

# Goodwin Model Simulator Guide

## Basics

This program provides a simulator of the Goodwin Model, which represents the relationship between the wage share (the percentage of national income that employees earn) and employment rate (the percentage of people employed). This simulator shows the equilibrium (where the growth is 0) points and the extrema of the model (the minimum and maximum points). The model takes in seven inputs when a linear model is used and eight inputs when an exponential model is used. The eight inputs are:

$u_0$  - (Initial Wage Share): The percentage of national income that employees earn at time 0 as a decimal (ex: 100% as a decimal is 1, 50% is 0.5)

$\mu_0$  - (Initial Employment Rate): The percentage of people employed in the economy at time 0 as a decimal

$v$  - (Capital-Output Ratio): The amount of capital (resources) needed to produce one unit of output in the economy (also referred to as  $K/Y$ )

$\theta$  - (Natural Growth Rate of the Labor Productivity): The natural rate at which the labor force grows in productivity (in this case labor productivity increases exponentially)

$n$  - (Natural Growth Rate of the Number of Workers): The natural rate at which the labor force grows in the economy (in this case labor grows exponentially)

$\alpha$  - (Negative Inflation at Full Employment): The negative value of the rate of inflation when everyone is employed in the economy.

$\beta$  - (Negative Inflation Slope): The negative value of the slope of inflation as a function of unemployment

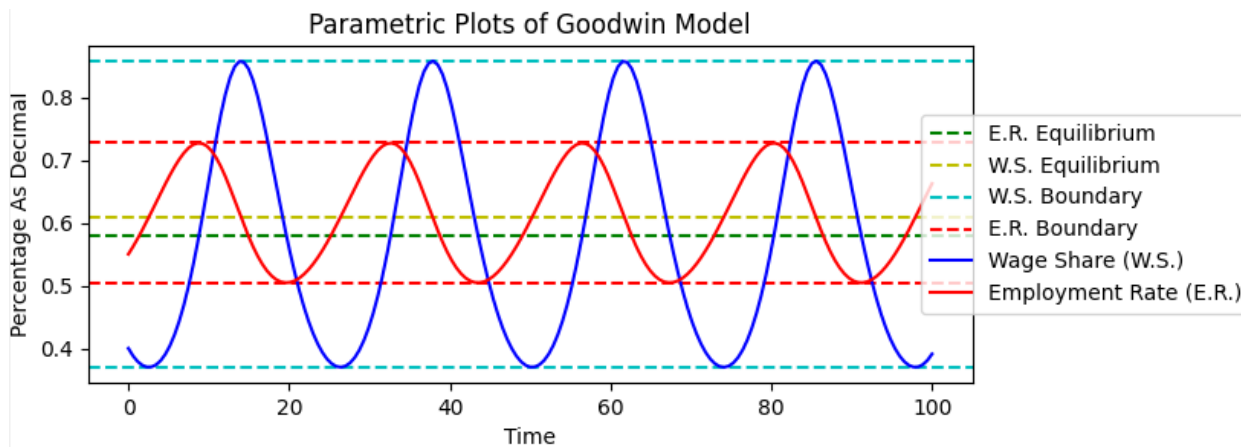
$k$  - (Inflation exponent): Used in the exponent model, represents the natural rate that inflation shrinks as unemployment increases.

Note that some values will make the models nonsensical.  $\mu_0$  and  $u_0$  should always be greater than 0 and no greater than 1. The same can be said of the calculated wage share and employment rate.

The model then generates three different graphs based on the inputs:

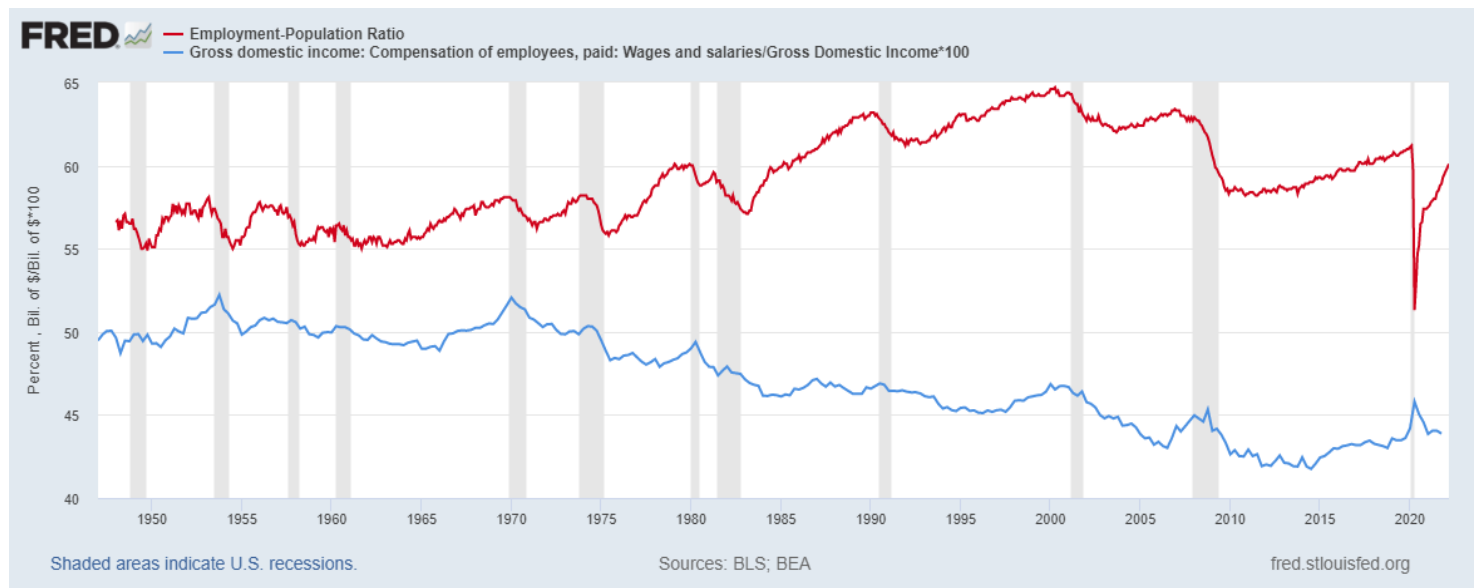
- A Phillips Curve, which represents the relationships between inflation and unemployment in the economy
- Parametric Plots of the Goodwin model, showing the percentages over a time span of 100 units
- A cycle of the Goodwin model, plotting employment rate vs wage share.

Let's go over some of the characteristics of the model:



For the parametric plots:

- There seems to be a small-time lag between the employment rate and the wage share. This also seems to be the case with actual FRED data as shown below. As seen below, the red plot (employment rate) is slightly ahead of the blue plot (wage share) when shifts occur.



The Goodwin Model is expressed as two differential equations. These equations when solved give the equilibrium of the wage share and employment rate. It turns out these equations are Lotka-Volterra equations. The Lotka-Volterra equations represent how predators and prey interact in biology. It follows these steps that occur in cycles:

1. As the number predators increases, the number of prey decreases.
2. As the number of prey decreases, the number of predators decrease.
3. As the number of predators decreases, the number of prey increases.
4. As the number of prey increases, the number of predators increases.

And this cycle repeats assuming the number of prey doesn't reach zero. We can apply this to wage share and the employment rate:

1. As the wage share increases, the employment rate decreases.
  - a. This happens because employees become more expensive to have as the wage share increases, so companies lay off workers.
2. As the employment rate decreases, the wage share decreases.
  - a. This happens because there are less workers, so more of the profit goes to the company owners.
3. As the wage share decreases, the employment rate increases.
  - a. This happens because the company owners now spend their increased profits to expand their companies and increase the number of workers.
4. As the employment rate increases, the wage share increases.
  - a. This happens because the market is now tight, so now companies must pay workers more to attract and retain them.

In a sense, the wage share is the “predator” and the employment rate is the “prey”.