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Increasing Returns to Scale and the Long-Run Phillips Curve

by

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Abstract:
A growing body of empirical evidence shows that there exists a long-run positive tradeoff between inflation and real macroeconomic activity. Within a New Keynesian framewok, we examine how increasing returns generate a positive long-run relation between inflation and output.

Keywords: Phillips curve, Inflation, Increasing returns, nominal inertia, monetary policy.
JEL classification: E3, E20, E40, E50.

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1 Introduction

There is a growing body of empirical evidence that there is a long-run tradeoff between inflation and real macroeconomic activity. Mankiw (2001) writes that "..if one does not approach the data with a prior favoring long-run neutrality, one would not leave the data with that posterior. The data's best guess is that monetary shocks leave permanent scars on the economy". Akerlof, Dickens and Perry (1996, 2000) find that the Phillips curve becomes downward-sloping at low inflation rates when there are permanent downward wage rigidities or departures from rational expectations. Ball (1997) provides evidence indicating that countries which had comparatively large and long declines in inflation also tended to have comparatively large increases in their NAIRUs. Dolado, López-Salido and Vega (2000) find some evidence of a long-run inflation-unemployment tradeoff for Spain during 1964-1995. Fair (2000), Fisher and Seater (1993), King and Watson (1994), and Karanassou, Sala and Snower (2003, 2005) find such a tradeoff for the U.S. and the E.U. as well.

This body of evidence is somewhat at odds with mainstream theory. The microfounded New Keynesian Phillips Curve (NKPC), often written as $\pi_t = \beta E_t \pi_{t+1} - a\left(u_t - u^n\right) + \varepsilon_t$ (where π_t is inflation, u_t is unemployment, and β is the discount factor), implies a long-run inflation-unemployment tradeoff, but this tradeoff is generally considered too steep to account for evidence such as that above. When the microfoundations of the NKPC are analyzed, as in Ascari (1998, 2000), Devereux and Yetman (2002) and Graham and Snower (2003), we find that the long-run Phillips curve tradeoff is due to three factors:

1. When prices are sticky due to Taylor or Calvo price staggering, inflation causes relative prices to vary over the contract period. The relative price variations lead consumers to substitute between goods - a phenomenon we may call "product cycling". If these goods are imperfect substitutes, then product cycling is inefficient, so that a rise in inflation leads to a fall in aggregate product demand.

2. When the output is produced by labor (or other productive factors), then product cycling gives rise to "labor cycling", i.e. substitutions among factors producing the products. In the presence of diminishing returns to labor, such labor cycling is inefficient, so that a rise in inflation leads to a further fall in output.

3. Under price staggering, the price of a product depends on the present and future price level. The greater the rate of time discount, the more closely the product price depends on the current (rather than the future) price level - for the simple reason that the future is valued less. Thus, the greater the rate of money growth and inflation, the lower will prices be set relative to the money supply. Consequently real money balances rise, leading to a rise in output.

The first two effects imply a negative relation between inflation and output, whereas the third implies a positive effect. It can be shown that, except at very low inflation rates, the first two effects dominate the third (Graham and Snower, 2003).

The contribution of this paper is to examine the implications of increasing returns on this analysis. The empirical evidence indicates that increasing returns are observable in various sectors of the economy, including firms and plants both in the manufacturing and in the retailing sector (see, for example, Betancourt and Malanoski, 1999, Ramey, 1991, and Roberts and Supina, 1997).

We show that in the presence of increasing returns, labor cycling leads to efficiency gains. The greater the inflation rate, the greater the degree of labor cycling and the greater these efficiency gains. Consequently, labor cycling gives rise to a positive relation between inflation and output. For reasonable calibrated values, we show that this effect is sufficiently strong as to generate a positive inflation-output tradeoff, even in the presence of product cycling. An increase in money growth (and thus inflation) leads to a sufficiently large increase in output to be roughly consonant with the empirical evidence above. The upshot of our analysis is that returns to scale matter for the shape of the long-run Phillips curve.

The paper is organized as follows. Section 1 presents our dynamic general equilibrium model, which is quite standard, except for the inclusion of increasing returns to scale. We derive the corresponding long-run Phillips curve. Section 2 clarifies the underlying intuition for our results. Section 3 concludes.

2 The Model

The economy has three markets: a perfectly competitive labour market, a monopolistically competitive intermediate goods market with staggered prices, and a perfectly competitive final goods market. The money supply grows at rate $(\mu - 1)$. All nominal values are detrended in terms of the money supply.

Consumers maximize their utility over consumption (c_t), real money holdings ($\frac{m_t}{p_t}$) and working time (n_t) subject to the budget and resource constraints:

$$\max_{\{c_t,m_t,n_t\}} \sum_{t=0}^{\infty} \beta^t \left[\ln c_t + V\left(\frac{m_t}{p_t}\right) - \kappa \frac{n_t^{1+\phi}}{1+\phi} \right]$$
$$\text{subject to } p_t y_t = p_t c_t + m_t - \frac{m_{t-1}}{\mu}$$
$$p_t y_t = w_t n_t + p_t \pi_t$$

where p_t is the aggregate price level, y_t is the level of output, π_t are profits, β is the time discount factor, and κ and ϕ are positive constants. First-order conditions for consumption, labour and money holdings are

$$\frac{1}{c_t} = \lambda_t \tag{1}$$

$$-\kappa n_t^{\phi} + \lambda_t \frac{w_t}{p_t} = 0 \tag{2}$$

$$V_m\left(\frac{m_t}{p_t}\right)\frac{1}{p_t}-\frac{\lambda_t}{p_t}+\frac{\lambda_{t+1}}{p_{t+1}}\frac{1}{\mu}=0 \tag{3}$$

In the intermediate product market, each firm is an imperfectly competitive price setter, under Taylor price staggering. Specifically, the i'th firm sets the price p_{it} of the i'th good in period t for a contract period that lasts until period $t+N$. This price is set so as to maximize its profit subject to its product demand (derived from (7), below) and its production function:

$$\max_{\{p_{i,t}\}} E_t \sum_{i=0}^{N-1} \beta^{t+i}\left[\frac{p_{i,t}}{p_{t+i}\mu^i}y_{i,t+i}-\frac{w_{t+i}}{p_{t+i}}n_{t+i}\right] \tag{4}$$

$$\text{subject to} \quad y_{i,t+i}=\left(\frac{p_{i,t}}{p_{t+i}\mu^i}\right)^{-\theta_p} y_{t+i}$$

$$y_{i,t+i}=n_{i,t+i}^{v} \tag{5}$$

where $y_{i,t+i}$ is the i'th output at time $t+i$, w_{t+i} is the nominal wage, n_{t+i} is employment, and y_{t+i} is aggregate output. The elasticity of substitution among intermediate goods, θ_p, is a positive constant. Since there are increasing returns to scale, $v>1$ in the production function.

The first-order condition implies the following price setting equation:

$$p_{i,t}=\frac{\theta_p}{v\left(\theta_p-1\right)}\frac{\sum_{i=0}^{N-1}\beta^{t+i}y_{i,t+i}^{\frac{1}{v}}\frac{w_{t+i}}{p_{t+i}}}{\sum_{i=0}^{N-1}\beta^{t+i}\frac{y_{i,t+i}}{p_{t+i}\mu^i}} \tag{6}$$

The second-order condition implies that $v<\frac{\theta_p}{\theta_p-1}$.

In the final product market, perfectly competitive firms buy an horizontally differentiated input, $y_{i,t}$, to produce an homogenous output, y_t. They set output so as to maximize their profit subject to their production function:

$$\max_{\{y_{i,t}\}} p_t y_t-\sum_{i=0}^{N-1}\frac{p_{i,t}}{\mu^i}y_{i,t} \tag{7}$$

$$s.t. y_t=\left(\sum_{i=0}^{N-1}y_{i,t}^{\frac{\theta_p-1}{\theta_p}}\right)^{\frac{\theta_p}{\theta_p-1}}$$

Solving (7), we obtain the demand function for the intermediate good $y_{i,t}$:

$$y_{i,t}=\left(\frac{p_{i,t}}{p_t\mu^i}\right)^{-\theta_p} y_t \tag{8}$$

The free entry condition gives the aggregate price index:

$$p_t = \left[\sum_{i=0}^{N-1} \left(\frac{p_{i,t}}{\mu^i} \right)^{1-\theta_p} \right]^{\frac{1}{1-\theta_p}} \tag{9}$$

The general equilibrium is the solution of the equation system comprising the consumption condition (1), the leisure condition (2), the money balance condition (3), the production function (5), the price setting equation (6), the intermediate good demand (8), the price index (9), as well as the market clearing condition:

$$y_t = c_t \tag{10}$$

The solution technique is outlined in the appendix.

We calibrate the system for standard parameter values showed in Table 1. The resulting long-run relation between money growth (equal to inflation) and output (for two different values of the elasticity of substitution θ_p) is pictured in Fig. 1. Observe that a permanent increase in money growth has a sizable effect on the level of output. The classical dichotomy breaks down in a non-trivial way: the real and monetary sides of the economy are not independent of one another in the long run. Furthermore, note that a rise in the elasticity of substitution θ_p implies an increase in the output effect of monetary policy, given that substitution inefficiencies decrease.

Our analysis does not however imply that the Phillips curve necessarily remains upward-sloping over the entire range of relevant money growth rates. The reason is that production functions often display increasing returns only as long as factor utilization is not too high. Once output exceeds some critical level, diminishing returns often set in and then the Phillips curve becomes downward-sloping.

Finally, we turn to the intuition underlying our results.

3 Intuition

As noted in the introductory section, aggregate price level inflation under staggered price setting leads an instability of relative prices that generates "product cycling" (households' substitutions among different products) and "labor cycling" (firms' substitutions among different labor types). Product cycling is inefficient when the products are imperfect substitutes; labor cycling is inefficient under diminishing returns, but efficient under increasing returns.

The nature of the latter inefficiency or efficiency is illustrated in Fig. 2, which pictures a total cost function. Under increasing returns, the marginal cost function is declining, and thus when production fluctuates between $A + \epsilon$ and $A - \epsilon$, there is an increase in efficiency due to the concavity of the cost function, as the average total cost is equal to C_2 and not to C_1. Conversely, under diminishing returns, the marginal cost function is increasing, so that when production fluctuations between $B + \epsilon$ and $B - \epsilon$ take place, there is a drop in efficiency, since the average total cost is equal to C_3 and not to C_4.

The greater is the elasticity of substitution among products, the smaller is the inefficiency from product cycling and thus the greater the permanent output gain from an increase in inflation.

In sum, the long-run Phillips curve tradeoff depends on the technologies available to the firms: increasing returns imply a positive relation between macroeconomic activity and money growth; and - abstracting from the time discounting effect that is dominant at very low inflation rates - diminishing returns imply a negative relation.

4 Appendix: Solving the General Equilibrium System

For sake of simplicity we normalize the real wage to 1. Then given that $p_{i,t}$ is constant in steady state at the value p_0, we used (9) to obtain:

$$\frac{p_0}{p} = \left[\frac{1}{N}\frac{1-\mu^{N(\theta_p-1)}}{1-\mu^{(\theta_p-1)}}\right]^{\frac{1}{\theta_p-1}} \tag{11}$$

From (6), we find the level of output for cohort zero:

$$y_0 = \left\{\frac{\theta_p}{v\left(\theta_p-1\right)}\frac{p}{p_0}\frac{\sum_{i=0}^{N-1}\beta^i\mu^{i\frac{\theta_p}{v}}}{\sum_{i=0}^{N-1}\beta^i\mu^{i(\theta_p-1)}}\right\}^{\frac{v}{v-1}} = \left\{\frac{\theta_p}{v\left(\theta_p-1\right)}\frac{p}{p_0}\frac{\frac{1-\beta^N\mu^{N\frac{\theta_p}{v}}}{1-\beta\mu^{\frac{\theta_p}{v}}}}{\frac{1-\beta^N\mu^{N(\theta_p-1)}}{1-\beta\mu^{(\theta_p-1)}}}\right\}^{\frac{v}{v-1}} \tag{12}$$

Then it is possible to use

$$y_0 = \left(\frac{p_0}{p}\right)^{-\theta_p} y \tag{13}$$

to derive the steady state level of aggregate output, y.

The steady state values of $y_{i,t+i}$ for $i = 1, ..., N$ can be computed by taking the ratio of (8) for different cohorts. For instance for cohort zero and cohort one:

$$\frac{y_0}{y_1} = \frac{\left(\frac{p_0}{p}\right)^{-\theta_p} y}{\left(\frac{p_0}{p\mu^i}\right)^{-\theta_p} y} = \mu^{-i\theta_p} \tag{14}$$

where variables without subscripts are at their steady state values. From y_i, one can derive n_i by using (5) :

$$n_i = y_i^{\frac{1}{v}}$$

n_i is the demand for labour of cohort i, therefore summing n_i over all the cohorts of the firms will gives n, the aggregate quantity of labour. Having this in hand, it is possible to set κ endogenously by using (2)

$$\kappa n_t^{\phi} = \lambda_t \frac{w_t}{p_t}$$

the consumption first order condition

$$\frac{1}{c_t} = \lambda_t$$

and the aggregate equilibrium condition

$$y_t = c_t$$

so that

$$\kappa = n^{-\phi} \frac{1}{y} \frac{w}{p}$$

where variables without time subscripts are variables at their steady state values.

Recalling that $\frac{1}{c} = \lambda$ and $y = c$ (3) yields the steady state value of $\frac{m_t}{p_t}$:

$$\frac{m}{p} = V_m^{-1} \left[\lambda \left(1 - \frac{1}{\mu} \right) \right]$$

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Table 1 – Baseline Calibrated Parameter Values

ϕ	θ_p	N	β	v
5	10	4	$0.98^{(1/N)}$	1.01

Figure 1 – The Long-Run Output-Inflation Relationship for Different Values of θ_p and ν=1.01

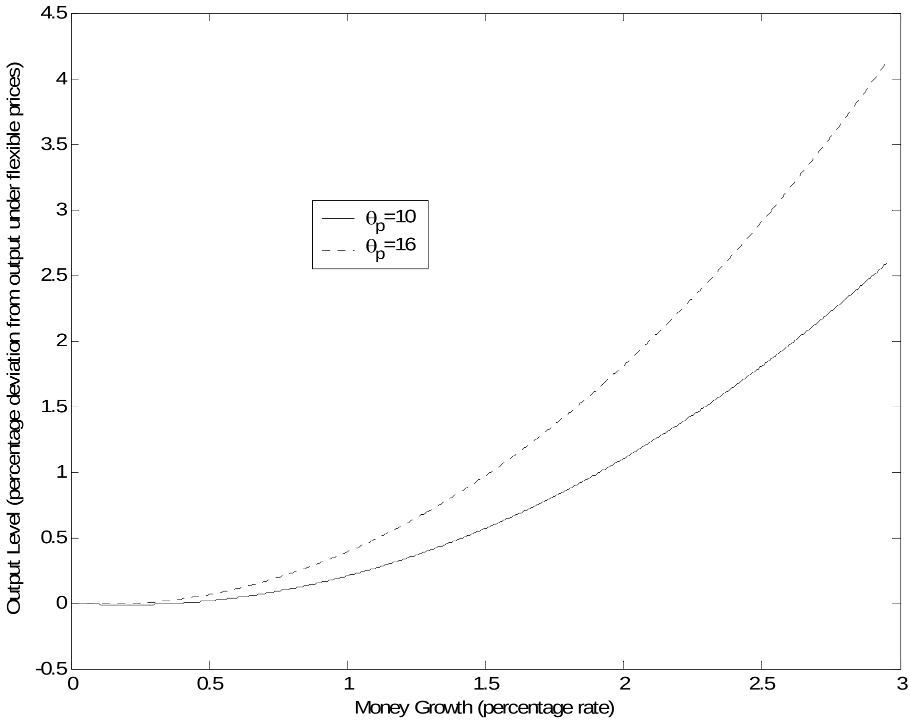

Figure 2 – The Cost Function