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Impact of International Outsourcing on Domestic Wage of Singapore Manufacturing Sector

Sandip Chakraborty[1], Ram Kumar Kakani[2] & Bernadette C. Canasa[3]

[1] Domain Consultant (Statistics), Tata Consultancy Services, India

[2] Professor, XLRI Xavier School of Management, Jamshedpur, India

[3] Project Manager, SCSI Singapore Pte., USA

Correspondence: Ram Kumar Kakani, XLRI Xaviers School of Management, Jamshedpur, Jharkhand -831001, India. Tel: 91-657-665-3104. E-mail: kakani@xlri.ac.in

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Abstract

This study focuses on measuring the extent of international outsourcing across Singapore manufacturing sector and the impact on domestic wages of workers. Based on the framework of Feenstra and Hanson (1999), this study measured the narrow and wide outsourcing from the overseas intermediate imports. In estimating the impact of international outsourcing on wage, this study reviews the model developed by Geishecker and Görg (2008) and modifies the same by incorporating the parametric stability approach of Hamilton's (1989) Markov Switching model. Results after incorporating the nonlinearity, indicates that outsourcing dynamics can be better understood through modified framework developed.

Keywords: international trade, outsourcing, Singapore, manufacturing, domestic wages, switching regression models

1. Introduction and Literature Review

Trade liberalization has changed the way of doing business from local dependency to global. Traditionally, manufacturers used to rely heavily on internal local production processes for the manufacturing of goods. As the market needs change, consumer goods require constant innovation and cost competitiveness. To advance economic growth, Governments tie up with other countries and opens opportunities for lower trade barriers. Manufacturing firms take advantage of the open economy by obtaining the efficient way of producing goods internationally. They have the opportunity to source out external supply of materials, components and parts from low-cost manufacturer *or* to obtain highly technological materials from different suppliers.

Against this backdrop of trade liberalization, international outsourcing and subcontracting activities gained increased research focus in recent decades. Glass and Saggi (2001) concluded that the impact of international outsourcing affects the welfare of importing firm as it lowers the relative wage of workers which can be offset by the positive effect from faster innovation. Various studies (say, Dyer & Ouchi, 1993; Gilley & Rasheed, 2000) reiterated that outsourcing based on cost leadership have proven to be a big success. This growing importance of international outsourcing and its successive inclusion in various decision models both at micro and macro level has led to a stream of theoretical and empirical researches.

The connectivity of manufacturing strategy to outsourcing has been discussed in the decision framework of Dekkers (2000). Adding further to decision framework and strategy, Kumar et al. (2008) have examined the total cost of international outsourcing by developing a closed loop sourcing decision model for effective manufacturing strategy. Bertrand and Sridharan (2001) contributed further, enriching the framework by developing four-heuristic decision rules with varying informational needs and complexity to determine when and which orders should be subcontracted, limiting the focus to operational decisions. Chen and HungAn (2010) have presented an integrated fuzzy approach for selecting a suitable outsourcing manufacturing partner in pharmaceutical R&D based on the determined weights of criteria and sub-criteria such as financial considerations, quality, service performance, compliance, environmental health & safety compliance, and culture.

The decision framework of outsourcing and linking it to manufacturing strategy has been discussed not only on

macro level but also at firm level. For example, Holl et al. (2010), have studied on firm level in the electronics and automotive industry the subcontracting linkages in Just-In-Time (JIT) manufacturing system and determinants of geographical extent. Using multivariate probit model, the study found that JIT has significant positive influence on probability of subcontracting locally. Business entities are likely to outsource at the local level for goods of low added value while high value added, complex goods, by contrast, appear to be outsourced in extra-regional location, such as entities engaged in technology networking. Thus, the spatial organization of a corporate entity is closely related to modes of production organization.

Along with the micro level relationship based learning's and economic benefits observed by Holl et al. (2010), typification of outsourcing *or* mode of outsourcing has also been found to be playing an important role in transferring the benefits of outsourcing to economic profit. For example, Bengtsson et al. (2009) found that outsourcing represents a trade-off between improving innovation capability and lowering the cost. The study also showed that manufacturing and supplier integration in product design processes is beneficial when applying innovation-oriented outsourcing, and particularly at complex manufacturing processes.

Amidst evidences of various benefits of outsourcing that have led to the development of various decision making frameworks there have also emerged a parallel stream of researches as on the potential consequences of firm or sector being engaged in increased outsourcing on the wage structure of skilled and unskilled labors. Houseman (2007) found evidence that has shown rapid growth of outsourcing in the United States has not been accompanied by widespread improvement of American worker's wage. Moreover, productivity improvements from international outsourcing may largely measure cost savings, not improvements in output per hour worked by American labor. Several researchers have attempted to trace this particular impact of outsourcing in different periods and across different spatial contexts.

Wood (1995) has contributed to the debate about the trade being the main contributor to the deteriorating situation of unskilled worker in the developed countries through substitutability of unskilled workers in a situation where factor endowments (for example, new technology factors) are generated because of trading activity. Supporting theories from Feenstra (1998), explained that globalization through international outsourcing of intermediate inputs has implication in wage inequality through the reduction of relative demand for unskilled labor of developing countries. Feenstra (1998) illustrated that increase in outsourcing activity in 1980s was contributed by the development of communication technology, thus they are complementary rather than competing factor in explaining the change in employment and wage inequality. Wood (1995) observed that increase in trade openness of developing countries has widened the wage gap between skilled and unskilled worker in East Asia during 1960s and 1970s thereby contradicting the convention that the impact has been supposed to be otherwise, i.e., decline in wage inequality through increase in demand for both skilled and unskilled labors. He attributed such relation as the outcome of increased participation of China and other low-income Asian countries into the world market for trade of labor intensive goods. Similar findings are documented in Katz and Murphy (1992) who found increasing trend of wage gap after studying supply and demand factors relative to wage changes covering the period 1963-87. The long term growth in the demand for labor through change in allocation of labor between industries and occupations has been concluded to be the driving force in wage structure.

With this behavior of widening wage gap at the onset of increased trading activity seems critical to a research attention as noted by Geishecker (2008), who postulated that international outsourcing would gather more negative impact for manual workers due to the eastern enlargement of Europe in the light of growing world market integration. In terms of behavior of equilibrium in this context involving heterogonous firms, trade has been opined to likely to contribute in higher average profits, higher unemployment and larger wage dispersion (Egger & Kreickemeier, 2008). Egger and Stehrer (2003) showed the significant impact of outsourcing (through trade of intermediate goods with) on the change of skilled-to-unskilled wage bill ratio in Hungary, the Czech Republic and Poland, which was more pronounced in the exports of intermediate goods than for imports. However, Falk and Koebel (2002) presented different view in the relationship of demand for labor and factor endowments after examining the effects of imports of material and services on labor demand through estimating a factor demand system based on Box-Cox cost functions. The results showed that output and capital growth have more significant impact in the demand of heterogeneous labor as compared to substitution of material and services inputs. Furthermore, output growth stems from the substitution of material and services inputs rather than substitution of input induced imported materials and services. Based on the typification of outsourcing, however, Falk and Wolfmayr (2008) observed that the narrowly defined outsourcing of intermediate materials from China and the East Asian countries appeared to have a relatively small negative impact on the demand for labor as compared to those from Central and East European countries. In addition to this Munch and Skaksen

(2005) have observed asymmetric roles played by domestic and foreign outsourcing with reference to Danish labor market data. Foreign outsourcing has a positive impact on the wages of workers with high education and negative impact on workers with vocational education. In contrast, domestic outsourcing has a positive impact on wages for workers with vocational educations while it has no impact on wages of workers with high education. Arbache et al. (2004) has shown that an increase in degree of trade openness substantially lowered the wages of traded sector on lower education groups and insignificant for those in top two education groups within sectors in Brazil. Ho et al. (2004) has also found an evidence of widening wage gap in Hong Kong labor force through the increase in trade with China. There was a positive impact on wages for well-educated workers and a negative impact for less-educated workers during the period of 1991-2000.

Feenstra and Hanson (1999) looked into the technological changes in its role in determination of wage gap. Their results suggested that both outsourcing and capital upgrading contributed to rising wage inequality in the US during the 1980's. They estimated the relative influence of technology twice as large as outsourcing on relative wages of nonproduction worker in a setting where technological change affects product prices.

Transnational corporations have restructured their operations by increasingly subcontracting. Recently, Anner (2011) have examined the impact of international outsourcing on the unionization and wages in apparel export sector in Central America. They find that horizontal dispersion of production facilities weakens labor's positional power in manufacturing, further hindering its ability to push for better wages. Segmentation has also increased labor costs as a percentage of total costs in the subcontractors while reducing sunk investment costs. This move had induced subcontractors and vendors to keep wages low and deter unionization through plant mobility.

In the context of Singapore, since the late 13th century of the Old harbor settlement, international trading in Singapore becomes a significant activity because of its geographical location and free port policy from British rule. From becoming a trading host to over 600 other ports in 123 countries, Singapore moves to bringing in raw materials and re-exporting after processing as host country to USA, Japan, and Europe. According to Lloyd and Sandilands (1986), domestic exports have high import content, netting it out showed that in 1980 around three-quarters of the value of domestic exports were the value of imported components, materials and other inputs. Later work by Hoon and Ho (2001), reported that import requirement made up to 60% of the total value of export of goods and services in 1990. Moreover, the percentage of imported intermediate inputs in manufacturing was reported to be at 80%. Hoon and Ho (2001) have also highlighted the role of multinational corporations as the main driver of cross-border activities in Singapore in the changing pattern of production fragmentation.

According to Arndt (2003), the ability of trade-oriented Singaporean economy to compete in global market depends on how well it is able to source from lowest cost suppliers, which could have productivity and efficiency gains to the country. In the light of these findings, Thangavelu et al. (2008) studied and suggested a strong positive impact of cross border outsourcing on the productivity of the manufacturing sector.

As the future trends of outsourcing is expected to increase in size and manufacturing is identified as one of the higher performing segments by Auguste et al. (2002), more concern emerged. Houseman (2007) suggested that the benefits of outsourcing are more optimistic to low-wage countries. The joint conclusion of Hoon and Ho (2001) and Thangavelu et al. (2008) that production fragmentation is expected to have a widening impact on the wage gap between skilled and unskilled workers as the well-planned Singaporean economy restructures towards a knowledge intensive economy has not been thoroughly investigated. Table 1 summarizes key empirical studies, their limitations and contribution of present study.

Table 1. Key studies addressing regime switching on outsourcing measurement and its impact on wages

Past Studies	**Outsourcing Measurement**	**Outsourcing types**	**Impact on Wage**	**Skill Differentiation**	**Regime Classification on the basis of outsourcing intensity**	**Doesthe estimation method address Regime Switching?**
Feenstra and Hanson (1996, 1999)	Using Combined Metrices of Intermediate Import in Combination with Total Import	Narrow and Wide	Analyzed	Not differentiated	Not Analyzed	Two stage OLS wage regression without regime switch

Anderton and Brenton (1999)	Total Import penetration	Not differentiated	Analyzed	Partially Differentiated in High and Low skill	Not Analyzed	Three stage Linear OLS panel estimation
Hijzen (2007); Hijzen, A et al. (2005)	Same as Feenstra and Hanson	Narrow and Wide	Analyzed assuming constant returns to scale (linear and homogenous production process)	International Standard Occupational Classification	Not analyzed	Same as Feenstra and Hansen with additional variables for Sector and Factor bias
Hoon and Ho (2001)	Theoretical work	-	-	-	-	-
Egger and Stehrer (2003)	Final Trade	Not differentiated	Analyzed	Assuming Manual workers as Unskilled and Non-manual workers as Skilled	Not Analyzed	Panel OLS regression with time dummy
Geishecker & Görg (2008)	Same as Feenstra and Hanson	Narrow and Wide	Analyzed	International Standard Occupational Classification	Not Analyzed	Static OLS Panel model with dummies
Thangavelu, Toh and Ng (2008)	Same as Feenstra and Hanson	Only Narrow	Not Analyzed (Impact of labour productivity is analyzed)	Not Considered	Not Analyzed	Static OLS Panel model with dummies
This study	Same as Feenstra and Hanson	Narrow and Wide	Analyzed	International Standard Occupational Classification	Considered through Markov Switching Dynamic regression	Address through Maximum Likelihood estimation of Markov Switching Auto-Regression

Hence there lies a scope for future research to understand the relationship of outsourcing in the worker's wage of the domestic country. This paper investigates the impact of international outsourcing on skilled and unskilled worker in manufacturing industry utilizing individual and industry characteristics. As individual firms benefit from the cost-saving they achieved from international outsourcing, government needs to quantify its impact on labor force and economy.

The objective of this paper is to investigate the impact of international outsourcing in the wages of manufacturing workers in Singapore. As the Singapore manufacturing structure developed and business firms relied on external resource for their production supply, effect of outsourcing on wage gap for skilled and unskilled employees becomes a concern on Singapore domestic market that has not been investigated in the economy.

Rest of study work is organized as follow. Section 2 briefly discusses the theoretical base wherein the body of the knowledge in this study is based. Section 3 surveys the primary studies and posteriori investigation on international outsourcing and wages paying attention to the methodology adapted and results. The evaluations end with a discussion of the feasible methodological improvements over these existing empirical accounts of international outsourcing. Section 4 details the research paper design, which includes measurement procedure, data description and frame of analysis. Empirical results of the study are covered in Section 5 and conclusions follow in Section 6.

2. Theoretical Base

The connection of international outsourcing and rising inequality of relative wages are based on Heckscher-Ohlin (HO) model and Stolper-Samuelson (SS) theorem. In the HO propositions, the skilled labor abundant nation A will export skill intensive goods to other nation 'B' with scarce resource of skilled labor. This situation will limit the abundant supply of skill intensive goods in nation 'A' which will result in increase in its relative prices. In accordance to SS proposition, the price movement will increase the skilled wage and decrease the unskilled wage in nation 'A'.

Figure 1 show the impact of import on wage and labor. Labor supply ($S_{B,W}$) is not affected with the international

outsourcing, however labor demand (D) contracted as the international outsourcing level increases, labor shifts from point A to B. In response to labor surplus, wages decreases to promote labor demand. The corresponding increase of outsourcing level from O1 to O2 resulted to downward shift of wages from point A to C.

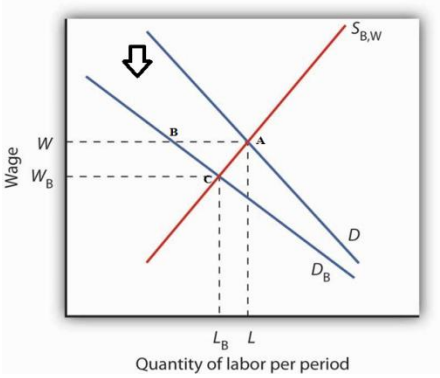

Figure 1. Labor and wage impact

This process of international trade caused the wage gap between skilled and unskilled laborers in domestic market of nation with limited supply of unskilled labor and abundant supply of skilled labor. Lately, the HO model and SS theorems validity in modern context has been questioned. For example, Davis and Mishra (2007) argue that the SS theorem is "history" because following trade liberalization in some developing countries, wage inequality rose. On the other hand, under the assumption that these countries are labor-abundant, the SS theorem predicts that wage inequality should have fallen.

3. Primary Studies and Posteriori Investigation of Methodology Adopted

Studies that have been taken in the past between trade and wages differ with respect to dimensionality, structure and calibration. Pioneering studies suggest building of a theoretically consistent equilibrium model that allows introduction of shocks representing changes in trade to test HO models and SS theorem suggesting thereby how future research should proceed.

These pioneering studies were the first to contribute on trade and wage inequality. The surveyed studies, reveal that trade has led to the formation of wage gap of skilled and un-skilled workers by at most 5 percent. Perhaps, this means that trade does not fully explain the formation of wage gap and there exist other factors impacting more to the wage gap as compared to trade. Supporting evidences has been found from Tyers and Yang (1997), Tokarick (2005) and Winchester (2008) that have concluded of declining wage inequality with respect to an increase in quantum of trade.

De Santis (2003) explained the 18 per cent increase in the UK skill premium between 1979 and 1992 by adopting technology shocks. According to De Santis, there are two type of shocks, the first which is termed as trade shock, imply reduction in trade cost which results in an increase in wage inequality as it encourages trading between nations of skill and unskilled abundant resources. The second shock is the fixing of number of foreign capital goods by introducing an endogenous skilled labor boosting technical change in manufacturing which resulted in an increase in wage inequality. This variant on the reduction of trade cost explains the large increase of capital goods imports and contraction of manufacturing in the UK.

Robinson and Theirfelder (2002) studied a fifteen-sector and six factor model calibrated to the 1982 US economy. Two shocks were considered which includes the 50 percent reduction in the world price of imports and a $200 billion increase in trade balance. The combined effects of these two shocks resulted in 1.25 percent increase in the professional to low skill relative wage. Thus, the authors conclude that trade is responsible for very little of the wage gap,

From more than a decade of analysis in the impact of international trade on wages using HO propositions has explained relatively lesser as compared to the role played by other factors though in the short run, when it is difficult for unskilled workers to move out of the manufacturing sectors, trade shocks can have a strong impact on the wage gap (Davis & Mishra, 2007).

Tyers and Yang (1997) have studied the effect of trade liberalizations and development of rapidly developing economies. The study has covered Old Country Economies (OIE's) namely, North America, the EU, Australasia, Japan and the Rapidly Developing Economies (RDE's) namely, China, Indonesia, Republic of Korea, Hong

Kong, Malaysia, Singapore, Taiwan and Thailand. Five explanatory factors of production and thirty-two sectors have been considered in the study. The authors have conducted a backward examination of the effects of increased trade openness and dramatic expansion of RDE's between periods of 1970-92. The study has found that trade has increased the wage inequality of skilled-unskilled by 0.2 per cent, 0.3 per cent and 0.9 per cent in North America, Australia, and Asia, respectively, and by about 6 percent in the EU.

Winchester (2008) explored the impact of trade on wages in New Zealand as they imported more from RDEs than either the US or the UK. Conducting the study that includes data for four labor types with different qualifications and controlling for trade shocks, import tariffs and export taxes in other regions between years 1980 to 2001. The author documented that trade shock has reduced the wage inequality in New Zealand for those with degree compared to no qualifications by 3.46 per cent. The same study has concluded that a Country has an advantage to make full use of unskilled labor in large sector of agriculture products.

Despite the strong link between trade and wages in pioneering studies, empirical studies provide support for the consensus in the wider empirical literature as it presents a real world investigation to validate the propositions.

Borjas and Ramey (1994) conducted a time series investigation based on the USA samples to identify the change in wage of non-educated employees. The measure of outsourcing was based on trade of durable goods using Input and Output information. The study found a high correlation between wage inequality and trade in durable goods between years 1964-91.

Supporting evidences have also been found from Rigby and Breau (2008) who have used a matched employer-employee data in Los Angeles to analyze the trade and inequality link. Resorting to a different measure of outsourcing as reflected in components of foreign competition that is composed of trade openness, import competition and trade competition, results from this study has shown that the three measure of outsourcing has significantly reduced the wages of workers with the lowest educational attainment across manufacturing sector.

In Hong Kong, Ho et al. (2004) studied the impact on wage inequality of outward processing trade with Chinese Mainland using a quarterly time-series data and adopting the measure of outsourcing from Feenstra and Hanson (1999). The same study has shown that the outward processing trade has compressed the wage of less skilled workers while raising the wage for more skilled workers.

In Germany, Geishecker and Görg (2008) have studied the change in wage for three skill group using a panel data for years 1991-2000. Their measure of outsourcing adopted the Feenstra and Hanson (1999) measure in terms of imports of overseas intermediate goods, results has shown that international outsourcing has positive effect on high skilled workers by receiving higher wages while a negative effect on low-skilled workers does exist.

In Japan, Yamashita (2007) tested the hypothesis that firms involved in international outsourcing in production undergo skill upgrading due to increased share of non-production workers in total workforce. Their measure of outsourcing focused on imports and exports of intermediate components and parts in production. The hypothesis of the study has been proved since the greater reliance from East Asian countries components and parts has contributed to change in share employment in skilled worker over the period of 1980-2000.

In China, Anwar and Sun (2010) measured the impact of trade liberalization and market competition on the wage inequality of skilled and unskilled worker in China in year 2003, 2006 and 2007. Their empirical investigation has implied that trade liberalization has positive impact while market competition has negative impact on wage inequality of skilled and unskilled workers in China.

4. Research Design

4.1 The Baseline Emperical Literature

The empirical method followed in this study starts with a structure laid down by Geishecker & Görg (2008). In their framework, the specification comes in what is given below.

$$\ln(W_{ij,t}) = \alpha + \beta DEMOG_{it} + \gamma WORK_{it} + \delta EDUC_{it} + \theta IND_{jt} + \lambda OUT_{jt} + \varepsilon_{it}$$

Where the dependent variable $\ln(W_{ij,t})$ is the hourly wage of worker i in industry j at time t.

With additional support from the literature, e.g., (Mincer, 1974; Brown & Medoff, 1989; and Schmidt & Zimmerman, 1991), control variables in the standard regression have been adopted. The list of variables under study are respectively named as $DEMOG_{it}$ representing demographic control variables for gender and age, $WORK_{it}$ representing individual characteristics related to the workplace such as firm size and nature of ownership of the firm, $EDUC_{it}$ representing the skill structure in the manufacturing industry based on educational attainment such as high education (ISCED: high), medium education (ISCED : med); and low

education (ISCED: low), IND_{jt} representing the industry characteristics in terms of its size based on output and value of capital structure of plant & machineries and the explanatory variable OUT_{jt} narrow and a wide based on definition of international outsourcing. The error term ε_{it} assumed the model to be normally distributed.

In the context of measurement of international outsourcing, Feenstra and Hanson (1999) measure of international outsourcing has been widely used in academic literature (see Strauss-Kahn, 2003; Ito & Fukao, 2005; Hijzen et al., 2005; Hsieh & Woo, 2005), wherever they have used the Input and Output information to measure to measure the degree of international outsourcing. Following the same approach that has been used in the above stated studies, this study considers narrow outsourcing that includes imported intermediate inputs from the same industry abroad while wide outsourcing includes all imported intermediate goods from the other industry abroad as a share of the industry's production total value. Thus narrow and wide outsourcing is given by following expressions:

$OUT_{jt}^{Narrow} = \frac{IMP_{jt}}{Y_{jt}}$ and $OUT_{jt}^{Wide} = \sum_j \frac{IMP_{jt}}{Y_{jt}}$ Where *jt* denotes the respective 2-digit manufacturing industry at time *t*, *IMP* is value of imported intermediate inputs from foreign industry and *Y* represent the industry output value.

4.2 Data and Revised Methodology

The data is sourced from Singapore Input and Output table (I-O, henceforth) that comprises of Import matrix having records of the imported commodities purchased by industries and types of usage in terms of intermediate goods of final demand. The I-O tables were composed based on 152 industrial sectors and 152 commodities. The industrial classification is based on the 2000 Singapore Industrial Classification (SSIC 2000) and the commodity classification follows the Standard International Trade Classification (SITC).

For the final estimation process this study critically reviews the model of Geishecker and Görg (2008) and finds the same having some limitations and can be further improved upon. First, it does not take into considerations auto correlations and cross correlations among dependent and independent variables. Second, the parameters of estimation does not ascertain stability of consistency should there be any structural changes or regime switching process which may stem from institutional changes. To address the first limitation, the modified model takes into account a lead–lag relationship among the dependent and independent variables thereby allowing the past values of outsourcing amongst other to influence the wage gap. To address the second limitation, the modified model incorporates an element of hidden regime switching factor. Regime switching is phenomena that comes from instuitional changes and has strong influence on a dynamic system of equation. The model of Geishecker and Görg (2008) can work in a situation where there are no structural breaks (regime switches) which is very unlikely to happen in a temporal dependence structure. One of the most popular models in addressing and estimating regime switching effect is the Markov Switching Model. A number of studies have used Markov Switching model to describe the causal structure amongst the variables. For example, see the works of (Jerzmanowski, 2005; Hansen, 1992; Engel, 1993; Simon, 1996; Krolzig et al., 2002; McCulloch & Tsay, 1994).

In view of the above mentioned literature on Markov Switching framework, the modified model can be represented by:

State/Regime 1

$$\ln(W_{ij,t}) = \alpha_1 + \beta_1 DEMOG_{it} + \gamma_1 WORK_{it} + \delta_1 EDUC_{it} + \theta_1 IND_{jt} + \lambda_1 OUT_{jt} + \psi_1 \ln(W_{ij,t-1}) + \varepsilon_{it} \ (when\ S_t = 1)$$

State/Regime 2

$$\ln(W_{ijt}) = \alpha_2 + \beta_2 DEMOG_{it} + \gamma_2 WORK_{it} + \delta_2 EDUC_{it} + \theta_2 IND_{jt} + \lambda_2 OUT_{jt} + \psi_2 \ln(W_{ij,t-1}) + \varepsilon_{it} \ (when\ S_t = 2)$$

with the probabilities pertaining to different regimes, given by

$$P(S_t = 1|S_{t-1} = 1) = p_{11}$$
$$P(S_t = 2|S_{t-1} = 1) = p_{12}$$
$$P(S_t = 1|S_{t-1} = 2) = p_{21}$$
$$P(S_t = 2|S_{t-1} = 2) = p_{22}$$

Such that $\sum_j p_{ij} = \sum_i p_{ij} = 1\ , i, j = 1,2$

Or, in the combined form,

$$\ln(W_{ijt}) = \alpha_{k,S_t} + \beta_{k,S_t} DEMOG_{it} + \gamma_{k,S_t} WORK_{it} + \delta_{k,S_t} EDUC_{it} + \theta_{k,S_t} IND_{jt} + \lambda_{k,S_t} OUT_{jt} + \psi_{k,S_t} \ln(W_{ij,t-1}) + \varepsilon_t,$$

where $\varepsilon_t \sim NIID(0, \sigma^2|\Omega_{t-1})$

Under the assumption of normality, the conditional density function of $\ln(W_{ijt})$ is given by

$$f[\ln(W_{ijt})\,|S_t = j, \Omega_{t-1}; \tau] = \frac{1}{\sqrt{2\pi}\sigma} \exp[\frac{-\{\ln(W_{ijt}) - \phi_j'\Delta_t\}^2}{2\sigma^2}]$$

where, $\Delta_t = [1, DEMOG_{it}, WORK_{it}, EDUC_{it}, IND_{jt}, OUT_{jt}, ln(W_{ij,t-1})]'$, $\phi_j = (\alpha_{k,S_t}, \beta_{k,S_t}, \gamma_{k,S_t}, \delta_{k,S_t}, \theta_{k,S_t}, \lambda_{k,S_t}, \psi_{k,S_t})$, $\tau = (\phi_1', \phi_2', p_{11}, p_{22}, \sigma^2)'$

The log-transformed density can be represented by

$$Ln[f(.)] = \sum_{j=1}^{2} f[ln(W_{ijt})\,|S_t = j, \Omega_{t-1}; \tau].P(S_t = j|\,\Omega_{t-1}; \tau)$$

The maximum likelihood estimation is done with the conditions that

$$\frac{\partial\{Ln[f(.)]\}}{\partial(\alpha_{k,S_t}, \beta_{k,S_t}, \gamma_{k,S_t}, \delta_{k,S_t}, \theta_{k,S_t}, \lambda_{k,S_t}, \psi_{k,S_t})} = 0$$

And

$$\frac{\partial\{Ln[f(.)]\}}{\partial(\phi_1', \phi_2', p_{11}, p_{22}, \sigma^2)} = 0$$

The estimated probabilities are given by

$$\widehat{p_{ij}} = \frac{\sum_{t=2}^{n} P(S_t = j, S_{t-1} = i|\Omega_n; \hat{\tau})}{\sum_{t=2}^{n} P(S_{t-1} = i|\Omega_n; \hat{\tau})}$$

One regime is expected to be the regime of low level of outsourcing probability and the other is expected to be the high level.

Ideally, this paper would have liked to explore the potential usefulness of this model before actually attempting to estimate it. However, according to Zivot and Wang (2006) no such test for Markov Switching Model is available. Only after estimating in a 2-regime model can one assess the relevance of the additional regime. To address the question whether additional regime adds significantly to explaining the dynamic behavior of the time series, the paper compares the in-sample fit of the regime switching model with nonlinear model. Null hypothesis when Ho: $\theta_1 = \theta_2$ which is tested against the alternative hypothesis H1: $\theta_1 \neq \theta_2$.

The statistical test which either take one of the three regime switching models as alternative all suffer from the problem of unidentified nuisance parameter under Null Hypothesis. For this reason, BDS test is more appropriate to use since it is nuisance parameter free and requires no adjustment when applied to fitted model residuals. Brock et al. (1996) proposed BDS test can be used to detect dependence and the presence of a nonlinear structure. This test examines whether the given data is deterministic or stochastic based on a calculation of the Correlation integral (Note 1) as given by

If the test value, $F = \dfrac{C_2^m(r) - \left[C_2^1(r)\right]^m}{\sigma m}$

with a known distribution function is significantly different from a standard normal distribution, by performing a Gauss test - Test for non-normal-distributed data (Note 2), it can be concluded that the given signal is deterministic.

BDS tests that the proposed model adequately captures all nonlinear features of the time series under investigation. BDS examine the remaining non-linearity to an estimated model. Our BDS test results suggest that the model is adequate in the sense the p-value are such that neither null hypothesis needs to be rejected. Thus, the original nonlinear model cannot be rejected.

The basic framework is adopted from International Standard Classification of Occupations. The Singapore Standard Occupational Classification basically categorized occupations based on the type of work performed. In its basic concept, skill is adopted in defining the type of work. Skills refer to the ability to carry out the tasks and duties of an occupation and have the dimension of skill level and skill specialization. Skill level is based on the complexity and range of the tasks and duties involved while skill specialization is based on the field of knowledge required, tools and machinery, the materials worked on and as well as the kind of goods and services produced (Note 3).

Singapore skill levels are based on International Standard Classification of Education (ISCED). *Low skill* is for occupations requiring primary or no education, secondary or post-secondary education - Production blue collar workers such as assemblers, operators and manual workers. *Medium skill* is for occupations requiring tertiary education leading to an award that is not equivalent to a first university degree = Non-production white collar

workers such as engineers, programmers, buyer, and planner. *High skill* is for occupations requiring tertiary education leading to a university or postgraduate university degree or the equivalent - thus, more skilled workers are managers, advertising and sales, and accountants. Further, informal training and experiences may be the source to acquire additional skill aside from formal education.

Our study employs individual and industry specific characteristics from 19 manufacturing sectors for the years 1990, 2000, 2005 and 2007 (Note 4). The data was taken from Ministry of Manpower covering individual characteristics information such as number of employees on each gender and age group. The respondents included in the Ministry of Manpower survey were male and female, aged 15-70 years old who were full-time employed more than 6 months in the organization.

Share of employee on each skill classification were obtained through survey conducted by Singapore Statistics Office covering both female and male who are stated to be economically active employee, following the International Standard Classification of Occupations.

The data from industry specific characteristics such as wages, capital structure, firm size and capital expenditures were sourced from Singapore Economic Development Board website. Wages refers to the average gross hourly income which includes bonuses, contribution to central provident fund and the value of other benefits provided by employer. Capital structure refers to the number of employee under each type of firm ownership if wholly locally, more than half local or foreign and wholly foreign. Capital expenditures cover all expenditures on capital assets namely plant and machinery or equipment.

5. Results

Using a non-linear Markov-switching model allows us to analyze the dynamics of the switching to high and low level of outsourcing probability in Singapore. The estimation results are interpreted, within the theoretical framework taking regime shifts as jumps between different levels of outsourcing probabilities. According to the theoretical model, these jumps are generated by shifts in internal factors such as business objective and confidence on outsourcing suppliers; and external factors such as international trade agreements and policies. Thus, regime shifts are generated by shift in manufacturing business objectives and international trade policies. To prove whether shift in levels of outsourcing probability has an impact of wage level for skilled and unskilled workers, the paper estimates a Markov-switching model with two regimes. One regime is expected to be the regime of low level of outsourcing probability and the other is expected to be the high level.

Table 2. Wage regression of outsourcing

Overall Outsourcing – MSAR			**Narrow Outsourcing –MSAR**			**Wide Outsourcing -- MSAR**		
Parameter	**Coefficient**	**t-prob**	**Parameter**	**Coefficient**	**t-prob**	**Parameter**	**Coefficient**	**t-prob**
Constant(0)	64.3969	0.0000	Constant(0)	68.5631	0.0000	Constant(0)	67.9158	0.0000
Constant(1)	9.8337	0.0000	Constant(1)	1.8689	0.0000	Constant(1)	61.9374	0.0000
NO(0)	0.0180	0.0130	NO(0)	0.0175	0.0130	A1(0)	0.0001	0.9820
NO(1)	-0.0088	0.5830	NO(1)	0.0074	0.5160	A1(1)	0.0000	1.0000
WO(0)	0.0080	0.0000	A1(0)	0.0001	0.5340	A2(0)	0.0000	0.9970
WO(1)	0.0001	0.9830	A1(1)	-0.0006	0.9800	A2(1)	-0.0010	0.9980
A1(0)	0.0000	0.9210	A2(0)	0.0000	0.8850	A3(0)	0.0000	0.9990
A1(1)	-0.0003	0.9550	A2(1)	0.0000	0.9990	A3(1)	-0.0009	0.9990
A2(0)	0.0000	0.9640	A3(0)	0.0000	0.9170	A4(0)	0.0007	0.8120
A2(1)	-0.0001	0.9900	A3(1)	0.0001	0.9950	A4(1)	0.0028	0.9850
A3(0)	0.0000	0.9050	A4(0)	0.0004	0.0110	A5(0)	0.0000	0.9990
A3(1)	-0.0001	0.9920	A4(1)	0.0004	0.9940	A5(1)	0.0003	0.9990
A4(0)	0.0006	0.0040	A5(0)	0.0001	0.5110	A6(0)	0.0000	0.9970
A4(1)	0.0008	0.9730	A5(1)	-0.0007	0.9870	A6(1)	0.0012	0.9940
A5(0)	-0.0001	0.4860	A6(0)	0.0000	0.9820	A7(0)	-0.0001	0.9820
A5(1)	-0.0002	0.9920	A6(1)	-0.0002	0.9970	A7(1)	0.0003	0.9980
A6(0)	0.0000	0.8690	A7(0)	0.0000	0.8380	A8(0)	0.0000	0.9950
A6(1)	0.0001	0.9960	A7(1)	0.0001	0.9990	A8(1)	-0.0002	0.9990
A7(0)	0.0000	0.9190	A8(0)	0.0000	0.9980	A9(0)	0.0000	0.9990
A7(1)	0.0001	0.9950	A8(1)	0.0003	0.9970	A9(1)	-0.0004	0.9990
A8(0)	0.0001	0.9670	A9(0)	-0.0001	0.9540	A10(0)	-0.0001	0.9990
A8(1)	0.0000	1.0000	A9(1)	0.0007	0.9960	A10(1)	-0.0003	0.9990

A9(0)	0.0001	0.9710	A10(0)	-0.0001	0.9750	A11(0)	0.0000	1.0000
A9(1)	0.0002	0.9990	A10(1)	0.0006	0.9970	A11(1)	-0.0002	1.0000
A10(0)	0.0001	0.9780	A11(0)	0.0000	0.9860	A12(0)	0.0000	1.0000
A10(1)	0.0002	0.9990	A11(1)	0.0003	0.9970	A12(1)	-0.0001	1.0000
A11(0)	0.0000	0.9910	A12(0)	0.0000	0.9960	G1(0)	-0.0003	0.0000
A11(1)	0.0001	1.0000	A12(1)	0.0001	0.9990	G1(1)	-0.0005	0.1570
A12(0)	0.0000	0.9980	G1(0)	-0.0004	0.0000	G2(0)	0.0009	0.5780
A12(1)	0.0000	1.0000	G1(1)	0.0007	0.2600	G2(1)	0.0013	0.8880
G1(0)	-0.0002	0.0000	G2(0)	0.0007	0.0060	FS1(0)	0.0000	0.9980
G1(1)	0.0005	0.2200	G2(1)	-0.0002	0.9860	FS1(1)	0.0005	0.9980
G2(0)	0.0012	0.0000	FS1(0)	0.0000	0.8060	FS2(0)	0.0000	0.9990
G2(1)	-0.0001	0.9900	FS1(1)	-0.0002	0.9970	FS2(1)	0.0000	1.0000
FS1(0)	0.0000	0.8910	FS2(0)	0.0000	0.7750	FS3(0)	0.0000	0.9960
FS1(1)	0.0000	1.0000	FS2(1)	-0.0001	0.9990	FS3(1)	-0.0003	0.9810
FS2(0)	0.0000	0.9080	FS3(0)	0.0000	0.9550	FS4(0)	0.0000	0.9970
FS2(1)	0.0000	0.9990	FS3(1)	0.0001	0.9960	FS4(1)	0.0000	0.9970
FS3(0)	0.0000	0.8960	FS4(0)	0.0000	0.9410	CS1(0)	-0.0006	0.0000
FS3(1)	0.0000	0.9990	FS4(1)	0.0002	0.9900	CS1(1)	-0.0010	0.5870
FS4(0)	0.0000	0.9290	CS1(0)	-0.0003	0.0100	CS2(0)	0.0000	0.9990
FS4(1)	0.0001	0.9920	CS1(1)	-0.0003	0.9150	CS2(1)	-0.0002	1.0000
CS1(0)	-0.0010	0.0000	CS2(0)	0.0001	0.5050	CS3(0)	0.0000	0.9550
CS1(1)	-0.0006	0.6940	CS2(1)	-0.0005	0.9830	CS3(1)	0.0003	0.9450
CS2(0)	-0.0001	0.6310	CS3(0)	0.0000	0.7630	P(0)	0.1548	0.0000
CS2(1)	-0.0002	0.9920	CS3(1)	-0.0003	0.9660	P(1)	0.1015	0.0000
CS3(0)	0.0000	0.7180	LOW(0)	-36.7763	0.0000	EM(0)	0.0949	0.0000
CS3(1)	-0.0001	0.9790	LOW(1)	-2.1273	0.0350	EM(1)	0.5608	0.0000
LOW(0)	-35.9820	0.0000	MEDIUM(0)	50.7904	0.0000	TO(0)	2.3886	0.0000
LOW(1)	-5.5270	0.0000	MEDIUM(1)	-4.3107	0.0000	TO(1)	-2.0571	0.0130
MEDIUM(0)	49.4558	0.0000	HIGH(0)	-13.5191	0.0000	WO(0)	0.0106	0.0000
MEDIUM(1)	0.9742	0.0680	HIGH(1)	6.6810	0.0000	WO(1)	-0.0028	0.6570
HIGH(0)	12.7074	0.0000	P(0)	0.1790	0.0000	LOW(0)	-38.3007	0.0000
HIGH(1)	4.6858	0.0070	P(1)	0.0703	0.0300	LOW(1)	-27.9228	0.0000
P(0)	0.2101	0.0000	EM(0)	0.0841	0.0000	MEDIUM(0)	53.5699	0.0000
P(1)	0.0881	0.0060	EM(1)	0.5561	0.0000	MEDIUM(1)	37.6403	0.0000
EM(0)	0.0877	0.0000	TO(0)	2.2878	0.0000	HIGH(0)	-14.2172	0.0000
EM(1)	0.5501	0.0000	TO(1)	-1.6733	0.0320	HIGH(1)	-10.6581	0.0000
TO(0)	2.2491	0.0000						
TO(1)	-1.5373	0.0630						

Our empirical results tabulated in table 2 displaying the regression results show that post-estimation outsourcing has been found to have an impact on wages of manufacturing sector in Singapore during the two regimes. Both narrow and wide outsourcing are found to be impacting wage during regime of high level of outsourcing (state 1) while narrow and wide outsourcing has no impact on wage during regime of low level of outsourcing (state 2).

Estimating the impact on wages based on overall outsourcing level during the regime of high level of outsourcing (state 1), showed that there is an overall significant impact on wages. As shown in table 2, a one per cent increase in the outsourcing level decreases the wage of low skilled worker by 35 per cent and high skilled worker by 12.7 per cent while it increases the wage of medium skilled worker by 49 Per cent. A shift in low level of outsourcing (state 2), showed no significance on the impact of narrow and wide outsourcing on wages. Other industrial characteristics showed a more significant factor on wages during low level of outsourcing (state 2). The same results were observed when we tried to test the existence of narrow outsourcing and wide outsourcing separately.

The negative impact of outsourcing on low skilled worker by 35% is true based on the Heckscher-Ohlin trade model; Singapore dependence on unskilled intensive commodity from RCD countries reduced the demand for unskilled labor in domestic market which resulted in a negative shift of wage to induce demand. However, another surprising result was shown on the relative reduction of skilled worker wages by 12 percent. In a more

competitive goods market, the competition forces firms to employ more productive workers, namely the skilled labor that have higher productivity. Since in a competitive labor market workers are paid at the value of their marginal product, the wage of skilled labor will decline as the employment of skilled labor increases, given the law of diminishing marginal product, which results in the decrease of the wage gap.

Concretely, after estimating autoregressive parameter of the dependent variable wage, the results presented in table 3 further show that the previous wage has more significance on the prediction of current wage compared to the outsourcing both at high level and low level of outsourcing intensity.

Table 3. Wage auto regression of outsourcing

Overall Outsourcing – MSAR			**Narrow Outsourcing –MSAR**			**Wide Outsourcing -- MSAR**		
Parameter	**Coefficient**	**t-prob**	**Parameter**	**Coefficient**	**t-prob**	**Parameter**	**Coefficient**	**t-prob**
Constant(0)	55.0089	0.0000	Constant(0)	52.8759	0.0000	Constant(0)	61.0525	0.0000
Constant(1)	114.6010	0.0000	Constant(1)	135.0240	0.0000	Constant(1)	168.7740	0.0000
NO(0)	0.0195	0.0100	NO(0)	0.0126	0.0390	A1(0)	0.0001	1.0000
NO(1)	-0.0596	0.0000	NO(1)	-0.0512	0.0000	A1(1)	0.0001	0.0000
WO(0)	0.0043	0.0180	A1(0)	0.0001	1.0000	A2(0)	0.0000	1.0000
WO(1)	0.0064	0.0030	A1(1)	-0.0011	0.0000	A2(1)	-0.0010	0.0000
A1(0)	0.0001	1.0000	A2(0)	0.0000	1.0000	A3(0)	0.0000	1.0000
A1(1)	0.0000	0.9990	A2(1)	-0.0011	0.0000	A3(1)	-0.0011	0.0000
A2(0)	0.0000	1.0000	A3(0)	0.0000	1.0000	A4(0)	0.0003	0.9990
A2(1)	-0.0008	0.9890	A3(1)	-0.0012	0.0000	A4(1)	0.0029	0.0000
A3(0)	0.0000	1.0000	A4(0)	0.0002	0.9980	A5(0)	0.0001	1.0000
A3(1)	-0.0009	0.9510	A4(1)	0.0022	0.0000	A5(1)	0.0017	0.0000
A4(0)	0.0003	0.9990	A5(0)	0.0001	1.0000	A6(0)	0.0000	1.0000
A4(1)	0.0029	0.9690	A5(1)	0.0014	0.0000	A6(1)	0.0018	0.0000
A5(0)	0.0001	1.0000	A6(0)	0.0000	1.0000	A7(0)	0.0000	1.0000
A5(1)	0.0015	0.9880	A6(1)	0.0019	0.0000	A7(1)	0.0009	0.0000
A6(0)	0.0000	1.0000	A7(0)	0.0000	1.0000	A8(0)	0.0000	1.0000
A6(1)	0.0015	0.9840	A7(1)	0.0016	0.0000	A8(1)	-0.0011	0.0000
A7(0)	0.0000	1.0000	A8(0)	0.0000	1.0000	A9(0)	-0.0001	1.0000
A7(1)	0.0009	0.9570	A8(1)	-0.0014	0.0000	A9(1)	-0.0014	0.0000
A8(0)	0.0000	1.0000	A9(0)	-0.0001	0.9990	A10(0)	-0.0001	1.0000
A8(1)	-0.0011	0.9860	A9(1)	-0.0009	0.0000	A10(1)	-0.0011	0.0000
A9(0)	-0.0001	1.0000	A10(0)	-0.0001	0.9990	A11(0)	0.0000	1.0000
A9(1)	-0.0012	0.9950	A10(1)	-0.0005	0.0000	A11(1)	-0.0006	0.0000
A10(0)	-0.0001	1.0000	A11(0)	0.0000	1.0000	A12(0)	0.0000	1.0000
A10(1)	-0.0009	0.9950	A11(1)	-0.0003	0.0000	A12(1)	-0.0002	0.0120
A11(0)	0.0000	1.0000	A12(0)	0.0000	1.0000	G1(0)	-0.0002	0.9130
A11(1)	-0.0005	0.9910	A12(1)	-0.0001	0.0080	G1(1)	-0.0010	0.0000
A12(0)	0.0000	1.0000	G1(0)	-0.0002	0.9830	G2(0)	0.0004	0.9960
A12(1)	-0.0002	0.9930	G1(1)	-0.0002	0.0000	G2(1)	0.0042	0.0000
G1(0)	-0.0002	0.4870	G2(0)	0.0002	0.9990	FS1(0)	0.0000	1.0000
G1(1)	-0.0007	0.0000	G2(1)	0.0031	0.0000	FS1(1)	0.0009	0.0000
G2(0)	0.0005	0.9500	FS1(0)	0.0000	1.0000	FS2(0)	0.0000	1.0000
G2(1)	0.0030	0.0000	FS1(1)	0.0006	0.0000	FS2(1)	0.0003	0.0000
FS1(0)	0.0000	1.0000	FS2(0)	0.0000	1.0000	FS3(0)	0.0000	1.0000
FS1(1)	0.0007	0.7490	FS2(1)	0.0002	0.0000	FS3(1)	-0.0003	0.0000
FS2(0)	0.0000	1.0000	FS3(0)	0.0000	1.0000	FS4(0)	0.0000	1.0000
FS2(1)	0.0003	0.8080	FS3(1)	-0.0003	0.0000	FS4(1)	-0.0003	0.0000
FS3(0)	0.0000	0.9980	FS4(0)	0.0000	1.0000	CS1(0)	-0.0003	0.9660
FS3(1)	-0.0003	0.0420	FS4(1)	-0.0003	0.0000	CS1(1)	-0.0030	0.0000
FS4(0)	0.0000	0.9980	CS1(0)	0.0000	0.9990	CS2(0)	0.0001	1.0000
FS4(1)	-0.0003	0.3360	CS1(1)	-0.0028	0.0000	CS2(1)	0.0008	0.0000
CS1(0)	-0.0003	0.3840	CS2(0)	0.0001	0.9990	CS3(0)	0.0000	0.9990
CS1(1)	-0.0025	0.0000	CS2(1)	0.0005	0.0000	CS3(1)	0.0008	0.0000

CS2(0)	0.0001	1.0000	CS3(0)	0.0000	1.0000	P(0)	0.1299	0.0070
CS2(1)	0.0007	0.9950	CS3(1)	0.0005	0.0000	P(1)	0.1405	0.0000
CS3(0)	0.0000	0.9830	LOW(0)	-30.2948	0.0000	EM(0)	0.0526	0.0010
CS3(1)	0.0007	0.0000	LOW(1)	-47.4825	0.0000	EM(1)	0.2932	0.0000
LOW(0)	-33.1452	0.0000	MEDIUM(0)	39.8323	0.0000	TO(0)	1.6657	0.0000
LOW(1)	-41.3915	0.0000	MEDIUM(1)	62.4896	0.0000	TO(1)	-1.5371	0.0000
MEDIUM(0)	43.6310	0.0000	HIGH(0)	-8.9685	0.0000	WO(0)	0.0060	0.0010
MEDIUM(1)	53.2199	0.0000	HIGH(1)	-21.9780	0.0000	WO(1)	-0.0100	0.0000
HIGH(0)	-9.6204	0.0000	P(0)	0.1573	0.0040	LOW(0)	-34.0642	0.0000
HIGH(1)	-17.5447	0.0000	P(1)	0.1112	0.0000	LOW(1)	-60.2390	0.0000
P(0)	0.1879	0.0000	EM(0)	0.0387	0.0050	MEDIUM(0)	45.6853	0.0000
P(1)	0.0900	0.0000	EM(1)	0.2884	0.0000	MEDIUM(1)	79.1927	0.0000
EM(0)	0.0470	0.0010	TO(0)	1.4663	0.0000	HIGH(0)	-11.1203	0.0000
EM(1)	0.2918	0.0000	TO(1)	-0.4587	0.0000	HIGH(1)	-27.8992	0.0000
TO(0)	1.5537	0.0000						
TO(1)	0.1787	0.4550						
WAGE_-1(0)	0.2394	0.0000	WAGE_-1(0)	0.2834	0.0000	WAGE_-1(0)	0.2410	0.0000
WAGE_-1(1)	0.2604	0.0000	WAGE_-1(1)	0.3250	0.0000	WAGE_-1(1)	0.3767	0.0000

Extraneous individual characteristics impact on wage showed that age and gender do not have any significant impact on the domestic wage in manufacturing industry both for two states. This suggests that Singapore work environment has no biasness among its labor force regardless of age and gender. Current labor standards and policies are in place to maintain a fair compensation system. Industry characteristics have a positive impact on wage on all skill level. Regression analysis revealed that the output per employee, capital structure and firm size are significant factors on domestic wage in manufacturing industry for both the states. This showed a positive growth of industry increases wages of employees.

A formal testing procedure of the non-linearity for post Markov estimation was applied using a BDS test, the default values residual error used in the test are converted back to the units of original data, and the null hypothesis that data are independent and identically distributed is rejected at conventional 5 per cent significance level (see Table 4). Since there is no discernible linear structure in the results from the BDS test suggest that there is nonlinearity in the data and the parameters estimated through the Markov Switching Dynamic Regression are stable without any additional nonlinearity.

Table 4. BDS test for independence and identical distribution

Test Statistics =				
	[4.59]	[9.17]	[13.76]	[18.34]
[2]	7.091	6.9642	7.2382	6.6207
[3]	7.3585	6.8022	6.6888	5.9175
[4]	7.6054	6.6478	6.0892	5.2597
[5]	8.6228	6.6429	5.5294	4.4768
p-value =				
	[4.59]	[9.17]	[13.76]	[18.34]
[2]	0	0	0	0
[3]	0	0	0	0
[4]	0	0	0	0
[5]	0	0	0	0

6. Conclusions

This paper successfully measured the extent of international outsourcing across manufacturing sector in Singapore by employing panel of industry data on an annual time series for the period of 1990 to 2007 as compared to Glass and Saggi (2001) who used trade data instead in the analysis. The calculation of international outsourcing differs from scope of total imports from a particular source country, as used by Anderton and Brenton (1999) or the method of Feenstra and Hanson (1999) wherein outsourcing was calculated through the use of combined-use matrices in combination with total import penetration ratios calculated from trade data. The direct measure of intermediate goods imported is superior compared to total import penetration, since

manufacturing fragmentation of production is not driven by increase of trade of final goods but of intermediate goods. The findings of this paper add to the literature of international trade and wage in Singapore context. It provides empirical observation that as individual firms benefit from the cost-saving they achieved from international outsourcing, the labor force wages create an impact across skill levels in Singapore. This result is similar with the previous observation of Geishecker and Gäorg (2008) in Germany. These findings have policy implications for external trade-dependent nations by hinting that the level of international outsourcing impacts the work force skill levels through labor wage rates.

Additionally, this paper extends previous empirical approaches (Glass & Saggi, 2001; Hijzen et al., 2005; Egger & Stehrer, 2003; Hijzen, 2007) in the estimation using two models of different regimes of high and low outsourcing probability for three skills data set by allowing switching between regimes so that more complex dynamic patterns can be characterized in time series data.

As have been hypothesized by Hoon and Ho in 2001, the possibility of having a widening wage gap as a result of increasing product fragmentation in Singapore was attempted to answer by this paper. The present findings found that there is a widening impact of wage between skilled and unskilled worker with the existence of narrow and wide outsourcing. Given recent literature (see, Parteka & Wolszczak-Derlacz, 2015) findings that international outsourcing plays a negligible role in wage equalization, the results have significant policy implications on countries that move through similar economic shifts and progressively increasing socio-economic development. Our findings warn that in the long run this widening gap in wages can impact even the genie index of the economy

The workforce of Singapore in the 21st century moved to a more skill intensive structure resulting to upward shift labor demand domestically and internationally, propelled by increased human capital accumulation as well as technological progress. International outsourcing has impacted on the widening wage gap of all skill level. The dependence on overseas labor intensive intermediate goods and the steady shifts in the industrial and occupational structure of employment toward sectors and job categories that use a greater proportion of more educated workers have contributed to this phenomenon. This leads to another area of concern as the manufacturing industry matures and dependence becomes high on intermediate goods. The impact of displacement of workforce from unskilled to skilled but also displacement from manufacturing industry to other industry has not been examined in the economy. This concern would be of interest to the Singapore Ministry of Manpower and Economic Development Board to ensure that industrial sector will have sufficient and proper placement of workers according to their skill sets. We also expect that the policy implications of our work will impact many other similar economies, especially dependent on their manufacturing sector.

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Notes

Note 1. The Correlation integral defined in Grassberger and Procaccia (1983), Characterization of strange attractors. Phys. Rev. Lett., 50(5), pp. 346-349.

Note 2. A Kolmogorov-Smirnov test is performed to examine the differences between the cumulative probability distribution functions of the given data and a Gaussian normal distribution. This is referred to as "Test for non-normal-distributed data".

Note 3. Singapore Standard Occupational Classification.

Note 4.We avoid using data post 2007 for the key reason that post global financial crisis in 2008-09, the Singapore trade economy had consolidated its position in the economic development and trade indicators – and thus the learnings of the development curve of this trade-driven growth economy could be lost (see, for example, the Global Enabling Trade Reports of 2008, 2010 and 2014 by the World Economic Forum – wherein Singapore has been consistently ranked # 1 for all the three reports).