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DYNAMIC LABOUR DEMAND FUNCTIONS WITH NON-WAGE LABOUR COSTS: THEORY AND ESTIMATION TECHNIQUES *

by

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1. INTRODUCTION

The creation of employment opportunities in order to reduce the high levels of unemployment has been one of the biggest challenges facing Caribbean governments. In 1995, official unemployment rates varied from 11.1% in the Bahamas to 19.7% in Barbados. While the government has provided several incentives to the private sector to increase the level of employment, it has played a direct role by offering employment in public enterprises, statutory bodies and central government. Despite these measures the absorptive capacity of private and public sector agencies has still remained low.

Little empirical work has been undertaken in the Caribbean to identify the factors which influence employment (and unemployment) in a systematic way [see Downes, 1992, for a survey]. Although several 'possible causes' of employment growth have been suggested (e.g. the effective demand for output, production and organisational technologies, relative factor prices, socio-legal framework and the availability of other inputs), there has been little empirical verification of the magnitude and/or significance of these 'causes' of employment growth in the region [see Farrell, 1980]. The available empirical studies on aggregate employment in the Caribbean suggest the following:

i. output growth is the main factor influencing employment growth;

ii. the elasticity of employment with respect to output varies between 0.25 and 0.64;

iii. real wage rates have a weak influence on employment expansion;

iv. adjustment costs (hiring and firing costs) as captured in a lagged employment variable are important in employment growth;

v. highly unionized sectors (as in the case of Jamaica) have experienced slower rates of employment growth.

[see Brewster, 1971; Boamah, 1985; Mascoll, 1985; Leon and Mascoll, 1986; Charles & St.Cyr, 1988; Bourne, 1988; Gafar, 1988, Coppin, 1994a, 1994b; Rama, 1995a, 1995b].

The traditional neoclassical approach to labour demand specifies it as a function of a vector of relative input prices and an output variable [see Hamermesh, 1993; Sapsford & Tzannatos, 1993]. Legislative measures in the form of severance or redundancy payments, unemployment insurance and advance notice along with other institutionally determined measures add to the overall costs of hiring and firing of persons[1]. These non-wage adjustments costs make the labour input a quasi-fixed factor of production and leads to the dynamization of the labour demand function [Oi, 1962]. These costs can dampen employment growth in the long run.

This paper, which is part of a research project on the impact of labour market regulation on employment in the Caribbean (i.e. Bahamas, Barbados, Belize; Guyana, Jamaica and Trinidad & Tobago) outlines the underlying theoretical principles of dynamic labour demand functions in the context of Caribbean labour market characteristics. In Section 2, the nature and role of non-wage labour costs in labour demand (employment) functions are examined. The alternative specifications of the labour demand function with non-wage labour costs are presented in Section 3. The principles for estimating these specifications are given for both time series and panel data models in Section 4. The paper concludes by outlining the future work to be undertaken.

2. THE NATURE AND ROLE OF NON-WAGE LABOUR COSTS

The employment of a person in an enterprise involves various costs. These labour costs can be classified into (direct) wage costs and (indirect) non-wage costs.

Direct wages and salaries relate to remuneration for work performed. These include pay for normal time worked; premium pay for overtime and holiday work; premium pay for shift work and night work; incentive pay and family and cost-of-living allowances.

Non-wage labour costs are generally considered as adjustment costs and consist largely of hiring costs (i.e. the costs incurred by the employer in recruiting employees) and firing costs (i.e. the costs of terminating the employment of workers in an enterprise). Hiring costs include advertising positions, screening applicants to evaluate their qualifications and processing successful applicants. In addition to these costs, there are overhead costs associated with the employment of additional workers (e.g. record-keeping, computing and issuing paychecks, providing information to government authorities, etc.). New employees may require training, hence the costs associated with such training should also be considered. The hiring of workers therefore involves search, screening and training costs to the employer. Hiring and training costs can be regarded as fixed or sunk costs to the firm.

Once the worker is hired there are several other costs associated with his/her continued employment in the enterprise. These include:

i. remuneration for time not worked (annual vacation and other paid leave; public and other holidays; other time off granted with pay; severance and termination pay);

ii. bonuses and gratuities (year-end and seasonal bonuses; profit-sharing and gainsharing bonuses);

iii. cost of food, drink and other payments in kind;

iv. housing and rent allowances provided by the employer;

v. employers' social security payments on behalf of the employee (i.e. direct payments by the employer to employees regarding social security payments; employer's contributions to social security and pension schemes, both statutory and non-statutory). Social security schemes tend to cover such items as sickness, maternity, invalidity, employment injury, unemployment and old age pension payments.

vi. employer's cost for vocational training, welfare services (canteens, educational, cultural and recreational facilities and services) and other labour costs (e.g. work clothes, recruitment costs, costs of transporting workers to and from work).

vii. taxes regarded as labour costs (e.g. taxes on employment or payroll) adjusting for allowances or rebates by the State.

Non-wage labour costs therefore consist of the costs of hiring and training new employees; legally required social insurance programs and other measures and negotiated fringe benefits. The existence of the non-wage labour costs makes labour a quasi-fixed factor of production. An important implication of these costs is that the firm has a choice between hiring more (or fewer) workers and employing existing workers for longer (or shorter) hours as the production requirements change. Once a set of workers has been hired, many of these non-labour costs become fixed employment costs which do not vary with the number of hours worked as in the case of wage costs. A firm can therefore produce a given a level output with various combinations of:

i. the number of persons hired, and
ii. the number of hours worked per unit of time.

The production function is therefore specified as

$$q = q\,(e, h; \theta) \qquad (1)$$

where, q is the flow of output
e is the number of workers
h is the average number of hours worked per employee
θ is other factors of production.

If non-wage labour costs represent a high proportion of total labour costs, then the employment (i.e. hiring) of labour can be retarded as firms seek to meet any unexpected increase in the demand for their produce by increasing the hours worked by existing staff. Low non-wage labour costs can encourage the greater employment of workers when demand for output increases.

The different components of non-wage labour costs also have differential effects on the demand for labour. Firing costs may be higher than hiring costs and can lead to some degree of inertia (e.g. labour hoarding) in the employment process. It can also result in more careful screening in the hiring process since firms would not like to incur a high contingent payment associated with termination.

The existence of non-wage labour costs therefore has implications for the dynamics of labour demand and the employer's choice between the number of workers and the number of hours worked per employee. They also have implications for the incidence of lay-offs by skill level since differences in such turnover costs by skill level can result in firms being more reluctant to lay-off skilled than unskilled employees in response to a decline in demand (i.e. the hoarding of skilled labour).

3. DYNAMIC LABOUR DEMAND FUNCTIONS

Dynamic labour demand functions can be motivated via the existence of adjustment costs and the role of expectations. These two factors suggest that we can have several specifications of dynamic labour demand functions depending on the nature of adjustment costs and expectations. For example, labour adjustment costs may be symmetric or asymmetric with respect to the hiring or firing of labour or linear or non-linear (e.g. quadratic) with respect to the rate of increase in hiring or firing costs. Expectations can take various forms, for example, adaptive or rational.

In addition to adjustment costs and expectations, alternative labour demand models can be specified according to the assumptions made about the production technology used by the firm; the vintage of the capital stock; the structure of the commodity and labour markets and the institutional framework governing labour market behaviour (e.g. the role of trade unions). Recent literature on the economics of collective bargaining and trade union behaviour indicates several models which govern the negotiations process. The two main models are the labour demand and the efficient bargain. There are two variants of the labour demand model; first, the monopoly union model where the wage rate is set unilaterally by the union and the firm determines the appropriate level of labour demand and secondly, the right-to-manage model whereby the firm determines the demand for labour after the wage rate is determined by the bargaining process. In the efficient bargain model the union and the employer bargain over both the wage rate and the level of employment.

The specification of a dynamic labour demand function must therefore reflect the institutional features of the labour market and the behaviour of firms in the product and labour markets.

In this paper, a simple dynamic labour demand model will be developed. This model can easily be extended to incorporate alternative institutional and behavioural features of the Caribbean labour market. We assume that the representative firm faced with adjustment costs seeks to minimize the costs of production subject to a technological (production function) constraint. The firm's intertemporal optimization problem is given as:

$$\text{Min } V = \int_0^\infty [w_t L_t + m_t K_t + AC(L_t^o)] e^{-rt} dt \qquad (2)$$

subject to

$$q_t = q_t(K_t, L_t, \omega^{\cdot}_t) \qquad (3)$$

where w_t is the nominal wage rage; m_t is the rental price of capital, q_t is output, L_t is labour input, K_t is the capital input and $\omega^{\cdot}_t$ is a technical change variable and r is a discount rate (L^o is defined as dL_t/dt). Adjustment costs (AC) are assumed to be generated through changes in labour and not capital.

The AC function can take on special forms:

i. Quadratic and symmetric:

$$AC(L^o) = a L_t^{o\,2} \qquad (4)$$

ii. Quadratic and asymmetric:

$$AC(L^o) = a(L_t^o - b)^2 \qquad (5)$$

iii. Piecewise linear:

$$AC(L_t^o) = \begin{cases} a_1 L_t^o & \text{if } a_1 > 0 \\ a_2 L_t^b & \text{if } a_2 < 0 \end{cases} \qquad (6)$$

if $a_1 = a_2$, we have symmetric AC; otherwise it is asymmetric.

iv. Lumpy and Possibly asymmetric:

$$AC(L_t^o) = a_1 R_1 L_t^o + a_2 R_2 L_t^o \qquad (7)$$

where R_1, R_2 are indicator functions with $R_1 = 1$ if $L^o>0$ and 0 otherwise and $R_2 = 1$ if $L^o<0$ and 0 otherwise a_1, $a_2 >0$ indicate the sizes of the lumpy costs. {see Hamermesh and Pfann, 1996}.

If we assume that adjustment costs are quadratic and symmetric; that is, firing costs are equal to hiring costs for all changes in employment [i.e. equation (4)], then we can generate one form of the dynamic labour demand function.

The optimization problem can be solved via the principles of calculus of variations as the firm seems to find the optimal path of employment over time[2]. Substituting equation (4) in equation (2) and forming a Lagrangean equation with (3) we have:

$$V = \int_o^\infty [w_t L_t + m_t K_t + aL_t^{o\,2}] e^{-rt} dt + \lambda [q^* - q_t (K_t, L_t, \omega^{\cdot}_t)] \qquad (8)$$

where λ is the Lagrangean multiplier, and q^* is planned output.

The necessary first order condition for an optimum path for employment is given by the Euler equation:

$$\frac{\partial V}{\partial L_t} - \frac{d}{dt} \frac{(\partial V)}{(\partial L_t^o)} = 0 \qquad (9)$$

while for capital it is

$$\frac{\partial V}{\partial K_t} - \frac{d}{dt} \frac{(\partial V)}{(\partial K_t^o)} = 0 \qquad (10)$$

Equation (10) becomes, where K_t^o is defined as dK_t/dt

$$\frac{\partial V}{\partial K_t} = 0 \qquad (11)$$

Since K^o is not part of the Lagrangean function (i.e. $K^o = 0$) the Lagrangean multiplier yields a first order condition:

$$\frac{\partial V}{\partial \lambda} = 0 \qquad (12)$$

Taking equations (9), (11) and (12), we have the following first order conditions:

$$e^{-rt} [w_t + 2a\, r\, L_t^o - 2a\, L_t^{oo}] - \lambda q_L = 0 \qquad (9^1)$$

$$m_t e^{-rt} - \lambda q_K = 0 \qquad (11^1)$$

$$q_t^* - q_t(\ _o\ ) = 0 \qquad (12^1)$$

Dividing equation (9^1) by (11^1) gets rid of the Lagrangean multiplier λ; that is

$$(w_t + 2a\, rL_t^o - 2a\, L_t^{oo}) / m_t = q_L / q_K \qquad (13)$$

The system of equations (12[1]) and (13) can then be solved to yield a dynamic labour demand function:

$$L_t^d = L_t^d \left(w_t / m_t, q_t^*, D(L_t)\right) \qquad (14)$$

where the optimal demand for labour is a function of relative labour to capital prices (w_t / m_t); planned or expected output (q^*) and a distributed lag function of labour demand $D(L_t)$. The specific form of equation (14) derived from equations (12[1]) and (13) depends on the specification of the production function.

As indicated earlier, alternative assumptions about firm behaviour (e.g. profit maximization); adjustment costs (non-quadratic and non-symmetric); institutional arrangements (e.g. right-to-manage model of bargaining) and production technology can generate different dynamic labour demand functions.

One of the limitations of using equation (14) is that the sources of adjustment costs are subsumed in the $D(L_t)$ variable. As Nickell (1986) has noted, the size and structure of adjustment costs affect the dynamic demand for labour. An alternative form of the labour demand function which is more useful for policy purposes is the specification of indices for different regulatory measures [see Lazear, 1990)]. The demand function becomes:

$$L_t^d = L_t^d (w_t / m_t, q_t^{\,o}, \underline{R}) \qquad (15)$$

where $\underline{R}$ is a vector of regulatory indices.

4. ESTIMATION TECHNIQUES

The time series behavior of the variables (the level of integration of variables), the level of firm aggregation, the level of temporal aggregation (i.e. annual versus other frequencies), the linearity or nonlinearity of the parameters, the objective of estimation (i.e., long-run or short-run estimates), the data configuration (time series or panel data), determine, among others, the appropriate estimation technique(s) for equations (14) and (15)[3].

At the outset while equation (14) can be transformed to suit time series investigation, equation (15) can be easily adopted in a panel data approach.

4.1 Time Series Approach

Assuming linearity in parameters, rationality in output expectation and very short lag distribution, equation (14) can be rewritten as follows:

$$L_t = a + \beta \left(\frac{w_t}{m_t} \right) + \gamma\, q_t + \delta_1\, L_{t-1} + \delta_2\, L_{t-2} + u_t \qquad (16)$$

where u_t represents the disturbances, q is the output, $t = 1,2,3,\ldots,T$ is the time index, and other variables are defined as above.

As far as the data frequency is concerned, while the literature (i.e. Hamermesh (1995)) points out that data frequency must be at least quarterly and not annual because of shortness of lags in employment adjustment, we underline that in some instances annual frequency may be relevant[4].

Among others, two methods of estimation can be suitable for equation (16): the general method of moments (GMM) and the Johansen's cointegration maximum likelihood procedure.

Since the disturbances are most likely autocorrelated in equation (16) and some of the explanatory variables, i.e., lagged dependent variables, are correlated with the disturbances, GMM estimation is appropriate here since it takes "a broad view" of the above correlations. In other words, using a criterion provided by a weighting matrix, the GMM estimator "sets the calculated correlations of the instruments and disturbances as close to zero as possible[5]."

Using sample moment conditions:

$$W' \ (L - X\,\theta) \qquad (17)$$

where W is the matrix of valid instruments, X is the matrix of explanatory variables and $\theta = (\alpha\ \beta\ \gamma\ \delta_1\ \delta_2)'$ is the vector of parameters.
The GMM criterion function is then:

$$(L - \mathrm{X}\,\hat{\theta})' W\, \hat{A}(L) W' (L - \mathrm{X}\,\hat{\theta}) \qquad (18)$$

where $\hat{A}(L)$ is the inverse of the covariance matrix of sample moment. The GMM estimator is :

$$\hat{\theta} = (\mathrm{X}' W\, \hat{A}(L) W'\, \mathrm{X})^{-1}\, \mathrm{X}' W\, \hat{A}(L) W'\, L \qquad (19)$$

Note that only systems whose parameters are identified can be estimated by GMM. When the system is exactly identified, GMM is the classical method of moments. In the over identified case, GMM needs a weighting matrix $\hat{A}$, for which there are several choices.(Eviews, p.253). With an appropriate choice of weighting matrix, the estimators are consistent and asymptotically efficient.

From the estimates $\hat{\theta}$ we can derive the estimates of the impact of non-wage cost.

If the variables are non-stationary but cointegrated then we can exploit the Johansen's maximum likelihood procedure to estimate the parameters of interest[6]. The idea is to use the multivariate error correction model to test for cointegration (i.e., the number of cointegrating vectors or the number of common trends) as well as to obtain the estimates of interest. This framework allows to model short-run as well as long-run dynamics.

Basically,

$$\Delta Z_t = \sum_{i=1}^{k-1} \Gamma_i \, \Delta Z_{t-i} + \Pi Z_{t-k} + \varepsilon_t \tag{20}$$

$$\Gamma_i = -I + A_1 \; A_2 + \ldots + A_i$$
$$Z_t = (L_t \; w_t \,/\, m_t \; q_t \; L_{t-1} \; L_{1-2})'$$
$$where \;\; \Pi = -(I - A_1 - A_2 - \ldots - A_k)$$

A_i:matrix associated with Z_t
Δ:first difference operator

Equation (20) is estimated using the maximum likelihood method. If there are r cointegrating vectors, then equation (20) can be rewritten as:

$$\Delta Z_t = \sum_{i=1}^{k-1} \Gamma_i \, \Delta Z_{t-i} + \alpha \, \beta' \, Z_{t-k} + \varepsilon_t \tag{21}$$

where α is a T x r matrix of adjustment coefficients and β is a T x r matrix of cointegrated vectors. The matrix $\beta' Z_{t-k}$ represents a set of r error correction mechanisms "separating out the long and short run responses in the model."

4.2 Panel Data Estimation

Using the same assumptions (as in the time series approach), equation (15) can be rewritten as:

$$L_t = a + b\left(\frac{w_t}{m_t}\right) + cq_t + d_1 \, UI_t + d_2 \, Sev_t + d_3 \, TC_t + u_t \tag{22}$$

where UI is unemployment insurance, Sev stands for severance payments and TC represents other non wage costs.

While this model can be estimated using a time series approach, it is also a good candidate for a panel data treatment, since there may be little variation in non-wage cost element over time. In the latter form, equation (22) is rewritten as:

$$L_{it} = ai + b\left(\frac{w_{it}}{m_{it}}\right) + cq_{it} + d_1\ UI_{it} + d_2\ Sev_{it} + d_3\ TC_{it} + u_{it} \qquad (22)$$

where $I = 1,2,3,4,..., N$ is the number of countries or firms[7] and the parameters a_i are the individual country or firm effects that can be either fixed or random.

Whether or not the explanatory variables, in particular the non-wage costs are correlated with the error term is crucial in devising appropriate methods of estimation. If the exogenous variables are exogenous, then the fixed or random effect model will be of interest.

The choice between fixed and random effect model is determined by the type of inference one wants to make. Moreover, some test statistics can also be conducted to help decide between the two types of model.

If one is only interested in the sample that one has studied and not in the population as well as if the country/firm specific effects are correlated with some explanatory variables, then the fixed effect model is the model of interest. In that case, equation (22) represents the fixed effect model. The estimator $\hat{\beta}_w = (\hat{b}\ \hat{c}\ \hat{d}_1\ \hat{d}_2\ \hat{d}_3)'$, called within estimator or LSDV estimator, is obtained by regressing variables in deviation with respect to the group means:

$$\hat{\beta}_w = (X'\ M_D\ X)^{-1}\ X'\ M_D\ L \qquad (23)$$

where X is the matrix of explanatory variables and M_D X is the matrix of deviations of X from the group means $\bar{X}_i$ Under regular conditions, this estimator is consistent and efficient.

If one wants to make inferences about the population, then the so-called random effects model is the appropriate model. It amount in equation (23) to having α_i as random variables. The generalized least squares (GLS) estimator, a weighted average of between and within estimators, is then of interest.

If the assumption of non-correlation between the explanatory variables and the error term is not fulfilled, then the GMM estimation method developed above is the method of interest.

5. CONCLUSION

This is a preliminary paper outlining the theoretical principles behind dynamic labour demand functions and the estimation techniques for deriving the paprameter in time series and panel data set situations. As indicated, there are several functional forms which the labour demand function can take depending on the institutional and behaviour conditions specified. In terms of future work, the following are planned:

i. derivation of alternative labour demand functions with special reference to the Caribbean (e.g. the incorporation of the role of collective bargaining);

ii. the calculation on non-wage cost indices (unemployment insurance, severance pay, etc.);

iii. the estimation of dynamic labour demand function on a time series basis for Jamaica, Trinidad and Tobago and Barbados and on a panel data basis for the 6 countries.

NOTES

1. In Barbados, an employer contributes 10% of maximum insurable earnings ($3,100 per month) towards national insurance, severance, unemployment insurance, training levy.

2. In addition to the first order conditions specified below, there are also terminal conditions (and transversality conditions. These do not affect the general results in the paper (see Intriligator, 1971).

3. By appropriate estimation, it is meant estimation that yields, under certain circumstances, estimators that have at least good large sample properties (i.e., consistency, asymptotic normality, and asymptotic efficiency).

4. Firing, hiring and tenure at the University level, for example are usually made on yearly basis.

5. Note that stationarity of the error term is required for GMM.

6. The procedure is standard and can be found in any serious econometrics book (see Greene, 1997).

7. Note that one can go further by pooling countries. The problem with country pooling is that the time series dimension will be far bigger than the cross section dimension.

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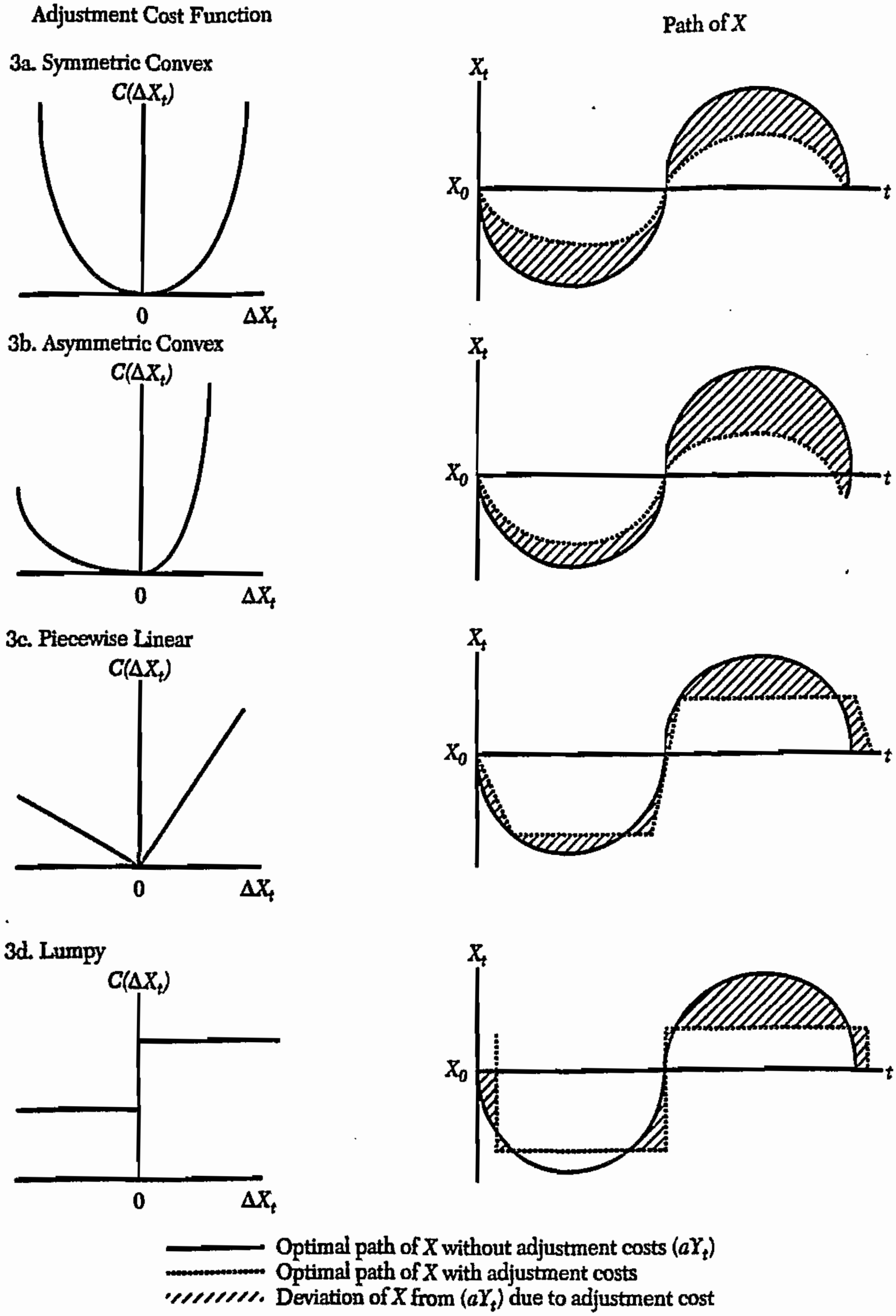

Adjustment Costs and Input Dynamics