Bottlenecks and the Phillips Curve

by

George W. Evans
University of Oregon and University of St. Andrews

Presentation to: The Better Policy Project, Lisbon

December 7, 2022

UO Economics Macro Group: January 19, 2023

Introduction

- This talk is primarily based on my 1985 *Economic Journal* paper "Bottlenecks and the Phillips Curve: a Disaggregated Keynesian Model of Inflation, Output and Unemployment."

  – I started thinking about these issues in a chapter in my PhD thesis on the time-series variation in the cross-sectional variance of inflation.

  – I constructed a theoretical model, with bottlenecks in some sectors, relating the cross-section variance of inflation to rapid positive or negative aggregate output growth, relative to potential, with the relationship strongest at high levels of output.

  – I found empirical support for the model using US Wholesale Price Index data for 1947 -1975.

- I sent the paper to JPE, which rejected it.

- I decided to develop the theoretical model further, change its focus, and submit it to EJ (good call),
  – but I didn't try another journal with the empirical results from the paper (probably a bad call?),
  – because I was working on other things (which worked out well).

- Time is the ultimate scarce resource.

- The EJ "bottleneck" set-up was my way out of opposing macro views on price-adjustment, in the 1970s, which both seemed too extreme.

  – In Classical/New Classical models wages and prices jump instantaneously to market-clearing levels.

  – In the short-run fix price + gradual price-adjustment approach of Tobin, Barro&Grossman, and Malinvaud, quantities traded are determined by the short side of the market.
  – But then (i) it's difficult to explain at the aggregate level how a positive output gap can arise, and (ii) a disaggregated model becomes borderline intractable with a multiplicity of regimes.

- The EJ paper shows how to overcome these issues in a model in which, in each sector, prices are "fixed" at low levels of output but flexible at high levels of output.

The Model

Aggregate Demand

Aggregate demand is given by the "quantity theory" equation

$$m_t = p_t + q_t - v_t, \text{ where } v_t \text{ is exogenous white noise,}$$

where m_t is exogenous and set by the CB (central bank). This could also be viewed as nominal income targeting by the CB.

Here p, q are the aggregate price and output levels, in logs. There are N goods sectors and

$$q_t = N^{-1} \sum_{j=1}^{N} q_{it} \text{ and } p_t = N^{-1} \sum_{j=1}^{N} p_{it}.$$

We are assuming for simplicity that the demand for the N goods is governed by a Cobb-Douglas utility function so that income and price elasticities are equal to one, and

$$q_{it} = q_t - (p_{it} - p_t) + d_{it}, \text{ where } d_{it} = d_{i,t-1} + u_{it}^d,$$

with u_{it}^d exogenous white noise that is "nearly" independent across sectors (since $N^{-1} \sum d_{it} = 0$).

Firms

Firms in sector i produce output using one input, a type of labor specific to that sector, under constant returns to scale

$$q_{it} = n_{it} - k_i,$$

where k_i is the log unit labor requirement in i and n_{it} is log quantity of labor.

Firms produce under perfect competition, hiring labor at log wage x_{it}.
With perfectly competitive output markets, the log price is

$$p_{it} = x_{it} + k_i.$$

Remark: Perfect competition could be replaced by monopolistic competition. The key assumption is that prices are flexible.

The Labor Market

Every worker is located in a particular sector i. In the short run the labor supply in market i is fixed inelastically at l_{it}.

There is a *base wage*, the log of which is w_{it}, which acts as a *floor* to wages, but otherwise wages move flexibly to clear the market. We thus have

$$x_{it} \geq w_{it} \text{ and } n_{it} \leq l_{it} \text{ with complementary slackness.}$$

In labor market i there are two possible states, as shown in Figure 1: (i) $n_{it} = l_{it}$ and $x_{it} \geq w_{it}$, a *bottleneck state*, or (ii) $n_{it} < l_{it}$ and $x_{it} = w_{it}$, an *excess supply* state.

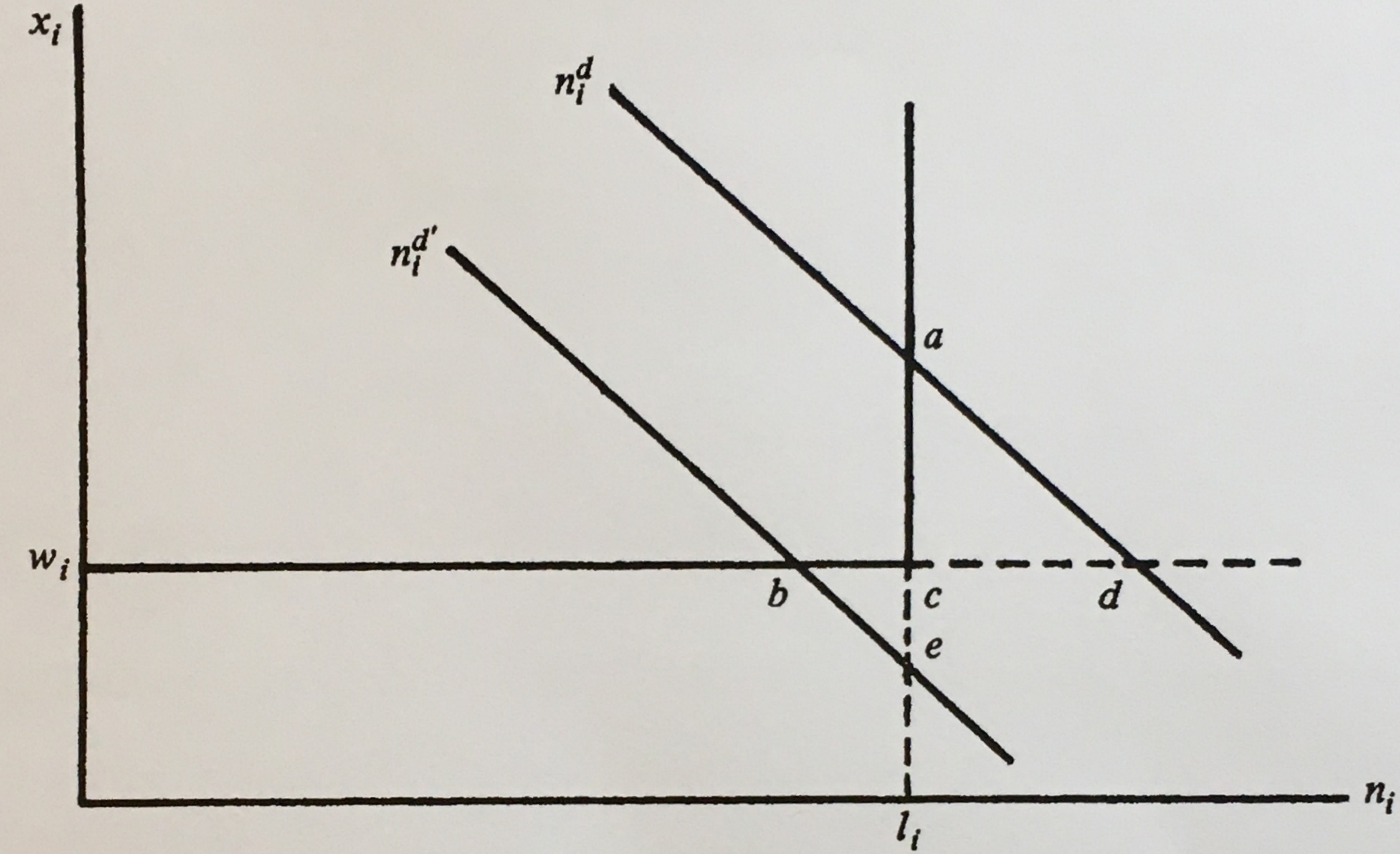

Fig. 1. Labour market in sector *i*. *Note*: w_i is the base wage or wage floor. n_i^d and n_i^d are two different possible derived demand curves for sector *i*, with equilibria *a* and *b* respectively. With demand n_i^d the excess demand for labour D_i that would obtain at the base wage is the length of segment *cd* and the market clearing wage is the height of point *a*. With demand n_i^d the excess supply of labour $-D_i'$ is the length of *bc*, and the wage that would be necessary to clear the market is the height of point *e*.

Model Dynamics

The remainder of the model specifies the *dynamics* for the *adjustment of base wages* and for *sectoral labor movements*.

Base wages adjust according to augmented Phillips curves

$$\Delta w_{it} = \xi D_{i,t-1} + z_t + u^a_{it} + \Delta e_t,$$

where $0 \leq \xi \leq 1$, u^a_{it} is a white noise shock to sector i base wage, e_t is a white noise shock to average base wages, and z_t is *inflationary momentum*.

D_{it} is *excess demand* for labor in i computed *at the base wage* w_{it},

$$D_{it} = p_t + q_t - w_{it} - l_{it} + d_{it}.$$

D_{it} can of course be be positive or negative. See Fig. 1.

Base wage changes:

$$\Delta w_{it} = \xi D_{i,t-1} + z_t + u_{it}^a + \Delta e_t,$$

The z_t term is "*inflationary momentum*," which can be viewed as capturing the effect of inflation expectations on the setting of base wages, and which is assumed to follow

$$z_t = \beta \Delta x_{t-1} + (1 - \beta) z_{t-1} \text{ for } 0 < \beta \leq 1.$$

The second dynamic adjustment is labor flows from low to high wage sectors. More precisely the net flow of labor into a sector depends on its '*shadow relative wage*,' the difference between the sector's expected *market-clearing wage*, given by $n_{it} = l_{it}$, and the *average market clearing* wage. For $\theta_{it} = l_{it} - l$ we get

$$\Delta\theta_{it} = \lambda E_{t-1}(d_{it} - \theta_{it}) + u_{it}^\theta \text{ for } 0 < \lambda < 1 \text{ and } u_{it}^\theta \text{ white noise.}$$

Note: A high $d_{it} - \theta_{it}$ will manifest as either as a sector i higher actual wage, lower unemployment or both.

Short-run Equilibrium, Long-run Equilibrium and Medium-run Dynamics

We can now study the model over different time frames:

- Short run: How time t endogenous variables depend on exogenous and predetermined variables

- Long run: Properties of the stationary stochastic process: the distribution of bottlenecks, the long-run equilibrium supply curve, and the mean natural rate of unemployment.

- Medium-run dynamics: The medium-run responses of inflation and output achieved through monetary policy.

Short-run Equilibrium

The predetermined variables at t are $S_t = \left\{ m_t, v_t, \{d_{it}, l_{it}, w_{it}, k_i\}_{i=1}^{N} \right\}$.

Given S_t the "short-run" equilibrium values can be calculated for

$$\{p_{it}, x_{it}, q_{it}, n_{it}\}_{i=1}^{N} \text{ and aggregate } p_t, x_t, q_t, n_t.$$

The *AS curve* generated by the ordered distribution of bottlenecks $R = \{r_1, \ldots, r_N\}$, where $r_i = d_i - (w_i - w) - (l_i - l)$, takes the form

$$p = w + k + f(q - l + k),$$

where f is weakly increasing and convex.

The *AD curve* is simply $D = m + v - w - l$. See Figure 2.

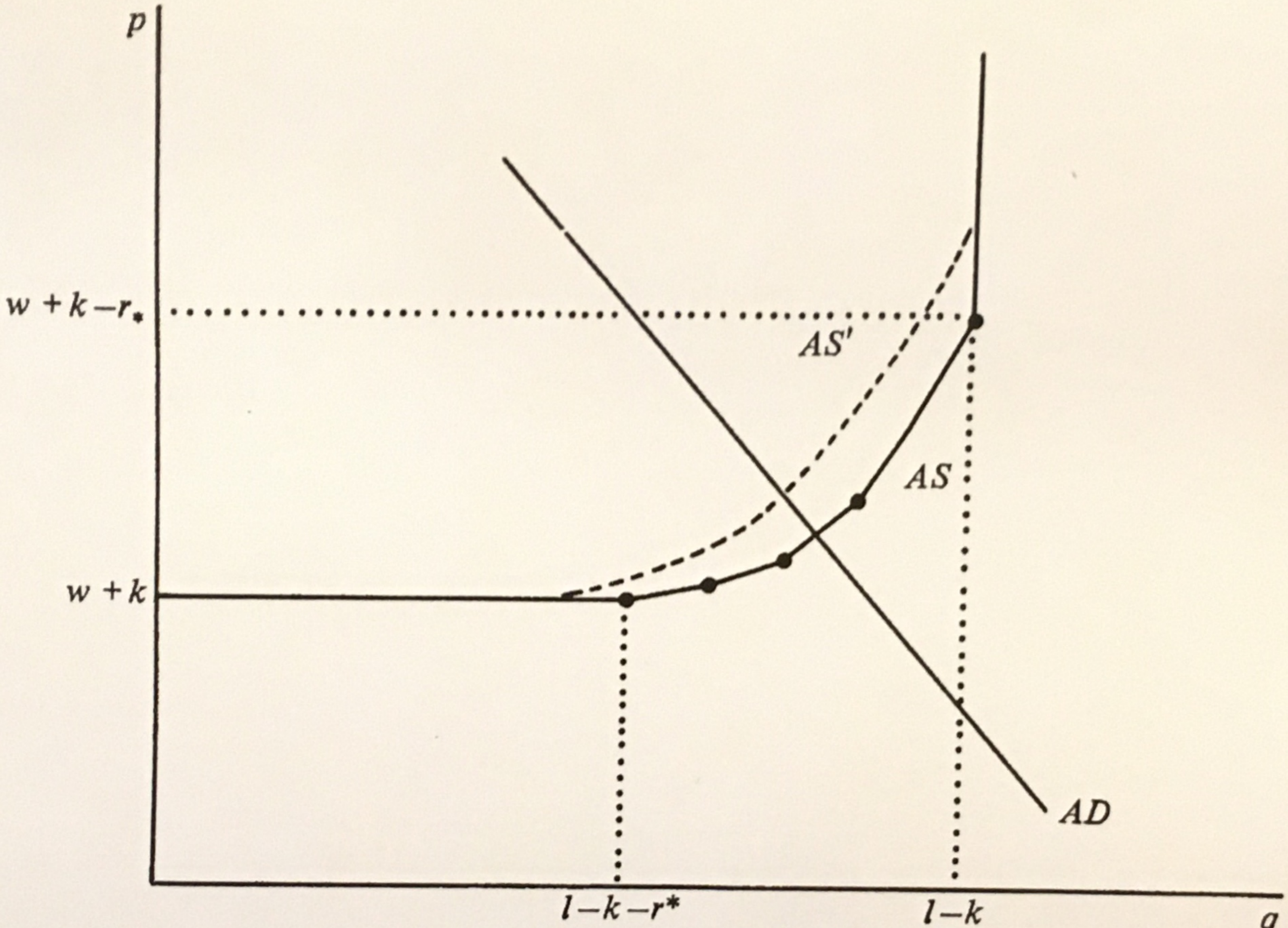

Fig. 2. Determination of short-run equilibrium. *Note*: *AS* is the aggregate supply curve and *AD* is the aggregate demand curve. *AS′* is an aggregate supply curve with a greater dispersion in the distribution of bottlenecks.

Short-run comparative statics results

- The proportion of sectors in bottleneck $b = b(R, D)$ is a nondecreasing function of $D = m + v - w - l$ and, holding R fixed,

$$\partial p/\partial m = b \text{ and } \partial q/\partial m = 1 - b.$$

- Holding R fixed, the slope f' of the AS curve $p(q) = w + k + f(q - l + k)$ is

$$dp/dq = b/(1 - b)$$

- For $R' = \{\mu r_i\}$ where $\mu > 1$, the AS curve shifts up and left, so that q falls for given AD.

- $b = 0$ and $b = 1$ correspond to Classical and Keynesian limiting cases.

Equilibrium in the long run

- Assume $\Delta m = g$. The economy is driven by stochastic shocks and in the long run converges to a stationary stochastic process.

- For large N as $t \to \infty$ the distribution of bottlenecks converges to a normal distribution, with suitable variance σ_r^2, and a corresponding long-run equilibrium AS curve $p = w + k + f(q - l + k)$.

- See Figure 3. Output q_t converges to a stationary process. Then the mean inflation rate is $E(\Delta p) = g$ and the corresponding mean unemployment rate is given by

$$\bar{U} = 1 - \exp\left[-\sigma_r/\sqrt{2\pi}\right].$$

$$p = w + k + f(q - l + k)$$

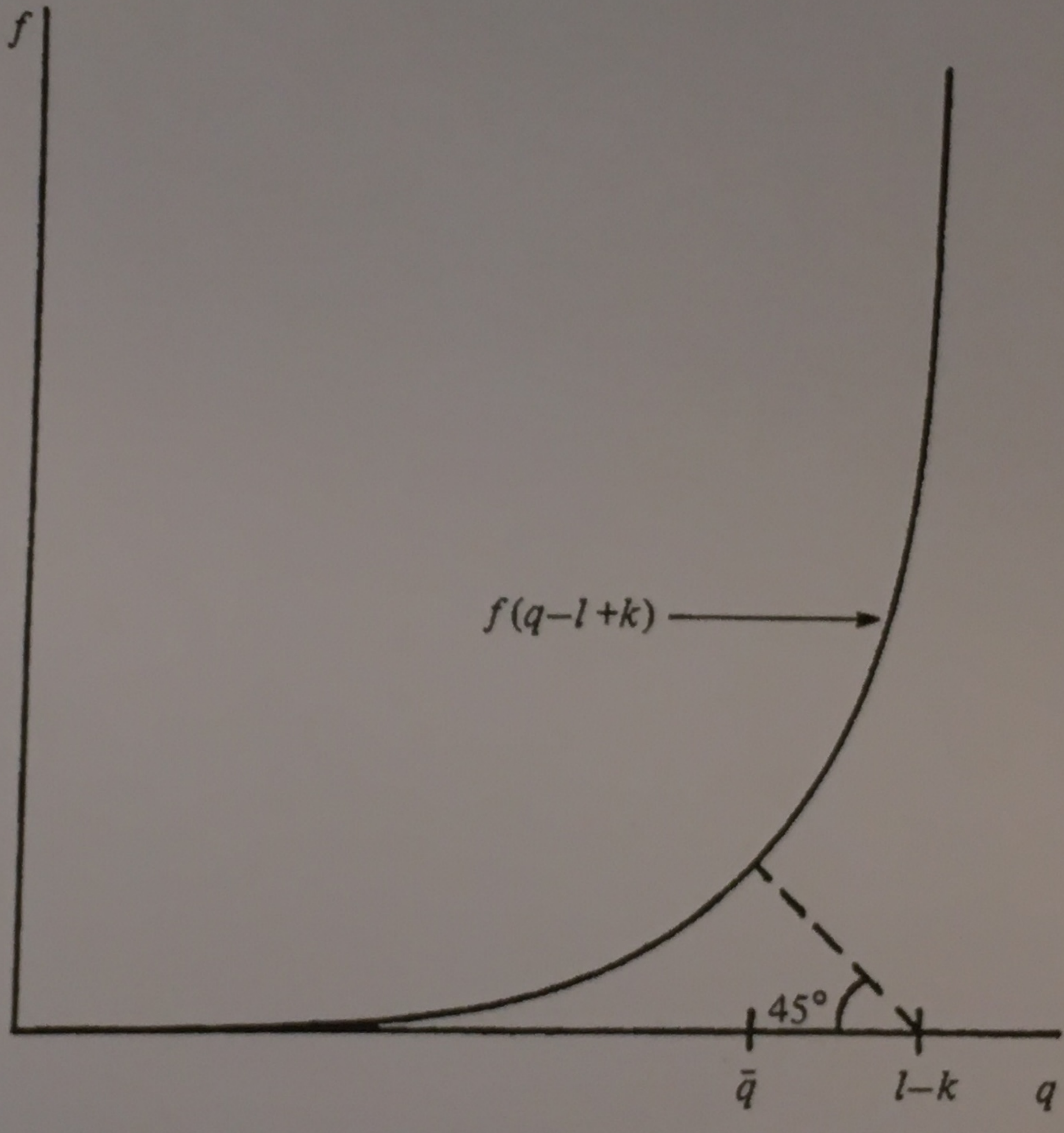

Fig. 3. Determination of natural rate of output.

Bottlenecks and Short-run/Medium-run Inflation Dynamics

- The bottleneck model yields novel inflation dynamics over the medium run when aggregate output changes.

- To see this, ignore random sectoral shocks and suppose
  - $\xi = 0$, so no Phillips curve effect on base wages
  - $\beta = 0$, so inflationary momentum does not change
  - $\lambda = 0$, so no sectoral labor movements.

- Consider a change in q_t over, say, one year resulting from monetary policy. From the AS curve $p_t = w + k + f(q_t - l + k)$, we have, to first order,

$$\Delta p_t = b(1-b)^{-1}\Delta q_t.$$

$$\Delta p_t = b(1-b)^{-1}\Delta q_t.$$

- In particular, starting from a high level of q, with $b < 1$ high, a reduction in q will lead to a large reduction in inflation Δp.
  – This is separate from the Phillips curve effect of lower q on base wages.

- In the context of the late 2022/early 2023 US economy, with labor and supply-chain bottlenecks still important, a reduction in the output gap may substantially reduce inflation through the easing of bottlenecks.
  – If $\beta > 0$ then reduced inflation would also be incorporated into inflation momentum, leading to lower inflation.
  – If $\lambda > 0$ there will also be sectoral movements to ease bottlenecks, leading to lower inflation.

Concluding remarks

- The bottleneck dynamics just described is the optimistic view
  – it ignores the possibility that higher inflationary "momentum" (expectations), arising from recent high inflation, may remain stubbornly high
  – also, there is the possibility of what Olivier Blanchard calls a "false dawn." This is because the effect is due to *changes* in the output gap (not due to its *level*).

- On the other hand, in the US it appears inflation expectations, while above target, are not greatly elevated – the current 10-year TIPS break-even inflation rate is about 2.2%.
  – and (with $\lambda > 0$) market forces can be expected to ease bottlenecks over time because of sectoral adjustments.