Journal of Economic Dynamics & Control 39 (2014) 273–286

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

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

Capital maintenance and depreciation over the business cycle ☆

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ARTICLE INFO

Article history:
Received 8 April 2013
Received in revised form
7 November 2013
Accepted 12 December 2013
Available online 25 December 2013

JEL classification:
E22
E32
E37

Keywords:
Real business cycle
Endogenous capital depreciation
Maintenance

ABSTRACT

This paper develops and estimates a stochastic general equilibrium model with capital maintenance, which affects endogenously the depreciation rate of capital. The estimate of maintenance series is found to track survey-based measures for Canada quite closely and to generate the procyclical pattern of maintenance observed in the data. We use our model estimates to infer the time profile of equipment capital depreciation in Canadian and US manufacturing. The depreciation rate is estimated to be volatile and highly procyclical in both countries.

1. Introduction

Casual empiricism suggests that expenditures on capital maintenance constitute an integral part of the capital accumulation process. Broadly, outlays on capital maintenance cover the "*deliberate utilization of all resources that preserve the operative state of capital goods*" (Bitros, 1976). As pointed out by Feldstein and Foot (1971), surveys on planned investment in the US for the period 1949–1968 suggest that roughly one-half of 'gross' investment aimed at maintaining the operative state of capital goods (replacement and modernization) as opposed to 'new' investment (expansion). Capital maintenance is, thus, directly related to capital depreciation and many authors have studied the optimal maintenance level at the firm level with the depreciation rate modeled as an endogenous function of maintenance outlays.[1]

☆ An online Appendix of the paper is available at www.eui.eu/Personal/Pappa/research.html.

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[1] See, among others, Schmalensee (1974), Nickell (1978), Schworm (1979) and Parks (1979) for early contributions in this literature. Also, some empirical studies at the sectoral level have confirmed that capital deterioration is affected by maintenance expenditures; see Nelson and Caputo (1997) and the references cited therein for a brief survey of the empirical findings.

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http://dx.doi.org/10.1016/j.jedc.2013.12.008

McGrattan and Schmitz (1999) were the first to provide a detailed picture on the size of aggregate capital maintenance using evidence from the Canadian survey on Capital and Repair Expenditures, which is the only source of aggregate long-run data on capital expenditures in newly purchased assets ('new' investment) and maintenance available at the national level. According to this survey, total (private and public) maintenance and repair expenditures in Canada amounted on an average to around 6.3% of GDP for the period 1956–1993. This number is roughly equal to one-third of spending on 'new' investments and, when compared to other 'engines of growth', is somewhat lower than education spending (6.8% of GDP), but far above the average spending on R&D (1.4% of GDP) over the same period, suggesting that maintenance expenditures are 'too big to ignore'.

This paper develops and estimates a Dynamic Stochastic General Equilibrium (DSGE) model, in which capital maintenance together with capital utilization affect endogenously the capital depreciation rate. Our model is found to perform well in replicating key features of the data and allows us to derive the time profile of endogenous capital depreciation in a general equilibrium setup. Several studies have attempted to estimate the depreciation rate, mainly in US manufacturing, using various single or multi-equation econometric approaches (see Epstein and Denny, 1980; Hulten and Wykoff, 1981a,b; Nadiri and Prucha, 1996a,b; Jorgenson, 1996; Oliner, 1996; Huang and Diewert, 2011). Most of these papers find that the depreciation rate is fairly stable and that a constant depreciation rate may be a valid approximation for calibration exercises. On the other hand, Tevlin and Whelan (2003) point out that the rapid depreciation of computing equipment that took place in the 1990s led to a rise of the estimated depreciation rate for aggregate equipment capital. This assessment is confirmed by Doms et al. (2004) and Geske et al. (2007). Our results complement the findings in those studies: the implied depreciation rate for equipment capital in Canadian and US manufacturing displayed substantial volatility and a highly procyclical pattern over the last 50 years.

What generates the difference in our estimate relative to the previous ones is the behavior of capital maintenance. While investment spending can be typically obtained from fixed non-residential private investment on property, plant and equipment in national accounts, and capital outlays from panel data for two-digit or plant-level manufacturing firms (in the US Compustat Industrial database), capital maintenance is mainly undertaken by employees. Hence there are no recorded market transactions. Moreover, maintenance and repair services purchased by firms in the market are typically treated as transactions involving intermediate goods. Thus, although maintenance activities are included in measured real output, their magnitude cannot be recovered by standard sources, like national accounting systems. Given the scarcity of available estimates for maintenance, we use the 'Capital and Repair Expenditures,' survey, which covers the period 1956–2005, to obtain proxies for maintenance and 'new' investment of equipment capital in the Canadian manufacturing sector. According to this data, total expenditures in 'new' investment and maintenance was on an average 16.7% of manufacturing output, with the average share of maintenance over total investment amounting to 36.1% and accounting for 6% of output and 4.9% of the capital stock. Turning to the cyclical properties of the data, we observe that maintenance expenditures are procyclical. Fig. 1a and b plots spending on capital maintenance and the associated maintenance to capital ratio (henceforth, *MK* ratio), and manufacturing output. Both measures of maintenance are strongly procyclical in agreement with the evidence reported by McGrattan and Schmitz (1999).[2]

We set up an otherwise standard Real Business Cycle (RBC) model in which capital outlays comprise, apart from 'new' investment that adds directly to the capital stock, maintenance expenditures that affect the capital decay rate. We also employ a general specification for the depreciation function that embeds the effect of capital utilization on depreciation, as in Burnside and Eichenbaum (1996), and its interactions with capital maintenance. The structural parameters of the model are estimated with Bayesian techniques using aggregate Canadian manufacturing data for output, capacity utilization, total investment, consumption and hours worked as observables for the period 1956–2005. The model generates estimates for capital maintenance expenditures that mimic reasonably well the cyclical behavior of actual survey-based series for Canada. Given the success of the model for Canada we also obtain consistent estimates for capital maintenance in the US over the period 1958–2009, a period for which there has been no systematic data collection on this type of outlays.[3] We then use these estimates to obtain the time profile of the depreciation rate of equipment capital in Canadian and US manufacturing over the business cycle.

To the best of our knowledge very few DSGE macroeconomic models have attempted to endogenize maintenance outlays. Early contributions to this literature can be found in Licandro and Puch (2000) and Collard and Kollintzas (2000). In both studies maintenance moves countercyclically, which contradicts the stylized facts presented in Fig. 1a and b. Collard and Kollintzas (2000) consider two types of labor that can be used in production and maintenance, respectively. Since higher productivity causes labor in production activities to be more efficient, maintenance activities may fall after a total

[2] Descriptive statistics point towards a contemporaneous correlation between maintenance and *MK* ratio with output of 0.63 and 0.60, respectively. This correlation seems to be higher in the first part of the sample: for the period 1956–1983 the corresponding correlation coefficients amount to 0.85 and 0.86.

[3] We note that the US Census Bureau has added in the Annual Survey of Manufacturers entries on Repair and Maintenance services of buildings and/or machinery for the years 2007, 2008, and 2009. The definition includes payments on purchased services for all maintenance and repair work on buildings and equipment. Payments made to other establishments of the same company and for repair and maintenance of any leased property also are included. Excluded are extensive repairs or reconstruction that was capitalized, which is considered capital expenditures, costs incurred directly by the establishment in using its own work force to perform repairs and maintenance work, and repairs and maintenance provided by the building or machinery owner as part of the rental contract. 'New' investments and maintenance account on an average for 8.7% of total (equipment and structures) US manufacturing output, with maintenance amounting to 20.9% of total investment.