889
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EFFECTS OF R&D EXPENDITURE ON EMPLOYMENT GROWTH: A DYNAMIC PANEL ANALYSIS

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ABSTRACT

This paper estimates the effects of research and development (R&D) expenditure on the employment growth in Malaysian manufacturing sector during the period 2000 to 2008. Theoretical literatures devote the link between R&D and employment structure tends to suggest technological change has positive effects on job. Using dynamic panel GMM system estimation and 3 digit industry levels from manufacturing survey over the period 2000 to 2008, this paper find there is negative and significant relationship between R&D expenditure and employment growth. This is true when we consider with the second lag of the variable. Employment growth in Malaysian labour market however still favour to labour oriented and the absorption of the new technology is consideredlow.

Field of Research: *R&D, Labor Force and Employment, and Technological Change.*

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1. Introduction

This paper estimates the effect of research and development (R&D) on employment at the industry level using a dynamic panel approach. Research and development is considered to be an important factor to stimulate growth and enhance productivity. The relationship between research and development and employment is remains unclear and thus calls for an empirical work. The relationship can be explained through two main channels. Firstly the direct effects of employment. The effects is clear through product and process of research and development at firms level which is depend on the types of research and development. Katsoulacos et.al (1986) contributes the theoretical reason and stress the importance of distinction between product and process of R&D at firm level. Product innovations lead to new products on the market which stimulate new demand and automatically increase the demand for labour at particular industries. Therefore the direct effects of product innovations on employment should be a positive relationship. Secondly, the indirect effects of research and development on innovators' employment. This situation depends on the state of the technology that determines how much R&D improves productivity and demand condition that can induce different dynamic effects. As Lachenmaier and Rottmann (2011) argue that, if a firm introduces a product which is new to the market, there is no direct competitor and there is no employment effects until the firm exploit monopoly power and maximize its profits. This situation can lead to a decreasing in output and thus to a reduction in employment. The worst case of relationship can be explained if the new products are substitutes for existing products of the firm. The new workers can simply replace old workers or the new product required new technology and fewer workers. Hence the overall effects of R&D on employment are unclear in theory.

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This paper presents some empirical evidence on the effects of R&D on employment growth in Malaysian manufacturing sector during the period 2000 to 2008. The manufacturing sector is actuators to economic development in Malaysia. In 2011 the contribution of this sector to gross domestic product was 27.5 per cent which is the second largest after the services sector. Looking at employment contributions, the sector absorbs 28.9 per cent of total employment in 2011. In line with the country aspiration to be developed country, industrial sector is targeted to shift towards activities with higher added value to cope with a more global environment challenging. In other word, manufacturing sector is targeted to lead Malaysia's economic growth throughout invention of new venture area and elevate the higher technology.
The paper is organized as follows: Section 2 presents the previous literature, section 3 describes data, model and econometric strategy, section 4 the results and section 5 provides a conclusion.

2. Previous Literature

Analysis the impact of innovation on employment growth is not a new topic but it has been discussed comprehensively with the classical economists such as Say (1964), Ricard (1951) and Max (1961). This topic often a matter of debate due to the poor clarity of the innovation effect on employment growth whether in theory or empirical. Previous studies prove that innovation not only increase or decrease employment growth but also may have either a puzzle. According to Chih Chun Hung Hai Yang and A. Lin, 2008, innovation is one of the key sources of changes in employment. Until now, the relationship between innovations and employment frequently argued by many researchers. Piva and Vivarelli (2003), Yang and Huang (2005) and Jaanika Merikull (2010) have proved that innovation have positive impact on employment growth. Similarly, Entorf and Pohlmeier (1990) documented that innovations have been established positive effects of employment size. These analyses carried out over 7023 firms in Germany and proved that there is a positive relationship between employment growth and innovation. Product innovation has increased the employment growth of 3.3% and 5.5% increase in employment growth is due to the process innovation.

However, Evangelista & Savona, (2003); Antonucci & Pianta (2002) and Lachenmaier and Rottmann (2007) wrap up that innovation leads to a decrease in the utilization of employment. Brouwer, Kleinknecht and Reijnen (1993), using the OLS approach, rate of employment growth expected rise when there is the element of innovation. Yet the opposite research findings indicate overall negative influence of innovation on employment growth rate during 1983 to 1988 in 859 firms in Netherland. The R&D intensity of firms is not just negative effects on employment but also it is not significant. Taking into consideration Norwegian manufacturing firm, Klette and Forre (1998) does not show any clear cut relationship between innovation and employment. Census data were combined with data from the questionnaires to analyze the level of technology between firms and R&D as a measure of innovation. In early 1980s, firm in R&D intensive did quite well in terms of net job création, but this condition changed at the end of the 80s and early 90s which majority job has been abolished as a result of R&D.

Other important issues that always documented in past literatures are the issues related between product and process of innovation strategies. Green and Guellec (2000) exploit French survey data in 1991 and found that product and process innovation strategy increased the employment growth for innovated firms compared to non-innovated firms. In four Latin American countries[1] product innovation led to an increase in employment growth at the firm level, while process innovation affects employment growth only on Chile (Crespi and Tacsir, 2011). Empirical analyses often differentiate between product and process innovation in proving the theory

[1] Argentina, Chile, Costa Rica and Uruguay

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viewing relationship between employment growth and innovation. Most of the analyses reflect positive effect of product innovation on employment growth. Contrast the effect of process innovation remains unclear. In some studies it has a positive effect whereas in other studies, it indicates a negative effect. Nevertheless, it is difficult to differentiate between the two strategies, product and process innovation. Generally firms will apply these innovation strategies simultaneously. Thus, most of previous literature just look at the whole process without differentiate whether firms had apply product and process innovation strategies.

Without differentiate between product and process innovation, In UK, Van Reenen (1997) use firms data from the list on the London Stock Exchange with English innovation database of the Social Policy Research Unit (SRPU) to predict the impact of innovation on employment growth. Using the GMM SYS with the intention to control fixed effect, dynamic and endogenity, he found that technological innovation was related with higher firm-level employment. Similar with the case of high tech firms, Greenhalgh, Longland; and Bosworth (2001) found that firms which register intellectual property through patents and acquire commercial assets through trademarks are exposed to have higher levels of employment. In Italy, using 575 manufacturing firms level data, implementation of intermediate technology through non-R&D expenditure gave a positive impact on employment growth or vice versa (Piva and Vivarelli 2005). However, the effects of R&D expenditure just around 1.43 percent on employment growth.

3. Data and Methodology

3.1 Data Description

This study exploits the data from the Annual Survey Report of Manufacturing Industries issued by the Department of Statistics Malaysia (DOS). Sample in this survey comprises a registered establishment which involved in manufacturing activities. There are 71 industry groups at the 3-digit level base on Malaysia Standard Industrial Classification (MISC), 2008. However, due to some constraints of information, this study takes into consideration for only 56 industry groups between 2000 and 2008. R&D expenditure variables consists expenditure on the process and techniques of producing output as well as research for new discoveries made by commercial basis expenses.

Employees also cover to those active business partner and family employees unpaid; whether they are paid full-time employees or paid part-time employees. An employee categorized as full-time employees if they work for at least 6 hours per day or 20 days within one month. Any employee who works less than 6 hours per day or less 20 days per month is categorized as part-time employees.

We use output, wages and capital stock as a control variable. Output refer to items such as the value of goods sold in the same condition as purchased either the closing stock of finished goods or closing stocks of goods-in-process. Wages refers to gross emoluments paid to employees for a mention years, inclusive of bonus, commission, over time pay and dismissal pay. This wage was deflating using the GDP deflator in the direction to obtain real wages. The capital stock include all fixed capital goods, tangible and intangible, whether new or used, which have a normal economic life span of more than one year. It is the net worth to have less accumulated depreciation. It is net worth after deduct depreciation.

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3.2 Methodology

Employment effects of R&D can be explained through neoclassical production theory. Based on this theory, the demand for labor is derived from profit maximization conditions. Various econometric methods used in estimating the labor demand. This paper adopt specifications highlighted by Van Reenen (1997). In order to obtain a constant production function, elasticity of substitution production function is constant (CES). Firms that in the competitive markets conduct operations based on CES production function:

$$Y = A[(\alpha L)^{\rho} + (\beta K)^{\rho}]^{1/\rho} \quad (1)$$

where Y is output, A is Hick-neutral technology parameter, α is a labour augmenting Harrod-neutral technology, β is the Solow-neutral technical change, L is employment and K is capital. If W represents the cost of labor and P is the price of output, profit maximization leads to the following labor demand (in logarithm):

$$\log L = \log Y - \sigma log(W/P) + (\sigma - 1) log(\alpha) \quad (2)$$

Where $\sigma = 1/(1-\rho)$ indicate the elasticity of substitution between capital and labour.

Subsequently, corresponding the marginal product of capital through the real price of capital and substituting via this second order condition for the output in the equation 2, gives the following labor demand function.

$$\log L = (\sigma - 1)\, log\left(\alpha/\beta\right) - \sigma\, log(W/P) + \log K + \sigma \log R \quad (3)$$

After that, Van Reenen (1997) replaces the unobserved technology variable with innovation and produces the stochastic form of the labor demand function. The stochastic version of labor demand for a panel of firms (i) over time (t) is:

$$l_{it} = \beta_1 w_{i,t} + \beta_2 y_{i,t} + \beta_3 k_{i,t} + \beta_4 innov_{i,t} + \mu_{it} \quad (4)$$

where $\mu_{i,t} = \gamma_i + \varepsilon_{i,t}$

$$l_{it} = \beta_1 w_{i,t} + \beta_2 y_{i,t} + \beta_3 k_{i,t} + \beta_4 innov_{i,t} + (\gamma_i + \varepsilon_{i,t}) \quad (5)$$

where lower case letters designate natural logarithms, l is labor, y output, w wage, $innov$ innovation, γ_i the idiosyncratic individual and time-invariant firm's fixed effect and ε the usual error term. It is also possible to put in a complete set of time dummies to capture the time dimension.

Specification equation (5) is static. In empirical studies, the latter static specification of labor demand should be extended with dynamic adjustment for employment and innovation. Therefore, a dynamic one should be more

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suitable for studying the correlation between labor and innovation. The dynamic panel model is considered that include unrestricted lag structure in order the slow adjustment. The lagged values of the innovation also included to account for a time lag between the implementation of an innovation and its effect on employment. This estimation approach leads to the following estimation equation:

$$l_{i,t} = \alpha l_{i,t-1} + \beta_1 w_{i,t} + \beta_2 y_{i,t} + \beta_3 k_{i,t} + \beta_4 innov_{i,t} + \beta_5 innov_{i,t-2} + (\gamma_i + \varepsilon_{i,t}) \qquad (6)$$

3.3 Estimation Strategy

A number of questionable consequential from dynamic specification model leads to the issue of how to estimate equation (6) which is a dynamic model. Among these, first, the lag dependent variable $l_{i,t-1}$ associated with individual fixed effects which are usually looking upon for panel data. This effect has the potential relationship with regressor on the right, such that

$$\mu_{i,t} = \gamma_i + \varepsilon_{i,t}$$

where γ_i is a firm effect that corresponds to the permanent, unobserved heterogeneity of the particular nature of a firm's production, but not inside a firm ultimately. Term $\varepsilon_{i,t}$ is a white noise error term.

There are two main concerns in our estimation strategy, first the problem of fixed effects. The problem of endogeneity of the innovation variables. They might be correlated with the error term of the labour demand function. Bear in mind that, the unobserved individual effects cannot be responsible for such a correlation since they dropped out as we took first differences of our estimation equation. If there is no autocoloration in the error terms, the only factor leading to an endogeneity problem might be a contemporaneous correlation of the innovation variable with the error term $\varepsilon_{i,t}$. In this case a possible solution of this problem in our strategy would be an instrumental variable strategy. To solve individual fixed effects, equation (6) was incarnated using the first differential equation as below

$$\Delta l_{i,t} = \alpha\, \Delta l_{i,t-1} + \beta_1\, \Delta w_{i,t} + \beta_2\, \Delta y_{i,t} + \beta_3\, \Delta k_{i,t} + \beta_4\, \Delta innov_{i,t} + \beta_5\, \Delta innov_{i,t-2} + \epsilon_{i,t} \qquad (7)$$

Second, we concern about the potential endogeneity of variable. There are two approaches to deal with the problem of endogenous innovation choice. One is known as two stage approach and second called as GMM. The later approach (GMM) provides an alternative to deal with the endogenous innovation choice by including the lagged variable as instrumental variable.

4. Result

Table 2 presents the results of the panel estimation of Equation (7). In this analysis, wage, capital and innovation are treated as endogenous in GMM estimation (Merikull, 2010; Lachenmaier and Rottmann, 2011). In the GMM

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SYS variable which is not directly exogenous can be treated either as predetermined or endogenous. Innovation can be predeterimined variable if decision of innovation by firms are usually based on long-term at least $(t-1)$, while hiring decisions are assumed to be based on short term (t). The high cost are required in implementing innovation lead firms make decision based on the long term. As declare above, in this study innovation is treated as endogenous variable. These variables can affect the next period's employment decisions. Industries considers a number of factors such as employment first lag, wage, output, capital and innovation second lag in decision making either to increase or decrease of number of employees that will be taken at one time. The decisions influence employment growth whether the employment grow up positively or negatively.

Table 1 : R&D Expenditure Effect on Employment, 2000-2008

Explanatory Variable	Overall Firm
Employment (-1)	0.836 (0.000)*
Wage	-0.468 (0.0710)***
Output	0.136 (0.020)**
Capital	-0.0002 (0.043)**
Innovation	0.0003 (0.352)
Innovation (-2)	-0.0008 (0.045)**
Constant	5.671 (0.054)***
AR(1)	0.001**
AR(2)	0.742
Hansen Test	0.404
Number of Observation	392

* Significat p <0.001
** Significant p < 0.05
*** Singificant p < 0.1
AR(1) test : Significant p < 0.05
AR(2) test and Hansen Test: Significant p> 0.05
Sargan Test and Hansen Test: Significant p> 0.05

The result indicates that R&D has a negative and significant effect on employment growth. R&D Expenditure decreased employment growth by 0.8 percent for the two years after implementation. Even though the result contrary to the theory, this results consistent with the result derived by Evangelista and Savona (2003); Antonucci and Pianta (2002). Firm that allocate a great expenditure on R & D will reduce the use labor. R&D expenditure encourage firms apply the technologies in the production. The use of technology support firms

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manufacture the same level of output with a decreased number of workers. This situation reflects that Malaysian manufacturing sector are labour saving oriented in their production activity.

The study also analyzes the effects of lagged dependent variable on employment growth. The results shows that there is a significant effect of 0.836 for the first lag which is very similar to the results of other studies such as Piva and Vivarelli (2005) and Van Reenen's (1997). Firms made decision to raise or drop off the employees hire base on employment lag one for that reason the number of employees appoint is efficient amount to avoid occurrence diminish in labour productivity. Moreover, it is important to take into consideration the lagged dependent variable in the model on order to explain the dynamic model. When we look the relationship between wage and employment growth, the result shows a significant negative relationship between changes in employment and wage. The results shows, 0.468 per cent of labor would be increased when wage rate decline by one percent. This result in line with the efficiency wage theory which is increases in wages will reduce number of labour employed in the production activities. Firms necessitate to increase the demand of employment toward carry out the growing demand for goods. Expansion in labour quantity will increase production cost that borne by firm and with unchanged firm total expenditure, firm's profit will decline. In order to maximize profits, the increase in quantity of labor will followed by reduction in the wages

This study also demonstrated positive relationship between employment and output growth. According to Okun's law, firms alter their output due to change in aggregate demand. This leads to change in labor demand and therefore affects the unemployment rate. Empirical result by Zaleha et all. (2007) supported this negative relationship between output and unemployment in Malaysia. Moreover, a sustainable consumer spending due to an increase in household income has increased the demand for goods. To accommodate the increase in output due to increase demand goods, the more labor is required.

5. Conclusion

Our results indicate that overall R&D expenditure has a negative and statistically effects on employment growth in Malaysian Manufacturing during the period 2000 to 2008. In general this result confirms the firms and industry level results (Antonucci and Pianta (2002)). This situation occurs due to the industry in Malaysian Manufacturing still at developing stage hence, a great expenditure on R & D will reduce the use labor. R&D expenditure encourages firms to apply new technologies in the production. The use of new technology support firms to produce the same level of output with a decreased number of workers. This situation reflects that Malaysian manufacturing sector is labour saving oriented in their production activities. Moreover, the nature of Malaysian manufacturing sector is more supported by small medium enterprise (SMEs), this situation lead to the problem of absorption of the new technology and cause the reduction in employment.

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References

Aghion, Philippe, and Peter Howitt. (1992). A Model of Growth through Creative Destruction. *Econometrica,* 60(2), 323–35.

Anderson, T.W. and Hsiao, C. (1982). Estimation of Dynamic Models with Error Components. *Journal of the American Statistical Association*, 76, 598-606.

Antonucci, T. and Pianta M. (2002). Employment Effects of Product and Process Innovation in Europe. *International Review of Applied Economics*, 16 (3), 295-307.

Arellano, M. and Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *Review of Economic Studies*, 58,277-297.

Blundell, R. and Bond, S. (1998). Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics*, 87, 115-143.

Brouwer, Erik; Alfred Kleinknecht; and Jeroen O. N. Reijnen. (1993). Employment Growth and Innovation at the Firm Level. *Journal of Evolutionary Economics,* 3,(2), 153–159.

Chih Chun Hung Hai Yang and A. Lin (2008). Developing employment effects of innovations: Microeconometric evidence from Taiwan. *The Developing Economies*, XLVI-(2) ,109–134

Crespi G and Tacsir E. 2011 Effects of Innovation on Employment in Latin America, Science and Innovation Policy, 2011 Atlanta Conference on Science and Innovation Policy 2011

Entorf, H., and Pohlmeier, W. (1990). Employment, Innovation and Export Activity: Evidence from Firm-Level Data. In *Microeconometrics: Surveys and Applications*. Oxford: Basil Blackwell

Evangelista, R., and Savona. M. (2003). Innovation, employment and skills in services. Firm and sectoral evidence. *Structural Change and Economic Dynamics*, 14, 449–74.

Evangelista R, and Mastrostefano V. (2005). Firm Size, Sectors and Countries as Sources of Variety of Innovation. *Economics of Innovation and New Technology*, 15 (3), 247–270.

Greenan, N., and Guellec D. (2000). Technological Innovation and Employment Reallocation. *Labor*, 14 (4), 547–590.

Greenhalgh, C., Longland, M., and Bosworth, D. (2001). Technological Activity and Employment in a Panel of UK Firms. *Scottish Journal of Political Economy*, 48 (3), 260–282.

Harrison, R., Jaumandreu, J., Mairesse, J., Peters, B., (2008). Does innovation stimulate employment? A firm-level analysis using comparable micro-data from four European countries. NBER Working Paper 14216, Cambridge, MA

Holtz-Eakin, D., Whitney. N., and Rosen, H.S. (1988). Estimating Vector Autorgressions with Panel Data. *Econometrica*, 56, 1371-1395.

Merikull, J. (2010). The Impact of Innovation on Employment Firm and Industry Level Evidence from a Catching – Up Economy. *Eastern European Economics*, 48 (2), 25-38.

ISBN: 978-967-5705-05-2. WEBSITE: *www.internationalconference.com.my*

Klette, T. J., and Forre S.E. (1998). Innovation and Job Creation in a Small Open Economy—Evidence from Norwegian Manufacturing Plants 1982–92. *Economics of Innovation and New Technology*, 5 (2–4), 247–272.

Lachenmaier, S., and Rottmann, H. (2007). Effect of Innovation on Employment: A Dynamic Panel Analysis. *International Journal of Industrial Organization*, 29, 210-220.

Lundin, N., Sjoholm, F., Ping, H., Qian, J., 2007. Technology Development and Job Creation in China. IFN Working Paper Series, No. 697.

Marx, K. (1961) *Capital*. Foreign Languages Publishing House.

Nagaraj, R. (2004). Fall in Organized Manufacturing Employment: A Brief Note. *Economic & Political Weekly*, July 24:3387-3390.

Peters, B. (2004). Employment effects of different innovation activities: Microeconometric evidence," ZEW Discussion Paper 04-73, ZEW.

Piva, M. and Vivarelli, M. (2003). Innovation and Employment: Evidence from Italian Microdata, IZA Discussion Paper n. 730.

Piva, M. and Vivarelli, M. (2005). Innovation and Employment: Evidence from Italian Microdata. *Journal of Economics*, 86, 65-83.

Ricardo, D. (1951) Principles of Political Economy, in P. Sraffa. (Ed.) The Works and Correspondence of David Ricardo, Cambridge: Cambridge University Press, vol. 1, third edn1821.

Romer, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy*, 98 (5), 71–102.

Say, J.B. (1964) *A Treatise on Political Economy or the Production, Distribution and Consumption of Wealth*. M. Kelly, New York

Van Reenen, J. (1997). Employment and Technological Innovation: Evidence from U.K. Manufacturing Firms. *Journal of Labor Economics*, 15(2), 255–284.

Vivarelli, M., Evangelista, R., and Pianta, M. (1996). Innovation and Employment in the Italian Manufacturing Industry. *Research Policy*, 25, 1013–1026.

White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, 48, 817-838.

Yang, Chih-Hai, and Chia-Hui Huang. (2005). R&D, Size and Firm Growth in Taiwan's Electronics Industry. *Small Business Economics*, 25 (5), 477–487.