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The influence of Flexible Manufacturing Technology adoption on productivity of Malaysian manufacturing industry

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ABSTRACT

This paper investigates the influence of the adoption of Flexible Manufacturing Technology (FMT) on the Total factor Productivity Growth (TFPG) of Malaysia Manufacturing Industry. The Principal Component Analysis has been adopted to extract the most appropriate underlying dimensions of FMT to use in place of the eight FMT variables owing to the potential multicollinearity. The study has been conducted within FMT intensively adopted 16 three-digit industries that encompass 50 five-digit industries covering the years 2000–2005. The results obtained from the two situations, one, including the industry fixed effects dummy variables and the other without these, are contrasted. It is established that the model that included the industry fixed effect dummy variables has a greater explanatory power. The two principal components that account for the greater variation in FMT show positive and moderately significant relationship with TFPG. The study provides sufficient evidence to conclude that FMT has a direct and moderately significant relationship with TFPG.

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1. Introduction

The average gross domestic product (GDP) growth of Malaysia (5.5%) during 2000–2007 is lower than that (7.0) during 1990–2000. Malaysian Manufacturing sector GDP (13.0%) during 2000–2007 is much lower than the same (4.8%) for the period 1990–2000. These are some of the key indicators to the declining competitiveness of the Malaysian manufacturing industry over the period 2000–2007. It is widely believed that intensive regimes of contemporary manufacturing paradigms such as mass customisation, customerisation and instant customerisation can pave the way for a competitive manufacturing industry. The studies show that mass customisation is the core manufacturing paradigm. The studies also showed that the crucial determinant of the successful implementation of mass customisation is the abundant use of Flexible manufacturing Technology (FMT) (Wind and Rangaswamy, 2001; Da Silveria and Fogliatto, 2005).

Moreover, Malaysian Industrial Development Authority (MIDA) (MIDA, 2007) has recognised a number of promoted activities and products (for the development and production) for high technology establishments which makes them entitled to pioneer status or investment tax allowance under the promotion of Investment Act 1986. This includes FMT products such as, Computer process control systems/equipment, Process instrumentation, and Robotic equipment and Computer numerical control machine tools. The Ninth Malaysia Plan which is compiled by the Economic Planning Unit of the Prime Minister's Office presents the first five-year blueprint of the National Mission, outlining the policies and key programmes aimed at fulfilling the Mission's 'Thrusts' and objectives for the period 2006–2010. This aims to achieve changes in the structure and improved performance of the economy with every economic sector achieving higher value added and total factor productivity. The 'Thrust 1' of the Plan is aimed at making the economy more centred on human capital, particularly with increasing competition from globalisation and progressive market liberalisation. This states that,

'Application of high technology and production of higher value added products will be given emphasis. Measures will be undertaken to migrate the electrical and electronics (E&E) industry towards high-technology and higher value added activities'.

The empirical studies on FMT are clustered in the following areas; types of flexibility, types of FMT, procedure bias on investment appraisal of FMT, operational problems, market structure and competitiveness. Nonetheless, it is observed that the influence of FMT adoption on the competitiveness of the Malaysian manufacturing industry has not been adequately explored. Studies have revealed that due to the potential operational problems of FMT implementation, potential benefits of FMT might not be derived (Sharma, 2002; Gale et al., 2002; Roller and Tombak, 1993). Moreover, Slagmulder and

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Bruggeman (1992) and Fine and Freund (1990) showed that due to 'procedure bias on investment appraisal of FMT', investments in FMT do not take place smoothly or effectively. Hence, additional studies need to be carried out to measure the extent to which FMT contributes to the productivity in the manufacturing industry.

Evidently, only a few studies have examined the impact of specific technologies on the industry level productivity using less aggregated data. Berndt and Morrison (1995) examined the impact of high-tech investments on multifactor productivity (MFP) and three profitability measures. While the study found only limited evidence of a positive relationship between profitability and the share of high-tech capital in the total physical capital stock, it established that they were negatively correlated with MFP. Amato and Amato (2000) have investigated the impact of high-tech investments on MFP and Price Cost margin. This study established that there was a positive impact from high-tech investments regardless of whether or not the specification includes industry effects dummy variables to account for the differences in technological opportunity among industries.

According to Henricsson and Ericsson (2005), Wysokinska (2004) and Porter (1990), productivity is the only relevant measure of competitiveness. Zhi et al. (2003) showed that there were three productivity concepts currently adopted to measure the productivity in the manufacturing industry. Chau (1993) and Oulton and O' Mahony (1994) emphasised on the unresolved academic debate over whether MFP and Total Factor Productivity Growth (TFP) are the same. On account of this, the present study adopts a widely recognised productivity measure, growth of TFP (TFPG). A number of studies have been conducted in the manufacturing industry of Malaysia that adopted TFPG to measure productivity at industry level. Menon (1998) studied TFPG of foreign and domestic firms in the Malaysian manufacturing industry. Tham (1997, 1995), Choong and Tham (1995) and Fatimah and Mohd (2004) adopted TFPG to examine the influence of trade policies and industry characteristics on the productivity growth of the Malaysian manufacturing industry. Abdullah and Hussein (1993) adopted TFPG to examine the productivity growth of the Malaysian resource based industries. These studies indicate that TFPG has been used in Malaysia to measure productivity growth in the manufacturing industry. Moreover, Elsadig (Elsadig, 2006a, 2006b, 2006c, 2007, 2008a, 2008b), estimate TFPG contribution to Malaysia's manufacturing in relation to input driven, positive and negative externalities, such as the impact of information and communications technology, human capital, foreign direct investment, carbon dioxide emissions and Biochemical Oxygen demand emissions.

The purpose of this paper is to examine the influence of FMT adoption on TFPG in selected manufacturing industries of Malaysia. This adds to the previous literature by focusing more narrowly on the influence of adoption of FMT on productivity. This study developed inclusion criteria and selected FMT intensively adopted 16 MSIC three-digit industries and 50 MSIC five-digit industries included within them. All secondary data required for the study came from the Annual Surveys of Manufacturing Industries (ASMI) during 2000–2005 and Economic census data maintained by the Department of Statistics Malaysia (DOS). Another novelty in this study is that prior similar studies have been carried out at the four-digit level whereas the present study is carried out at five-digit level. The present study contributes to the previous studies by considering less aggregated data and also by considering TFPG in place of MFP.

This study also considers a higher number of specific FMT variables such as, Computer Numerical Control machine tools, Numerical Controlled Machine Tools (NC), Robotics (ROB), Programmable Logic Controllers (PLC), Automated Inspections (INS), Automated Storage and Retrieval Systems (ASR), Computer Aided Design (CAD) and Local Area Networks (LAN). In order to overcome multicollinearity among FMT variables, the study extracts three underlying dimensions of FMT by adopting Principal Component Analysis. They are namely; 'process control' technologies, 'production and quality control' technologies and the 'general control' technology. The study adopts a questionnaire survey to compute the degree of adoption of FMT among the selected 50 five-digit industries. The present study considers eight types of FMT instead of five specific technologies, evidently the maximum number considered in a prior study. The study covers only six years from 2000 to 2005 due to the limitation of data availability. The fact is that the DOS follows the MSIC 2000 in classifying industries for the collection and publication of data. The Annual Survey of Manufacturing Industries (ASMI) reports from 2000 onwards have been prepared according to this classification and up to 1999 according to the older version of the MSIC. The older classification system is so different that more than 30% of the MSIC five digit industries (classified according to MSIC 2000) considered in this study is neither listed nor coded or described differently in ASMI reports published up to 1999 which were based on older classification system. Hence, the earliest year that was considered for this study is 2000. Since ASMI 2006 which publishes data for the reference year 2005 was released in early June 2008, the latest year considered is 2005. This has been done by Amato and Amato (2000) too in their study on impact of high-tech investments in profitably and productivity have considered only five years. Since the data for six year have been reviewed the total number of resultant observations (cases) available for this study was 300 ($6 \times 50 = 300$).

2. Methodology

The basic research hypothesis of the study is: a high degree of FMT adoption enhances TFPG of the manufacturing industry of Malaysia. TFP is measuring the relationship between output and its total inputs (a weighted sum of all inputs), by this means giving the residual output changes not accounted by total factor input changes. Being a residual, changes in TFP are not influenced by changes in the various factors which affect technological progress such as the quality of factors of production, flexibility of resource use, capacity utilisation, quality of management, economies of scale, and the like (Rao and Preston, 1984).

In addition, it has been documented in empirical work on economic growth by Solow (1956, 1957), that after accounting for physical and human capital accumulation, "something else" accounts for the bulk of output growth in most countries. Both physical and human capital accumulations are certainly critical for economic growth. The process becomes more complicated with the role of knowledge in the economic growth process. Knowledge obviously accounts for a part of the growth that is not accounted for by the other factors of production; namely capital and labour. In growth theory, the Solow residual is an unexplained residual of labour and capital and it is attributable to the growth of TFP. The notion of TFP is interpreted as an "index of all those factors other than labour and capital not explicitly accounted for but which contribute to the generation of output." TFP refers to the additional output generated through enhancements in the efficiency accounted for by such things as advancement in human capital, skills and expertise, acquisition of efficient management techniques and know-how, improvements in an organisation, gains from specialisation, introduction of new technology, innovation or upgrading of present technology and enhancement in Information and Communication Technology (ICT), (Elsadig, 2006a,b,c, 2007, 2008a,b).

2.1. Estimation of TFPG

There are two stages in the methodology. The first stage is to estimate TFPG for all the industries considered in the sample. The second is to identify the explanatory variables of TFPG. The TFPG approach to measuring productivity is widely used in the manufacturing industry (Sharma, 2002; Bloch and Tang, 1999; Leung, 1997; Yean, 1997). Jorgenson et al. (1987), based on the pioneering works of

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