Economics Letters 142 (2016) 59–63

Contents lists available at ScienceDirect

Economics Letters

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

Markups, technology, and capital utilization in the Great Recession

Ludger Linnemann *

TU Dortmund University, Department of Economics, D-44227 Dortmund, Germany

HIGHLIGHTS

- The paper specifies a two-level CES production function for US aggregate data.
- Recently available quarterly gross output data allow to analyze supply side fluctuations during the Great Recession.
- Evidence points to low substitution elasticities and strong markup fluctuations.

ARTICLE INFO

Article history:
Received 25 September 2015
Received in revised form
26 February 2016
Accepted 3 March 2016
Available online 14 March 2016

JEL classification:
E32
E23

Keywords:
Aggregate production function
Elasticity of substitution
Gross output
Imperfect competition
Capital utilization

ABSTRACT

A two-level CES aggregate production function is used to empirically analyze the fluctuations in markups, technology, and utilization in the Great Recession. Quarterly US gross output data suggest a strong markup increase, limited technology movements, and a low labor–capital substitution elasticity.

1. Introduction

In the Great Recession of 2008/9 (GR henceforth) and its aftermath, there were unusually large fluctuations in aggregate output and factor inputs. This paper empirically analyzes what can be inferred from these movements concerning the implied behavior of price-marginal cost markups, technological change, and cyclical capital utilization. The contribution of these factors to the dynamics of the GR episode is debated in the literature. For example, Christiano et al. (2015) explore technology shocks, and Kaplan and Menzio (forthcoming) propose a model with time-varying market power, as does the New Keynesian literature where markup variability arises from price stickiness; see Hall (2015) for a survey.

The analysis is based on recently published quarterly gross output data for the US private business sector. The availability of gross output data is important because it offers the possibility to use the optimal demand for intermediate inputs as an additional margin to explore the relation between variable factor input and output adjustments. The newly available quarterly frequency of these data is important for short-run analyses in a business cycle accounting context.

I postulate an aggregate two level normalized constant elasticity of substitution (CES) gross output production function in hours worked, intermediate inputs, and capital services, along with optimality conditions for intermediate input and hours demand, allowing for imperfect competition on the product market and cyclical capital utilization. The advantage of the chosen specification is that it is much more general than the Cobb–Douglas model frequently used in macroeconomics, yet still parsimonious in parameters. Normalized CES production functions have recently been used by León-Ledesma et al. (2010) and Cantore et al. (2014). The present approach generalizes this for a gross output framework. Bils et al. (2014) use a non-normalized but otherwise similar two-level CES with trend-adjusted annual gross output data. The present analysis differs, apart from using different data and abstaining from trend-cycle decompositions, in that I also allow for cyclical capital utilization and aim at identifying a range of suitable parameters.

* Tel.: +49 0231755 3102.
E-mail address: ludger.linnemann@tu-dortmund.de.

http://dx.doi.org/10.1016/j.econlet.2016.03.001

Technology and markups are unobserved components that enter aggregate production and factor input relations. I will first also treat capital utilization as unobservable, and will then compare the results to those obtained when utilization is treated as observed by using the series constructed by Fernald (2014).

In general, identification of the unobservable variables requires an estimate of the parameters of the production function. Econometrically estimating production function parameters is difficult due to the endogeneity problem, since firms' factor input decisions will generally depend on the realizations of the unobservables, whose innovations are thus correlated with the explanatory variables. Plausible instrumental variables are rarely available in a macro context. Usually, thus, the production function literature aims at achieving identification through rather restrictive assumptions on the unobservables (e.g. technology following a deterministic trend function in León-Ledesma et al., 2010) or the way they interact with observable inputs (e.g. the Cobb–Douglas unitary substitution assumption used to identify the markup through the inverse labor share in the New Keynesian literature).

Here, I follow a different approach to avoid constraining the stochastic processes of the unobservable variables a priori. I calculate the implied values of technology, markups, and utilization for various candidate values of two key parameters, the elasticity of substitution between intermediate and primary inputs and the one between hours and utilized capital services. Then, I narrow down the range of admissible substitution elasticities by using the plausible assumption that capital utilization should have declined from the pre-GR peak to its trough. The justification is that in standard macroeconomic models (e.g. Smets and Wouters, 2007 and Justiniano et al., 2010), capital utilization is strongly procyclical, since firms would optimally adjust it in the same direction as hours worked. Thus, in a severe recession where labor input declined strongly, it is highly likely that firms have reduced the intensity of capital utilization.

Using this as an identifying restriction, I find the following empirical results. While it is not possible to pin down the intermediate input substitution elasticity, there is a strong markup increase in the GR period for any of its possible values. The markup increase is only partially reversed during the post-GR recovery. The substitution elasticity between labor and utilized capital services needs to be surprisingly small to rationalize the data. Labor and utilized capital thus appear strongly complementary in the short-run. The implied series of technology does not show large movements in the vicinity of the GR, lending little support to technology shock based explanations. These results are robust to using Fernald's (2014) measure of utilization as the observed utilization series.

In Section 2, the method is described. Section 3 presents results, Section 4 discusses robustness, and Section 5 concludes. Details on the data used are relegated to the Appendix.

2. Method

Suppose that aggregate real gross output y_t is produced with a normalized two-level CES production function

$$\frac{y_t}{y_0} = \left[\gamma \left\{X\right\}^{\frac{\sigma-1}{\sigma}} + (1-\gamma)\left\{\frac{m_t}{m_0}\right\}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

$$\text{with } X = \left[\alpha \left(z_t \frac{n_t}{n_0}\right)^{\frac{\theta-1}{\theta}} + (1-\alpha)\left(u_t \frac{k_t}{k_0}\right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}},$$

where m_t is intermediate inputs, n_t hours worked, z_t the level of labor augmenting technology, k_t the capital stock, and u_t its utilization rate. The parameters are the substitution elasticity $\sigma > 0$ between intermediate inputs and the primary inputs collected in $X(.)$, the substitution elasticity $\theta > 0$ between the primary inputs, and the share parameters $\alpha, \gamma \in (0, 1)$. Intermediates, labor hours, and capital are observable inputs, whereas technology z_t and the utilization rate u_t are treated as unobservable here. Technology is labor augmenting to allow for balanced growth with non-unitary substitution elasticities; the results are robust, however, to assuming Hicks neutral technology. The quantities of the inputs and outputs are normalized by the constants y_0, m_0, n_0, and k_0 which are the sample values at a particular data point, where $z_0 = u_0 = 1$ is imposed. Normalization follows Klump and de La Grandville (2000), León-Ledesma et al. (2010), and Cantore et al. (2014), and serves to express all variables as indices irrespective of their units of measurement.

Of course, even if the parameters were known, countless combinations of z_t and u_t would be compatible with (1). To impose more structure, assume a representative firm that minimizes costs subject to (1) under monopolistic competition on the output market, taking nominal factor prices as given. Denoting by μ_t the (potentially time-varying) price-marginal cost markup, the optimality conditions for the variable factors intermediates and hours read

$$\mu_t q_t = (1-\gamma)\,(y_0/m_0)^{\frac{\sigma-1}{\sigma}}\, y_t^{1/\sigma} m_t^{-1/\sigma}, \tag{2}$$

$$\mu_t w_t = \alpha\gamma y_0^{\frac{\sigma-1}{\sigma}} n_0^{-\frac{\theta-1}{\theta}} y_t^{1/\sigma} X^{\frac{\sigma-1}{\sigma}-\frac{\theta-1}{\theta}} n_t^{-1/\theta} z_t^{\frac{\theta-1}{\theta}}, \tag{3}$$

where q_t is the real price of intermediates and w_t the real hourly labor cost, both in terms of gross output prices. No optimality condition for capital is used, in order to remain agnostic with respect to the precise nature of adjustment costs and financial frictions. Following Cantore et al. (2014), the parameters α and γ can be calibrated to match the chosen normalization constants. With all variables at their normalization points, (2)–(3) imply $1-\gamma = \mu_0 q_0 m_0/y_0$, such that $1-\gamma$ is the share of intermediate inputs in gross output at the normalization point, adjusted by μ_0, the price-marginal cost markup prevailing at this point. Likewise, $\alpha = \frac{\mu_0}{\gamma} w_0 n_0/y_0$ is the adjusted labor share in gross output. Below, I take the normalization constants to be the sample values at the pre-recession peak in 2007q4, and choose the markup at this point as $\mu_0 = 1.1$ (robustness checks ascertain that varying the latter in $\mu_0 \in (1, 1.2)$, or taking normalization at sample means, does not change any conclusion). This allows to treat α and γ as known henceforth.

Econometric estimation of the remaining parameters of (1)–(3), the substitution elasticities σ and θ, would require a specification of the stochastic processes for the unobservables, and needs to recognize the fact that the innovations to these are likely correlated with the observable variables. The resulting endogeneity of input variables to innovations in technology etc. poses the well-known identification problem dealt with in the literature on production function estimation. Identification requires availability of suitable instrumental variables or specific assumptions concerning the unobservable processes (e.g. that technology follows a deterministic trend function, see León-Ledesma et al., 2010).

In this paper, I pursue an alternative route. Note that for each choice of $\{\sigma, \theta\}$, the system (1)–(3) – given the observable variables $\{y_t, n_t, k_t, m_t\}$ – uniquely determines the set of unobservables $\{\mu_t, z_t, u_t\}$ for each t. I narrow down the range of possible values $\{\sigma, \theta\}$ by imposing a deliberately weak, but arguably plausible identification constraint. Specifically, I require that the utilization rate u_t declines during the GR period. This is an implication of standard business cycle models with variable utilization, where utilization typically comoves positively with labor input. Since hours worked declined by over 8% peak-to-trough in the GR, it is plausible that capital utilization should not rise at the same time. The NBER dates the peak to trough of the recession as