household is given by:

$$V(M_t(i)/T_{t-1}, K_t(i), \bar{S}_t, W_t) =$$
$$\max_{N_t(i)} E_{(\bar{S}_t, W_t)} \left\{ \begin{array}{c} \max_{C_{1t}(i), C_{2t}(i), M_{t+1}(i), K_{t+1}(i)} \log([\alpha C_{1t}(i)^\sigma + (1-\alpha) C_{2t}(i)^\sigma]^{1/\sigma}) \\ +B \log(1 - N_t) \\ +\beta E_{S_t} V(M_{t+1}(i)/T_t, K_{t+1}(i), \bar{S}_{t+1}, W_{t+1}) \end{array} \right\}$$

subject to

$$\begin{aligned} & M_t(i) + W_t N_t(i) + R_t K_t(i) + (T_t - 1) M_t \\ \geq \; & M_{t+1}(i)/T_t + P_t \left[K_{t+1}(i) - (1-\delta) K_t(i) + C_{1t}(i) + C_{2t}(i)\right] \end{aligned}$$

$$M_t(i) + (T_t - 1) \geq P_t C_{1t}(i).$$

In the first stage maximization, the household chooses their labor supply schedule, given $\bar{S}_t$. This means that the household chooses their labor supply for every possible wage, given their knowledge of the state. In choosing this labor supply schedule, the household optimally forecasts the technology and monetary shocks from the current state and the nominal wage. This can be seen in the household's first order condition (f.o.c.) for choosing labor:

$$-B/(1 - N_t(i)) + W_t E\{\Lambda_t | W_t, \bar{S}_t\} = 0.$$

In this equation, the household is equating the marginal utility of leisure to the *expected* marginal utility of wealth, scaled by the nominal wage. The household solves this expectational equation using standard signal extraction formulas. The Appendix presents the details of this signal extraction problem.

After the household chooses its labor supply, S_t given its state and the nominal wage, the full state is revealed and the household chooses cash goods consumption, credit goods consumption, money holdings for next period, and investment during the second stage. The f.o.c.'s for the second stage maximization are given respectively by:

$$[\alpha C_{1t}(i)^\sigma + (1-\alpha) C_{2t}(i)^\sigma]^{-1} \alpha C_{1t}(i)^{\omega - 1} - (\Lambda_t + \Psi_t) P_t = 0$$

$$[\alpha C_{1t}(i)^{\omega} + (1-\alpha)C_{2t}(i)^{\omega}]^{-1}(1-\alpha)C_{2t}(i)^{\omega-1} - \Lambda_t P_t = 0,$$

$$\beta E_t V_1/T_t - \Lambda_t = 0$$

$$\beta E_t V_2 - \Lambda_t P_t = 0$$

The envelope conditions for $M_t(i)$ and $K_t(i)$ are

$$V_1 = E\{\Lambda_t + \Psi_t|\bar{S}_t, W_t\}$$

and

$$V_{2,t} = E\left\{\Lambda_t\left(R_t + 1 - \delta\right)|\bar{S}_t, W_t\right\}$$

Producer's Problem: Given that the firm knows S_t, and given that each type of labor sells for the same price, the firm's maximization problem can be simplified as:

$$\max_{K_t, N_t} P_t Z_t (K_t)^{\gamma}(N_t)^{1-\gamma} - W_t N_t - R_t K_t$$

The f.o.c.'s for this problem are

$$\begin{aligned} P_t Z_t \gamma (N_t/K_t)^{1-\gamma} &= R_t \\ P_t Z_t (1-\gamma)(K_t^d/N_t^d)^{\gamma} &= W_t \end{aligned}$$

Market Clearing and Aggregate Consistency Conditions:

The market clearing conditions are

$$M_t(i) = T_t,$$

$$Y_t = C_{1t} + C_{2t} + K_{t+1} - (1-\delta)K_t,$$

$$N_t = N_t(i),$$

$$K_t = K_t(i),$$

where $N_t(i)$ and $K_t(i)$ denote the labor input and capital input supplied by the representative household.

The aggregate consistency condition is

$$K_{t+1}(i) = H(S_t),$$

where $K_{t+1}(i)$ is capital stock at the beginning of the next period for the representative household.

C. The Wage-Setting Model

In this model each type of household sets their nominal wage given $\bar{S}$. The model is otherwise identical to the misperceptions model.

Producer's Problem: Because households are setting their wage, we include the CES labor aggregate in the firms problem to derive the firm's labor demand schedule for each type of labor. The profit maximization problem is given by:

$$\max_{K_t^d, N_t^d} P_t Z_t (K_t^d)^{\gamma} \left(\left[\int_0^1 N_t^d(i)^{\theta} di \right]^{1/\theta} \right)^{1-\gamma} - \int_0^1 W_t(i) N_t^d(i) di - R_t K_t^d$$

The f.o.c.'s for this problem are

$$P_t Z_t \gamma (N_t^d / K_t^d)^{1-\gamma} = R_t$$

$$P_t Z_t (1-\gamma)(K_t^d / N_t^d)^{\gamma} \left[\int_0^1 N_t^d(i)^{\theta} di \right]^{(1-\theta)/\theta} \frac{1}{\theta} N_t^d(i)^{\theta - 1} \theta = W_t(i).$$

This second equation yields the following labor demand function

$$N_t^d(W_t(i)) \equiv \left[\frac{P_t Z_t (1-\gamma)(K_t/N_t)^{\gamma} (N_t)^{1-\theta}}{W_t(i)} \right]^{\frac{1}{1-\theta}}$$

Consumer's problem:

The consumer's two stage problem is given by

$$
V(M_t(i), K_t(i), \bar{S}_t) =
$$

$$
\max_{W_t(i)} E_{(\bar{S}_t)} \left\{ \begin{array}{c} \max_{C_{1t}(i), C_{2t}(i), M_{t+1}(i), K_{t+1}(i)} \ \log([\alpha C_{1t}(i)^\sigma + (1-\alpha) C_{2t}(i)^\sigma]^{1/\sigma}) \\ +B \log(1 - N_t^d(W_t(i))) \\ +\beta E_{S_t} V(M_{t+1}(i)/T_t, K_{t+1}(i), H(S_t), z_t, \tau_t) \end{array} \right\}
$$

subject to

$$
\begin{aligned}
& M_t(i) + W_t N_t(i) + R_t K_t(i) + (T_t - 1) M_t \\
\geq \ & M_{t+1}(i) + P_t \left[K_{t+1}(i) - (1-\delta) K_t(i) + C_{1t}(i) + C_{2t}(i) \right]
\end{aligned}
$$

$$
M_t(i) + (T_t - 1) \geq P_t C_{1t}(i).
$$

The f.o.c. for choosing $W_t(i)$ is

$$
E_{\hat{S}_t} \left\{ \frac{-B N_t^{d\prime}}{1 - N_t^d} + \Lambda_t \left(N_t + W_t(i) N_t^{d\prime} \right) \right\} = 0.
$$

This implies that

$$
0 = E_{\hat{S}_t} \left\{ \left(\frac{-B}{1 - N_t^d} + \Lambda_t W_t(i) \right) N_t^{d\prime} + \Lambda_t N_t^d \right\}
$$

Note that in equilibrium,

$$
\begin{aligned}
\Rightarrow \quad N_t^{d\prime} &= -\left(\frac{1}{1-\theta} \right) \left[\frac{P_t Z_t (1-\gamma) (K_t/N_t)^\gamma (N_t)^{1-\theta}}{W_t(i)} \right]^{\frac{1}{1-\theta}} W_t(i)^{-1} \\
&= -\left(\frac{1}{1-\theta} \right) \frac{N_t}{W_t}, \qquad (2)
\end{aligned}
$$

and hence the wage equation becomes

$$
\begin{aligned}
0 &= E_{\hat{S}_t} \left\{ \left(\frac{-B}{1 - N_t} + \Lambda_t W_t \right) \left[-\left(\frac{1}{1-\theta} \right) \frac{N_t}{W_t} \right] + \Lambda_t N_t \right\} \\
&= E_{\hat{S}_t} \left\{ \left[\left(\frac{1}{W_t} \frac{B}{1 - N_t} \right) - \theta \Lambda_t \right] N_t \right\} \qquad (3)
\end{aligned}
$$

In addition to this condition we have the firm's first order condition for hiring labor, which determines labor demand given the wage. This condition simplifies to the same profit maximization condition that characterized the misperceptions model:

$$P_t Z_t(1-\gamma)(K_t^d/N_t^d)^\gamma \left(N_t^d\right)^{1-\theta} N_t^d(i)^{\theta-1} = W_t(i)$$

$$\Rightarrow \quad P_t Z_t(1-\gamma)(K_t/N_t)^\gamma = W_t. \tag{4}$$

D. The Impact of Monetary Shocks in the Models

The only difference between these two models is the size of the impact of a money shock on output. Below we will show that the sticky wage model delivers a large impact, and the misperceptions model delivers a smaller impact. Thus, choosing one model over the other just boils down to choosing whether you want a very large impact or a smaller impact of a monetary shock [4]

The impact of a monetary shock in both models boils down to three equations: the household's labor/leisure condition, the firm's first order condition for hiring labor, and the production function. The impact of a monetary shock is qualitatively very similar in the two models. This is because all of the log-linearized equations in the two models are identical, except for the household's labor/leisure decision which differs only in terms of the information set households use to infer the aggregate state.[5] In the wage-setting model the household only uses $\bar{s}_t$ to condition on to forecast the entire state of the economy, while in the misperceptions model the household also uses the nominal wage to condition on. Thus, we have:

$$\begin{aligned} \text{Misperceptions Model:} \qquad & w_t - \frac{n_t N}{1-N} = -E\{\lambda_t | w_t, \bar{s}_t\}, \\ \text{Wage-Setting Model:} \qquad & w_t - \frac{n_t N}{1-N} = -E\{\lambda_t | \bar{s}_t\}, \end{aligned}$$

This difference in the household's information, however, implies that the impact of a money supply shock in the wage setting model will be bigger than that in the misperceptions

[4] There is really no distinction between these models if one considers a sticky wage model with higher frequency wage adjustment than one year. In this case, the real impact of a money shock in this model falls, and thus the model becomes observationally equivalent to the misperceptions model.

[5] The analysis refers to log-deviations from the respective steady states of each model. It is worth noting that steady state values of all real variables in the wage setting model are lower than in the misperceptions model, due to the wage mark-up reflecting imperfect substitutability of labor.

model. This is because the nominal wage does not respond at all to a money shock in the sticky wage model, while the nominal wage in the misperceptions model does respond to a money shock.

The degree of wage response to a money shock in the misperceptions model is determined by the relative variances of the technology and monetary shocks. For example, as the variance of the technology shock approaches zero, the nominal wage responds to a money shock as it would in a perfect information model, in which money shocks are neutral. Alternatively, as the variance of the money shock approaches zero, then the nominal wage responds very little to a money shock, and the real wage rises almost as much as in the wage setting model.[6]

The impact effect of a money shock with respect to the percentage change in the real wage in each model is proportional to the induced percentage change in the price level, with the proportionality factor differing between the two models. Indexing the two models by "i", we have:

$$w_{it} - p_{it} \approx \phi_i(p_{it} - p_{it-1}), \text{ where } \phi_{sticky} < \phi_{misper} \leq 0,$$

and the impact coefficient for the misperceptions model ϕ_{misper} depends on the value of the signal extraction parameter. Table 2 shows the initial impulse response function of output to a one percent unexpected i.i.d. decrease in the money supply for the sticky wage model and for the maximum impact for the misperceptions model. Output in the sticky wage model falls 1.55 percent, and output in the misperceptions model falls 0.92 percent. Different choices for the signal extraction parameter will of course also yield impact coefficients in the misperceptions model that are smaller than 0.92.

While the elasticity of output with respect to a money supply shock is bigger in the sticky-wage model, recall from the earlier discussion that the elasticity of output with respect to a real wage change is the same in both models, and in fact will be the same in any

[6] To understand the partial response in the misperceptions model, note that if there was a negative money shock, then at the steady state nominal wage there would insufficient demand for labor. As the nominal wage falls, this would increase the demand for labor by firms. However, it also decreases the supply of labor as households interpret part of the fall as a fall in the real wage. Hence, in equilibrium the nominal wage does not fall proportionately to the monetary shock and the real wage is higher.

model that has the same production function. For the Cobb-Douglas case, the equilibrium relationship between the real wage and employment is given by the firm's log-linearized first order condition that equates the marginal product of labor to the real wage:

$$(5) \quad n_t = -\frac{1}{\gamma}(w_t - p_t).$$

The equilibrium relationship between output and the real wage is given by combining the change in labor with the log-linearized production function:

$$(6) \quad y_t = \frac{-(1-\gamma)}{\gamma}(w_t - p_t),$$

Note that the elasticity of output with respect to a real wage change is minus one times the ratio of labor's share to capital's share. With the standard value of labor's share of 2/3, this equation shows that a one percent rise in $w_t - p_t$ is associated with a two percent output decrease in both models.

To summarize, monetary shocks in both models work as follows. First, a negative monetary shocks creates unanticipated deflation, which raises the real wage. The higher real wage then lowers employment as firms move up their labor demand curve. The decrease in employment lowers output through the production function.

3. Parameter Values and the Monetary Shock

We now discuss the parameterization of the model. Table 1 presents the parameter values. A number of these are fairly standard, including the discount rate (0.95), the exponent on labor in the production function (0.67), and the depreciation rate (0.092), which yields a steady-state capital/output ratio of 2.5. We choose the preference parameters α and σ such that the steady state of the model matches two long-run observations: an interest semi-elasticity of money demand of -.08, and an average velocity level of 3.2. We choose the leisure parameter B so that households spend about 1/3 of their time working in the deterministic steady state.

We chose the autocorrelation coefficient for the technology shock to be 0.9. We chose the autocorrelation coefficient for money growth (ρ_τ) to be zero. We conducted a sensitivity analysis for values of this parameter between -0.5 and 0.5, and found that our results were not sensitive to values in this range. The innovation variances for the money supply and the technology shock matter only for the misperceptions model, as these objects determine the signal extraction parameter We discuss the choices for the signal extraction parameter below.

We now discuss how we construct the monetary shocks. We construct money shocks so that the model price level in each country and in each year matches the actual price level. We choose money shocks this way because a successful monetary model of the Depression should account for both the decrease in the price level and the decrease in labor input and output. This approach allows the model to get the price level fall, and then we will see if the models can get the output fall.

4. Can the Theory Account for the U.S.?

Before studying the international cross section, we first assess how well the theory can account for the U.S. Depression. Bordo, Erceg, and Evans (BEE, 2000) present evidence that shows that the magnitude of the impact of a money shock commensurate with the high wage story can account for much of the U.S. Depression, if one takes the view that the manufacturing wage is the relevant wage for all labor in the economy during the Depression.[7]

We conduct a similar analysis to BEE. We use our log-linearized sticky wage model, using the parameterization described above. We feed constructed money shocks into the model so that the price level in the model matches the actual U.S. price level in each year between 1930-33. We do not feed in any technology shocks. We then compare the actual real wage to the model real wage, and we compare actual real output to real output in the model.

We follow this particular strategy in matching the price level, because a successful monetary model of the Depression should account for both the price level fall and the output fall. This approach lets the model get the price level fall, and then we assess how well it captures the output fall.

Table 3 shows that both the model real wage and model output match up quite well with the actual real wage and actual output through 1932. In particular, actual output in 1932

[7] In recent work (Cole and Ohanian, 2001), we argue that the manufacturing wage may not be the relevant wage for the representative worker, because of changes in the composition of employees, and because real wage rates in other sectors (such as agriculture) fell. We set aside these reservation for this exercise.

is 33 percent below its 1929 value, while model output in 1932 is 25 percent below its 1929 value.[8] Thus, the high wage story - using either the sticky wage model or the misperceptions model with maximum nonneutrality - has some success for the U.S. We will next assess the implications of the story for the international cross section.

5. The Data and the Cross-Sectional Relationship Between Wages and Output

We use annual data from Cole, Leung, and Ohanian (2001) for 17 major countries that have time series for real GDP, the GDP deflator, the money supply, and a wage rate available each year through the early 1930s. These countries are Australia, Austria, Canada, Czechoslovakia, Denmark, Finland, France, Germany, Hungary, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland, the U.K. and the U.S. The wage rates are for the industrial/manufacturing sector.

Table 4 summarizes the cross-country means and standard deviations for output, real wages, and deflation for each year. The statistics are based on equally-weighted data, rather than on size-weighted data. The table presents the means for each year between 1930-33, relative to 1929. There are 3 main facts about these mean changes: (1) prices begin falling in 1930, (2) real wages begin rising in 1930, and (3) output begins falling in 1931. These averages raise the possibility that for 1931-33, the high real wage story may be able to account for the mean decrease in output across countries.

The second 3 columns of Table 4 present standard deviations of these variables. These standard deviations show that output volatility is greater than either deflation volatility or real wage volatility. This high output volatility suggests that much of the decrease in output across countries is due to country-specific effects, rather than a common effect. We assess this by decomposing output changes across countries into a mean component and country-specific component. This decomposition is:

$$y_{it} = \bar{y}_t + u_{it},$$

[8] It should be noted that the model misses on labor input and productivity. Labor input falls too much in the model relative to the data. This is because labor productivity in the model rises, while labor productivity in the data falls significantly.

where y_{it} is country i's log output deviation from 1929, $\bar{y}_t$ is the mean output deviation across countries, and ε_{it} is the country-specific output deviation. The last column of Table 4 shows the fraction of the sum of squared output deviations accounted for by the country-specific effect in each year. This fraction shows that there is a lot of country-specific variation in the Depression across countries.[9] These data show that the fraction of output deviations accounted for by the country-specific component ranges between 57 and 97 percent, and averages about 73 percent over these 4 years. This means that most of the International Great Depression is due to country-specific, idiosyncratic effects, rather than a common effect hitting all countries equally.

This large country-specific component has an important empirical implication for the high wage story. It means that the theory can account for the international cross section of output changes only if the countries with the biggest real wage increases are those with the most severe depressions.

Figures 1-4 show the cross-country relationship between real wages and output for each year from 1930-33. There is one figure for each year, and each figure shows the log-deviation of output in each country for that year from its 1929 value, plotted against the log-deviation of the real wage in each country for that same year from its 1929 value. The figure also shows a line that is the log-linearized equilibrium relationship between output from the Cobb-Douglas production function and the real wage given. This line assumes no shift in the production function, and uses a labor share of 2/3.

The simple high real wage story says that the output-real wage observations in the data should lie roughly along the line in the figures, and that the correlation between these two variables should be roughly -1.[10] We do not see this in the data. The cross-country output-real wage observations in these figures deviate substantially from this line, and the

[9] This fraction is the sum of squared country-specific effects, divided by the sum of squared output deviations:

$$share_t = \sum_{i=1}^{N} u_{it}^2 \;/\; \sum_{i=1}^{N} (\bar{y}_t + u_{it})^2$$

[10] Note that this test does not rely on details about the production function, such as capital-labor substitutability or factor share numbers. All we assume is a downward sloping labor demand curve with no shift in the marginal product of labor.

cross-country real wage-output correlation is positive, not -1. The actual real-wage output correlations are listed on each figure and are for each year respectively: 0.33, 0.35, 0.18 and 0.20.[11]

These pictures and correlations tell us that the International Depression is not just the high wage story of firms moving up their labor demand curves in response to high real wages. Instead, these findings tell us we need some quantitatively important shock that *shifts* the labor demand curve. An alternative way of understanding the need for a labor demand shifter is to note that the simple high wage story without the shifter cannot identify which countries did relatively well and which countries did poorly. This is because the correlation between actual output and predicted output in these graphs is simply equal to the negative of the real wage-output correlation. Thus, the correlation between actual output and predicted output in these graphs for each of the 4 years is -0.33, -0.35, -0.18, and -0.20, respectively.[12] These correlations between real wages and output and predicted and actual output are robust predictions of the high wage story. They follow directly from a downward sloping labor demand curve with no shift in the marginal product of labor.

6. Adding a Labor Demand Shifter

Figures 1-4 tell us that we need to add a labor demand shifter to the models to pursue the high wage story further for the international cross section. That is, we will need to add a second shock to the models that shifts labor demand. Before we conduct the analysis with both money shocks and the labor demand shifter, we need to address two questions. The first is what is the labor demand shifter? The second question is what magnitude of the real impact of a money shock should be used?

We choose productivity shocks as the labor demand shifter, since they shift the marginal product of labor schedule, and because there is evidence of large cross-country differences

[11] It is natural to wonder if these findings are affected by measurement error. Note that classical measurement error *strengthens* our findings about the positive real wage-output correlation, since this type of error yields correlations that are biased downwards.

[12] To see this, note that in a model with a fixed capital stock that predicted output is equal to -$\alpha(w-p)$. This implies that the correlation between actual and predicted output is equal to -corr(y,w-p). We have also done some dynamic experiments in which we matched the real wage, and found that the real wage-output correlation in the model is between -0.96 and -1, and that the models do poorly in predicting the international depression. In particular, the correlation between the actual and predicted output levels is very close to the negative of the actual output-to-real-wage correlations in the data.

in productivity shocks that are qualitatively consistent with the positive cross-country correlation between real wages and output. Table 7 shows data for 4 countries, and indicates that countries with mild depressions had mild productivity shocks while countries that had major depressions had large negative productivity shocks. The table shows aggregate labor productivity (real GNP per worker) and output for Australia, Canada, the U.K., and the U.S. Australia and the U.K. had mild depressions (-1 and -4 percent) and little productivity change. In contrast, Canada and the U.S. had severe depressions (-36 and -31 percent in 1933) and substantial productivity decreases. We will therefore feed productivity shocks into the model economies, along with monetary shocks.

Given that we will be adding productivity shocks to the model, the second question is the magnitude of the real impact of a money shock in the model. Recall that the *only* difference between the two models is the impact of a money shock on output. We require that a reasonable impact coefficient is one such that with money shocks alone, the model does not overpredict the average decrease in output in the international cross section. This is because we know from figures 1-4 and the real wage-output correlations that the labor demand shifter will also be contributing the Depression.

We first consider whether the maximum real impact of a money shock - which is the impact in the sticky wage model - is reasonable. We do this by examining the predictions of this model for the international cross section when there are only money shocks. We use the same parameter values and followed the same strategy as in the previous U.S. analysis. That is, we constructed money shocks such that the model matched the price level in each country and for each year between 1930-33, and we then evaluated the output change in the model.

We find that this maximum impact coefficient is much too large to study the international cross section. This is because with money shocks alone, this model drives down output way too much. In particular, this model predicts the average output decrease in the cross-section for 1931 is 15 percent, when the actual average decrease this year is only 6 percent. For 8 of the 17 countries, the model overpredicts the output decrease by more than 10 percentage points, and for 3 out of the 17, it overpredicts the decrease by more than 20 percentage points (Japan, Denmark, and Switzerland). (Appendix Table A1 shows the details of these results).

Given that the maximum impact coefficient substantially overpredicts the output decrease in the international cross section, we now turn to the misperceptions model, which gets a smaller impact coefficient, and which also displays a range of impact coefficients depending on the value of the signal extraction parameter (η). We first choose a value of this parameter such that we minimize the sum of squared output errors in the model for the 1930-33 period for the international cross section, when the model is driven by money shocks alone. Thus, we find the impact coefficient that allows the model to do the best possible job with money shocks alone, using the mean square error metric. This impact coefficient is such that a surprise 10 percent decrease in the money supply drives down output 6.5 percent, compared to the sticky wage model, in which the same monetary surprise drives down output by almost 16 percent. (Table 6 shows some details about the performance of this model by year, including root mean square output forecast error by year, root mean square output deviation by year, average error by year, and the correlation between real wages and output in the model.)

The results from the model with this lower impact coefficient looks much more sensible relative to the sticky wage model. Note that the misperceptions model overpredicts average output only in 1930, and underpredicts output in the remaining years. On average, the model with this impact coefficient underpredicts output by about 2.5 percentage points in the cross section between 1930-33, which seems reasonable, given that the labor demand shifter will be accounting for some of the decrease in output. We therefore use the misperceptions model with this value of the signal extraction parameter in the next section when we include both money and productivity shocks.

We will test the robustness of the results by considering an alternative impact coefficient which was chosen based on historical evidence from earlier depressions. Specifically, we use U.S. annual data on real GNP and the GNP deflator from Gordon (1986) for the 1893 and 1907 Depressions. We use these episodes because they are typically associated with monetary/financial shocks. We calculated the impact coefficient as the average of the ratio of the percent decrease in real GNP to the percent decrease in the deflator. This impact coefficient is such that a surprise 10 percent decrease in the money supply drives down output about 3.5 percent.[13]

[13] Including data from the 1920-22 recession in this calculation would have resulted in an even smaller

We now turn to simulating the model with both money and productivity shocks. We will focus our analysis on the relative contributions of these two shocks to the Depression, and whether the productivity shocks in the model look like productivity measures from the data.

7. Accounting for the Depression with Money and Productivity Shocks

We now are in a position to pursue the analysis with both productivity shocks and money shocks. Ideally, we would conduct this two shock analysis by feeding in productivity shocks from the data. Unfortunately, TFP is available only for the U.S. and Canada in our 17 country sample. We therefore conduct an alternative experiment as follows.

We use the misperceptions model parameterized to minimize the sum of squared output deviations as described in the previous section. We then construct country-specific productivity shocks and country-specific monetary shocks in the model so that output and the price level in the model for each country and for each year matches the data. This boils down to solving 2 linear equations in the 2 shocks for each year and each country. We then calculate the fraction of the sum of squared output deviations in the international cross-section accounted for by each these shocks for each year.

Before we can conduct these decomposition accounting exercises, however, we need to orthogonalize these shocks. We follow the standard practice of calculating the two bounds on the orthogonalizations; the first orthogonalization attributes all of the non-orthogonal movements in the two shocks to productivity, and the second orthogonalization attributes all of the non-orthogonal movements in the two shocks to money.

Table 7 reports characteristics about the constructed raw productivity shocks and the orthogonalized components, and reports the output variance decomposition. This table and the subsequent tables denote productivity as "z" and orthogonalized productivity as "$\hat{z}$". There are two main findings. The first is that the model needs large productivity shocks to account for the Depression, even after taking into account the effect of the negative monetary shocks. The raw productivity shocks are about 4 percent below their 1929 values at the

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impact coefficient.

trough of the depression in 1932 and 1933, compared to a 9 percent average output decrease. The second main finding is that productivity shocks account for a substantial fraction of the Depression. Productivity shocks account for an average of 87 percent of the sum of squared output deviations over 1930-33 for the first orhtogonalization, and account for an average of 45 percent for the second orthogonalization over 1930-33. (Tables 8 and 9 show the statistics on the two different orthogonalizations of productivity, while Appendix Table A2 reports the raw values of the productivity shocks).

There are other orthogonalizations between the two orthogonalization bounds we have considered. A particularly interesting alternative orthogonalization decomposes productivity into a component that is orthogonal to deflation, and a non-orthogonal component. This is an interesting case because the standard story is that deflation caused the Great Depression, and this decomposition lets us control for productivity movements that may be proxying for the effects of deflation. In particular, this orthogonalization allows us to correct for deflation-induced changes in capital utilization or other deflation-related measurement issues.

We therefore focus on the contribution of productivity shocks that are orthogonal to deflation. Table 10 presents the results of this third orthogonalization. Productivity orthogonal to deflation accounts for between 50-96 percent of the sum of squared output deviations between 1930-33, with an average of 68 percent over the four year period. Moreover, most of the variation in productivity is due to this orthogonal component. Between 1930-33, the orthogonal component accounts for 85 percent of the movements in productivity.

One of the key reasons why productivity shocks are playing such a major role in this specific orthogonalization is because deflation and output tend to be *negatively* correlated during this period. For example, the correlation between deflation and the log-deviation of output from 1929 is -0.34 for 1930 and -0.25 for 1931. Note that productivity orthogonal to deflation accounts for 96 percent and 72 percent of squared output fluctuations for these years, respectively. The only year in which there is a sizeable positive correlation is in 1932, when the correlation is 0.47. This is the year in which orthogonal productivity accounts for the smallest fraction of output: 50 percent.

These results show that productivity shocks are playing a major role in the model. We now check to see if the constructed productivity shocks from the model are similar to the data. We do this two ways. We first compare labor productivity from the model to labor productivity in the data for the 4 countries for which we have economy-wide labor productivity: Australia, Canada, the U.K., and the U.S. Table 11 shows that the labor productivity in the model is very similar to labor productivity in the data for each year and for each country. For 1933, labor productivity in the actual data vs. the model is: U.S., -16% (actual) vs. -15% (model), U.K., -2% vs. -2%, Australia, 4% vs. 1%, and Canada, -25% vs. -15%.

It is important to recognize that labor productivity in the model could have turned out to be anything - there is no presumption that labor productivity in the model should be similar to that in the data. In fact, it is interesting to note that if we undertake this same experiment with the sticky wage model, then labor productivities in the model are rising, rather than falling as in the data. The reason for this is that in the sticky wage model deflation is driving down output to a greater degree, hence requiring less from real shocks, but the mechanism by which it does so drives up labor productivity. For example, labor productivity is predicted to up 9% in the U.S. in 1932, while in the data it's down 9%. In 1931, labor productivity in Australia is predicted to be up 14%, while in the data it's up only 1%. (Appendix Table A3 shows these results in detail.)

We now go beyond the 4 countries for which we have economy-wide labor productivity data, and compare the constructed productivity shocks in the model to manufacturing labor productivity in the data. We have this measure for 15 countries, which is all the countries in the sample except Czechoslovakia and Denmark.[14] We then take an average of TFP between 1930-32, and calculate the correlation between averaged TFP and averaged orthogonalized TFP in the model (orthogonal to deflation) to the 1930-32 average of manufacturing labor productivity in the data. These correlations are high, between 0.70 and 0.74.[15]

We also conducted the analysis for the alternative impact coefficient of money. We

[14] For Austria, France and Germany, data limitations allowed us to only use deviations from their 1930 levels.

[15] We chose to compare correlations between the model TFP shocks and industrial labor productivity, rather than compare the labor productivities in the model to the manufacturing labor productivities because there may have been a level difference between the manufacturing sector and the overall economy. For example, the shocks may differ because the manufacturing sector tends to get hit harder during downturns than the overall economy.

found that our results are robust to this change. The output decompositions are the same out to the third decimal point, the labor productivities in the model for the 4 countries differ somewhat, but still are similar to the actual labor productivities, and the correlation between labor productivity in the model and manufacturing labor productivity in the data for the 15 countries remains around 0.7. Appendix tables A4-A10 present the details for this alternative parameterization.

These similarities between productivity changes in the model and productivity changes in the data indicate that a shock that (1) works like a productivity shock, and (2) is largely orthogonal to deflation, and (3) looks a lot like productivity in the data is a quantitatively important factor in accounting for the International Depression.

8. Are the Productivity Shocks Proxying for Other Factors?

Despite the similarity between the constructed and actual productivity changes, it is possible that the constructed productivity shocks are proxying for some other factor. We assess this possibility by calculating the correlation between the values of productivity and the orthogonal component of productivity across countries with three country-specific factors - differences in international trade, differences in the size of the agricultural sector, and differences in the real effects of deflation. Table 12 presents these results.

The first factor we consider is the size of a country's trade sector in 1929. The idea here is that more open economies would be more vulnerable to foreign shocks. We measure the size of the trade sector as the sum of exports and imports divided by output. We have data for all the countries in the sample except Czechoslovakia and Germany. The correlation is low - about 0.10 - and the sign is the opposite of what we would have expected. Thus, productivity does not seem to be proxying for trade, at least as measured by the share of output in exports and imports.

We now consider whether productivity is proxying for country-specific differences in the real effects of high real wages. We first consider the share of output accounted for by agriculture in 1929. The idea here is that our wage measure is for the industrial sector, and it may be that deflation affected agricultural wages much differently. For example, Cole and Ohanian (2001) document that agricultural nominal wages fell more than industrial nominal wages during the U.S. Great Depression. If this was the case, we should see a strong positive correlation between productivity and the agricultural share, but a much lower correlation between the agricultural share and the orthogonalized productivity shock.

We have data for 12 countries out of the 17 for the agricultural share - we do not have data on this factor for France, Japan, the Netherlands, Norway, and Switzerland. The correlations of this factor with both productivity and orthogonalized productivity are around 0.45. This indicates that countries with larger agricultural shares did have lower output decreases, but this seems unrelated to deflation, since the correlation is the same for both the raw shock and the orthogonalized shock. Thus, perhaps there is some relationship here worthy of further study, but it appears to be unrelated to deflation.

We next assess whether productivity is proxying for specific differences in the real effects of deflation beyond the measurement of real wages. For example, suppose that for unspecified reasons that the countries with large depressions had large output responses to deflation, and that the countries with small depressions had small output responses to deflation. Of course, one needs some data to measure these country specific differences. We measure these country-specific differences using data from the 1920s, when many countries in our sample experienced large deflations. For each country for which we have data, we measure the country-specific 1920s response to deflation as the ratio of the log-deviation in output to the log-deviation in prices over the two years of the deflation. We then multiply this ratio by the log-deviation in prices during the 1930-32 period. This yields an estimate of the country-specific decrease in output during the 1930s, given each country's 1920s deflation response. This measure proxies for country-specific deflation effects if country-specific effects in the 1930s were similar to those in the 1920s. We find that the correlation between the country-specific output decrease from deflation and the constructed productivity shock across countries is only around 0.10. Thus, if productivity is proxying for country-specific differences in the real effects of deflation, then these country-specific effects must have fundamentally changed from the previous decade.

We therefore conclude that the constructed productivity shocks are not easily accounted for these 3 other factors. We have not analyzed whether these productivity movements are due to input measurement error or increasing returns/aggregate externalities.[16] However, focusing on productivity shocks orthogonal of deflation provides some control for these factors. While moving beyond these deflation-related mismeasurement issues is beyond the scope of this paper, we make the following observations. Regarding input mismeasurement, Ohanian (2001) made some calculations regarding the potential importance of labor hoarding, capital utilization, and changes in the composition of output and employee quality for accounting for lower productivity during the U.S. Great Depression. Taking all these factors together, he estimated that they could explain about 25-30% of the measured productivity decrease, which thus leaves a big, productivity residual. Moreover, even if one assumed that all productivity shocks were due to input mismeasurement, one would then need to come up with some alternative shock that shifts labor demand schedules in order to account for the positive correlation between real wages and output.

Regarding increasing returns/aggregate externalities, these do not eliminate productivity shocks unless the increasing returns are considerably larger than the standard empirical finding of constant returns to scale (see Basu and Fernald, and Burnside, Eichenbaum, and Rebelo (1995)). Moreover, if one considers increasing returns large enough to eliminate productivity shocks, such as the returns to scale numbers used originally by Benhabib and Farmer, then this raises questions about the high real wage story in the first place. This is because the labor demand curve in these models slope *up*, rather than down. Thus, one cannot tell a story about firms moving up their labor demand curves in response to high real wages in a Benhabib-Farmer model. Instead, this model would explain the Depression on the basis of extrinsic uncertainty.

9. Summary and Conclusion

This paper presented evidence that a labor demand shifter - productivity shocks - is a key addition to the standard high wage story for the International Great Depression. We evaluated the relative contributions of productivity shocks, and of money shocks operating through high real wages, to output changes for 17 countries between 1930-33. We estimate

[16] Bernanke and Parkinson (1991) document negative productivity shocks in U.S. manufacturing data during the Depression, but argue that these productivity changes are proxying for either input mismeasurement or increasing returns.

that about 2/3 of output changes in the international cross section is accounted for by a productivity or productivity-like shock which is orthogonal to deflation, and about 1/3 of output changes is accounted for by money shocks.

This finding about the importance of productivity shocks is reminiscent of our findings about why the U.S. Great Depression was so much worse than the 1920-22 recession, despite the fact both episodes had very similar deflations. We argued that a key reason why the U.S. Great Depression of 1930-33 was so severe was because productivity fell substantially between 1930-33, and that a key reason why the 1920-22 recession was comparatively mild was because productivity rose between 1920-22. (See Cole and Ohanian 2001.)

This analysis has followed the standard practice in general equilibrium model of decomposing output changes into changes in inputs and changes in productivity. Since we have restricted the analysis to two shocks, it remains an open question whether the relative importance of productivity is an artifact of abstracting from other shocks that could move around the inputs. If this was the case, there would probably be a mis-match between labor productivity in the model and labor productivity in the data. The fact that labor productivity in the model lines up with labor productivity suggests that our decomposition is not an artifact of just considering two shocks. However, more work is required to systematically address this interesting question.

Our findings suggest a key puzzle: what economic factors are causing these productivity-like shocks? It is of course unlikely that these negative productivity shocks are technological regress. Thus, future research should develop and analyze theories that can shed light on what these productivity-like shocks might be standing in for in our simple growth model. Some possibilities for these productivity-like shocks might include breakdowns in borrowing/lending relationships and credit (see Bernanke (1983)), large decreases in organization/information capital (see Ohanian (2001)), or government policy interventions that affected efficiency, such as Herbert Hoover's jawboning of U.S. firms to practice work sharing rather than use layoffs during the downturn (see Cole and Ohanian (2001)). A key point is that any candidate factor cannot be a shock that affects only inputs. Rather, a candidate factor must work so that it looks like a productivity shock in a simple neoclassical production function.

10. References

(To Be Added)

11. Tables

Table 1: Benchmark Parameters Values

γ	β	θ	δ	α	ω	σ_z	ρ_z	σ_τ	ρ_τ
.33	.94	.9	.023	.5	.92	.01	.90	.01	.00

Table 2: Impulse Response to

One Percent Negative Money Shock:

Sticky Wage Model and Maximum Misperceptions Model

	y	w − p	p
Sticky Wage	-1.55	0.78	-0.78
Misperceptions	-0.92	0.46	-0.87

Table 3: U.S. Results from the Sticky Wage Model:

Deflation Experiment:

	Data			Model	
Year	y	w − p	p	y	w − p
1930	-0.099	0.033	-0.028	-0.056	0.028
1931	-0.188	0.083	-0.116	-0.179	0.083
1932	-0.332	0.100	-0.239	-0.248	0.099
1933	-0.353	0.097	-0.265	-0.052	-0.019

Table 4: Cross-Sectional Data Statistics:

(Log Deviation From 1929)

	Mean			Standard Deviation			Idiosyncratic
Year	y	w − p	dp	y	w − p	dp	y Share
1930	0.00	0.05	-0.05	0.05	0.03	0.03	.97
1931	-0.06	0.09	-0.07	0.08	0.05	0.03	.63
1932	-0.10	0.09	-0.05	0.11	0.06	0.05	.57
1933	-0.08	0.09	-0.02	0.14	0.08	0.05	.74

Table 5: Log Deviations in Output and Labor Productivity

1933 relative to 1929

Country	**Y**	**Y/L**
Australia	-.01	.04
Canada	-.36	-.25
U.K	-.04	-.02
U.S.	-.31	-.16

Table 6: Results for the Best-Fitting Misperceptions Model

Monetary Shock Set to Match Price Level

	R.M. Square	**R. M. Square**	**Mean**	**Corr($\mathbf{y, w - p}$)**	
Year	**Error**	**Output Dev.**	**Error**	**Model**	**Data**
1930	0.059	0.042	0.03	-1.00	0.33
1931	0.081	0.094	-0.01	-0.98	0.35
1932	0.115	0.144	-0.06	-0.97	0.18
1933	0.141	0.152	-0.06	-0.96	0.20
Overall	0.103	0.117	-0.03		

Table 7: Characteristics of Productivity Shocks in the Misperceptions Model

(Shocks: Money and Productivity)

	$\mathbf{z}$		
Year	**Mean**(z)	**Mean**(z^2)	**Corr**(z, y)
1930	0.01	0.001	0.13
1931	0.00	0.002	0.27
1932	-0.04	0.005	0.71
1933	-0.04	0.007	0.62

Table 8: Orthogonalizing the Productivity Shocks

Attribute All Non-Orthogonal Changes to Monetary Shock

(Shocks: Money and Productivity)

	$\hat{\mathbf{z}} = \mathbf{z} \perp \boldsymbol{\varepsilon}_t$			$\%(y)$
Year	**Mean**$(\hat{z})$	**Mean**$(\hat{z}^2)$	**Corr**$(\hat{z}, y)$	**explained**
1930	0.00	0.001	0.99	96
1931	0.00	0.002	0.97	56
1932	0.00	0.003	0.74	31
1933	-0.012	0.005	0.71	49

Table 9: Orthogonalizing the Productivity Shocks

Attribute All Non-Orthogonal Deviations to Productivity

(Shocks: Money and Productivity)

	$\hat{\mathbf{z}} = \mathbf{z}$			$\%(y)$
Year	**Mean**$(\hat{z})$	**Mean**$(\hat{z}^2)$	**Corr**$(\hat{z}, y)$	**explained**
1930	0.01	0.001	0.13	56
1931	0.00	0.002	0.27	62
1932	-0.04	0.005	0.71	91
1933	-0.04	0.007	0.62	95

Table 10: Orthogonalizing the Productivity Shocks

Orthogonalize Productivity to Deflation

(Shocks: Money and Productivity)

	$\hat{\mathbf{z}} = \mathbf{z} \perp \mathbf{dp}$			$\%(y)$
Year	**Mean(z)**	**Mean(z^2)**	**Corr(z, y)**	**explained**
1930	0.02	0.001	1.00	96
1931	-0.00	0.002	0.98	72
1932	-0.04	0.004	0.79	50
1933	-0.04	0.007	0.90	81

Table 11:Aggregate Labor Productivity in the Model and in the Data

(Shocks: Money and Productivity)

	Model				**Data**			
Country	**1930**	**1931**	**1932**	**1933**	**1930**	**1931**	**1932**	**1933**
Australia	0.07	0.03	0.02	0.01	0.05	0.01	0.03	0.04
Canada	-0.00	-0.04	-0.08	-0.15	-0.01	-0.14	-0.19	-0.25
U.K	0.01	0.00	-0.01	-0.02	0.02	-0.01	-0.02	-0.02
U.S.	-0.02	-0.03	-0.08	-0.15	-0.04	-0.05	-0.09	-0.16

Table 12: Correlations of Productivity Shocks with Other Factors

(Shocks: Money and Productivity)

Factors	$\mathbf{z}$	$\hat{\mathbf{z}} = \mathbf{z} \perp \mathbf{dp}$
1920s Deflation Response	0.10	0.09
Trade Share	0.13	0.12
Agricultural Share	0.49	0.45
Industrial Labor Productivity	0.71	0.74

12. Appendix

A. Characterizing the Equilibrium of the Misperceptions Model

We have the following set of equations:

1. $Z_t K_t^{\gamma} N_t^{1-\gamma} = C_t + K_{t+1} - (1-\delta)K_t$

2. $\bar{\tau} e^{\tau_t} = P_t \tilde{C}_t$

3. $-B/(1-N_t) + W_t E\{\Lambda_t | W_t, \hat{S}_t\} = 0.$

4. $\left[\kappa \tilde{C}_t^{\omega} + (1-\kappa)\hat{C}_t^{\omega}\right]^{-1} \kappa \tilde{C}_t^{\omega-1} - (\Lambda_t + \Psi_t)P_t = 0$

5. $\left[\kappa \tilde{C}_t^{\omega} + (1-\kappa)\hat{C}_t^{\omega}\right]^{-1} (1-\kappa)\hat{C}_t^{\omega-1} - \Lambda_t P_t = 0$

6. $\beta E_t\{\lambda_{t+1} + \Psi_{t+1}\}/T_t - \Lambda_t = 0$

7. $\beta E_t \left\{\lambda_{t+1} \left(R_{t+1} + P_{t+1}(1-\delta)\right)\right\} - \Lambda_t P_t = 0$

8. $P_t Z_t \gamma (N_t/K_t)^{1-\gamma} = R_t$

9. $P_t Z_t (1-\gamma)(K_t/N_t)^{\gamma} = W_t$

10. $\tilde{C}_t + \hat{C}_t = C_t.$

The next step is to log-linearize the set of equations we're solving. We denote the log deviations in lower case. Note that Λ's log deviation is given λ and Ψ's log-deviation is given by ψ. We denote by the untime-subscripted capitals the values around which we're taking our approximation.

The steady state of our model is therefore determined by

1. $ZK^{\gamma}N^{1-\gamma} = C + \delta K$

2. $\bar{\tau} = P\tilde{C}$

3. $-B/(1-N)+\Lambda W=0$

4. $\left[\kappa\tilde{C}^{\omega}+(1-\kappa)\hat{C}^{\omega}\right]^{1/\omega-1}\kappa\tilde{C}^{\omega-1}-\Lambda\bar{P}-\Psi\bar{P}=0$

5. $\left[\kappa\tilde{C}^{\omega}+(1-\kappa)\hat{C}^{\omega}\right]^{-1}(1-\kappa)\hat{C}^{\omega-1}-\Lambda\bar{P}=0,$

6. $\beta(\Lambda+\Psi)/T-\Lambda=0$

7. $\beta(\bar{R}+P(1-\delta))-P=0$

8. $PZ\gamma(N/K)^{1-\gamma}=\bar{R}$

9. $PZ(1-\gamma)(K/N)^{\gamma}=W$

10. $C=\tilde{C}+\hat{C}$

11. $Z=1$

12. $T=1$

The deviations of our model around this steady state is determined by the following system of equations, where in an abuse of notation we denote the deviations of the shocks to technology and money growth from their means by z_t and τ_t respectively:

1. $z_t+\gamma k_t+(1-\gamma)n_t=\frac{C}{Y}c_t+\frac{K}{Y}(k_{t+1}-(1-\delta)k_t)$

2. $\tau_t=p_t+\tilde{c}_t.$

3. $-n_tN/(1-N)+w_t+E\{\lambda_t|w_t\}=0.$

$$
\begin{aligned}
4.\ 0 \;=\; & \left\{(\omega-1)-\left[\kappa\tilde{C}^{\omega}+(1-\kappa)\hat{C}^{\omega}\right]^{-1}\kappa\tilde{C}^{\omega}\omega\right\}\tilde{c} \\
& -\left\{\left[\kappa\tilde{C}^{\omega}+(1-\kappa)\hat{C}^{\omega}\right]^{-1}(1-\kappa)\hat{C}^{\omega}\omega\right\}\hat{c} \\
& -p-\frac{\Lambda P\lambda+\Psi P\psi}{\Lambda P+\Psi P}
\end{aligned}
$$

5. $$\begin{aligned} 0 = & -\left\{\left[\kappa\tilde{C}^{\omega}+(1-\kappa)\hat{C}^{\omega}\right]^{-1}\kappa\tilde{C}^{\omega}\omega\right\}\tilde{c} \\ & +\left\{(\omega-1)-\left[\kappa\tilde{C}^{\omega}+(1-\kappa)\hat{C}^{\omega}\right]^{-1}(1-\kappa)\hat{C}^{\omega}\omega\right\}\hat{c} \\ & -(\lambda+p) \end{aligned}$$

6. $\beta E\{\Lambda\lambda_{t+1}+\Psi\psi_{t+1}\}-\bar{\tau}\Lambda(\lambda_t+\tau_t)=0.$

7. $E\{(\beta R/P)r_{t+1}+\lambda_{t+1}+\beta(1-\delta)p_{t+1})\}-(\lambda_t+p_t)=0.$

8. $p_t+z_t+(1-\gamma)(n_t-k_t)=r_t.$

9. $p_t+z_t+\gamma(k_t-n_t)=w_t$

10. $\tilde{C}\tilde{c}_t+\hat{C}\hat{c}_t=Cc_t.$

11. $z_t=\rho_z z_{t-1}+\varepsilon_t^z,$

12. $\tau_t=\rho_\tau\tau_{t-1}+\varepsilon_t^\tau.$

B. Solving the Model via the Method of Undetermined Coefficients

In this case we define the state vector to be $s_t=(k_t,z_{t-1},\tau_{t-1},\varepsilon_t^z,\varepsilon_t^\tau)$ and assume that our controls can all be written as a linear function of the state. Thus we define our controls to be $d_t=(k_{t+1},n_t,c_t,p_t,w_t,r_t,\lambda_t,\psi_t)$, and our system has the form $d_t=Ds_t$. For example, $c_t=D_cs_t$, and $k_{t+1}=D_ks_t$. We will also want to define the selector matrices for k_t, z_t and τ_t :

$$\begin{aligned} I_k &= [1\ 0\ 0\ 0\ 0] \\ I_z &= [0\ \rho_z\ 0\ 1\ 0] \\ I_\tau &= [0\ 0\ \rho_\tau\ 0\ 1] \end{aligned}$$

and the forecasting matrix H for s_{t+1} :

$$H = \begin{bmatrix} D_k \\ I_z \\ I_\tau \\ 0_5 \\ 0_5 \end{bmatrix}$$

Handling the expectational equation:

Equation (4) involves an expectational term. Given that $\lambda_t = D_\lambda s_t$ and $w_t = D_w s_t$, and that all but the last two terms of the state vector are common knowledge at the beginning of the period, the inference problem for the workers to extract a forecast of

$$D_{\lambda 4}\varepsilon_t^z + D_{\lambda 5}\varepsilon_t^\tau$$

from observing

$$D_{w4}\varepsilon_t^z + D_{w5}\varepsilon_t^\tau.$$

This is a standard signal extraction problem, and the solution is given by

$$E\{D_{\lambda 4}\varepsilon_t^z + D_{\lambda 5}\varepsilon_t^\tau | D_{w4}\varepsilon_t^z + D_{w5}\varepsilon_t^\tau\} = \eta\left(D_{w4}\varepsilon_t^z + D_{w5}\varepsilon_t^\tau\right)$$

$$\text{(7)} \qquad \text{where } \eta = \frac{E([D_{\lambda 4}\varepsilon_t^z + D_{\lambda 5}\varepsilon_t^\tau]\,[D_{w4}\varepsilon_t^z + D_{w5}\varepsilon_t^\tau])}{E([D_{w4}\varepsilon_t^z + D_{w5}\varepsilon_t^\tau]^2)} = \frac{D_{\lambda 4}D_{w4}\sigma_z^2 + D_{\lambda 5}D_{w5}\sigma_\tau^2}{(D_{w4})^2\sigma_z^2 + (D_{w5})^2\,\sigma_\tau^2}.$$

Hence,

$$E\{\lambda_t | w_t\} = [D_{\lambda 1}, D_{\lambda 2}, D_{\lambda 3}, \eta D_{w4}, \eta D_{w5}] * s_t,$$

C. Characterizing the Equilibrium of the Sticky Wage Model

The system of equations characterizing the sticky wage model is the same as the misperceptions model with exception of the third equation in our system which is now given by

3. $E_{\hat{S}_t}\left\{\left[\left(\frac{1}{W_t}\frac{B}{1-N_t}\right)-\theta\lambda_t\right]N_t\right\}=0$

When we linearize equations (3), we derive the following steady state

$$\left(\frac{B}{(1-N)}\right)-\theta\Lambda W=0,$$

and deviation equation

$$E_{\hat{S}_t}\left\{\frac{N}{(1-N)}n_t-\theta\Lambda(\lambda_t+n_t)\right\}=0,$$

which, becomes

$$\left(\begin{array}{c}\left\{\left[\frac{N}{(1-N)}\right]D_n-\theta\Lambda(D_\lambda+D_n)\right\}\hat{S}\\ +Dw*(1-\hat{S})\end{array}\right)s_t=0,$$

where $\hat{S}=[1\ 1\ 1\ 0\ 0\ ]$.

D. Deriving the Shock from Prices

In our computations, we have chosen to treat the price sequence as the fundamental object from which we derive our shocks to money. Assume that we're starting with some price sequence $\{\bar{p}_t\}_{t=0}^{T}$, where $\bar{p}_t$ denotes the log of the price index in period t in the data, and $t=0$ is taken to be the starting point.

The initial deviation in the price level is therefore given by $\bar{p}_1-\bar{p}_0$, and hence, we can infer our shock directly from

$$s_{1,5}=\frac{\bar{p}_1-\bar{p}_0-D_{p,1:4}s_{1,1:4}}{D_{p,5}}.$$

Now, because of our normalization, the price level in the second period in our model has be adjusted upwards by the negative of the money growth rate this period, hence $p_2-\tau_1$

corresponds to the price level in the model. Therefore,

$$s_{2,5} = \frac{\bar{p}_2 - \tau_1 - \bar{p}_0 - D_{p,1:4}s_{2,1:4}}{D_{p,5}}.$$

Hence,

$$s_{t,5} = \frac{\bar{p}_t - \sum_{r=1}^{t-1} \tau_r - \bar{p}_0 - D_{p,1:4}s_{t,1:4}}{D_{p,5}}$$

is the formula that we should use in computing the implied innovation to our money supply sequence in the model.

This results indicates that we can compute the implied outcomes of our model, given that we are requiring it to reproduce the normalized price sequence, or

$$\bar{p}_t = p_t + \sum_{r=1}^{t-1} \tau_r,$$

by iteratively computing the innovation to money $s_{t,5}$, given $\{\bar{p}_t\}$ and $s_{t,1:4}$, then computing the outcomes implied by this innovation in period t, which in turn implies $s_{t+1,1:4}$.

E. Monetary Shock = Real Wage Experiments

Our approach here is as follows. We feed in the monetary shock for 1930 to replicate the real wage in each country, and then compute equilibrium output, investment, labor, real wage, consumption and capital stock for each country for 1930. We repeat this procedure for each year and country through 1933. This procedure yields sequences of all the equilibrium objects in the model for each country between 1930-33.

Table A1: Comparing the Sticky Price Model to the Data

Monetary Shock = Deflation

	Error Share	Mean Error	Corr($\mathbf{y}, \mathbf{w}-\mathbf{p}$)		Corr($\mathbf{w}-\mathbf{p}, \mathbf{dp}$)	
Year	$\frac{\sum(\mathbf{y}-\hat{\mathbf{y}})^2}{\sum \mathbf{y}^2}$	$\frac{\sum(\mathbf{y}-\hat{\mathbf{y}})}{\mathbf{N}}$	**Model**	**Data**	**Model**	**Data**
1930	8.33	0.09	-1.00	0.33	-1.00	-0.63
1931	2.17	0.09	-0.98	0.35	-0.98	-0.33
1932	0.51	0.00	-0.97	0.18	-0.97	-0.44
1933	0.85	-0.04	-0.96	0.20	-0.96	-0.51

Table A2: Constructed Productivity Shocks in the Model
(Shocks: Money and Productivity)

Country	**1930**	**1931**	**1932**	**1933**	**Country Avg.**
Australia	0.05	-0.01	-0.01	0.00	0.01
Austria	-0.01	-0.06	-0.14	-0.15	-0.09
Canada	-0.02	-0.08	-0.13	-0.21	-0.11
Czech.	-0.01	-0.02	-0.06	-0.09	-0.04
Denmark	0.07	0.07	0.04	0.03	0.05
Finland	0.03	0.02	-0.03	0.01	0.01
France	-0.01	-0.03	-0.07	0.00	-0.03
Germany	-0.01	-0.06	-0.09	-0.05	-0.05
Hungary	0.04	0.04	0.02	-0.02	0.02
Italy	-0.02	0.01	0.02	0.01	0.00
Japan	0.05	0.08	0.02	0.03	0.05
Netherlands	0.04	0.01	-0.01	-0.06	-0.01
Norway	0.04	-0.01	0.02	0.03	0.02
Sweden	0.05	0.02	-0.01	0.00	0.02
Switzerland	0.01	0.06	0.00	0.02	0.02
U.K	0.00	-0.02	-0.02	-0.02	-0.01
U.S.	-0.05	-0.08	-0.15	-0.20	-0.12
Year Avg.	0.02	0.00	-0.04	-0.04	-0.02

Table A3: Aggregate Labor Productivity:

Sticky Wage Model vs. The Data

(Shocks: Money and Productivity)

	Model				**Data**			
Country	**1930**	**1931**	**1932**	**1933**	**1930**	**1931**	**1932**	**1933**
Australia	0.10	0.14	0.11	-0.04	0.05	0.01	0.03	0.04
Canada	0.02	0.06	0.06	0.24	-0.01	-0.14	-0.19	-0.25
U.K	0.01	0.04	0.03	-0.04	0.02	-0.01	-0.02	-0.02
U.S.	0.03	0.07	0.09	-0.24	-0.04	-0.05	-0.09	-0.16

Table A4: Comparing the Historically Calibrated Misperceptions Model to the Data

Monetary Shock Matches Deflation

($\eta = -0.775$)

	R. M. Sq.	**R. M. Sq.**	**Mean**	**Corr(y, w − p)**	
Year	**Error**	**Output Dev.**	**Error**	**Model**	**Data**
1930	0.049	0.043	0.01	-1.00	0.33
1931	0.082	0.094	-0.03	-0.98	0.35
1932	0.126	0.144	-0.08	-0.97	0.18
1933	0.145	0.152	-0.07	-0.96	0.20
Overall	0.107	0.117	-0.04		

Table A5: Characteristics of Productivity Shocks in the Model

(Shocks: Money and Productivity, $\eta = -0.775$)

	z		
Year	**Mean(z)**	**Mean(z^2)**	**Corr(z, y)**
1930	0.01	0.001	0.17
1931	-0.02	0.003	0.28
1932	-0.05	0.007	0.72
1933	-0.04	0.009	0.60

Table A6: Orthogonalizing the Productivity Shocks

Attribute All Non-Orthogonal Deviations to Monetary Shock

(Shocks: Money and Productivity, $\eta = -0.775$)

	$\hat{\mathbf{z}} = \mathbf{z} \perp \boldsymbol{\varepsilon}_t$			$\%(y)$
Year	**Mean($\hat{z}$)**	**Mean($\hat{z}^2$)**	**Corr($\hat{z}, y$)**	**explained**
1930	0.00	0.001	0.99	95
1931	0.00	0.003	0.96	56
1932	0.00	0.003	0.71	34
1933	-0.016	0.005	0.71	53

Table A7: Orthogonalizing the Productivity Shocks

Attribute All Non-Orthogonal Deviations to Productivity

(Shocks: Money and Productivity, $\eta = -0.775$)

	$\hat{\mathbf{z}} = \mathbf{z}$			$\%(y)$
Year	**Mean($\hat{z}$)**	**Mean($\hat{z}^2$)**	**Corr($\hat{z}, y$)**	**explained**
1930	0.01	0.001	0.17	80
1931	-0.02	0.003	0.28	91
1932	-0.05	0.007	0.72	98
1933	-0.04	0.009	0.60	96

Table A8: Orthogonalizing the Productivity Shocks

Orthogonalize Productivity to Deflation

(Shocks: Money and Productivity, $\eta = -0.775$)

	$\hat{\mathbf{z}} = \mathbf{z} \perp \mathbf{dp}$			$\%(y)$
Year	**Mean(z)**	**Mean(z^2)**	**Corr(z, y)**	**explained**
1930	0.02	0.001	1.00	96
1931	-0.00	0.002	0.98	72
1932	-0.04	0.004	0.79	50
1933	-0.04	0.007	0.90	81

Table A9:Aggregate Labor Productivity in the Model and in the Data

(Shocks: Money and Productivity, $\eta = -0.775$)

	Model				**Data**			
Country	**1930**	**1931**	**1932**	**1933**	**1930**	**1931**	**1932**	**1933**
Australia	0.05	-0.02	-0.01	-0.01	0.05	0.01	0.03	0.04
Canada	-0.02	-0.08	-0.12	-0.13	-0.01	-0.14	-0.19	-0.25
U.K	0.00	-0.02	-0.02	-0.02	0.02	-0.01	-0.02	-0.02
U.S.	-0.05	-0.07	-0.14	-0.14	-0.04	-0.05	-0.09	-0.16

Table A10: Correlations of Productivity Shocks with Other Factors

(Shocks: Money and Productivity, $\eta = -0.775$)

Factors	$\mathbf{z}$	$\hat{\mathbf{z}} = \mathbf{z} \perp \mathbf{dp}$
1920s Deflation Response	0.09	0.21
Trade Share	0.18	0.08
Agricultural Share	0.44	0.48
IP / Industry Labor Index	0.73	0.72

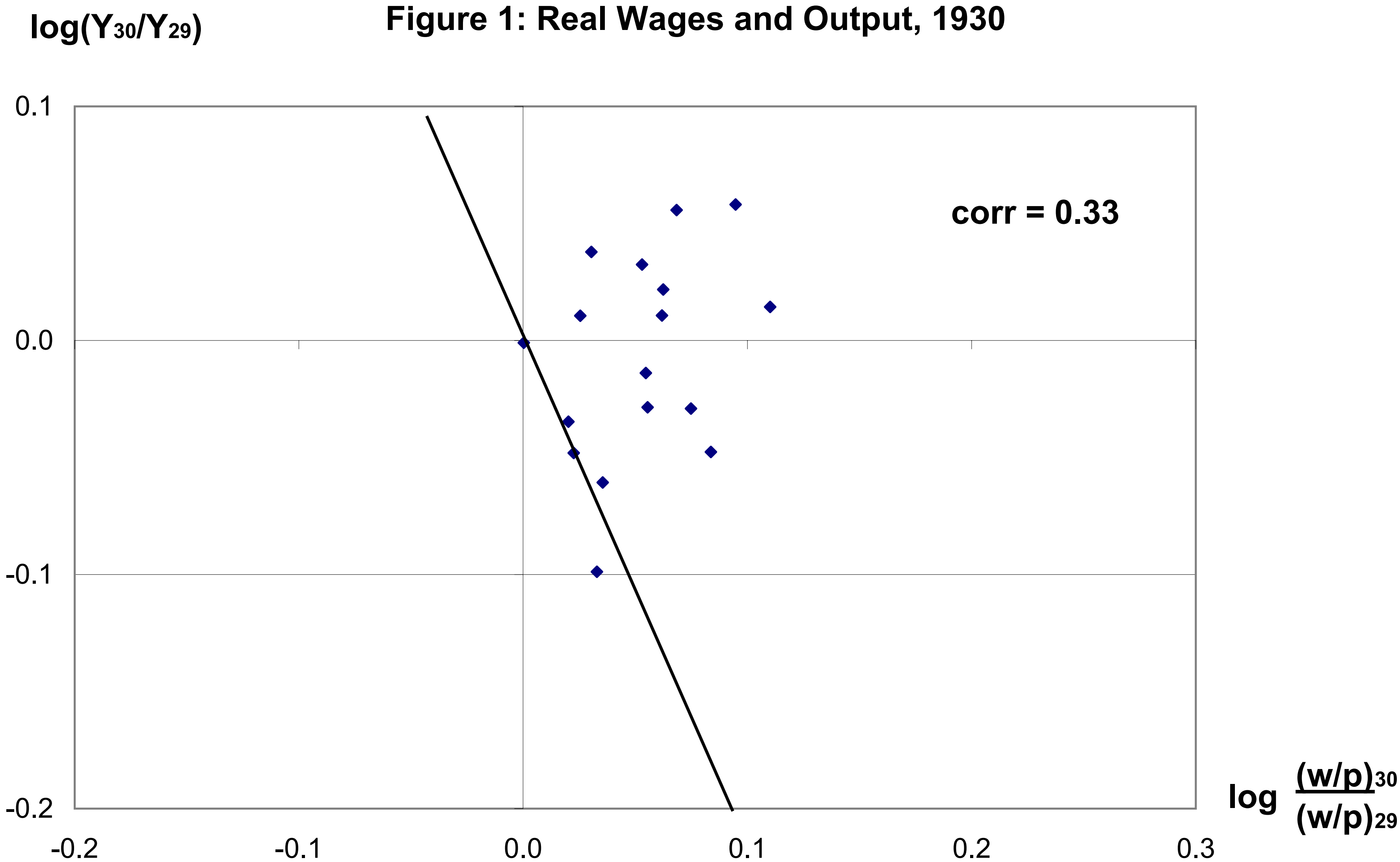


Figure 1: Real Wages and Output, 1930

Figure 2: Real Wages and Output, 1931

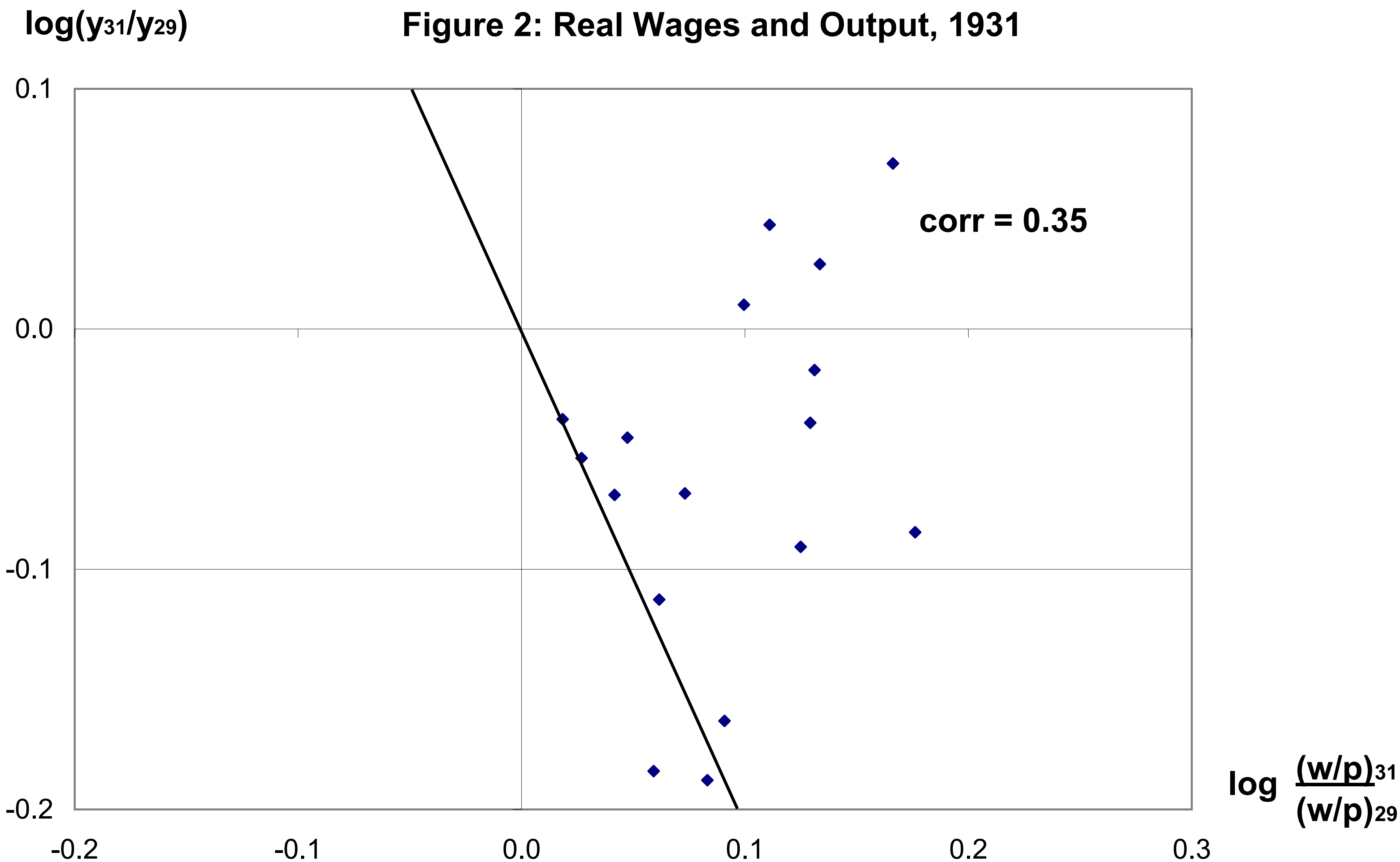
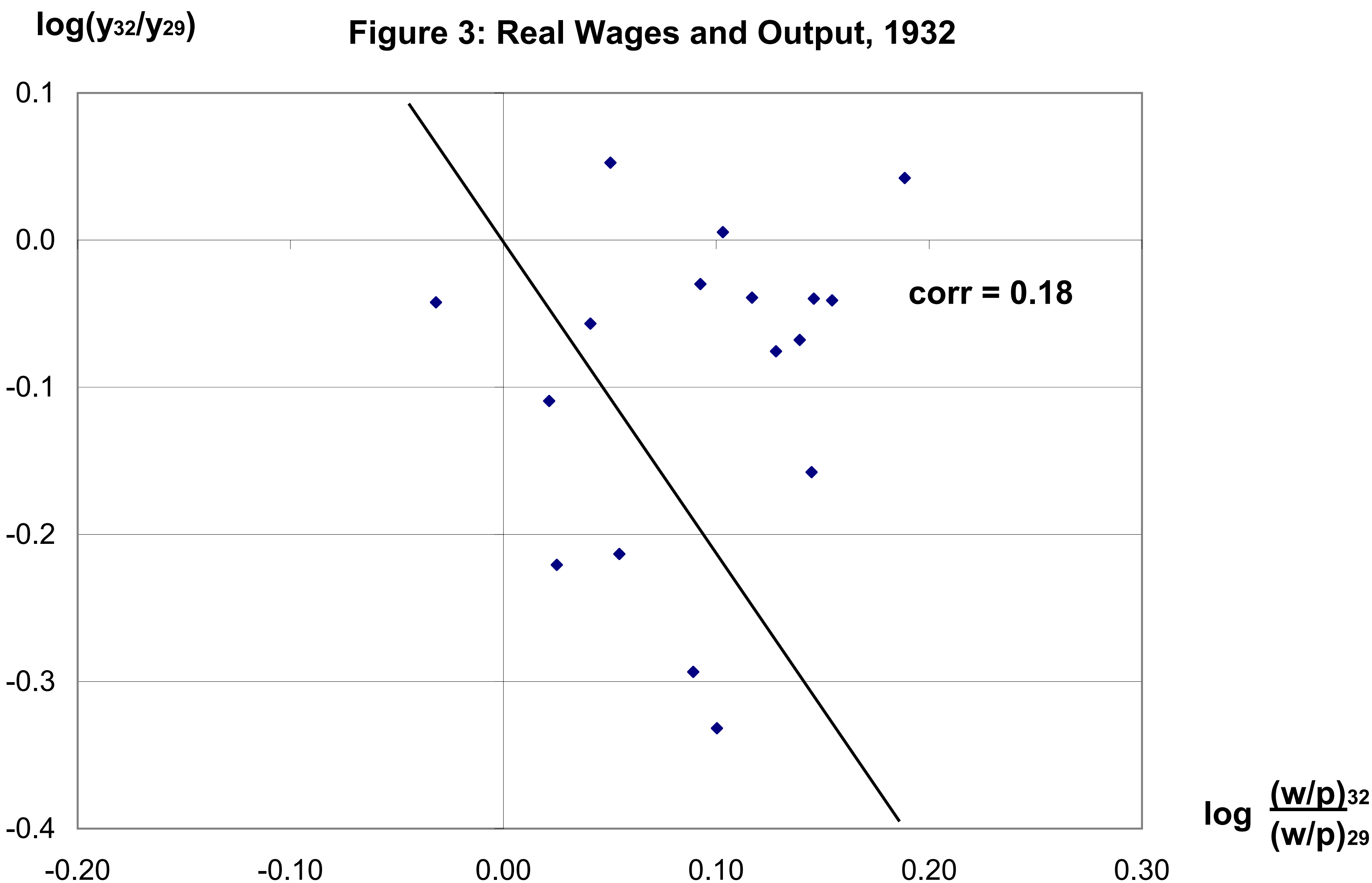
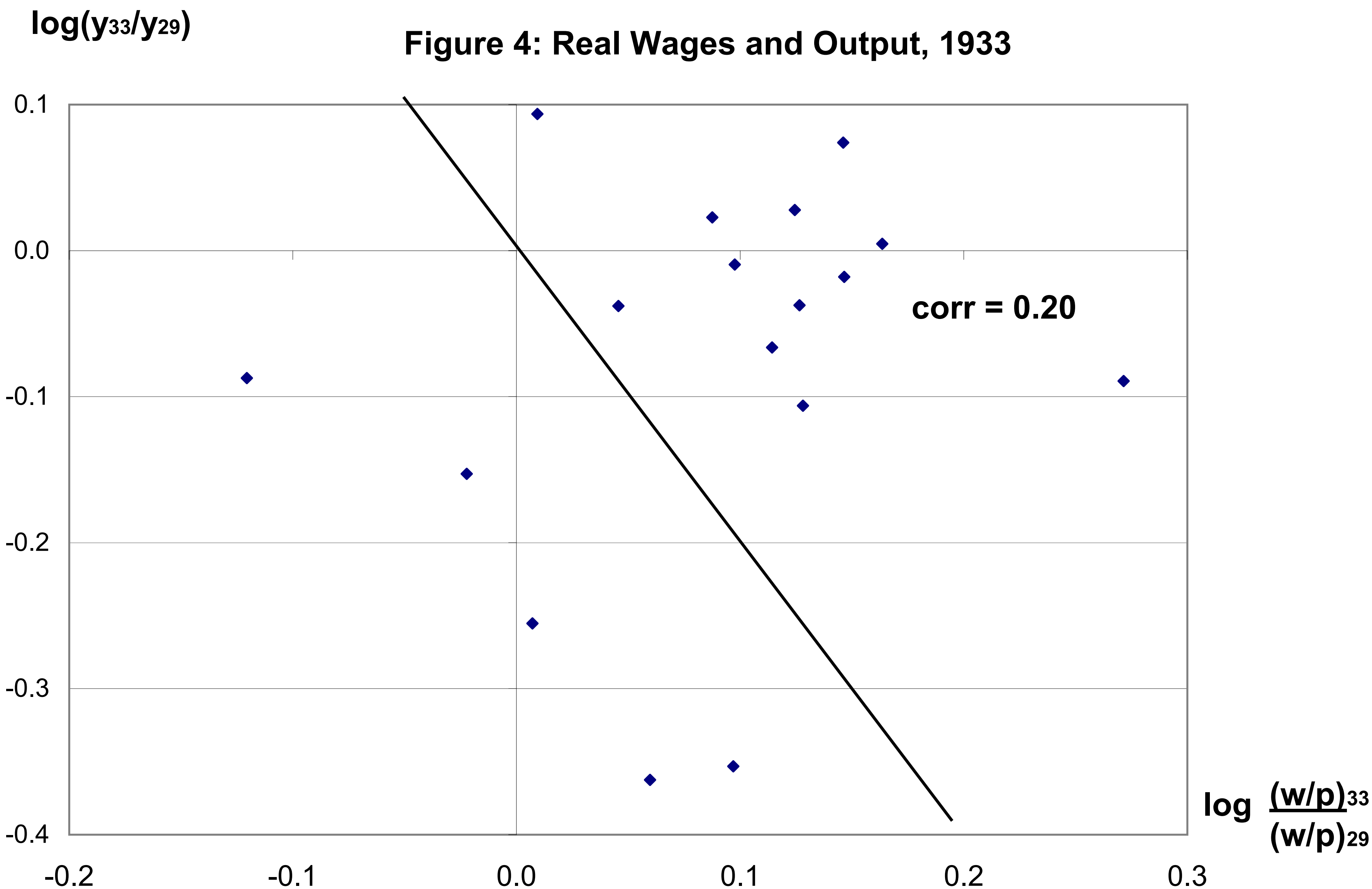


Figure 3: Real Wages and Output, 1932




log(y33/y29)
Figure 4: Real Wages and Output, 1933
corr = 0.20
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.2
-0.1
0.0
0.1
0.2
0.3
log (w/p)33 / (w/p)29

Documentation for wage, output and deflator data by country

country	wages	nominal output	real output	deflator
australia	Butlin '77, p87, T IV.4	Butlin '77, p78, T-IV.1	Butlin '77, p84, T-IV.3	computed from nGDP/rGDP
austria	Mitchell 92, T-B4	Mitchell 92, T-J1, p892	Mitchell 92, T-J1, p892	computed from nGDP/rGDP
belgium	Mitchell 92, T-B4	Mitchell 92, T-J1, p892 (NNP)	Mitchell 92, T-J1, p892 (GNP)	computed from nNNP/rGNP
canada	SC-HS, series E202	SC-HS, series F13	Altman 1919-25; SC-HS 1926-40	computed
czech	Mitchell 92, T-B4, p183	na	Mitchell 92, T-J1, p892	na
denmark	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p893	Mitchell '92, T-J1, p893	computed
estonia	ILO YB 42, p104	na	na	na
finland	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p893	Mitchell '92, T-J1, p893	computed
france	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p893	Mitchell '92, T-J1, p893	computed
greece	na	Mitchell '92, T-J1, p894 (NNP)	Mitchell '92, T-J1, p894 (NNP)	computed
germany	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p894 (NNP)	Mitchell '92, T-J1, p894 (NNP)	computed
hungary	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p894 (NNP)	Mitchell '92, T-J1, p894 (NNP)	computed
italy	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p895 (GNP)	Mitchell '92, T-J1, p895 (GNP)	computed
japan	100J, T-17, p74	Mitchell '95, T-J1, p1003	Mitchell '95, T-J1, p1003	computed
latvia	ILO YB 42, p105	na	na	na
netherlands	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p895 (NNP)	Mitchell '92, T-J1, p895 (NNP)	computed

norway	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p896	Mitchell '92, T-J1, p896	computed
poland	Mitchell '92, T-B4, p183	na	na	na
rumania	Mitchell '92, T-B4, p183	na	na	na
spain		Mitchell '92, T-J1, p896 (NNP)	Mitchell '92, T-J1, p896 (NNP)	computed
sweden	Statistics Sweden	Krantz & Nilsson '75, Table 1.2 col 4	Krantz & Nilsson '75, Table 3.1	computed by Hassler
swiss	Mitchell '92, T-B4, p183	Mitchell '92, T-J1, p894 (NNP)	Mitchell '92, T-J1, p894 (NNP)	computed
UK	Mitchell '92, T-B4, p184	Feinstein, T9	Feinstein T15,16	computed
US	Hanes, p856-7	Romer 1919-29; NIPA 1930-40	Romer 1919-29; NIPA 1930-40	computed

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