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Relative productivity growth and the secular "decline" of U.S. manufacturing

Milton Marquis [a], Bharat Trehan [b,*]

[a] Florida State University, United States
[b] Federal Reserve Bank of San Francisco, Economic Research, 101 Market Street, San Francisco, CA 94707, United States

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ABSTRACT

There has been considerable debate about the causes of the "decline" of U.S. manufacturing over the post-war period. We show that the behavior of employment, prices and output in manufacturing relative to services over this period can be explained by a two-sector growth model in which productivity shocks are the only driving forces. Household preferences turn out to play a key role in our model. The data are consistent with a specification where households are unwilling to substitute goods for services (the estimated elasticity of substitution is statistically indistinguishable from zero), so the economy adjusts to differential productivity growth entirely by re-allocating labor across sectors.

1. Introduction

Over most of the post-war period, employment in the manufacturing sector in the United States has grown noticeably more slowly than employment in services, while the relative price of manufactures has declined. Faster productivity growth in the manufacturing sector is often cited as an explanation.[1] Moving resources to services may be the optimal response to higher productivity growth in manufacturing because it could allow increased consumption of both goods. However, others have emphasized the role of rising imports[2]; indeed, in popular discussions, the decline in manufacturing employment is often seen as evidence of the decline of U.S. manufacturing. In rebuttal, it has often been noted that a significant role for imports is hard to reconcile with output data which show little, if any, secular decrease in manufacturing output relative to real GDP.[3]

However, an approximately constant ratio of manufacturing output to GDP does not necessarily imply that increased imports have had little effect on the U.S. economy. For example, the constant share of manufacturing output to GDP could be the result of two roughly offsetting changes: an increase in demand (of any size) for manufactures in response to productivity-induced declines in the relative price and an increase in imports to satisfy this demand.

How much the demand for manufactures will go up in response to falling prices depends upon household preferences. Consequently, in Section 2 below, we specify a two-sector model (manufactures and services) in which close attention is paid to how the parameters of the household utility function affect the response of the economy to various disturbances. Specifically, we assume that household utility is given by a *CES* utility function, so that the economy's response to productivity shocks depends upon how willing the consumer is to substitute between manufactures and services. On the supply side, in order to focus on the role of productivity, we assume the same constant-returns-to-scale production technology in the two sectors, but allow them to experience different rates of exogenous technological progress.

Our objective is to try and determine how much a productivity-driven model can explain. As we show below, the production side of our model imposes restrictions on the relationship between the growth rates of relative prices, output and employment in the two sectors. These restrictions are not rejected in our data sample which spans the 1950–2006 period. Two other findings are worth noting. First, we find that the average growth rate of manufactured goods output is statistically indistinguishable from that of the output of services. Second, the decline in the price of investment goods relative to the price of services is of the same size as the decline in manufacturing employment relative to services employment. In our model these findings are equivalent, in the sense that one

* Corresponding author. Tel.: +1 415 974 3207.
E-mail address: bharat.trehan@sf.frb.org (B. Trehan).

[1] Baumol (1967) makes the earliest such argument that we know of; see also Baumol, Blackman and Wolff (1989).

[2] See Revenga (1992) and Sachs and Shatz (1994) for analyses of the effects of increased imports on U.S. manufacturing employment and wages.

[3] See, for example, Bernanke (2003).

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implies the other. In addition, since relative prices depend only upon relative productivity in the two sectors, the latter finding also suggests that relative productivity shocks have been the dominant factor behind the decline in manufacturing employment over this period.

We also show that the utility function imposes restrictions upon how the ratio of goods to services consumption should grow relative to the growth rate of prices. It turns out that while the consumption of manufactures has grown at the same rate as the consumption of services over our sample, the price of manufactures relative to services has fallen quite sharply over this period. In the model this implies that the elasticity of substitution is zero, that is, consumers appear to be completely unwilling to substitute manufactures for services. We go on to discuss the model's implications for relative consumption growth rates if the elasticity of substitution were somewhat larger than zero.

Equal growth rates of consumption over a roughly 50-year span in the face of a pronounced trend in relative prices do not, by themselves, prove the case for a zero elasticity of substitution between manufactures and services. To take one example, a relatively high income elasticity of demand for services could offset the effect of technologically induced declines in the relative price of manufactures and make it appear as though consumers were unwilling to substitute between the two goods. The sample period under study turns out to contain a natural experiment that provides a way to distinguish alternative hypotheses. It turns out that there is a statistically significant acceleration in the rate of productivity growth in the manufacturing sector relative to productivity growth in the services sector during the late 1960s.

Our model implies that this permanent change in relative productivity growth rates should show up in the various quantities and prices determined in the model. Consistent with the model, we find evidence of breaks in the relative employment series and in the series measuring the price of investment goods relative to services. Another implication of the productivity-driven model (which is not intuitively obvious) is that the change in the growth rate of the relative price variable equal the change in the growth rate of relative employment in the two sectors. This restriction is not rejected by the data. However, we find no evidence of any break in relative consumption growth rates following the break in relative productivity growth (even though relative prices appear to break), a finding that is hard to explain without invoking a zero elasticity of substitution.

The remainder of the paper is organized as follows. Section 2 lays out the theoretical model and derives the restrictions placed by the model on the behavior of output, employment and prices in the two sectors. Section 3 presents the data as well as the results of the empirical tests based upon the model while Section 4 concludes.

2. A two-sector model with differential productivity growth

We study a two-sector model of a closed economy in which the production technologies in the manufacturing and service sectors differ only with respect to the rate of technological progress. Households may view the goods as imperfect substitutes. Adjustments to productivity differentials can take the form of changes in the relative price of goods versus services, changes in relative outputs or shifts of employment between sectors.

2.1. Households

The economy consists of a large number of identical households that derive utility by consuming services, s, and manufactured goods, m^c, in accordance with a *CES* utility function:

$$U(s, m^c) = [\eta s^{-\rho} + (1-\eta)(m^c)^{-\rho}]^{-1/\rho}, \quad \eta > 0, \quad \rho \geq -1 \tag{1}$$

The intratemporal elasticity of substitution between services and manufactures is given by

$$\sigma = \frac{1}{1+\rho}, \quad \sigma \geq 0 \tag{2}$$

and determines the intratemporal marginal rate of substitution between m^c and s:

$$\frac{U_s}{U_{m^c}} = \left(\frac{\eta}{1-\eta}\right)\left(\frac{m^c}{s}\right)^{1/\sigma} \tag{3}$$

The representative household maximizes lifetime utility by choosing the mix of services and manufactured goods to purchase, the allocation of labor between the production of services (n^s) and the production of manufactures (n^m), and gross investment (i) in capital (k) that is rented to the producing firms:

$$\max_{\{s, m^c, i, n^s, n^m\}} \int_0^\infty e^{-\nu t} U(s, m^c), \quad \nu \in (0, 1) \tag{4}$$

The household's choices take the initial capital stock, k_0, as given and are subject to a budget constraint:

$$s + q(i + pm^c) \leq w^s n^s + w^m n^m + qrk \tag{5}$$

where q is the relative price of investment goods in units of services, r is the real rate of return on capital, pq is the relative price of household manufactured goods to services, and w^s and w^m are real wage rates for employment in the two sectors.

Net investment in capital is given by

$$\frac{dk}{dt} = i - \delta k, \quad \delta \in (0, 1) \tag{6}$$

where δ is the depreciation rate.

Labor allocations also must satisfy the resource constraint:

$$n^s + n^m \leq 1 \tag{7}$$

The set of optimality conditions that solve the household's problem is

$$\left(\frac{\eta}{1-\eta}\right)\left(\frac{m^c}{s}\right)^{1/\sigma} = \frac{1}{pq} \tag{8}$$

$$w^s = w^m \tag{9}$$

$$\frac{1}{U_s}\frac{dU_s}{dt} = \nu - r + \delta - \frac{1}{q}\frac{dq}{dt} \tag{10}$$

$$\frac{1}{U_{m^c}}\frac{dU_{m^c}}{dt} = \nu - r + \delta + \frac{1}{p}\frac{dp}{dt} \tag{11}$$

Eq. (8) represents the efficiency condition that determines the household's intratemporal consumption bundle, and Eq. (9) is the condition that induces an optimal allocation of labor. Eqs. (10) and (11) indicate how relative prices affect the trends in the marginal utilities of services and manufactures. As discussed below, a secular decline in the relative price of investment goods, that would occur in the event of faster productivity growth in the manufacturing sector than in the services sector, increases the marginal utility of services, while a secular decline in the relative price of household manufactures, that may come about through a combination of economic growth and a lack of substitutability between manufactures and services in consumption, would reduce the growth in the marginal utility of manufactures. These relationships impose restrictions from household preferences that relate the relative