Economics Letters 137 (2015) 182–186

Contents lists available at ScienceDirect

Economics Letters

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

Does market structure affect labour productivity and wages? Evidence from a smooth coefficient semiparametric panel model

Michael L. Polemis [a], Thanasis Stengos [b,*]

[a] University of Piraeus, Department of Economics Piraeus, Greece
[b] University of Guelph, Department of Economics, Guelph, Ontario, Canada

HIGHLIGHTS

- We investigate the impact of market structure on labour productivity and wages.
- We employ a smooth coefficient semi-parametric panel model.
- We use the concentration ratio (CR-4) as a smooth threshold variable.
- There is a negative non-linear relationship of competition and labour productivity.
- Oligopolistic structure decreases the level of wages of non-manual workers.

ARTICLE INFO

Article history:
Received 18 July 2015
Received in revised form
18 October 2015
Accepted 2 November 2015
Available online 10 November 2015

JEL classification:
C14
L6

Keywords:
Market structure
Smooth coefficient semiparametric model
Manufacturing sector
Labour productivity
Wages

ABSTRACT

This paper investigates the impact of market structure on labour productivity and wages using a panel data set of US manufacturing industries over the period 1958–2007. To account for nonlinear effects, we employ a smooth coefficient semiparametric model (SCSM). We find evidence in support of a nonlinear relationship between market concentration and labour productivity and wages. Lastly, our empirical findings shed new light on the competition–labour productivity nexus.

1. Introduction

Within the last twenty years there is a plethora of studies examining the effect of market structure on labour productivity and wages (Nickell, 1996; Hay and Liu, 1997; Disney et al., 2003; Symeonidis, 2008). Despite the rich body of the literature, existing studies impose strong theoretical assumptions. First, they argue that any possible impact is apparent in a linear form. However, this is a rather restrictive assumption that has to be tested rather than assumed since it may lead to biased results. Second and most importantly, they adopt parametric regression models that may lead to misspecification of their functional form unless it is correctly specified by the economic theory (Tran and Tsionas, 2010).

In order to overcome this problem, we rely on panel data semiparametric methodology where little prior restriction is imposed on the model's structure. We use a particular type of semiparametric panel data model, the SCSM with fixed effects (Li et al., 2002; Mamuneas et al., 2006; Stengos and Zacharias, 2006). This specification traces the effects of the concentration ratio of the four largest companies in each 4-digit sector (CR-4) on the coefficient of each regressor (marginal response) over the sample. Put it another way, the CR-4 acts as a (smooth) threshold variable in order to capture the marginal effect of a given variable as an unknown function of an observable covariate (CR-4), introducing heterogeneity.

* Corresponding author.
E-mail addresses: mpolemis@unipi.gr (M.L. Polemis), tstengos@uoguelph.ca (T. Stengos).

http://dx.doi.org/10.1016/j.econlet.2015.11.004

Our findings based on data from 459 US manufacturing industries over the period 1958–2007 reveal the existence of two nonlinear relationships between market structure and labour productivity and wages respectively. The rest of the paper is organized as follows. Section 2 introduces the data and describes the SCSM, while Section 3 discusses the empirical results and concludes the paper.

2. Data and empirical modelling

The panels used in this study consist of 459 SIC 4-digit industries and thirteen years: 1958, 1963, 1966, 1967, 1970, 1972, 1977, 1982, 1987, 1992, 1997, 2002 and 2007.[1] This sample period is selected based on data availability. All variables are taken from the National Bureau of Economic Research (NBER).

We estimate a SCSM following the methodology described in Li et al. (2002). Let the model be given by the following equation:

$$y_i = a(z_i) + x_i^T \beta(z_i) + \varepsilon_i = (1, x_i^T) \begin{pmatrix} a(z_i) \\ \beta(z_i) \end{pmatrix} + \varepsilon_i \tag{1}$$

where $\delta(z_i) = (\alpha(z_i), \beta(z_i)^T)^T$ is a smooth but unknown function of z_i, x_i and z_i are vectors of exogenous regressors with dimension $p \times 1$ and $q \times 1$ respectively and ε_i are zero mean i.i.d. innovations. In this case, we could estimate $\delta(z)$ using a local least squares approach[2]:

$$\begin{aligned} \hat{\delta}(z) &= \left[(nh^q)^{-1} \sum_{j=1}^{n} X_j X_j^T K\left(\frac{z_i - z}{h}\right) \right]^{-1} \\ &\quad \times \left\{ (nh^q)^{-1} \sum_{j=1}^{n} X_j y_j K\left(\frac{z_i - z}{h}\right) \right\} \\ &= [D_n(z)]^{-1} A_n(z) \end{aligned} \tag{2}$$

where $D_n(z) = (nh^q)^{-1} \sum_{j=1}^{n} X_j X_j^T K\left(\frac{z_j - z}{h}\right)$, $A_n(z) = (nh^q)^{-1} \sum_{j=1}^{n} X_j y_i K\left(\frac{z_j - z}{h}\right)$ $K(.)$ is a kernel function and $h = h_n$ is the smoothing parameter for sample size n chosen by cross validation, see Li et al. (2002) and Stengos and Zacharias (2006) for details.

The equation of interest is a simple extension of Eq. (1), where we also add a component to the model that contains information that is not considered to be of the hedonic type and as such not directly affected by z (Mamuneas et al., 2006; Stengos and Zacharias, 2006; Baglan and Yoldas, 2014). In this case, the model that we estimate is given by the following expression:

$$y_i = w_i^T \gamma + x_i^T \beta(z_i) + \varepsilon_i. \tag{3}$$

The dependent variables that enter the y vector are the value added per employee as a proxy for labour productivity (VADD_EMP) and the average real wage of non-manual workers (PRODWOTH) per industry over the time period. Additionally, the w-vector includes the year dummy variables, while the x-vector includes the list of the independent variables of the SCSM including the constant term. These are the capital to labour ratio (K/L), the real total value of shipments (SHIP) as a proxy for market size, the real total capital expenditure (INV) as a proxy for capital, the real total cost of materials (MAT) as a proxy for intermediate inputs and the real cost of electricity and fuels (ENER) that serves as a proxy for energy cost. Finally, we include the CR-4 as a proxy for market structure allowing for certain cyclical behaviour (nonlinearities) in the effect of the covariates on the dependent variables as the z-variable.[3]

Table 1
The linear model.

Variable	Without the year dummies		With the year dummies	
	Model I	Model II	Model I	Model II
lnK/L	1.316*** (0.022)	0.729*** (0.020)	0.137*** (0.013)	−0.195*** (0.015)
lnSHIP	0.352*** (0.052)	0.193*** (0.048)	0.139*** (0.022)	0.052** (0.027)
lnINV	0.150** (0.032)	0.237*** (0.030)	0.032** (0.014)	0.144*** (0.017)
lnMAT	0.058** (0.057)	0.362*** (0.053)	−0.028 (0.024)	0.362*** (0.029)
lnENER	−0.012*** (0.034)	0.325*** (0.031)	−0.044*** (0.014)	0.194*** (0.017)
Cr4*lnK/L	−0.0005*** (0.0004)	−0.0007* (0.000)	0.0003 (0.002)	−0.0004 (0.000)
Cr4*lnSHIP	0.0005*** (0.000)	0.002** (0.000)	0.0006 (0.000)	0.0007 (0.000)
Cr4*lnINV	−0.0003*** (0.000)	−0.0008 (0.000)	0.0002 (0.000)	0.00008 (0.000)
Cr4*lnMAT	−0.0003*** (0.000)	−0.001 (0.000)	−0.0004 (0.000)	−0.0015*** (0.000)
Cr4*lnENER	0.0006*** (0.000)	0.0007 (0.000)	−0.0001 (0.000)	0.0008*** (0.000)
Constant	−2.220*** (0.060)	−1.884*** (0.056)	1.402*** (0.046)	0.8004*** (0.054)
Diagnostics				
Adjusted R^2	0.482	0.496	0.870	0.808
F-statistic	12.04*** [0.00]	24.59*** [0.00]	23.60*** [0.00]	51.73*** [0.00]
Observations	4361	4361	4361	4361
Industries	459	459	459	459

Note: The dependent variable is either the value added per employee (Model I) or the average real wage of non-manual workers (Model II). To preserve space, we have deleted the results of the time dummies and their interactions with the threshold variable CR-4. Robust standard errors are in parentheses. The numbers in square brackets are the p-values. Y_{2002} was excluded from the model because of collinearity.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

3. Results and discussion

Table 1 presents the results from the benchmark linear specification that will be contrasted with the SCSM and is given by the following equation:

$$y_i = a + x_i^T \beta + w_i \gamma + z_i \theta + \varepsilon_i. \tag{4}$$

It is evident that nearly all of the variables are statistically significant in either of the two models (with or without the year dummies). The magnitude and the sign of the estimates are on average in line with the current empirical literature (see for example Symeonidis, 2008). Specifically, there is strong evidence that capital intensity (lnINV) increases labour productivity and wages of non-manual workers. Similarly, market size (lnSHIP) increases both wages and productivity. On the other hand, there is little evidence supporting the notion that the market structure (CR-4) is positively correlated with a higher productivity growth,

[1] For the years 2002 and 2007 we use the concordance between SIC and NAICS codes.

[2] For presentational simplicity for the observations we only use subscript i and omit t.

[3] The CR-4 variable was transformed to log (CR-4 + 0.001) in order to eliminate some zero values.

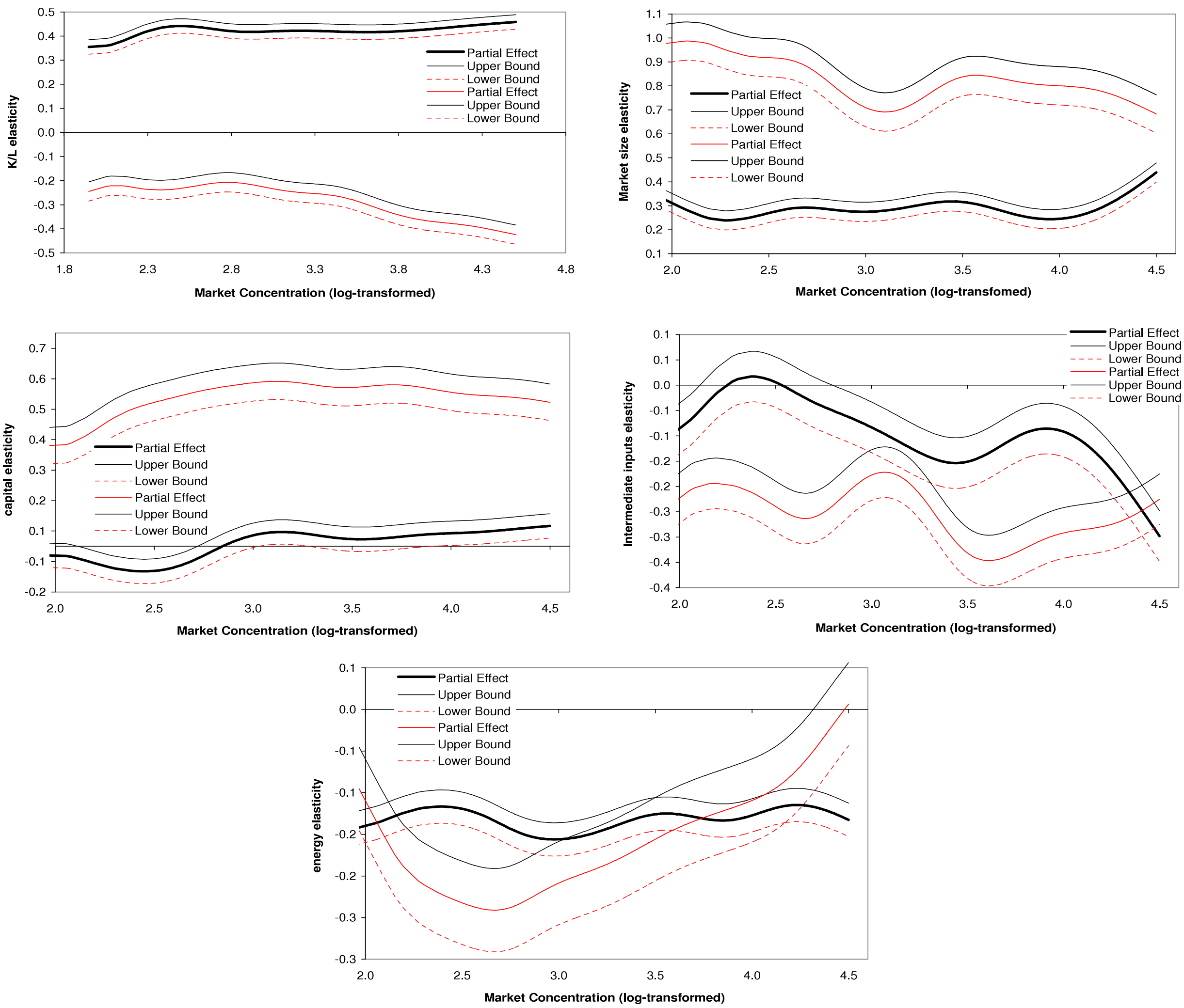

Fig. 1. Nonparametric estimates of labour productivity and wages in the SCSM. **Note**: The solid black line is the partial effect (elasticity) of each variable (K/L elasticity, Market size elasticity, Capital elasticity, Intermediate inputs elasticity and Energy elasticity) entering the labour productivity model (Model I). The light red line represents the partial effect (elasticity) of each variable (K/L elasticity, Market size elasticity, Capital elasticity, Intermediate inputs elasticity and Energy elasticity) entering the wage model (Model II). The light black and red (dashed) lines report the upper and the lower bounds of the 95% confidence intervals. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

while the opposite holds for wages.

Next we apply the linearity test of Li et al. (2002) of the benchmark linear specification of Eq. (4) against the semiparametric alternative given in Eq. (3). The test results suggest that all linear specifications of Equation (4) are rejected with p-values of 0.001 or lower in all cases. This means that the benchmark model does not capture the nonlinear effects generated by the interaction of the smooth coefficient variable (CR-4) with the set of regressors.

We proceed to estimate the SCSM given in Eq. (1). We also perform the test for serial correlation of first order for semiparametric panel data models introduced by Li and Hsiao (1998) and generalized for large T (time span) by Li and Stengos (2003). The p-values for Models 1 and 2 with labour productivity (VADD_EMP) and the average real wage of non-manual workers (PRODWOTH) per industry over the time period as dependent variables respectively are 0.452 and 0.473. This finding indicates that the errors do not display any dependence. The graphical presentation of the semiparametric estimation of $\delta(.)$ along with the 95% confidence bands is portrayed in Fig. 1. It is evident that the relationship between market structure and the main determinants (elasticities) of labour productivity and wages is nonlinear exhibiting a similar pattern except for the capital to labour case (K/L). From the inspection of the upper left part of the figure, it is argued that market concentration increases (decreases) the capital to labour ratio in the labour productivity and wages model respectively. This finding portrays that industries with high levels of market concentration and entry barriers which usually are characterized by low competition intensity are associated with increased labour productivity growth. This result is in contrast with the previous studies (see for example Symeonidis, 2008) where the absence of competition (collusion) has a negative impact on labour productivity.

The opposite holds for the lower part of this figure where increased concentration and thus oligopolistic structure of an industry is associated with a decrease in the level of wages of non-manual workers. It is worth mentioning that market structure is positively correlated with the market size providing strong evidence that market size increases both productivity and wages.

Similarly, regarding capital elasticity (INV) it is evident that apart from a small range, the 95% confidence bands do not include zero indicating a strong non-linear effect. Finally, in the case of intermediate inputs elasticity, it is clear that except for a short range, there is very little overlap between the two sets of confidence bands, while the opposite holds for the cost of energy (ENER).

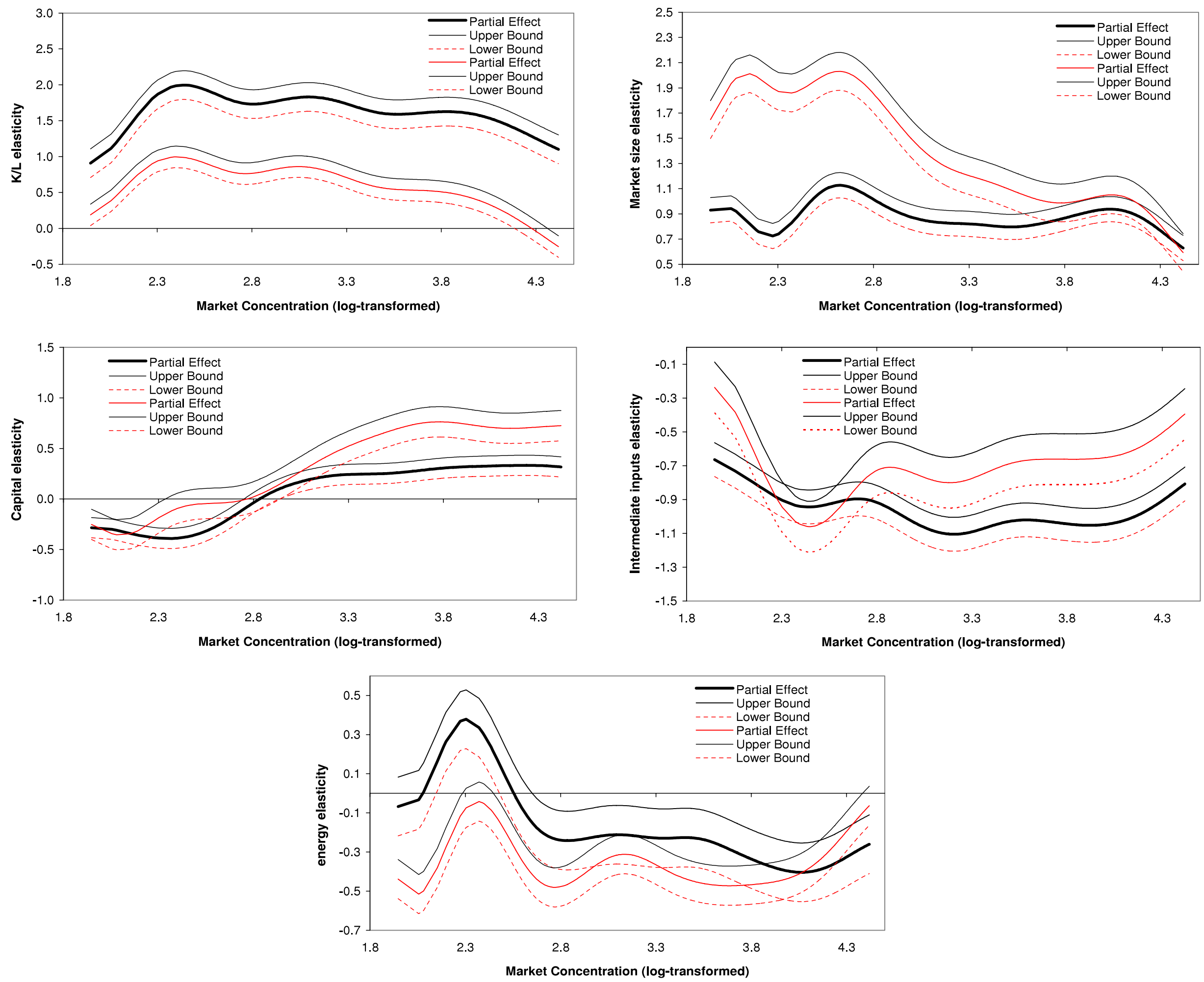

Fig. 2. Nonparametric estimates of labour productivity and wages in the IV model. **Note**: The solid black line is the partial effect (elasticity) of each variable (K/L elasticity, Market size elasticity, Capital elasticity, Intermediate inputs elasticity and Energy elasticity) entering the labour productivity model (Model I). The light red line represents the partial effect (elasticity) of each variable (K/L elasticity, Market size elasticity, Capital elasticity, Intermediate inputs elasticity and Energy elasticity) entering the wage model (Model II). The light black and red (dashed) lines report the upper and the lower bounds of the 95% confidence intervals. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

We proceed to investigate the robustness of our findings by checking for possible endogeneity in the model.[4] The approach that we follow is based on Cai et al. (2006), Cai (2011) and its generalization to panel data by Cai and Li (2008). The empirical technique relies on Instrumental Variable (IV) methodology for smooth coefficient models based on local linear methods. Given the vector of instruments v_i of dimension d, x_i is the vector of endogenous regressors with dimension $p \times 1$ and z_i is the vector of exogenous variables of dimension $q \times 1$, where d will being equal or larger than p. In the panel context with both a cross section and time dimension it is assumed that the data are independently and identically distributed over the cross sectional dimension and stationary across time (weakly dependent alpha-mixing), allowing for possibly serially correlated errors. However, in the case of Eq. (1) without allowing for endogenous x's the errors did not exhibit any first degree serial correlation. We note that in this framework we assume that the variable z that enters the smooth coefficient function is exogenous and we concentrate on the possible endogeneity of the x's. Furthermore, the approach in Cai and Li (2008) does not allow for fixed effects.[5] We used lagged values as instruments following the (Cai et al., 2006) two stage procedure and we found the results to be fairly robust as the curvatures of the graphs presented in Fig. 1 were overall preserved irrespective of the different lags used as instruments.[6] Fig. 2 presents the results using first lags as instruments.

Overall, we find a nonlinear relationship between market structure and labour productivity/wages. However, unlike previous studies, we find little evidence to support a positive relationship between competition and labour productivity growth.

Acknowledgements

We are grateful to Professor Wayne Gray from Clark University and NBER for his valuable assistance in collecting the data. The authors would like to express their gratitude for the fruitful

4 An instrumental approach has also been reported in the paper of Symeonidis (2008) within a linear framework, in order to account for the possible endogeneity of collusion among the sample industries.

5 As far as we are aware an approach that would allow both an endogenous z variable and fixed effects has not yet appeared in the theoretical literature.

6 We used first and second lagged values as possible instruments separately, in order to avoid curse of dimensionality issues that may arise in the first stage of the two step procedure if we were to use more lags. To conserve space we only report the results from the first lag.

comments and suggestions made by an anonymous referee of this journal that substantially enhanced the merit of the paper. They would also like to thank the Editor of the journal who gave them the opportunity to revise their work. The second author would like to acknowledge financial support from NSERC of Canada (401004). The usual disclaimer applies.

References

Baglan, D., Yoldas, E., 2014. Non-linearity in the inflation–growth relationship in developing economies: Evidence from a semiparametric panel model. Econom. Lett. 125, 93–96.

Cai, Z., 2011. Functional coefficient models for economic and financial data. In: Ferraty, F., Romain, Y. (Eds.), Oxford Handbook of Functional Data Analysis. Oxford University Press, Oxford, UK.

Cai, Z., Das, M., Xiong, H., Wu, X., 2006. Functional coefficient instrumental variable models. J. Econom. 133, 207–241.

Cai, Z., Li, Qi., 2008. Nonparametric estimation of varying coefficient dynamic panel data models. Econometric Theory 24, 1321–1342.

Disney, R., Haskel, J., Heden, Y., 2003. Restructuring and productivity growth in UK manufacturing. Econ. J. 113, 666–694.

Hay, D.A., Liu, G.S., 1997. The efficiency of firms: What difference does competition make? Econ. J. 107, 597–617.

Li, Q., Hsiao, C., 1998. Testing serial correlation in semiparametric panel data models. J. Econom. 87, 207–237.

Li, Q., Huang, C., Li, D., Fu, T., 2002. Semiparametric smooth coefficient models. J. Bus. Econ. Stat. 20, 412–422.

Li, D., Stengos, T., 2003. Testing serial correlation in semiparametric time series models. J. Time Ser. Anal. 24, 311–335.

Mamuneas, T., Savvides, A., Stengos, T., 2006. Economic development and the return to human capital: a smooth coefficient semiparametric approach. J. Appl. Econometrics 211, 111–132.

Nickell, S., 1996. Competition and corporate performance. J. Polit. Econ. 1044, 724–746.

Stengos, T., Zacharias, E., 2006. Intertemporal pricing and price discrimination: a semiparametric hedonic analysis of the personal computer market. J. Appl. Econometrics 213, 371–386.

Symeonidis, G., 2008. The effect of competition on wages and productivity: Evidence from the United Kingdom. Rev. Econ. Stat. 901, 134–146.

Tran, K., Tsionas, E.G., 2010. Local GMM estimation of semiparametric panel data with smooth coefficient models. Econom. Rev. 29, 39–61.