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Efficiency, Distortions and Factor Utilization during the Interwar Period

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Efficiency, Distortions and Factor Utilization during the Interwar Period*

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Abstract

In this paper, we analyze the International Great Depression in the US and Western Europe using the business cycle accounting method a la Chari, Kehoe and McGrattan (CKM 2007). We extend the business cycle accounting model by incorporating endogenous factor utilization which turns out to be an important transmission mechanism of the disturbances in the economy. Our main findings are that in the U.S. labor wedges account for roughly half of the drop in output while efficiency and investment wedges each account for a quarter of it during the 1929-1933 period while in Western Europe labor wedges account for more than one-third of the output drop and efficiency, government and investment wedges are responsible for the remaining during the 1929-1932 period. Our findings are consistent with several strands of existing descriptive and empirical literature on the International Great Depression.

JEL Classifications: E13; E32; N10

Keywords: International Great Depression; Business Cycle Accounting; Efficiency, Market Distortions

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1 Introduction

In this paper, we analyze the Great Depressions in the U.S. and Western Europe using the business cycle accounting method of Chari, Kehoe and McGrattan (CKM 2007) with an extension to incorporate endogenous factor utilization. We quantify the importance of labor and capital market distortions as well as production inefficiencies in order to understand the differences and similarities of the output performance between the Western Europe and the U.S. over the 1925-1938 period. We find that endogenous factor utilization plays an important role in transmitting the disturbances to the economy. Our quantitative results show that labor market distortions and deterioration in production efficiency are important in accounting for the depressions in both economies while investment wedges contribute to the output drop in the U.S. but not in Western Europe.

In order to discuss the economic situation in the world during the interwar period, we construct a unique data set of GDP, private consumption, investment, employment, and hours worked for 12 Western European countries, form a hypothetical aggregate Western European economy and compare it to the U.S. Due to data availability, the sample European countries are limited to Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, and UK.[1] Figures 1a and 1b present the per capita output, consumption, investment and employment in the U.S. and the Western Europe economy normalized at 1925 = 0.[2] In the U.S., output fell dramatically by approximately 0.44 in terms of log differences between 1929 and 1933, which is equivalent to a 36% drop. Consumption, investment and employment all collapsed along with output by 0.26, 1.17 and 0.21. All variables show recovery after 1933, however, none of them return to their 1929 level by 1939. In the Western Europe, output hits its trough in 1932. The log difference between the 1929 and 1932 level is 0.16. Consumption, Investment and employment also fall by 0.09, 0.41 and 0.12 during this period. While output, investment and employment shows recovery after 1932, consumption keeps falling throughout the 1930s.

Over the past 80 years, the source and mechanism of the International Great Depression (IGD) has been a heated topic of interest. Literature on

[1] The sources of the data series are listed in the data appendix.

[2] Output, consumption and investment are detrended by the long run per capita output growth rate over the 1900-2008 period. Employment is not detrended because it is considered a mean stationary variable.

IGD emerged from the research on the Great Depression by shifting its focus from the United States to other countries. The literature can be split into two main strands based on their proposed origin of the Great Depression. The first strand maintains that the monetary contraction in the United States is at the heart of the Great Depression (e.g. Eichengreen 1992). Specifically, the U.S. monetary contraction in 1928 aimed to stem the stock market boom and prevent a gold outflow caused a rise in interest rates and deflation, which was exported to the rest of the world due to the Gold Standard. Figure 2 illustrates the main point by clearly showing that both the U.S. and Western Europe were facing substantial drops in the prices. The literature identified two channels through which worldwide deflation led to the IGD: labor market distortions and capital market distortions. As for the former, Bernanke and Carey (1996), for example, estimate aggregate supply and wage adjustment equations and show that nominal wage stickiness propagated the negative effect of monetary shocks on output in 22 countries. As for the latter, Bernanke and James (1991), for example, argue that financial crises caused by debt deflation had a negative impact on industrial output using data from a sample of 24 countries during 1930-36.[3]

The second strand of literature on the IGD turns to non-monetary shocks. Temin (1976) argues that a housing recession and declining consumer spending led by pessimism drove the U.S. economy into depression. Harrison and Weder (2006) use a sunspot model in which animal spirits affect investors' expectations and find that a collapse in investment led to the downturn in the U.S. In a simple dynamic stochastic general equilibrium model, we can interpret pessimistic animal spirits as negative expectational shocks that manifest themselves as distortions in the investment market. Cole and Ohanian (1999) provide an alternative non-monetary approach to understand the U.S. Great Depression by using a standard neoclassical growth model. They show that total factor productivity (TFP) alone can account for 40 percent of the decline in output between 1929 and 1933.[4] This study led to a series of research on the Great Depressions in various countries using the neoclassical growth model evaluating the role of TFP.[5] In the follow up paper, Cole,

[3]More detailed review of the literature and evidence is provided in the next section.

[4]Ohanian (2001) further investigates the sources of the TFP drop in the US during the Great Depression and claims that the loss of organizational capital due to bankruptcies is the most convincing candidate among others.

[5]Cole and Ohanian (2002) study the UK interwar depression and show that the drop in output was due to the decline in the labor input rather than TFP and conclude that

Ohanian and Leung (2005) study IGD in a sample of 17 countries and using a signal extraction model with monetary and productivity shocks they find that productivity shocks explain two-thirds of the drop in output.[6] In further examination of the non-monetary causes of the Great Depression, Cole and Ohanian (2013) find that cartelization policies account for about 40 percent of the squared change in output and 60 percent of the square changed in labor for a sample of 7 countries including the large depressions in U.S., Italy, Germany and Australia.

We use business cycle accounting to shed light on the factors behind the IGD in Western Europe and the U.S. The strength of the business cycle accounting method is that we can quantify the importance of each distortion on the IGD within a unified dynamic stochastic general equilibrium model. The original business cycle accounting method introduced by CKM (2007) proceeds as follows. First, a competitive equilibrium in a prototype neoclassical growth model is defined. Next, "wedges" in the equilibrium conditions are computed using the data of output, consumption, investment and total hours worked. These wedges are defined as exogenous disturbances in relevant markets: efficiency wedges are disturbances to the production process; government wedges are disturbances in the resources available to private agents; labor wedges are distortions in the labor market; investment wedges are distortions in the capital market. Finally, the responses of endogenous variables to wedges are computed by simulating the model with one wedge at a time.

This paper makes an important modification to the original CKM (2007) model by disentangling the fluctuation of factor utilization from disturbances in production efficiency. We do so by incorporating endogenous capital and

labor market policies were to blame. Amaral and MacGee (2002) study the Canadian case and show that the TFP slow down can account for more than half of the output drop during the Great Depression. Beaudry and Portier (2002) show that movements in inputs in response to a stagnation in investment specific technical progress are sufficient to account for the French Great Depression without relying on declines in TFP. Fisher and Hornstein (2002) investigate the German case and find that total factor productivity, countercyclical real wage shocks and fiscal policy shocks were all important in accounting for the Great Depression. Kehoe and Perri (2002) show that trade restrictions and real wage regidities are sufficient to account for the Great Depression in Italy without changes in TFP.

[6] In addition, Ritschl and Woitek (2000) and Ahmadi and Ritschl (2009) used VAR and FAVAR models to examine the role of monetary policy in the US and find that it has only a modest role in explaining the decline of real activities in US.

labor utilization following Greenwood, Hercowitz and Huffman (1988) and Burnside, Eichenbaum and Rebelo (1993) respectively. Endogenous factor utilization affects the measurement of production efficiency by incorporating unobserved fluctuations in factor inputs. This is important as distortions in the factor markets affect output not only through the quantity of inputs but also through their effects on factor utilization.

Our quantitative results show that in the U.S. labor wedges account for roughly half of the drop in output while efficiency and investment wedges each account for a quarter of it during the 1929-1933 period. In Western Europe labor wedges account for one-third of the output drop and efficiency, government and investment wedges account for the remaining during the 1929-1932 period. In terms of the persistence of the depression, in the U.S. efficiency and labor wedges account for roughly one-third and two-thirds of the recovery in output respectively. In Europe the improvement in government wedges alone would have led to a recovery more rapid than in the data while the deterioration in efficiency counteracts with these forces.

Our method is also used to study the role of the interwar Gold Standard played as the transmission mechanism of the Great Depression across countries. Our results suggest that government wedges, which include the trade balance, contributed to the recovery of the countries which left the Gold Standard in the early 1930s. This is consistent with the view that depreciation of currencies that left the Gold Standard stimulated foreign demand of goods and improved the trade balance (e.g. Eichengreen and Sachs 1985, Eichengreen and Irvin 2010). Our results also show that investment and labor wedges prolonged the depression in the countries that left the Gold Standard later in the mid-1930s. This is consistent with the view that deflationary pressure generated by the Gold Standard distorted the factor markets.

Finally, we compare the results with the 2008 Great Recession by conducting business cycle accounting over the 1999-2012 period using the same model. The Great Recession drew attention to the IGD as these episodes are both considered as worldwide economic crises originated by the U.S. economy. We find that in the U.S. labor wedge accounts for all of the output drop over the 2007-2012 period. On the other hand, in Europe efficiency wedges account for half of the output drop while labor wedges account for a quarter. The results imply that the nature of the Great Recession seems different from that of the IGD.

The remainder of the paper is constructed as follows. In section 2, we review the literature on market distortions during the IGD. In section 3, we describe the business cycle accounting model with endogenous factor utilization. In section 4, we present the quantitative results. Section 5 concludes the paper.

2 Market Distortions and The International Great Depression

As was mentioned in the previous section, in the past three decades, the Great Depression has been increasingly considered a global phenomenon not only because it affected many countries, but mainly because of the global character of its transmission. Indeed, several papers (Choudhri and Kochin 1980, Eichengreen and Sachs 1985, Temin 1989, Eichengreen 1992, Bernanke and James 1991, Bernanke and Carey 1996) examined possible transmission mechanisms and concluded that the International Great Depression had its roots in the interwar Gold Standard (often called gold exchange standard). The times of the interwar period Gold Standard were the times of capital mobility and fixed exchange rates which meant that high interest rates in one country led to high interest rates in the rest of the countries on Gold Standard as a result of interest rate arbitrage. Hence a deflationary policy in one country could have been transmitted to other countries through the operation of the Gold Standard regime. That explanation has called for further investigation of the channels through which the decline of money supply affected real economic activities; in other words, to explain the non-neutrality of money. Extensive research over the past decades has found that distortions on the labor and capital markets caused the decline of money supply to affect real economy. In this section, we discuss the findings of that literature.

2.1 The Labor Market

The interwar period presents a break-up from pre-1914 labor markets which were characterized by little or no welfare policies and very little unionization (Ritschl and Strausmann 2010, Feinstein et al. 2008). Post WWI period, on the other hand, witnessed a rise of social institutions promoting welfare policies and unemployment benefits, increase in unionization, and collective bargaining.[7] The timing of this development was different in Europe and the U.S. While Europe had witnessed those changes already in the 1920s, the U.S. labor market had become more rigid largely during the New Deal policies in the 1930s. The effect of labor market institutions on unemployment in the inter-war period is still debated (e.g. Eichengreen and Hatton 1988). Indeed, while there were countries with high unemployment throughout the entire inter-war period (e.g. UK, Denmark, Sweden); other countries experienced high unemployment only in the 1930s (e.g. France, Belgium, Germany). On the other hand, there seems to be an emerging consensus about the role of nominal wage rigidities in the propagation of the Great Depression, usually ascribed to labor market institutions which made labor market adjustment, if not rigid, then very slow.

The main story of the nominal wage stickiness during the Great Depression goes as follows. If the nominal wages are inelastic, firms cannot adjust to deflation, face high real wages and respond by laying off workers or curtailing production. Empirical assessment of the link between deflation, nominal wages, and real output has been carried out in several papers. Eichengreen and Sachs (1985), using a sample of ten European countries in 1935, show a negative relationship between real wages and industrial production which is suggestive of nominal-wages stickiness. Newel and Symons (1988) investigate 14 countries during the Great Depression in an attempt to uncover the transmission mechanism of negative monetary shocks leading to the spread of the Great Depression across countries. They show that the interwar economies were characterized by substantial nominal rigidities on the supply side which led to an increase in the real wage, hence high unemployment and low output. Bernanke and Carey (1996) extended Eichengreen and Sachs (1985) by carrying out an extensive empirical analysis of nominal wages behavior for twenty two countries in 1931-1936 and found a substantial degree of nominal wage stickiness. Similar result was found by Dimsdale et al. (1989) by analyzing the behavior of real wages in Britain from the mid-1920s to 1938. Specifically, they estimates show nominal wage inertia in that period and maintain that inflexibility of the supply side of the economy and wage setting behavior enabled the price shocks to have real impact on the economy. The findings of those studies are consistent with the literature on the

[7] The role of unemployment benefits was extensively studied for the UK, going back to Benjamin and Kochin (1979) (e.g. Crafts 1989). Other studies for the UK stressed the role of unionization and eight-hour day on labor supply (Broadberry 1986, Broadberry 1990).

European labor markets which finds that they had become less flexible in the interwar period (e.g. Eichengreen and Hatton, 1988).[8] This was because the rise of collective bargaining, advent of unemployment insurance, and growing power of labor unions caused nominal wages to adjust only slowly to the changes in the economy.[9]

The role of labor market rigidities has also been prominent in the studies investigating very slow and uneven recovery from the Great Depression in the U.S. Some studies have argued that the New Deal programs caused labor market not to clear, leading to a very slow recovery (Bordo et al. 2000, Cole and Ohanian 2004). Very recent empirical investigation of the New Deal relief spending by Neumann et al. (2010) finds that even though it increased employment and earning in the short-run, its long-run effect was negative as it crowded out private sector jobs. Since the peak of unemployment was reached before the New Deal policies, several studies analyzed Hoover's high-wage policies and their contribution to nominal wage rigidity (e.g. Vedder and Galloway 1993, Ebell and Ritschl 2008, Ohanian 2009). A conclusion that we can draw is that even if the loss of jobs might not have been directly caused by the Hoover's policies and the New Deal, they created an environment which made downward real wage adjustment difficult (Hatton and Thomas 2010).[10]

To illustrate the arguments reviewed above, Figure 3 presents the real wages in the U.S. and Western Europe.[11] In both economies the real wages rise dramatically during the early 1930s.[12] This is consistent with the em-

[8]Recently, several studies have also explored the role of wage rigidities on country-basis. Fisher and Hornstein (2002) find that in Germany, real wages were above their market clearing levels and thus contributed to the decline of output during the Great Depression. The role of real wage rigidities was studied for Italy as well (Perri and Quadrini 2002). Though arguing that the fall of international trade was a major cause of output fall in Italy, that drop was amplified by the real wage stickiness.

[9]This conclusion is not unchallenged. Madsen (2004) argues that price rather than wage stickiness played a major role in the propagation of the Great Depression.

[10]Eggertson (2012) studies the impact of NIRA and the New Deal policies within a model with staggered price setting. He finds that the anti-competitive policies could have been expansionary under emergency conditions with zero interest rate bounds and large deflationary shocks.

[11]The real wage is computed as the nominal wage in industry divided by the wholesale price index. The real wage is detrended by the long run output growth rate and normalized at 1925=0 since the units are not comparable. For the Western Europe the normalized real wages are summed weighted by the output share of each country at 1925.

[12]Rising real wages in Europe and North America has been extensively documented by

pirical findings in the literature that nominal wage stickiness and deflation increased the cost of labor. In the U.S., the real wage remained well above the 1925 level during the late 1930s, unlike that in Europe which returned the 1925 level in 1937. The fact that the real wage remained high in the U.S. is consistent with the literature that views the New Deal policies as the cause of the increased the bargaining power of labor unions. We show in the appendix that both monetary shocks with sticky wages and time varying labor union bargaining power distort the labor market in a similar way.

2.2 The Capital Market

Similarly to the labor market distortions, the capital markets experienced substantial distortions during the Great Depression years which caused the decline of money supply to affect real economy. Three channels were discussed in the literature: nominal interest rate rigidity, bank failures, and pessimistic expectations.

Rigid nominal interest rates distort capital markets by affecting the real interest rate. If the nominal interest rate fully adjusts to nominal shocks, the deflation will be cancelled out by the drop in nominal interest rates and real interest rates will remain constant. However, when the nominal interest rate does not fully adjust, money neutrality does not hold. The lack of adjustment can occur due to passive monetary policy (Friedman and Schwartz 1963) or when the nominal interest rate hits the zero lower bound (Eggertson 2012).[13] Rising real interest rates should discourage current consumption and investment through the intertemporal optimization of the agents. Figure 4 illustrates the point by presenting the real interest rates in the U.S. and Western Europe.[14]

In both economies the real interest rate rises dramatically over the 1929-1931 period reflecting the huge deflation during this period. This corresponds to the drop in investment and consumption in both countries shown in Figure

Williamson (1995).

[13] Chadha and Dimsdale (1999) shows that nominal interest rates were not responsive to changes in the inflation rate during the 1920-1938 period in the UK, US, France and Germany.

[14] The real interest rate is defined as the nominal policy discount rate minus the expected inflation rate of the wholesale price. We define the expected inflation rate as the average of the actual inflation and the inflation of the previous year. The real interest rate for Europe is an average of individual country rates weighted by the output share of each country in 1925.

1. After 1931 the real interest rate in both countries falls dramatically, which corresponds to the recovery of investment in both economies. While the investment in Europe returns to the 1925 level by 1936, that in the U.S. does not recover despite the real interest rate dropping below zero during the 1933-1936 period. Therefore, the change in real interest rates does not seem to be the only issue in the capital market.

Another channel linking deflation and real output proposed by the literature is bank failures which caused the decline of money supply (e.g. Friedman and Schwartz, 1963) and increasing costs of credit intermediation (e.g. Bernanke 1983). In the U.S., the waves of bank failures led to the nation-wide bank closure by president Roosevelt in March 1933.[15] In Europe, countries also experienced banking crisis, though the banking system was not disrupted as severely as in the U.S.[16] The exceptions are Austria and Germany. Austria was the first one to experience a banking crisis which peaked in May 1931 when its largest deposit bank, Creditanstalt, failed.[17] Germany also experienced run on banks and German mark resulting in the failure of Danatbank, the second largest bank in the country when it went bankrupt in July 1931.[18]

To illustrate the arguments above, Table 1 presents the growth rates of money in our sample countries. We define money as the sum of central bank issues, deposit in commercial banks and deposit in savings banks, which corresponds to M2. This table shows that the decline in money supply in Austria, Germany and the U.S. was much more severe than in the other countries. This supports the view that banking crises led to a fall in the

[15] December 1930: failure of Bank of the United States. August to October 1931: a series of banking panics and failures of 1860 banks. June 1932: a series of bank failures in Chicago. October 1932: a series of bank failures in Midwest and Far West.

[16] Indeed, according to Bernanke and James (1991), countries like Denmark, Finland, Netherlands, Norway, Spain, Sweden and the UK survived the depression years without general banking crises. Reasons for relatively mild banking crises on the European continent include sound banking structure, the proactive role of government and central banks, and exchange-rate policies (Feinstein et al. 2008, Grossman 1994).

[17] Being one of the largest short-term debtors in Europe, very close relationships between the banks and industry, and a long-lasting negative impact of the collapse of Austria-Hungary made the banking sector very vulnerable to the Depression. The collapse of the Credit-Anstalt had not only a profound impact on the domestic economy, but also caused the bank crisis to spread to other countries as well (Eichengreen 1992, Feinstein et al. 2008).

[18] Even though it is generally viewed as a twin crisis largely independent from the events in Austria (e.g. Feinstein et al. 2008), it was argued that the events in Austria had a significant indirect impact on the crisis in Germany (Eichengreen 1992).

supply of credit, which in turn reduced lending and output.[19]

Table 1. The Growth Rate of Money Supply

	1929	1930	1931	1932	1933
Austria	12.2	−15.3	−20.5	−5.2	1.6
Belgium	12.5	8.3	−2.2	−0.3	1.1
Denmark	4.5	−3.0	−1.1	3.5	0.7
Finland	4.4	−1.8	−1.7	4.7	4.6
France	10.9	7.3	4.2	−1.9	−0.8
Germany	0.1	−16.6	−10.7	5.3	6.1
Italy	9.1	2.3	4.7	5.4	1.9
Netherlands	6.5	−4.1	2.8	−3.1	−2.5
Norway	−3.8	−4.7	−4.9	−4.4	−4.5
Spain	9.8	−3.8	3.1	3.5	4.0
Sweden	4.2	0.6	2.3	2.2	1.5
UK	3.1	−6.9	9.3	4.1	4.0
U.S.	1.3	−4.7	−11.7	−2.9	4.5

There is a substantial literature analyzing the cause of the banking crisis during the Great Depression.[20] Recently, however, a few studies emerged attempting to quantify the impact of banking crises on output. Bernanke and James (1991) examine the effect of banking crisis on industrial output on a sample of 24 countries in 1930-36. They found a large negative effect – a bank panic was estimated to reduce industrial output by more than 16 percentage points. Calomiris and Mason (2003b) follow upon Bernanke (1983) and test his hypothesis that banking crises led to an increase in the cost of credit intermediation which then negatively affected output. They find that the decrease in the growth of loan supply significantly reduced U.S. state income.

[19] Temin (1976), on the other hand, argues that the decline in money stock was due to the decrease in money demand.

[20] The focus in the literature has been whether bank failures were caused by illiquidity or insolvency (Richardson 2007). Calomiris and Mason (2003a) find that fundamentals — both the attributes of individual banks and the exogenous shocks that affected their health — had close links with the likelihood of US bank failures over the 1930 to 1933 period. There is also a substantial body of research on the role of central banks, bank regulation, and bank structure on propagation of banking crisis during the Great Depression, e.g. Grosmann (1994), Mitchener (2005), Mitchener (2007), Richardson and Troost (2007), Carlson and Mitchener (2009).

The third channels through which the capital markets can influence real economy during the Great Depression was advocated by Temin (1976) who argues that the pessimistic expectations of private agents led to a collapse in aggregate demand and the decline in money stock was due to the endogenous decrease in money demand. Harrison and Weder (2006) follow-up on this view and construct a dynamic stochastic general equilibrium model with sunspot shocks in investment and show that negative expectation shocks estimated from interest spread data can account for the U.S. Great Depression and slow recovery. We show in the appendix that a model with expectation shocks to future output can operate as a distortion in the investment market.[21]

In sum, there is a substantial body of research which argues for substantial distortions of the labor and capital markets during the Great Depression and growing literature which empirically shows how those distortions transmit the negative money supply shocks into the real economy. The following sections, using the business cycle accounting, quantify the importance of labor and capital market distortions in Western Europe and the U.S. respectively.

3 The Benchmark Model

3.1 Household

The representative household's lifetime utility is defined as

$$E_0 \sum_t \beta^t \left[\Psi \ln c_t + (1-\Psi) \left(\ln (1-l_t) - \alpha l_t u_{l,t}^{\mu} \right) \right] \tag{1}$$

where the arguments are consumption c_t, labor supply l_t and labor utilization $u_{l,t}$ respectively. In this model, labor supply is defined as the fraction of population that is employed. We assume that the household allocates a fraction of people into the labor market to earn wage and the rest at home to provide home services. For simplicity, we assume that the production of home services is a linear function of the fraction of the non-employed members $(1-l_t)$, which leads to a utility gain of $(1-\Psi)\ln(1-l_t)$. Market labor is costly not only because it reduces home services, but also because market

[21] CKM (2007) shows that financial frictions can be mapped into a prototype business cycle accounting model with invesment wedges.

labor incurs disutility from the intensity of working. That is, the higher the labor utilization rate the higher the utility cost of working, $(1-\Psi)\alpha l_t u_{l,t}^{\mu}$.

The household maximizes the utility (1) subject to the following budget constraint

$$\omega_{l,t} w_t u_{l,t} l_t + \omega_{k,t} r_t u_{k,t} k_t + \pi_t + \tau_t = c_t + x_t.$$

The household earns labor income from the firm, which depends on the employment level and its utilization rate, i.e. the effective labor supply: $u_{l,t} l_t$. The household also owns the capital stock k_t and rents this to the firm to earn capital income, which depends on the amount of capital rented adjusted for its utilization rate, i.e. the effective capital $u_{k,t} k_t$. Labor and capital income are affected by distortions in the labor and capital market, $\omega_{l,t}$ and $\omega_{k,t}$, which we define as labor and investment wedges respectively. In addition, the household receives firm profits π_t as the owner of the firm and transfer income from the government τ_t. The household uses income from these sources in order to finance consumption and investment x_t.

Capital stock accumulates according to the following capital law of motion

$$\Gamma k_{t+1} = x_t + (1-\delta_t) k_t,$$

where the depreciation rate δ_t depends on the utilization rate of capital stock as in Greenwood, Hercowitz and Huffman (1988):

$$\delta_t = \delta u_t^{\chi}.$$

In this model, the household chooses the level of both labor and capital utilization. From the household's perspective, a rise in labor utilization increases labor income but it is costly due to the utility cost. On the other hand, capital utilization increases capital income whereas it is costly as it increases the depreciation rate of capital.

3.2 Firm

The representative firm produces a single final good using effective labor $u_{l,t} l_t$ and effective capital $u_{k,t} k_t$ which it hires from the household at the rates of w_t and r_t, respectively. Therefore, the firm's profit maximization problem is as follows:

$$\max \pi_t = y_t - w_t u_{l,t} l_t - r_t u_{k,t} k_t.$$

For the production technology, we assume a Cobb-Douglas production function:

$$y_t = \omega_{e,t} \left(u_{k,t}k_t\right)^{\theta} \left(u_{l,t}l_t\right)^{1-\theta}$$

where $\omega_{e,t}$ is the time varying productivity of the firm, which we define as efficiency wedges.

3.3 Government

The government collects labor and capital income taxes from the household in order to finance its exogenous purchases g_t. The remainder is transferred to the household in a lumpsum fashion. Therefore, the government budget constraint is:

$$\left(1 - \omega_{l,t}\right) w_t u_{l,t} l_t + \left(1 - \omega_{k,t}\right) r_t u_{k,t} k_t = \tau_t + g_t.$$

For convenience, we rewrite government purchases as a fixed government purchases level g times government wedges $\omega_{g,t}$ so that $g_t = g\omega_{g,t}$.

We can combine the household budget constraint, the firm's profit and the government budget constraint to derive the resource constraint of the economy:

$$y_t = c_t + x_t + g_t.$$

Since the economy is closed, the trade balance does not appear in the resource constraint. As the original Chari, Kehoe and McGrattan (2007), we treat the trade balance as part of the government purchases.

3.4 Wedges

In this model, we have four exogenous variables which we defined as wedges:

$$\omega_t = \left(\omega_{e,t}, \omega_{g,t}, \omega_{k,t}, \omega_{l,t}\right)'.$$

For convenience, we defined them so that their means are equal to one. We assume that the log deviation of the wedges from their means follow a first order vector autoregressive process:

$$\widetilde{\omega_t} = P\widetilde{\omega_{t-1}} + \varepsilon_t, \varepsilon_t \sim N(0, V).$$

The error terms are assumed to be mean zero, however, there is no restriction on the variance covariance matrix V. Therefore, wedges are allowed to have contemporaneous correlations. In terms of the transition matrix P, we follow Chari, Kehoe and McGrattan (2007) and impose a restriction such that

3.5 Equilibrium

The competitive equilibrium is a sequence of quantities and prices

$$\{y_t, c_t, x_t, l_t, u_{k,t}, u_{l,t}, k_{t+1}, \tau_t, \omega_{e,t}, \omega_{g,t}, \omega_{k,t}, \omega_{l,t}, w_t, r_t\}$$

such that, (i) the household optimizes given $\{w_t, r_t\}$ and $\{\tau_t, \omega_{k,t}, \omega_{l,t}\}$; (ii) the firm optimizes given $\{w_t, r_t\}$ and $\omega_{e,t}$; (iii) the government budget constraint and the resource constraint holds; and (iv) the wedges follow the stochastic process.

In summary, the equilibrium is characterized by the following seven equations:

$$\frac{1}{c_t} = \widehat{\beta} E_t \left[\frac{1}{c_{t+1}} \left(\omega_{k,t+1} \theta \frac{y_{t+1}}{k_{t+1}} + 1 - \delta u_{k,t+1}^{\chi} \right) \right], \tag{2}$$

$$\frac{1}{1-l_t} = (\mu - 1) \alpha u_{l,t}^{\mu}, \tag{3}$$

$$\omega_{l,t} (1-\theta) \frac{y_t}{l_t} = \frac{1-\Psi}{\Psi} \frac{\mu}{\mu - 1} \frac{c_t}{1-l_t}, \tag{4}$$

$$\omega_{k,t} \theta \frac{y_t}{k_t} = \chi \delta u_{k,t}^{\chi}, \tag{5}$$

$$y_t = \omega_{e,t} (u_{k,t} k_t)^{\theta} (u_{l,t} l_t)^{1-\theta}, \tag{6}$$

$$\Gamma k_{t+1} = x_t + \left(1 + \delta u_{k,t}^{\chi}\right) k_t, \tag{7}$$

$$1 = \frac{c_t}{y_t} + \frac{x_t}{y_t} + \frac{\omega_{g,t}}{y_t}, \tag{8}$$

where $\widehat{\beta} = \beta / \Gamma$.

4 Quantitative Analysis

4.1 Parameters

The parameters that define the steady state of the model are calibrated to target data values assuming that the world is in steady state at 1925[22]. For simplicity, we assume that utilization rates are equal to one in 1925. The calibrated parameters and steady states are listed in Table 2.

Table 2. Parameter and Steady State Values

Parameters			Steady States		
	U.S.	Europe		U.S.	Europe
$\widehat{\beta}$	0.96	0.96	c/y	0.731	0.788
δ	0.1	0.1	x/y	0.199	0.132
θ	0.333	0.333	y/k	0.661	0.934
Γ	1.032	1.023	l	0.383	0.438
χ	1.417	1.417	ω_e	1	1
μ	1.219	1.343	ω_g/y	0.070	0.080
Ψ	0.791	0.783	ω_k	0.643	0.455
α	7.388	5.186	ω_l	1	1

Due to data restrictions, we could not calibrate the subjective discount factor $\widehat{\beta}$, capital depreciation rate δ and the capital income share θ.[23] Therefore, we assume 0.96, 0.1 and 0.333 for $\widehat{\beta}$, δ and θ respectively. The growth trend Γ is computed as the average growth rate of total GDP over the 1900-2008 period. We compute the consumption to output ratio c/y, investment to output ratio x/y and employment to population ratio l directly from the data in 1925. The output to capital ratio y/k is calibrated to match the investment to output ratio x/y in equation (7). The steady state efficiency wedge ω_e is normalized at one as this only affects the scale of the economy. The steady state government wedge to output ratio ω_g/y is calibrated to match c/y and x/y in equation (8). The steady state investment wedge is

[22]The exceptions are Germany and Denmark where we assume that they are in steady state at 1925 and 1921 respectively.

[23]In order to calibrate the depreciation rate δ and the capital income share θ, we need data of investment to capital stock ratio and capital income. Furthermore, the subjective discount factor β cannot be directly calibrated in our model using the capital Euler equation because it involves the level of steady state investment wedges, which is a latent variable.

calibrated to match the output to capital ratio in equation (2). The steady state labor wedge ω_l is set equal to 1 as it does not affect any of the results.[24]

The elasticity of capital utilization is calibrated to match ω_k and y/k in equation (5). On the other hand, the elasticity of labor utilization μ cannot be calibrated because we have 2 equations (3) and (4) to pin down 3 parameters, the labor utilization disutility parameter α, the preference weight on consumption Ψ and μ. Therefore, we estimate μ jointly with the stochastic process. Once we estimate μ, we calibrate α to match l using (3) and Ψ to match ω_l, l and c/y using (4) respectively.

The parameters in the stochastic process and μ are estimated using the Bayesian method available in DYNARE[25]. The main reason why we resort to structural estimation is because our model contains several latent variables. In particular, we cannot directly observe the levels of investment wedges because they are defined in an expectational equation and efficiency wedges because factor utilization are unobservable. The information of the prior and posterior distributions are listed in the appendix.

4.2 Wedges

In order to reproduce wedges, we first solve the model for linear decision rules following Uhlig (1999) so that

$$\begin{aligned} \widetilde{k_{t+1}} &= A\widetilde{k_t} + B\widetilde{\omega_t} \\ \widetilde{q_t} &= C\widetilde{k_t} + D\widetilde{\omega_t}, \end{aligned}$$

where q_t is a vector of endogenous observable variables: $q_t = (y_t, c_t, x_t, l_t)$. The "~" refers to the log linear deviation of the variable from its steady state. We first assume that capital stock and the observables are in steady state in 1920, which implies that wedges in 1920 in steady state as well. Therefore, $\widetilde{k_{1925}} = \widetilde{q_{1925}} = \widetilde{\omega_{1925}}, = 0$. From 1926 and onwards, the wedges

[24]We can only identify the joint level of ω_l and Ψ in equation (4). Neither of them apppear in the linearized equilibrium conditions so their levels have no impact on the dynamics.

[25]We follow CKM (2007) and assume that government wedges do not have spillovers on other wedges and vice versa. CKM (2007) imposes this restriction to "avoid having the large movements in government consumption associated with World War I dominate the estimation of the stochastic process." Although we do not include World War I period in our sample, we believe that the government consumption in the late 1930s was also affected by war related expenses. Therefore, we impose the restriction on our estimation.

can be computed by solving the system of equations while updating the capital stock one period ahead by its linear decision rule using the computed wedges:

$$\begin{aligned} \widetilde{\omega_t} &= D^{-1}\left(\widetilde{q_t} - C\widetilde{k_t}\right), \\ \widetilde{k_{t+1}} &= A\widetilde{k_t} + B\widetilde{\omega_t} \end{aligned}$$

The computed wedges for the U.S. and Western Europe are plotted in Figures 5a and 5b. In the U.S., efficiency, government, investment and labor wedges all fall during the 1929-1933 period. These all should contribute to the decline in output during this period. In Western Europe, all wedges except for efficiency wedges fall during the 1929-1932 period.

A drop in efficiency wedges reduces output directly as well as the demand for capital and labor. A drop in government wedges leads to an increase in resources available to the private sector. The positive income effect stimulates consumption and leisure, which reduces labor utilization and output. A drop in investment wedges reduces the return on effective capital and thus leads to a decline in the supply of capital utilization and output. A drop in labor wedges reduces the return on labor and thus the decline in labor supply and output. The question is, how large are these effects?

4.3 Simulation

In order to quantify the effects of each wedges, we simulate the model by plugging in wedges into the model one-by-one and measuring the fluctuations in each endogenous variable. Table 3 summarizes the results. The first column for each country shows the difference between the output level in 1929 and at the trough, 1933 in the U.S. and 1932 in the Europe. The second column presents the difference between the output level in the trough and in 1938. The third row presents the decomposition of output fluctuations into the contributions of each wedge defined as

$$\begin{aligned} contv_j &= corr(\widetilde{v_t^{\omega_j}}, \widetilde{v_t}) * \frac{std(\widetilde{v_t^{\omega_j}})}{std(\widetilde{v_t})} \\ &= \frac{cov(\widetilde{v_t^{\omega_j}}, \widetilde{v_t})}{var(\widetilde{v_t})}, \end{aligned}$$

where $\widetilde{v_t^{\omega_j}}$ is the linearized fluctuation of variable v in response to $\widetilde{\omega_j}$ while $\widetilde{v_t}$ is that of the data.

Table 3. Contribution of Each Wedge on Output

	U.S.			Europe		
	1929-33	1933-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.128	0.054	0.34	−0.033	−0.041	0.23
Government	0.012	0.008	−0.05	−0.039	0.107	0.09
Investment	−0.100	−0.024	0.38	−0.033	0.024	0.09
Labor	−0.226	0.117	0.33	−0.067	−0.015	0.58
Data	−0.443	0.155	1	−0.171	0.075	1

First, in terms of the depth of the Great Depression, in the U.S. labor wedges account for half of the drop in output during the 1929-1933 period while efficiency and investment wedges account for a quarter each.[26] In Europe labor wedges account for more than one-third of the output drop during the 1929-1932 period, efficiency, government and investment wedges are equally responsible for the remaining. Next, in terms of the persistence of the depression, in the U.S. efficiency and labor wedges account for roughly one-third and two-thirds of the recovery in output respectively while investment wedges hinder the recovery over the 1933-1938 period.[27] In Europe the improvement in government wedges alone would have lead to a recovery twice as rapid as in the data while the deterioration in efficiency counteracts with these forces. Finally, in terms of overall contribution, in the U.S. efficiency, investment and labor wedges each account for approximately one-third of the output fluctuation over the 1925-1938 period. In Europe, labor wedges account for more than half while efficiency wedges account for a quarter of the output fluctuation.

Figures 6a and 6b show the year by year reaction of output to selected wedges for the U.S. and Western Europe. In the U.S. efficiency wedges alone does account for a significant drop in output during the Great Depression as shown above, however, they predict the trough at 1934. When we simulate the model with efficiency and labor wedges, the model correctly predicts

[26] Our result that investment wedges are important in accounting for the output drop in the US is different from CKM (2007) who finds otherwise. We discuss this in more detail in the following section.

[27] Our result that labor wedges contribute to the recovery in the US is different from CKM (2007) and Cole and Ohanian (2004) that find otherwise. This issue will be discussed in detail in the following section.

the trough at 1933. Moreover, the magnitude of the Depression is closer to the data, however, the model cannot fully account for the depth of the Great Depression. Finally, when we add investment wedges, the three almost perfectly account for Great Depression and the slow recovery. In Europe efficiency wedges can account for a significant drop in output, however, they cannot predict the recovery through the latter half of the 1930s. When we combine efficiency and labor wedges together, the model generates a depression with a magnitude much closer to that in the data. However, efficiency and labor wedges predict the depression to worsen throughout the 1930s. When we add government wedges, the model almost perfectly accounts for the Great Depression and the recovery. Therefore, government wedges are important in accounting for the European recovery after 1932.

Our results are informative in terms of discussing the sources of the IGD. The importance of labor wedges on the U.S. Great Depression lends support to the view that Hoover's high-wage policies contributed to the severity of the depression (e.g. Ohanian 2009). One important result is that investment wedges play a significant role in accounting for the U.S. Great Depression, which is in contrast with CKM (2007) that finds that their role is limited. Our result implies that we cannot reject the possibility that the financial turmoil aggravated the depression through a rise in financial frictions and deterioration in animal spirits as discussed in previous literature. We show in the following section that the endogenous factor utilization is the key to explain the differences in our results. In Western Europe, the importance of labor wedges can be attributed to the growing inflexibility of labor markets, accompanied by the deflationary pressure transmitted through the Gold Standard, as discussed earlier.

Our results also shed light on the recovery from the IGD. In Western Europe, investment and government wedges contribute to the recovery while efficiency and labor wedges dominated recovery in the U.S. The role of government wedges in the recovery of Western Europe is consistent with economic history literature. Whilst there has been a debate whether government policies resembled Keynesian fiscal push or not (e.g. Ritschl 2002), there is little doubt that governments tried various policies to induce recovery and to relieve unemployment (Feinstein et al 2008). In addition, since government wedges include the trade balance, the improvement in the trade balance in the countries that abandoned Gold Standard early could have contributed as well. In terms of investment wedges, one explanation is that rearmament during the mid 1930s dramatically increased government investment especially in Germany, Italy and the UK.[28] A rapid increase in military investment with little marginal economic return should manifest itself as investment wedges in our model. In addition, Crafts and Mills (2013) has shown that government expenditure provided a boost to real GDP after 1935 driven by the response of private sector to the news of massive future defense spending. In the U.S. improvement of labor wedges contribute to recovery, which is surprising given the literature blaming labor policies during this period for prolonging the Great Depression (CKM 2007, Cole and Ohanian 2004). We discuss this issue in detail in the following section.

It is interesting to point out the similarities and differences in the roles played by efficiency wedges in both economies. In both the U.S. and Western Europe efficiency wedges account for a significant drop in output in the early 1930s. This is an important finding as after decomposing TFP into endogenous factor utilization and exogenous production efficiency, we find that supply side shocks still have significant impact on the IGD. In terms of the recovery, while efficiency hindered output growth in Western Europe while it facilitated it in the U.S. This is consistent with recent research by Field (2006) who shows that in the U.S. both labor and capital productivity and hence TFP were growing in the depression years which resulted from advances in manufacturing sector combined with advances in transportation, distribution, and public utilities. Feinstein et al (2008) show that European labor productivity rises during the IGD. However, we find that efficiency, taking capital accumulation and factor utilization into consideration, actually falls and surpresses output growth over the recovery period.

4.4 Discussion

Our benchmark results lead to several discussions. First we will discuss how our setting differs from CKM (2007) and the implication of these differences. The most important difference is that we assume time-varying factor utilization which is not considered in their model. Another difference is that they consider total hours worked, which is the product of employment and hours worked per workers, as labor input whereas we consider employment

[28]In Germany, the work-creation program and motorway building program were accompanied by the Nazi economic planning, which brought about the revitalization of investment and the rise of government expenditure, mainly due to rearmament (Temin 1991). In Italy, Mussolini launched a program of public works and, following Germany, also embarked on large military spending.

as labor input and separately define labor utilization which includes hours worked per worker. We show that these differences cause discrepancies in results[29]. Next we assess whether there are differences across countries that abandoned the Gold Standard shortly after the outbreak of IGD and those that remained on the Gold Standard longer during the IGD. Finally, we discuss the similarities and differences between the IGD and the recent Great Recession. All simulations presented in this section are based on reestimated parameters given that we use different model settings or data samples.

4.4.1 Factor Utilization and TFP

One important difference between our model and that of CKM (2007) is that we consider endogenous capital and labor utilization. Consequently, our definition of efficiency wedges is different from theirs. CKM (2007) defines efficiency wedges as the Solow residual:

$$\widetilde{A_t} = \widetilde{y_t} - \theta\widetilde{k_t} - (1-\theta)\widetilde{l_t}.$$

On the other hand, we define efficiency wedges as

$$\widetilde{\omega_{e,t}} = \widetilde{y_t} - \theta\left(\widetilde{k_t} + \widetilde{u_{k,t}}\right) - (1-\theta)\left(\widetilde{l_t} + \widetilde{u_{l,t}}\right). \tag{9}$$

The discrepancy between Solow residuals and our measure of efficiency wedges are

$$\widetilde{A_t} - \widetilde{\omega_{e,t}} = \theta\widetilde{u_{k,t}} + (1-\theta)\widetilde{u_{l,t}}.$$

Therefore, Solow residuals are a poor measure of productivity if factor utilization rates fluctuate over the business cycle.[30]

In order to illustrate the effect of factor utilization on output fluctuation, we simulated the model with constant factor utilization. This model

[29] There are also differences in data series besides the labor input. First, we use consumption expenditure as consumption whereas CKM (2007) uses expenditure on non-durables and services as consumption. Since we do not have data on expenditure on durables for most European countries, we could not make this adjustment. Next, we use gross fixed capital formation as investment whereas CKM (2007) uses private gross fixed capital formation and includes government investment in government wedges. Since we do not have separate data for private and government investment, we could not make this adjustment as well.

[30] Another discrepancy is the definition of labor. We use employment whereas CKM (2007) uses total hours worked. We will explicitly discuss this in the next section.

corresponds to the original model of CKM (2007). Table 4 shows that without endogenous factor utilization efficiency wedges would have accounted for most of the depression, recovery and over all fluctuation in output in both economies. Therefore, endogenous factor utilization is an important channel for the transmission of factor market distortions and without these channels we would significantly understate their contributions.[31]

Table 4. Contribution of Each Wedge on Output: Constant Utilization

	U.S.			Europe		
	1929-33	1933-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.292	0.194	0.61	−0.167	0.024	1.09
Government	0.003	−0.004	−0.02	−0.009	0.030	−0.01
Investment	−0.044	−0.081	0.21	0.033	0.020	−0.31
Labor	−0.110	0.046	0.21	−0.028	0.000	0.23
Data	−0.443	0.155	1	−0.171	0.075	1

Next, we consider how each wedge affects the factor utilization rates. First, we focus on the fluctuation of capital utilization. Figures 7a and 7b present the simulated capital utilization in U.S. and Europe. Since capital utilization is a latent variable in our model, the data series refers to the simulated capital utilization in the model with all wedges. The figures show that capital utilization drops dramatically during the IGD in both economies. In the U.S., labor wedges are the most important in accounting for the drop in capital utilization while in Europe investment wedges are the most important. Next we investigate the effect of labor utilization. Figures 8a and 8b present the simulated labor utilization. Labor utilization also drops sharply during the IGD. Labor wedges account for most of the drop in labor utilization in both economies. In Western Europe government wedges cause labor utilization to rise dramatically in the second half of the 1930s. These figures show that the factor utilization fluctuated quite dramatically during the IGD and that Solow residuals are not a good measure of production efficiency.

4.4.2 Labor and Hours Worked

Another difference between our model and CKM (2007) is the definition of labor. The standard business cycle accounting literature defines labor input

[31] Cole and Ohanian (2013) and Weder (2006) also show that capital utilization is important in accounting for the US Great Depression.

as total hours worked, i.e. the product of employment and hours worked per worker, while we define labor as employment and consider hours worked per worker as part of labor utilization which is a latent variable. This definition is convenient for us because the data of hours worked is not available for several European countries. However, data of hours worked per worker is certainly available for the U.S. The data of employment per capita and hours worked per worker in the U.S. is shown in Figure 9. This figure shows that hours worked per worker fell by roughly the same amount as employment and remained much lower than employment after the depression. Therefore, total hours worked decreased much more and remained lower than employment.

There is a literature which tries to explain the differences between employment and hours worked. Specifically, several papers have attempted to quantify the effect of 1933 National Industrial Recovery Act and later the National Labor Relations Act as well as President's Reemployment Agreement of 1933 on employment, real wages, and hours worked. These acts introduced codes which included fixed prices, minimum wages, and maximum hours worked. One of the rationales was that by reducing the workweek from about 40-45 hours to around 35 hours, work could be 'shared' among more people. Bernanke (1986) and Taylor (2011) find that New Deal policies contributed to reducing hours worked and increasing employment.

In relation with the discrepancy between our results and CKM (2007), since total hours worked remained lower than employment during the recovery period, efficiency wedges defined in (9) computed with employment as the measure of labor recover slower than those computed with total hours worked. In addition, labor wedges

$$\widetilde{\omega_{l,t}} = \widetilde{c_t} + \frac{1}{1-l}\widetilde{l_t} - \widetilde{y_t},$$

computed with employment recover faster than those computed with total hours worked. This is why, unlike CKM (2007) which defines labor as total hours worked, we find that labor wedges lead to a much more rapid recovery than efficiency wedges do.

In our model, the discrepancy between labor utilization and hours worked per worker can be considered as the level of effort as defined in Burnside, Eichenbaum and Rebelo (1993). As shown in Figure 8b, labor utilization in the U.S. recovers rapidly after 1933. We can interpret this result that while the hours worked per worker remained low, the level of effort per worker was rising. Unfortunately we have no data on workers' effort, however, it is not hard to imagine that workers' effort could rise when the depression persists and the fear of unemployment remains high.

4.4.3 The Gold Standard

As was argued earlier in the paper, the research over the past few decades concluded that the deflationary pressures were transmitted across countries through the operation of the Gold Standard and that the distortions of the labor and capital markets channeled that deflation into the real economy. As a consequence, leaving the Gold Standard might have fostered a recovery by ending these deflationary pressures. Indeed, several papers (e.g. Eichengreen and Sachs 1985, Eichengreen 1992, Cole and Ohanian 2013) showed that the countries which left the Gold Standard early on experienced a faster recovery than the countries which stayed on gold longer. In this section we are going to contribute to that debate by discussing the implications of our findings from the business cycle accounting for the recovery from the Great Depression taking into account the adherence to the Gold Standard.

There are several reasons, discussed in the literature, why the abandonment of the Gold Standard could have led to the recovery of the Early Leavers. Leaving the fixed exchange-rate regime allowed currencies to depreciate hence to increase countries' competitiveness on the international market which then improved their balance of payment and increased aggregate demand (e.g. Eichengreen and Sachs 1985, Eichengreen and Irvin 2010). Leaving the Gold Standard also removed the imperative of cutting domestic spending and rising taxes to defend the exchange rate and allowed changing the expectations from deflation to inflation thus enabling to escape the liquidity trap (Eichengreen 2008, Eggertsson 2008, Crafts et al 2010). Indeed, according to Eichengreen and Sachs (1985), once prices began to rise, increased profitability - both current as well as future - encouraged investment which lead to the raising industrial production and recovery. Finally, inflation lowered real wages which then stimulated labor demand (Eichengreen and Sachs 1985).

Table 5 presents the dates at which each European country changed the Gold Standard policy according to Bernanke and James (1991) along with the changes of the detrended output over the 1929-1932 and 1932-1938 periods. The policy changes from the Gold Standard are either devaluation, foreign exchange control or suspension. We split the countries into two groups; those that abandoned the Gold Standard in 1931 which we call the Early Leavers

(Austria, Denmark, Finland, Germany, Norway, Spain, Sweden and UK) and those that abandoned it after 1934 which we call the Late Leavers (Belgium, France, Italy and the Netherlands). From the aggregate of the two groups, we cannot find much difference in the magnitude of the depression in the two groups while there is a clear difference in the persistence; the Early Leavers recovered quite rapidly compared to the Late Leavers. Among the countries that abandoned the Gold Standard in 1931, Denmark and Spain are the only ones that did not show significant recovery. However, Denmark did not experience a large output drop to begin with and the collapse of Spain was due to the civil war which is exogenous shock unrelated to the Gold Standard.

Table 5. Changes in the Gold Standard Policies

Early Leavers: Countries Abandoning Gold Standard in 1931				
Country	Date	Policy	1929-32	1932-38
Austria	September 1931	Devaluation	−0.289	0.073
Denmark	September 1931	Suspension	−0.040	−0.008
Finland	October 1931	Suspension	−0.138	0.193
Germany	July 1931	ForEx Control	−0.241	0.288
Norway	September 1931	Suspension	−0.052	0.055
Spain	May 1931	ForEx Control	−0.134	−0.491
Sweden	September 1931	Suspension	−0.078	0.137
UK	September 1931	Suspension	−0.113	0.104
Sub Total	-	-	−0.166	0.127
Late Leavers: Countries Abandoning Gold Standard after 1934				
Country	Date	Policy	1929-32	1932-38
Belgium	March 1935	Devaluation	−0.144	−0.055
France	October 1936	Devaluation	−0.230	0.007
Italy	May 1934	ForEx Control	−0.115	−0.016
Netherlands	October 1936	Devaluation	−0.177	−0.068
Sub Total	-	-	−0.179	−0.017

Although we do not have enough samples to conclude that staying on the Gold Standard longer led to a slow recovery of the Late Leavers, we can compare how the distortions on the factor markets interplayed with the adherence to the deflation-transmitting Gold Standard. Table 6 compares the simulation results for the Early Leavers and Late Leavers. The results shows that the main source of the depression for the Early Leavers was the deterioration in the labor wedges while government wedges also played a significant role. In terms of the recovery, the government wedges have a strong positive impact on output growth of the Early Leavers after 1932. On the other hand, the main source of the depression in the Late Leavers was the deterioration in the efficiency wedges while investment and labor wedges also played significant roles. The sluggish recovery in the Late Leavers was due to the further deterioration in the investment and labor wedges.

Table 6. Contribution of Each Wedge on Output: Gold Standard

	Early Leavers			Late Leavers		
	1929-32	1932-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.001	−0.067	0.01	−0.106	0.012	0.31
Government	−0.048	0.126	0.32	−0.013	0.054	−0.09
Investment	−0.020	0.061	0.05	−0.023	−0.045	0.32
Labor	−0.098	0.007	0.62	−0.038	−0.038	0.46
Data	−0.166	0.127	1	−0.179	−0.017	1

The results that the Early Leavers were primarily affected by labor wedges while Late Leavers were primarily affected by efficiency wedges gives an interesting comparison. One possible interpretation of this result is that the Early Leavers left early because the economy suffered from labor market distortions generated by the deflation imported through the Gold Standard while the Late Leavers stayed on the Gold Standard because the economy was affected primarily by the deterioration in production efficiency rather than the monetary transmission of the deflation. Another interesting result is that the government wedges played a significant role in both the depression and recovery of the Early Leavers while they had less impact on the Late Leavers. One possible interpretation of this result is that the Early Leavers who were hit strongly by the deterioration of the trade balance during the early stage of the depression abandoned the Gold Standard to stimulate foreign demand through currency depreciation.[32] Finally, the result that the deterioration of labor wedges further depressed the economy of Late Leavers is consistent with the view that staying on the Gold Standard prolonged the deflation leading to distortions in the capital and labor markets.[33]

[32] On the other hand, the Late Leavers should have suffered in the international trade market from the relative appreciation of their currency while the Early Leavers were recovering.

[33] In France, for example, deflationary policies prevailed despite the growing domestic opposition against them. Indeed, even though the government of Pierre-Etienne Flandin,

4.4.4 The Great Recession

Finally, the recent financial crisis of 2008 drew attention to the IGD as these episodes are both considered as worldwide economic crises originated by the U.S. economy. The literature is diverse: there are studies which discuss the causes of recent crisis (e.g. Brunnermeier 2009, Levine 2010), studies focusing on the differences in the magnitude between the two crises and the responses of policy makers (e.g. Almunia et al 2010, Crafts et al 2010, Grossman et al 2010.), then studies which compare the causes of both crises (Temin 2010; Bordo et al 2009, Bordo et al. 2010), and finally studies which examine the transmission of the recession across countries (Bagliano et al 2012). Unlike the research on the IGD, however, research on the recent financial crisis is still young and the jury is still out there. The results that we currently have suggest that insolvency and the fear of insolvency of counterparties was the deepest problem of recent crisis (Bordo and Landon-Lane 2010) and that the asset prices were the main channel transmitting shocks of financial sector to real economy (Bagliano et al. 2012). Bagliano et al. (2012) also analyses the transmission of recent recessions across economies and find that the contraction of output in the U.S. had a sizable effect on the contraction of foreign economic growth. In this section we contribute to the research on the recent financial crisis by comparing it with the Great Depression using the same business cycle accounting model.

Table 7 shows the simulation results for Europe and the U.S. over the 1999-2012 period.[34] We present the simulated change in output over the 2007-2012 period and the over all contribution of each wedge on output fluctuation. The results show that the main source of the recession in Europe was the collapse in efficiency. On the other hand, in the U.S. most of the

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formed in November 1934, initiated reflationary policies, it fell back to the deflationary policies once the fixed parity between franc and the gold came under attack. After the fall of Flandin's government in 1935, the new government led by Pierre Laval reversed all Flandin's reflationary policies and issued a series of so-called deflationary decrees (Moure 1988, Eichengreen 1992). Even when the Front Populaire won the election in May 1936 with the election program of no further deflation, France did not leave the Gold Standard immediately. It was argued that France wanted to coordinate its exit and the devaluation of franc with Britain (Moure 1988). The announcement of 21bln franc rearmament program in September 1936, however, provided the final push to exit the gold standard and France devaluated in the following weeks (Moure 1988, Eichengreen 1992, Wolf 2008).

[34] The data sources are OECD and Eurostat data base. Since this period does not involve large war time expenses, we do not impose any restriction on the stochastic process.

drop in output can be accounted for by the deterioration in labor wedges. One remaining issue is that while the literature suggests that the financial market played an important role in the recession, investment wedges do not account for much of the output drops in both economies. Therefore it will be interesting to consider channels through which financial frictions lead to deteriorations in efficiency or labor wedges.

Table 7. Contribution of Each Wedge on Output: Great Recession

	U.S.		Europe	
	2007-12	Cont	2007-12	Cont
Efficiency	−0.000	0.01	−0.062	0.90
Government	0.010	−0.11	−0.016	0.09
Investment	0.011	−0.01	−0.014	−0.05
Labor	−0.127	1.11	−0.030	0.07
Data	−0.106	1	−0.122	1

The key differences between the recent recession and the IGD are revealing. In the case of the U.S. labor wedges account for all of the output drop during the recession years of 2007-2012. This is in contrast to the depression years of 1929-1933 when, efficiency, investment and labor wedges were all important driving forces of the output drop. In Western Europe, over the 2007-2012 period, half of the output drop was driven by efficiency wedges, one quarter was driven by labor wedges and the remaining was driven by government and investment wedges. In contrast, labor wedges were the main drivers of the output drop during the IGD. In addition, in terms of overall contribution, labor wedges contributed the most to the U.S. output fluctuation while efficiency wedges account for most of the output fluctuation in Europe over the 1999-2012 period. Therefore, in the U.S. labor wedges played a much more important role, relative to other wedges, in the Great Recession than it did in the Great Depression while in Europe efficiency wedges played a much more important role than it did in the IGD.

5 Conclusion and Extensions

In this paper we compare the U.S. and Western Europe and analyze the International Great Depression (IGD) with the business cycle accounting method assuming endogenous factor utilization. We find that efficiency and labor wedges are important in accounting for the Great Depression in Western Europe while efficiency, investment and labor wedges all contributed to the Great Depression in the U.S. The result that investment wedges had a significant negative impact on output in the U.S. implies that banking crisis and pessimism may have played an important role in the U.S. Great Depression. The result that labor wedges were most important in both Western Europe and the U.S. is consistent with the view that labor market distortions caused by the deflationary forces transmitted through the Gold Standard and rigid nominal wages are the main source of the IGD. We also find that labor and efficiency wedges played an important role in the recovery in the U.S. while government and investment wedges helped the European recovery.

There are several possible extensions left for future research. First, individual country analyses is possible for all Western European countries. This would help understand the business cycle episodes in each country during the interwar period. For instance, it would be interesting to compare the results of countries that have gone through banking crises such as Austria and Germany to those that haven't. Second, our model contains three key latent variables: efficiency, capital utilization and labor utilization. It would be helpful to seek for micro-level evidence of the fluctuation of these during the IGD. Finally, our quantitative results depend on the choice of the mathematical representation of functions that consist the model, especially the preference function. Since we do not have knowledge of the true form of preferences we use the most commonly used preference function, the log utility. Alternative preferences could be tested, but at the risk of generating misspecification errors. These will be left for future research as they are beyond the scope of this paper.

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A Equivalence Results

A.1 Predetermined Wage Model and Labor Wedges

Following Chari, Kehoe and McGrattan (2007), consider a model in which labor unions have monopoly power on differentiated labor $l_t(j)$ and has a bargaining power on nominal wage contracts that are set one period ahead of employment. Assume that the total labor l_t is as an aggregation of differentiated labor

$$l_t = \left[\int l_t(j)^{\frac{1}{\zeta_t}} di \right]^{\zeta_t},$$

where ζ_t represents the labor union's bargaining power. Following Eggertson (2012) we consider this as a time varying parameter. The firm's cost minimization leads to the demand for each differentiated labor

$$l_t(j) = \left[\frac{W_{t-1}(j)}{W_{t-1}} \right]^{\frac{\zeta_t}{1-\zeta_t}} l_t,$$

where $W_{t-1}(j)$ is the predetermined nominal wage for labor j and W_{t-1} is the aggregate wage index.

Now consider the union's problem which is to maximize the members' utility:

$$E_t \sum \beta^t \left[u\left(c_t(j), l_t(j) \right) \right].$$

For simplicity we assume that the labor is the only production factor in the economy so that the budget constraint is

$$W_{t-1}(j) l_t(j) = P_t c_t(j),$$

where P_t is the general price level and c_t is consumption. Optimization leads to the following condition

$$W_{t-1} = \zeta_t \frac{E_{t-1} \left[-u_{lt} l_t \right]}{E_{t-1} \left[\frac{u_{ct}}{P_t} l_t \right]},$$

where we assume a symmetric equilibrium and drop the j notation.

Finally, the firms' problem leads to the following optimality condition:

$$\frac{W_{t-1}}{P_t} = mpl_t.$$

Therefore, the labor market equilibrium condition is

$$mpl_t = \frac{\zeta_t}{P_t} \frac{E_{t-1}\left[-u_{lt} l_t\right]}{E_{t-1}\left[\frac{u_{ct}}{P_t} l_t\right]}. \tag{10}$$

Comparing (10) to the benchmark labor equilibrium condition (4):

$$mpl_t \omega_{l,t} = -\frac{u_{l,t}}{u_{c,t}},$$

we can see that an unexpected deflation i.e. $P_t < E_{t-1}[P_t]$ creates a wedge between the marginal product of labor and the marginal rate of substitution between labor and consumption. Intuitively speaking, deflation raises the real wage that the firm must pay given the predetermined nominal wage, and hence reduces labor demand. An increase in the union's bargaining power also creates a wedges in the labor market. This is because a rise in the monopoly power of labor gives an incentive for the union to demand higher contract wages for members and as a result the labor demand will fall. This corresponds to the mechanism proposed by Cole and Ohanian (2004) which explains how the New Deal policies may have prolonged the Great Depression.

A.2 Expectational Shock Model and Investment Wedges

Following Harrison and Weder (2006), the firm maximizes its profit

$$\pi_t = y_t - w_t l_t - r_t u_{k,t} k_t.$$

where

$$y_t = A_t^{\gamma} \left(u_{k,t} k_t\right)^{\theta} l_t^{1-\theta}$$

and A_t represents aggregate externality. The externality is taken as exogenous for individual producers and is defined as

$$A_t = \left(\overline{u_{k,t}}\overline{k_t}\right)^{\theta} \overline{l_t}^{1-\theta}$$

where variables with "–" are aggregate variables. The parameter $\gamma > 0$ represents the degree of externality.

Now consider the consumer's problem which is equivalent to that of the benchmark model without labor utilization and wedges. The household maximizes lifetime utility

$$E_0 \sum_t \beta^t \left[\Psi \ln c_t + (1-\Psi) \ln (1-l_t)\right]$$

subject to

$$w_t l_t + r_t u_{k,t} k_t + \pi_t + \tau_t = c_t + x_t.$$

The capital law of motion is the same as (7) in the benchmark model.

In equilibrium

$$\theta \frac{y_t}{k_t} = \chi \delta u_{k,t}^{\chi},$$

so that

$$y_t = \left(\frac{\theta}{\chi\delta}\right)^{\frac{(1+\gamma)\theta}{\chi-\gamma\theta}} k_t^{\frac{(\chi-1)\theta(1+\gamma)}{\chi-\gamma\theta}} l_t^{\frac{\chi(1-\theta)(1+\gamma)}{\chi-\gamma\theta}}.$$

The main feature of this model is that the labor demand curve is upward sloping. From the labor first order condition

$$w_t = (1-\theta)\frac{y_t}{l_t} = (1-\theta)\left(\frac{\theta}{\chi\delta}\right)^{\frac{(1+\gamma)\theta}{\chi-\gamma\theta}} k_t^{\frac{(\chi-1)\theta(1+\gamma)}{\chi-\gamma\theta}} l_t^{\frac{\chi(1-\theta)(1+\gamma)}{\chi-\gamma\theta}-1},$$

if $\frac{\chi(1-\theta)(1+\gamma)}{\chi-\gamma\theta} > 1$ labor demand is increasing in wage.

This model contains multiple equilibria due to the upward sloping labor demand curve. Imagine that there is an exogenous negative expectational shock to the future output, y_{t+1}^*. A decrease in expected lifetime income leads to an decrease in current and future consumption and an increase in labor supply. If the slope of the labor demand curve is steeper than the labor supply curve, this will lead to a decrease in labor input and wages. The decrease in current labor input leads to a decline in the current marginal product of capital and hence a drop in capital utilization. The decrease in future labor input leads to a fall in expected future marginal product of capital and hence a drop in current investment. The decline in capital stock due to the drop in investment validates the pessimistic expectation.

Comparing the capital Euler equation

$$\frac{1}{c_t} = \widehat{\beta} E_t \left[\frac{1}{c_{t+1}}\left(\frac{\chi-1}{\chi}\theta\frac{y_{t+1}^*}{k_{t+1}} + 1\right)\right],$$

to that in the benchmark model, (2) combined with (5),

$$\frac{1}{c_t} = \widehat{\beta} E_t \left[\frac{1}{c_{t+1}} \left(\omega_{k,t+1} \frac{\chi - 1}{\chi} \theta \frac{y_{t+1}}{k_{t+1}} + 1 \right) \right],$$

we can see that expectational shocks can be observationally equivalent to investment wedges.

B Estimation Results

Table A1(a). Bayesian Estimation Results: U.S.

Name	Prior				Posterior	
	Dist.	Mean	S.E.	Support	Mode	S.E.
P_{ee}	norm	0.5	0.5	$\boldsymbol{R}$	0.6088	0.1456
P_{gg}	norm	0.5	0.5	$\boldsymbol{R}$	0.6546	0.1023
P_{kk}	norm	0.5	0.5	$\boldsymbol{R}$	1.1496	0.0766
P_{ll}	norm	0.5	0.5	$\boldsymbol{R}$	0.6976	0.0942
P_{ek}	norm	0	0.5	$\boldsymbol{R}$	0.1404	0.1077
P_{el}	norm	0	0.5	$\boldsymbol{R}$	0.2426	0.0748
P_{ke}	norm	0	0.5	$\boldsymbol{R}$	-0.3645	0.2058
P_{kl}	norm	0	0.5	$\boldsymbol{R}$	0.2906	0.1264
P_{le}	norm	0	0.5	$\boldsymbol{R}$	0.4869	0.1943
P_{lk}	norm	0	0.5	$\boldsymbol{R}$	-0.2867	0.1685
σ_e	inv_g	0.01	0.1	$\boldsymbol{R}^+$	0.0186	0.0034
σ_g	inv_g	0.01	0.1	$\boldsymbol{R}^+$	0.2326	0.0405
σ_k	inv_g	0.01	0.1	$\boldsymbol{R}^+$	0.0048	0.0018
σ_l	inv_g	0.01	0.1	$\boldsymbol{R}^+$	0.0439	0.0071
ρ_{ek}	beta	0	0.3	$[-1, 1]$	-0.0874	0.3377
ρ_{el}	beta	0	0.3	$[-1, 1]$	0.4341	0.1752
ρ_{kl}	beta	0	0.3	$[-1, 1]$	0.1128	0.3402
μ	gamma	0.9	0.05	$[1, \infty)$	1.1258	0.1010

Table A1(b). Bayesian Estimation Results: Europe

Name	Prior				Posterior	
	Dist.	Mean	S.E.	Support	Mode	S.E.
P_{ee}	norm	0.5	0.5	$\boldsymbol{R}$	1.0178	0.1546
P_{gg}	norm	0.5	0.5	$\boldsymbol{R}$	0.9632	0.0547
P_{kk}	norm	0.5	0.5	$\boldsymbol{R}$	0.5865	0.2314
P_{ll}	norm	0.5	0.5	$\boldsymbol{R}$	0.9614	0.0479
P_{ek}	norm	0	0.5	$\boldsymbol{R}$	-0.3639	0.2791
P_{el}	norm	0	0.5	$\boldsymbol{R}$	0.0302	0.0511
P_{ke}	norm	0	0.5	$\boldsymbol{R}$	0.1791	0.1875
P_{kl}	norm	0	0.5	$\boldsymbol{R}$	-0.0568	0.0703
P_{le}	norm	0	0.5	$\boldsymbol{R}$	0.0590	0.1335
P_{lk}	norm	0	0.5	$\boldsymbol{R}$	-0.1127	0.2716
σ_e	inv_g	0.01	0.1	$\boldsymbol{R}^+$	0.0070	0.0014
σ_g	inv_g	0.01	0.1	$\boldsymbol{R}^+$	0.1775	0.0304
σ_k	inv_g	0.01	0.1	$\boldsymbol{R}^+$	0.0048	0.0017
σ_l	inv_g	0.01	0.1	$\boldsymbol{R}^+$	0.0183	0.0033
ρ_{ek}	beta	0	0.3	$[-1,1]$	-0.1409	0.3265
ρ_{el}	beta	0	0.3	$[-1,1]$	-0.0071	0.2304
ρ_{kl}	beta	0	0.3	$[-1,1]$	-0.0900	0.3437
μ	gamma	0.9	0.05	$[1,\infty)$	1.3216	0.2222

C Data Appendix

- Austria

GDP, Private Consumption, Gross Fixed Capital Formation: Sonderheft, W., (1965), Oesterreichs Volkseinkommen 1913 bis 1963, Monatsberichte des Oesterrechischen Institutes fur Wirtschaftsforschung, 14, page 38.

Employment: Clark, C., (1951), The Conditions of Economic Progress, London, Macmillan & Co. Ltd, Page 153.

Population: Mitchell, B.R. (2013), International Historical Statistics: Europe 1750-2010: Europe, Palgrave Macmillan: Basingstoke, Table A5.

Wholesale Prices, Money Wages, Money Supply: Mitchell, B.R. (2013), International Historical Statistics: Europe, 1750-2010, 5th edition, Palgrave Macmillan: Basingstoke, Table H1, B4, G1-G3.

Nominal Interest Rate: Historical Financial Statistics, International Policy Rates.

http://www.centerforfinancialstability.org/hfs.php

- Belgium

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Nominal Interest Rate: Historical Financial Statistics, International Policy Rates.

- Denmark:

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Nominal Interest Rate: Historical Financial Statistics, International Policy Rates.

- Finland

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Money Wages: Singer-Kerel, J. (1961), Le cout de la vie a Paris de 1840 a 1954, Colin.

Nominal Interest Rate: Historical Financial Statistics, International Policy Rates.

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Nominal Interest Rate: Historical Financial Statistics, International Policy Rates.

Figure 1a. US Business Cycle Data: 1925-1938

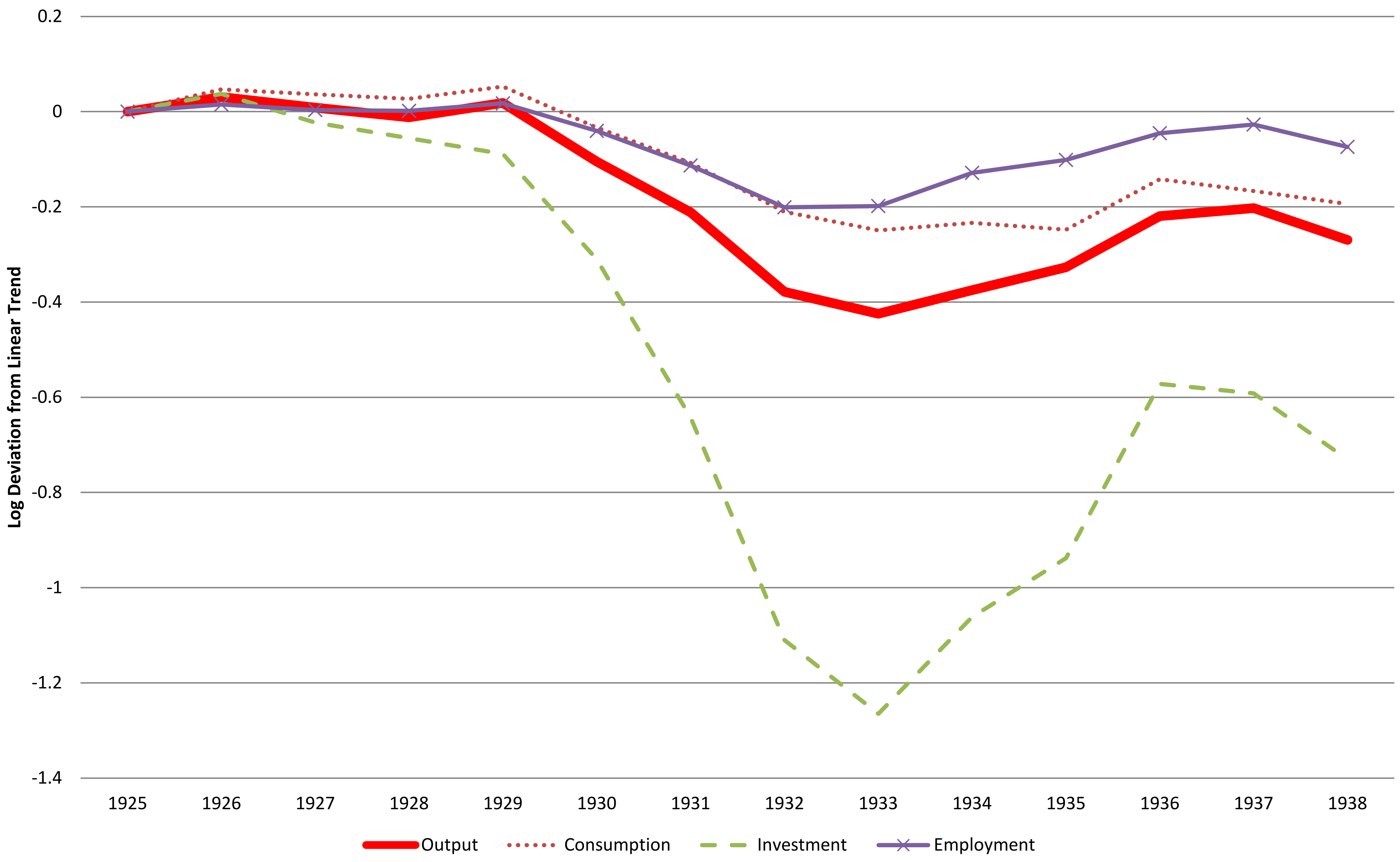


Figure 1b. Europe Business Cycle Data: 1925-1938

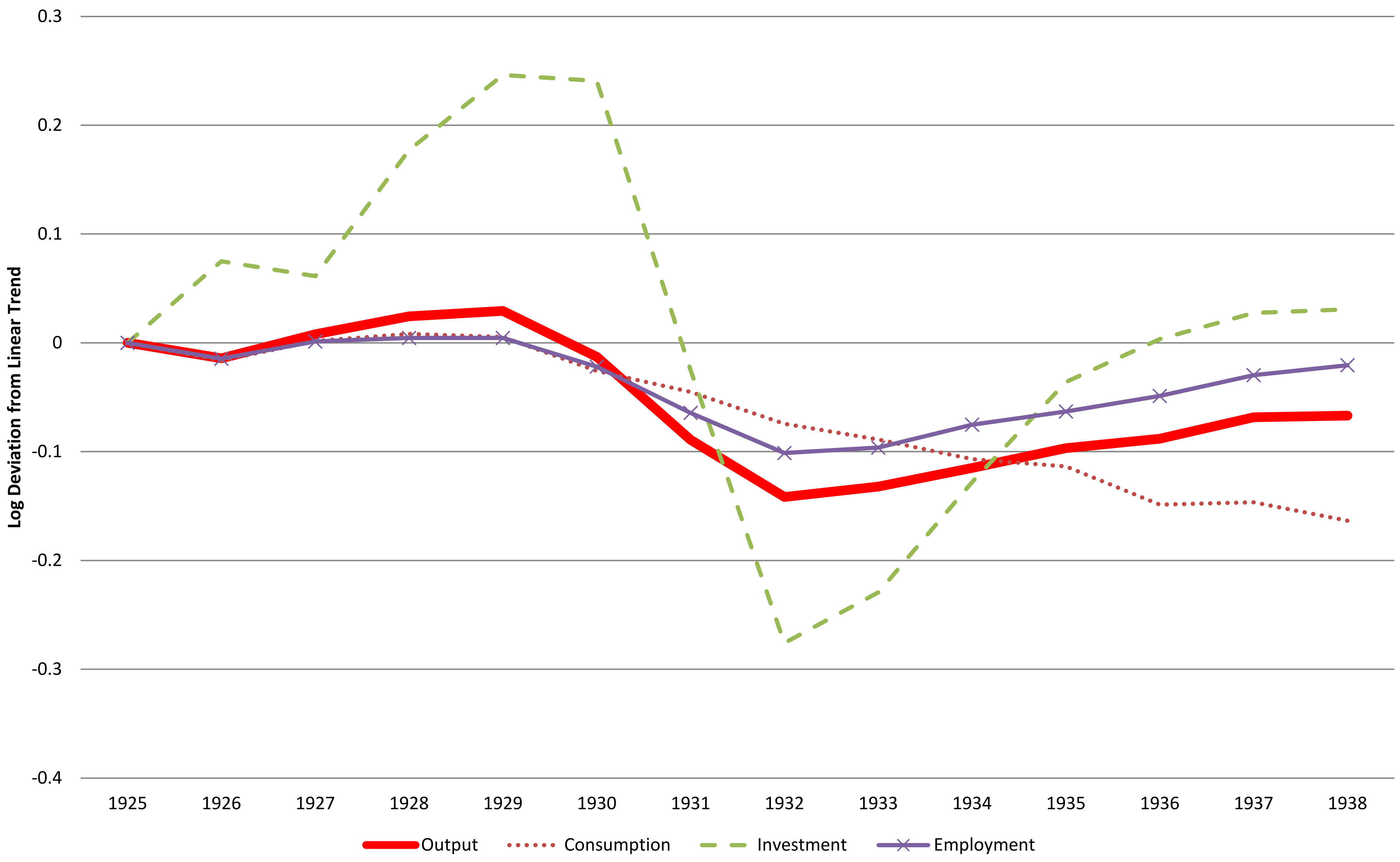
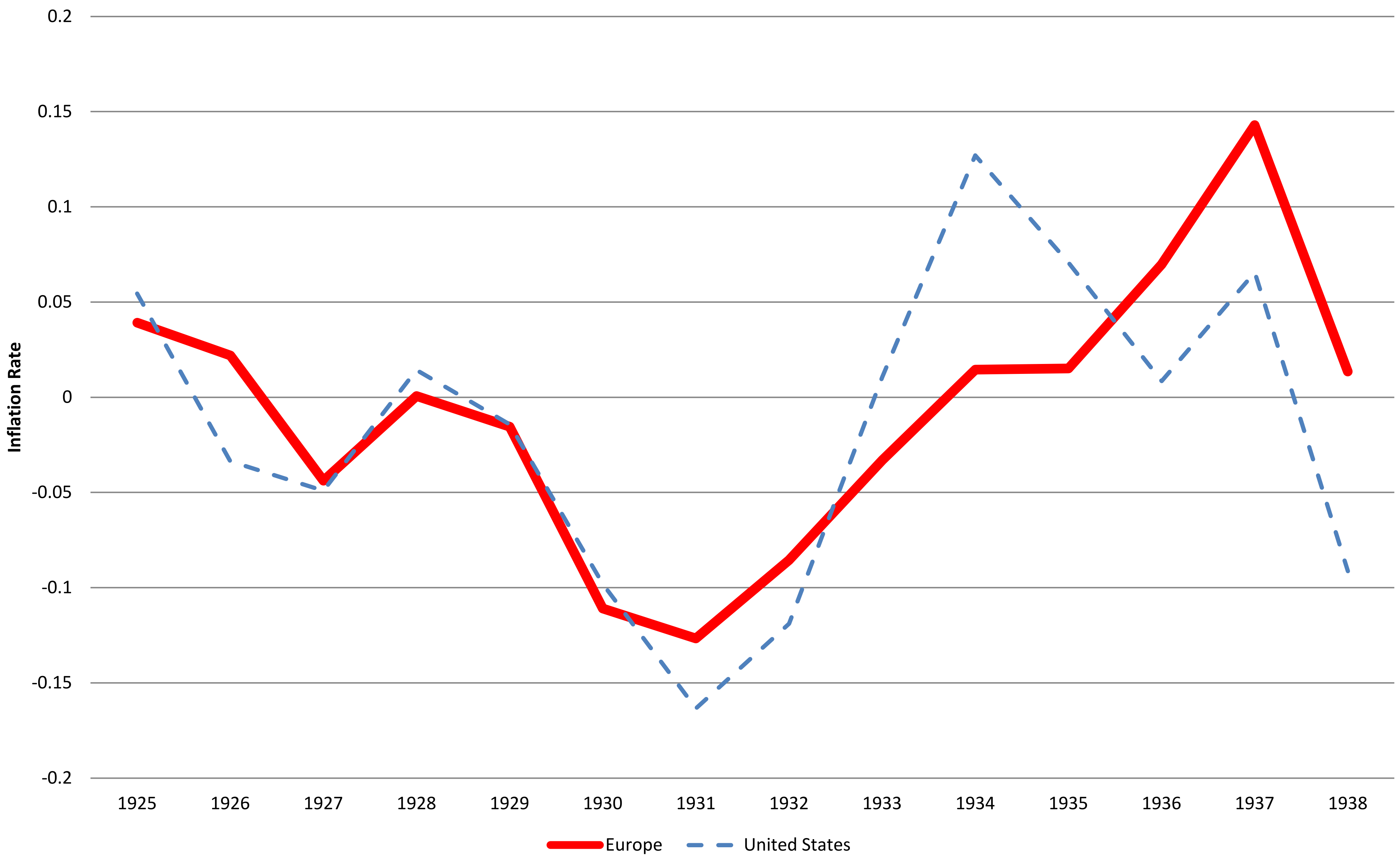


Figure 2. Inflation in US and Europe: 1925-1938



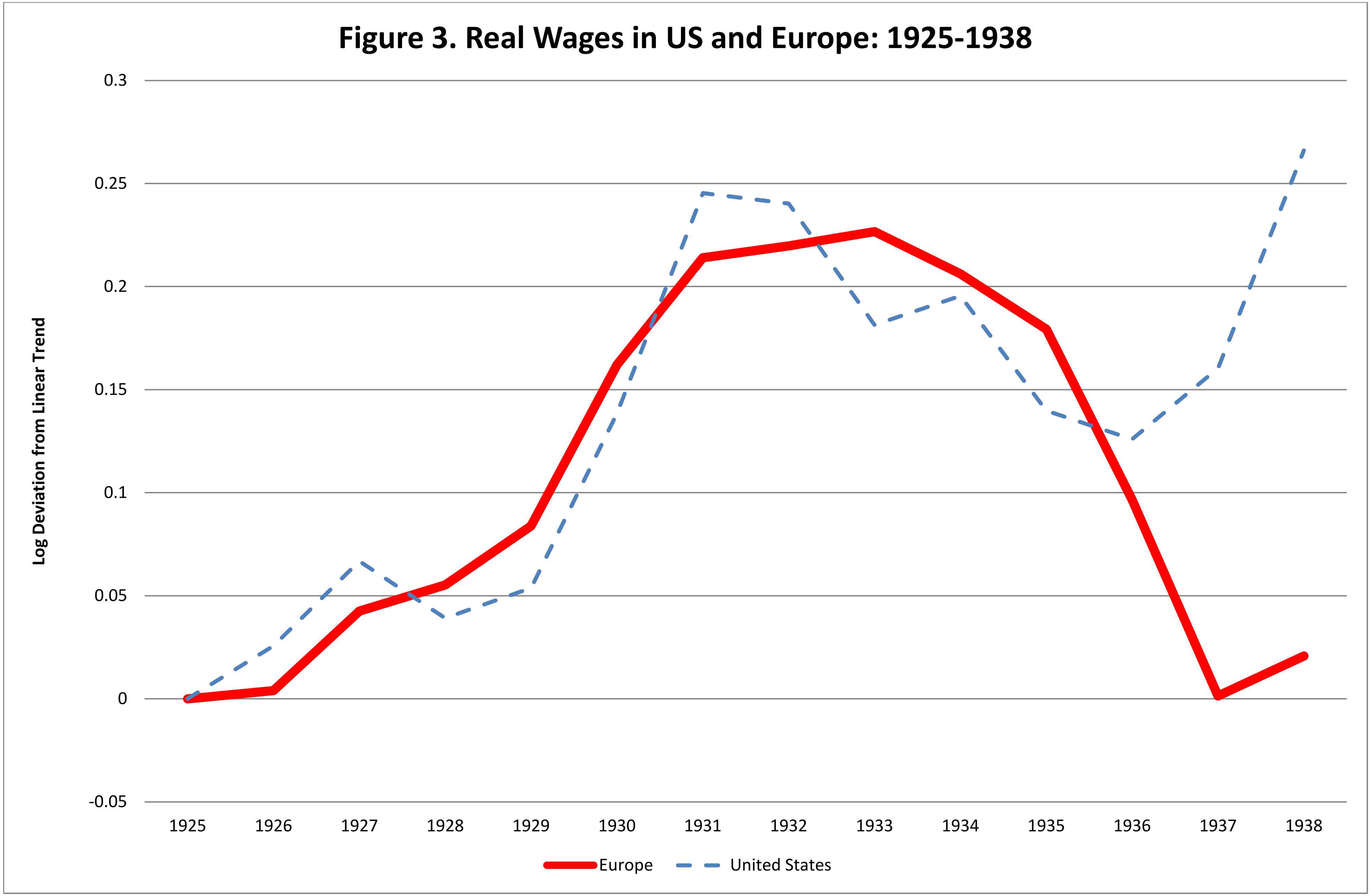


Figure 3. Real Wages in US and Europe: 1925-1938
Log Deviation from Linear Trend
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
Europe
United States

Figure 4. Real Interest Rates in US and Europe: 1925-1938

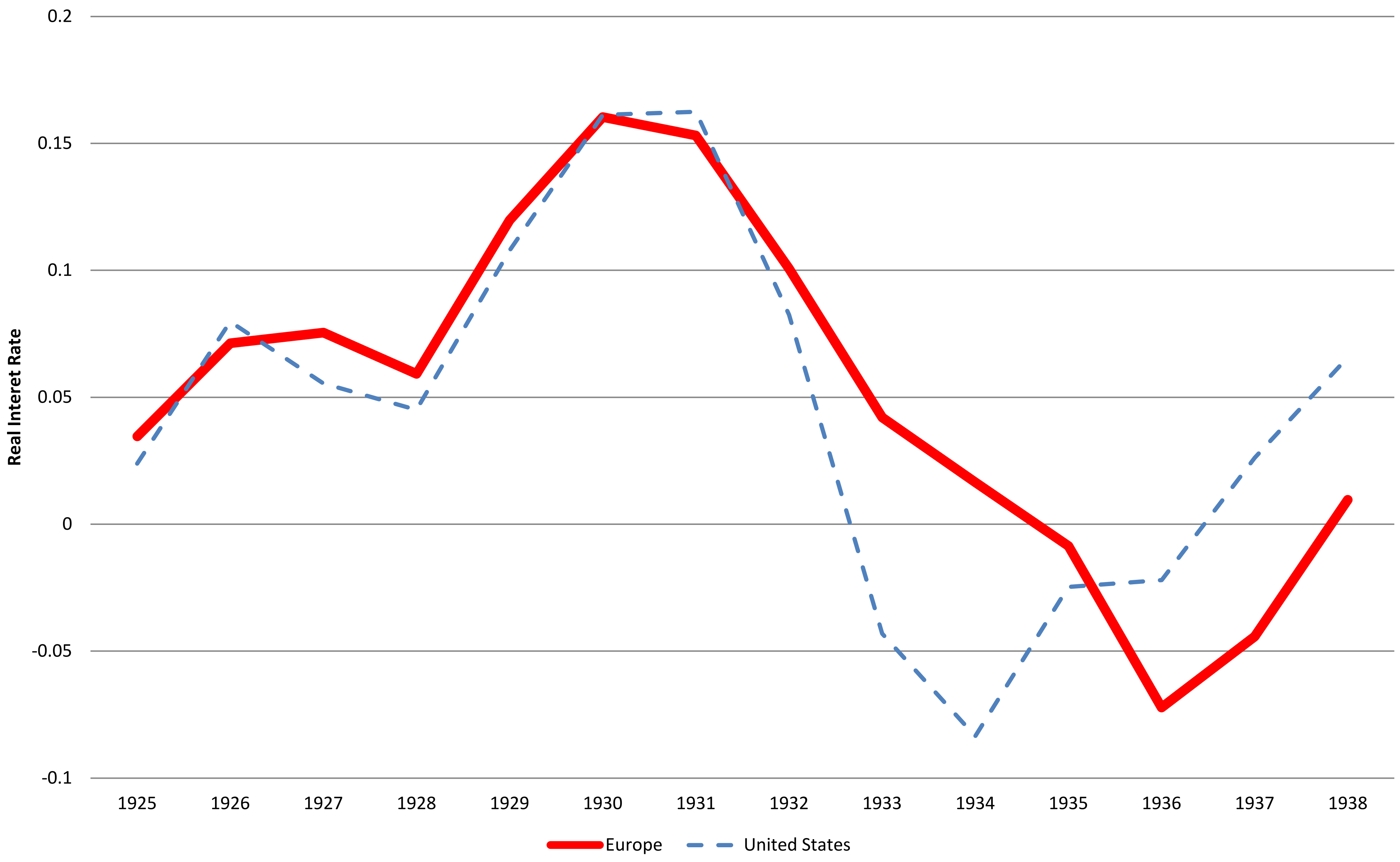
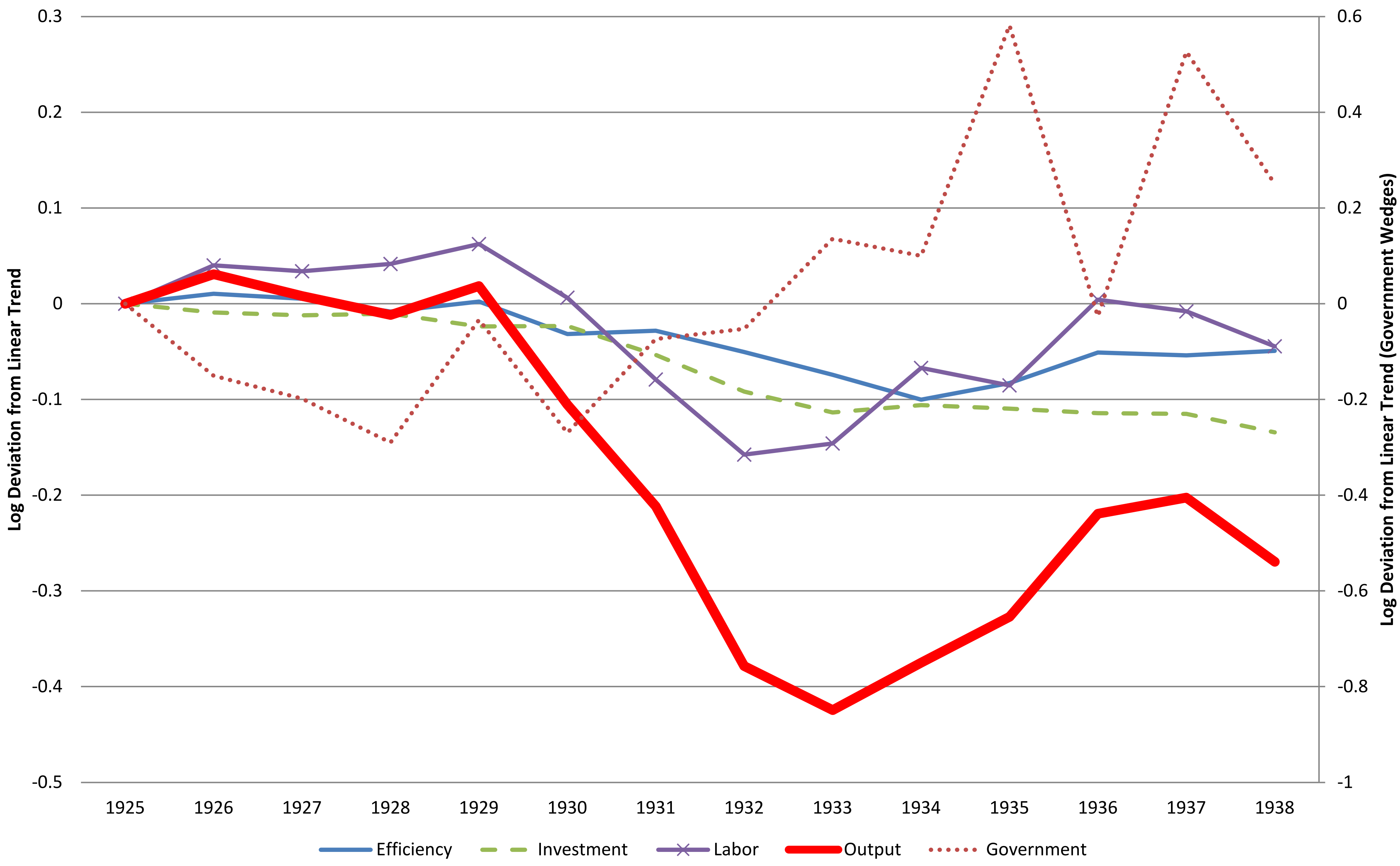


Figure 5a. Wedges: US



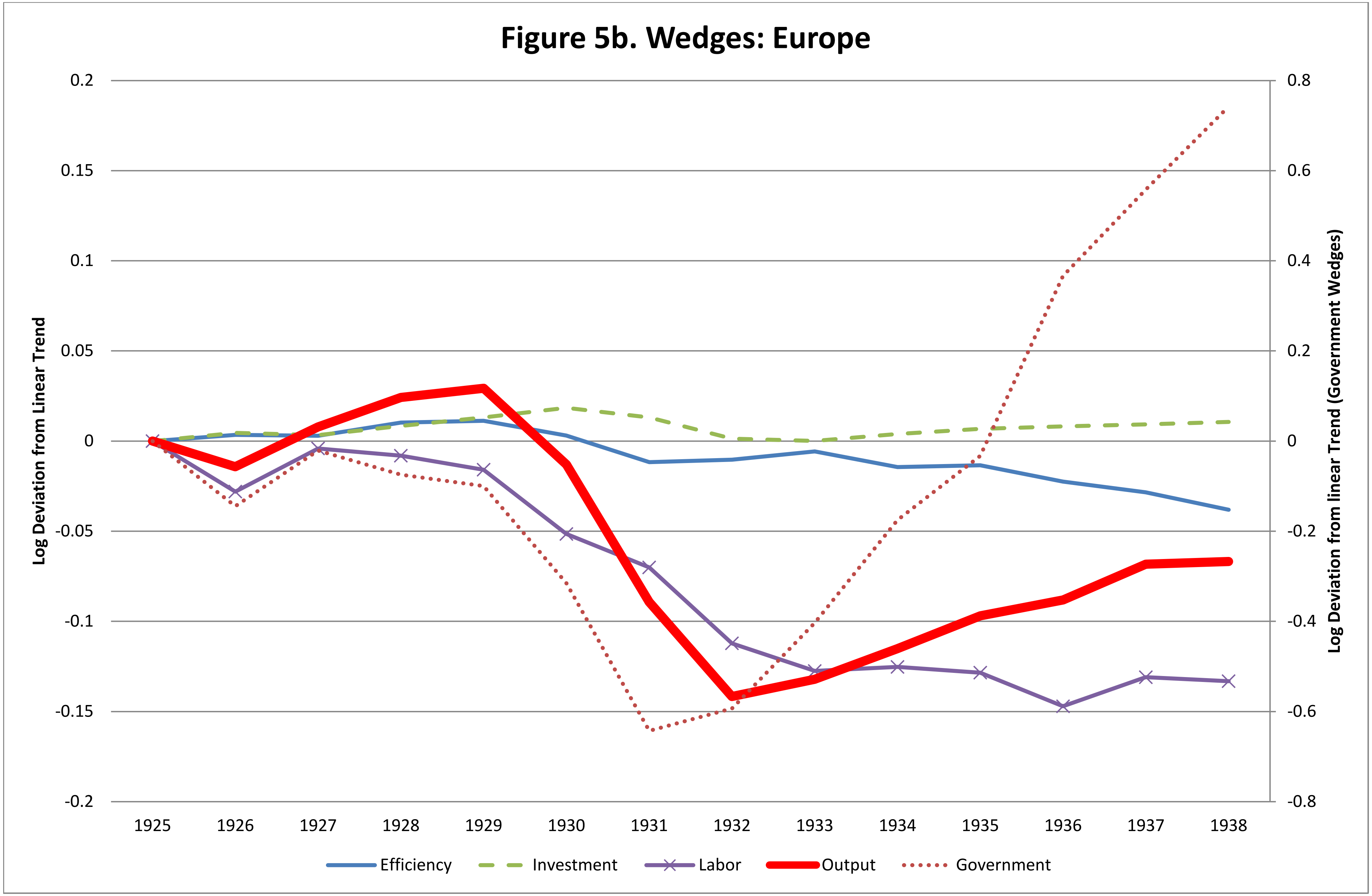


Figure 5b. Wedges: Europe
Log Deviation from Linear Trend
Log Deviation from linear Trend (Government Wedges)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
Efficiency
Investment
Labor
Output
Government

Figure 6a. Simulated Output: US

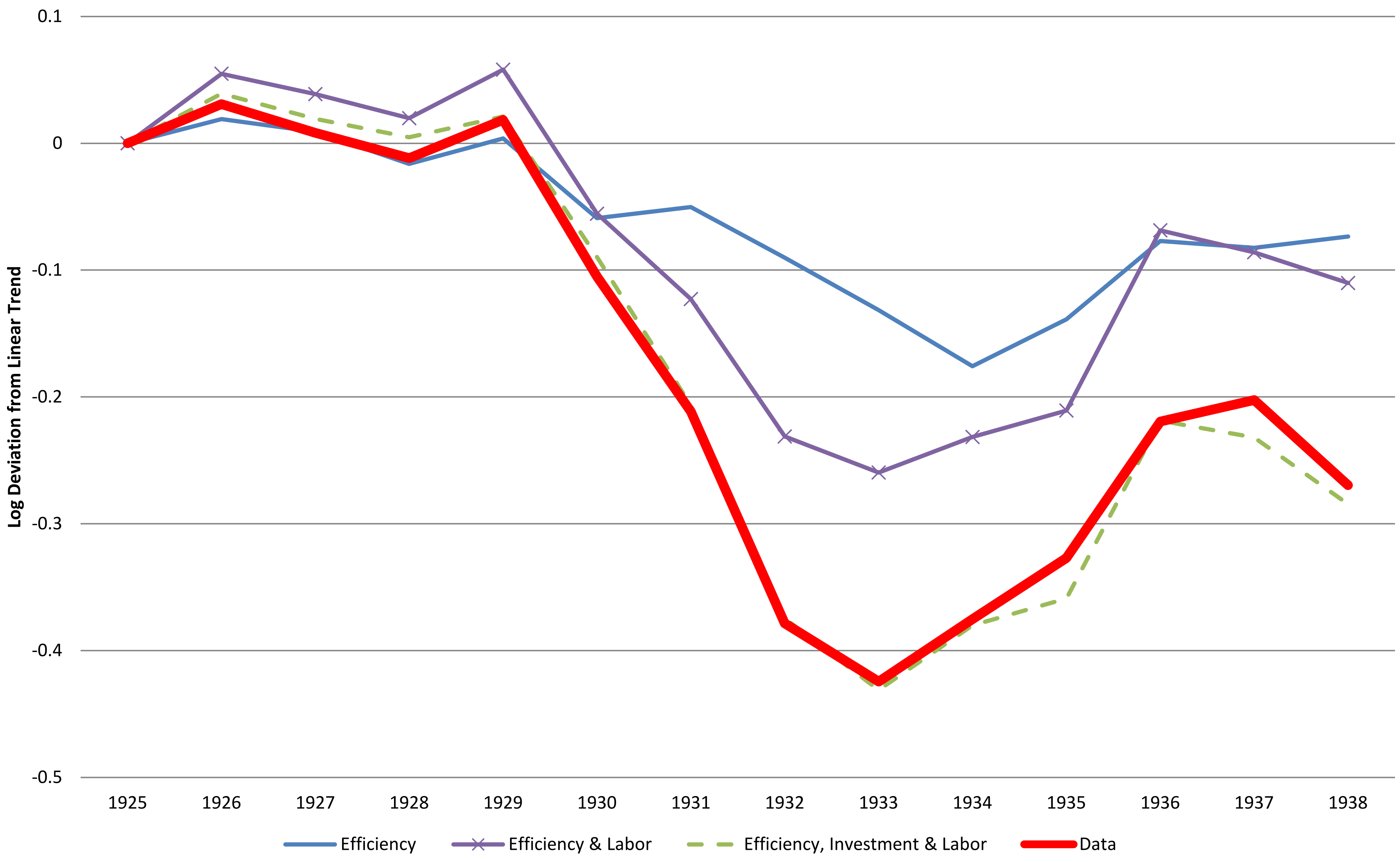


Figure 6b. Simulated Output: Europe

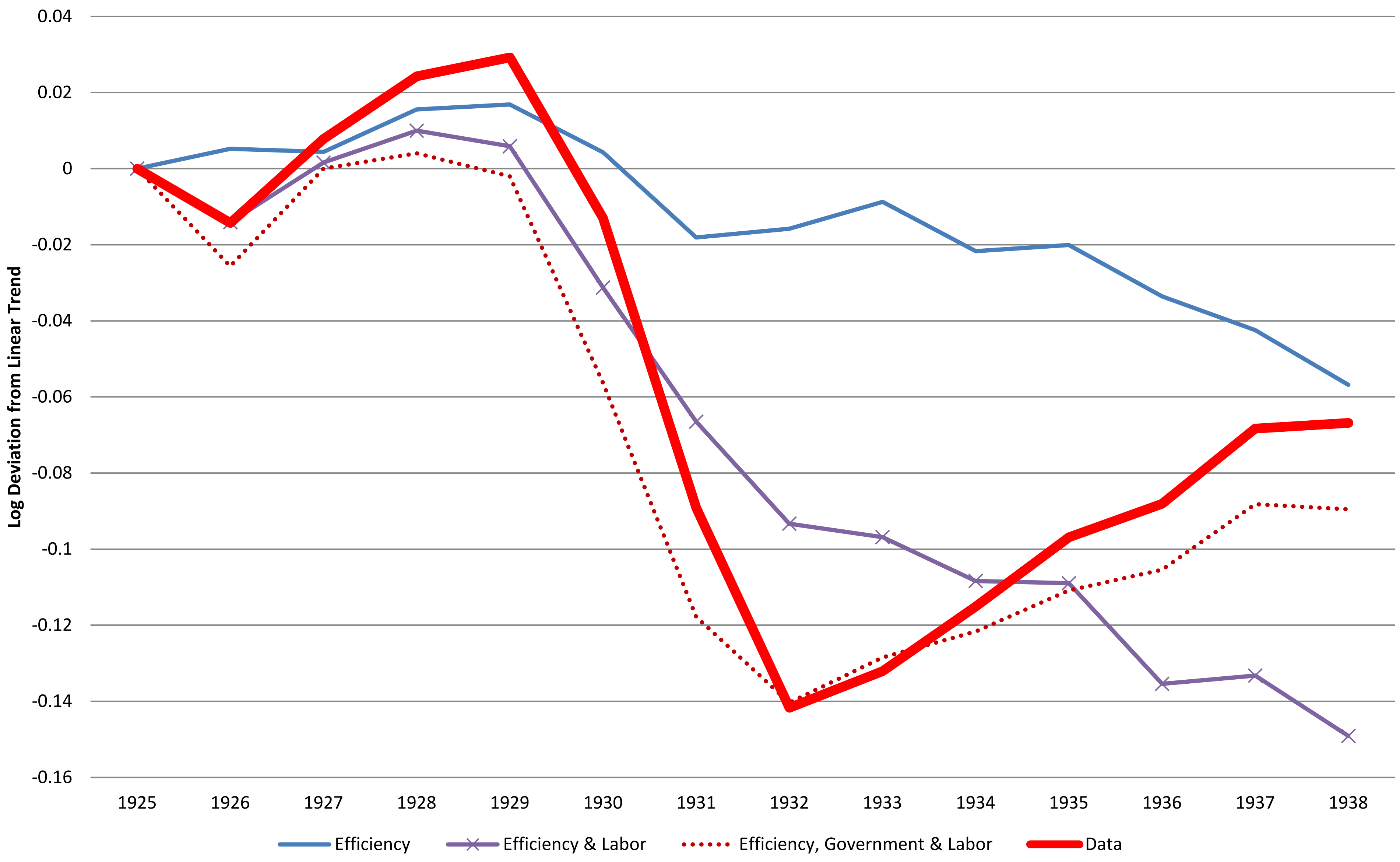
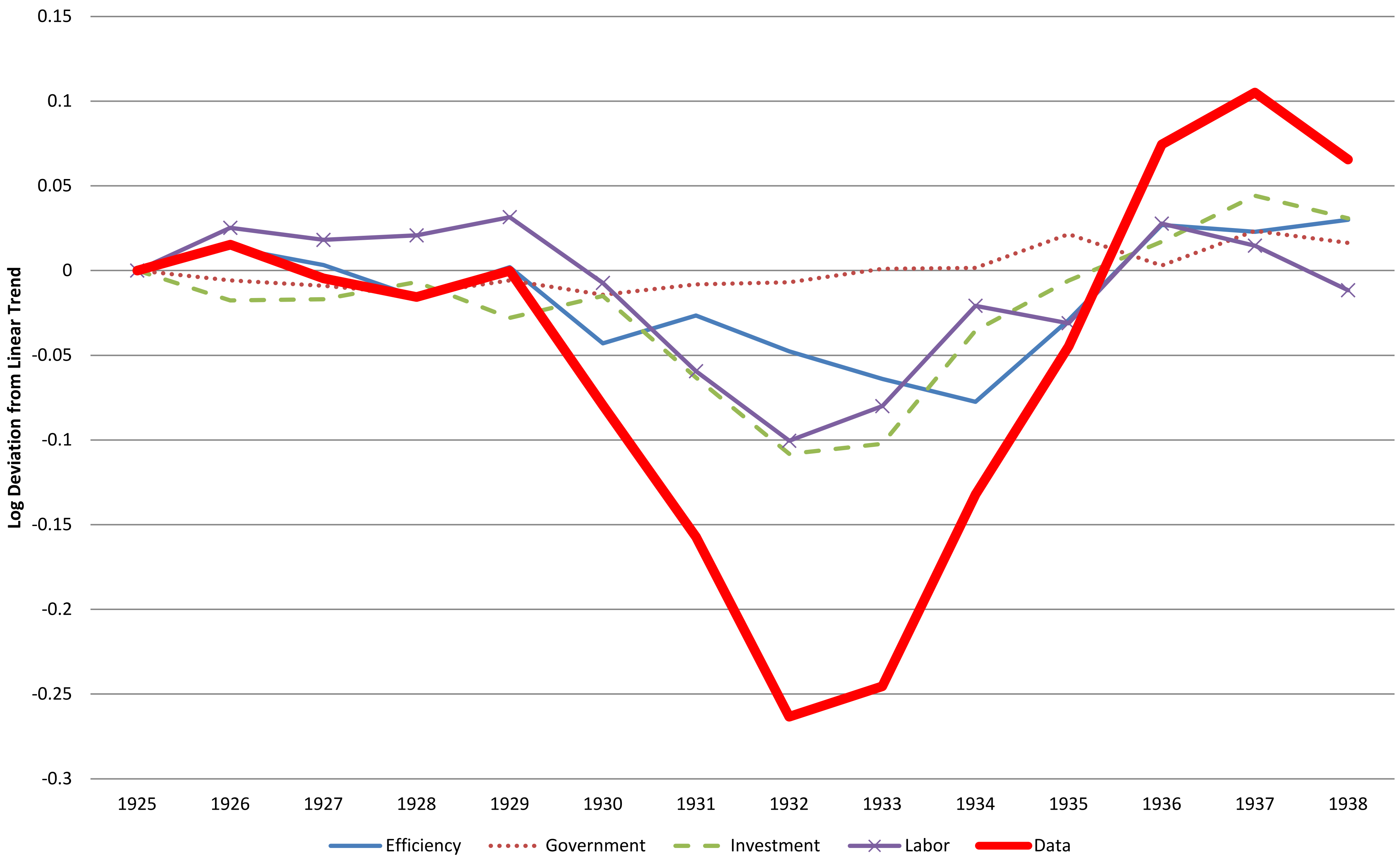


Figure 7a. Simulated Capital Utilization: US



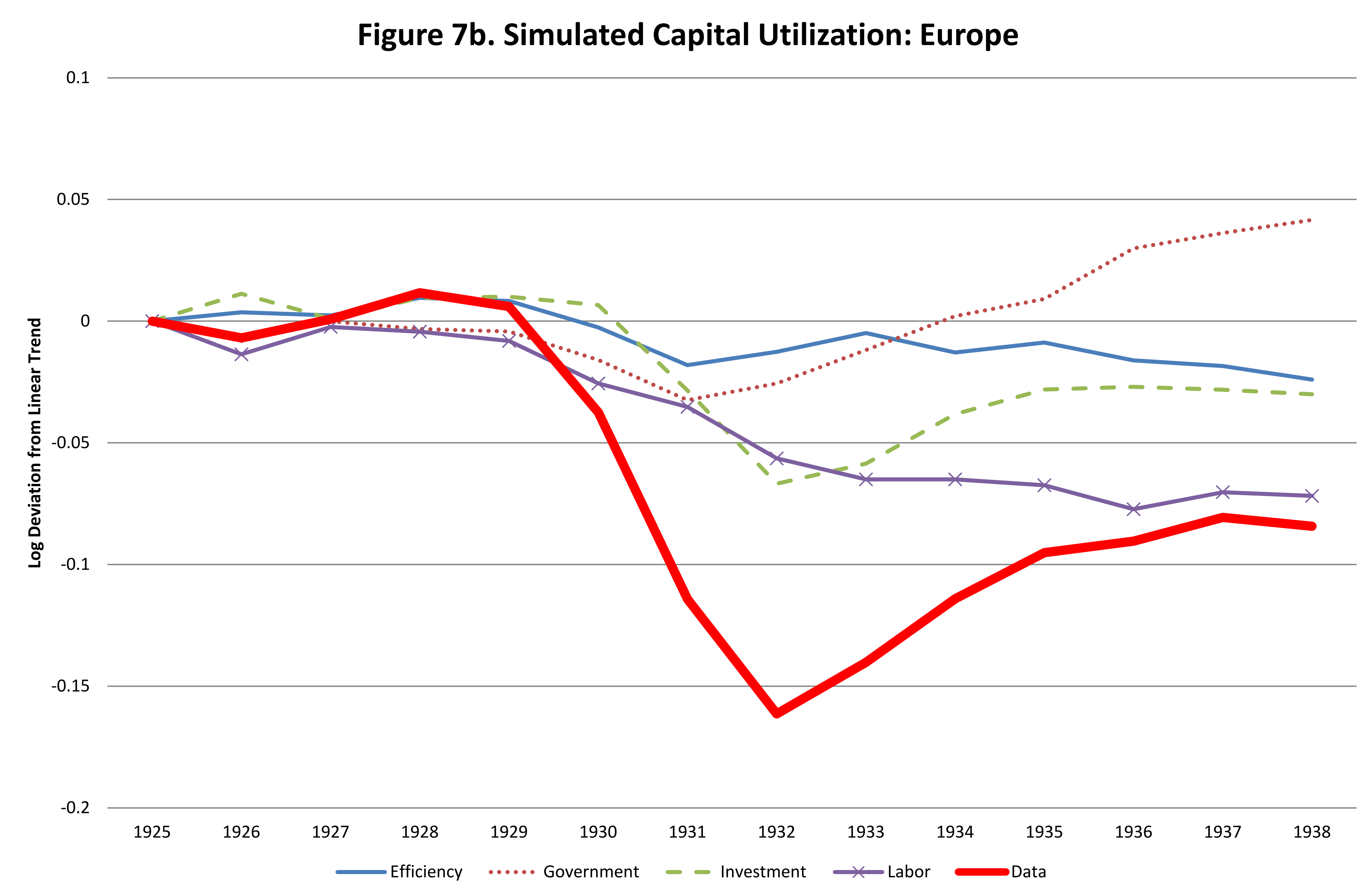


Figure 7b. Simulated Capital Utilization: Europe
Log Deviation from Linear Trend
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
Efficiency
Government
Investment
Labor
Data

Figure 8a. Simulated Labor Utilization: US

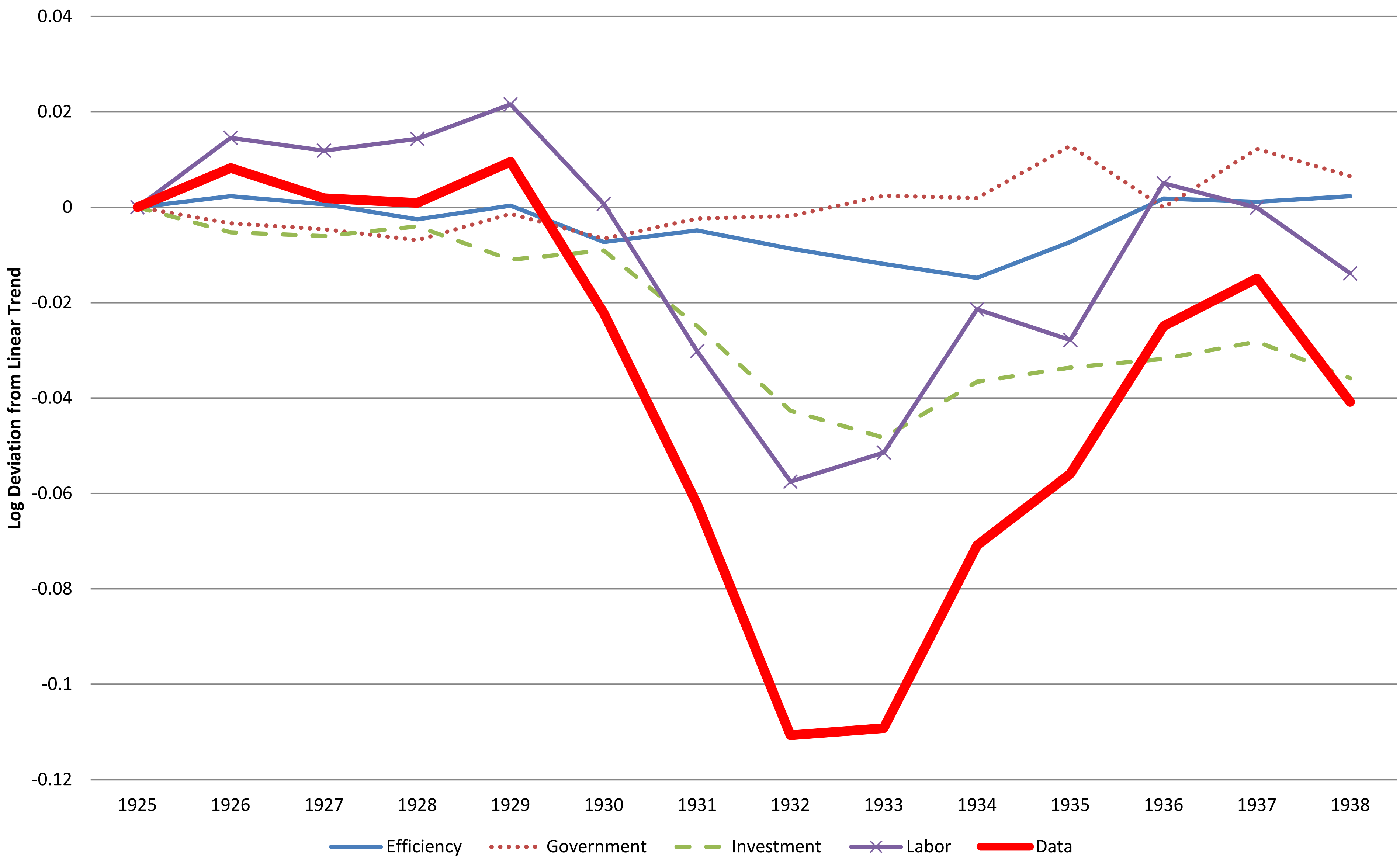


Figure 8b. Simulated Labor Utilization: Europe

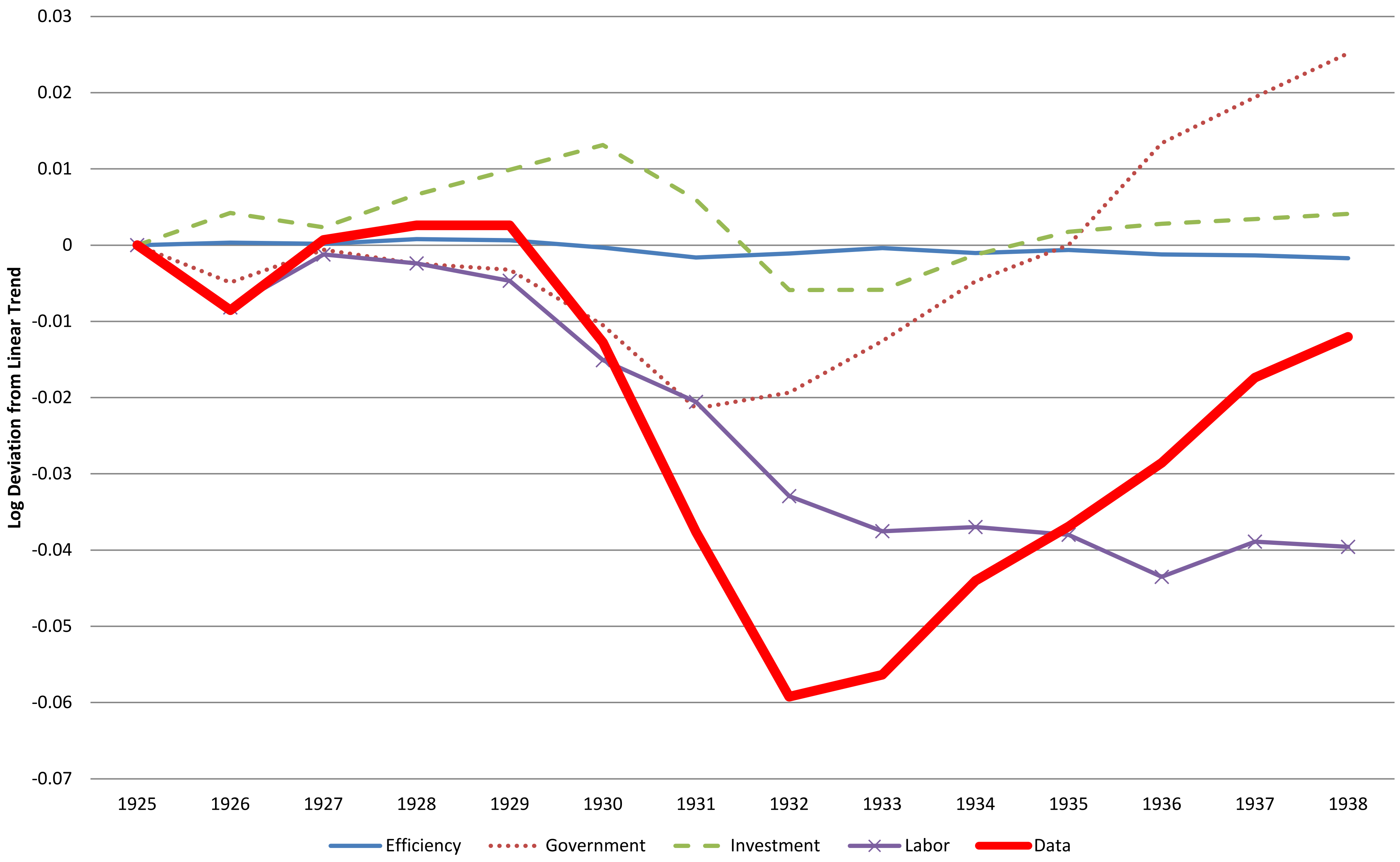


Figure 9. Employment and Hours Worked per Worker: US