Adjustment Costs

in the Real Business Cycle Model

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Abstract

In this paper, we construct a real business cycle model where agents face moderate adjustment costs when entering or exiting the labor market. We find that these adjustment costs introduce an endogenous propagation mechanism for both technology and consumption shocks. Consequently, impulse response functions of output to both shocks are persistent and hump-shaped. Adjustment costs also lead to improvements in the statistical properties of the model; specifically to the correlation between hours and productivity.

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1. Introduction

Since the early papers of Kydland and Prescott (1982) and Long and Plosser (1983), which show that a standard Real Business Cycle (RBC) model does fairly well in explaining some important business cycle facts, a number of papers have pointed to the failures of the RBC model. Cogley and Nason (1995) point to the lack of a propagation mechanism whereby the impulse response of output to a technology shock is not hump-shaped as in the data. In addition, Cockrane (1994) and Wen (2002) find demand shocks to be important sources of business cycle fluctuations, while the standard RBC model omits these shocks. When these shocks are taken into account they typically play a minor role and the impulse response of output is again not hump-shape as in the data. [1]

In this paper, we construct a RBC model where agents face moderate adjustment costs when entering or exiting the labor market. We find that these adjustment costs introduce an endogenous propagation mechanism for both technology and consumption shocks. We also find that the statistical properties of the model with adjustment costs, as compared to without, are improved, when both shocks are present.

2. Model

We build on the model of Kydland and Prescott (1991) where adjustment costs are introduced into a standard RBC model.[2] These adjustment costs help to propagate technology and consumption shocks, as long as adjustment costs are moderately large.

Output in the economy is produced using the following technology:

[1] Benhabib and Wen (2003) and Wen (2003) show that with externality the impulse response of output to consumption and government shocks can better match the data. Kim (2003) and Christianno, Eighenbaum and Evans (2001) find that models with wage rigidity, are able to achieve hump-shape responses to monetary shocks but not real shocks. Janko (2004) finds that labor adjustment costs improve the endogeneous propagation mechanism of both monetary and technology shocks in Kim's (2003) model.

[2] We introduce consumption shocks into a simplified version of the Kydland and Prescott (1991) model, where adjustment costs are present in order to obtain variability of total hours from both the intensive and the extensive margin.

$$y_t = e^{z_t} h_t k_t^{\alpha} n_t^{1-\alpha}, \qquad 0 < \alpha < 1 \tag{1}$$

where k_t is capital stock, h_t is hours per worker, n_t is number of workers, and z_t is the technology shock that evolves according to an AR(1) process.

Output is used for consumption c_t, investment i_t and for adjustment costs

$$c_t + i_t + \frac{\eta}{2}(n_t - n_{n-1})^2 = y_t, \qquad \eta \geq 0, \tag{2}$$

where η is the quadratic adjustment costs parameter. Adjustment costs are quadratic costs associated with workers entering or exiting the work place.

Capital in the economy evolves according to the following law of motion:

$$k_{t+1} = i_t + (1-\delta)k_t, \tag{3}$$

where δ is the depreciation rate.

The equilibrium can be found as the solution to a social planner's problem

$$\max E_t \sum_{t=0}^{\infty} \beta^t \left\{ \log(c_t - \Delta_t) + n_t A \log(1 - h_t) \right\}, \tag{4}$$

s.t. (1), (2), (3), the law of motion for technology shock, and the law of motion for consumption shocks Δ_t, where β is the discount factor and A is the parameter on hours.[3]

3. The Dynamics

The model is calibrated as follows: α is set at 3.6, β equals 0.989 corresponding to a one percent quarterly real interest rate, delta (=0,025) is set such that annual depreciation rate is at 10%, and A (=1.95) is chosen to match the average total hours at steady state. The parameter values of the AR(1) shocks are both persistent and = 0.95.[4] Lastly the

[3] The consumption shock Δ_t is modeled as a log normal stationary AR(1) process as in Wen (2003).

[4] These are values used in the literature as in Wen (2003).

parameter value η (=1) is chosen so that on average adjustment costs are less than one hundred of one percent of output.

Figure 1 shows the impulse response functions of output to a technology shock. Once adjustment costs are introduced output takes several quarters to reach a maximum as the central planner slowly increases n_t to smooth out adjustment costs across periods. Figure 2 shows that the response to demand shocks given positive adjustment costs is hump-shaped as well. Hence, these adjustment costs introduce an endogenous propagation mechanism for both technology and consumption shocks without the need of externalities as in Wen (2003) and Benhabib and Wen (2003). [5]

Figure 1: Impulse Response of Output to a Technology Shock

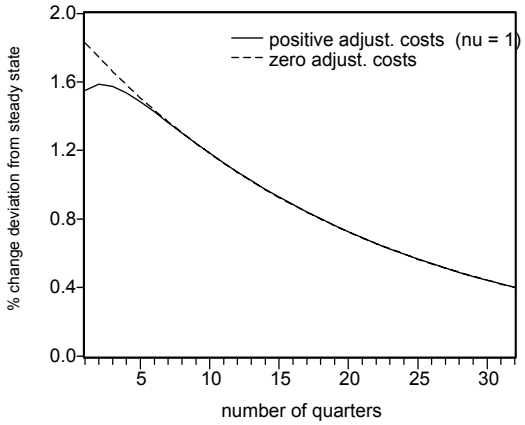

Figure 2: Impulse Response of Output to a Consumption Shock

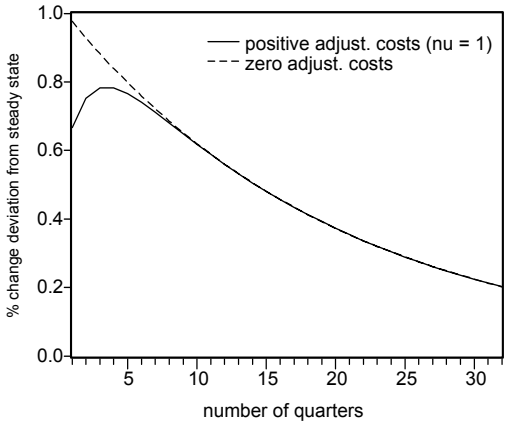

Table 1 summarizes the cyclical properties of the model and compares them to the data when both shocks are present. With adjustment costs the volatility of the output and total hours falls. This is consistent with Figure 1 and 2. The correlation between hours and productivity is 0.1 and -0.21 with adjustment costs and without adjustment costs respectively. In this respect the model improves upon the standard RBC model that has a

[5] I find that for extreamly high η (such as 500) all variation in total hours is coming from number of hours not at all from employment and hence the response of output to either shock is no longer hump-shaped.

correlation of 0.93.[6]

4. Conclusion

In this paper, we build a Real Business Cycle model with adjustment costs. We find that adjustment costs introduce an endogenous propagation mechanism for both consumption shocks and technology shocks. Consequently, impulse response functions of output to both shocks are persistent and hump-shaped. Furthermore, adjustment costs improve upon the business cycle properties of the model, when both shocks are present. The volatility of output/hours as well as the correlation between hours and productivity match the data quite well.

Table 1: Cyclical Properties

	Volatility		**Correlations**	
	Output	Total Hours	(Output, Productivity)	(Total Hours, Productivity)
Data	1.65	1.51	0.49	0.07
nu = 0	1.88	1.83	0.28	-0.21
nu = 0.5	1.69	1.44	0.33	0.10

note: Total Hours and Productivity are based on Household Survey data. The data is detrended using the Hodrick Prescott Filer.

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[6] Hansen and Wright (1992) find this correlation to be 0.49 in a RBC model with government shocks.