Accounting for the International Great Depression: 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 U.S. and Western Europe by applying the business cycle accounting method to a dynamic stochastic general equilibrium model with time-varying production efficiency and factor market distortions. We measure the size of labor and capital market distortions with endogenous factor utilization and their relative importance in accounting for output fluctuation during the interwar period. Our main findings are that labor market distortions accounted for two-thirds of the output drops in both the U.S. and Western Europe, endogenous factor utilization amplified the negative effects of labor market distortions, and government spending played an important role in the recovery from

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the Great Depression in European countries who left the Gold Standard in the early 1930s.

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1 Introduction

In this paper, we analyze the interwar Great Depressions in the U.S. and Western Europe during the 1929-38 period using a variation of the business cycle accounting method a la Chari, Kehoe and McGrattan (CKM 2007). We incorporate endogenous capital utilization which disentangles the fluctuations of capacity utilization from disturbances in productivity efficiency. Doing so, we quantify the importance of labor and capital market distortions and production inefficiencies to offer new insights into the economic performance of Western Europe and the U.S. in the interwar period. We find that labor market distortions are the main sources of the Great Depressions in both the U.S. and Western Europe, and that endogenous capital utilization amplifies their depressing effects in both economies. We also find that increases in government spending played an important role in the recovery from the Great Depression in European countries that left the Gold Standard in the early 1930s while countries that remained in the Gold Standard were hindered from recovery by further deterioration in labor market distortions.

The research on the International Great Depression (IGD) received wide attention after the recent Great Recession of 2008 since the depression of the 1930s was the largest worldwide economic crisis in terms of severity and broadness before the 2008 financial meltdown.[1] Despite eight decades of research on the IGD, there is still little consensus on its source and amplification mechanism. The literature on IGD can be split into two main strands based on their proposed origin. The first strand maintains that the monetary contraction in the United States is at the heart of the Great Depression. Specifically, the U.S. monetary contraction in 1928 aimed to stem the stock

[1] Several studies focus on the differences in the magnitude between the two crises and the responses of policy makers (Almunia, Benetrix, Eichengreen, O'Rourke and Rua 2010, Crafts and Fearon 2010, Grossman and Meissner 2010) while others compare the causes of both crises (Temin 2010, Bordo and James 2009, Bordo and Landon-Lane 2010).

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 (Eichengreen 1992). The literature identified two channels through which worldwide deflation led to the IGD: labor market distortions caused by nominal wage rigidity (Eichengreen and Sachs 1985, Newel and Symons 1988, Bernanke and Carey 1996) and capital market distortions caused by debt deflation and financial crises (Fisher 1933, Bernanke 1983, Bernanke and James 1991).

The second strand of literature on the IGD turns to non-monetary shocks. Cole and Ohanian (1999) show that total factor productivity (TFP) alone can account for 40 percent of the decline in output between 1929 and 1933 in the U.S. by using a standard dynamic stochastic general equilibrium (DSGE) neoclassical growth model.[2] 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.[3] Cole, Ohanian and Leung (2005) further study the IGD in a sample of 17 countries using a DSGE model with a signal extraction problem of monetary and productivity shocks and find that productivity shocks explain two-thirds of the drop in output between 1929 and 1933.[4] Cole and Ohanian (2004) and Christiano, Motto and Rostagno (2004) construct DSGE models with labor bargaining and show that the cartelization policies introduced after 1933 in the U.S. which increased the bargaining power of workers contributed to the slow recovery. Cole and Ohanian (2013) con-

[2]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.

[3]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 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. Perri and Quadrini (2002) show that trade restrictions and real wage rigidities are sufficient to account for the Great Depression in Italy without changes in TFP.

[4]Ritschl and Woitek (2000) and Ahmadi and Ritschl (2009) use VAR and FAVAR models and also find that monetary policy shocks play only a modest role in explaining the decline of real activities in the U.S.

struct a monetary DSGE model with productivity shocks, monetary shocks and cartelization policies to assess the performance of 18 countries during the IGD and find that cartelization policies account for a substantial portion of the Depressions in the countries that adopted significant anti-competitive policies.

In order to analyze the IGD, we collect data of output, consumption, investment and total hours worked for Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, the UK and the U.S.[5] To the best of our knowledge, our paper is the first to construct such an extensive dataset for the interwar period and conduct business cycle accounting for the IGD.[6] The business cycle accounting method can be described as follows. First, a competitive equilibrium in a prototype neoclassical growth model is defined. Next, "wedges" in equilibrium conditions, namely efficiency, government, investment, and labor wedges, are computed using macroeconomic data.[7] Finally, the model is simulated to quantify the impact of each wedge on the business cycle.

In this paper we conduct the business cycle accounting exercise within a closed-economy framework focusing on the roles played by distortions in domestic markets. This does not mean that we ignore the importance of transmissions of shocks across countries during this period. The strength of the business cycle accounting method is that it does not limit the analysis to selected shocks but instead it identifies the channels through which the important disturbances operate.[8] We believe that this method complements existing studies such as Cole, Ohanian and Leung (2005) and Cole and

[5] One of the challenges for business cycle analysis of the IGD is data availability during the interwar period. For instance, Cole and Ohanian (2013) had to drop 11 out of 18 countries from their sample for the quantitative analysis due to the availability of consistent employment and capital stock data. Among the data we use, total hours worked, especially hours worked per worker, is the most difficult to obtain.

[6] The original CKM (2007) uses business cycle accounting to study the U.S. Great Depression. There are also recent studies such as Pensieroso (2011) and Bridji (2013) which use the business cycle accounting method to investigate the Great Depressions in Belgium and France individually.

[7] Efficiency wedges are disturbances to the production process, government wedges are disturbances in the resources available to private agents, investment wedges are distortions in the capital market, and labor wedges are distortions in the labor market.

[8] In order to explicitly understand the roles played by international capital markets during the IGD, we need an open economy framework such as the capital flow accounting method of Ohanian, Restrepo-Echavarria and Wright (2018).

Ohanian (2013) by painting a broader picture of the IGD.

We make one important modification to the original CKM (2007) model which is to disentangle the fluctuation of factor utilization from disturbances in production efficiency. We do so by incorporating endogenous capital utilization following Greenwood, Hercowitz and Huffman (1988).[9] This is important because a model with constant factor utilization is likely to overstate the fluctuation of production efficiency and understate the effects of other distortions. Within our model distortions in the factor markets affect output not only through the quantity of inputs, but also through their effects on capital utilization giving them a fairer shot in accounting for the IGD.

Our quantitative results offer both evaluation of existing theories in the literature as well as new insights into the initial output decline and the recovery phase of the IGD. In terms of the initial phase of the IGD, we find that labor wedges are important in accounting for the output drop in the U.S. and Europe. This supports the empirical results pointing to labor market rigidities and the deflationary pressure as the main culprits of the IGD. It also shows that the original conclusion of CKM (2007) that models with frictions manifested primarily as investment wedges cannot account for the U.S. Great Depression holds for Europe as well. Our finding new to the literature is that endogenous capital utilization accounts for a significant amount of the fluctuation in total factor productivity which dwarfs efficiency wedges and amplifies the depressing effects of labor wedges. For the recovery phase, we find that in the U.S. efficiency wedges alone would have led to a much faster recovery while labor wedges prevented that. This result is consistent with CKM (2007) even with endogenous capital utilization and supports the finding of Cole and Ohanian (1999, 2004, 2013) that government policies increasing labor bargaining power hindered U.S. recovery. Furthermore, the improvement in government wedges contributed to the recovery of the countries who left the Gold Standard during the early 1930s while the further deterioration in labor wedges hindered the recovery of the countries that remained on the Gold Standard till the mid-1930s. We also find that while the IGD was mainly driven by labor wedges, the recent Great Recession was mainly driven by efficiency wedges.

The remainder of the paper is constructed as follows. In section 2, we re-

[9] CKM (2007) provides a sensitivity analysis assuming hours worked per worker as the utilization rate of capital. Cavalcanti et al (2008) incorporates endogenous capital utilization into the business cycle accounting framework as an observable variable to directly compute the investment wedges in Argentina.

view the literature on labor and capital 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 The International Great Depression and Market Distortions

2.1 Business Cycle Features in the Interwar Period

The Great Depression has been increasingly considered a global phenomenon not only because it affected many countries, but also because of the global character of its transmission mechanism. In order to discuss the economic situation in the world during the interwar period, we construct a unique data set of output, consumption, investment, and labor for 12 Western European countries and compare it to the U.S. economy. Due to data availability, the sample European countries are limited to Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, and the UK.[10]

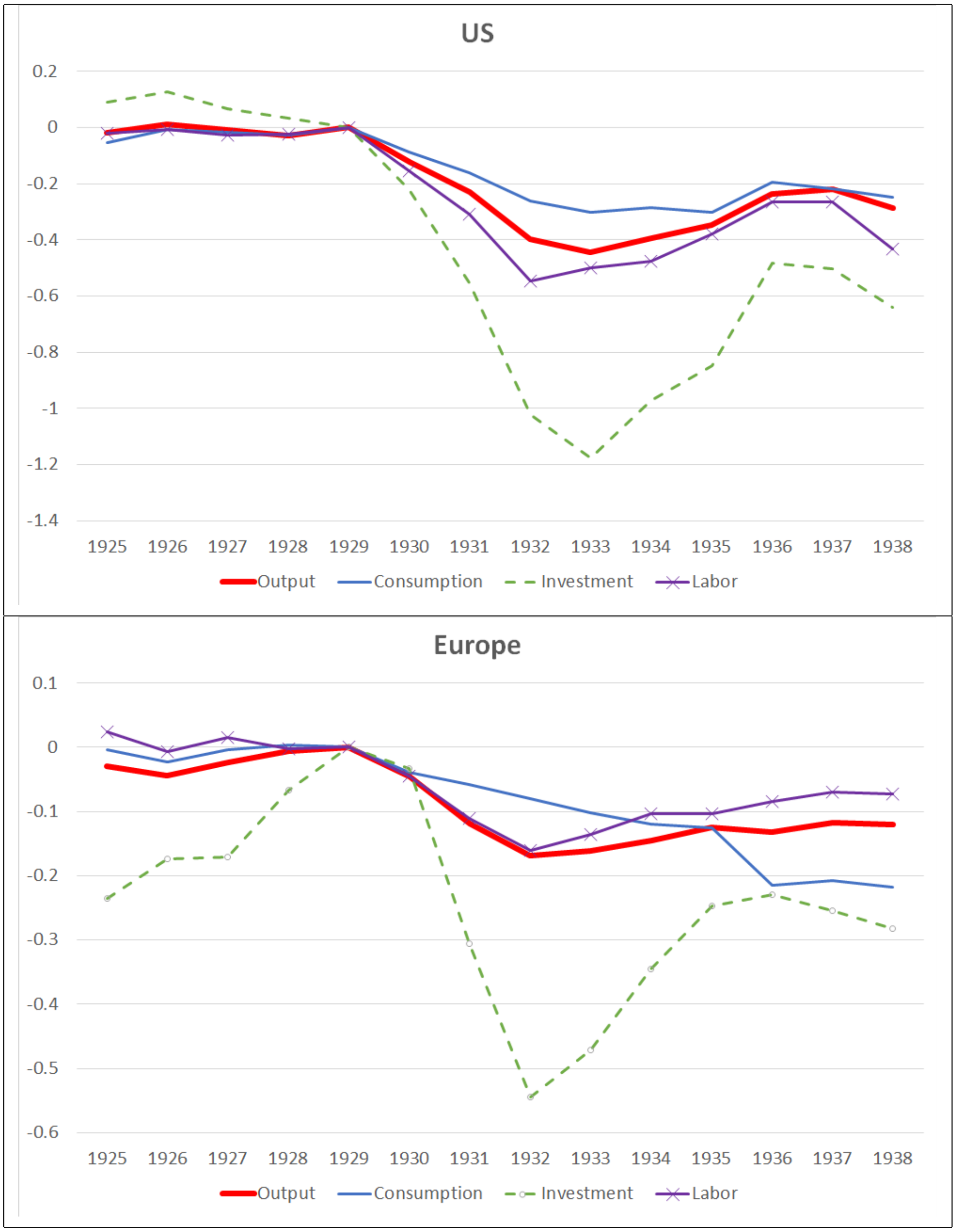
Figure 1 presents the log deviations of detrended per capita output, consumption, investment and labor in the U.S. and Europe from their 1929 level.[11] For Europe we present the population weighted average. In the U.S., output fell dramatically by approximately 0.443 in terms of detrended log differences (or 35.8%) between 1929 and 1933. Consumption, investment and labor all collapsed along with output by 0.302, 1.176 and 0.498 (or 26.1%, 69.2%, and 39.2% respectively). All variables show recovery after 1933, however, none of them return to their 1929 level by 1938. In Europe, output hits

[10] Output, consumption, investment and labor represent GDP, private consumption, domestic gross capital formation and total hours worked respectively. One of the challenges for business cycle analysis of the IGD is data availability during the interwar period. For instance, Cole and Ohanian (2013) had to drop 11 out of 18 countries from their sample for the quantitative analysis due to the availability of consistent employment and capital stock data. Among the data we use, consistent data of total hours worked, especially hours worked per worker, is the most difficult to obtain and we make best use of what is available. The sources of the data series are listed in the data appendix.

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

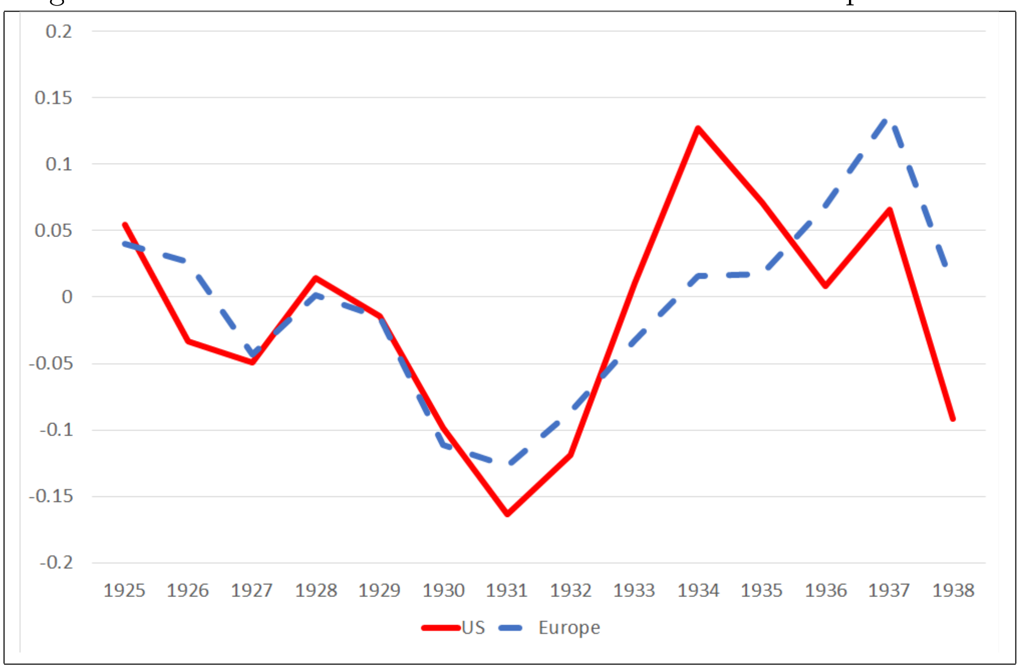
its trough in 1932 where the detrended log difference between the 1929 and 1932 level is 0.169 (or 15.6%). Consumption, investment and labor also fall by 0.079, 0.545 and 0.161 (or 7.6%, 42.0%, and 14.8% respectively) during this period. While output, investment and labor show recovery after 1932, consumption keeps falling throughout the 1930s.

Figure 1. Interwar Business Cycle Data in the U.S. and Europe



Numerous research (Choudhri and Kochin 1980, Eichengreen and Sachs 1985, Temin 1989, Newel and Symons 1988, Bernanke and James 1991, Eichengreen 1992, Bernanke and Carey 1996) concluded that the IGD had its roots in the interwar Gold Standard (often called gold exchange standard) as a transmission mechanism of deflationary policies and argue that labor and capital markets operated as channels through which worldwide deflation led to output drops. Figure 2 plots the inflation rate in the U.S. and Europe showing that they were facing substantial drops in prices during the IGD.[12] While both economies did indeed experience massive deflationary pressures in the early1930s, the inflation rate turned positive by the mid-1930s. In the following sub-sections, we will review the literature focusing on distortions in factor markets.

Figure 2. Inflation in Wholesale Prices in the U.S. and Europe



2.2 The Capital Market

In January 1928, in response to gold outflows to France and to curb the stock market boom, the U.S. chose to embark a contractionary monetary policy (Hamilton 1987). The policy discount rates increased from 3.8 percent in 1927 to 4.5 percent in 1928 and further to 5.2 percent in 1929. In order to

[12]The European inflation rate is the sum of individual inflation rates weighted by the output shares of each country.

maintain the gold parity, other countries of the Gold Standard followed the U.S. contractionary monetary policy.

The role played by deflation in the capital market depends on whether it was well anticipated or not. When the deflation is anticipated, it will increase the ex-ante real interest rate and depress aggregate demand if nominal interest rates did not fully absorb the deflationary shock due to perhaps passive monetary policy (Friedman and Schwartz 1963) and/or the zero lower bound of nominal interest rates (Eggertson 2012).[13] On the other hand, when the deflation is unanticipated, the ex-post real interest rate turns out to be higher than the ex-ante rate, which creates difficulties for debtors to honor their debts leading to bankruptcies, deterioration in bank balance sheets, bank runs and bank failures (Bernanke 1983, Hamilton 1987, Bernanke and James 1991).[14]

Figure 3 presents the real interest rates in the U.S. and Western Europe computed as the nominal policy discount rate minus the subsequent year's realized inflation rate.[15] In both economies real interest rates increased dramatically in the late 1920s reflecting the deflation during this period. After peaking in 1930, the real interest rates fell dramatically and returned to their 1925 levels by 1933 whereas it took much longer for investment and consumption to recover in both economies as shown in Figure 1. Therefore, whether the deflation was anticipated or not, it seems difficult to claim that

[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, the U.S., France and Germany.

[14] There is a substantial body of literature analyzing the causes of the banking crisis during the Great Depression. 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 such as Grossman (1994), Mitchener (2005), Mitchener (2007), Richardson and Troost (2009), Carlson and Mitchener (2009).

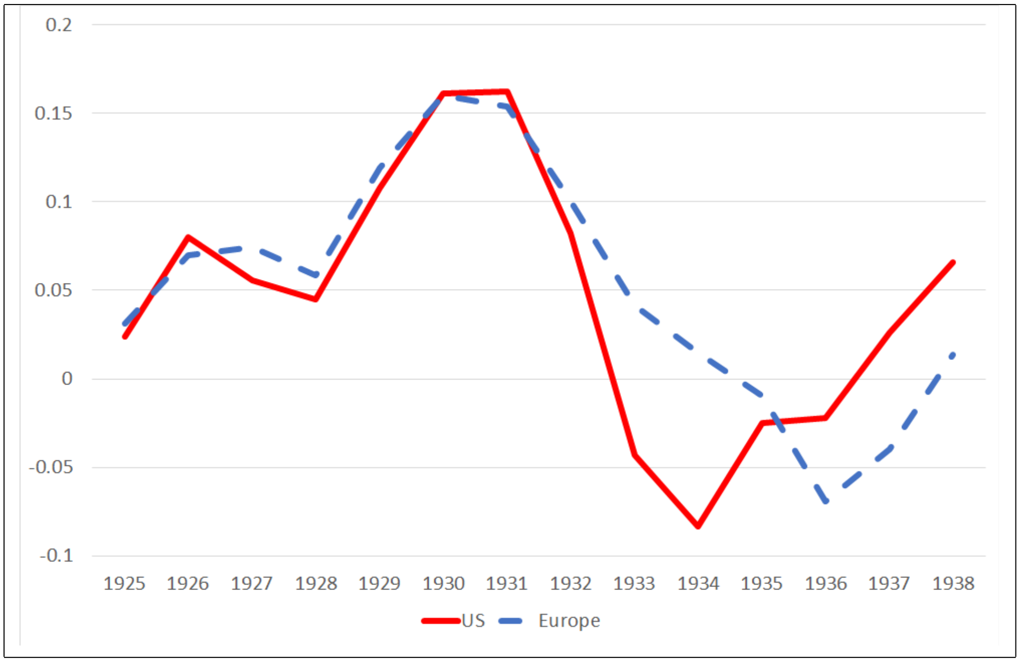
[15] For instance the real interest rate q in year t is

$$q_t = R_t - (\ln P_{t+1} - \ln P_t)$$

where R is the nominal policy discount rate and P is the wholesale price index. The real interest rate for Europe is an average of individual country rates weighted by the output shares of each country.

the deflation caused the real interest rates to depress the aggregate demand during the IGD.

Figure 3. Real Interest Rates in the U.S. and Europe



Since the real interest rate presented above is the riskless policy rate, it may not exactly represent the cost of capital. Bernanke (1983) focuses on the cost of credit intermediation between lenders and certain classes of borrowers, which includes screening, monitoring, and accounting costs, as well as the expected losses inflicted by bad borrowers, as a key indicator of financial distress during the IGD. Hamilton (1987) shows that the U.S. credit spread between Baa corporate bonds and long term government bonds rates peaked in 1932 and did not return to its 1925 level until 1936. This suggests that although the real interest rate was falling the cost of credit intermediation was rising during the early 1930s and remained higher than the initial level until later. CKM (2007) shows that credit market frictions in a dynamic stochastic general equilibrium model of Bernanke, Gertler and Gilchrist (1999) operate as distortionary taxes on investment, i.e., investment wedges.

Temin (1976) considers pessimism as the source of the Great Depression and claims that the decline in money stock was due to the endogenous decrease in the demand for money during the U.S. Great Depression. Harrison and Weder (2006) take this idea further and construct a dynamic stochastic general equilibrium model with sunspot shocks estimated as the non-fundamental shocks to the credit spread between Baa and Aaa bonds. They find that pessimistic animal spirits which cause a collapse in investment demand can quantitatively account for the depth of the U.S. Great Depression and its slow recovery. We show in the appendix that expectational shocks to future output operate as distortionary taxes on capital income, i.e., investment wedges.

Next, we focus on the circulation of money. Table 1 presents the growth rates of money during the IGD.[16] This table shows that the decline in money circulation in Germany and the U.S. experienced a larger drop in money circulation than in the other countries. In the U.S., the waves of bank failures beginning in late 1930 led to the nation-wide bank closure by President Roosevelt in March 1933.[17] Friedman and Schwartz (1963) claims that the banking crisis in the U.S. led to a fall in the supply of money, which in turn reduced lending and output.[18] In Europe, countries also experienced banking crises, though the banking system was not disrupted as severely as in the U.S.[19] The exception is Germany which experienced a 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.[20]

[16] We define money as the sum of central bank issues, deposit in commercial banks and deposit in savings banks, which corresponds to M2.

[17] 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.

[18] Temin (1976) argues that the pessimistic expectations of private agents led to the collapse in aggregate demand and that the decline in money stock was due to the endogenous decrease in the demand for money during the U.S. Great Depression.

[19] 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).

[20] Austria was the first one to experience a banking crisis which peaked in May 1931 when its largest deposit bank Credit-Anstalt failed. Even though the financial crisis in Germany 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).

Table 1. The Growth Rate of Money Supply

	1929	1930	1931	1932	1933
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

Bernanke and James (1991) find a significant negative effect of banking crisis on industrial output on a sample of 24 countries in 1930-36. Calomiris and Mason (2003b) find that contractions in loan supply induced by bank distress played an important role in U.S. state level income growth during the Great Depression. In context of business cycle accounting, Brinca, Chari, Kehoe and McGrattan (2015) shows that a credit crunch in the form of a tightening of borrowing constraints on firms with heterogeneous productivity levels can be mapped into efficiency, investment and labor wedges.

2.3 The Labor Market

The interwar period presents a break-up from pre-1914 labor markets in the US and Europe which were characterized by little or no welfare policies and very little unionization (Ritschl and Strausmann 2010, Feinstein et al. 2008). Post WWI period witnessed a rise of social institutions promoting welfare policies and unemployment benefits, increase in unionization, and collective bargaining (Eichengreen and Hatton 1988, Cole and Ohanian 2013).

In the U.S., several labor market policies were introduced by Presidents Hoover and Roosevelt during the Great Depression. In 1929 Hoover introduced an industrial labor program which demanded employers to fix or raise nominal wages and share work among employees in return for protection from union demands (Ohanian 2009). The subsequent New Deal labor policies of Roosevelt included the National Industrial Recovery Act (NIRA) introduced in 1933 which guaranteed the right of workers to organize trade unions. The National Recovery Administration codes included fixed prices, minimum wages, maximum hours and covered over 80 percent of private non-agricultural employees. The National Labor Relations Acts (NLRA) from 1935 gave even more collective bargaining power to unions than had the NIRA (Hatton and Thomas 2010).

The situation in Europe during the IGD differed across the countries, with some of them pursuing direct government interventions into the labor market, and some of them increasing labor market protection. In Germany, labor market policies in 1933-35 involved direct government interventions consisting of reducing female labor-force participation, migration restrictions into urban areas as well as into mining, metallurgy, construction, brickwork and railway construction, and the replacement of workers younger than 25 with older heads of families (Silverman 1988). In Italy, the Fascist government was also actively intervening into the labor market which involved nominal wage reductions followed by a 40 hour work week restriction in the end of 1934, and restriction on female and teenage labor market participation (Toniolo and Piva 1988, Giordano, Piga and Travato 2013). In Belgium, the unemployment insurance substantially increased in the interwar period and by 1937, 66 percent of industrial workers were covered (Goossens, Peeters and Pepermans 1988). In France, major changes in labor market institutions happened after 1936 when Front Populaire led by Leon Blum put in place labor market reforms which introduced the 40 hour work week, and compelled employers to recognize trade unions, and grant collective bargaining privileges. In addition, nominal wages increased and annual paid vacation was legislated (Eichengreen 1992, Bridji 2013). Sweden witnessed the growth of unionization and the fraction of workers covered by collective agreements negotiated by unions reached 80 percent by the late 1930s (Holmlund 2013). In the UK several important labor market reforms took place in the 1920s reflecting the recommendations of the Whitely Report in 1917 and a sharp recession in the early 1920s. The number of Trade Boards that set minimum wages increased to 63 covering 3 million workers while unemployment benefits expanded dramatically covering 63 % of the labor force in 1921. In contrast to the 1920s, the 1930s there were essentially no changes in UK labor market institutions (Hatton and Thomas 2010).

Extensive research on labor market institutions suggest that various interwar labor market reforms raised collective bargaining power of the workers and caused nominal wage rigidities (Eichengreen and Hatton 1988, Hatton

1988, Thomas 1992, Hatton and Thomas 2010).[21] The general motivation of these studies was to show that worldwide deflation led to inflation in real wages due to nominal wage rigidity and depressed the economy by depressing labor demand.[22] Numerous empirical studies using a wide sample of countries found evidence of nominal wage rigidity and counter-cyclicality of the real wage (Eichengreen and Sachs 1985, Newel and Symons 1988, Bernanke and Carey 1996).[23]

Figure 4 presents the real wages in the U.S. and Europe.[24] In both economies the real wages rise dramatically during the early 1930s.[25] This is consistent with the empirical findings in the literature that nominal wage stickiness and deflation increased the cost of labor during IGD. Interestingly, however, the real wages in the U.S. and Europe remained well above their 1929 level even after the inflation rate recovered to a positive level in the mid-

[21] Benjamin and Kochin (1979) claim that unemployment benefits raised the opportunity cost of working and increased unemployment during the interwar period. Hatton and Thomas (2010) conclude that while the effects of unemployment benefits on labor supply is limited, they influenced wages set by collective bargaining by reducing the negative consequences of unemployment.

[22] 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.

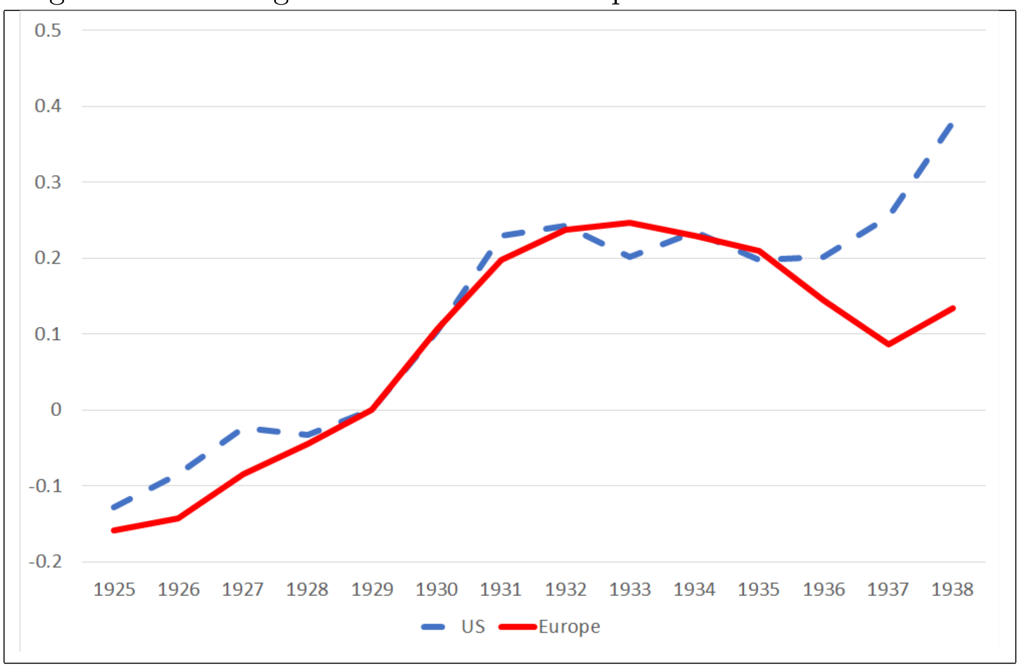
[23] Several studies have also explored the role of wage rigidities on country-basis. Fisher and Hornstein (2002) find that in Germany, real wages were above their market clearing levels and thus contributed to the decline of output during the Great Depression. Perri and Quadrini (2002) find that though the fall of international trade was a major cause of output fall in Italy, it was amplified by the real wage stickiness. Dimsdale, Nickell and Horsewood (1989) analyze the behavior of real wages in Britain from the mid-1920s to 1938 and find 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. Several studies find that Hoover's industrial labor program contributed to nominal wage rigidity causing the U.S. Great Depression in conjunction with the deflation (Vedder and Galloway 1993, Bordo, Erceg and Evans 2000, Ebell and Ritschl 2008, Ohanian 2009). Gorodnichenko, Mendoza and Tesar (2012) and Lama and Medina (2019) show that real wage rigidity can amplify the effects of external and fiscal shocks. Their mechanism is consistent with the decline in output experienced during the International Great Depression, as well as the recovery driven by government spending.

[24] The real wage is computed as the nominal hourly wage in industry divided by the wholesale price index. The real wage is detrended by the output growth rate and normalized at $1929 = 0$ since the units are not comparable across countries. For Europe the aggregate real wage is the average of detrended and normalized individual wages weighted by the output share of each country.

[25] Rising real wages in Europe and North America has been extensively documented by Williamson (1995).

1930s. Bordo, Erceg and Evans (2000) find that the contractionary monetary policy can quantitatively account for more than half of the economic downturn in the U.S. over the 1929 to 1933 period in a sticky wage model, whereas it cannot account for the slow recovery. Cole and Ohanian (2004), Christiano, Motto and Rostagno (2004) and Cole and Ohanian (2013) conclude that the anti-competitive New Deal policies enhancing the bargaining power of labor unions led to a rise in real wages and slow recovery, which is consistent with the rise in the nominal wage.[26] In order to illustrate the arguments reviewed above, we show in the appendix that both unanticipated monetary shocks with nominal wage rigidity and increasing collective bargaining power operate as distortionary taxes on labor income, i.e., labor wedges.[27]

Figure 4. Real Wages in the U.S. and Europe



In sum, there is a large body of research which argues for substantial distortions in the labor and capital markets. We have discussed that these dis-

[26]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.

[27]Buera and Moll (2018) show that credit market frictions can also manifest themselves as labor wedges. However, the literature suggests that labor market frictions could have played a preponderant role in driving the dynamics of the labor wedges.

tortions can be mapped into wedges in the business cycle accounting framework. In the following sections, we use the business cycle accounting method to investigate the quantitative significance of these distortions in Europe and the U.S. respectively.

3 The Benchmark Model

Our benchmark model departs from the original CKM (2007) model in that we incorporate endogenous capital utilization. The main reason we introduce capital utilization is to disentangle the exogenous and endogenous components of production efficiency. The capital and labor market distortions we discussed above can affect production efficiency by affecting the demand for capital services. Ignoring this channel will understate the quantitative impacts of capital and labor market distortions on the Great Depression. Details of the model are as follows.

3.1 Household

The representative household's lifetime utility is defined as

$$E_0 \sum_t \beta^t u(c_t, l_t).$$

where the periodical utility depends on consumption c_t, and labor l_t:

$$u(c_t, l_t) = \Psi \ln c_t + (1 - \Psi) \ln (1 - l_t).$$

In our model, labor supply is defined as total hours worked per population normalized such that the maximum hours worked per worker is equal to one.

The household maximizes the lifetime utility subject to the following budget constraint

$$(1 - \tau_{l,t}) w_t l_t + (1 - \tau_{k,t}) r_t u_{k,t} k_t + \pi_t + \tau_t = c_t + x_t$$

where $\tau_{l,t}$ and $\tau_{k,t}$ are labor and capital income taxes, w_t and r_t are the real wage and the rental rate on capital, k_t and $u_{k,t}$ are capital stock and the utilization rate of capital, π_t is the dividend income received as the owner of the firm, τ_t is transfer income from the government and x_t is investment.

We define labor and investment wedges as

$$\begin{aligned}\omega_{l,t} &= (1-\tau_{l,t}),\\ \omega_{k,t} &= (1-\tau_{k,t}),\end{aligned}$$

respectively.

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). We assume the functional form of depreciation as

$$\delta_t = \delta u_{k,t}^{\chi}.$$

From the household's perspective, a higher capital utilization rate increases capital income while at the same time it increases the depreciation rate of capital.

3.2 Firm

The representative firm produces a single final good using labor l_t and capital service $u_{k,t}k_t$ 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:

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

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

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

where $\omega_{e,t}$ is the time varying productivity of the firm, which we call 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 lump sum fashion. Therefore, the government budget constraint is:

$$\tau_{l,t} w_t l_t + \tau_{k,t} r_t u_{k,t} k_t = \tau_t + g_t.$$

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 CKM (2007), we treat the trade balance as part of g_t.

For convenience, we define government wedges $\omega_{g,t}$ as the deviation of government purchases from its steady state level

$$\omega_{g,t} = \frac{g_t}{g}.$$

3.4 Exogenous Stochastic Process

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

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

We assume that the wedges follow a first order vector autoregressive process:

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

where the "~" refers to the log linear deviation of each variable from its steady state. The error terms are assumed to be mean zero and are allowed to have contemporaneous correlations among each other. In terms of the transition matrix P, we follow CKM (2007) and impose a restriction such that the government wedges do not have any spill-over effects from and onto other wedges.

3.5 Equilibrium

The competitive equilibrium is a sequence of quantities and prices

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

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 six equations:[28]

$$
\begin{aligned}
\frac{1}{c_t} &= \widehat{\beta} E_t\left[\frac{1}{c_{t+1}}\left(\omega_{k,t+1}\theta\frac{y_{t+1}}{k_{t+1}} + 1 - \delta u_{k,t+1}^{\chi}\right)\right], && (1)\\
\omega_{l,t}\left(1-\theta\right)\frac{y_t}{l_t} &= \frac{1-\Psi}{\Psi}\frac{c_t}{1-l_t}, && (2)\\
\omega_{k,t}\theta\frac{y_t}{k_t} &= \chi\delta u_{k,t}^{\chi}, && (3)\\
y_t &= \omega_{e,t}\left(u_{k,t}k_t\right)^{\theta} l_t^{1-\theta}, && (4)\\
\Gamma k_{t+1} &= x_t + \left(1+\delta u_{k,t}^{\chi}\right)k_t, && (5)\\
y_t &= c_t + x_t + g\omega_{g,t}. && (6)
\end{aligned}
$$

In particular, equation (3) characterizes efficient capital utilization. This states that households will supply capital utilization up to the point where the marginal benefit (return on capital service) equals the marginal cost (increased depreciation rate).

4 Quantitative Analysis

4.1 Parameters

The parameters that define the steady state of the model are calibrated to target data values as described below. The calibrated parameters and steady states are listed in Table 2. For simplicity, for Europe we report the population weighted average parameter and steady state values. For estimation and simulation, we use country specific values.

[28] Equations (3) and (5) can be used to substitute capital utilization and capital stock so that we have four equations and four observables: output, consumption, investment and labor.

Table 2. Parameter and Steady State Values

Parameters			Steady States		
	U.S.	Europe		U.S.	Europe
$\widehat{\beta}$	0.96	0.96	c/y	0.788	0.774
δ	0.05	0.05	x/y	0.146	0.146
θ	0.333	0.333	g/y	0.066	0.080
Γ	1.032	1.024	y/k	0.559	0.506
χ	1.833	1.833	l	0.215	0.273
Ψ	0.244	0.304	ω_k	0.492	0.544

We set the subjective discount factor $\widehat{\beta}$, capital depreciation rate δ and the capital income share θ at 0.96, 0.05 and 0.333 for all countries.[29] The growth trend Γ represents the average growth in technology and population which is computed as the average growth trend of total GDP over the 1900-2008 period. We compute the consumption to output ratio c/y, investment to output ratio x/y and total hours worked per capita l directly from the data in the 1925-1938 period. For simplicity, we assume that the steady state efficiency wedge ω_e and capital utilization rate u_k are equal to one. The steady state output to capital ratio y/k is calibrated to match the steady state investment to output ratio x/y in equation (5). The steady state government purchases to output ratio g/y is calibrated to match c/y and x/y in equation (6) while the steady state government wedge is normalized at 1. The steady state investment wedge ω_k is calibrated to match the output to capital ratio y/k in equation (1). The steady state labor wedge ω_l is set equal to 1 as it does not affect any of the results.[30] The elasticity of capital utilization χ is calibrated to match ω_k and y/k in equation (3). Finally, we calibrate Ψ to match l and c/y using (2).

The parameters in the stochastic process are estimated using the Bayesian method available in DYNARE. The main reason why we resort to structural

[29] These are in line with quantitative research of the Great Depression. CKM (2007) set $\widehat{\beta}, \delta$ and θ equal to 0.97, 0.0464 and 0.35. Bridji (2013) set them to 0.96, 0.0664 and 0.34 for France. Fisher and Hornstein (2002) set them to 0.96, 0.0112 and 0.25 for Germany. Perri and Quadrini (2002) set them to 0.96, 0.1 and 0.33 for Italy. Cole and Ohanian (2002) set them to 0.93, 0.06 and 0.3 for the U.K. Pensierosa (2011) set them to 0.96, 0.1 and 0.33 for Belgium.

[30] We can only identify the joint level of ω_l and Ψ in equation (2) given μ. Neither ω_l nor Ψ appear in the linearized equilibrium conditions so their levels have no impact on the dynamics. Therefore, normalizing ω_l to 1 does not affect the results.

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 the expectational capital Euler equation. We use data of output, consumption, investment and labor over the 1925-1938 period normalized at 1929 = 0. Due to feasibility in a non-linear setting, CKM (2007) imposes a restriction on the persistence matrix such that there are no spillover effects related to government wedges. Since we are applying a linearized method, we have virtually no problem in terms of feasibility and hence do not impose this restriction.[31] The posterior means of the estimated parameters are listed in Table 3. P_{ij} represents the spill-over of wedges j on wedges i. σ_i represents the standard deviation of the error term of wedges i. ρ_{ij} represents the correlation coefficient of the error terms of wedges i and j. The information of the prior distributions is listed in the appendix.

[31] Since we use annual data over a short period, increasing the number of parameters estimated might exacerbate the weak identification problem as described in Brinca, Iskrev and Loria (2018).

Table 3. Estimated Parameters

	BEL	DEN	FIN	FRA	GER	ITA	NET	NOR	SPA	UK	US
P_{ee}	0.906	0.761	0.911	0.842	0.856	0.816	0.805	0.882	0.603	0.921	0.910
P_{gg}	0.737	0.901	0.871	0.728	0.834	0.822	0.734	0.732	0.964	0.798	0.702
P_{kk}	0.762	0.820	0.805	0.759	0.786	0.759	0.775	0.811	0.863	0.803	0.751
P_{ll}	0.846	0.778	0.817	0.895	0.869	0.840	0.908	0.864	0.701	0.820	0.966
P_{eg}	0.009	-0.03	0.011	-0.002	-0.007	-0.009	0.000	0.008	-0.061	0.020	0.010
P_{ek}	-0.056	-0.108	-0.015	-0.130	-0.040	-0.033	-0.052	-0.004	-0.162	-0.004	-0.020
P_{el}	0.075	-0.011	0.109	0.032	0.003	-0.016	-0.006	0.038	-0.003	0.077	0.006
P_{ge}	0.001	-0.022	0.006	0.021	-0.030	0.001	-0.110	0.000	-0.014	-0.025	-0.019
P_{gk}	-0.006	-0.060	0.056	-0.009	0.014	0.024	0.130	0.001	0.073	-0.050	0.011
P_{gl}	0.000	-0.068	-0.051	0.010	-0.030	-0.082	-0.148	-0.023	0.024	-0.007	0.020
P_{ke}	0.021	-0.098	-0.067	-0.027	-0.086	-0.057	-0.039	-0.015	0.073	-0.024	-0.056
P_{kg}	0.017	-0.004	0.007	0.005	0.022	0.008	0.000	-0.003	-0.016	-0.012	0.018
P_{kl}	-0.041	-0.050	-0.069	0.028	-0.075	-0.072	-0.034	-0.075	-0.140	0.075	0.042
P_{le}	0.068	-0.038	0.114	0.113	0.042	0.103	0.109	0.045	0.130	-0.009	0.118
P_{lg}	-0.004	-0.007	-0.007	0.006	-0.007	-0.033	0.007	0.007	0.016	-0.028	-0.030
P_{lk}	0.042	0.065	0.027	-0.033	-0.047	-0.143	-0.142	-0.023	0.046	-0.001	0.007
σ_e	0.026	0.021	0.022	0.040	0.028	0.050	0.029	0.027	0.077	0.020	0.030
σ_g	0.341	1.694	0.228	1.795	0.306	0.249	3.221	0.212	0.966	0.272	0.277
σ_k	0.038	0.048	0.038	0.058	0.043	0.062	0.045	0.037	0.237	0.034	0.033
σ_l	0.024	0.055	0.062	0.060	0.072	0.072	0.026	0.052	0.173	0.028	0.110
ρ_{eg}	0.225	-0.277	0.176	-0.010	-0.062	-0.017	0.453	0.546	-0.630	0.424	-0.064
ρ_{ek}	-0.304	-0.316	-0.387	-0.424	-0.262	-0.473	-0.406	-0.301	0.249	-0.382	-0.262
ρ_{el}	-0.181	-0.272	0.042	-0.263	-0.266	-0.355	-0.143	-0.285	-0.039	-0.083	-0.318
ρ_{gk}	0.110	-0.247	0.108	-0.130	0.081	0.105	0.576	0.151	-0.288	0.333	-0.004
ρ_{gl}	-0.150	-0.574	-0.597	-0.143	0.145	-0.348	-0.218	-0.333	-0.469	-0.132	0.162
ρ_{kl}	-0.313	-0.132	-0.089	-0.286	-0.162	-0.372	-0.282	-0.254	-0.636	-0.184	-0.176

4.2 Wedges

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

$$\begin{aligned} \widetilde{k_{t+1}} &= A\widetilde{k}_t + B\widetilde{\omega}_t \\ \widetilde{q}_t &= C\widetilde{k}_t + D\widetilde{\omega}_t, \end{aligned}$$

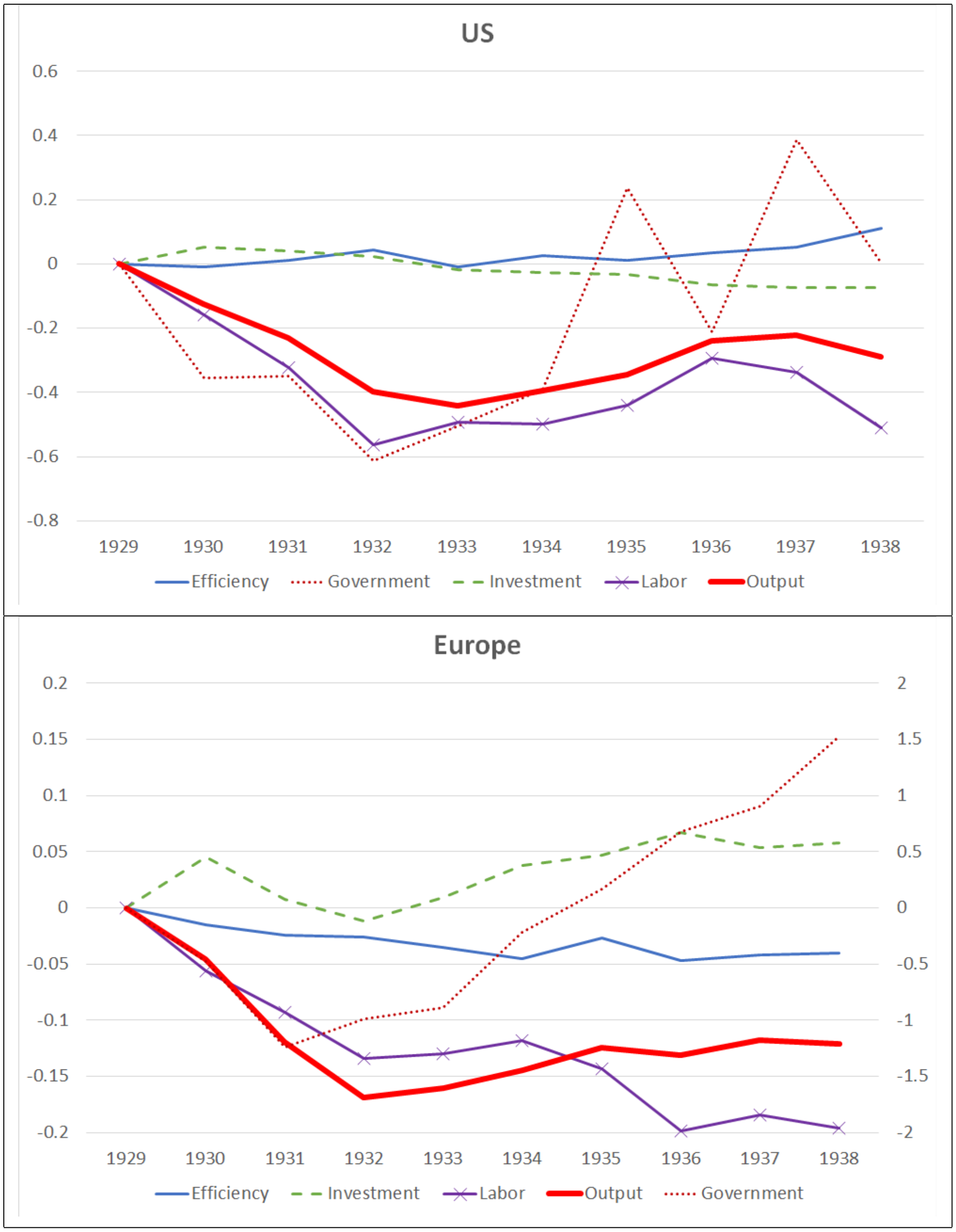
where q_t is a vector of endogenous observable variables: $q_t = (y_t, c_t, x_t, l_t)$. We first assume that capital stock and the observables are in steady state in 1929, which implies that wedges in 1929 in steady state as well. Therefore, $\widetilde{k_{1929}} = \widetilde{q_{1929}} = \widetilde{\omega_{1929}}, = 0$. From 1930 and onwards, the wedges 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 Figure 5. The European wedges are population weighted average of each country's wedges. In the U.S., labor wedges fall sharply while efficiency and investment wedges decline mildly during the 1929-1933 period. In Europe, government and labor wedges fall sharply during the 1929-1932 period.[32]

[32] One concern of our results is that the linearization method might not be appropriate for studying large economic fluctuations. In the appendix, we present the difference between the labor wedges directly computed from the non-linearized labor first order condition (2) and those computed from the linearized model. We find that the linear approximation errors of labor wedges are not significant.

Figure 5. Computed Wedges in the U.S. and Europe



A drop in efficiency wedges reduces output directly as well as the demand for capital and labor. A drop in government wedges leads to a positive income effect which reduces labor supply and output. A drop in investment wedges reduces the return on effective capital and thus leads to a decline in capital utilization and output. A drop in labor wedges reduces the return on labor and thus the decline in labor supply and output. Therefore, these should all have contributed to the output declines during the IGD. The question is, how large are these effects?

4.3 Simulation

In order to quantify the effects of each wedge, we simulate the model by plugging wedges into the model one-by-one and measure the reactions of each variable. Figure 6 shows the year-by-year reaction of output to each wedge. The European results are population weighted average of each country's result. In the U.S. the model with labor wedges alone predicts not only the drop in output but also the persistence of the depression quite well. In Europe the model with only labor wedges predicts the initial drop in output well but it predicts a much more severe and prolonged depression throughout the mid-1930s. In Europe the improvement in government wedges account for a recovery much more rapid than that in the data while efficiency and labor wedges counteract with these forces.

Figure 6. Simulated Output in the U.S. and Europe

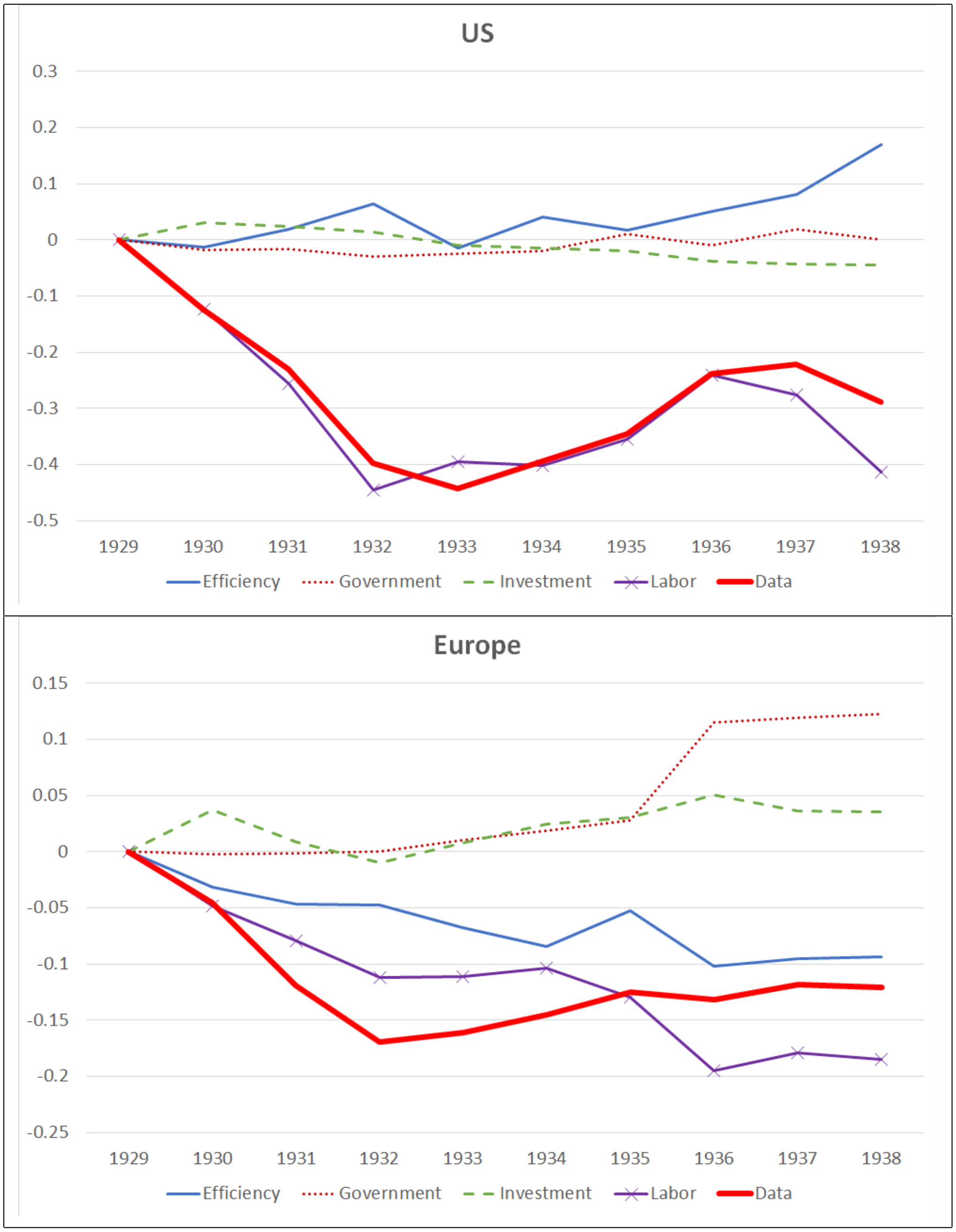


Table 4 summarizes the results. The first column reports the effect of each wedge on the drop in output from its 1929 level to its level in the trough, 1933 for the U.S. and 1932 for Europe. In terms of the depth of the depression, labor wedges account for two-thirds of the drop in output from 1929 to their respective troughs in both the U.S. and Europe. In Europe, efficiency wedges account for the remaining drop of output while in the U.S., both efficiency and government wedges share the remaining blame. The second column reports the effect of each wedge on the recovery of output from their relative troughs. In the U.S. efficiency wedges alone would have led to a recovery more rapid than that in the data over the 1933-1938 period. The third column reports 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. Due to linearity, the sum of the contributions of each wedge to the overall fluctuation of output is equal to 1. In terms of overall contribution, labor wedges are clearly the most important source of output fluctuation in both economies; in the U.S. they account for almost all and in Europe they account for more than three quarters of the output fluctuation during the 1929-1938 period.

Table 4. Contribution of Each Wedge on Output

	U.S.			Europe		
	1929-33	1933-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.014	0.184	−0.069	−0.047	−0.046	0.415
Government	−0.024	0.024	0.042	0.000	0.122	−0.209
Investment	−0.010	−0.034	0.038	−0.010	0.045	0.009
Labor	−0.394	−0.020	0.989	−0.112	−0.073	0.785
Data	−0.443	0.155	1	−0.169	0.048	1

Our results are informative in terms of discussing the sources of the IGD. The importance of labor wedges in both economies supports the view that the growing inflexibility of labor markets accompanied by the deflationary pressure transmitted through the Gold Standard facilitated the drops in output (Eichengreen and Sachs 1985, Newel and Symons 1988, Bernanke and

Carey 1996). It is also consistent with the view that cartelization policies which increased labor bargaining power contributed to the severity of the depression (Christiano, Motto and Rostagno 2004, Ohanian 2009, Cole and Ohanian 2004, 2013). In addition, efficiency wedges also account for a significant drop in output in the early 1930s. One important result is that the role of investment wedges in accounting for the Great Depression is limited, which is consistent with CKM (2007), even when we include endogenous capital utilization. Therefore, if financial frictions triggered the IGD, it must have manifested themselves as labor and/or efficiency wedges and not as investment wedges.

Our results also shed light on the recovery during the IGD. The role of government wedges in the recovery of Europe is consistent with the view that the rearmament contributed to the recovery (Ritschl 2002, Temin 1991, Thomas 1983). According to the 1947 System of National Accounts report, all military expenditure was treated as government consumption.[33] Therefore, rearmament manifests itself as a rise in government wedges in our model.

Next, we investigate how each wedge affects the capital utilization rate. Table 5 presents the simulated capital utilization in both economies. Since capital utilization is a latent variable in our model, the "Data" refers to the simulated fluctuation of the utilization rate in the model with all wedges. The results show that capital utilization drops dramatically during the initial period of IGD in both economies. In the U.S. labor wedges are the most important in accounting for the drop in capital utilization during the initial period while in Europe all wedges contribute significantly to its drop.

Table 5. Contribution of Each Wedge on Capital Utilization

	U.S.			Europe		
	1929-33	1933-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.015	0.088	0.078	−0.014	0.023	0.162
Government	−0.013	0.013	0.087	−0.008	0.018	0.235
Investment	−0.028	−0.020	−0.089	−0.022	0.038	0.360
Labor	−0.136	0.078	0.925	−0.044	0.046	0.244
Data	−0.192	0.159	1	−0.088	0.125	1

[33] Note that in our model government wedges do not include government investment. Scherner (2013) claims that part of military spending was actually counted as government investment in Germany. If this was truely the case, the adjusted government wedges should have had an even larger effect during the recovery period.

4.4 Sensitivity Analysis

In this section we modify the model and provide several sensitivity analyses. The contribution indexes of each wedge are listed in Table 6 along with the results from our benchmark (BM) model. First, we compare our results with those from a model with fixed factor utilization. This corresponds to original business cycle accounting model of CKM (2007). Next, we introduce a model with investment adjustment costs following Christiano and Fisher (2006) which we call the AC model. Finally, we introduce a model with endogenous labor utilization as in Burnside, Eichenbaum and Rebelo (1993) which we call the labor hoarding (LH) model.

Table 6. Sensitivity Analysis: Contribution Index

	U.S.			
	BM	CKM	AC	LH
Efficiency	−0.069	0.096	−0.163	−0.424
Government	0.042	0.025	0.045	0.063
Investment	0.038	0.009	0.164	−0.254
Labor	0.989	0.871	0.954	1.614
Data	1	1	1	1
	Europe			
	BM	CKM	AC	LH
Efficiency	0.415	0.453	0.115	0.104
Government	−0.209	−0.024	0.026	−0.382
Investment	0.009	−0.061	0.255	−0.098
Labor	0.785	0.631	0.604	1.376
Data	1	1	1	1

4.4.1 Fixed Utilization

One important difference between our model and the original business cycle accounting model in CKM (2007) is that we consider endogenous capital utilization.[34] In order to illustrate the effect of capital utilization on output

[34] There are also differences in data series. First, we use private consumption expenditure as consumption whereas CKM (2007) uses household expenditure on non-durables and services as consumption. Next, we use gross fixed capital formation as investment whereas CKM (2007) uses the sum of gross capital formation and household expenditure on durables as investment. Since we do not have data on expenditure on durables for most

fluctuation, we simulated the model with $u_{k,t} = 1$ which is equivalent to the original model of CKM (2007).

In the model with constant factor utilization efficiency wedges are equivalent to Total Factor Productivity (TFP) i.e. the Solow residual:

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

On the other hand, in our model efficiency wedges are defined as

$$\widetilde{\omega_{e,t}} = \widetilde{y_t} - \theta\left(\widetilde{k_t} + \widetilde{u_{k,t}}\right). \tag{7}$$

Therefore, we can decompose TFP into exogenous efficiency wedges and endogenous factor utilization

$$\widetilde{A_t} = \widetilde{\omega_{e,t}} + \theta\widetilde{u_{k,t}}. \tag{8}$$

The simulation results presented in Table 5 show that efficiency wedges would have accounted for much more of the depressions in both economies in a model without endogenous capital utilization.[35]

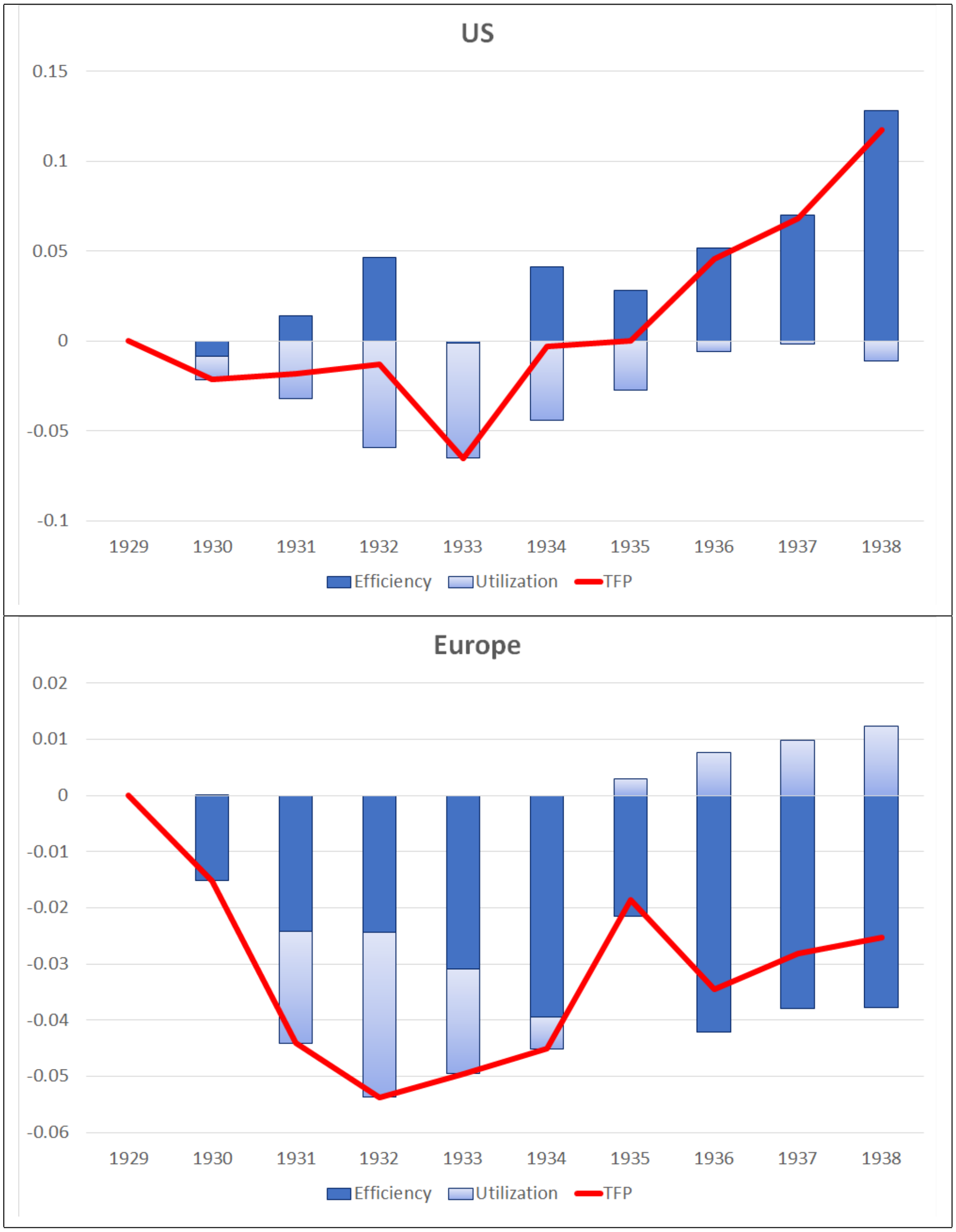
Figure 7 plots the measured TFP and its decomposition into the two components on the right-hand side of (8). TFP in the U.S. showed a much more severe decline while the recovery was more rapid than that in Europe. Overall, TFP in the U.S. ended up higher in 1938 than in 1925 while in Europe it ended up lower.[36] The decomposition indicates that endogenous utilization accounts for a significant amount of the drop in TFP during the IGD in both economies. Therefore, endogenous capital utilization is an important channel for the transmission of factor market distortions and without these channels we significantly overstate the contribution of efficiency wedges on the IGD.

European countries, we could not make this adjustment. Finally, CKM (2007) removes military compensation from GDP while we could not make this adjustment.

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

[36]This is consistent with Field (2006) which shows that in the U.S. both labor and capital productivity and hence TFP were growing in the depression years as a result of advances in manufacturing sector combined with advances in transportation, distribution, and public utilities.

Figure 7. TFP Decomposition



4.4.2 Capital Adjustment Cost

Christiano and Fisher (2006) points out that capital adjustment costs increase the importance of investment wedges.[37] We follow their setting and modify the capital law of motion to

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

where

$$\Phi_t = \frac{\phi}{2}\left(\frac{x_t}{k_t} - \frac{\overline{x}}{\overline{k}}\right)^2.$$

This will lead to a change in the capital Euler equation

$$\frac{1}{c_t}\frac{1}{1-\Phi_t'} = \widehat{\beta}E_t\left[\frac{1}{c_{t+1}}\left(\omega_{k,t+1}\theta\frac{y_{t+1}}{k_{t+1}} + \frac{1}{1-\Phi_{t+1}'}\left(1-\delta u_{k,t+1}^{\chi} + \Phi_{t+1}'\frac{x_{t+1}}{k_{t+1}} - \Phi_{t+1}\right)\right)\right].$$

We set the parameter value ϕ so that the marginal Tobin's q is equal to 1/4 following CKM (2007). The results in Table 5 show that the introduction of the capital adjustment cost dramatically increases the importance of investment wedges. In fact, investment wedges become the second most important in both the U.S and Europe. In our model, the quantitative importance of investment wedges increases much more than they do in CKM (2007) due to endogenous capital utilization. However, this does not overturn the result that labor wedges are the most important wedge for the IGD.

4.4.3 Labor Hoarding

Up to now we considered capital utilization as the sole endogenous component of TFP but we can also consider endogenous labor utilization. We follow Burnside, Eichenbaum and Rebelo (1993) and modify the production function to

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

where $u_{l,t}$ is the labor utilization which can be considered as the intensity of the job or the effort of the workers that provide total hours of work l_t. The firm's profit maximization problem changes accordingly to

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

[37] They show that the procyclicality of the marginal adjustment cost generates investment wedges even though there are actually no frictions.

We also modify the periodical preference function to

$$u(c_t, l_t) = \Psi \ln c_t + (1 - \Psi) \left(\ln (1 - l_t) - \alpha l_t \frac{u_{l,t}^{1+\mu}}{1 + \mu} \right),$$

where $(1 - \Psi)\alpha l_t \frac{u_{l,t}^{1+\mu}}{1+\mu}$ represents the utility cost of the intensity of the job or the effort. The household maximizes the life time utility subject to the following budget constraint

$$(1 - \tau_{l,t}) w_t u_{l,t} l_t + (1 - \tau_{k,t}) r_t u_{k,t} k_t + \pi_t + \tau_t = c_t + x_t.$$

The model leads to an additional equilibrium condition for the labor utilization

$$\frac{1}{1 - l_t} = \frac{\mu}{1 + \mu} \alpha u_{l,t}^{1+\mu}, \tag{9}$$

and the labor first order condition will change to

$$\omega_{l,t} (1 - \theta) \frac{y_t}{l_t} = \frac{1 - \Psi}{\Psi} \frac{1 + \mu}{\mu} \frac{c_t}{1 - l_t}. \tag{10}$$

For simplicity, we set the steady state level of $u_{l,t}$ equal to 1. With no clear target to pin down the parameter μ we set this equal to 1. This will pin down the level of α from (9). We also recalibrate the level of Ψ from (10). The results in Table 5 show that the introduction of the labor utilization increases the importance of labor wedges. This is true for $\infty > \mu \geq 1$ while the labor hoarding model with $\mu = \infty$ is equivalent to the benchmark model because the fluctuation of labor utilization relative to labor becomes infinitesimally small from (9).

5 Discussion

5.1 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 such as

Eichengreen and Sachs (1985), Eichengreen (1992) and 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 it longer. In this section we are going to discuss the implications of our findings from the business cycle accounting for the recovery from the IGD 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 (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, Eggertson 2008, Crafts and Fearon 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 rise in industrial production and recovery. Finally, inflation lowered real wages which then stimulated labor demand (Eichengreen and Sachs 1985).

Table 7 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 could be 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 (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 whereas 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 Spanish output was due to the civil war which is an exogenous shock unrelated to the Gold Standard.

Table 7. Changes in the Gold Standard Policies

Country	Date of Leaving	Alternative Policy	Output Growth 1929-32	Output Growth 1932-38
Early Leavers: Countries Abandoning Gold Standard in 1931				
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	-	-	-0.170	0.087
Late Leavers: Countries Abandoning Gold Standard after 1934				
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	-	-	-0.171	-0.013

Although, due to the outbreak of the WWII we do not have enough of data 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 8 compares the simulation results for the Early Leavers and Late Leavers. The results show that the main source of the depression for both groups was the labor wedges. Since both groups were on the Gold Standard during this period, this result is consistent with the view that sticky wages and the global deflation created labor market distortions. In terms of the recovery in the Early Leavers, the government wedges had a strong positive impact on output growth after 1932. On the other hand, the sluggish recovery of the Late Leavers was mainly due to the further deterioration in the labor wedges.

Table 8. Contribution of Each Wedge on Output: Gold Standard

	Early Leavers			Late Leavers		
	1929-32	1932-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.016	−0.161	0.124	−0.103	0.131	0.208
Government	−0.007	0.171	0.060	0.009	0.049	−0.214
Investment	−0.058	0.096	0.325	0.063	−0.035	−0.201
Labor	−0.089	−0.019	0.491	−0.140	−0.158	1.207
Data	−0.170	0.087	1	−0.171	−0.013	1

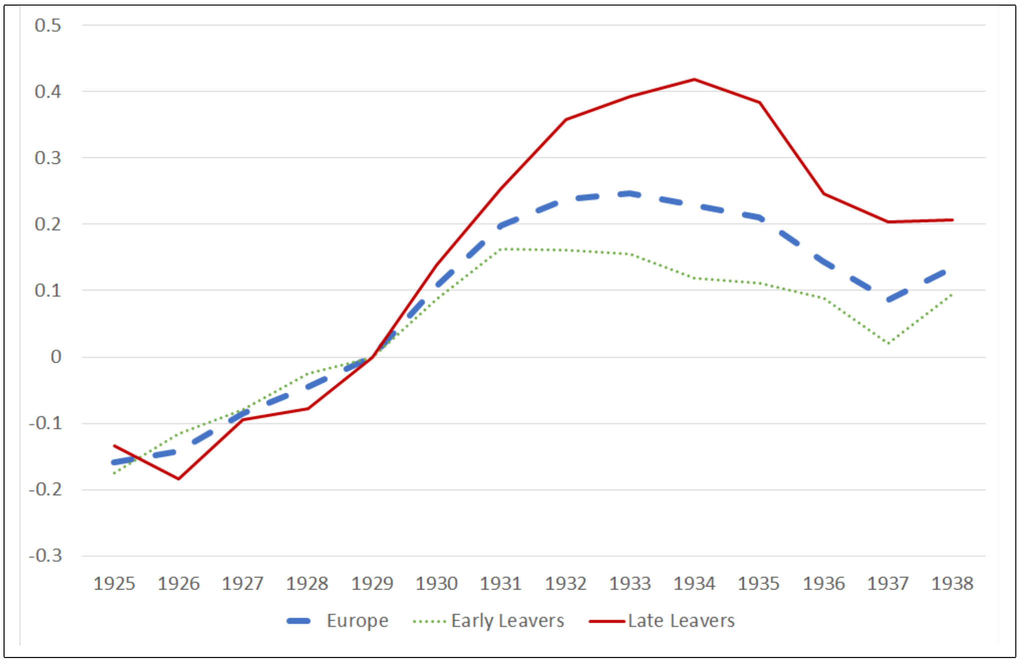
An interesting result is that the government wedges had a significant contribution to the depression and recovery of the Early Leavers while they had less impact on the Late Leavers. One possible interpretation of this result is that the Early Leavers who were hit strongly by the deterioration of the trade balance during the early stage of the depression abandoned the Gold Standard to stimulate foreign demand through currency depreciation. However, our country-by-country results in the appendix shows that the large contribution of government wedges on the recovery of Early Leavers is mainly driven by the increase in government wedges in Germany, which is mainly due to the increase in government consumption for rearmament.

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 labor markets.[38] In order to illustrate this view, we plot the real wages in Early Leavers and Late Leavers in Figure 8. This figure clearly shows that the real wage of Early Leavers declined after 1931 while that of Late Leavers further increased until the mid-1930s. One remaining question is that the real wage in Late Leavers fell dramatically in 1936 whereas the depressing effect of

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

labor wedges persisted till 1938. This most likely reflects the drastic 40 hour work week policy introduced in Italy in the end of 1934 and in France in 1936, which reduced total hours worked while real wages declined.

Figure 8. Real Wages in Europe



5.2 Fiscal Policy during the IGD

Fiscal policy framework in the interwar years was different in its nature and magnitude relative to post WWII decades. Whilst many countries began to implement policies which closely resembles fiscal policies of the post WWII times – e.g. emergence of unemployment benefits, various forms of welfare support – their scope and target was small by today's standards. Attitude towards fiscal policies by policy-makers was also driven by pre WWI stance in which countries' economic success was tied to the commitment to the gold standard, and that monetary policy played a dominant role to achieve it. Indeed, return to the gold was a priority in many nations and an active large-scale fiscal policy was deemed inconsistent with that goal (e.g. Feinstein et al 2008). This is not to say that fiscal policy was only tied to by today's standards small scale welfare programs: defence spending was a large part of government expenditures. However, once the WWI was over, balanced government budget was again priority.

Fiscal policy framework began to change during the Great Depression. The most notable is the New Deal in the United State but other countries tried fiscal policies as well. The magnitude of the New Deal, though small by today's standards, was above and beyond anything tried in peace time before. The literature debates its overall effect on the recovery from the Great Depressions (see Fishback (2017) for an extensive overview of the New Deal Policies) but it a consensus emerges that it represented a policy regime change which, together with the abandonment of the Gold Standard, helped recovery. Eggertson (2008) builds a DSGE model to assess the importance of such policy regime change. He shows that unlike the policies of President Hoover characterized by small government, balanced budget, and the Gold Standard, Roosevelt's presidency since 1933 was a policy regime change which included not only abandonment of the Gold Standard, but also a significant fiscal expansion, leading to a large shift in expectations and subsequent recovery. United States was not the only country which left the Gold Standard and expanded fiscal policy though. United Kingdom, which left the gold in 1931, embarked on large fiscal expansion in 1935 in form of rearmament. Literature has debated its effect on the recovery from the Great Depressions, but recent estimates by Crafts and Mills (2013) suggest that the effect, though not large in magnitude, helped to further promote the recovery after leaving the Gold Standard.

5.3 The Great Recession

The Great Recession of 2008 was the largest worldwide economic crisis since the International Great Depression (IGD). This led to a spark of interest in the differences and similarities among the Great Recession and IGD. In this section, we compare the two episodes through the lens of business cycle accounting.

There are recent studies conducting business cycle accounting for various countries during the Great Recession. Brinca, Chari, Kehoe and McGrattan (2016) study the cases for 24 OECD countries and find that labor wedges were most important in the U.S. and efficiency wedges were most important in most other countries in accounting for the output drop. Gerth and Otsu (2018) find that efficiency wedges were most important in accounting for the prolonged post-crisis slump in 30 European countries. We use the same model and sample countries as our IGD exercise to compare the IGD with the Great Recession while avoiding the overstatement of efficiency wedges by incorporating endogenous capital utilization.

Figure 9 presents the business cycle accounting results on output in the US and Europe corresponding to Figure 6. In the U.S., the model with labor wedges alone predicts the initial drop in output over the 2007-2009 period very well. However, the extended recession can be attributed to the deterioration in efficiency wedges. One interesting result is that in the U.S. government wedges initially preventing the decline in output while they contribute to the prolonged recession after 2009. This reflects the temporary increase in government consumption as part of the stimulus package based on the American Recovery and Reinvestment Act of 2009. In Europe, the model with efficiency wedges alone predicts the economic downturn very well. Labor wedges also contribute to the economic downturn but at a lesser extent. Government wedges had little effect on output while the improvement in investment wedges counteracted the downward pressure caused by efficiency and labor wedges.

Figure 9. Simulated Output in the U.S. and Europe

Table 9 summarizes the results. The first two columns for both the U.S. and Europe report the effect of each wedge on the drops of output during the 2007-2009 and 2009-2016 periods, respectively. In the U.S. labor wedges was the main culprit of the initial decline in output. However, the dramatic improvement in labor wedges would have brought back output nearly to its trend level hadn't it been for the further deterioration of efficiency wedges during the 2009-2016 period. In Europe, efficiency wedges account for not only most of the initial drop of output, but also the prolonged slump during the 2009-2016 period. These results are consistent with the findings of Brinca, Chari, Kehoe and McGrattan (2016) and Gerth and Otsu (2018). The third column shows that efficiency wedges are the most important sources of the Great Recession in both U.S. and Western Europe; in the U.S. they account for nearly all and in Europe they account for more than 80 percent of the output fluctuation during the 2007-2016 period. Our results show that the Great Recession was driven primarily by deterioration in efficiency wedges, even after controlling for endogenous utilization, unlike the IGD which was driven primarily by labor wedges.

Table 9. Contribution of Each Wedge on Output

	U.S.			Europe		
	2007-09	2009-16	Cont	2007-09	2009-16	Cont
Efficiency	−0.028	−0.091	0.860	−0.081	−0.085	0.884
Government	0.041	−0.061	0.130	0.001	−0.003	0.014
Investment	0.002	0.032	−0.438	−0.002	0.035	−0.217
Labor	−0.102	0.079	0.447	−0.011	−0.029	0.347
Data	−0.087	−0.040	1	−0.092	−0.082	1

6 Conclusion

In this paper we compare the U.S. and Western Europe and analyze the International Great Depression (IGD) using the business cycle accounting method with endogenous capital utilization. We find that labor wedges are important in accounting for the Great Depression in both economies and that endogenous capital utilization reinforces the impact of labor wedges. This is consistent with the view that anti-competitive labor market policies which increased labor bargaining power and deflationary forces transmitted through the Gold Standard are the main sources of the IGD. Furthermore, models with frictions which manifest themselves as investment wedges cannot explain the output drops in the U.S. and Europe during the early 1930s. We also find that government wedges helped the recovery from the IGD in Europe, especially the countries which left the Gold Standard in the early 1930s. This implies that the increase in government consumption for rearmament were important in accounting for the recovery in Europe. On the other hand, countries that remained on the Gold Standard further suffered from deterioration in labor wedges. The result that IGD was mainly driven by labor wedges is in stark contrast with results for the Great Recession which points to efficiency wedges as the main driver. A comparison of the differences in labor institutions and production efficiency during the IGD and the Great Recession is left for future research.

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A Equivalence Results: Detailed Models of Investment and Labor Wedges

A.1 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 with constant labor utilization and no 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 (5) in the benchmark model.

In equilibrium

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

so that

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

From the labor first order condition

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

where if $\frac{\chi(1-\theta)(1+\gamma)}{\chi-\gamma\theta} > 1$ the labor demand is increasing in wage. This model can contain multiple equilibria due to an upward sloping labor demand curve.

Imagine that there is an exogenous positive non-fundamental expectational shock to the future output, y^*_{t+1}. The increase in future expected output raises the future expected marginal product of capital and hence increases current investment demand. An increase in future expected income also increases demand for consumption and decreases labor supply. If we assume that the labor demand curve is upward sloping with a slope steeper than the labor supply curve, this shift in the labor supply curve will lead to an increase in current labor input and wages. The increase in current labor input raises the current marginal product of capital which leads to an increase in capital utilization. The increase in current labor and capital utilization enables current output, consumption and investment to increase. Finally, an increase in future output due to the growth in capital stock validates the optimistic 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, (1) combined with (3),

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

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

A.2 Predetermined Wage Model and Labor Wedges

Consider a model as Cole and Ohanian (2004) 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

$$mpl_t = \frac{\zeta_t}{P_t} \frac{E_{t-1}\left[-u_{lt} l_t\right]}{E_{t-1}\left[\frac{u_{ct}}{P_t} l_t\right]}. \tag{11}$$

Comparing (11) to the benchmark labor equilibrium condition (2):

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

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 ζ_t also creates a wedges in the labor market. This is because a rise in the monopoly power of labor unions 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.

B Estimation for the Benchmark Model

In our model, investment wedges as well as factor utilization and hence efficiency wedges are all latent variables so that we cannot directly estimate the stochastic process of wedges. Therefore, we rely on structural estimation of the persistence matrix P, variance covariance matrix V. The estimation results are listed in Table A1.[39] P_{ij} represents the spill-over of wedges j on wedges i. σ_i represents the standard deviation of the error term of wedges i. ρ_{ij} represents the correlation coefficient of the error terms of wedges i and j.

[39] Estimation results are available upon request.

Table A1. Bayesian Estimation Prior

Parameter	Distribution.	Mean	S.E.	Support
P_{ee}	normal	0.8	0.1	$\boldsymbol{R}$
P_{gg}	normal	0.8	0.1	$\boldsymbol{R}$
P_{kk}	normal	0.8	0.1	$\boldsymbol{R}$
P_{ll}	normal	0.8	0.1	$\boldsymbol{R}$
P_{eg}	normal	0	0.1	$\boldsymbol{R}$
P_{ek}	normal	0	0.1	$\boldsymbol{R}$
P_{el}	normal	0	0.1	$\boldsymbol{R}$
P_{ge}	normal	0	0.1	$\boldsymbol{R}$
P_{gk}	normal	0	0.1	$\boldsymbol{R}$
P_{gl}	normal	0	0.1	$\boldsymbol{R}$
P_{ke}	normal	0	0.1	$\boldsymbol{R}$
P_{kg}	normal	0	0.1	$\boldsymbol{R}$
P_{kl}	normal	0	0.1	$\boldsymbol{R}$
P_{le}	normal	0	0.1	$\boldsymbol{R}$
P_{lg}	normal	0	0.1	$\boldsymbol{R}$
P_{lk}	normal	0	0.1	$\boldsymbol{R}$
σ_e	inverse gamma	0.05	2.0	$\boldsymbol{R}^+$
σ_g	inverse gamma	0.05	2.0	$\boldsymbol{R}^+$
σ_k	inverse gamma	0.05	2.0	$\boldsymbol{R}^+$
σ_l	inverse gamma	0.05	2.0	$\boldsymbol{R}^+$
ρ_{eg}	beta	0	0.3	$[-1, 1]$
ρ_{ek}	beta	0	0.3	$[-1, 1]$
ρ_{el}	beta	0	0.3	$[-1, 1]$
ρ_{gk}	beta	0	0.3	$[-1, 1]$
ρ_{gl}	beta	0	0.3	$[-1, 1]$
ρ_{kl}	beta	0	0.3	$[-1, 1]$

C Linearization Errors

One concern of our results is that the linearization method might not be appropriate to study large economic fluctuations. When fluctuations of the variables become large, the linear approximation errors will increase. In this section we focus on the labor wedge to understand the magnitude of this issue.

Since the labor first order condition (2) is a static equation in which only the labor wedge is unknown, we can directly calculate non-linear labor wedges using data of observable variables. We take a log of the computed non-linear labor wedge and normalize at 1929 = 0 to compare them with the labor wedges computed from the linearized model. The standard deviations of each series for each country are listed in Table A2. It turns out that the magnitude of errors from linear approximation in computing labor wedges are not significant.

Table A2. Standard Deviations in Labor Wedges

	Non-Linear FOC	Model	Difference
Denmark	1.71%	1.72%	0.01%
Finland	7.48%	7.44%	-0.04%
France	10.80%	10.83%	0.03%
Germany	9.41%	9.67%	0.27%
Italy	9.19%	9.36%	0.17%
Netherlands	15.32%	15.47%	0.15%
Norway	10.49%	10.53%	0.03%
Spain	7.78%	7.77%	0.00%
Sweden	22.27%	22.27%	0.00%
UK	5.51%	5.55%	0.04%
US	6.18%	6.14%	-0.05%

D Individual Simulation Results of European Countries

In Table A3 we present the individual simulation results for the European countries. We mainly focus on France, Germany, Italy and the UK because they are significantly larger than other European economies; the GDP shares in 1929 relative to the aggregate European economy in our sample are 18.6%, 25.1%, 12.0% and 24.1% respectively, which adds up to 79.8 %.

France experienced one of the largest and persistent depressions in Europe. In France labor wedges contribute the most to the overall output fluctuation. Both labor and efficiency wedges individually account for the initial drop of output equally as large as in the data while investment wedges counteract this effect during the 1929-1932 period. Investment and labor wedges further depress the economy while efficiency wedges are counteracting this effect during the recovery period. A notable shock to the labor market is the

40 hour work week policy introduced in 1936 which caused a decline in labor supply.

The German depression was as large as that in France whereas, unlike in France output fully recovered by 1938. In Germany government and labor wedges contribute roughly half each to the overall output fluctuation. Labor wedges account for most of the initial drop of output during 1929-1932 while government wedges account for most of the recovery during the 1932-1938 period. The large role played by government wedges on the recovery can be attributed to the increased government spending on rearmament (Ritschl 2002, Temin 1991).

The output drop in Italy between 1929 to 1932 was about half of that in France and Germany where output remained at its trough level throughout the 1930s as in the case of France. In Italy labor wedges are by far the most important wedge in accounting for the overall fluctuation in output. Labor wedges account for more than all of the initial drop in output. The slow recovery is mainly due to the further deterioration in labor wedges while government wedges were counteracting these forces. The deterioration in labor wedges are consistent with the Fascist labor market policies including the 40 hour work week restrictions introduced in 1934. The increase in government wedges is consistent with the increase in military expenditure due to the Italo-Ethiopian war during 1935-36.

The depression in the UK during the 1930s was half the size of those in France and Germany and relatively short-lived. In fact, the Great Depression in the UK began in the early 1920s and the 1930s was a continuation of this depression period.[40] In the UK labor wedges contribute most to the overall output fluctuation. Efficiency wedges alone can fully account for the initial output drop. Unlike other countries, labor wedges did not contribute much to the drop in output during the 1929 to 1932 period partially because the work week was already reduced significantly due to union bargaining in the early 1920s (Broadberry 1986, 1990, Cole and Ohanian 2002). Moreover, the improvement in labor wedges accounts for most of the recovery in output during the 1932-1938 period. Also, as in Germany and Italy, government wedges contributed to the recovery implying the expansionary effect of rearmament as stated in Thomas (1983). Crafts and Mills (2013) argues that

[40] The UK Great Depression in the 1920s is documented in Cole and Ohanian (2002). They find that the labor policies that discouraged labor supply were to blame for the depression.

the news of massive future defense spending after 1935 provided a boost to real GDP in the UK by stimulating private expenditure. This is consistent with the positive effect of investment wedges on output during the recovery period.

Table A3. Contribution of Each Wedge on Output

	Belgium			Denmark		
	1929-32	1932-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.124	−0.072	0.902	0.081	−0.072	0.348
Government	−0.009	0.013	−0.019	0.080	−0.058	−0.580
Investment	−0.007	0.017	0.006	−0.002	0.067	−0.504
Labor	−0.004	−0.014	0.112	−0.199	0.056	1.736
Data	−0.144	−0.055	1.000	−0.040	−0.008	1.000
	Finland			**France**		
	1929-32	1932-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.072	0.092	0.340	−0.180	0.275	0.209
Government	0.050	−0.025	−0.153	−0.015	0.031	−0.002
Investment	0.052	−0.036	−0.115	0.081	−0.155	0.176
Labor	−0.168	0.162	0.928	−0.117	−0.144	0.617
Data	−0.138	0.193	1.000	−0.230	0.007	1.000
	Germany			**Italy**		
	1929-32	1932-38	Cont	1929-32	1932-38	Cont
Efficiency	0.054	−0.015	−0.083	−0.023	0.075	0.515
Government	−0.069	0.185	0.465	0.032	0.089	−0.463
Investment	−0.009	0.078	0.166	0.075	0.031	−0.865
Labor	−0.217	0.039	0.452	−0.199	−0.212	1.813
Data	−0.241	0.288	1.000	−0.115	−0.016	1.000
	Netherlands			**Norway**		
	1929-32	1932-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.085	−0.114	0.675	0.059	0.028	0.490
Government	0.034	−0.035	0.081	0.007	−0.001	−0.013
Investment	−0.027	0.170	−0.707	0.051	0.013	−0.309
Labor	−0.098	−0.089	0.952	−0.169	0.016	0.831
Data	−0.177	−0.068	1.000	−0.052	0.055	1.000

	Spain			Sweden		
	1929-32	1932-38	Cont	1929-32	1932-38	Cont
Efficiency	−0.060	−0.907	1.677	0.012	0.034	0.100
Government	0.180	0.517	−1.383	−0.032	0.015	0.041
Investment	−0.350	0.295	−0.166	−0.009	0.036	0.235
Labor	0.097	−0.396	0.872	−0.048	0.051	0.623
Data	−0.134	−0.491	1.000	−0.078	0.137	1.000

	UK		
	1929-32	1932-38	Cont
Efficiency	−0.087	−0.040	0.054
Government	−0.018	0.023	0.209
Investment	−0.001	0.050	0.263
Labor	−0.006	0.071	0.475
Data	−0.113	0.104	1.000

E Data Appendix

- Belgium

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Hours: Clark, C., (1951), The Conditions of Economic Progress, London, Macmillan & Co. Ltd
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Nominal Interest Rate: Historical Financial Statistics, International Policy Rates.

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

- Germany

GDP, Private Consumption, Gross Fixed Capital Formation: Ritschl, A. (2002), Deutschlands Krise und Konjunktur. Binnenkonjunktur, Auslandsverschuldung und Reparationsproblem zwischen Dawes-Plan und Transfersperre 1924-1934, Berlin: Akademie-Verlag.

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

Population: Hoffmann, W.G. (1965): Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts, Berlin: Springer Verlag, Table 1.

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

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- Spain

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