Journal of Economic Dynamics & Control 51 (2015) 341–355

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

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

Factor adjustment costs: A structural investigation

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ARTICLE INFO

Article history:
Received 19 January 2012
Received in revised form
2 October 2014
Accepted 3 October 2014
Available online 5 November 2014

JEL classification:
C32
E22
E23
E24
E32

Keywords:
Adjustment costs
DSGE models
Labor market frictions
Bayesian estimation

ABSTRACT

This paper assesses various capital and labor adjustment costs functions estimating a general equilibrium framework with Bayesian methods using US aggregate data. The estimation finds that the adjustment costs are convex in both capital and labor and allowing for their joint interaction is important. The structural model enables us to identify the response of factor adjustment costs to exogenous disturbances, and to establish that shocks to technology and the job separation rate are key drivers of adjustment costs. The analysis shows that factor adjustment costs enable the model to explain fluctuations in the firm's market value in the data.

1. Introduction

An extensive literature finds that capital and labor inputs are costly to adjust.[1] Factor adjustment costs make the asset values of capital and labor fluctuate according to their underlying marginal adjustment costs whereas they would be constant otherwise. Moreover, adjustment costs generate rents when demand rises unexpectedly, whose movements, in principle, may explain fluctuations in the market value of the firm relative to the underlying factor input costs. In this respect, a structural investigation on the size and dynamics of factor adjustment costs is important in order to understand aggregate fluctuations in the price of capital and labor inputs, and the firm's market value.

The contribution of this paper is to assess factor adjustment costs by estimating a dynamic stochastic general equilibrium (DSGE) model for several competing adjustment costs functions using US aggregate data. This is the first study that conducts the analysis in a general equilibrium framework and that uses a system approach estimated using Bayesian methods. Our approach has several advantages. First, the theoretical setting is microfounded and based on a prototype, production-based model enriched with labor market frictions and factor adjustment costs. Second, rather than estimating asset price functions in a single-equation setting, we pursue a multivariate approach by estimating the entire structural model. The system approach optimally adjusts the estimation of the asset price equations' coefficients for the endogeneity of the variables.

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[1] See Bond and Van Reenen (2007) and references therein for a recent review on the topic.

http://dx.doi.org/10.1016/j.jedc.2014.10.003
0165-1889/

Moreover, we are able to exploit cross-equation restrictions that link agent's decision rules with the coefficients in the asset price equations. To conduct the estimation we assign prior distributions to the parameters of the adjustment costs function and exogenous disturbances and use Bayesian inference. Posterior distributions are used to determine the functional form of the adjustment costs functions and posterior odds ratio to assess their empirical adequacy. To the best of our knowledge, this is the first time that such a methodology has been applied to investigate factor adjustment costs.

To establish the empirically suitable adjustment costs function, the theoretical model allows, but does not require, capital and labor adjustment costs to include linear and convex cost components, and it also lets capital and labor adjustment costs interact. This formulation encompasses a broad range of adjustment costs functions. In this way, the theoretical model allows for both investment and hiring decisions to simultaneously affect the asset prices of capital and labor, and consequently the firm's market value. The posterior odds ratio shows that the data prefer the adjustment costs function that includes both linear and convex cost components, and that also accounts for the joint interaction between capital and labor costs. Specifications with capital adjustment costs only (as in the investment literature) or with labor adjustment costs only (as in the labor demand literature) are rejected by the data. The econometric estimation finds that adjustment costs are small for both input factors. According to the theoretical framework, total adjustment costs represent 3.3% of total output per quarter. In addition, the cost of hiring an additional worker amounts to 1.4 weeks of wages, whereas the cost of an extra unit of investment equals 0.22% of average output per unit of capital. Such estimates are within the range of values estimated using disaggregated data as in Shapiro (1986) and Gilchrist and Himmelberg (1995), and in line with Bloom (2009).

The use of a structural approach enables additional interesting results. The estimation identifies structural disturbances in the data based on the dynamic effects that they have on the model's observable variables. The model's reduced form enables us to extend the identification of shocks to the model's unobservable variables, and we are therefore able to map the response of key macroeconomic variables and factor adjustment costs to the exogenous disturbances to technology, labor supply, job and capital destruction rates and tax changes. We find that total factor adjustment costs are pro-cyclical for all the shocks, except for shocks to the job and capital destruction rates. We also detect that the asset prices of capital and labor mirror one-for-one the reaction of the marginal costs of investing and hiring, which in turn determine the firm's market value. Forecast error variance decompositions show that technology shocks play a prime role on output, factor adjustment costs and the firm's market value in the short run, whereas shocks to the job separation rate compete with technology shocks to explain the bulk of fluctuations of factor adjustment costs in the long run.

In addition, the structural model allows us to estimate the unobservable shocks using a Kalman smoothing algorithm that uses the information contained in the full sample of the data. By feeding the estimated structural shocks into the theoretical model we generate time series for the firm's market value that can be compared against the actual series in the data. We find that the adjustment costs function that allows for both linear and convex capital and labor adjustment costs, and that also allows for their joint interaction, is able to replicate more closely the fluctuations in the firm's market value in the data.

Before proceeding, we discuss the context provided by related studies. As mentioned, one contribution of the paper is to estimate the adjustment costs function that fits aggregate data. In general, estimates of factor adjustment costs are based on disaggregated firm-level data, as surveyed by Bond and Van Reenen (2007), and only a few studies focus on aggregate data. Of these, the majority estimates either capital adjustment costs, or labor adjustment costs individually, assuming that the other factor is flexible. In particular, Ireland (2003), Christiano et al. (2005) and Smets and Wouters (2007) use DSGE models to estimate capital adjustment costs in a frictionless labor market. On the other hand, Cogley and Nason (1995), Chang et al. (2007) and Janko (2008) estimate labor adjustment costs in the absence of capital adjustment costs. Our paper uses a similar methodology but it assesses the adequacy of various adjustment costs functions that allow for both capital and labor adjustment costs.

Similar to our approach, Dib (2003) estimates a DSGE model using maximum likelihood methods that allows for simultaneous capital and labor adjustment costs. However, the model abstracts from the joint interaction between capital and labor costs, and the analysis focuses neither on the size of adjustment costs, nor on their implication for the model's dynamics. Merz and Yashiv (2007), Bloom (2009) and Yashiv (2013) develop partial equilibrium models to study the interaction of capital and labor adjustment costs. They estimate asset pricing equations in a single-equation setting, using the generalized method of moments and instrumental variables. Instead, we use a fully-defined DSGE model that uses the same asset price equations and also exploits the cross-equation restrictions of the entire structural model, thereby overcoming the identification issues encountered in single-equation estimates.

The remainder of the paper is organized as follows. Section 2 lays out the model. Section 3 presents the econometric methodology and the data. Section 4 presents the estimation results, illustrates the steady-state and dynamics properties of the model and assesses the empirical fit of alternative adjustment costs functions. Section 5 concludes.

2. The model

In our model the standard production-based model by Cochrane (1991) is enriched with labor market frictions as in Blanchard and Gali (2010) and a factor adjustment costs function as in Merz and Yashiv (2007) and Bloom (2009). This framework relies on the assumption that the process of job search and recruitment is costly for both the firm and the worker. Job creation takes place when a firm and a job seeker meet and agree to form a match at a negotiated wage, which