The Dynamics of General Equilibrium

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What is General Equilibrium?

There is one generally accepted model of the large-scale behavior of the market economy, known as Walrasian general equilibrium.

The Swiss economist Léon Walras created this theory in 1874-1877 in his Elements of Pure Economics.

Léon Walras, 1834-1910

What is General Equilibrium?

The Walrasian economy consists of households and firms.

Firms buy or rent the services of inputs at given market prices,

combine them to produce outputs

which they sell at given market prices to the households.

What is General Equilibrium?

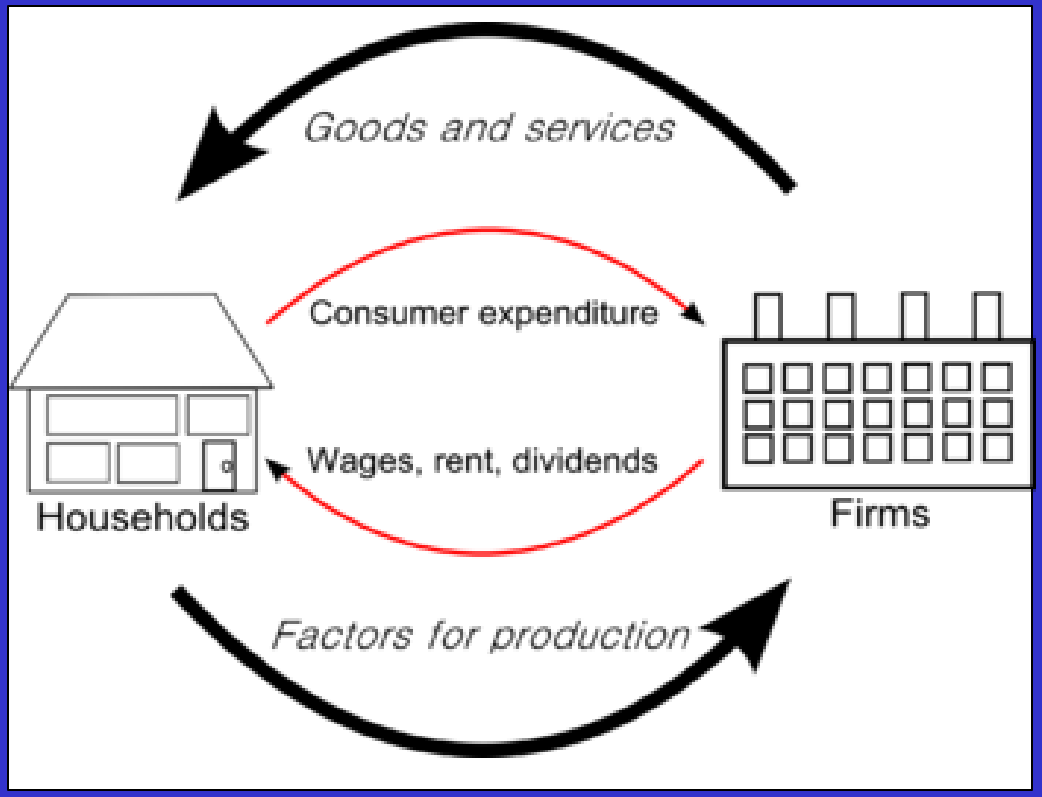
Inputs include labor, capital goods (rented), raw materials, and the outputs of other firms (purchased).

Inputs, as well as shares in the net profit of the firms, are owned by the households, and form their wealth.

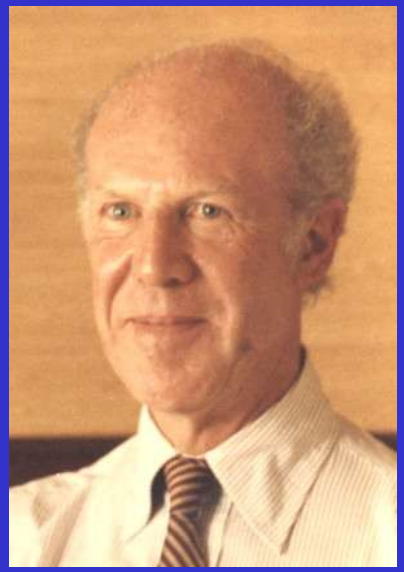
In each period, households buy the output of the various firms, some of which they consume, and some of which they add to their stock of wealth.

What is General Equilibrium?

The economy is in equilibrium when the prices p are set so that supply = demand in each sector (a sector is a set of firms who all sell the same good).



What is General Equilibrium?



Gerard Debreu, 1921-2004

In the period 1952-1954, Kenneth Arrow and Gerard Debreu showed that with plausible assumptions, there exists a set of equilibrium (market clearing) prices.

Kenneth Arrow, 1921-

Walras' Problem

If firms and households are both price-takers (that is what is meant by "perfect competition"), how can prices change?

Walras' Auctioneer

Walras assumed there is an "auctioneer" (commissaire-priseur) who, before any buying and selling takes place,

1. "calls out" a set of prices,
2. asks firms and households say how much they want to buy and sell at these prices,
3. calculates the "excess demand" or "excess supply" for each sector,
4. adjusts the prices to bring the markets closer to equilibrium,
5. Then back to 1, until all markets are in equilibrium.
6. Only then is production and trade permitted, at the specified market-clearing prices.

Auctioneer---Not!

There are two glaring problems with Walras' solution:

1. The idea of an auctioneer is completely antithetical to the idea that the market economy is decentralized.
2. Can the auctioneer (or whatever replaces the auctioneer) really bring about equilibrium by "adjusting the prices"?

In other words, is there a price adjustment mechanism through which equilibrium is rendered dynamically stable?

Chaos

Neither Walras nor anyone since has discovered a plausible decentralized price determination process to replace the auctioneer process for an economy with production.

With the auctioneer, even with the most favorable (and unrealistic) assumptions, price movements are generally chaotic (Saari 1985, Bala and Majumdar, 1992).

Alternative to Chaos

The problem is that the market economy is a complex, dynamic, nonlinear system that cannot be correctly modeled using standard dynamical systems tools (differential equations on smooth manifolds).

I provide an effective price dynamic through an agent-based simulation of the market economy.

This dynamic explains why the market economy tends to suffer repeated large excursions from equilibrium (bubbles, melt-downs, crises).

The Plight of Traditional Macroeconomic Theory

Modern macroeconomics rejects Walrasian general equilibrium in favor of highly aggregated (toy) models of the economy driven by peculiarities of individual decision-making.

Keynesian theory assumes one good with two uses, consumption and investment,

and two prices: the wage rate and the interest rate.

The wage rate is rigid downwards because workers will not accept wage cuts,

and the interest rate does not clear the savings/loans market because of liquidity preference.

The Plight of Traditional Macroeconomic Theory

Chicago-schools macroeconomics rejects the `irrationalities' of the Keynesian model in favor of `rational expectations',

retaining the toy economy assumptions,

to which are added

stable and continuously clearing markets.

The Plight of Traditional Macroeconomic Theory

The financial crisis of 2007 undermined the Chicago `efficient markets' model,

leading to a resurgence of the Keynesian notion that the irrationality of individual behavior (irrational exuberance, noise traders, downward wage rigidity) entails

- market instability,
- the tendency to ignore market fundamentals, and
- rampant speculative excesses.

The Plight of Traditional Macroeconomic Theory

George Akerlof and Bradley Schiller's ***Animal Spirits*** (Princeton, 2009) has become the rallying-cry for the reassertion of the importance of regulating the market economy.

Akerlof and Schiller's conclusion:

> "if we thought that people were totally rational, and that they acted almost entirely out of economic motives,
>
> we too would believe that government should play little role in the regulation of financial markets, and perhaps even in determining the level of aggregate demand." (p. 173).

The Plight of Traditional Macroeconomic Theory

Yet there is nothing in economic theory, and no empirical evidence, that markets are intrinsically stable.

Let me make this clear: I mean absolutely nothing.

Nothing.

The Plight of Traditional Macroeconomic Theory

I do not disagree with the need for regulation, although I prefer more effective regulation to more regulation.

Effective regulation depends on understanding the problem, which I shall argue is

systemic

and the result of rational behavior.

The Market Economy as Complex Dynamical System

A market economy is a complex dynamic, nonlinear system that can be studied by agent-based modeling.

I implement an agent-based economy with a fixed number of production sectors and a fixed number of agents (households) who consume, work, and own capital.

Basic Assumptions

The general equilibrium model generally assumes

consumers and producers know all prices;

firms know all relevant characteristics of their labor force, other firms in the industry, and all other information needed to perform an explicit maximization of profits subject to constraints.

By contrast, our agent-based model assumes that

prices are private, not public;

consumers must engage in price searches in each period;

each worker has a reservation wage that he uses to determine whether to accept a job offer;

firms know their production costs, but not their demand curves, and hence must experiment and learn.

Basic Assumptions

Workers periodically search for alternative job opportunities, updating their reservation wage;

firms maximize profits by experimentally varying their operating characteristics and copying the behavior of other firms that are more successful than themselves.

both prices and quantities respond to conditions of excess supply or demand.

all adjustment parameters are agent- and firm-specific, and evolve endogenously.

Adjustment Processes

In each period:

- For each firm, inventory growth leads to lowering of price a small amount, and excess demand leads to raising price a small amount.
- average sector profits > 0 leads to a single firm entering the sector, and average profits < 0 leads to a single firm going bankrupt.
- firms make limited searches for alternative employees, and workers make limited searches for alternative employers.
- agents revise their consumption, production, employment, and trading strategies by sampling the population, and imitating the strategies of others who appear to be relatively successful.
- all adjustment rates are endogenous.

Adjustment Processes

Because all players (firms and workers) adjust their behavior by imitating the successful,

the economic dynamic is an evolutionary dynamic

the dynamic is governed by replicator equations analytically

imitation leads to correlated errors, so the iid assumptions that plague traditional macroeconomic models are absent here:

"fat tails" are the rule,

and there are large excursions from equilibrium in the absence of macro-level shocks.

Main Results

The dynamical system satisfies the complex systems counterpart to stability and uniqueness:

excess supply in each sector;

excess labor demand, as well as excess labor supply in each period,

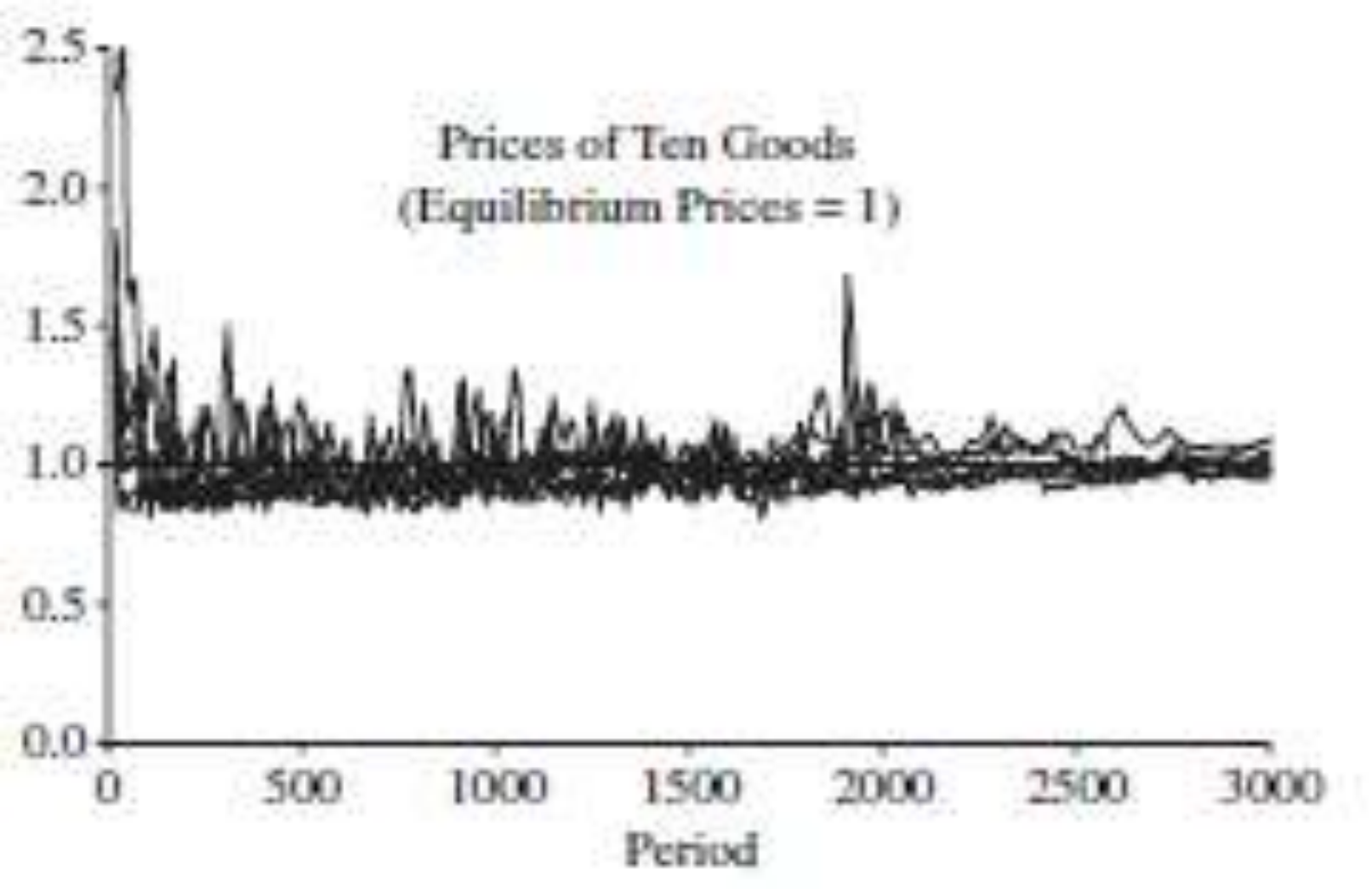
labor demand 🕯 labor supply to within a few percent;

prices 🕯 production costs and achieve equilibrium value, with lots of noise in each period; i.e., firm profits are zero on average, as expected.

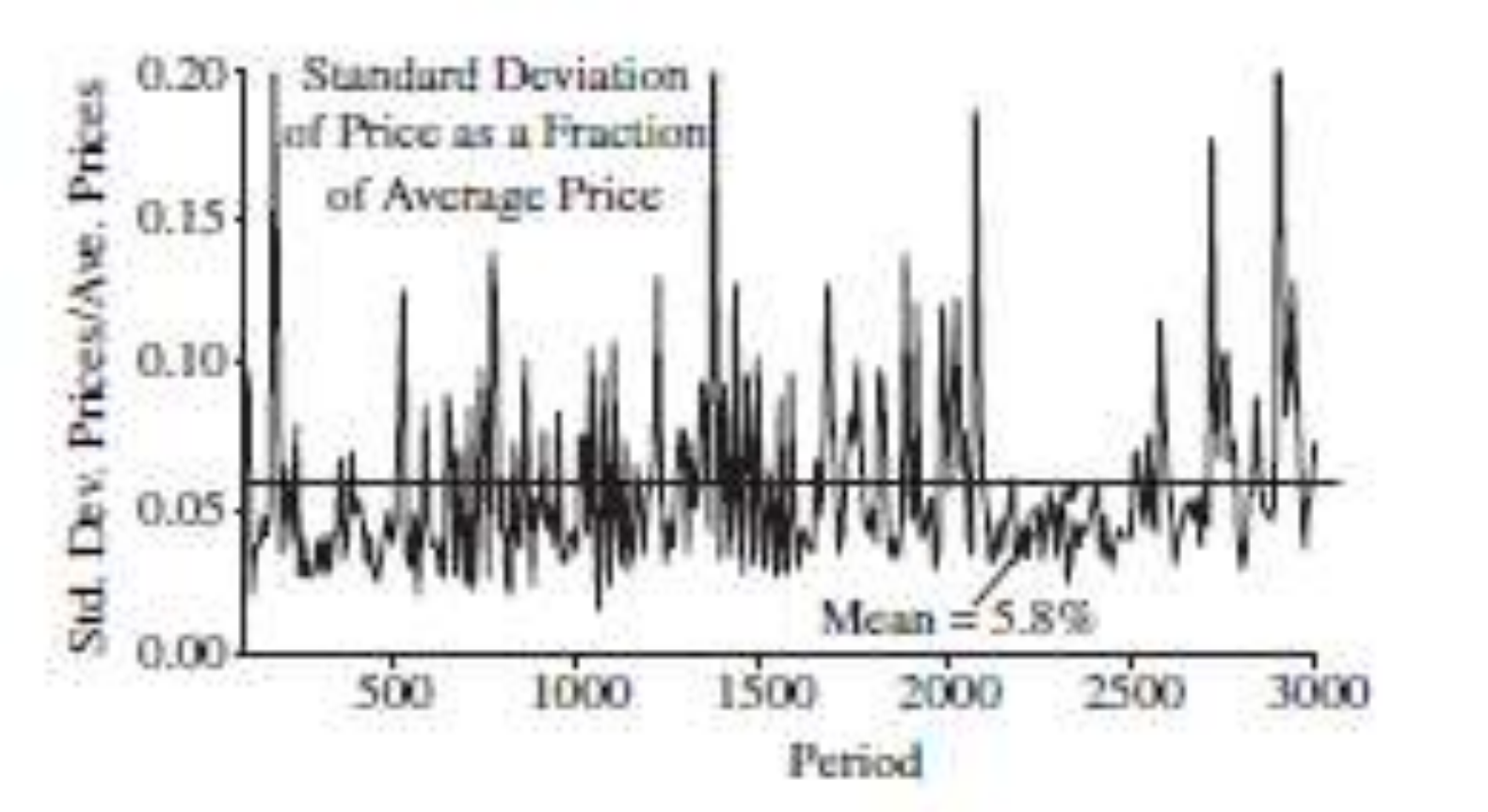
the wage rate in each sector is fairly stable, and wages are approximately equal across sectors.

there is a considerable level of fluctuation in price and quantity series, even though there are no aggregate stochastic shocks to the system.

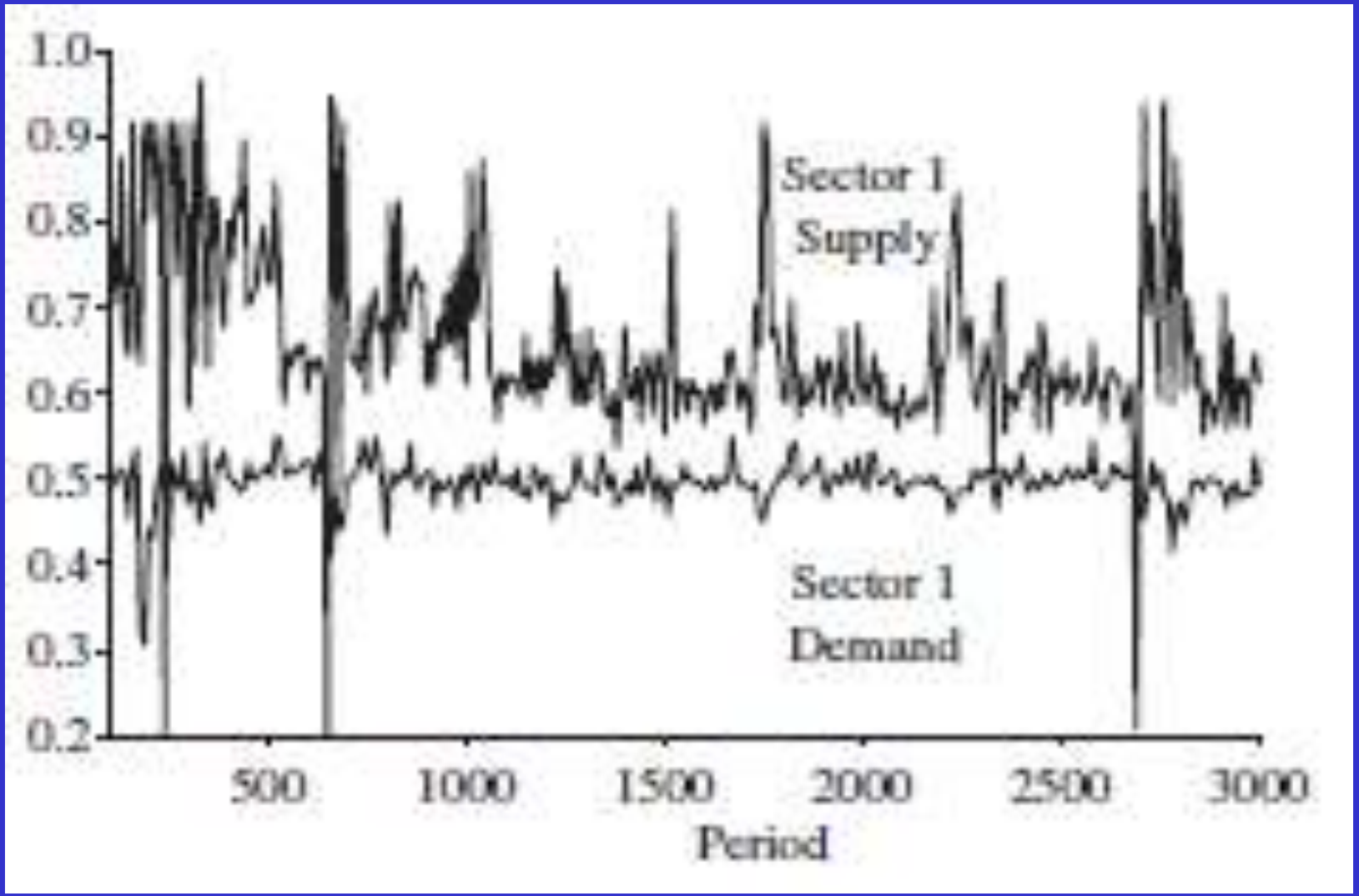
Price Stability with Excursions



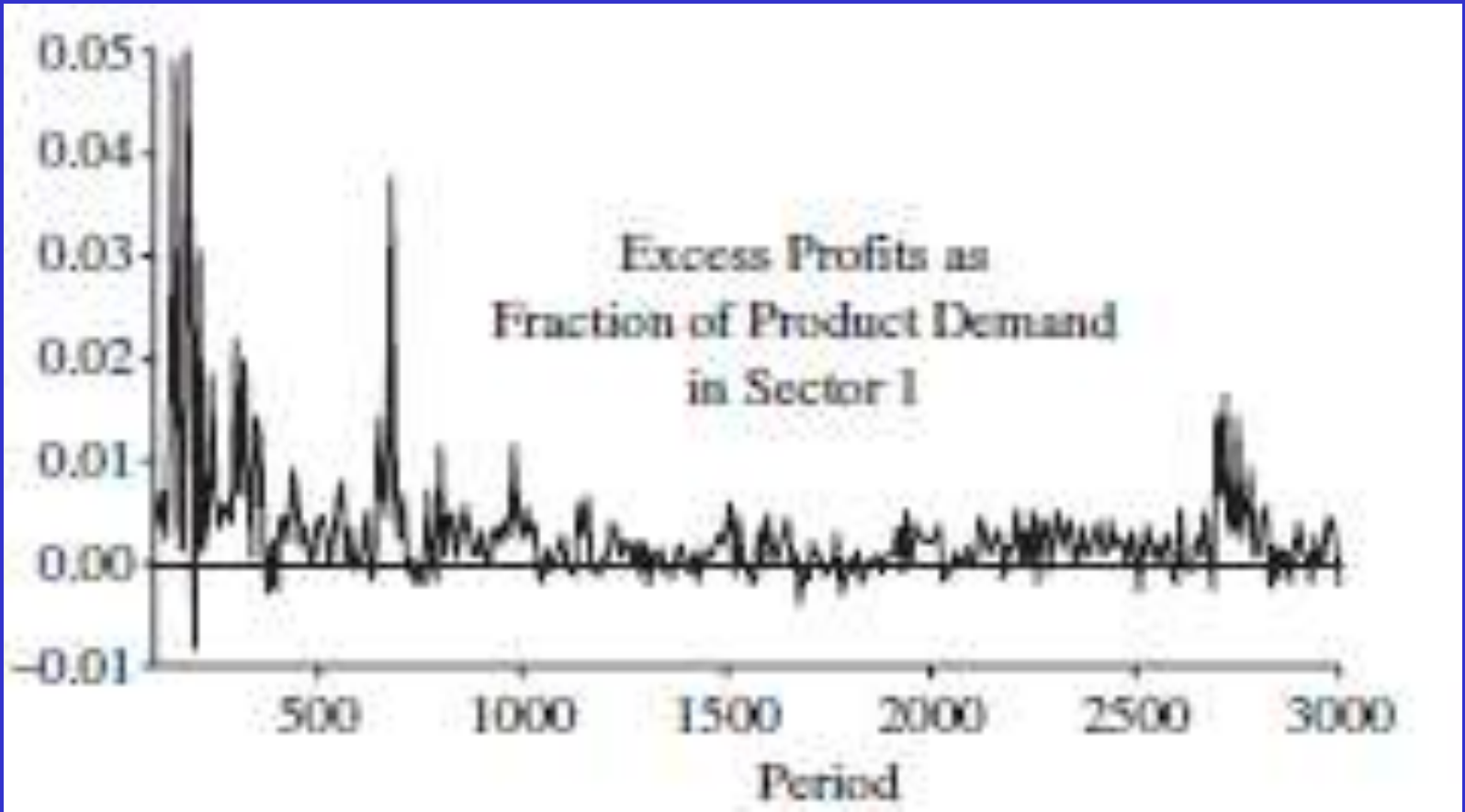
Price Stability with Excursions



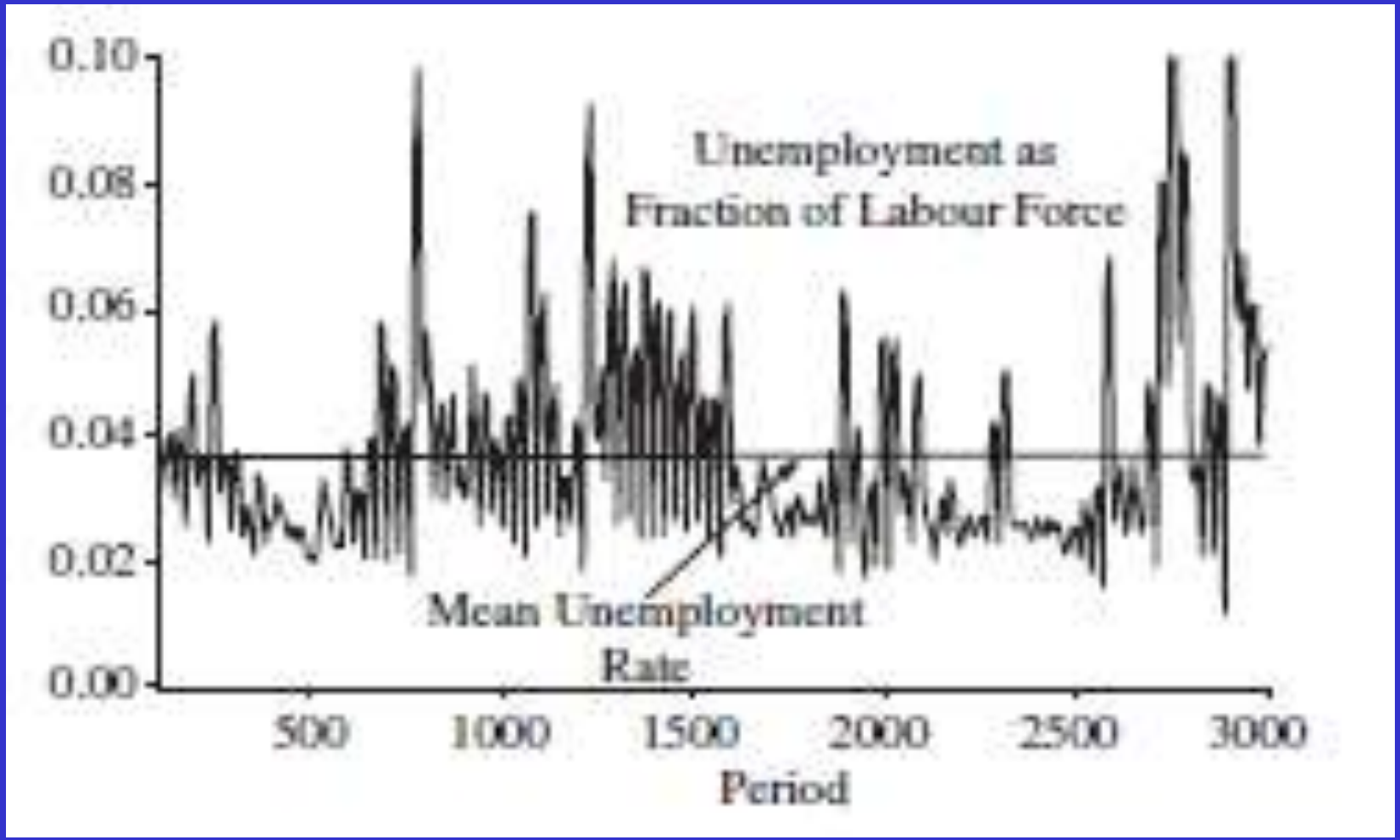
Excess Demand and Supply



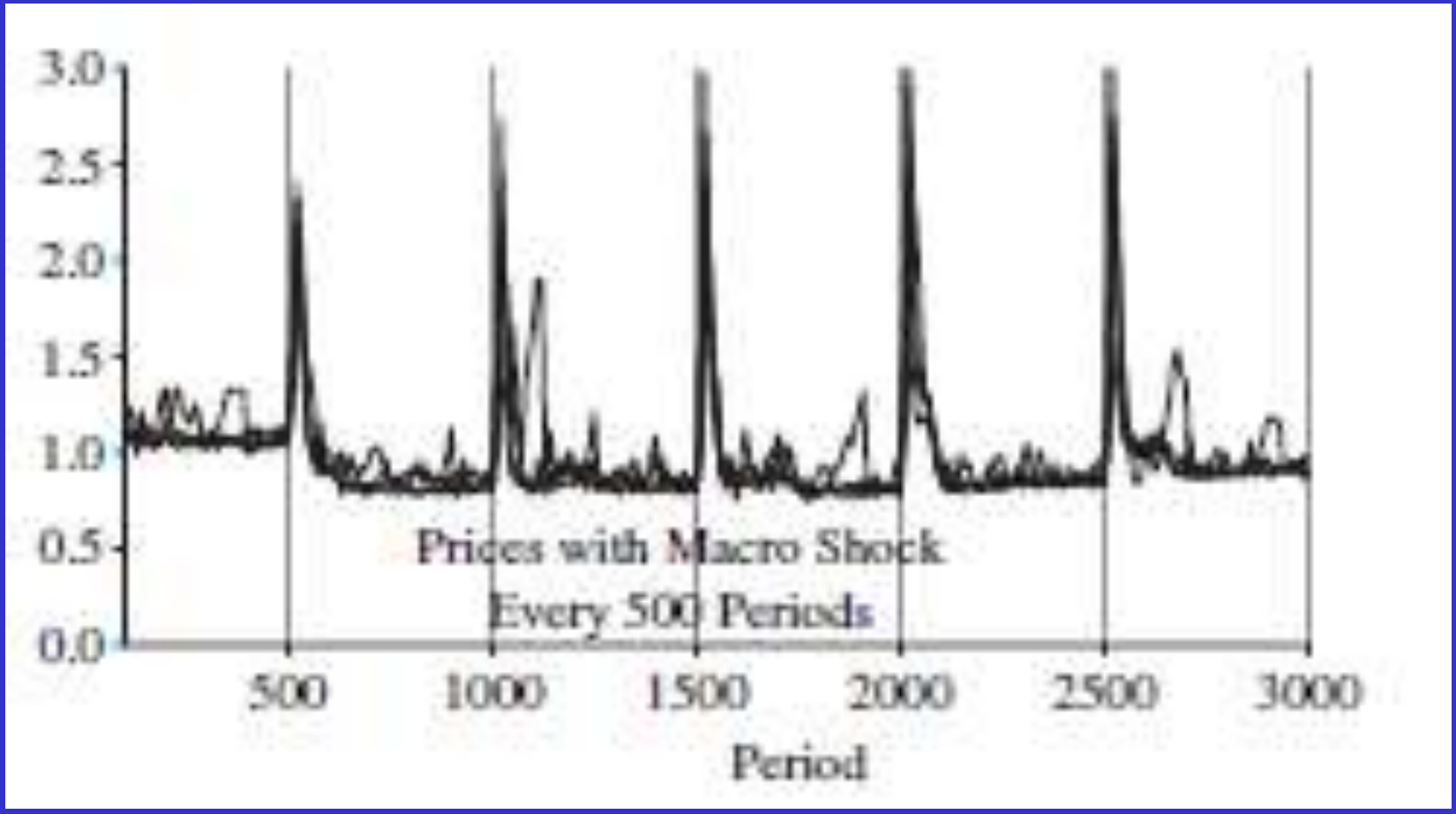
Profits


0.05
0.04
0.03
0.02
0.01
0.00
–0.01
Excess Profits as
Fraction of Product Demand
in Sector 1
500
1000
1500
2000
2500
3000
Period

Unemployment

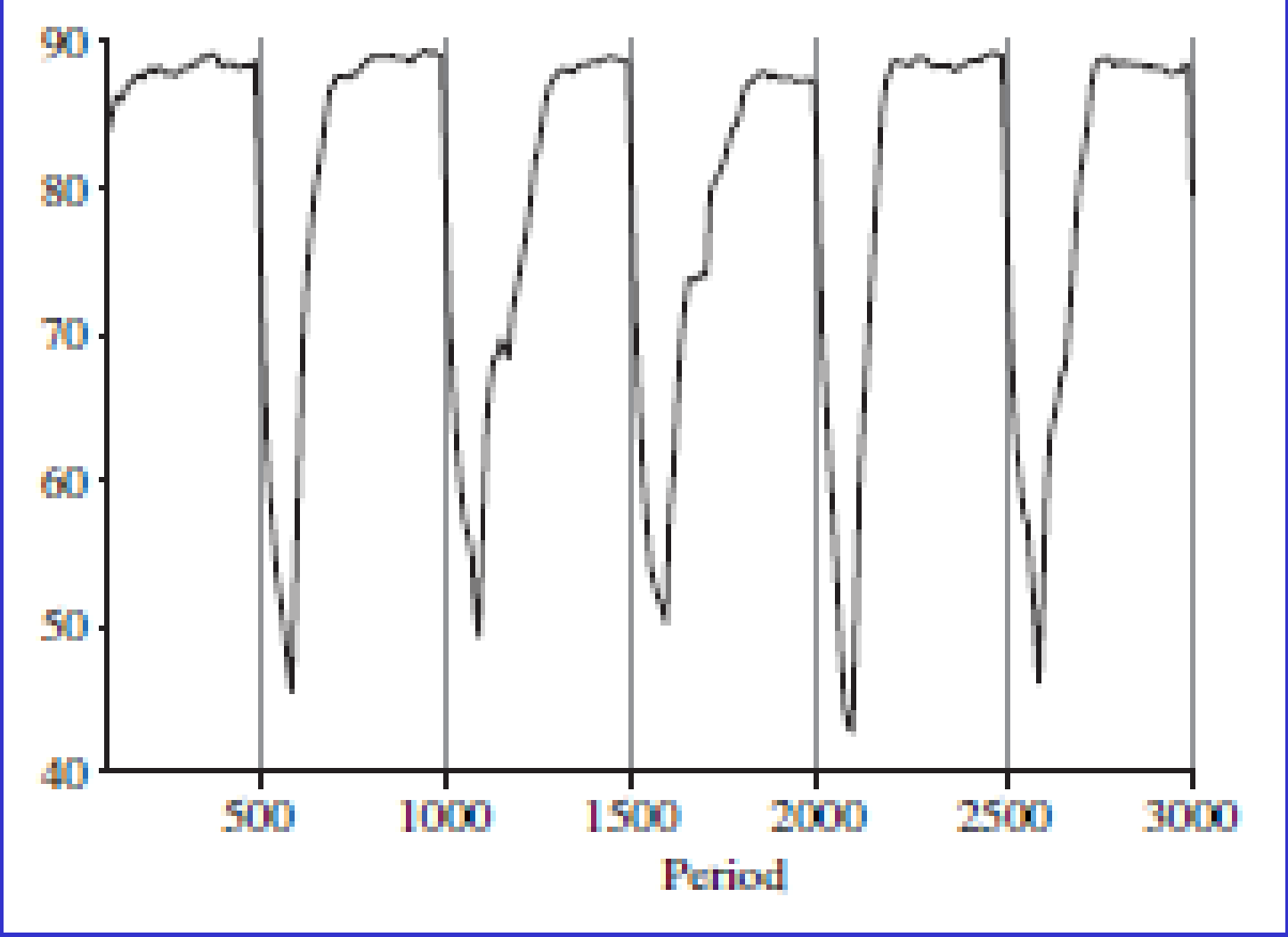


Stability



Every 500 periods, the economy sustains a shock whereby each firm's optimal size is reduced from 35 to 14. The shock lasts for 10 periods, after which the original optimal firm size is restored. Note that goods prices stabilise after a few hundred periods, and are approximately equal across all runs

Stability



- The vertical axis shows percentage efficiency.

Stability

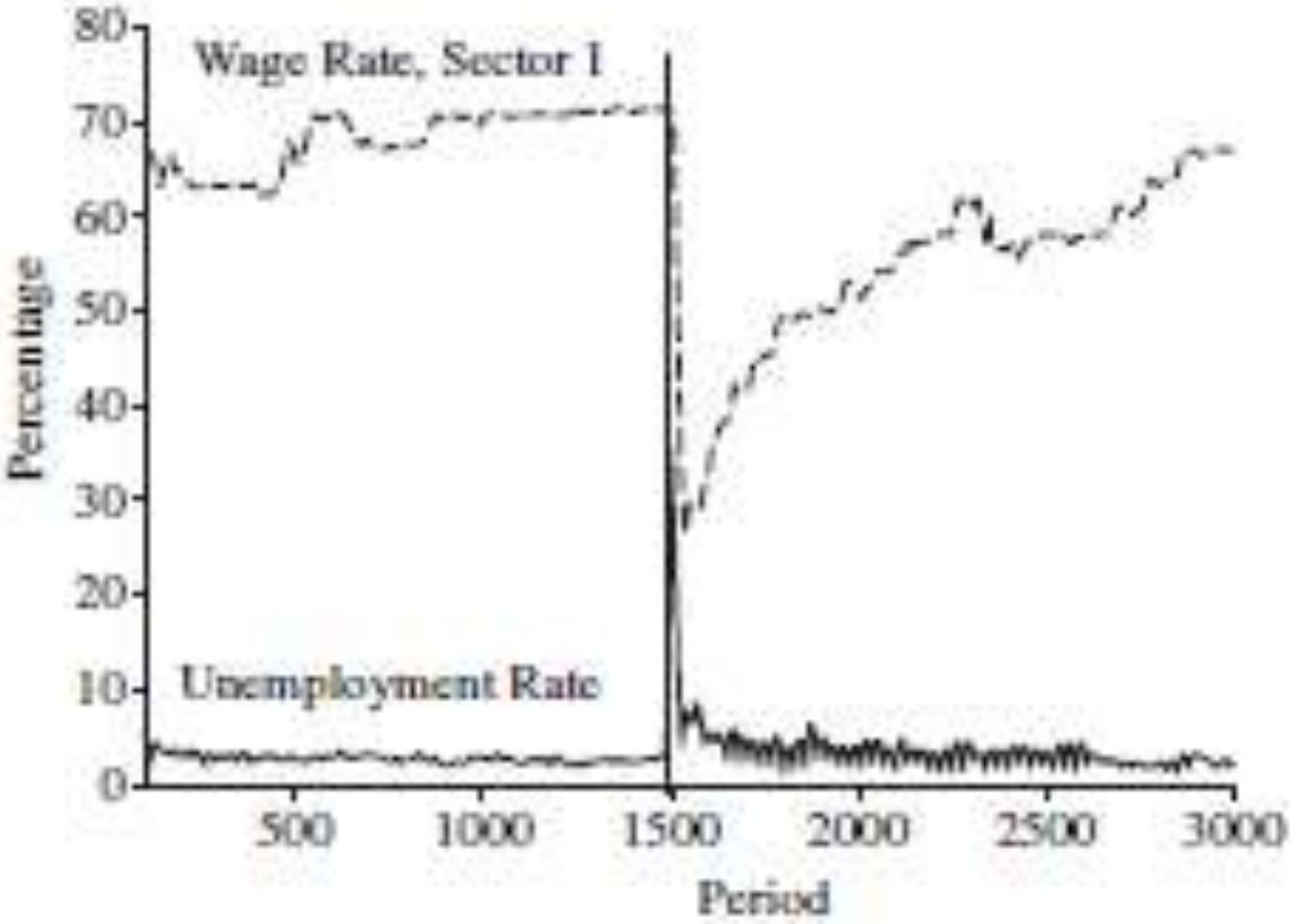


Fig. 17. *Unemployment and Wages after a Large Labour Force Increase in Period 1500*
Note that the wage rate returns to its long-run value quite slowly (the vertical axis is relevant for the unemployment rate alone). The unemployment rate returns quickly to its long-run average but with increased volatility for more than 1,000 periods