Structural Change and Economic Dynamics 23 (2012) 117–126

Contents lists available at SciVerse ScienceDirect

Structural Change and Economic Dynamics

journal homepage: www.elsevier.com/locate/sced

Wage bargaining and induced technical change in a linear economy: Model and application to the US (1963–2003)

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ARTICLE INFO

Article history:
Received 23 November 2009
Received in revised form
12 November 2010
Accepted 3 November 2011
Available online 25 November 2011

JEL classification:
E24
E25
J52
O31

Keywords:
Bargaining
Induced technical change
Factor shares
Employment

ABSTRACT

In a simple one-sector, two-class, fixed-proportions economy operating at full capacity, wages are set through generalized axiomatic bargaining *à la* Nash (1950). As for choice of technology, firms choose the direction of factor-augmenting innovations to maximize the rate of unit cost reduction (Kennedy, 1964; Funk, 2002). The aggregate environment resulting by self-interested decisions made by economic agents is described by a two-dimensional dynamical system in the employment rate and output/capital ratio. The economy converges *cyclically* to a long-run equilibrium involving a Harrod-neutral profile of technical change, a constant rate of employment of labor, and constant input shares. The type of oscillations predicted by the model matches qualitatively the available data on the United States (1963–2003). Institutional change, as captured by variations in workers' bargaining power, has a positive effect on the rate of output growth but a negative effect on employment.

1. Introduction

The standard literature on the direction of technical progress assumes in Neoclassical fashion that productive inputs are paid their marginal contribution to a smooth production function, so that in the absence of frictions in the labor market labor is constantly fully employed (Acemoglu, 2003 is an authoritative example). Foley and Michl (1999) first, and more recently Basu (2009) have shown using a broad cross-section of countries that the empirical support for the hypothesis of marginal productivity pricing of labor is very little, to use an euphemism.

On the other hand, wages need not equal marginal product of labor in models of production where factors of production enter in fixed proportions (Leontief). Thus, these frameworks accommodate naturally for unemployment of the labor force even when the labor market is assumed to work smoothly. However, fixed-proportions models leave typically open the determination of factor prices, in assuming the prevailing wage to be set exogenously through social mechanisms, and not through the profit maximization or cost minimization behavior typical of the capitalist firms that economic theorists are familiar with.

Being convinced by the overwhelming evidence, for instance the one presented by Basu (2009), against marginal productivity pricing of labor is one thing, handwaving on wage determination is another, though. It is therefore surprising that not much effort has been dedicated by economists trained in linear production models into 'digging deeper' in the social features of distribution operating behind the black box labeled 'wages', so as to come up with analytical theories of wage-setting behavior. Scholars working in more mainstream traditions,

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doi:10.1016/j.strueco.2011.11.001

on the other hand, have spent a great deal of time and brainpower in figuring out theories of wages, such as efficiency wages (Solow, 1979; Shapiro and Stiglitz, 1984), insiders-outsiders (Lindbeck and Snower, 1987), trade unions' behavior (see for instance the survey by Oswald, 1985), efficient bargaining (McDonald and Solow, 1981), just to cite some. The problem with most of these theories is that what determines the equilibrium employment rate is still firms' labor demand schedule, which is supposed to be elastic to the wage. Thus, at an equilibrium of these models wages are still equal to marginal product of labor.

The purpose of this paper is to take one step toward an analysis of social determination of wages in an otherwise standard one-sector, two-class, fixed-proportions model with induced technical progress, and to study what are the implications of this step for choice of technology, growth and distribution in capitalist economies. The reason for the choice of a fixed-coefficient technology is twofold. On the one hand, the issues highlighted by the Cambridge Capital Controversy of the 1960s and 1970s warn against generalizing distributional propositions valid in corn models with instantaneous input substitution to disaggregated frameworks with more than one sector (Robinson, 1956; Sraffa, 1960; Samuelson, 1966). On the other hand, Leontief models allow to determine factor demands and factor prices without any reference to marginal products.[1] Furthermore, embedding wage-setting in a framework with class-distinction and induced technological progress has the purpose of linking income distribution and class-conflict to economic growth, this way accounting for the movements of factor productivities, factor shares, and unemployment, and relating to the existing literature on the subject. The class struggle model by Goodwin (1967), for instance, is built around an assumption linking wage growth with the employment rate as a proxy for workers' bargaining power. More recently, models of distribution and growth extending the Goodwin (1967) analysis of growth cycles to include induced factor-augmenting technological change have been developed by Shah and Desai (1981), van der Ploeg (1987), and Julius (2005). All of these models feature an exogenously determined wage and an underlying fixed-proportions economy.

In contributing to the scientific production on class-struggle, growth and income distribution, I assume that two types of economic units, workers and capitalists, populate a simple one-sector economy. In the baseline version of the model, workers possess only labor power, and consume all their income. Capitalists own the means of production, hire labor and tie up capital to undertake production, and save over time in order to accumulate capital. The paper is built around two assumptions about the behavior of economic agents regarding price-setting and innovation choice:

1. wage setting occurs institutionally through generalized axiomatic bargaining *à la* Nash (1950) between workers and capitalists;
2. in choosing factor-augmenting technologies, firms behave according to what Funk (2002) called *hypothesis of induced innovation*, namely they choose rates of factor augmentation so as to maximize the rate of unit cost reduction given the costs of technology adoption (Kennedy, 1964; Drandakis and Phelps, 1965; Samuelson, 1965).

The main implications of the present analysis are that economic decisions on wage determination, innovation and capital accumulation eventually boil down to a two-dimensional dynamical system in output/capital ratio and the employment rate. The dynamics of the economy evolves so as to ensure a Harrod-neutral path of technical progress, and a constant long-run employment rate which adjusts so as to ensure the constancy of factor shares at the long-run equilibrium. Convergence to the equilibrium path of growth and distribution occurs cyclically, and these oscillations are shown to be consistent with the available empirical evidence for post-war United States. Also, out of equilibrium both the profit rate and the growth rate of capital productivity decline with the employment rate, while the growth rate of output per worker and the real wage increase with the employment rate. Finally, variations in the relative contractual power of the bargainers have important implications for patterns of growth and distribution through induced technical change: a higher contractual weight of the workers induces a higher long-run rate of labor-augmenting innovations, coupled however with higher long-run unemployment.

The remainder of the paper is organized as follows. In Section 2, I first describe the economic environment, given by the technology for output production and the wage bargaining structure. Then, I define a static equilibrium for the economy, in which real wage, profit rate, and factor demands are determined. I turn to the consumption and savings decisions of capitalists, and to the choice of technology adoption under the hypothesis of induced innovation. Section 3 is devoted to derive the dynamical system describing the economy, characterize its long-run equilibrium, study its stability properties, analyze qualitatively the behavior of the system in the phase space, and carry comparative dynamics exercises for varying exogenous parameters. To check the relevance of the theoretical model proposed, in Section 4 I use annual data on output/capital ratio from the Extended Penn World Tables (3.0) and annual unemployment rate from the Bureau of Labor Statistics (BLS) to show that the type of dynamic behavior predicted by the model is consistent with the available evidence on the United States (1963–2003). Finally, I extend the model to include workers' savings, and show that the conclusions of the baseline framework are robust with respect to such different behavioral assumption. Section 6 concludes.

[1] For readers familiar with such kind of issues, here is a valuable remark suggested by Duncan Foley. From a strictly mathematical point of view, Leontief production functions do have 'marginal products'. What happens is that the 'gradient' one gets from the tangent plane to the isoquant in the smooth substitution case is generalized to a 'subgradient', which is a set of direction vectors normal to the Leontief isoquant. As one anonymous referee points out, a wage rate determined through bargaining need not lie within the range of such direction vectors.