Labor Market Policies and the "Missing Deflation" Puzzle: Lessons from Hoover Policies during the U.S. Great Depression*

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Abstract

We document the existence of a "missing deflation" puzzle during the U.S. Great Depression (1929-1941) and show that the solution of this puzzle lies in Hoover policies. Herbert Hoover made multiple public announcements asking firms not to cut wages, most of which complied. The consequences of such a policy are ambiguous since it affects aggregate fluctuations via two channels: as a negative aggregate supply shock this policy decreases output while increasing inflation, but more inflation can postpone the occurrence of a liquidity trap when the economy is hit by a large negative aggregate demand shock. We develop and estimate a medium scale New Keynesian model to measure the effect of Hoover policies during the Great Depression and we find evidence that without such polices the U.S. economy would have ended up in a liquidity trap three years before it actually did, suffering an even deeper recession with a larger deflation.

JEL classification: C11, E24, E31, E32, E44, E52, N12.

Key words: Zero lower bound, Deflation, Great Depression.

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1 Introduction

The Phillips curve lies at the heart of the New Keynesian model, linking inflation to changes in output gap. If the output gap is negative enough (e.g. in a deep recession), this model usually predicts deflation. However, the large negative output gap observed during the Great Recession has not been coupled with a large and protracted deflation, but mostly low inflation. There is an ongoing debate about what are the causes for this lack of deflation.[1] Interestingly, this is not the first time that the Phillips Curve has been shown to deliver counterfactual predictions. The first ever article to estimate a Phillips Curve on U.S. data is Samuelson & Solow (1960). They plot CPI inflation against the unemployment rate for the period 1890 to 1960. What they find is that inflation was higher than what the Taylor Rule predicted during the Great Depression. To explain the lack of a large deflation, Samuelson & Solow (1960) point to New Deal policies carried out by F.D. Roosevelt.

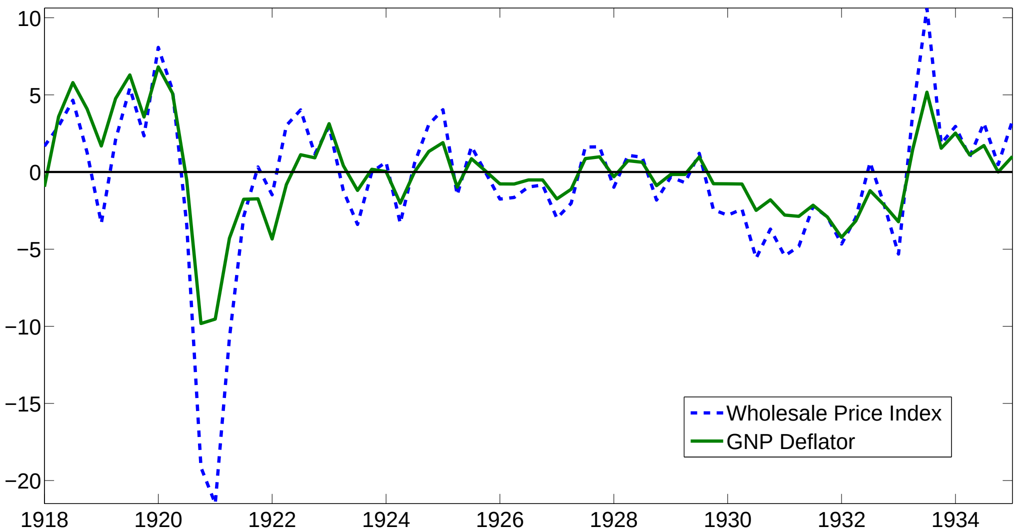

Figure 1.1: Quarterly inflation rates in the Interwar period: Wholesale price index (blue dashed line); GNP deflator (green line).

Similar policies were pursued by H. Hoover during 1929-1933, with the objective to encourage growth in real wages (see Ohanian (2009) and Rose (2010)). One can see from Figure 1.1 that, whatever the measure, the deflation in prices during the Great Depression was not that large. In particular, the deflation of 1921 after the young Federal Reserve raised brutally the nominal interest rate was much more pronounced. From Figure 1.2, it is clear that this does not come from a larger fall in output in 1921. Based on what happened in 1921, one would expect a comparatively larger deflation during the Great Depression.

[1]See for example Ball & Mazumder (2011), Hall (2011), Gordon (2013), Del-Negro et al. (2014), Christiano et al. (2015) and Coibion & Gorodnichenko (2015).

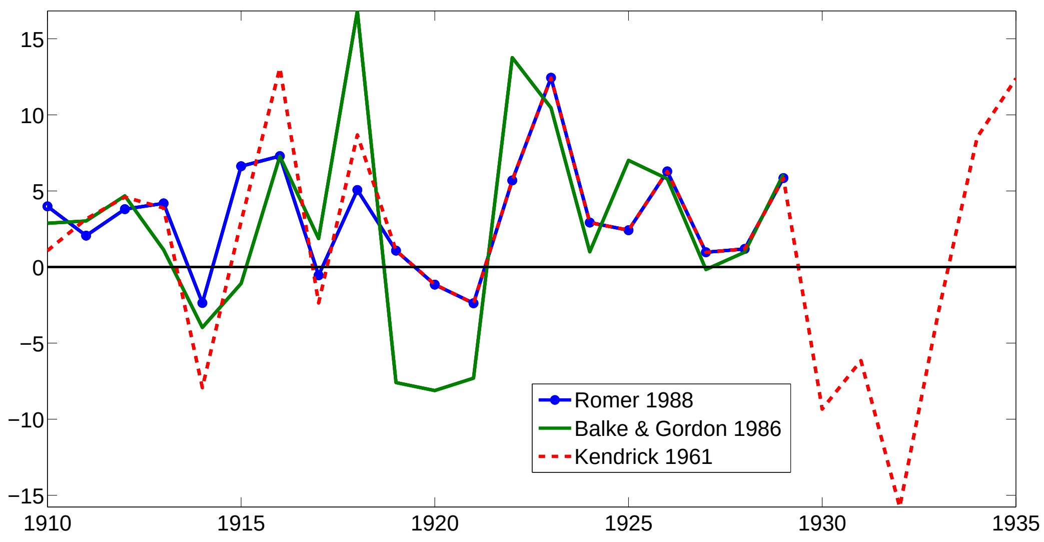

Figure 1.2: Annual real output growth in the Interwar period. Source: Romer 1988 (blue line with circles); Kendrick 1961 (red dashed line); Balke & Gordon 1986 (green line).

The main result of this paper is to show that Hoover policies can explain why the U.S. economy did not experience a full-blown deflation comparable with 1921 during the early stages of the Great Depression. By promoting high wages, Hoover policies had the effect to dampen the fall in real marginal cost of firms. Under the premise that prices are set as a markup over real marginal cost, these policies did tend to limit deflation. Another contribution of the paper is to show that regardless of an initial negative impact on output through the labor market adjustments, Hoover policies were overall beneficial since they postponed entering the zero lower bound.

Our paper is related to recent work published on the Great Depression, which has focused on labor market and cartelization policies. In contrast with previous studies on this period, which did not develop formal models, the recently published papers look at the Great Depression using Dynamic Stochastic General Equilibrium models. In a series of papers, Harald Cole and Lee. E. Ohanian push forward the contractionary effects of those kind of policies.[2] Indeed, those tend to hinder necessary adjustments on the labor market. For example, for the time period we are interested in, Ohanian (2009) uses an RBC model to show that by keeping real wages artificially high, Hoover policies prevented the labor market to clear, thereby generating a fall in output (relative to the frictionless model).[3] The same goes for New Deal policies carried out later by F.D. Roosevelt. Closest to our setup, in another series of papers Gauti. B. Eggertsson shows that the results obtained by the two previous authors critically depend on the assumption of flexible prices.[4] When one takes into account that

[2]See Cole & Ohanian (2004),Ohanian (2009) and Cole & Ohanian (2013).

[3]On this subject, see also Ebell & Ritschl (2008)

[4]See Eggertsson & Pugsley (2006), Eggertsson (2008) and Eggertsson (2012)

prices do not adjust perfectly and that monetary policy can be constrained by the zero lower bound, one reaches the conclusion that policies of cartelization like Roosevelt's infamous New Deal are expansionary since they decrease expected real interest rate and thus increase aggregate demand. Conversely, it can be shown that when the economy is in a liquidity trap, austerity policies will be contractionary.[5]

Like Roosevelt policies, the ones carried out by H. Hoover can be seen as negative aggregate supply shocks. As such, they tend to generate a fall in output coupled with a rise in inflation. Such policies could potentially prevent the economy from falling in a liquidity trap. To investigate this issue, we develop a medium scale model with financial frictions as in Christiano et al. (2003, 2013). To account for Hoover policies, we explicitly model union negotiation. In our setup the Federal Reserve targets the price level, an assumption that is made in many studies of the same period and considered to approximate rather well the Gold Standard regime.[6]

We estimate a log-linear version of the model on quarterly data using nine macroeconomic time series for the period of 1922:Q3-1932:Q3 with Bayesian methods. A series of negative aggregate demand shocks generates deflation. As a response, the Central Bank will lower its interest rate as long as it is not constrained by the zero lower bound. It turns out that the posterior distribution of our parameters unveils an important role to the aspiration wage shock during the period 1929:Q4-1932:Q3. This is precisely the time when president Hoover gave his two speeches in front of the major business leaders and pledged them not to cut wages in return for protecting them from union strikes.

Once the parameters are estimated we do a counterfactual exercise that consists in shutting off the path of the aspiration wage shock during 1929:Q4-1932:Q3. We then feed this new series of the aspiration shock into the model having the paths of other shocks unchanged. We show that by dampening the fall in real marginal cost Hoover policies dampened the deflationary effects of the negative aggregate demand shocks. Had it not been for Hoover policies, the U.S. economy would have experienced a more severe deflation and because of a larger fall of prices, the economy would have entered a liquidity trap three years before it actually did, generating a larger recession.

Our main research question is also closely related to the one studied in Bhattarai et al. (2014), who show that more flexible prices/wages can destabilize the economy after a large preference shock. According to their counterfactual analysis, if prices or wages would have been more flexible in the period they are interested in (from 1966 to 2004), then output and inflation would have exhibited much more variability, with a negative consequence on welfare.[7] However, since the degree of (downward) price stickiness is a structural parameter of their model, it is difficult to interpret this counterfactual experiment. In our setup, the degree of wage stickiness stems partly from Hoover policies. In this case, the interpretation of the counterfactual experiment is straightforward: what would have happened if Hoover did not carry out the policies that were effectively pursued?

[5]See the example of the Mistake of 1937 in Eggertsson & Pugsley (2006).

[6]We will discuss this assumption in more details later.

[7]In their setup, most of the excess volatility comes from supply instead of demand shocks.

The structure of the paper is as follows: in section 2 we briefly develop the historical context surrounding Hoover policies. In section 3 we develop a medium scale model that we use to evaluate the effects of Hoover policies. In section 4 we use our medium scale model to quantify them. We conclude in section 5.

2 The historical context

To further motivate our study, it is useful to take a step back and look at the recession of 1920-1921—readers familiar with the historical context of that time may directly jump to the next section. Its most remarkable feature is the magnitude of the observed deflation, associated with a comparatively mild decrease in output. Whether we measure inflation with the GNP deflator or the Wholesale Price Index, deflation was much worse during 1921 than during the Great Depression.[8] The reverse happens for output. Since data before 1929 is usually constructed using indirect sources, a brief discussion of the different series is in order. In Figure 1.2, we compute annual GNP growth rates for three series : 1) the Commerce Department Series, 2) the Kendrick (1961) series and 3) the Romer (1988) series (based on Kendrick (1961)). All GNP series for this period are at annual frequency, but Balke & Gordon (1986) produce a quarterly series on GNP by interpolating the Commerce Department series using the Chow-Lin method.[9] This series generates a decline of 8.12% between 1919:Q4 and 1921:Q1. However, Romer (1988) shows that the Commerce Department series is not reliable during the 1920-1922 period for many reasons.[10] She makes a strong case that the Kendrick (1961) series, itself based on the Kuznets estimates, is a better series. This criticism becomes immaterial after 1922 as the Balke & Gordon (1986) series closely tracks the two other GNP series. From the Romer (1988) and Kendrick (1961) series, one can see that the decline in output in 1921 is very mild, reaching a trough of -2.39%, compared to -15.77% for the Great Depression. Since after 1929 the Kendrick (1961) and annual Balke & Gordon (1986) series are identical, so is the measured decline in GNP during the Great Depression.

The large decline in prices in 1921 followed a period of accelerating inflation after the end of World War I. Worrying about the decrease in credit standards, the young Federal Reserve increased its nominal interest rate all the way up to 7%, sending the economy into recession (see Bordo et al. (2007)). As such, the economy was not suffering from a negative natural interest rate that the Fed couldn't reach because of the zero lower bound. This is partly why the drop in output during this period was not very large.[11] Sitting in the oval office at that time was Woodrow Wilson. Following the experience of government involvement

[8] The Wholesale Price Index exhibits more volatility during 1921 because of the contemporaneous commodity crash.

[9] As interpolators, they use a constant, linear time trend and an index of industrial production and trade from W.M Persons, *Forecasting Business Cycles* (New York; Wiley, 1931).

[10] John Kendrick actually produced the Kendrick (1961) series after the Commerce Department series. In additon, the relative price for government expenses is higher than it should be in the Commerce series, making the decrease in government spending around 1921 more important than it actually was.

[11] In results that we will report later on, we find that monetary was also pretty tight during the Great Depression. On top of that, the economy suffered a succession of negative aggregate demand shocks that eventually sent it into a liquidity trap during the period 1929-1933.

in economic activity during the War, the President would have surely done something to dampen the unfolding recession. However, he was too busy campaigning for the formation of a League of Nations and suffered a stroke that incapacitated him during his campaign tour. In his recent book on the 1921 recession, Grant (2014) calls this period "Laissez-faire by accident". Shortly after, Warren G. Harding was elected president of the United States. Contrary to Wilson, he was far more in favor of letting the markets play their role. The deflation was then seen as a necessary cure to the former excesses that generated high inflation just a few years ago.

During this period, we have then an economy in free fall with no attempt by consecutive administrations to dampen it. This is not to say that there weren't any attempts to do so. For example, then Secretary of Commerce H.Hoover was keen on using government power to mitigate the impact of deflation on economic activity. He never got his way in the end, having been constantly prevented to do so by President Harding. After this failure, H.Hoover continued to push for government intervention in the management of the business cycle after the 1921 recession. To influence the business cycle one has to measure it first; as a result he pushed for more data collection from the central administration, especially on unemployment. This does not come as a surprise then that, when faced with an even more severe recession starting in 1929 he tried to dampen it by all means. As we have already seen, the Great Depression was characterized by a drop in production much larger than the one in inflation.

This tells us that there has been a dramatic change in the relationship between output and inflation during the 1920's. Both Ebell & Ritschl (2008) and Ohanian (2009) put forward the rise in unionization during that period. Indeed, by ruling the pro union provisions of the Clayton Act unconstitutional, the Supreme Court ushered in a new era for trade unions. During this period, trade union activity decreased dramatically (see Ebell & Ritschl (2008)), only to rise again in the end of the decade.[12] In this context, during the period 1929-1931, president Hoover promised firms that did not cut *nominal* wages to prevent unions from striking. H.Hoover also resorted to more direct interventions when he gathered leading industrialists for a series of conferences in which he specifically asked CEOs not to cut wages.[13] Since union density was not very high during this period (hovering around 12% during the period 1922-1933. See Goldin (2000)), we focus on the public interventions of Hoover during which he asked for non-decreasing nominal wages.

Ohanian (2009) argues that Hoover policies are the reason why the deflation that occurred between 1929 and 1933 had such dramatic effects. Since the nominal wages were prevented from falling, falling prices had the effect to raise the real wage and thus hinder necessary labor market adjustments. Since nominal wages were more flexible at the beginning of the decade, the argument goes, falling prices did not wreak havoc on the labor market. However, this analysis is cast in the terms of a neoclassical RBC model with flexible prices, in which

[12] In mid-1929, the Supreme Court followed the decision of lower courts in taking the side of the Brotherhood of Railway and Steamship Clerks against Texas and New Orleans Railroad. This marked a real change in the industrial relationships of the time, with the decisions of the Supreme Court that were now more sympathetic to trade unions demands.

[13] See Rose (2010) for an analysis of the effects of these conferences on the actual wage policy of concerned firms.

the deflation is taken as given. In this paper, we look at this phenomenon through a different angle: how did union and government policies affect inflation dynamics? To be able to jointly talk about inflation and nominal/real wages, we will cast our analysis in the framework of a New Keynesian model in which firms cannot change prices every period and there is a role for trade unions.[14] In this setup, the setting of prices depends on the real marginal cost, which in turns mainly depends on the real wage.

Viewed in this way, the large deflation of 1920-1921 follows from a fall in real marginal cost brought about by a fall in the real wage (which is free to do so). Conversely, the deflationary shocks that hit the U.S. economy during the 1929-1933 period did not generate much deflation precisely because nominal and real wages were not allowed to fall, maintaining high real marginal costs in the process. It follows that, if debt contracts are denominated in nominal terms, then more deflation will increase the real value of debt. In turn, this will prompt a fire sale of assets, generating more deflation and increase even more the real value of debt. This is the Fisher (1933) debt deflation channel. This connection between wage dynamics, inflation and financial frictions arises naturally in a New Keynesian model augmented with a financial accelerator *à la* Bernanke et al. (1999) such as the one we will develop in the next sections. However, it is interesting to note that this connection was understood intuitively by contemporaneous advocates of Hoover-like wage policies. O'Brien (1989) describes the emergence of a consensus on fighting deflation in the 1920's. In this paper, he quotes economic historian Thomas Wilson as saying the following on the contemporary mindset of the period (emphasis is ours)[15]:

> *"Many business men had begun to learn that* ***wages and prices are connected****, and they felt that by maintaining the former the dangers of the vicious spiral might be avoided."*

The only feature of the model that was not reckoned with at that time was the now infamous liquidity trap. This concept was introduced first by J-M Keynes but shortly after the Great Depression. As a result, proponents of Hoover policies did not put in the balance the argument that limiting deflation could prevent the economy from falling in a liquidity trap if the Central Bank followed a nominal interest rule that reacted to economic activity. We will show in the remainder that Hoover policies had precisely this effect in the early stages of the Great Depression.

3 The Medium Scale Model

3.1 General Setup of the model

The model that we study is close to the ones studied in Gilchrist & Zakrajsek (2011), Christiano et al. (2013), Carlstrom et al. (2014a) and Del-Negro et al. (2014). Specifically,

[14]As in much of the recent new Keynesian literature, this is mostly a shortcut that we use to introduce wage rigidities and Hoover policies.

[15]Wilson, Thomas, *Fluctuations in Employment and Income*, 3rd Ed. London: Pittman and Sons, 1948.

we add costly state verification[16] - type financial frictions *à la* Bernanke et al. (1999) to a medium scale model that resembles the one developed in Christiano et al. (2005), Smets & Wouters (2007) and Justiniano et al. (2011). The main difference with these papers is the labor market setup. To save space, we mainly report the log linear equilibrium conditions here and leave the full description of the model in the technical appendix (which can be downloaded here). Throughout this section, we use the following notations: (i) a small case letter denotes a variable that has been de-trended by the stochastic component of technology (ii) a hatted variable x_t is defined as $\hat{x}_t = log(x_t/x_*)$, where (iii) a variable with a subscript $*$ denotes the steady state value of a variable. Time is discrete and there are eight type of agents: a wholesale producer, a retailer, a final good producer, household members, unions, capital producers, entrepreneurs and a Central Bank.

3.2 Households

The representative household receives income from its working members and returns on holding of nominal deposits. The second one is not indexed to inflation. He also gets profits from monopolistic retailers. He uses these resources to buy final consumption goods and one-period deposits to carry over to the next period. The labor supply decision is effectively done by the unions representing the workers. The household chooses optimally deposits and consumption[17], which gives the following maximization program:

$$\max_{\{C_{t+s}\}_0^\infty, \{D_{t+s}\}_0^\infty} \mathbb{E}_t \sum_{s\geq 0} \beta^s \left\{ log\left[C_{t+s} - h \cdot \overline{C}_{t+s-1}\right] + S_{t+s}\mathcal{V}\left(\frac{D_{t+s}}{P_{t+s}}\right) - \chi \cdot \frac{(L_{t+s})^{1+\varphi}}{1+\varphi} \right\}$$

$$s.t \quad \frac{D_{t+s-1}}{P_{t+s}} R_{t+s-1} + W_{t+s}L_{t+s} - T_{t+s} + T^e_{t+s} + \mathcal{P}_t \geq C_{t+s} + \frac{D_{t+s}}{P_{t+s}} + W^e,$$

where D_t stands for deposits, C_t is private consumption, $\overline{C}_{t-1}$ is aggregate consumption from last period —which is taken as given by the stand-in household[18], h is the degree of *external* habit formation, $W_{t+s} = \int_0^1 W_{t+s}(k)dk$ is the **average real wage** over all occupations within the firm, $\mathcal{P}_t$ are profits from monopolistic competitive firms, T_t are lump-sum taxes from the government, T^e_t are transfers coming from exiting entrepreneurs which will be described later and W^e is a *constant* transfer to newly born entrepreneurs. We follow Fisher (2014) and assume that households value the liquidity services of real holdings of government bonds. Therefore, S_t is a shock that generates a *flight to quality* behavior.

We show in the technical appendix that optimal choice for deposits and consumption

[16]Early contributions to the role of costly state verification in business cycle include Williamson (1987), Carlstrom & Fuerst (1997) and Fisher (1999).

[17]While the assumption of *log* utility with respect to consumption is standard, we experimented with a more general CRRA utility and estimated values for the risk aversion parameter that were consistently very close to 1.

[18]In a symmetric equilibrium, we will have $\overline{C}_{t-1} = C_{t-1}$.

yields the following Euler equation:

$$(1 + he^{-z_*^*})\hat{c}_t = -(1 - he^{-z_*^*})(\hat{R}_t - \mathbb{E}_t\hat{\pi}_{t+1}) - \hat{b}_t + he^{-z_*^*}(\hat{c}_{t-1} - \hat{z}_t) \\ + \frac{\rho_z - 1}{1 - \alpha}\tilde{z}_t + E_t\hat{c}_{t+1}, \tag{1}$$

where $\hat{\pi}_t = P_t/P_{t-1} - 1$ and $\hat{z}_t$ is the log deviation of Z_t^* —which is the the economy's stochastic trend—with a steady state value of z_*^*. We refer to $\hat{z}_t$ as a neutral-technology shock. We have imposed the following normalization:

$$\hat{b}_t \equiv \frac{(1 - he^{-z_*^*})\mathcal{V}'(d)}{\xi} s_t$$

to better estimate the flight to quality shock. An increase in s_t translates into a positive value for $\hat{b}_t$, which causes an immediate drop in private consumption, everything else equal. This effectively embodies the "decline in autonomous spending" put forward by Temin (1978) as the main cause of the beginning of the Great Depression. Indeed, Temin (1978) shows that what differentiate the downturn of 1921 with the Great Depression is the fall in consumption during the latter, given that investment fell by the same relative amount in both downturns. This has been labeled the "spending hypothesis" (in contrast to the "monetary hypothesis" put forward by Friedman & Schwartz (1963)). When we estimate the model, we will therefore be able to say whether the spending hypothesis is borne out by the data or not.

3.3 Wage setting

At the heart of the model is the *Monopoly union model* developed initially by Dunlop (1944) and which has been cast into the New Keynesian framework in Zanetti (2007) and Mattesini & Rossi (2009). In these models, unions and firms strike a bargain every period. We extend this setup and assume that there is a probability that negotiations between unions and firms might fail, in which case the pair keeps the wage from last period. We describe this setup in more detail in what follows. We use this setup in order to have a model with which we can make sense of Hoover policies and their effects. In addition, this model will help us generate a real wage that is too high without having to rely on the fact that marginal rate of substitution is high during this period. In fact, as it is show in Figure 3.1, this latter was falling throughout the Great Depression[19].

We assume that there is a continuum [0; 1] of occupations in each firm in the wholesale sector. Employed members in these are randomly assigned to different occupations. For each occupation k in the wholesale sector, household members organize themselves as a job-specific union that negotiates directly with the firms. It follows that unions are atomistic at the economy level and do not take into account the reaction of monetary policy when setting the wage. The union acts as a Stackelberg leader and the firms as a Stackelberg follower.

[19]The marginal rate of substitution is computed using the medium scale model, see equations (3) and (4) in the technical appendix. In a related paper, Cole & Ohanian (2002) find that the gap between the marginal rate of substitution and the wage widened by as much as 40% between 1929 and 1939.

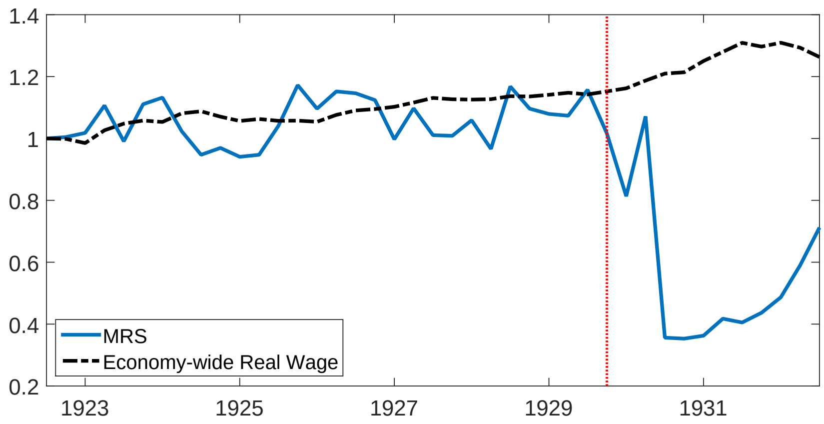

Figure 3.1: Marginal Rate of Substitution and Real Wage 1922:Q3 - 1932:Q2

Note: The marginal rate of substitution is recovered using the medium scale model, see equations (3) and (4) in the technical appendix. All variables are in level and normalized to 1 at 1922:Q3. For the description of the data see Section 4. Blue solid line - marginal rate of substitution. Black dashed line with dots - economy-wide real wage.

When setting its desired wage, the union takes into account the fact that labor demand by the firms is a decreasing function of it. The firm then sets its labor demand consistent with the prevailing real wage.

In our model, one period is one quarter and we assume that unions try to negotiate the wage every period. For some exogenous reasons (Court rulings that are more or less prone to give in to union demands, for example), negotiations fail with a probability ξ_w. When this happens, union workers in this occupation just keep the last period wage. For simplicity, we assume that unions negotiate directly over the *real* wage in this sector. Following Mattesini & Rossi (2009), we assume that workers have an aspiration wage, $\overline{W}_t^A(k)$, which we will specify shortly and is *occupation-specific* in our setup. Consequently, unions want to maximize the expected total excess wage of all the workers in a given occupation, taking into account that the wage might last for more than one period. Formally, unions in occupation k solve the following maximization program:

$$\max_{W_t(k)} \mathbb{E}_t \sum_{s=0}^{\infty} (\beta\xi_w)^s \left[W_t(k) - W_{t+s}^A(k)\right] L_{t,t+s}(W_t(k)),$$

where $L_{t,t+s}(W_t(k))$ denotes the amount of labor services for occupation k demanded by a generic wholesale firm in period $t+s$, conditional on the fact that the real wage has been set at period t. Note that since all household members are *ex ante* identical, the demand for labor services is the same for each occupation. It is only after the wage has been negotiated that workers are sorted in different occupations and potentially earn different wages. Therefore, labor demand for each services will be characterized by the same labor demand curve, although after the wage is negotiated the demand for labor services will be different across occupations. In other words, all occupations face the same demand curve *ex ante*, but workers in different occupations will end up in different parts of the same curve after wage negotiations.

Remark With this setup, we depart from much of the literature that introduces *nominal* wage rigidity in (medium-scale) New Keynesian models. This literature usually relies on the framework developed by Erceg et al. (2000) in which every household member is specialized in a specific task. Workers are then imperfectly substitutable and there is a "labor packer" which bundles all the workers together and sells labor services to firms. In this setup, time-varying wage rigidity can come from two sources: either the elasticity of substitution across workers varies over time, or workers experience a shock that affects their disutility to work. It can be shown that both shocks are isomorphic and will appear in exactly the same way when the model is log linearized around its steady state (see Christiano et al. (2003)). If workers become less substitutable with one another, they will have more market power and the wage will tend to increase. If they suddenly become more lazy, a greater wage will be needed to get them to supply labor.

To explain the increase in real wages in the context of a huge economic crisis in this setup, one then has to assume that either people became more lazy precisely around 1929, or that they became less and less substitutable in the same period. The first assumption is highly unlikely and has as such been dubbed the "Great Vacation" by C.D.Romer. Regarding the second one, since the 1920's witnessed the rapid development of mass production, it is more likely that different workers became actually *more* substitutable with one another. More importantly for our purpose, there are absolutely no mechanisms in this framework through which Hoover policies could have influenced effective real wages.

Finally, as Christiano et al. (2003) point out, the mechanism through which firms with sticky nominal wages suffered from deflation does not seem to have played an important role. According to this framework, manufacturing sectors with the largest price decline should have experienced a larger increase in real wage and, as a consequence, a larger decline in output. However, data compiled in Mills (1934) points to the exact opposite : the durables manufacturing sector suffered both a milder deflation and a larger fall in output compared to the non-durable manufacturing sector. Such a behavior can be rationalized in our model if the durables manufacturing sector had been more prone to Hoover policies. At the sectoral level, those latter would have both mitigated the fall in inflation through higher real wages and accentuated the decline in output. A good example would be the presence of Automobile manufacturers during the two Hoover conferences at the end of 1929, the most famous of which was H. Ford.□

Since all the derivations that follow will hold for any specification of the reservation wage, we postpone its definition to the end of this subsection. We denote the optimal wage chosen by the union who is able to re-optimize by $W_t^*(k)$. Optimal setting of this latter gives the following equation:

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\xi_w)^s \left[\frac{\partial L_{t,t+s}(W_t^*(k))}{\partial W_t^*(k)} \left(W_t^*(k) - W_{t+s}^A(k) \right) + L_{t,t+s}(W_t^*(k)) \right] = 0. \tag{2}$$

To gain intuition about the implications of optimal wage setting by the union, it is useful to multiply the last equation by $\partial W_t^*(k)$ and re-arrange to obtain:

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\xi_w)^s L_{t,t+s} \partial W_t^*(k) = -\mathbb{E}_0 \sum_{s=0}^{\infty} (\beta\xi_w)^s \partial L_{t,t+s} \left(W_t^*(k) - W_{t+s}^A(k)\right). \tag{3}$$

In short, a higher wage has two effects on the total excess wage of union members. First, for a given amount of employed people in the occupation, a higher wage will increase the total excess wage earned by those latter. This is the left hand side of equation (3). Second, the wholesale firms will decrease their labor demand for occupation k when the wage increases, which will have the effect to *decrease* the total excess wage earned by employed people in this occupation. This is the right hand side of equation (3). In a nutshell, equation (3) states that, in equilibrium, those two effects cancel each other.

We show in the technical appendix that the *average* wage will follow the following law of motion:

$$\hat{w}_t = \xi_w e^{-z_*^*} \hat{w}_{t-1} + (1 - \xi_w e^{-z_*^*}) \hat{w}_t^*.$$

We assume further that the aspiration wage is a markup over the household members marginal rate of substitution between consumption and leisure,

$$\hat{w}_t^A = \hat{mrs}_t + \hat{\bar{w}}_t, \quad \hat{\bar{w}}_t \sim AR(1).$$

We think of Hoover policies as having an effect on the realized real wage through this markup variable. By claiming repeatedly that wages should not be cut, Hoover policies raised the expected premium over the Household's marginal rate of substitution (which is their effective reservation wage). We can combine the last two equations with the log linear approximation of equation (2) to get:

$$\hat{\pi}_t^w + \hat{z}_t = \frac{(1-\beta\xi_w)(1-\xi_w e^{-z_*^*})}{\xi_w e^{-z_*^*}} \left(\hat{mrs}_t - \hat{w}_t\right) + \tilde{w}_t + \beta e^{z_*^*} \mathbb{E}_t \hat{\pi}_{t+1}^w + \beta\xi_w e^{-z_*^*} \frac{\rho_z - 1}{1-\alpha} \tilde{z}_t, \tag{4}$$

where $\hat{\pi}_t^w = \hat{w}_t - \hat{w}_{t-1}$. We have normalized the aspiration wage shock as

$$\tilde{w}_t \equiv \frac{(1-\beta\xi_w)(1-\xi_w e^{-z_*^*})}{\xi_w e^{-z_*^*}} \hat{\bar{w}}_t.$$

Importantly, $\hat{\bar{w}}_t$ is an *average* across occupations. As such, we allow Hoover policies to have an effect on some occupations and not on others. What will matter at the aggregate level is the average aspiration wage shock across occupations. This is consistent with the notion that Hoover policies did not impact all sectors of the economy, especially agriculture.

With this in mind, given expected wage inflation between t and $t+1$, a higher aspiration wage will generate an increase in the real wage. Note also that, due to the Calvo structure, the real wage will adjust sluggishly even without Hoover-type policies. As an example, consider a negative aggregate demand shock. Because some firms/occupations pairs fail to strike a bargain, their wage will stay the same even if the marginal rate of substitution is now lower. As a result, the average real wage will have decreased less than it should have. On the other hand, had we followed Zanetti (2007) or Mattesini & Rossi (2009), then all of the lack of adjustment for the real wage would come from Hoover policies. We view our specification as more reasonable and much less prone to overestimate the actual effects of Hoover policies.

In addition, the wage Phillips curve that we get is different than the one in Erceg et al. (2000) in two respects. First, there is no price inflation term because unions care primarily about and negotiate the real wage with firms. Second, due to the fact that households / union members are identical, the slope of the curve is higher in our case. When household members are not perfectly substitutable, there is an additional term in the denominator that is higher than 1.

3.4 The Production Side

Intermediate firms are monopolistically competitive and produce an intermediate good used by wholesale firms as input. Wholesale firms rent labor services from households through the unions, while capital services are rented from entrepreneurs, which we will describe shortly. Intermediate firms have access to a Cobb-Douglas technology and are subject to a fix cost so that the production function reads:

$$\hat{y}_t = \Phi_p \left(\alpha \hat{k}_t + (1-\alpha)\hat{L}_t \right) + \frac{\Phi_p - 1}{1-\alpha} \tilde{z}_t, \tag{5}$$

where $\alpha \in (0,1)$ is the elasticity of output to the stock of capital and Φ_p is a re-parametrization of the fixed cost parameter (see the technical appendix for details). It is optimal for firms to choose the same capital to labor ratio, which is given by:

$$\hat{k}_t = \hat{L}_t + \hat{w}_t - \hat{r}_t^k, \tag{6}$$

where $\hat{r}_t^k$ is the log deviation of the user cost of capital services. Finally, the real marginal cost of producing one more unit of output is given by:

$$\hat{mc}_t = \hat{w}_t + \alpha(\hat{L}_t - \hat{k}_t). \tag{7}$$

Intermediate good producers sell their differentiated good to a competitive final good producer. We assume now that the latter combines the differentiated good using a production function with a constant elasticity of substitution Dixit-Stiglitz aggregator. In addition, we assume that intermediate firms that are not allowed to re-set their prices update them with a factor ι_p. Under these assumptions, the New Keynesian Phillips Curve reads:

$$\hat{\pi}_t = \frac{\beta}{1+\iota_p} \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\iota_p}{1+\iota_p \beta} \hat{\pi}_{t-1} + \kappa \cdot \hat{mc}_t, \tag{8}$$

where κ is now given by

$$\kappa = \frac{(1-\beta\zeta_p)(1-\zeta_p)}{(1+\iota_p\beta)\zeta_p}.$$

Note that we do not assume that the elasticity of substitution is time varying. Instead, we follow Primiceri & Justiniano (2009) and assume that there is a measurement error in the measurement equation for inflation[20].

3.5 Bank and Entrepreneurs

There is a bank that collects deposits from households and lends to the entrepreneurs for capital purchases. The deposits yield a *nominal* return of R_{t-1} in period t.[21] The entrepreneur combines the loan with his net worth from the end of last period n_{t-1} to buy *raw* capital $\overline{k}_{t-1}$ from capital producers. Once he has bought capital, the entrepreneur is subject to an idiosyncratic shock ω that alters the return from capital and follows a log-normal distribution. Specifically, this shock converts raw capital $\overline{k}_{t-1}$ into efficiency units $\omega_t\overline{k}_{t-1}$. For low values of ω, it is less likely that entrepreneurs will be able to repay the loan. Consequently, there exists a threshold value $\overline{\omega}_t$ under which the entrepreneur is not able to repay. For these entrepreneurs, the lender pays a monitoring cost which is a fraction μ of entrepreneurs' revenue and gets to keep the remaining part, which is a fraction $1-\mu$ of said revenues. In the technical appendix we show that the threshold is defined by the following equation:

$$\hat{\overline{\omega}}_t = \frac{1}{\zeta_{z,\overline{\omega}}}\left[(x_*)^{-1}\left(\hat{q}^k_{t-1} + \hat{\overline{k}}_{t-1} - \hat{n}_{t-1}\right) - \hat{\overline{R}}^k_t + \hat{R}_{t-1} - \frac{\zeta_{z,\sigma_\omega}}{\zeta_{sp,\sigma_\omega}}\tilde{\sigma}_{\omega,t-1}\right], \tag{9}$$

where $x_* = (k_* - n_*)/n_*$, the ζ's are functions of deep parameters — the precise expression of which can be found in the technical appendix— and following Christiano et al. (2013) and Del-Negro et al. (2014), we allow for the standard deviation of ω to be time varying. This will help us to capture the rise in spreads during this period. Since it is costly for the bank to verify whether the entrepreneur is able to repay the loan or not, the latter charges a premium over the deposit rate. This premium will depend on the leverage of the entrepreneur, which is given by $\hat{q}^k_{t-1} + \hat{\overline{k}}_{t-1} - \hat{n}_{t-1}$. In the technical appendix, we show that the premium over the deposit rate is given by the following equation in log linear terms:

$$\mathbb{E}_t\left[\hat{\overline{R}}^k_{t+1} - \hat{R}_t\right] = \zeta_{sp,b}\left(\hat{q}^k_t + \hat{\overline{k}}_t - \hat{n}_t\right) + \tilde{\sigma}_{\omega,t}. \tag{10}$$

Again, the coefficient $\zeta_{sp,b}$ is a positive function of deep parameters. The first term on the right hand side of equation (10) captures the fact that a rise in entrepreneurs' leverage is reflected by a rise in the spread charged by the lender, since it becomes less likely that the entrepreneur will be able to repay his loan. The second term on the right hand side of equation (10) captures the fact that as the variation in the shock that affects raw capital

[20] Indeed, when we experimented with a time-varying elasticity of substitution, we recovered a shock that exhibited a lot of short term variation, which is unlikely to come from actual variations in the desired markup of firms.

[21] In a related setup, Carlstrom et al. (2011) study the optimal degree of indexation of debt contracts in the presence of aggregate uncertainty. Contrary to our setup, they allow for the lender's return to be indexed to the return on capital. This goes beyond the scope of this paper, thus we follow the standard setup of Bernanke et al. (1999) in which the lender's return is predetermined, which implies that the number of bankruptcies varies inversely with the return on capital.

becomes greater, entrepreneurs effectively become more risky. In turn, this is reflected by a rise in the spread charged by lenders.

Before renting capital services to firms, the entrepreneur sets the utilization rate u_t to transform raw capital into capital services. The entrepreneur has to incur a sunk cost to set the utilization rate. The definition of capital services and the choice of the utilization rate are given by:

$$\hat{k}_t = \hat{u}_t + \hat{\bar{k}}_{t-1} - \hat{z}_t \tag{11}$$

$$\hat{r}^k_t = \frac{\Psi}{1-\Psi}\hat{u}_t, \tag{12}$$

where Ψ captures utilization costs. After renting capital services to firms, entrepreneurs sell the un-depreciated part of capital to capital producers. In the process, they get a real return of:

$$\hat{\tilde{R}}^k_t - \hat{\pi}_t = \frac{r^k_*}{r^k_* + 1 - \delta}\hat{r}^k_t + \frac{1-\delta}{r^k_* + 1 - \delta}\hat{q}^k_t - \hat{q}^k_{t-1}. \tag{13}$$

The first part on the RHS comes from the rental rate of capital services, while the second one comes from selling the remaining part of capital to capital producers. The last part is just the initial price of capital that has been bought from capital producers during period $t-1$.

To ensure that entrepreneurs do not accumulate enough wealth so that they are able to auto-finance, we follow Bernanke et al. (1999) and assume that each entrepreneur exits the economy with a probability $1-\varrho \in (0,1)$. When they exit, entrepreneurs consume a fraction Θ of aggregate entrepreneur equity v_t. It follows that the the aggregate net worth evolves according to the following law of motion:

$$\begin{aligned}\hat{n}_t = \zeta_{n,n}\hat{n}_{t-1} - \varrho\frac{v_*}{n_*}\hat{z}_t + \zeta_{n,\tilde{R}^k}\left(\hat{\tilde{R}}^k_t - \hat{\pi}_t\right) - \zeta_{n,R}\left(\hat{R}_{t-1} - \hat{\pi}_t\right) \\ + \zeta_{n,qk}\left(\hat{q}^k_{t-1} + \hat{\bar{k}}_{t-1}\right) - \frac{\zeta_{n,\sigma_\omega}}{\zeta_{sp,\sigma_\omega}}\tilde{\sigma}_{\omega,t-1},\end{aligned} \tag{14}$$

The fourth term of this equation reflects the presence of the Fisher (1933) debt-deflation feedback loop. Since entrepreneurs take on nominal loans, higher than steady state inflation will mean that the real value of their debt decreases so that it relaxes the participation constraint of the lender (which states that the net returns from a loan should be positive). In turn, this will increase the real net worth of entrepreneurs and thus lead to more investment. In general this will cause more inflation, which will further relax the participation constraint. Of course, this feedback loop can also play in reverse in which case we have the Fisher (1933) debt deflation spiral.

3.6 Capital Producers

At the end of the period, capital producers buy back the un-depreciated part of capital. They combine it with units of the final good that they transform into investment goods i_t

to create next-period's stock of *raw* capital. As a consequence, raw capital follows the law of motion:

$$\hat{\bar{k}}_t = (1-\delta)e^{-z_*^*}(\hat{\bar{k}}_{t-1} - \hat{z}_t) + \frac{i_*}{\bar{k}_*}\left(\hat{i}_t + S''(e^{z_*^*})e^{2z_*^*}(1+\beta)\tilde{\upsilon}_t\right), \tag{15}$$

The price of capital is given by the following equation:

$$\hat{q}_t^k = S''(e^{z_*^*})e^{2z_*^*}(1+\beta)\left[\hat{i}_t - \tilde{\upsilon}_t + \frac{1}{1+\beta}(\hat{z}_t - \hat{i}_{t-1}) - \frac{\beta}{1+\beta}\mathbb{E}_t\left(\hat{z}_{t+1} + \hat{i}_{t+1}\right)\right], \tag{16}$$

where we have normalized the investment specific technology shock as:

$$\tilde{\upsilon}_t \equiv \frac{\hat{\upsilon}_t}{S''(e^{z_*^*})e^{2z_*^*}(1+\beta)}. \tag{17}$$

3.7 Equilibrium

We can now derive the aggregate resource constraint of this economy. It states that the total amount of final good produced is used either for *i*) private consumption (from households and enterpreneurs) *ii*) government consumption *iii*) private investment *iv*) utilization costs and *v*) deadweight losses coming from bankrupt entrepreneurs. Formally, we have:

$$\begin{aligned}\hat{y}_t = &\frac{c_*}{y_*}\hat{c}_t + \frac{g_*}{y_*}\hat{g}_t + \frac{i_*}{y_*}\hat{i}_t + \frac{c_*^e}{y_*}\hat{c}_t^e + \frac{r_*^k\bar{k}_*}{y_*\Upsilon e^{z_*^*}}\hat{u}_t \\ &+ \frac{\mu G(\overline{\omega})\tilde{R}^k e^{-z_*^*}\bar{k}_*}{y_*}\left[\zeta_{G,\overline{\omega}}\hat{\overline{\omega}}_t + \hat{\tilde{R}}_t^k + \hat{q}_{t-1}^k + \hat{\bar{k}}_{t-1}\right].\end{aligned} \tag{18}$$

where $G(\overline{\omega}) = \int_0^{\overline{\omega}} \omega dF(\omega)$ and $\zeta_{G,\overline{\omega}}$ is the elasticity of G with respect to ω. We define GDP as output minus resources used in utilization and monitoring costs. It follows that

$$\widehat{gdp}_t = \frac{y_*}{gdp_*}\left[\frac{c_*}{y_*}\hat{c}_t + \frac{g_*}{y_*}\hat{g}_t + \frac{i_*}{y_*}\hat{i}_t + \Theta\frac{1-\varrho}{\varrho}\frac{n_*}{\bar{k}_*}\frac{\bar{k}_*}{y_*}\hat{n}_t\right], \tag{19}$$

where the last term on the right hand side is just a rewriting of $\frac{c_*^e}{y_*}\hat{c}_t^e$.

3.8 Monetary and Fiscal Policy

We now specify how monetary and fiscal policy are conducted. The government spends g_t on final goods and finances its purchase through lump-sum taxation. Ricardian equivalence holds and the budget is balanced each period. We assume that the central bank controls the *nominal* interest rate R_t, which it sets according to:

$$\hat{R}_t = \max\left(-log(R_*), \hat{R}_t^{not}\right) \tag{20}$$

$$\begin{aligned}\hat{R}_t^{not} = &\rho_R\hat{R}_{t-1}^{not} + (1-\rho_R)\left(\phi_1(p_t - p_t^*) + \phi_2\cdot\widehat{gdp}_t\right) \\ &+ \phi_3\left[\widehat{gdp}_t - \widehat{gdp}_{t-1}\right] + r_t^m,\end{aligned} \tag{21}$$

where r_t^m is a shock to the nominal interest rate. In a nutshell, the Central Bank sets its interest rate equal to $\hat{R}_t^{not}$ when it can do so. Otherwise the gross nominal interest in level is equal to 1 so that $log(R_t/R_*) = -log(R_*)$. It should be noted that in the estimated model, $\hat{R}_t = \hat{R}_t^{not}$ is assumed to hold at all times, which will be the case in the data. However, to study the possibility that in the absence of Hoover policy the economy might have end up in a liquidity trap, we take this feature into account ex-post following the algorithm developed in Bodenstein et al. (2010) and Carrillo & Poilly (2013).

We believe that price-level targeting is the most relevant setup because the United States was on the Gold Standard during the period we are interested in.[22] One could argue that a Gold Standard implies targeting the price of gold through a constraint on money growth which cannot exceed the commitment to pay a certain number of gold units for every dollar issued (see for e.g. Eggertsson (2008) and Barro (1979)). However Eggertsson (2008) and Bordo et al. (2002) defend the idea that this constraint was never binding. Bordo et al. (2002) in their empirical exercise showed that even a 1-billion-open-market purchase over the period October 1930-February 1931 aiming at preventing the banking panics couldn't violate this constraint because the gold reserve were excessive due to massive sterilization of gold inflows by the US (as well as other countries like France and the UK) in the 1920s. The latter evidence can be use to justify the idea that the long-run demand/supply fundamentals could not have a substantial importance on target determination.

In this respect, our model is different from Christiano et al. (2003) who use a money supply rule and do not explicitly analyze how the Zero Lower Bound might have played a role in the early stages of the Great Depression. The fact that the Rederal Reserve is following a Taylor rule is going to be key for our results, therefore we believe it is useful to spend some time discussing this assumption.

Orphanides (2003) describes how the Federal Reserve can gradually be understood through the lenses of a standard Taylor Rule as a Central Bank that sets its nominal interest rate (through the action on the money supply) as a reaction to data on aggregate economic activity. Interestingly, the large swings in prices during the 1921 recession were the reason to start investigating how monetary policy could shape aggregate activity with the goal to stabilize it and avert those swings in the future. The Rederal Reserve was using actively the open-market operations in order to insure the price stability and stability of credit. It was also in those years that researchers started to put together measures of aggregate activity for the Central Bankers to observe and react to. It turns out that as Secretary of State under president Wilson, H. Hoover played an important role in fostering better data collection through government agencies (i.e unemployment data through the BLS). Orphanides (2003) quotes future Board member Walter Stewart as saying:

> *The fluctuations in the physical volume of production must be measured before they can be interpreted or controlled.*

In related work, Hetzel (1985) emphasizes the role of B.Strong in implementing rule-based

[22] In a related paper, Bordo et al. (2007) assume that the nominal interest is set as a feed back rule which depends on the deviation of the price level to an exogenous target. Ohanian (2014) also assumes that the Rederal Reserve targets the price level.

(versus discretion-based) monetary policy during the 1920s, with the objective to generate a stable price level. We follow this argumentation in our empirical exercise and we start estimating the model in 1922:Q3. In addition, we add a monetary policy shock r_t^m that will help us take into account changes in the nominal rate that come from features outside of our model.

4 Estimation Results and Policy Experiments

In order to carry out the counterfactual exercise without Hoover policies we first estimate the medium scale model using Bayesian methods.[23]

4.1 Data and Priors

We plot the 9 macroeconomic time series that we use for estimation in Figure 4.1. All the variables are at quarterly frequency and span the period of 1922:Q3-1932:Q3.[24] Real GNP, consumption, Dow-Jones industrial stock price index and investments are converted in real per capita terms. Although we have data after 1932:Q3, we do not use it for estimation since the economy was in a liquidity trap after this date. All variables but the short-term nominal rate and the spread are in level and normalized to 1 at 1929:Q2.

As we can see from the upper-right Panel of Figure 4.1 and as was pointed out by many researchers the drop in investment was much more dramatic than the one in output or consumption. By the year 1933 investment fell by more than 80% comparing to the level of 1929:Q2. This fact, coupled with a large increase in the spread constitutes further motivation to incorporate financial frictions in our model.[25] At first glance, the mutual dynamics of real GNP and real wages seems consistent with the fact that variations in the average real wage have been caused by explicit policies in the U.S. that we take into account by developing a

[23]See An & Schorfheide (2007) for a survey and description of the method.

[24] Our time series for macroeconomic variables are almost the same as the ones used in Christiano et al. (2003). Data on nominal GNP, nominal investments and nominal consumption, which is household consumption of non-durable goods and services, are taken from Balke & Gordon (1986). GNP deflator, Dow-Jones industrial stock price index and data on employment taken from the National Bureau of Economic Research's Macro History database at `http://www.nber.org/databases/macrohistory/contents`. We use the measure of total population, 16 and over, to convert variables in per capita terms. The annual data is taken from Ellen R. McGrattan personal webpage and is linearly interpolated to construct quarterly data. The short-term interest rate is the three-month rate on Treasury securities, in percent per annum. The interest rate spread is the difference between yields on Baa and Aaa corporate bonds, also in percent per annum. The data on short term interest rate and the spread are obtained from the NBER database. Both are transformed in percent per quarter terms by applying the following transformation: (1 + data/400). Our measure of the average real wage is the index of composite wages taken from NBER database and divided by the GNP Deflator. Wages are not seasonally adjusted. Using The X-13ARIMA-SEATS Seasonal Adjustment Program we checked that there is no seasonal component in wage series. As employment measure we use index of factory employment, total durable goods for the United States, seasonally adjusted.

[25]Alternatively, we could have introduced a *risk premium shock* as in Smets & Wouters (2007). This shock mechanically drives a wedge between the returns from government bonds and capital. However, this shock is hard to interpret and we prefer to have a model in which such a spread can arise endogenously.

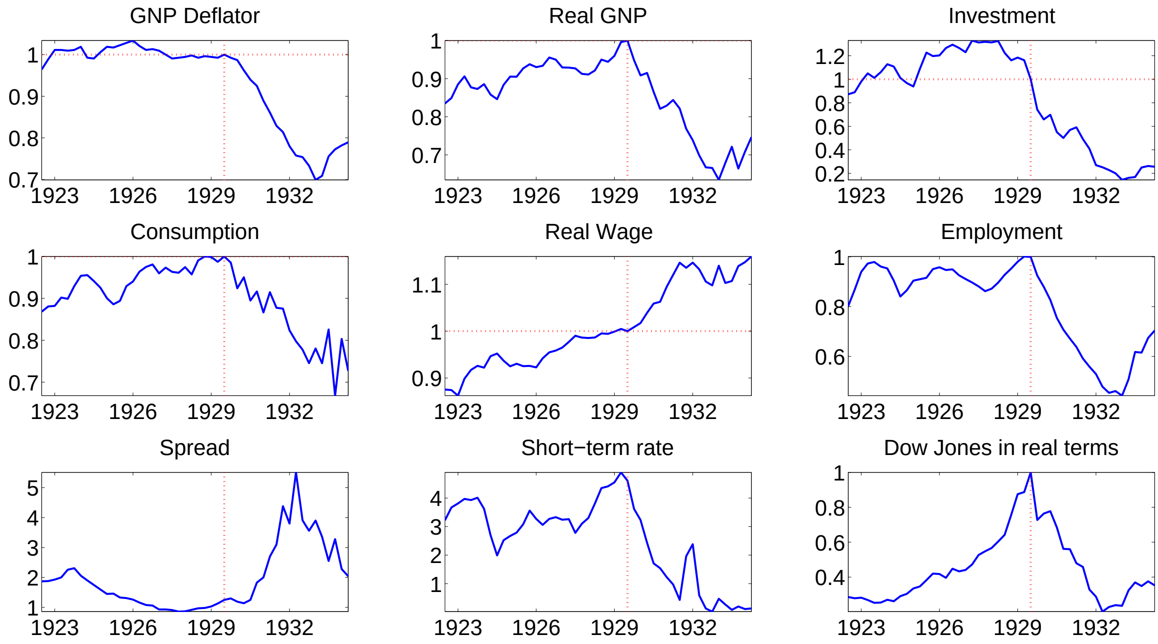

Figure 4.1: Key Macroeconomic Time Series: 1922:Q2 and 1933:Q1

monopoly union model. The measurement equations that relate the model variables and the data are the following:

$$\begin{aligned}
\text{Output growth} &= \gamma + \hat{y}_t - \hat{y}_{t-1} + \hat{z}_t \\
\text{Consumption growth} &= \gamma + \hat{c}_t - \hat{c}_{t-1} + \hat{z}_t \\
\text{Investment growth} &= \gamma + \hat{i}_t - \hat{i}_{t-1} + \hat{z}_t \\
\text{Real wage growth} &= \gamma + \hat{w}_t - \hat{w}_{t-1} + \hat{z}_t \\
\text{Industrial stock price growth} &= \gamma + \hat{n}_t - \hat{n}_{t-1} + \hat{z}_t + e_{n,t} \\
\text{Inflation} &= \pi^* + \hat{\pi}_t + e_{\pi,t} \\
\text{Employment} &= \hat{l}_t - \hat{l}_{t-1} + e_{l,t} \\
\text{Interest rate} &= exp(log(R^*) + \hat{R}_t) \\
\text{Spread} &= log(spread^*) + E_t(\hat{\hat{R}}^k_{t+1} - \hat{R}_t)
\end{aligned}$$

We follow Christiano et al. (2003) and assume that the Dow Jones industrial stock price average is an informative, albeit imperfect, measure of net worth in our model and add a measurement error to this equation. The data on employment that we have is an index: factory employment for total durable goods, so we also add a measurement error term here. Instead of having a time-varying elasticity of substitution between different goods, we follow Primiceri & Justiniano (2009) and assume that there is a measurement error in the measurement equation for inflation.[26]

Calibrated Parameters. All calibrated parameters are presented in Table 1. Given the particularity of our data sample we calibrate γ, π^* and $spread^*$. The growth rate γ is set slightly below the average of real GNP growth computed on the sample 1922:Q2-1929Q2, which is 0.77%. Steady state inflation is set to $\pi^* = 0.1\%$ and the steady state spread is set to $spread^* = 1.5\%$ so that both are consistent with the average on the same sample as well as the steady state value of employment l^*. The elasticity of substitution across goods is set to the standard value of $\lambda_f = 10$ and the depreciation of raw capital is $\delta = 0.025$. We found it hard to identify the aggregate Frisch elasticity, so we resort to calibrate it to a standard value, *i.e* we impose $\varphi = 1$.[27] Government spending was much smaller in GDP terms during the interwar period; accordingly we set the steady state share of government spending in total output to 7% following Christiano et al. (2003). The survival probability of entrepreneurs is $\varrho = 0.99$ and the share of net worth consumed by exiting entrepreneurs is $\Theta = 0.005$. Both values are standard, see e.g Christiano et al. (2013).

The choice of priors are standard for the most part and presented in Table 2 and 3.[28] In most of the cases we follow Smets & Wouters (2007).

4.2 Recovered Smoothed Shocks and Parameters

Our shocks recovered from the estimation procedure are presented in Figure 4.2. We review their smoothed paths in order to get a sense of how our model explains what most likely happened during the early stages of the Great Depression.

The upper-middle Panel of Figure 4.2 shows a strong increase in aspiration wage shock above its mean after 1929:Q3, i.e. after H. Hoover's first conference with major business leaders in which he urged them not to cut wages. The aspiration wage shock remains high until the beginning of 1932, indicating that Hoover policies were effective during this period.

Another interesting fact to observe is an increase in the monetary policy shock in 1931:Q2 (see the lower-middle Panel of Figure 4.2). It stands for the response of the Federal Reserve to the British decision of abandoning the gold standard. This spike is accommodated by positive monetary shocks in our model since we do not model explicitly this event. It seems like monetary policy was rather tight during the early stages of the Great Depression. This echoes findings by Friedman & Schwartz (1963) and many others. The risk shock increases sharply just after the beginning of the Great Depression, proving that our model is able to capture the financial disturbances that plagued that period.[29] We normalize government spending shock by its steady state share in output.

[26] See the presentation of the full model in the appendix for more details.

[27] Estimating φ gives us a flat posterior. We did a robustness check imposing $\varphi = 0.5$ and $\varphi = 2$ and it had no significant impact on our results.

[28] For the role of priors in Bayesian estimation see Del-Negro & Schorfheide (2008).

[29] The risk shock is an idiosyncratic shock experienced by the individual entrepreneur and can be interpreted as his or her luck in managing business. We borrow this name for the shock from Christiano et al. (2013).

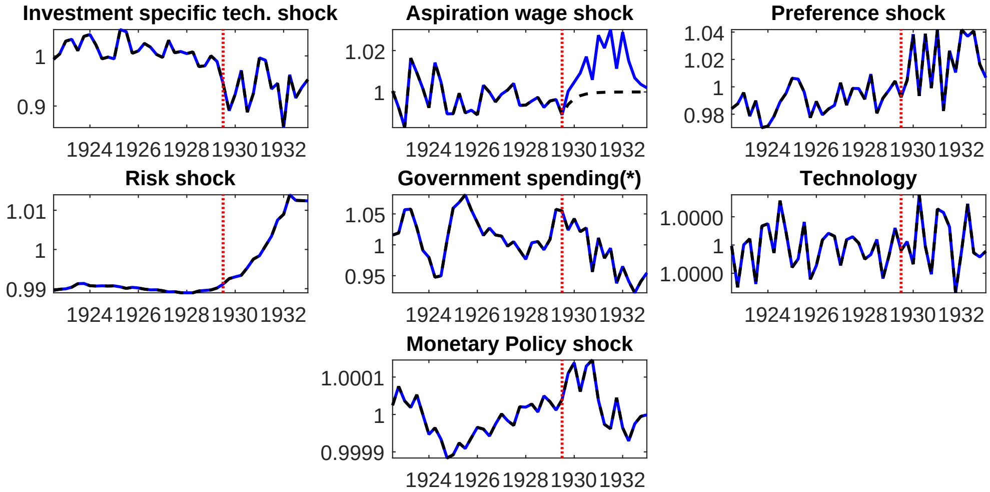

Figure 4.2: Historical Time Series for Exogenous Processes. AR1 processes

Note: Black dashed line - counterfactual path of the aspiration wage shock; counterfactual period: 1929Q3 - 1931 (red dashed line corresponds to 1929Q3); (*) government spending shock is normalized by its steady state share in output, i.e. it is computed as $\frac{G_t - G}{Y} = \frac{g^*}{y^*} * \hat{g}_t$.

Estimated Parameters. The posterior mode of our estimated parameters is reported in Table 2. We find that the monetary authority reacts strongly to deviations of the price level from its target as $\phi_1 = 1.39$ and not much to the output gap or output growth, $\phi_2 = 0.04$ and $\phi_3 = 0.001$. Due to the large fluctuations of private investment in the data, the estimation procedure favors a rather moderate level for the adjustment cost parameter $S''(e^{\gamma}) = 0.78$, while similar empirical exercises on post WWII data tend to generate somewhat higher values. We estimate a standard degree of habit formation $h = 0.78$.

Part of the behavior of real wages, which do not fall on average despite a huge economic downturn, is explained with a high probability that negotiations between firms and unions fail, $\zeta_w = 0.88$. Therefore, even without Hoover policies, a lot of firms/occupations would have been stuck with their last period wage as negotiations failed, with the effect of an average real wage higher than the aggregate marginal rate of substitution. A critical part of our estimation has to do with the aspiration wage shock. Since we think about this shock as a temporary policy, we should not get a high value for the persistence parameter ρ_{asw}. A high value for this parameter would be a sign that we are picking up factors related to labor supply over the medium to long run. Consistent with our intuition, we estimate a rather low value for $\rho_{asw} = 0.54$.

As is the case in Del-Negro et al. (2014) demand shocks play an important role in the estimation and inflation does not vary much relative to output. To reconcile the large effect of negative aggregate demand shocks with a low reaction of inflation, the estimation procedure gives a rather flat Phillips curve. Indeed, we estimate a rather high value for $\zeta_p = 0.88$. In our setup, this translates into a elasticity of inflation to real marginal cost of $\kappa = 0.012$, which is in the lower range of estimates for κ that can be found in the literature.[30] Estimating a much simpler New Keynesian on the same period, Eggertsson (2011) gets a value of 0.00315. The reason why we get a higher value for this parameter is that part of the small decrease in inflation is explained by Hoover policies. To see this, we reproduce the log linear version of the New Keynesian Phillips curve here:

$$\hat{\pi}_t = \frac{\beta}{1+\iota_p}\mathbb{E}_t\hat{\pi}_{t+1} + \frac{\iota_p}{1+\iota_p\beta}\hat{\pi}_{t-1} + \kappa \cdot \hat{mc}_t, \tag{22}$$

where $\iota_p \in (0,1)$ is the coefficient of price indexation. Instead of relying on value of κ as low as in Eggertsson (2011), what we get from our estimation procedure is that $\hat{\pi}_t$ did not fall by much because $\hat{mc}_t$ was downward rigid due to Hoover policies that dampened the fall in the average real wage. Another reason behind the small decrease in inflation is due to price indexation with a posterior mode of $\iota_p = 0.35$. It therefore seems that, indeed, Hoover policies are one of the main reasons for not observing a full-blown deflation during the early stages of the Great Depression.

4.3 The Aspiration Wage Shock in the Medium Scale Model

To understand the mechanisms through which Hoover policies impacted the economy, we now present distributions of the impulse responses of selected variables to a positive aspiration wage shock in Figure 4.3. More specifically, we present the reaction of inflation, investment, output and the nominal interest rate. The colored shaded areas are the highest posterior density intervals, they correspond to the 10% and 90% percentiles.

As expected, a positive aspiration wage shock has a positive effect on the real wage. This higher average real wage translates into a higher aggregate real marginal cost and thus higher inflation. Following a surge in price level, the Central Bank increases the nominal interest rate more than one for one so that the real interest rate increases and thus consumption decreases on impact. Because the price level has to go back to its target eventually, inflation will actually *decrease* in the medium term. To ensure that the price level is on target, the central bank will have to keep the nominal rate high in the medium to long term.

The increase in real wage decreases labor demand from the firms, which causes a drop in employment. Firms anticipate that since the shock is persistent, the marginal productivity of capital services will be lower in the future, so that they cut back on investment. At the end of the day, Hoover policies are unambiguously a negative aggregate supply policy: they raise inflation while lowering output, GDP and all of its components. It follows that without Hoover policies, inflation should be expected to be lower.

4.4 A Counterfactual Experiment

The main question we ask in this subsection is the following: *What would have happened if Hoover policies were never carried out?* To answer it we will proceed as follows: we take as

[30] See Schorfheide (2008) and the references therein.

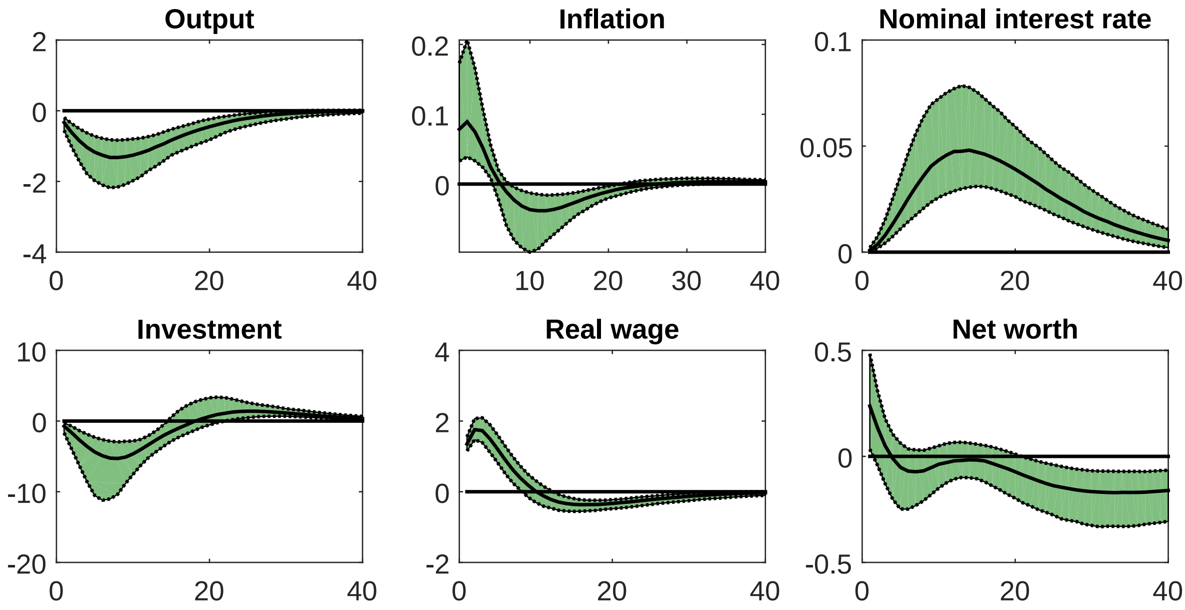

Figure 4.3: Impulse Response of Variables to an Aspiration Wage Shock

Note: Median of a distribution - black solid line; 10% percentile - upper line of the shaded area; 90% percentile - lower line of the shaded area.

given the estimated shocks and the posterior mode of parameter values from the model that have been described earlier. Then, we turn off the aspiration wage shock during the period of Hoover actions and compute the dynamics of the economy under this new path for the shocks. To do so we need to take a stand on exactly when did Hoover policies have their effects.

Following Bodenstein et al. (2010), Carrillo & Poilly (2013) and Del-Negro et al. (2014), we take into account ex-post the possibility that the economy might end up in a liquidity trap. We use a shooting algorithm to find the duration of the ZLB and work backwards from here, assuming perfect foresight. The algorithm is described in more details in the appendix.

Since we are working with a linear model, there might be approximations errors if and when the economy enters a liquidity trap. Carlstrom et al. (2014b) show that New Keynesian models can exhibit explosive behavior when the duration of the zero lower bound is stochastic. They show that if the duration is instead *deterministic*, then this explosive behavior is much less likely and the New Keynesian model behaves like it has been solved exactly in non-linear form. The shooting algorithm that we develop here has a liquidity trap of *deterministic* duration. Therefore, by doing so we reduce the possibility of overestimating the effects of Hoover policies by potentially avoiding this explosive behavior.

According to our estimation procedure, Hoover policies were effective all the way until 1932. Therefore, we shut off the aspiration wage shock during this period. We plot the results of this experiment in Figure 4.4. Without Hoover policies, the real wage would have increased less than it actually did during the early stages of the Great Depression (see the lower-right panel). As a result, marginal cost and inflation would have fallen by more (see the upper left panel of Figure 4.4). In this case, the path of inflation inches closer to the one observed in the 1921 recession.

Because the Central Bank is following a Taylor Rule that responds aggressively to the changes in price level (our posterior mode for the reaction to the price level is 1.39), lower price level calls for a lower nominal interest rate, which eventually reaches its zero lower bound in 1930:Q2. In the data, the economy entered a liquidity trap in the beginning of the year 1933. Therefore, according to our model, without Hoover policies the economy would have entered a liquidity trap two and a half years before it actually did. When the economy enters a liquidity trap, there is a large drop in aggregate demand and firms cut down on labor demand, which explains why the average real wage actually decreases at this point, only to recover after.

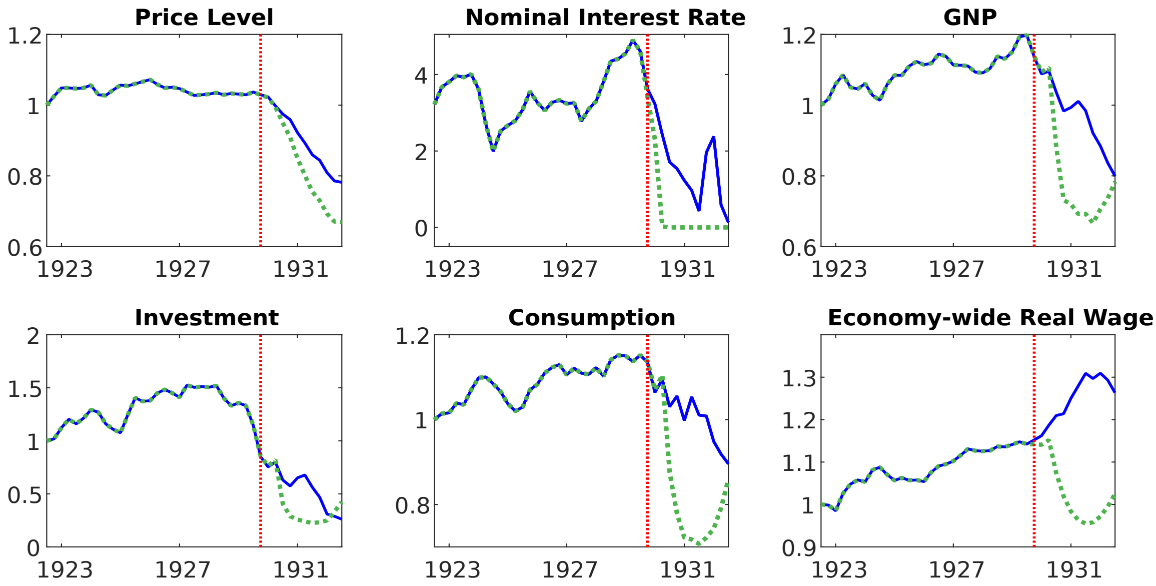

Figure 4.4: Counterfactual Paths of Model Variables Without Hoover Policies

Note: Actual data until 1932Q2 - blue solid line; 1929Q3 - red dotted line; counterfactual paths - green dotted line. The paths are normalized to the beginning of the sample, 1922:Q2.

When the economy enters a liquidity trap, the fall in inflation generates a rise in the real interest rate so that consumption drops (see the upper right panel of Figure 4.4). In turn, the drop in consumption generates further deflation and raises even more the real interest rate. This can be seen in Figure C.2 in the appendix, where we plot the actual real interest rate computed from the data and its counterfactual computed from the model without Hoover policies. Since consumption makes up for most of the GDP, this latter drops as well relative the actual path. More deflation without Hoover policies also means that net worth of entrepreneurs would have been lower in this case. This has a negative effect on investment (see the lower-middle panel) and also helps to explain the drop in GDP.

Since Hoover policies are short lived, the effect on the real wage doesn't last long. Therefore, after a while inflation starts to increase towards its steady state level. Less deflation when the economy is still in a liquidity trap means that the real interest rate decreases and this prompts the household to consume more, which is why we observe an upward swing in consumption. This generates a rise in employment and in the real wage as labor demand increases. As for investment, on one hand it depends a lot on the net worth of entrepreneurs —which is a state variable. On the other hand, estimated investment adjustment costs are relatively low, so on average investment remains depressed up until 1931Q3 and starts increasing rapidly. Together, these two results imply that GNP is on average clearly below its data counterpart during the period we are interested in.

4.4.1 Discussion

An exercise presented in Christiano et al. (2003) goes in line with our results, however the authors comment it differently. As we mentioned before, their way to model the labor market power shock makes the interpretation of it hard to square with empirical evidence. However, their results can be given a clearer interpretation through the lenses of our model. By simulating their model only as a response to the labor market shock, they show that it is the only one that can explain such a fall in employment, but also they state that it does not provoke the drop in investment and output and that it even pushes the prices up. They conclude that this shock is not important in explaining the onset of the Great Depression precisely because it generates inflation. What we show instead is that this type of shock is indeed necessary to explain why the U.S. economy did not undergo a full-blown deflation during this period. Since they model this shock as a time-varying disutility parameter, they cannot interpret it as an effect of Hoover policies. We model it in such a way that we can give a meaningful interpretation to this shock.[31]

In addition, while Hoover was in power during the period 1929-1932, there is evidence that his attempts to dampen the fall in wages were only effective during a short period of time. First, Hoover organized his infamous conferences in the end of the year 1929 (the first one on November 21, the second one on December 5). Theses conferences and other public declarations notwithstanding, Rose (2010) shows that many firms started to lower their nominal hourly wages from 1931:Q1 onwards. As a consequence, shutting off the shock all the way until 1932 might lead us to overstate the effects of Hoover policies. Accordingly, as a robustness test, we also report the results when we shut off Hoover policies during this shorter period (see Figure C.1 in the appendix). The results are quantitatively very similar.

4.5 Does the debt-deflation channel matter?

There is a belief among macroeconomists that there is a link between price deflation and recessions. The experience of the recent crisis showed that policymakers perceive a persistent fall in prices rather negatively. However, a series of recent contributions find no strong

[31] Or, equivalently, as a time-varying elasticity of substitution across different types of labor. The two formulations are isomorphic in a first order approximation of the model.

empirical link between deflation and depressions —see for example Atkeson & Kehoe (2004) and Borio et al. (2015). The only episode that is an outlier in these studies is the Great Depression. Even though it is not the main goal of the paper, we believe we can shed some light upon the question of why researchers find a negative correlation between output growth and changes in price level during 1929-1934.

In our baseline model, where debt is not indexed to inflation, deflation potentially plays a big role in the amplification mechanism coming from financial frictions. And so the question we ask is whether inflationary policies may still dampen the recession if the debt deflation channel is completely shut off.

In what follows, we re-estimate the model, *counterfactually* imposing that debt is fully indexed to inflation. We follow Christiano et al. (2013) and assume that the household has access to both government bonds and deposits that can be indexed to inflation. The central bank still controls the nominal interest rate for government bonds. We refer the interested reader to the technical appendix for the detailed derivation of this version of the model. However, it is useful to look at how the equation for the law of motion of net worth is changed:

$$\begin{aligned}\hat{n}_t = \zeta_{n,n}\hat{n}_{t-1} - \varrho\frac{v_*}{n_*}\hat{z}_t + \zeta_{n,\tilde{R}^k}\left(\hat{\tilde{R}}^k_t - \hat{\pi}_t\right) - \zeta_{n,R}\left(\hat{R}^d_{t-1} + (\iota_b - 1)\hat{\pi}_t\right) \\ + \zeta_{n,qk}\left(\hat{q}^k_{t-1} + \hat{\bar{k}}_{t-1}\right) - \frac{\zeta_{n,\sigma_\omega}}{\zeta_{sp,\sigma_\omega}}\tilde{\sigma}_{\omega,t-1}, \qquad (23)\end{aligned}$$

where $\hat{z}_t$ is technology, $\hat{\tilde{R}}^k_t$ is the return on capital, $\hat{q}^k_t$ is the price of installed capital $\hat{\bar{k}}_t$, $\hat{R}^d$ is the real return on deposits and ι_b governs the degree of indexation with respect to inflation. Finally, $\tilde{\sigma}_{\omega,t}$ is a risk shock as in Christiano et al. (2013). If deposits are fully indexed to inflation, then $\iota_b = 1$. When this is the case, a surprise increase in inflation has no effect on net worth through the liability side of entrepreneurs. To gauge whether debt deflation is a powerful mechanism in our setup, we compare the marginal density obtained with the two specifications.

Both marginal densities are basically identical, with the one for the model with no indexation being slightly higher.[32] In other words, the data gives a very small quantitative role for the debt deflation mechanism.[33] In a way similar to what is usually done in the literature on sticky price, we also tried to let the data speak and estimate ι_b. Given the previous results, it should not come as a surprise that the data is not very informative about the degree of indexation and the estimated posterior mode is very close to the prior mean for this parameter.

As a consequence, it is hard to see a difference between the impulse response after an

[32]The Laplace approximation for the model with non-indexed debt is equal to 542.6553, whereas the one for the model with indexed debt is 542.35.

[33] There are two other papers that quantify the debt-deflation effect: Christiano et al. (2010) and Carrillo & Poilly (2013). The latter claim that it is not crucial to their results. Christiano et al. (2010) show that the impulse response functions to the shocks that provoke changes in consumption and inflation of the same sign, are almost of the same amplitude for the model with debt-deflation channel and the one where interest rate for the loan is state-contingent.

aspiration wage shock in the model with and without debt indexation.[34] It follows that the counterfactual path of the economy without Hoover policy delivers the same results as before. In the end, the result of this analysis is consistent with the recent finding of Borio et al. (2015): while price deflation and falling output are simultaneous in the data, there does not seem to be a powerful link between the two. As such, the dampening effects of Hoover policies do not rely on our baseline specification with debt deflation.

5 Conclusion

It is by now well known that policies that reduce the natural level of output can be expansionary, as long as they generate inflation and are carried out when the economy is at the zero lower bound (see Eggertsson (2012)). In this paper we extend this result and show that such policies can mitigate the slide in deflation that will send the economy at the zero lower bound. Since reaching the zero lower bound entails a large drop in output and its components, postponing the occurrence of the former will mitigate the recession. Depending on the relevant monetary policy rule, this is what could have happened during the Great Depression.

The message of this paper is more general however. Taking into account that deflation can be detrimental in the short-run (because of financial frictions like in this paper or for whatever other reason), labor market institutions/policies that have the effect to mitigate inflation fluctuations can potentially dampen the magnitude of recessions under inflation targeting rules.

[34] The Figure is not reported to save space but is available upon request.

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A Estimated parameters and exogenous processes

Inflation steady state	π^*	0.1
Growth rate of economy	γ	0.6
Calvo price parameter: fraction of firm unable to re-optimize their prices	ι_p	10
Depreciation rate	δ	0.025
Steady state government spending	g^*	0.07
Survival rate of enterpreneurs	γ^*	0.99
Entrepreneurs' steady-state default probability	$\bar{F}_w$	0.76
Spread steady state (annual)	SP^*	1.5
Parameter of the curvature of the disutility of labor	φ	1

Table 1: Calibrated parameters

		Prior distribution	Posterior distribution			
			Mode	Mean	10%	90%
The second derivative of the adjustment cost function	**S2**	Normal(4,1.5)	0.78	0.90	0.28	1.74
Habit parameter	$\boldsymbol{h}$	Beta(0.7,0.1)	0.72	0.70	0.64	0.77
Utilization cost	$\boldsymbol{\phi}$	Beta(0.5,0.15)	0.37	0.42	0.25	0.60
Fixed cost parameter		Normal(1.25,0.1)	1.18	1.18	1.06	1.30
Taylor rule response to inflation	$\boldsymbol{\phi_1}$	Normal(1.5,0.25)	1.39	1.40	1.11	1.69
Taylor rule response to output	$\boldsymbol{\phi_2}$	Normal(0.125,0.05)	0.04	0.05	0.01	0.10
Taylor rule response to the changes in output	$\boldsymbol{\phi_3}$	Normal(0.125,0.05)	0.001	0.002	0.001	0.002
Price indexation	$\boldsymbol{\iota_p}$	Beta(0.5,0.15)	0.35	0.39	0.21	0.58
Elasticity of production wrt labor	$\boldsymbol{\alpha}$	Normal(0.3,0.05)	0.38	0.38	0.31	0.44
Intertemporal discount rate	$\boldsymbol{\beta}$	Gamma(0.25,0.1)	0.19	0.24	0.14	0.36
Elastisity of borrowing constraint wrt debt	$\boldsymbol{\zeta_{spb}}$	Beta(0.05,0.0005)	0.04	0.04	0.04	0.05
Interest rate smoothing parameter	$\boldsymbol{\rho_r}$	Beta(0.5,0.2)	0.99	0.98	0.97	0.99
Calvo wage parameter: fraction of unions unable to re-bargain their wages	$\boldsymbol{\zeta_w}$	Beta(0.7,0.1)	0.88	0.88	0.84	0.91
Calvo price parameter: fraction of firms unable to re-optimize their prices	$\boldsymbol{\zeta_p}$	Beta(0.7,0.1)	0.88	0.87	0.81	0.92

Table 2: Prior and posterior distribution of structural parameters.

		Prior distribution	Mode	Mean	10%	90%
(a) Autoregressive parameters						
Technology	$\boldsymbol{\rho_z}$	Beta (0.5, 0.2)	0.52	0.64	0.29	0.95
Preferences	$\boldsymbol{\rho_b}$	Beta (0.5, 0.2)	0.41	0.36	0.18	0.54
Investment	$\boldsymbol{\rho_\mu}$	Beta (0.5, 0.2)	0.74	0.66	0.49	0.81
Government	$\boldsymbol{\rho_g}$	Beta (0.5, 0.2)	0.76	0.75	0.62	0.88
Monetary	$\boldsymbol{\rho_{rm}}$	Beta (0.25, 0.15)	0.21	0.23	0.16	0.30
Financial	$\boldsymbol{\rho_{\sigma_w}}$	Beta (0.75, 0.15)	0.99	0.99	0.97	1.00
Aspiration wage	$\boldsymbol{\rho_{asw}}$	Beta (0.5, 0.2)	0.54	0.55	0.43	0.67
(b) Standard deviations ($\sigma_i * 100$)						
Technology	$\boldsymbol{\sigma_z}$	INV Gamma (0.1, 2)	0.05	0.29	0.04	0.81
Preferences	$\boldsymbol{\sigma_b}$	INV Gamma (0.1, 2)	1.77	1.93	1.39	2.50
Government	$\boldsymbol{\sigma_g}$	INV Gamma (0.1, 2)	37.30	38.83	33.54	44.63
Monetary	$\boldsymbol{\sigma_{rm}}$	INV Gamma (0.1, 2)	0.01	0.02	0.01	0.02
Investment	$\boldsymbol{\sigma_\mu}$	INV Gamma (0.1, 2)	3.61	4.19	3.09	5.56
Financial	$\boldsymbol{\sigma_{\sigma_w}}$	INV Gamma (0.1, 2)	0.13	0.14	0.12	0.16
Aspiration wage	$\boldsymbol{\sigma_{asw}}$	INV Gamma (0.05, 4)	0.91	0.98	0.78	1.19
(c) Mesurements errors ($\sigma_i * 100$)						
on employment	$\boldsymbol{\sigma_{e_l}}$	INV Gamma (0.1, 2)	2.85	2.92	2.50	3.36
on real net worth	$\boldsymbol{\sigma_n}$	INV Gamma (0.1, 2)	11.50	11.89	10.27	13.66
on prices	$\boldsymbol{\sigma_\pi}$	INV Gamma (0.05, 4)	1.79	1.84	1.58	2.10

Table 3: Prior and posterior distribution of shock parameters.

B The Shooting Algorithm

Let $\mathcal{Y}_t$ denote the vector of endogenous variables of the model and $\mathcal{E}_t$ the vector of exogenous disturbances. When the economy is not constrained by the zero lower bound, the solution of the model is given by the following state space representation:

$$\mathcal{Y}_t = M_Y(\theta)\mathcal{Y}_{t-1} + M_E(\theta)\mathcal{E}_t, \tag{24}$$

where θ is the vector of all the model parameters. Without loss of generality, assume that the first row of this system of equations is the definition of the notional interest rate equation (21). When a particular series of exogenous disturbances send the economy in a liquidity trap, the *actual* nominal interest rate is not equal to the notional one and is given by:

$$\hat{R}_\tau = -log(R_*) \qquad \tau = \underline{T}, \underline{T}+1, \ldots, \overline{T}$$

where $\underline{T}$ is the date at which the economy enters in the liquidity trap and $\overline{T}+1$ is the date at which it gets out. As a consequence, during this period the dynamics of our economy are now given by:

$$\mathcal{Y}_t = \widetilde{M}_R + \widetilde{M}_Y(\theta,\tau)\mathcal{Y}_{t-1} + \widetilde{M}_E(\theta,\tau)\mathcal{E}_{t-1} \qquad \tau = \underline{T}, \underline{T}+1, \ldots, \overline{T}. \tag{25}$$

For $\tau = \overline{T}+1, \ldots,$ the economy again evolves according to equation (24). To determine $\overline{T}$, we use a shooting algorithm that works as follows.

Algorithm 1: Shooting Algorithm

1. Guess an upper bound for $\overline{T}$, $T^{(0)}$
2. Compute the path of the economy backward for $\underline{T}, \ldots, T^{(0)}$
3. Check if $\hat{R}^{not}_{\overline{T}} > -log(R_*)$ and $\hat{R}^{not}_{\overline{T}-1} < -log(R_*)$
4. If yes, then stop. Else $T^{(0)} \equiv T^{(0)} - 1$ and go back to step 1.

C Figures

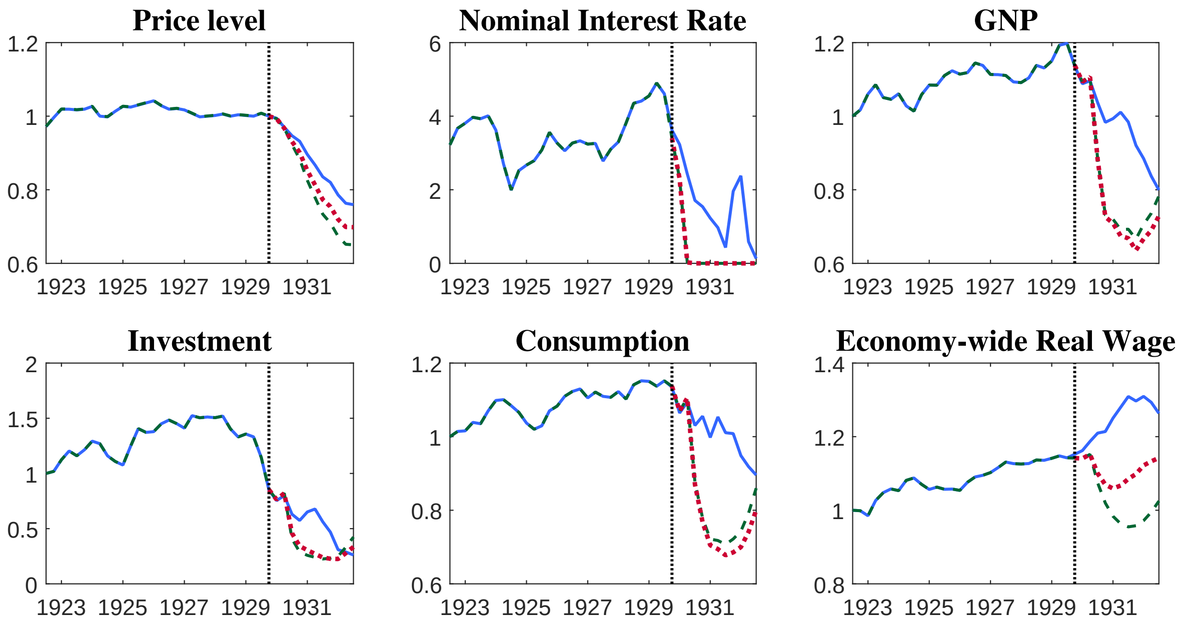

Figure C.1: Counterfactual Paths of Model Variables Without Hoover Policies. Robustness check.

Note: Actual data until 1932Q2 - blue solid line; 1929Q3 - red dotted line; counterfactuals paths - green dashed line. The paths are normalized to the beginning of the sample, 1922:Q2.

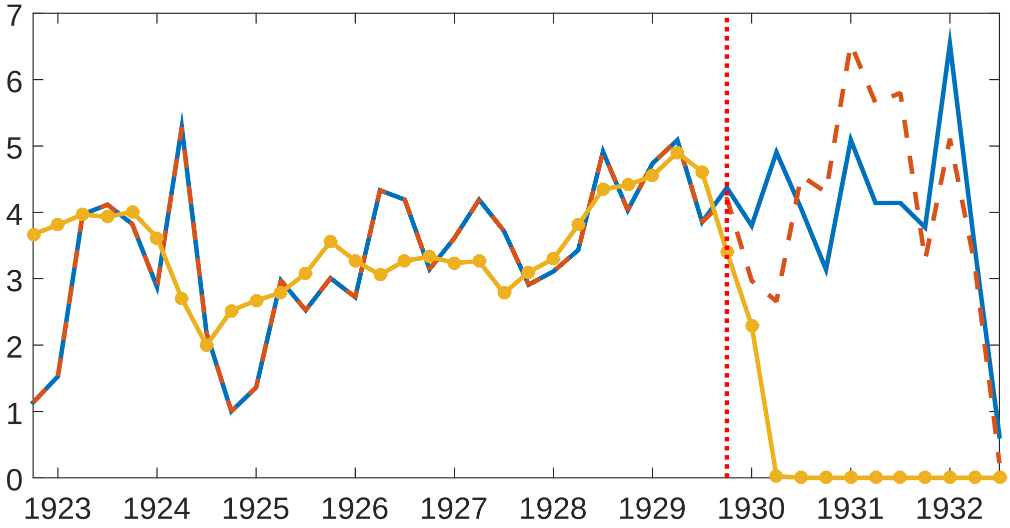

Figure C.2: Real Interest rate: Percent Per Annum

Note: Real interest rate (from the data) - blue solid line; Real interest rate (counterfactual path after 1929Q3) - red dashed line; Nominal interest rate (counterfactual path after 1929Q3), percent per annum in the baseline model- yellow line with circles; 1929Q3 - red dotted line.