CHAPTER 3
A CLOSED FORM SOLUTION FOR
A MODEL WITH TIME-TO-BUILD AND ADJUSTMENT COSTS
An application to the United States and Dutch manufacturing industry

3.1 Introduction

The realization of a physical capital stock investment plan can typically be characterized as an investment project that needs a period to be built, consumes (often irreversible) investment expenditures during the whole gestation, and is only useful to the investor when it is complete. Therefore, for the producer, who has to decide on new investment plans, events in a distant future (like product and/or factor markets and technological developments) are important. The irreversibility and non-productiveness during gestation of investment projects that need time-to-build, entail that longer lead times lead to more uncertainty.

As shown in chapter 2, Kydland and Prescott (1982) with the assumptions of 'time-to-build', are emphasizing these investment lags. In their view, fluctuations of macroeconomic variables are caused by persistent pure real shocks, like technology and productivity shocks, and the existence of time-to-build induces much more serial correlation. Dynamics in their general equilibrium model are described by persistent (stochastic) shocks and time-to-build.

In factor demand studies dynamics are mostly described by adjustment costs. Cost incurred when hiring or firing labour, which are labour adjustment costs, are modelled according Holt et al. (1960). In a similar way scrappage and installation costs of capital stock are modelled according Eisner and Strotz (1963). See also chapter 1, section 1.3.2-1.3.3.

These adjustment costs specifications for capital, assume that the capital stock can be adjusted within one period. The adoption of time-to-build in a factor demand model raises, however, the question whether additional costs to change the capital stock occur and are important. The chapter intends to answer this question.

The methodology to answer this question is as follows.

A factor demand model with time-to-build and adjustment costs is specified. The neoclassical assumptions of a profit maximizing and rational entrepreneur are adopted. As a linear-quadratic framework is chosen and additional assumptions (concerning
production factor prices and technology shocks) are made, a closed form solution is obtained. The implications of adjustment costs in addition to time-to-build, are analyzed by estimating the solution with quarterly manufacturing industry data from the United States (1960.I-1988.IV) and the Netherlands (1971.I-1990.IV).

The outline is as follows.
In section 2, the linear-quadratic model is presented for structures, equipment, and labour. Adjustment costs for all production factors and a multi-period time-to-build for structures are adopted. Attention is paid to the economic interpretation of adjustment costs in the way the literature proposes. The demand for structures that have on average more than one quarter time-to-build according to the findings in chapter 2, is scrutinized in section 3. Three models for structures investment are thereby derived; one without adjustment costs, one with adjustment costs of net capital stock and one with adjustment costs of gross investments. In section 4 the closed form solution of the multivariate model is given. Section 5 summarizes the theoretical results and gives the goals of estimation. Empirical results are presented in section 6. Maximum Likelihood estimates are presented for the closed form data from the United States and Dutch manufacturing industry. The implications of the model are tested. The necessity of modelling adjustment costs for a multi-period time-to-build for structures is further investigated. Section 7 summarizes and concludes.

3.2 The model

In the first part of this section the contingency plan of an entrepreneur is specified. In the second part attention is paid to the economic interpretation of adjustment costs in comparison with time-to-build.

3.2.1 A neoclassical factor demand model with time-to-build

An entrepreneur is assumed to be a representative of firms within the industry. The entrepreneur is rational in the sense that at each moment of decision, information available is used to forecast future events in order to make the optimal decision. Production can be increased by utilizing more physical capital stock and/or labour. The capital stock is disaggregated as a (productive) plant or structures stock and a (productive) equipment stock. Structures, equipment and labour are represented by $K^s_t$, $K^e_t$, $N_t$ respectively. The production function is assumed to be an approximation of an underlying economic production function that is more interpretable and is linear quadratically specified as,