Fiscal Deficits and Unemployment Dynamics: The Role of Productivity Gains and Wage Rigidities*

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Abstract

This paper studies the joint dynamics of fiscal deficits and unemployment in a neoclassical growth model with distortionary taxation, labor market search frictions, and real wage rigidities. First, we show that a tax increase or a reduction in government spending can improve the fiscal balance at the expense of a higher unemployment rate. However, under a scenario of rigid wages and productivity gains, it is possible to achieve a simultaneous reduction of the fiscal deficit and the unemployment rate. Second, we analyze the Swedish fiscal consolidation episode of the 1990s through the lens of the model. The model is capable of reproducing the simultaneous reduction in fiscal deficits and unemployment observed during this episode. Counterfactual simulations show that in the absence of TFP gains and rigid wages, fiscal consolidation measures alone would not have eliminated fiscal deficits, and the unemployment rate would have reached double digit levels.

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I. Introduction

Fiscal consolidation programs have been implemented in recent years in several advanced economies with the objective of reducing fiscal deficits and ensuring sustainable path for public debt. While there are tangible benefits from preserving the sustainability of public finances, fiscal consolidation programs might have negative short-run effects on economic activity and employment. Moreover, critics of consolidation plans argue that these can be self-defeating, as a fiscal tightening may reduce output and worsen the overall fiscal position as tax revenues decline. In this context, a key policy question is how to implement a fiscal consolidation that ensures a reduction in fiscal deficits while simultaneously minimizing output and employment losses. To shed light on this question, using a neoclassical growth model with distortionary taxation and labor search frictions, we analyze the extent to which the combination of productivity gains and wage rigidity can contribute to a simultaneous reduction of fiscal deficits and the unemployment.

Figure 1 motivates our quantitative analysis by illustrating the dynamics of fiscal deficits, unemployment, and total factor productivity (TFP) around major fiscal consolidation episodes in advanced economies. While governments introduced discretionary changes in taxes and spending aimed at reducing fiscal deficits in all those episodes, one salient feature of the data is that countries that experienced improvements in their primary fiscal balances also had significant gains in TFP. The association between TFP gains and improvements in the primary fiscal balance occurs through two channels: (i) an increase of fiscal revenues; and (ii) a reduction of the ratio of government spending to GDP. As TFP improves, there is a boost in output that expands the tax base, resulting in higher fiscal revenue and lower deficits for a given level of tax rates. Moreover, for a given path of government spending, higher TFP and output reduces the ratio of government spending to GDP, generating an improvement in the fiscal balance as percentage of GDP.

Furthermore, as shown in the second chart in Figure 1, countries that experienced higher TFP gains had larger declines in unit labor costs (measured by the ratio of labor compensation to labor productivity). This implies that labor productivity increased at a faster pace than labor compensation during these consolidation episodes. Since wage increases were outpaced by productivity gains (a manifestation of wage rigidities), the relative cost of hiring declined, resulting in a higher labor demand and a lower unemployment rate, as shown in the third chart in Figure 1. To summarize, Figure 1 illustrates that the productivity gains and wage rigidities (reflected in declining unit labor costs) are associated with simultaneous reductions in fiscal deficits and unemployment.

1 Using an action-based database, Guajardo et al. (2011) find that fiscal consolidations have negative effects on GDP and employment in the short-run. Blanchard and Leigh (2013) also find evidence on the negative impact of fiscal consolidations on growth forecast errors.

2 The fiscal consolidation episodes were taken from Devries et al. (2011). We analyze the changes in the primary fiscal deficit, unemployment rate, unit labor costs, and TFP during these episodes. We focus our analysis on the changes that occurred between the trough and the peak of the fiscal primary balance during the consolidation episode in each country. The underlying data for figure 1 are reported in Tables 1 and 2.
With the goal of analyzing the quantitative implications of productivity gains and wage dynamics on fiscal deficits and unemployment, we develop a neoclassical growth model with distortionary taxation, unemployment, and real wage rigidities. In a calibrated version of the model, we first illustrate the implications of fiscal adjustment strategies (a reduction in government spending and a tax rate increase) under different scenarios of productivity and wage dynamics, and show that under the assumption of productivity gains and wage rigidities, it is possible to achieve simultaneous reductions in the fiscal deficit and the unemployment rate. Then, we empirically evaluate the model in a specific episode—the Swedish fiscal consolidation episode (1994-2000). In our simulations, we consider three types of shocks in accounting for the macroeconomic outcomes during this period: (i) government consumption; (ii) tax rates; and (iii) productivity shocks.

The calibrated version of the model is capable of reproducing the simultaneous decline in fiscal deficits and unemployment observed in the Swedish economy during the 1990s. The paper also evaluates the contributions of different factors in accounting for the dynamics of the fiscal balance and unemployment by conducting counterfactual simulations. First, we find that fiscal consolidation measures alone were effective in reducing the fiscal deficit, but at the cost of increasing the unemployment rate. The decline in the unemployment rate during the period is explained by the combination of sustained TFP gains and wage rigidities. In the absence of TFP gains and high wage rigidities, fiscal consolidation measures alone would have resulted in persistent fiscal deficits and a double digit unemployment rate.

This paper is related to the extensive literature on the macroeconomic effects of fiscal policies. Our starting point is a neoclassical model with fiscal policy, as in Ohanian (1997), McGrattan and Ohanian (2010), and Uhlig (2010). However, we depart from the standard neoclassical model by incorporating two features. First, we include frictional unemployment, following Shimer (2005), Mortensen and Pissarides (1994), Merz (1995), and Andolfato (1996). Second, we consider real wage rigidities, as in Shimer (2012) and Gorodnichenko et al. (2012). These two features are key in allowing the model to reproduce the dynamics of unemployment rate during the fiscal episode. This paper contributes to the literature by quantifying the potential role of productivity gains and wage dynamics in offsetting the negative effects of a fiscal adjustment on output and employment.

The remainder of the paper is organized as follows. Section II lays out a neoclassical model with labor search frictions and distortionary taxation. Section III summarizes the calibration strategy. Section IV presents the implications of fiscal adjustment strategies.

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3 In our quantitative analysis, TFP gains are cyclical in nature, i.e., relative to the balanced growth path trend.
4 We consider the Swedish episode as a case study of an advanced economy that successfully implemented a fiscal consolidation program in an environment of high productivity growth and wage rigidities, as illustrated in Figure 1.
5 During the period 1994-2000 the primary balance went from -8 to 2 percent of GDP, while the unemployment rate declined from 9 to 6 percent.
6 Our paper is also related to the study by Anderson et al. (2013), who analyze the role of structural reforms in offsetting the impact of fiscal consolidation on aggregate demand. As opposed to their paper, our work focuses on the implications of fiscal policy and productivity gains on unemployment dynamics.
under different scenarios of productivity gains and wage dynamics. Section V discusses the model-based analysis of the Swedish fiscal consolidation episode. Section VI concludes.

II. A Neoclassical Growth Model with Labor Search Frictions

The starting point of our paper is a neoclassical model, as in Ohanian (1997) and Uhlig (2010). The model also includes two labor market frictions: labor market search and wage rigidities. The model features unemployment generated from the natural search process inherent to labor market transactions as in Mortensen and Pissarides (1994), Merz (1995), Andolfatto (1996), and Shimer (2005). We also introduce wage rigidities as in Shimer (2012) and Gorodnichenko et al. (2012).

The model assumes an economy populated by a mass of infinitely long-lived individuals with identical preferences. Following Merz (1995) and Andolfatto (1996), we assume all individuals live in a representative household that maximizes the sum of its members’ utility function. Final goods are either consumed by households, spent by the government, or invested in capital. The production of final goods is carried out with a constant returns to scale technology that requires labor and capital. A representative firm decides the amount of capital to rent and the number of workers to hire in order to maximize profits. Government spending is financed with debt and distortionary taxation on consumption, labor, and capital income.

Time is discrete and denoted by \( t = 0, 1, 2, \ldots \). The state of the economy at period \( t \) is defined by \( s_t \). Let \( s^t = \{s_0, s_1, \ldots, s_t\} \) denote the history of the economy. Thus, \( x_t(s^t) \) is the value of variable \( x \) in history \( s^t \), determined at period \( t \), and \( z_t(s^{t-1}) \) is the value of variable \( z \) at time \( t \), predetermined in the previous period. Exogenous variables, such as productivity, government spending, and distortionary taxes, depend on the history \( s^t \).

A. Labor market dynamics

At the beginning of each period, household’s members are either working or searching for a job. There are search frictions in the labor market, as in Diamond (1982), Mortensen (1982) and Pissarides (1985). Following Shimer (2010), in each history \( s^t \) in period \( t \), the representative firm divides its total workers between production and recruiting activities. Let \( n_t(s^t) \), \( v_t(s^t) \), and \( u_t(s^t) \) be the mass of employees, the share of employees in recruitment activities (which can be interpreted as a proxy of vacancies), and the mass of households searching for jobs, respectively. Assuming a constant participation rate implies that the unemployment rate satisfies \( u_t(s^t) = 1 - n_t(s^t) \). The number of new workers finding a job is defined by a matching function \( m_t \):

\[
m(u_t(s^t), v_t(s^t)n_t(s^t)) = \omega_{\pi}(u_t(s^t))^{1-l}(v_t(s^t)n_t(s^t))^l,
\]
where \( \omega_\pi \) determines the search efficiency. Note that, by assuming random matching, the probability of finding a job for an unemployed worker is given by:

\[
\frac{m(u_t(s^t), v_t n_t(s^t))}{u_t(s^t)} = \omega_\pi \left( \theta_t(s^t) \right)^t \pi \left( \theta_t(s^t) \right). \tag{1}
\]

where

\[
\theta_t(s^t) = \left( v_t(s^t) n_t(s^t) \right) / u_t(s^t), \tag{2}
\]

is the labor market tightness. Thus, \( l \) corresponds to the elasticity of the probability of finding a job with respect to the labor market tightness. Similarly, the job-filling rate is defined as the numbers of new workers that a firm finds for each worker devoted to recruiting activities:

\[
\frac{m(u_t(s^t), v_t(s^t) n_t(s^t))}{v_t(s^t) n_t(s^t)} = q(\theta_t(s^t)) = \frac{\pi(\theta_t(s^t))}{\theta_t(s^t)} = \omega_\pi (\theta_t(s^t))^{l-1}.
\]

We assume an exogenous destruction rate of jobs each period equal to \( 1 - \rho \). Thus, the household recognizes that the mass of employees evolves as:

\[
n_{t+1}(s^t) = \rho n_t(s^{t-1}) + \pi \left( \theta_t(s^t) \right) (1 - n_t(s^{t-1})). \tag{3}
\]

Importantly, both firms and households take probabilities \( q(\theta_t(s^t)) \) and \( \pi(\theta_t(s^t)) \) as given.

### B. Firms

Production \( (y_t(s^t)) \) takes place in a representative firm that combines capital and labor using a constant return to scale technology. Formally, the production function is given by:

\[
y_t(s^t) = a_t(s^t) k_t^{\alpha_P}(\Gamma_t(1 - v_t(s^t)) n_t(s^{t-1}))^{1-\alpha_P}, \tag{4}
\]

where \( k_t(s^t) \) is the stock of capital, \( v_t(s^t) \) is the fraction of workers in the firms devoted to recruitment, \( a_t(s^t) \) is the time-varying productivity shock and \( \Gamma_t \) is a labor augmenting productivity trend, which has a constant growth rate \( \Gamma_t / \Gamma_{t-1} = 1 + \gamma_g \). This labor augmenting productivity trend determines the growth rate of the economy along the balanced growth path. It is worth noting that production is net of recruitment activities since only a fraction \( 1 - v_t(s^t) \) of the employees is devoted to the production of goods. Having defined the number of new workers that each recruiter can attract, the evolution of employees in the firm is determined by the law of motion:

\[
n_{t+1}(s^t) = \rho n_t(s^{t-1}) + q(\theta_t(s^t)) v_t(s^t) n_t(s^{t-1}). \tag{5}
\]

The representative firm decides the fraction of recruiters, \( v_t(s^t) \), and the stock of capital to rent \( k_t(s^t) \), in such a way to maximize the expected present value of profits. We write the firm’s problem recursively by defining \( F(s^t, n) \) as the expected present value of profits of the firm at history \( s^t \) with a mass \( n \) of workers:

\[
F(s^t, n) = \max_{k_t, v} \left\{ a_t(s^t)(k_t^{\alpha_P}(\Gamma_t(1 - v)n)^{1-\alpha_P} - w_t(s^t)n - \gamma_t(s^t)k^d + E_t \left[ \Lambda_{t,t+1}F(s^{t+1}, n) \right] \right\}, \tag{6}
\]
subject to:
\[ n' = \rho n + q (\theta_t(s^t)) vn. \] (7)

where \( \Lambda_{t,t+1} \) is the stochastic discount factor defined in equilibrium as the marginal of substitution between consumption in period \( t \) and period \( t+1 \). Also, \( w_t(s^t) \) is the wage rate and \( r^k_t(s^t) \) is the rental rate of capital.\(^7\) The optimality conditions for the demand for capital and recruiters are:
\[ r^k_t(s^t) = \alpha_p \left( \frac{y_t(s^t)}{k^t(s^t)} \right)^{1-\alpha_p}, \]
\[ (1 - \alpha_p) \Gamma_t \left( \frac{y_t(s^t)}{\Gamma_t(1 - v_t(s^t))n} \right)^{\alpha_p} = q (\theta_t(s^t)) E_t \left[ \Lambda_{t+1} F_{t+1}(s^{t+1}, n') \right], \]
where \( F_{n,t}(s^t) \) is the value to the firm of having an additional worker at the history \( s^t \) in period \( t \). Finally, using the envelope condition for employment we obtain:
\[ F_{n,t}(s^t) = (1 - \alpha_p) \Gamma_t (1 - v_t(s^t)) \left( \frac{y_t(s^t)}{\Gamma_t(1 - v_t(s^t))n} \right)^{\alpha_p} - w_t(s^t) + (\rho + q (\theta_t(s^t)) v_t(s^t)) [\Lambda_{t+1} F_{n,t+1}(s^{t+1})]. \] (10)

C. Households

The household’s problem has two dimensions. First, they have to choose how much to consume or save in every period. Second, they have to choose how to allocate their savings between capital and government bonds. The household’s utility in the current history \( s^t \) is denoted by \( u_f(c_t(s^t), n_t(s^{t-1}), g_t(s^t)) \), where \( c_t(s^t) \) and \( g_t(s^t) \) are household’s consumption and government consumption in history \( s^t \) period \( t \). The household budget constraint is given by:
\[ (1 + \tau^c_t(s^t)) c_t(s^t) + inv_t(s^t) + b_{t+1}(s^t) = (1 - \tau^n_t(s^t)) w_t(s^t) n_t(s^{t-1}) + tr_t(s^t) + \tau^p_t(s^t) \delta p_{t-1}(s^t) k_t(s^{t-1}) + (1 - \tau^k_t(s^t)) r^k_t(s^t) k_t(s^{t-1}) + p_{k,t}(s^t) k_t(s^{t-1}) + R_{t-1}(s^{t-1}) b_t(s^{t-1}), \]
where \( b_t(s^{t-1}) \) is the amount of one-period government bonds that pays a gross interest rate equal to \( R_{t-1}(s^{t-1}) \). \( \tau^n_t(s^t), \tau^p_t(s^t), \) and \( \tau^k_t(s^t) \) are the labor income, capital income, and consumption tax rates, respectively. The market value of the physical capital depreciation, \( \delta p_{t-1}(s^t) k_t(s^{t-1}) \), is a tax credit on capital income. \( tr_t(s^t) \) represents government lump sum transfers. The capital stock evolves according to the following law of motion:
\[ k_{t+1}(s^t) = (1 - \delta) k_t(s^{t-1}) + \phi \left( \frac{inv_t(s^t)}{k_t'(s^{t-1})} \right) k_t(s^{t-1}), \] (12)

\(^7\) In our setting, the costs of posting vacancies is defined in term of recruitment efforts by firms \( (w_t n_t v_t) \) as in Shimer (2010). In other papers (e.g. Merz, 1995), the cost of posting vacancies is defined in terms of final goods, \( \kappa v_t \), where \( \kappa \) is the cost of each vacancy. Both approaches yield quantitatively similar labor market dynamics.
where $\phi(\cdot)$ is the capital adjustment cost. In equilibrium, the market price of one unit of additional capital stock, $p_{k,t}(s^t)$, satisfies:

$$p_{k,t}(s^t)\phi'\left(\frac{\text{inv}_t(s^t)}{k_t(s^{t-1})}\right) = 1$$  \hspace{1cm} (13)

The households' discount factor is denoted by $\beta \in (0, 1)$. The household must decide how much to save in capital and government bonds. Formally, we lay out the dynamic problem of the representative household in a recursive manner. We denote $H(s^t, n, k, b \cdot)$ as the lifetime utility of the representative household at history $s^t$ in period $t$, with a mass $n$ of members employed, capital stock of $k$ and government bonds of $b$. Then, the household maximization problem can be expressed in a recursive form as:

$$H(s^t, n, k, b \cdot) = \max_{c, b', k'} \left\{ u_f(c, n, g_t(s^t)) + \beta E_t [ H(s^{t+1}, n', k', b') ] \right\} , \hspace{1cm} (14)$$

subject to:

$$(1 + \tau_{ct}^c(s^t))c + \text{inv} + b' = (1 - \tau_{nt}^n(s^t))w_t(s^t)n + tr_t(s^t) + \tau_t^k(s^t)\delta p_{k,t}(s^t)k + (1 - \tau_{kt}^k(s^t))r_t^k(s^t)k + p_{k,t}(s^t)k + R_{t-1}(s^{t-1})b,$$  \hspace{1cm} (15)

$$n' = \rho n + \pi (\theta_t(s^t))(1 - n).$$  \hspace{1cm} (16)

The first order condition for consumption implies that:

$$\Lambda_{t,t+1} = \beta \frac{u_{fc,t+1}}{u_{fc,t}} \frac{1 + \tau_{ct}^c}{1 + \tau_{ct}^c} ,$$  \hspace{1cm} (17)

where $u_{fc,t}$ is the marginal utility of consumption in period $t$. The optimal conditions for capital and government bonds holdings yield:

$$p_{k,t}(s^t) = \mathbb{E}_t \left[ \Lambda_{t,t+1} \left( \frac{p_{k,t+1}(s^{t+1})}{p_{k,t+1}(s^{t+1})} + \frac{(1 - \tau_{kt}^k(s^{t+1}))(r_{t+1}^k(s^{t+1}) - \delta_{k,t+1}(s^{t+1}))}{(1 - \tau_{kt}^k(s^{t+1}))} \right) \right] ,$$  \hspace{1cm} (18)

$$1 = R_t(s^t)\mathbb{E}_t [ \Lambda_{t,t+1} ] .$$  \hspace{1cm} (19)

We define the marginal value for the households of having an additional member employed in history $s^t$, period $t$, as $H_{n,t}(s^t)$. Using the envelope condition, we obtain:

$$H_{n,t}(s^t) = u_{fn,t}(s^t) + \frac{1 - \tau_{nt}^n(s^t)}{1 + \tau_{ct}^c(s^t)}\frac{w_t(s^t)u_{fc,t} + (\rho - \pi (\theta_t(s^t)))}{\beta \mathbb{E}_t [ H_{n,t+1}(s^{t+1}) ]} ,$$  \hspace{1cm} (20)

where $u_{fn,t}$ is the marginal disutility of having one additional member employed in period $t$. 

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D. Wage determination

In the presence of search frictions, a surplus is generated when an unemployed worker is matched with a recruiting firm. This surplus is divided between the firm and the worker. Clearly, this division could be accomplished in many different ways. We follow the literature and assume that if wages are flexible, the surplus is divided between firms and workers as the result of a Nash bargaining. If \( \eta \) represents the bargaining power of the workers, then the Nash bargaining assumption implies that the following condition is satisfied under wage flexibility:\(^8\)

\[
\eta F_{n,t}(s^t) w_{f,c,t}(s^t) \frac{1 - \tau_n(s^t)}{1 + \tau_c(s^t)} = (1 - \eta) H_{n,t}(s^t).
\] (21)

We will denote \( w_t^*(s^t) \) as the wage rate that would prevail when this condition is satisfied.

When simulating the effects of a fiscal consolidation, we will assume that wages are rigid, and the actual wage rate \( w_t(s^t) \) is determined by the following equation:

\[
w_t(s^t) = \left(w_{t-1}(s^{t-1}) \right)^{\chi_w} \left(w_t^*(s^t)\right)^{1-\chi_w}.
\] (22)

where the parameter \( \chi_w \) controls the degree of wage rigidity. In order to determine if the wage rate \( w_t(s^t) \) is feasible, it is important to check that the values of both workers and firms are higher than their respective outside options at the wage \( w_t(s^t) \). These conditions correspond to verify that \( H_{n,t}(s^t) \geq 0 \) and \( F_{n,t}(s^t) \geq 0 \) at the actual wage \( w_t(s^t) \). If these two conditions hold, the household is willing to have an additional member working, and the firm is willing to hire an additional worker at the actual wage rate \( w_t(s^t) \).\(^9\)

E. Government and aggregate equilibrium

The primary balance of the government is defined as:

\[
ps_t(s^t) = \tau_n^t(s^t) w_t(s^t) n_t(s^{t-1}) + \tau_c^t(s^t) (r_k^t(s^t) - \delta p_{k,t}(s^t)) k_t(s^{t-1}) + \tau_c^t(s^t) c_t(s^t) - tr_t(s^t) - g_t(s^t),
\] (23)

where government consumption, labor, capital and consumption taxes follow stochastic processes. We assume that government transfers follow a rule that guarantees a stationary public debt. The stochastic process for the fiscal variables are explained in more detail in the calibration section.

The government budget constraint can be written as:

\[
ps_t(s^t) + b_{t+1}(s^t) = R_{t-1}(s^{t-1}) b_t(s^{t-1}).
\] (24)

The equilibrium condition in the market for capital services states that:

\[
k^d_t(s^t) = k_t(s^{t-1}).
\] (25)

\(^8\) For more details see Shimer (2010).

\(^9\) In the model simulations, we verified that \( H_{n,t}(s^t) \geq 0 \) and \( F_{n,t}(s^t) \geq 0 \) hold at the equilibrium wage rate.
Combining the household and government budget constraints, we obtain:

\[ y_t(s^t) = c_t(s^t) + g_t(s^t) + \text{inv}_t(s^t). \]  \hspace{1cm} (26)

A detailed description of the model equilibrium conditions can be found in appendix A.

### III. Calibration

In this section, we describe our calibration strategy in detail. Some of the parameters values relevant for capturing labor market frictions, technology, or preferences are chosen to match some features of the Swedish economy. However, a subset of the parameters is set to standard values used in the literature. The full set of parameters used for our baseline simulations is summarized in Table 3.

We calibrate the model to an annual frequency, with a labor augmenting technology that grows at 2.1 percent \((\gamma_g = 1.021)\). Consistent with an annual real interest of 4 percent, we set \(\beta = (1 + \gamma_g)/1.04\).

Following Shimer (2005), we use the average monthly job-finding rate of 0.45. The steady state unemployment rate is set to 5.5 percent. Based on the fact that the unemployment rate at the steady state is \((1 - \rho)/(1 - \rho + \pi(\bar{\theta}))\), we obtain the corresponding monthly separation rate, \(1 - \rho = 0.026\). With this information, we calculate the monthly transition probability matrix for employment and unemployment as:

\[
\begin{bmatrix}
1 - 0.026 & 0.45 \\
0.026 & 1 - 0.45
\end{bmatrix}.
\]

The annual transition probability matrix can be computed as \(P_a = (P_m)^{12}\). Thus, for the annual basis, we get \(\pi(\bar{\theta}) = P_a(1,2) = 0.9446\) and \(\rho = 1 - P_a(2,1) = 1 - 0.0550\). For the *matching function*, we choose \(l = 0.5\), which corresponds to the midpoint of the range of values typically used in the literature (see Hagedorn and Manovskii (2008), Shimer (2005), Hall (2005), Andolfatto (1996), and Merz (1995)). To obtain the efficiency parameter of the matching parameter, \(\omega\pi\), we follow the procedure in Shimer (2010), which accounts for the fact that recruiting effort uses approximately 4 percent of one worker’s quarterly wage, implying that a recruiter can attract approximately 25 new workers in a quarter, and 100 new workers in a year: \(q(\bar{\theta}) = \omega\pi(\bar{\theta})^{l-1} = 100\). Under this assumption, we obtain \(\omega\pi = 9.75\).\(^\text{10}\)

The uncertainty in the model, embedded in the history \(s^t\), is determined by time-varying productivity shock and fiscal variables. We assume that these variables follow univariate autoregressive processes:

\[
\begin{align*}
\log(a_t/\bar{a}) &= \rho_a \log(a_{t-1}/\bar{a}) + \varepsilon_{a,t} \\
\log(g_t/(\Gamma_t\bar{g})) &= \rho_g \log(g_{t-1}/(\Gamma_t\bar{g})) + \varepsilon_{g,t}
\end{align*}
\]  \hspace{1cm} (27)  \hspace{1cm} (28)

\(^{10}\) In monthly terms, the efficiency parameter turns out to be 1.94, which is close to the value used by Shimer (2010).
\[
\log((1 + \tau^c_t)/(1 + \bar{\tau}^c)) = \rho_{\tau^c} \log((1 + \tau^c_{t-1})/(1 + \bar{\tau}^c)) + \varepsilon_{\tau^c,t} \tag{29}
\]
\[
\log((1 + \tau^k_t)/(1 + \bar{\tau}^k)) = \rho_{\tau^k} \log((1 + \tau^k_{t-1})/(1 + \bar{\tau}^k)) + \varepsilon_{\tau^k,t} \tag{30}
\]
\[
\log((1 + \tau^n_t)/(1 + \bar{\tau}^n)) = \rho_{\tau^n} \log((1 + \tau^n_{t-1})/(1 + \bar{\tau}^n)) + \varepsilon_{\tau^n,t} \tag{31}
\]
\[
\log(tr_t/(\Gamma_t \bar{tr})) = \rho_{tr} \log(tr_{t-1}/(\Gamma_{t-1} \bar{tr})) - \varrho_G \log \left( \frac{b_t}{\Gamma_t \bar{b}} \right). \tag{32}
\]

\(\varepsilon_{j,t}\) is an i.i.d. shock with a zero mean and standard deviation equal to \(\sigma_j\) for \(j = a, g, \tau^c, \tau^n, \tau^k\). We impose \(\varrho_G > 0\) in order to guarantee that the government debt is stationary along the balanced growth path.

To estimate the process for the time-varying productivity shocks, \(a_t\), we use the series for TFP in Sweden from the AMECO database, which are calculated as a Solow residual. We detrend this series and normalize \(\bar{a} = 1\). The series for tax rates are calculated using data from Haver Analytics, AMECO, and OECD, following the methodology in Mendoza et al. (1994).\(^{11}\) Government expenditure corresponds to total government consumption of goods and services from Haver Analytics. Based on these series, we assume that, in the steady state, the consumption tax rate is 21 percent (\(\bar{\tau}^c = 0.21\)), the labor income tax rate is 50 percent (\(\bar{\tau}^n = 0.50\)), and the capital income tax rate is 33 percent (\(\bar{\tau}^k = 0.33\)). Government consumption as percentage of GDP is set at 29 percent. Finally, using these series, we estimate the AR(1) coefficients using OLS: \(\rho_a = 0.81\), \(\rho_g = 0.82\), \(\rho_{\tau^c} = 0.82\), \(\rho_{\tau^n} = 0.77\), \(\rho_{\tau^k} = 0.62\). From the OLS estimation for AR(1) we also obtain \(\sigma_a = 0.016\), \(\sigma_g = 0.015\), \(\sigma_{\tau^c} = 0.011\), \(\sigma_{\tau^n} = 0.015\), and \(\sigma_{\tau^k} = 0.012\). We set \(\rho_{tr} = 0.82\) and \(\varrho_G = 0.05\).\(^{12}\)

We assume that government debt is 65 percent of GDP at the steady state, which, combined with the government budget constraint, gives the amount of transfer at the steady state.

For production technology, we consider \(\alpha_p = 0.30\) consistent with the evidence shown in Gollin (2002). This capital share in production, the capital income tax rate at the steady state, and \(\delta = 0.04\) imply an average investment-GDP ratio around of 18.5 percent. To determine the equilibrium flexible wages, we first need the value of the bargaining power of workers, \(\eta\). As it is a common practice in the literature, we impose \(\eta = 1 - l\), which states that the bargaining power of workers is equal to the elasticity of the matching function with respect to the mass of unemployed workers. This choice guarantees that Hosios’s (1990) condition for efficiency is satisfied.

The capital adjustment cost is modeled as:
\[
\phi(x) = \phi_2(x - \delta - \gamma_g)^2 / 2.
\]

Using an elasticity of price of capital relative to investment capital ratio of 0.15, we set \(\phi_2 = 0.15 / (\delta + \gamma_g) = 2.41\), which matches the investment adjustment cost in Sweden estimated by Christiano et al. (2011).

---

\(^{11}\) The methodology is explained in Appendix B.

\(^{12}\) These values are consistent with the estimated range for fiscal reaction functions in advanced economies in D’Erasmo et al. (2015).
Households’ preferences are represented by the following functional form:

\[ u_{ft} = \frac{\chi_{g}}{\chi_{g} - 1} \log \left( (c_{t})^{1-1/\chi_{g}} + (g_{t})^{1-1/\chi_{g}} \right) - \xi_{N} \frac{1 + \sigma_{L}}{1 + \sigma_{L}}, \]

where we set \( \sigma_{L} = 1 \). The presence of \( g_{t} \) in the utility function introduces a complementarity between private consumption and government consumption if \( \chi_{g} < 1 \). This assumption allows the model to reproduce the correlation between private and government consumption observed in the data. We set \( \xi_{N} = 0.0591 \) in order to be consistent with the wage rate obtained in the steady state from the firm’s optimality conditions.

Finally, we need to choose values for the parameters controlling (i) the degree of complementarity between private and government consumption, \( \chi_{g} \), and (ii) the degree of wage rigidity, \( \chi_{w} \). Feeding the model with the stochastic processes described above, we set these parameters’ values to target two observed correlations in Sweden during 1995–2015: (i) the correlation between wage rate and TFP (0.36), and (ii) the correlation between private and government consumption (0.21). To compute these correlations, we use detrended series for private consumption, government consumption, real compensation per employee from AMECO for Sweden, and the detrended residuals of the TFP in Sweden computed above.\(^{13}\) This procedure implies that \( \chi_{g} = 0.21 \) and \( \chi_{w} = 0.93 \). It is worth noting that the value of \( \chi_{w} \) we obtain is close to the one assumed by Gorodnichenko et al. (2012), which captures the degree of wage rigidities in Nordic countries.

\[ \text{IV. Interaction Between Fiscal Adjustment, Productivity Gains, and Wage Dynamics} \]

In this section, we analyze the interaction between fiscal adjustment strategies (higher taxes and lower government spending) and different assumptions on productivity gains and wage dynamics. Figure 2 shows the macroeconomic effects from a negative government spending shock.\(^{14}\) The blue line depicts the scenario of low wage rigidity (\( \chi_{w} = 0.7 = 0.75 \times 93 \)).\(^{15}\) As anticipated in a neoclassical model, lower government spending generates a positive wealth effect that results in a higher unemployment rate and lower GDP. Consistent with a decline in labor supply, real wages increase. While this fiscal consolidation generates an increase in the unemployment rate, it improves the primary balance, as the ratio of government spending to GDP is lower.

\(^{13}\) To detrend these series we use the Hodrick-Prescott filter.

\(^{14}\) The size of the fiscal shock is calibrated to achieve approximately a 1 percent improvement in the fiscal balance as percentage of GDP under the scenario of low wage rigidity.

\(^{15}\) The quantitative results in this section are obtained from the model calibrated to the Swedish economy. However, we explored different calibrated versions of the model obtaining similar results. As long as productivity gains and wage rigidities are sufficiently large, it is possible to simultaneously improve the fiscal balance and reduce the unemployment rate.
Next, we assume the same fiscal adjustment, but with a simultaneous persistent increase in TFP (red line). As a result of higher TFP, there is a modest expansion in GDP and an improvement in the fiscal balance. However, as wages increase in response to gains in TFP, there is not much variation in the unemployment rate. Finally, we evaluate a reduction in government spending with the combined effect of an increase in TFP and higher wage rigidity ($\chi_w = 0.93$). This last experiment generate dramatic results in terms of the dynamics of the main macroeconomic variables. First, there is a substantial and persistent increase in GDP, coupled with a decline in the unemployment rate. Second, the improvement in the primary balance becomes more persistent. Real wages only increase gradually over time, resulting in a significant increase in labor demand that translates into a lower unemployment rate and higher GDP. The key result of this exercise is that the negative effect of a fiscal adjustment on GDP can be offset by the combination of productivity gains and wage rigidities. Under this scenario, not only it is possible to achieve a decline in the unemployment rate, but also a persistent improvement in the fiscal balance.

Figure 3 presents a similar exercise and shows the macroeconomic response to an increase in the labor tax rate. As expected, an increase in labor tax reduces the labor supply, resulting in a higher unemployment rate and lower GDP, but with an improvement in the primary balance. Higher TFP can partially offset the contractionary effects on GDP, but with limited impact on the unemployment rate as wages respond to TFP gains. Under the combination of productivity gains and wage rigidities, it is possible to reduce the unemployment rate, increase GDP, and improve the primary balance simultaneously. Consistent with the previous exercise, we find that fiscal adjustments in combination with productivity gains and wage rigidities, can ensure simultaneous reductions in unemployment and fiscal deficits. In the next section, we use our model to analyze the role of fiscal policy measures, productivity gains, and wage rigidities in driving the macroeconomic outcome during the Swedish fiscal consolidation episode.

V. A Model-Based Analysis of a Fiscal Consolidation Episode: Sweden 1994–2000

In this section, we simulate the calibrated model in order to match the dynamics of key macroeconomic variables during the Swedish fiscal consolidation episode (1994–2000). We first briefly document the initial macroeconomic conditions and fiscal policy responses, and then quantitatively analyze the role played by fiscal policy shocks, productivity gains, and wage rigidities in accounting for the macroeconomic outcome during this episode.

16 As in the previous case, the magnitude of the increase in the labor tax rate is set to achieve approximately a rise of a 1 percent in the fiscal balance as percentage of GDP.
A. Initial Macroeconomic Conditions and Fiscal Policy Responses in Sweden

Between 1990 and 1993, Sweden experienced one of the worst recessions since the Great Depression as a result of a global downturn and a subsequent domestic banking crisis. As shown in panel A of Figure 4, the GDP declined by 4 percent between 1990 and 1993. In terms of detrended output, the contraction was 10 percent. The impact of the recession on the labor market was striking. The unemployment rate soared, going from 1.7 percent to 9.1 percent. Moreover, the primary fiscal balance suffered a significant deterioration, reaching a deficit of 12 percent of GDP. Not only did government consumption, as a share of GDP, increase, but net taxes (tax revenues minus transfers) also deteriorated sharply in response to the cyclical conditions in the economy.\footnote{The banking crisis that occurred during 1992–93 also contributed to the widening of the fiscal deficits. Floden (2013) estimates that the fiscal costs associated with the banking crisis were around 4 percent of GDP. In this paper, we take as given the initial conditions, and do not model the banking crisis. We focus our analysis on the recovery period, when the fiscal consolidation and structural reforms take place.}

In this context, the Swedish government implemented an aggressive fiscal consolidation program, encompassing tax increases and spending cuts. Figure 5 shows how the fiscal consolidation measures resulted in increases in the effective tax rates on consumption, labor, and capital, and a reduction in detrended government consumption.\footnote{The effective tax rates were calculated following the methodology described in Mendoza et al. (1994). See Appendix B for more details on the estimation of these tax rates.} The estimated effective consumption tax increased during the sample period as a result of higher alcohol, tobacco, and energy taxes, as well as a broadening of the tax base. The increase in the labor tax rate reflected an increase in personal income tax, as well as higher social security contributions. The effective capital tax rate increased in response to higher taxation on dividends, capital gains, and real estate property. Finally, detrended real public consumption decreased as a result of discretionary measures, as well as the introduction of the new fiscal framework, which ensured that government spending increased at a lower rate than nominal GDP growth.

Changes in the fiscal policy variables were not the only factors operating during this period. Productivity gains were also very important drivers of the economic recovery. In fact, detrended TFP increased by about 5 percent between 1994 and 2000. The gains in TFP in Sweden were particularly large during this episode, twice as high as in the European Union as a whole.\footnote{The McKinsey Global Institute (2006) published a report showing how the regulatory reform and joining the EU contributed to the large gains in productivity during the 1990s in several economic sectors. Independent of the underlying factors behind the rise in TFP, these productivity gains facilitated the fiscal consolidation efforts that took place during the 1990s.}

The main goal of the model-based analysis is to disentangle the key driving factors behind these macroeconomic outcome during the fiscal consolidation episode. In the next subsection, we evaluate the contribution of fiscal measures, productivity gains, and rigid real wages in explaining the macroeconomic outcome of the Swedish episode.
B. Model-Based Analysis

In this subsection, we evaluate the performance of the model in reproducing key macroeconomic variable in Sweden during the period 1994–2000. Considering 1994 as the starting point, we feed the calibrated model with the estimated fiscal and productivity shocks. The model simulation is presented in Figure 6 along with the actual behavior of the main macroeconomic variables, namely, the unemployment rate, detrended GDP, primary fiscal balance as percentage of GDP, and government revenues as percentage of GDP. The model is capable of replicating the patterns of these variables. Particularly notable is the simultaneous reduction of the unemployment rate and fiscal deficit, in spite of the fiscal consolidation efforts. While the model can broadly account for the output expansion experienced during the sample period, it overstates detrended GDP by 4 percentage points. Next, we evaluate the role played by fiscal consolidation measures, TFP gains, and wage rigidity in accounting for the behavior of macroeconomic variables during this episode.

Figure 7 reports the model simulation when all shocks are operating (black line), and in the absence of fiscal policy shocks (green line). The latter simulation illustrates the counterfactual outcomes in the absence of a fiscal adjustment. As anticipated, without discretionary fiscal policy measures, detrended GDP would have experienced a further expansion of about 3 percentage points, and the unemployment rate would have declined further by 4 percentage points. However, the fiscal deficit would have reached 5 percent of GDP instead of the fiscal surplus of 2 percent predicted by the model. A notable feature of this counterfactual simulation is the resulting trade-off associated with fiscal consolidation measures. While the absence of fiscal adjustment might have generated higher output and a reduction in the unemployment rate, those outcomes would have been achieved at the expense of larger fiscal deficits.

The negative impact of fiscal consolidation measures on output and employment could be offset by higher TFP gains. As shown in Figure 8, in the absence of productivity gains, the unemployment rate would have increased beyond 15 percent, detrended output would have declined by 7 percentage points during the sample period, and the fiscal deficit would have stabilized at around 5 percent of GDP. Notice that the effect of productivity gains on the fiscal primary balance comes from two effects: higher revenue and a lower ratio of government expenditure to GDP. In Sweden’s case, the simulations suggest that the main channel comes from the expenditure side. Higher productivity resulted in an expansion of GDP faster than government spending, resulting in a reduction of government spending relative to the size of the economy.

Figure 9 shows the simulation for a scenario with a lower degree of wage rigidity. The simulation shows that in a scenario of lower wage rigidity ($\chi_w = 0.93 \times 0.75$), the unemployment rate would have increased to double digits, leading to lower output and slower improvement of the primary fiscal balance.

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20 Since our model is stochastic, fiscal and productivity shocks are modeled as unanticipated innovations that take place in each period as in McGrattan and Ohanian (2010).

21 We also evaluate lower values of the parameter $\chi_w$, which would generate higher rates of unemployment.
Finally, figure 10 evaluates the model results under three alternative preference specifications: (i) omitting government consumption, (ii) omitting leisure, and (iii) omitting both government consumption and leisure. As discussed in figure 6, the benchmark preferences (black line) are capable of broadly reproducing the key macroeconomic variables during the consolidation episode. When government consumption is not included in the utility function (green line), we observe an increase in unemployment and a decline in GDP. Since the wealth effect of government spending becomes weaker, the model generates a decline in the labor supply relative to the benchmark simulation, which in turn induces an increase in the unemployment rate and a decline in GDP. Also, when leisure is not part of the preferences (blue line), the model features a larger volatility of unemployment as households do not seek to smooth leisure over the business cycle. Hence, in response to fiscal consolidation shocks, the labor demand by firm declines, generating a substantial increase in unemployment and a decline in GDP. Finally, when we abstract from both leisure and government consumption in the preferences (red line), we observe a significant increase in unemployment and a decline in GDP, which captures the combined effect of the two previous specifications. Overall, these simulations suggest that the benchmark preferences, which in addition to private consumption include leisure and government consumption, are key for the ability of the model to replicate the observed macroeconomic data during the Swedish consolidation episode.

In sum, the model simulations of the Swedish episode illustrate the fact that the implementation of fiscal consolidation measures alone might be insufficient for a sustained reduction of the fiscal deficits. In addition, an improvement in TFP coupled with rigid wages, can contribute to the simultaneous reduction of fiscal deficits and unemployment.

VI. Conclusions

In this paper, we analyzed the role played by productivity gains, wage rigidities, and fiscal policy shocks in explaining the joint dynamics of fiscal deficits and unemployment. Using a neoclassical growth model with search frictions and wage rigidities, we first analyzed the interactions between fiscal policy measures, productivity gains and wage rigidities. Our main findings are: First, gains in TFP are a crucial factor that can contribute to a reduction of fiscal deficits. Second, wage rigidities ensures a simultaneous reduction of fiscal deficits and unemployment in a scenario of positive TFP shocks.

We also used the model to analyze the driving forces behind the success of the Sweden fiscal consolidation episode of the 1990s. Model simulations for this episode confirm the two main results for the Swedish case. During the 1990s, output and employment gains, as well as the substantial improvement in the fiscal balance, were, to a great extent, possible due to productivity gains and wage rigidities. 22

22 Although there are other potential factors that could have played a role in this consolidation episode, such as the adoption of an inflation targeting regime, the rescue of the banking system, and the exchange rate devaluation of 1992, our quantitative analysis shows that the persistent gains in productivity and wage...
The policy implication of our analysis is that, given the prevalence of wage rigidities in countries affected by the crisis (Schmitt-Grohé and Uribe, 2013), productivity gains are a crucial component in facilitating fiscal adjustment in advanced economies. In the absence of policies that encourage improvements in economic efficiency and TFP, fiscal consolidations might not be very effective; fiscal deficits might experience only modest reductions with large increases in unemployment rates. As discussed by Shimer (2012), under the presence of wage rigidities, negative shocks (real or fiscal) can induce a significant rise in the unemployment rate.

There are several possible extensions of this paper for future research. First, we could include a monetary sector in the model to evaluate the role of monetary policy in insulating the labor market during the consolidation episode. Second, we could extend our model to an open economy setting to assess the implications of fiscal consolidation, productivity gains and wage rigidities on the trade balance. Third, we could evaluate the role of credibility in shaping the outcome of a fiscal consolidation. Finally, we could conduct a cross-country analysis to corroborate the results of the Swedish experience. For instance, as discussed in Gorodnichenko et al. (2012), Finland experienced an even bigger recession than Sweden’s, and also implemented a fiscal consolidation. It might be interesting to apply the same methodology for evaluating the role played by productivity gains and wage rigidities during the Finnish consolidation episode.

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Table 1. Fiscal Primary Balance and TFP Gains in Advanced Economies

<table>
<thead>
<tr>
<th>Country</th>
<th>Primary Balance Trough</th>
<th>Primary Balance Peak</th>
<th>Δ Primary Balance</th>
<th>Δ TFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia (1992-2002)</td>
<td>-3.1</td>
<td>1.9</td>
<td>5.1</td>
<td>11.2</td>
</tr>
<tr>
<td>Austria (1994-2004)</td>
<td>-6.4</td>
<td>-0.2</td>
<td>6.2</td>
<td>6.4</td>
</tr>
<tr>
<td>Belgium (1980-1990)</td>
<td>-8.4</td>
<td>4.1</td>
<td>12.5</td>
<td>11.3</td>
</tr>
<tr>
<td>Canada (1981-2001)</td>
<td>-4.0</td>
<td>5.8</td>
<td>9.8</td>
<td>12.1</td>
</tr>
<tr>
<td>Denmark (1980-1990)</td>
<td>-6.2</td>
<td>7.9</td>
<td>14.2</td>
<td>8.7</td>
</tr>
<tr>
<td>Finland (1991-2001)</td>
<td>-8.5</td>
<td>7.6</td>
<td>16.1</td>
<td>22.4</td>
</tr>
<tr>
<td>France (1991-2001)</td>
<td>-3.7</td>
<td>1.3</td>
<td>5.0</td>
<td>9.1</td>
</tr>
<tr>
<td>Germany (1995-2005)</td>
<td>-6.4</td>
<td>3.6</td>
<td>10.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Italy (1988-1998)</td>
<td>-3.0</td>
<td>5.7</td>
<td>8.7</td>
<td>9.5</td>
</tr>
<tr>
<td>Japan (1980-1990)</td>
<td>-3.7</td>
<td>2.9</td>
<td>6.5</td>
<td>24.1</td>
</tr>
<tr>
<td>Spain (1982-1992)</td>
<td>-5.9</td>
<td>-0.6</td>
<td>5.3</td>
<td>10.3</td>
</tr>
<tr>
<td>Sweden (1992-2002)</td>
<td>-10.0</td>
<td>5.3</td>
<td>15.3</td>
<td>17.9</td>
</tr>
<tr>
<td>United Kingdom (1993-2003)</td>
<td>-5.4</td>
<td>2.8</td>
<td>8.1</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Source: AMECO and WEO.

Table 2. Unemployment Rate, Wages, and Unit Labor Costs in Advanced Economies

<table>
<thead>
<tr>
<th>Country</th>
<th>Δ Unemployment Rate</th>
<th>Δ Wage Compensation</th>
<th>Δ Unit Labor Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia (1992-2002)</td>
<td>-4.4</td>
<td>12.3</td>
<td>-1.8</td>
</tr>
<tr>
<td>Austria (1994-2004)</td>
<td>-0.2</td>
<td>4.6</td>
<td>-6.3</td>
</tr>
<tr>
<td>Belgium (1980-1990)</td>
<td>-2.8</td>
<td>7.8</td>
<td>-8.7</td>
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<tr>
<td>Canada (1981-2001)</td>
<td>-3.6</td>
<td>6.2</td>
<td>-6.3</td>
</tr>
<tr>
<td>Denmark (1980-1990)</td>
<td>-3.4</td>
<td>4.6</td>
<td>-4.7</td>
</tr>
<tr>
<td>Finland (1991-2001)</td>
<td>-6.5</td>
<td>9.6</td>
<td>-11.6</td>
</tr>
<tr>
<td>France (1991-2001)</td>
<td>-1.5</td>
<td>6.7</td>
<td>-4.2</td>
</tr>
<tr>
<td>Germany (1995-2005)</td>
<td>-0.3</td>
<td>3.7</td>
<td>-0.7</td>
</tr>
<tr>
<td>Italy (1988-1998)</td>
<td>1.5</td>
<td>9.5</td>
<td>-7.6</td>
</tr>
<tr>
<td>Japan (1980-1990)</td>
<td>0.1</td>
<td>23.7</td>
<td>-12.4</td>
</tr>
<tr>
<td>Spain (1982-1992)</td>
<td>0.5</td>
<td>3.6</td>
<td>-10.5</td>
</tr>
<tr>
<td>Sweden (1992-2002)</td>
<td>-3.5</td>
<td>17.3</td>
<td>-3.5</td>
</tr>
<tr>
<td>United Kingdom (1993-2003)</td>
<td>-4.8</td>
<td>14.7</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Source: AMECO and WEO.
Table 3: Baseline calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_g$</td>
<td>Growth rate of the labor aug. prod.</td>
<td>1.021</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Discount factor</td>
<td>0.982</td>
</tr>
<tr>
<td>$l$</td>
<td>Elasticity of matches to recruiters</td>
<td>0.5</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Worker bargaining power</td>
<td>0.5</td>
</tr>
<tr>
<td>$\pi(\bar{\theta})$</td>
<td>Job finding rate</td>
<td>Set to target monthly rate of 0.45</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Employment survival rate</td>
<td></td>
</tr>
<tr>
<td>$\omega_{\pi}$</td>
<td>Matching function constant</td>
<td>Set to target $q(\bar{\theta}) = 100$</td>
</tr>
<tr>
<td>$\alpha_p$</td>
<td>Share of capital in the prod. function</td>
<td>0.30</td>
</tr>
<tr>
<td>$\bar{a}$</td>
<td>Steady state value for detrended productivity</td>
<td>1.00</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Capital depreciation rate</td>
<td>0.04</td>
</tr>
<tr>
<td>$\phi_2$</td>
<td>Capital adjustment cost parameter</td>
<td>2.41</td>
</tr>
<tr>
<td>$\sigma_L$</td>
<td>Inverse of aggregate labor elasticity</td>
<td>1.00</td>
</tr>
<tr>
<td>$\xi_N$</td>
<td>Labor disutility parameter</td>
<td></td>
</tr>
<tr>
<td>$\bar{g}$</td>
<td>Detrended value for Govt. Spending</td>
<td>Set to target $g/GDP = 0.29$</td>
</tr>
<tr>
<td>$\bar{\pi}^c$</td>
<td>Steady state value for consumption tax rate</td>
<td>0.21</td>
</tr>
<tr>
<td>$\bar{\pi}^n$</td>
<td>Steady state value for consumption tax rate</td>
<td>0.50</td>
</tr>
<tr>
<td>$\bar{\pi}^k$</td>
<td>Steady state value for consumption tax rate</td>
<td>0.33</td>
</tr>
<tr>
<td>$\bar{b}$</td>
<td>Detrended value for Govt. debt</td>
<td>Set to target $b/GDP = 0.65$</td>
</tr>
<tr>
<td>$\rho_a$</td>
<td>Persistence of productivity shocks</td>
<td>0.81</td>
</tr>
<tr>
<td>$\rho_g$</td>
<td>Persistence of govt. spending shocks</td>
<td>0.82</td>
</tr>
<tr>
<td>$\rho_{pc}$</td>
<td>Persistence of consumption tax</td>
<td>0.82</td>
</tr>
<tr>
<td>$\rho_{pn}$</td>
<td>Persistence of consumption tax</td>
<td>0.77</td>
</tr>
<tr>
<td>$\rho_{pk}$</td>
<td>Persistence of consumption tax</td>
<td>0.62</td>
</tr>
<tr>
<td>$\rho_{tr}$</td>
<td>Persistence of govt transfers</td>
<td>0.82</td>
</tr>
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<td>$\theta_G$</td>
<td>Fiscal transfer rule parameter</td>
<td>0.05</td>
</tr>
<tr>
<td>$\sigma_a$</td>
<td>St. dev. of productivity shocks</td>
<td>0.016</td>
</tr>
<tr>
<td>$\sigma_g$</td>
<td>St. dev. of govt. spending shocks</td>
<td>0.016</td>
</tr>
<tr>
<td>$\sigma_{pc}$</td>
<td>St. dev. of consumption tax shocks</td>
<td>0.011</td>
</tr>
<tr>
<td>$\sigma_{pn}$</td>
<td>St. dev. of labor tax shocks</td>
<td>0.015</td>
</tr>
<tr>
<td>$\sigma_{pk}$</td>
<td>St. dev. of capital tax shocks</td>
<td>0.012</td>
</tr>
<tr>
<td>$\chi_w$</td>
<td>Parameter of wage rigidity</td>
<td>Set to target $corr(w, a) = 0.36$</td>
</tr>
<tr>
<td>$\chi_g$</td>
<td>Parameter for complementarity b/w c and g</td>
<td>Set to target $corr(g, c) = 0.21$</td>
</tr>
</tbody>
</table>
Figure 1: Fiscal Adjustment, Unemployment, and TFP Gains

Source: AMECO, WEO.
Figure 2: Fiscal adjustment through a fiscal spending cut

- GDP
- Unemployment
- Real wages
- Prim Bal/GDP
- Fiscal Rev/GDP
- Fiscal Spend/GDP

Legend:
- Blue line: Less wage rigidity ($\chi_w = 0.75 \times 0.93$)
- Red line: Less wage rigidity ($\chi_w = 0.75 \times 0.93$) and productivity gains
- Green line: Wage rigidity ($\chi_w = 0.93$) and productivity gains

Years vs. Deviation from SS: GDP, Unemployment, Real wages, Prim Bal/GDP, Fiscal Rev/GDP, Fiscal Spend/GDP

- GDP
- Unemployment
- Real wages
- Prim Bal/GDP
- Fiscal Rev/GDP
- Fiscal Spend/GDP

Deviation from SS: GDP, Unemployment, Real wages, Prim Bal/GDP, Fiscal Rev/GDP, Fiscal Spend/GDP

Years: 0 2 4 6 8 10

GDP, Unemployment, Real wages, Prim Bal/GDP, Fiscal Rev/GDP, Fiscal Spend/GDP: Deviation from SS

- GDP
- Unemployment
- Real wages
- Prim Bal/GDP
- Fiscal Rev/GDP
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GDP, Unemployment, Real wages, Prim Bal/GDP, Fiscal Rev/GDP, Fiscal Spend/GDP: Deviation from SS

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Deviation from SS: GDP, Unemployment, Real wages, Prim Bal/GDP, Fiscal Rev/GDP, Fiscal Spend/GDP

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GDP, Unemployment, Real wages, Prim Bal/GDP, Fiscal Rev/GDP, Fiscal Spend/GDP: Deviation from SS

- GDP
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- Prim Bal/GDP
- Fiscal Rev/GDP
- Fiscal Spend/GDP

Deviation from SS: GDP, Unemployment, Real wages, Prim Bal/GDP, Fiscal Rev/GDP, Fiscal Spend/GDP

Years: 0 2 4 6 8 10

GDP, Unemployment, Real wages, Prim Bal/GDP, Fiscal Rev/GDP, Fiscal Spend/GDP: Deviation from SS
Figure 3: Fiscal adjustment through a labor tax increase

- **GDP**
  - Deviation from SS
  - Years: 0, 2, 4, 6, 8, 10
  - Values: 0, 0.5, 1

- **Unemployment**
  - Deviation from SS
  - Years: 0, 2, 4, 6, 8, 10
  - Values: -0.5, 0, 0.5

- **Real wages**
  - Deviation from SS
  - Years: 0, 2, 4, 6, 8, 10
  - Values: -0.2, 0, 0.2, 0.4, 0.6

- **Prim Bal/GDP**
  - Deviation from SS
  - Years: 0, 2, 4, 6, 8, 10
  - Values: -0.3, -0.2, -0.1, 0, 0.1, 0.2, 1.5

- **Fiscal Rev/GDP**
  - Deviation from SS
  - Years: 0, 2, 4, 6, 8, 10
  - Values: -0.5, -0.2, -0.1, 0, 0.1, 0.2, 1.5

- **Fiscal Spend/GDP**
  - Deviation from SS
  - Years: 0, 2, 4, 6, 8, 10
  - Values: -0.5, -0.3, -0.2, -0.1, 0, 0.1, 0.2

Legend:
- Blue: Less wage rigidity ($\chi_u = 0.75 \times 0.93$)
- Red: Less wage rigidity ($\chi_u = 0.75 \times 0.93$) and prod gains
- Green: Wage rigidity ($\chi_u = 0.93$) and prod gains
Figure 4: Macroeconomic Fluctuations in Sweden (1980-2000)
Figure 5: Sweden 1994-2000. Fiscal consolidation measures and productivity gains
Figure 6: Sweden 1994-2000. Baseline simulation

A. Unemployment Rate (%)

B. GDP (detrended, 1992=100)

C. Primary Surplus (% of GDP)

D. Government revenues (% of GDP)
Figure 7: Sweden 1994-2000. The role of the fiscal consolidation
Figure 8: Sweden 1994-2000. The role of productivity gains
Figure 9: Sweden 1994-2000. The role of wage rigidity

A. Unemployment Rate (%)

B. GDP (detrended, 1992=100)

C. Primary Surplus (% of GDP)

D. Government revenues (% of GDP)
Figure 10: Sweden 1994-2000. Simulations under alternative Households’ preferences

- **A. Unemployment Rate (%)**
- **B. GDP (detrended, 1992=100)**
- **C. Primary Surplus (% of GDP)**
- **D. Government revenues (% of GDP)**
Appendix A: Equilibrium Conditions of the Model Economy

This appendix presents the full set of equilibrium conditions of the model economy.

- Labor market tightness:
  \[ \theta_t = \frac{v_t n_t}{u_t} \]  
  (33)

- Definition of unemployment rate:
  \[ u_t = 1 - n_t \]  
  (34)

- Evolution of total employment:
  \[ n_{t+1} = \rho n_t + \pi(\theta_t)(1 - n_t) \]  
  (35)

- Evolution of the capital stock:
  \[ k_{t+1} = \left(1 - \delta\right)k_t + \phi\left(\frac{\text{inv}_t}{k_t}\right)k_t \]  
  (36)

- The Tobin’s Q for the investment demand:
  \[ p_{k,t}\phi'(\frac{\text{inv}_t}{k_t}) = 1 \]  
  (37)

- The household marginal benefit of having one additional member working:
  \[ H_{n,t} = uf_{n,t} + \frac{1 - \tau_n}{1 + \tau_l}w_tuf_{c,t} + \beta(\rho - \pi(\theta_t))E_t[H_{n,t+1}] \]  
  (38)

- Households’ intertemporal condition to save through capital goods:
  \[ p_{k,t}\frac{uf_{c,t}}{1 + \tau_c} = \beta E_t\left[\frac{uf_{c,t+1}}{1 + \tau_c^{t+1}}\left(p_{k,t+1} + (1 - \tau^k)\left(\frac{\text{inv}_{t+1}}{k_{t+1}} - \frac{\text{inv}_{t+1}}{k_{t+1}}\right)\right)\right] \]  
  (39)

- Households’ intertemporal condition to save through government bonds:
  \[ \frac{uf_{c,t}}{1 + \tau_c} = \beta R_t E_t[\frac{uf_{c,t+1}}{1 + \tau_c^{t+1}}] \]  
  (40)

- Production technology:
  \[ y_t = a_t k_t^{\alpha_p}(\Gamma_t(1 - v_t)n_t)^{1 - \alpha_p} \]  
  (41)

where \( a_t \) is a detrended productivity shock, evolving as:

\[ \log(a_t/a) = \rho_a \log(a_{t-1}/a) + \varepsilon_{a,t}, \varepsilon_{a,t} \sim iidN(0, \sigma_a^2) \]  
(42)
• Rental rate of capital:
\[ a_t \alpha_p \left( \frac{\Gamma_t (1 - v_t)n_t}{k_t} \right)^{1-\alpha_p} = r_t^k \] (43)

• The fraction of recruiter satisfies:
\[ \Gamma_t a_t (1 - \alpha_p) \left( \frac{k_t}{\Gamma_t (1 - v_t)n_t} \right)^{\alpha_p} = \beta q(\theta_t)E_t \left[ \frac{uf_{c,t+1}}{uf_{c,t}} \frac{1 + \tau_{c,t+1}^c F_{n,t+1}}{1 + \tau_{c,t+1}^c F_{n,t+1}} \right] \] (44)

• The firm marginal benefit of having one additional worker is:
\[ F_{n,t} = \Gamma_t a_t (1 - v_t)(1 - \alpha_p) \left( \frac{k_t}{\Gamma_t (1 - v_t)n_t} \right)^{\alpha_p} - w_t \]
\[ + \beta (\rho + q(\theta_t)v_t)E_t \left[ \frac{uf_{c,t+1}}{uf_{c,t}} \frac{1 + \tau_{c,t+1}^c F_{n,t+1}}{1 + \tau_{c,t+1}^c F_{n,t+1}} \right] \] (45)

• Government primary balance:
\[ ps_t = \tau_t^n w_t n_t + \tau_t^k (r_t^k - \delta p_{k,t}) k_t + \tau_t^c c_t - tr_{t} - g_t \] (46)

• Evolution of government consumption:
\[ \log(g_t/\Gamma_t \bar{g}) = \rho_g \log(g_{t-1}/(\Gamma_{t-1} \bar{g})) + \varepsilon_{g,t}, \varepsilon_{g,t} \sim iddN(0, \sigma_g^2) \] (47)

• Evolution of consumption taxes:
\[ \log((1 + \tau_t^c)/(1 + \bar{\tau}_t^c)) = \rho_{\tau_c} \log((1 + \tau_{t-1}^c)/(1 + \bar{\tau}_{t-1}^c)) + \varepsilon_{\tau_c,t}, \varepsilon_{\tau_c,t} \sim iddN(0, \sigma_{\tau_c}^2) \] (48)

• Evolution of capital income taxes:
\[ \log((1 + \tau_t^k)/(1 + \bar{\tau}_t^k)) = \rho_{\tau_k} \log((1 + \tau_{t-1}^k)/(1 + \bar{\tau}_{t-1}^k)) + \varepsilon_{\tau_k,t}, \varepsilon_{\tau_k,t} \sim iddN(0, \sigma_{\tau_k}^2) \] (49)

• Evolution of labor income taxes:
\[ \log((1 + \tau_t^n)/(1 + \bar{\tau}_t^n)) = \rho_{\tau_n} \log((1 + \tau_{t-1}^n)/(1 + \bar{\tau}_{t-1}^n)) + \varepsilon_{\tau_n,t}, \varepsilon_{\tau_n,t} \sim iddN(0, \sigma_{\tau_n}^2) \] (50)

• Evolution of lump-sum transfers:
\[ \log(tr_t/\Gamma_t \bar{r}) = \rho_{tr} \log(tr_{t-1}/(\Gamma_{t-1} \bar{r})) - \varrho_G \log \left( \frac{b_t}{\Gamma_t b} \right) \] (51)

• Government budget constraint:
\[ ps_t + b_{t+1} = R_{t-1} b_t \] (52)
The flexible wages condition \( (\eta F_{n,t} u_{f,c,t} \frac{1-\tau_n^c}{1+\tau_c^c} = (1-\eta) H_{n,t} ) \) implies:

\[
\begin{align*}
  w^*_t &= \eta \Gamma_t a_t (1-\alpha_p) \left( \frac{k_t}{\Gamma_t (1-v_t) n_t} \right)^{\alpha_p} (1+\theta_t) - (1-\eta) \frac{u_{f,c,t} 1+\tau_c^c}{u_{f,c,t} 1-\tau_n^c} \\
  &+ \eta \beta (\rho - \pi(\theta_t)) E_t \left[ \frac{u_{f,c,t+1}}{u_{f,c,t}} \frac{1+\tau_c^c}{1+\tau_c^c} F_{n,t+1} \frac{\tau_{t+1}^n - \tau_t^n}{1-\tau_c^c} \right] 
\end{align*}
\]

(53)

Effective wage rate:

\[
w_t = \left( w_{t-1} - 1 \right) \chi w (w^*_t)^{1-\chi_w}
\]

(54)

The resource constraint of the economy:

\[y_t = c_t + g_t + inv_t\]

(55)

The balanced growth path is characterized by an annual growth rate equal to \( \gamma_g \), so

\[\Gamma_t = (1+\gamma_g)^t\]

An equilibrium for the detrended variables is defined as follows. Define \( X_t = \{ \theta_t, c_t, n_{t+1}, u_t, k_{t+1}/\Gamma_t, b_{t+1}/\Gamma_t, H_{n,t}/\Gamma_t, inv_t/\Gamma_t, p_{k,t}, y_t/\Gamma_t, r_k^t, v_t, F_{n,t}/\Gamma_t, p_{s,t}/\Gamma_t, w^*_t/\Gamma_t, w_t/\Gamma_t, R_t, g_t/\Gamma_t, 1+\tau_k^c, 1+\tau_c^k, 1+\tau_c^c, tr_t/\Gamma_t, a_t \} \) as the detrended variables. An equilibrium for the detrended variables given initial values for \( n_1, k_1, b_1 \), is a sequence \( X_t \) such as equations (33) to (55) are satisfied. A first-order log-linear solution for the detrended variables can be written as:

\[
\log(X_t) = \log(X) + P(\log(X_{t-1}) - \log(X)) + Q\varepsilon_t
\]

(56)

where \( \varepsilon_t = (\varepsilon_{a,t}, \varepsilon_{\tau_c,t}, \varepsilon_{\tau_c^c,t}, \varepsilon_{\tau_k^c,t}, \varepsilon_{g,t})' \). Here \( X \) denotes the detrended deterministic steady state value of each variable in \( X_t \).

Using annual data from 1994 to 2000, we feed in the path of productivity, taxes and government consumption in the log-linear solution of the model based on the calibration described in section III.
Appendix B: Estimated Effective Tax Rates

The data used for calculating the tax rates comes from the European Commission macroeconomic database AMECO (available at http://ec.europa.eu/economy_finance/db_indicators/ameco/) and OECD.Stat Extracts (available at http://stats.oecd.org/). The data from OECD provides the tax revenues, while the data from AMECO determines the tax base. The ratio of both components defines the effective tax rate. Next, we describe the series used from each database and then show the formulas used to calculate the tax rates based on the work of Mendoza et al. (1994).

Data from AMECO is the following:

- C: Nominal Private Consumption.
- G: Nominal Government Consumption.
- GW: Compensation of Employees, General Government.
- OSPUE: Gross operating surplus and mixed income, Households and NPISH.
- PEI: Net property income, Households and NPISH.
- W: Gross wages and salaries, Households.
- OS: Net operating surplus: Total Economy.

Data from the OECD database with their respective codes are:

- 5110: General taxes.
- 5121: Excise taxes.
- 1100: Income, profit and capital gains taxes of individuals.
- 3000: Payroll taxes.
- 2200: Social security contributions of employers.
- 1200: Income, profit, and capital gains taxes of corporations.
- 4100: Recurrent taxes on immovable property.
- 4400: Taxes on financial and capital transactions.
Using these series we follow the methodology of Mendoza et al. (1994) to calculate the effective tax rates. We focus on the tax rates on consumption, labor, and capital. As an auxiliary variable, we calculate the personal income tax. A fraction of the income tax is allocated to the labor tax while the rest is assigned to the capital tax. Based on the data the methodology of Mendoza et al. (1994) we use the following formulas for the effective tax rates:

a. Consumption tax:  \( \tau^c = \frac{5110+5121}{C+G-GW-5110-5121} \) 

b. Personal income tax:  \( \tau^i = \frac{1100}{OSPUE+PEI+W} \) 

c. Labor income tax:  \( \tau^l = \frac{\tau^i W+2000+3000}{W+2200} \) 

d. Capital income tax:  \( \tau^k = \frac{\tau^i (OSPUE+PEI)+1200+4100+4400}{OS} \)
References


