*American Journal of Multidisciplinary Research & Development (AJMRD)*
*Volume 03, Issue 09 (September - 2021), PP 13-28*
*ISSN: 2360-821X*
*www.ajmrd.com*

**Research Paper** **Open Access**

# Impact of trade on employment and wages in the manufacturing industry considering the heterogeneous character of workers: The case of Sri Lanka

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**Abstract:** This paper examines the impact of international trade on employment and wages in the manufacturing industry in Sri Lanka considering the heterogenous character of workers. The study models the effects of trade on employment and wages in the manufacturing industry in a labour demand and a wages framework on an integrated panel dataset of trade, labour and manufacturing industries. First, the impact of factor endowments on manufacturing employment and wages is empirically examined following the predictions of the Heckscher-Ohlin trade theorem. Empirical findings suggest exports to be positive and statistically significant across all types of manufacturing workers, while the statistical significance differs considerably. In the case of manufacturing wages, export-intensity is positive on manufacturing wages of skilled factory operatives and administrative/managerial workers as expected, yet statistically not significant. Secondly, the impact of technology on employment and wages in the manufacturing industry is examined following the predictions of the Neo-technology trade theory. Empirical findings suggest technology to be negative across all categories of manufacturing workers, while its statistical significance is more severe on unskilled factory operatives. On the wages model, technology is found to be positive and statistically significant on all classes of manufacturing workers, while its positive effect is more on the wages of technicians, managerial workers and skilled factory operatives compared to unskilled factory operatives. Lastly, the impact of global production-sharing on manufacturing employment and wages is empirically tested following global production sharing models and their predictions. Empirical findings suggest global production sharing to be statistically insignificant on all classes of manufacturing workers. Considering the wages model, global production sharing is negative and statistically significant on wages of skilled factory operatives and administrative/managerial workers, although these findings are against theoretical expectations.

**Key words:** Factor endowments, Technology, Global production sharing, Manufacturing, Employment, Wages
JEL code: F16

## I. Introduction

At independence, Sri Lanka pursued an open economic model. With the socialist influence, in the late 1950's, it tilted towards a closed economic model. With this shift, the country embarked on a rigorous programme of import substitution and the State directly intervened in economic affairs. Few years into experimenting closed economic policies, the Government realised the futility of inward-oriented economic policies and their potency in delivering economic independence. Against this backdrop, Sri Lanka, embarked on a rigorous path of economic liberalisation (DeMel, 2008). Having experimented with all manner of trade policy regimes and almost 40 years into liberalised trade, Sri Lanka's economic benefits in terms of employment and wages have not been a striking success when measured against expectations (Chandrasiri, DeMel, & Jayathunga, 2017; DeMel, 2020c). Trade theory offers several explanations for the pattern of trade between developed and developing economies and its consequent effect on employment and wages. In an earlier series of papers, an attempt was made to assess the impact of factor endowments (DeMel, 2020b), technology (DeMel, 2020a) and global production sharing (DeMel, 2021) on employment and wages treating all manufacturing workers as a one homogeneous unit. However, workers differ from each other in numerous ways including their education, skill, experience, geography, family background etc. Therefore, an analysis of the impact of factor endowments, technology and global production sharing on employment and wages in the manufacturing industry considering the heterogeneous characteristics of workers is critical and is the main objective of this paper.

Section 2 sets the theoretical basis for the study. Section 3 lays the detailed methodology. Analysis and findings are presented in section 4, while section 5 presents the conclusions.

## II. Theory and literature

*Heckscher-Ohlin trade theory and literature*

The orthodox Heckscher-Ohlin trade theory is the most commonly invoked theory to explain the link between trade, employment and wages. Heckscher (1919) and Ohlin (1933) extends the basic Ricardo (1963) model to include both labour and capital to isolate the differences in relative factor abundance among nations as the basic determinant of comparative advantage. Heckscher-Ohlin model predicts that a country will export based on its abundant factor and will import based on its scarce factor of production. Based on the Heckscher-Ohlin framework, Stolper and Samuelson (1941) argued that an increase in the relative price of one of the commodities will raise the real return of the factor used relatively intensively in the production of that commodity and decrease the real reward of the other factor.

Using a longitudinal dataset, Edin, Fredriksson, and Lundborg (2004) examined the effect of trade on worker earnings in the Swedish labour market. Exports were found to be positive on worker earnings, while imports were negative. Clerides, Lach, and Tybout (1998) find that firms that export to be more efficient and that ultimately results in a positive impact on worker earnings. Using labour force survey data and a wages model, Kosteas (2008) analysed the impact of imports on wages for blue-collar and white-collar workers in the United States for the period 1979-1988. Findings indicated that rising imports put downward pressure on the wages of both blue and white-collar workers although the impact was severe on blue-collar workers. Gaston and Trefler (1994); Kravis (1956) find exports to be positive on manufacturing wages of workers in the United States. Along the same lines, Aiginger, Ebmer, and Zweimuller (1996) find exports to be positive on manufacturing wages in Austria. In the case of the United Kingdom, Konings and Vandenbussche (1995) empirically tested the impact of foreign competition on employment and wages using a panel dataset of two hundred and seventy four firms covering the period 1982-1989. Findings indicated a negative effect of foreign competition on both employment and wages in the manufacturing sector, later to be confirmed by Greenaway, Hine, and Wright (1999); Greenaway, Wright, and Hine (2000); Hine and Wright (1998). Revenga (1997) analysed the impact of trade liberalisation on employment and wages in the case of Mexican manufacturing. Findings revealed a negative impact on employment and wages subsequent to the trade liberalisation episode that took place during the period 1985-87. These findings on wages were later confirmed by Cardero, Mantey, and Mendoza (2006) who found exports to be negative on Mexican manufacturing wages. Extending this work, Cervantes and Fujii (2012) analysed the impact of trade liberalisation in Mexico on employment of skilled and unskilled workers in labour-intensive industries for the period 1998-2004 using an input-output approach. Findings indicated a positive impact of trade on unskilled workers and a negative effect on skilled workers. Arbache, Dickerson, and Green (2004) examined the impact of trade liberalisation on manufacturing wages for Brazil using cross-sectional household data since 1976. Their findings revealed a negative impact of trade liberalisation on wages. Bayer, Rojas, and Vergara (1999) investigated the link between trade and wages inequality for Chile using labour force survey data for the period 1960-96. Findings indicated that a fall in the relative price of labour-intensive goods explained the widening wages inequality, while there was an increase in the proportion of college educated workers which reduced wage inequality in Chile. Using a panel of manufacturing industries over the period 1991-2010, Das, Raychudhuri, and Roy (2014) estimated the impact of trade liberalisation on Indian manufacturing employment. Their findings indicated a positive impact of exports on manufacturing employment as earlier confirmed by Banga (2005a, 2005b); Goldar (2009). Further, Hashim and Banga (2009); Krishna, Poole, and Senses (2012) find exports to be positive on manufacturing wages in the case of India. Although trade has had a positive effect on Indian manufacturing employment, its effect was minimal and not significant (Raj & Sen, 2012; Sen, 2008 ). Chamarbagwala (2006), investigated on the widening skills wage-gap in India using household level data for the period 1983-2000. Findings indicated that relative demand shifts resulted in relative wage shifts and the increase in the demand for skilled labour was due to skills upgrading within industries that occurred subsequent to trade liberalisation. In a contradicting argument, Mishra and Kumar (2005) found a decrease in wage inequality in India as a result of increased wages for unskilled workers following trade liberalisation in the 1990's, due to tariff reductions in industries where the unskilled were mostly employed.

*Neo-technology trade theory and literature*

Posner (1961) developed the theory of technological gap. It assumes dissimilar technology among trading partners while the transmission of technology occurs with a time lag. It predicts that a country will export those goods for which it has a superior technology compared to its trading partner, although both the countries are similarly factor endowed. The product cycle theory was developed by Vernon (1966) as an extension to the technological-gap model. It claims that new products are originally introduced in developed countries as they demand skilled labour, superior technology and other demands for designing and marketing (Stokey, 1991). As products mature, become standardized and patents expire, it becomes possible for the South to imitate them.

Using cross-sectional data and a wages model, Bound and Johnson (1992) were one of the pioneers to propagate skills-biased technology. Their findings indicated an increase in the demand for skilled workers and their wages in the United States as a result of skills-biased technology that favoured skilled workers over unskilled workers. Dunne and Schmitz (1995) analysed the impact of technology on employment and wages in the United States. Using a labour demand and a wages model, they found that manufacturing plants with advanced technology prefer skilled workers with high compensation over unskilled workers. Machin and Reenen (1998) extended this survey to six other countries using a panel dataset. Their findings suggest a skills-biased technical change to have a positive impact on the demand for skilled workers and their wages. Berndt, Morrison, and Rosenblum (1992) examined the impact of engaging high-tech information technology on the distribution of employment. These studies find high-technology capital to be positive on the growth of white-collar worker hours. It also shows skills upgrading in blue-collar workers due to engaging high-tech information technology. Sachs, Shatz, Deardorff, and Hall (1994) found research and development to have a negative effect on production workers and an insignificant effect on non-production workers keeping in line with the skills-biased technology hypothesis. Berman, Bound, and Machin (1998); Bernard and Jensen (1997); Haskel and Slaughter (1998) found skill-biased technological change to have decreased the demand for less-skilled workers in the United States and throughout the developed world, due their capital intensive nature (Corbo & Meller, 1979; Reza, 1978) . Of the very few studies in the case of developing economies, Goldar (2000); Krishnan (2010) confirmed technology engaged in Indian manufacturing to be labour saving in nature, while similar findings are reported in the case of Chilean manufacturing plants (Pavcnik, 2002). In empirically examining the skills biased technology, most literature has resorted to examine the impact of computers on employment and wages. Computers, or simply technology might act as a substitute or a complement to labour (Kruger, 1993). While computers substitute for workers performing manual and routine tasks, it complements workers performing non-routine and problem-solving tasks (Autor, Levy, & Murnane, 2003; Zoghi & Pabilonia, 2007). A plethora of empirical literature shows computer technology and automation to have a positive impact on the demand for highly skilled managers and professionals, while it has a negative effect on blue collar workers (Bresnahan, 1999). Feenstra and Hanson (1999) confirmed a 35 percent increase in wages of non-production workers who use computers in the case of the United States.

*Global production sharing models and literature*

Theoretical models that explain the growth of offshoring have proliferated (Kemeny & Rigby, 2012). Ardnt (1997) considers a global production sharing model that consists of capital and labour as two factors of production and two commodities, where one is labour-intensive and the other, capital-intensive. With technological advancement when offshoring becomes possible, the labour-intensive sub stages of production are allocated to countries that have a comparative advantage in labour-intensive production, and the capital-intensive stages of production are allocated to capital-intensive countries. Grossman and Esteban (2008) propose a model of task-trade where reduction in trade costs lead to increased offshoring on routine production operations. Feenstra and Hanson (1995, 1997) proposed a global production-sharing model with a continuum of goods and inputs. In another model, Feenstra and Hanson (1996, 2003) considered a scenario where offshoring is an offshoot of international competition in industries producing heterogeneous inputs subjected to differences in the relative demand for skilled and unskilled labour. Yeaple (2005) introduced a model of heterogeneous firms and workers where international competition spurs more productive firms to enter the export market thus raising the demand for skilled workers. Jones and Kierzkowski (1988, 1990) in their model of global production sharing focus on production blocks and service links. Here, when production is concentrated into one country, a fixed cost is involved. When production is sliced into production blocks, it incurs only service link costs such as communication, transportation, coordination, planning etc. Antras and Helpman (2004) developed a theoretical framework for studying global sourcing strategies. This model predicts that in choosing between a domestic supplier and a foreign supplier for parts and components, trade-off between lower variables costs in the South and the lower fixed costs in the North is of critical importance.

Banga (2016) analysed the impact of global production sharing on employment in India using a database of twenty-two manufacturing industries over the period 1998-2011. Results using a fixed effects model indicated backward linkages to have a replacement effect on employment and an insignificant effect on employment in the case of forward linkages. In the case of Thailand, Athukorala and Kohpaiboon (2013) found global production sharing to have a negative effect on manufacturing wages. Egger and Egger (2002) analysed the impact of international outsourcing on the wages of workers in seven Central and Eastern European countries over the period 1993-1998. They found a negative impact of international outsourcing (export of intermediate goods) on the wages of workers. Egger and Egger (2003) analysed the impact of foreign outsourcing on employment and wages using a panel of twenty Austrian two-digit industrial dataset over the period 1990-1998. They found that outsourcing to Central and Eastern European and the former Soviet Union significantly shifted relative employment in favour of high-skilled labour with a negative effect on the unskilled workers. Ebenstein, Harrison, McMillan, and Phillips (2014) analysed the impact of offshoring on workers in the United States using population surveys. They concluded that offshoring had put downward pressure on US wages due to the reallocation of workers away from higher-wage manufacturing jobs. This was mainly due to the outsourcing of most unskilled and routine tasks to developing economies. Similarly, Mullen and Panning (2009) examined the impact of international outsourcing on the employment of skilled workers in the United States using a panel of six-digit manufacturing industries over the period 1997 to 2002. Their results indicated a negative effect of outsourcing on the labour market outcomes for unskilled workers. Using four-digit level data for 450 manufacturing industries over the period 1958-1989, Paul and Seigel (2001) estimated the impact of foreign outsourcing of employment in United States. They found outsourcing to have a relatively negative effect on the demand for workers across all levels of education, with the strongest negative impact on workers with less than a college degree. McGregor, Stehrer, and deVries (2013) analysed the impact of international outsourcing on the demand for labour using a sample of forty countries covering the period 1995-2009. Results indicated a negative effect of offshoring on all skill levels, and the largest impact on medium skilled workers. For the United Kingdom, Hijzen, Gorg, and Hine (2005); Hijzen and Swaim (2007) examined the impact of international outsourcing on the skill structure of labour demand using import-use matrices of input-output tables for manufacturing industries for the period 1982-1996. Their findings indicated that international outsourcing had a strong negative impact on the demand for unskilled workers and a positive impact on skilled workers. Later, in assessing the impact of offshoring on employment in the European Union, Joanna and Parteka (2015) analysed the impact of international outsourcing on employment in twenty-seven European countries across thirteen manufacturing industries over the period 1995-2009. Findings indicated a negative impact of offshoring on domestic employment while the intensity of the negative impact is more severe on unskilled workers. On wage outcomes of global production sharing, a favourable effect is experienced by workers who are more educated, more skilled and knowledge workers. For Denmark, Munch and Skaksen (2009) examined the impact of outsourcing on wages of skilled and unskilled using a panel of manufacturing workers covering the period 1993-2002. They found that international outsourcing had raised the wages of workers with further education while lowering the wages of workers with basic and vocational education. Similarly, Hummels, Jorgensen, Munch, and Xiang (2014) estimated the effect of offshoring on worker wages in Denmark using a worker-firm-trade integrated database for the period 1995-2006. Findings indicated a positive effect on the wages of skilled workers and a negative effect on the wages of unskilled workers.

## III. Methodology

*Panel data*

This study uses a deductive method of economic analysis. It analyses the impact of trade on employment and wages in the manufacturing industry using industry-level data. It studies the behaviour of 1,327 manufacturing industries in total, at a detailed 4-digit level from 1994 to 2012. Since a given 4-digit manufacturing industry is followed over the period of study on an annual basis repeatedly, this kind of analysis requires a panel dataset to be constructed. Therefore, an industry based panel framework is engaged for this study following Greenaway et al. (1999); Greenaway et al. (2000); Hine and Wright (1998); Konings and Vandenbussche (1995); Milner and Wright (1998). Manufacturing data is drawn from the Annual Survey of Industries conducted by the Department of Census and Statistics. This is the most comprehensive and systematic source of data available on the subject of industrial activity in Sri Lanka. The survey includes manufacturing industries covering the private sector, public corporations, government owned business undertakings, and those that operate within the mandate of the Board of investment of Sri Lanka. The scope of the Annual Survey of Industries includes all industrial activity encompassing mining & quarry, manufacturing, electricity, gas and water supply. The study is concerned with the manufacturing industry. Therefore, data pertaining to manufacturing activity is carefully delineated from other activities using the manual on International Standard Industrial Classification (ISIC). The industry level data are acquired by using the appropriate weighting factor to transform firm-level data into industry level data. A distinctive feature of this rich manufacturing dataset is the availability of data at the level of an entity [Firm-level data]. This is a sample survey which supplements the industry census conducted once in every 10 years, providing a nationally representative sample of manufacturing industries. The survey takes the previous year as the reference period and includes all industrial establishments with 5 persons or more. The Industry Census frame is used to determine the sample of establishments to be surveyed each year. The sample frame is divided into two sections. All establishments with 25 persons or more form the Census part of this survey. This means that all establishments that falls into the Census part are covered in full in all Annual Surveys of Industries. Establishments that employ 5 to 24 persons forms the survey part where the industries are selected on a sample basis. The survey part uses a stratified sampling methodology based on geographical location, industrial activity and size. The Annual Survey of Industry sample includes 3500 to 4500 manufacturing firms each year. The geographical strata contain all 25 administrative districts of Sri Lanka. This survey captures a wide variety of data that is of great relevance to this study. It collects data on the value of goods moved out, receipts from industrial services, opening and closing stocks of output, raw materials sourced locally and internationally, consumption of fuel, electricity and water, fixed assets comprising of land, buildings, machinery and transport equipment purchased and data on employment and earnings. The data on employment and earnings contain information on the number of male and female workers, their salaries and wages by their type of engagement. The Annual Survey of Industry classifies workers as skilled and unskilled operatives, administrative, technical, clerical, working proprietors and unpaid family members.

Since the Annual Survey of Industries does not capture data on exports and imports, the UN Comtrade database is used to draw trade data. The database includes import and export data for over 170 countries. UN Comtrade records imports and exports data using several commodity classification methods. For this study, the Standard International Trade Classification (SITC) method at a 5-digit level is used to extract import and export data for Sri Lanka with the rest of the world. Exports are valued on free-on-board basis and imports are valued on cost-insurance-freight basis. Exports do not include re-exports. Trade data are maintained at a product level. Therefore, trade data pertaining to manufacturing were carefully delineated using a detailed concordance from the European Commission that matches trade data [SITC revision 3] to industry data [ISIC revision 3.1]. Subsequently, trade data were aggregated at a four-digit industry level using the ISIC classification system. The aggregated import and export data were then merged into industry data from the Annual Survey of Industries using the ISIC 4-digit codes as the unit of analysis.

Similarly, tariff data were captured using the World Trade Organisation (WTO) Tariff Analysis Online database and the Tariff guides prepared by the Sri Lanka Customs. WTO maintains tariff data based on Harmonized System (HS) of coding at a 6 digit–10-digit product level. Product level tariffs were matched to their respective manufacturing industry using a concordance prepared by the UN Comtrade. Subsequently the Customs data was merged with manufacturing data using the ISIC 4-digit codes as the unit of analysis. Similarly, Sri Lanka Customs maintains records of all the other levies [Para-Tariffs] at a 6 – 8-digit product level using HS coding system. Each individual type of other levies was matched to their respective manufacturing industry using a concordance from the UN Comtrade. These data were subsequently merged to the Annual Survey of Industries, using the ISIC 4-digit codes as the unit of analysis. In addition to custom duties, the government of Sri Lanka also charges a variety of tariffs on imports. Since these charges are outside the scope of customs duties specified by the WTO, these extra charges are commonly known as para-tariffs or other levies. They include charges such as National Security Levy, Road infrastructure Development Levy, Value Added Tax on imports, Excise duties, Ports Authority Levy etc. The tariff rates of these additional levies are captured from the Tariff Guides prepared by Sri Lanka Customs. Tariff guides by Sri Lanka Customs are maintained using HS Coding at a 6-digit and 8-digit level.

*Unit root test*

Panel datasets contain both cross-sectional and time-series properties. One problem with time-series data is that the independent variables can appear to be more significant than they are if they have the same underlying trend as the dependent variable. In Sri Lanka where inflation has often reached double digits in the past, spurious correlation can cause problems in panel datasets. Regressions with spurious correlation leads to high *t*-scores and overall fit to be overstated and untrustworthy (Studenmund, 2001). Therefore, to avoid inflation leading to spurious correlation, all nominal values have been adjusted for inflation to be comparable across different time points. In developed economies, an industry specific manufacturing price index is engaged to adjust for inflation. However, an industry specific manufacturing price index was not available for Sri Lanka at the time of conducting this survey. In the absence of a manufacturing industry specific price index, empirical literature has relied on their consumer price indices (Haouas, Yagoubi, & Heshmati, 2005; Harrison & Hanson, 1999), the GDP deflator, or the wholesale price indices (Revenga, 1997; Sen, 2008 ) as available. Therefore, for this study, the consumer price index is applied to adjust for inflation. Spurious correlation is caused by nonstationary time series. Therefore, a panel-based unit root test is engaged on the economic front, to avoid spurious regression. Various unit-root tests are performed in testing for stationarity. Levin, Lin, and Chu (2002) , Harris and Tzavalis (1999), Breitung and Das (2005) ,Im, Pesaran, and Shin (2003) , and Fisher type unit-root tests (Choi, 2001) are some tests. However, not all these unit-root test options are available to us, given that most of these tests require either strongly balanced panel data or panel data without data gaps. Given that the dataset is an unbalanced panel dataset with gaps, this can be accommodated by engaging a Fisher type unit root test. Fisher type unit-root tests do not require strongly balanced data and can have gaps in individual series. The Fisher type test offers the Augmented Dickey Fuller (Dickey & Fuller, 1979) test option and the Phillips-Perron (Phillips & Perron, 1988) unit-root test options. Both Fisher unit-root tests operate under the null-hypothesis that all panels contain a unit root, while the alternative is that at least one panel is stationary. Accordingly, both the Augmented Dickey Fuller test and the Phillips-Perron unit-root tests were conducted. The null hypothesis was rejected at less than 1 percent level of statistical significance.

*Conceptual framework*

What is the impact of factor endowments on manufacturing employment and wages as postulated by the Heckcher-Ohlin trade theory? This is the first research question carved out for empirical examination. The theoretical support for examining this research question is furnished by the Heckscher-Ohlin trade theory. The Heckscher-Ohlin trade theorem predicts that a capital-abundant country will have a comparative advantage in the export of capital-intensive goods, while a labour rich country will have a comparative advantage in the export of labour intensive goods (Heckscher, 1919; Ohlin, 1933). Along these predictions, an increase in the demand for labour and wages is predicted for a labour abundant developing economy following an increase in the demand for 'labour-intensive' commodities. The first research question stated above can be formulated into the following hypothesis for empirical examination.

Hypothesis: *Exports based on factor endowments have a positive impact on manufacturing employment and wages*

Is there any evidence that technology diffusion through trade has impacted manufacturing employment and wages as predicted by the Neo-technology trade theory? This is the second research question. The required theoretical basis for empirically testing this research question is facilitated by the Neo-technology trade theory. Technology gap theorem predicts that a country will export the goods of those industries in which it has a technology gap advantage over other countries, even though both exporting and importing countries may have similar factor endowments (Posner, 1961). The Product cycle model is an extension to the technology gap model. It predicts that when a new product is introduced, it usually requires highly skilled labour until the product technology becomes standardized and can be produced using mass production techniques and less-skilled labour (Vernon, 1966). The second research question stated above can be formulated into the following hypothesis for empirical examination.

Hypothesis: *Technology diffusion in international trade has a positive impact on manufacturing employment and wages in developing economies.*

How has global production sharing impacted manufacturing employment and wages as predicted by the global production sharing models? This is the third research question of this paper. The theoretical basis for empirically testing this research question is provided by the global production sharing models. With the splitting-up of the production process into parts and components, developing countries now have an opportunity to engage in the parts and components trade that is predicted to positively influence the demand for labour and wages (Ardnt, 1997; Feenstra, 2004; Feenstra & Hanson, 1995, 1996, 2003). The third research question stated above can be formulated into the following hypothesis for empirical examination.

Hypothesis: *Participation in global production sharing has a positive impact on manufacturing employment and wages in developing economies.*

In the context of this paper, these hypotheses will be tested considering the heterogeneous character of workers.

*Modelling*

Following Hine and Wright (1998) and Greenaway et al. (1999) Milner and Wright (1998), this paper uses the Cobb-Douglas production function of the following form, which serves as the core model in this analysis;

$$Q_{it} = A^{\gamma} K_{it}^{A} L_{it}^{\beta} \quad \text{……………………..(1)}$$

where for the representative firm in industry *i* in period *t*; *Q* = real output; *K* = capital stock; *L*= units of labour utilised; *A* = technology and α, β represent the factor share coefficients while $\gamma$ allows for factors changing the efficiency of the production process. Based on this, the following standard labour demand model equation (2) is derived, where *Lit* is total employment, *Wit* is average real wages, *Q*it is the real output and *K*it is real capital intensity in industry '*i*' at time '*t*' and *X*it is a vector of variables which affect the efficiency of production, so it is related to $A^{\gamma}$. The vector of variables includes the key independent variables and other control variables that impacts manufacturing employment. The *θ0* is the overall intercept and *θ1, θ2, θ3* and *θ4* are unknown slope parameters to be estimated and the error term u*it*. A profit maximising firm employs labour where the marginal revenue product of labour equals the wage (*W*). Following model is derived based on the assumption that all workers are homogeneous. This paper relaxes the former assumption, and the following model is re-estimated considering the heterogeneous character of workers. Therefore, the dependent variable of the following model is empirically tested for each category of manufacturing workers.

$$\ln L_{it} = \theta_0 + \theta_1 \ln W_{it} + \theta_2 \ln Q_{it} + \theta_3 \ln K_{it} + \theta_4 \ln X_{it} + u_{it} \quad \text{……………(2)}$$

Similarly, wages are determined by numerous factors, and following Greenaway et al. (1999); Hine and Wright (1998); Milner and Wright (1998), and the following wages equation is derived (3), where *Wit* is average real wages, *Lit* is total employment, *Q*it is the real output and *K*it is real capital intensity in industry '*i*' at time '*t*'. *Xit* represents a vector of variables that are engaged in the wage setting process and includes the key independent variables and other control variables that impacts wages. The *β0* is the overall intercept and *β1, β2, β3* and *β4* are unknown slope parameters to be estimated and the error term εit. Following model is derived based on the assumption that all workers are homogeneous. This paper relaxes the former assumption, and the following model is re-estimated considering the heterogeneous character of workers. Therefore, the dependent variable of the following model is empirically tested for each category of manufacturing workers.

$$\ln W_{it} = \beta_0 + \beta_1 \ln L_{it} + \beta_2 \ln Q_{it} + \beta_3 \ln K_{it} + \beta_4 \ln X_{it} + \varepsilon_{it} \quad \text{…………..(3)}$$

*Fixed effects model*

In deciding between the fixed effects estimator and the random effects estimator, a Hausman test is conducted (Hausman, 1978). This test compares an estimator ϴ1 that is known to be consistent with an estimator ϴ2 that is efficient under an assumption being tested. The null hypothesis being the estimator ϴ2 is indeed an efficient and a consistent estimator of the true parameter. If this is the case, there should not be a difference between the two estimators (Stata Corp, 2009). However, if there is a difference, a choice has to be made between the two estimators. Simply, the null hypothesis under this test is that the preferred model is the random effects model compared to the alternative fixed effect model. Therefore, to choose between the fixed and the random effects technique, both the labour demand and the wages models were subjected to a Hausman test (Hausman, 1978). Both tests were significant at less than 5 percent level of statistical significance, which rejected the null hypothesis. Accordingly, the fixed effect model was selected.

*Model specification*

A critical aspect of specifying an econometric equation is the selection of correct independent variables that should be included in the models. Omission of an important variable will lead to omitted variable bias. It can force the expected values of the estimated coefficients away from the true value of population coefficient. Similarly, the inclusion of an irrelevant variable in the equation will increase the variance of the estimated coefficients of the included variables. However, addition of an irrelevant variable does not cause bias (Studenmund, 2001). In practise, econometricians use several methods in choosing variables to a model. Data mining, stepwise regression procedure, sequential specification procedure and selection based on economic theory are some of the methods. A preference for economic theory over method was followed as recommended strongly by Studenmund (2001) for selecting variables to the models. As an example, the base specifications of the labour demand and wages models are derived using the Cobb-Douglas production function. It strongly suggests the important role played by labour and capital as core variables that determine aggregate output. Accordingly, these variables are included as core independent variables in the labour demand and wages models. Similarly, wages are brought into the labour demand model as a profit maximising firm engages labour to the extent that the marginal product of labour is equivalent to wages paid to workers. Trade flow variables represented by export intensity and import penetration are included in the models following Heckscher-Ohlin neo-classical trade theory. Technology variables are introduced to the model to reflect the technology differences across the trading partners following the Neo-technology trade theory. Global production sharing under new trade theory suggests trade based on parts and components and final assembly in contrast to what the classical trade theory suggest. Therefore, to capture the effects of global production sharing, several variables are included in the model. Priority was given to theory over statistical fit. Under the sequential specification search method, we estimated an undisclosed number of regressions and the final choice specification is presented to the reader. This method was followed to ensure the stability of the regression results that have been derived. Under this, the coefficients of the independent variables were checked for significant changes when the model is augmented by a new variable. However, to complement the above rigorous process of model specification, several alternative formal model specification tests such as the Akaike's Information Criteria (Akaike, 1973), Schwarz's Information criteria (Schwarz, 1978), and the Ramsey Regression Specification test (Ramsey, 1969) were performed simultaneously in arriving at both the labour demand and the wages models.

*Variables*

In the labour demand model, the dependent variable is manufacturing labour *(L).* Similarly, in the wages model, the dependent variable is average real wages *(W).* Given the heterogeneous nature of workers in manufacturing, the labour demand model is estimated separately for skilled factory operatives *(SL),* unskilled factory operatives *(UL),* managerial and administrative labour *(ML),* and technical and supervisory labour *(TL)* which becomes the dependent variable for each category of labour for which the labour demand model is estimated. Given the heterogeneous nature of workers in manufacturing, the wages model is estimated separately for unskilled factory operative wages *(WUL),* skilled factory operative wages *(WSL),* managerial and administrative wages *(WML),* and technical and supervisory wages *(WTL)* which becomes the dependent variable for each worker category for which the wages model is estimated. The analysis also controls for other factors that have a considerable impact on manufacturing employment and wages.

The first research question is interested in analysing the impact of factor-endowments on manufacturing employment and wages. Based on the hypothesis developed, exports based on factor endowments are captured by the key independent variable; export-intensity *(EI).* The second research question is geared to analyse the impact of technology on manufacturing employment and wages. Based on the hypothesis developed, technology diffusion in international trade is the key independent variable in this instance. Technology is captured via the share of imported raw materials consumption *(IRS)*. The third research question is about analysing the impact of global production sharing on manufacturing employment and wages. Based on the hypothesis developed, 'global production sharing' is the key independent variable in this instance. 'Global production sharing' is depicted by the share of exports in parts and components *(P&C_EX).* The analysis also controls for variables that are discussed below.

Table 1: Variable definition

| Variable | Definition |
|---|---|
| *L* | Labour is expressed in its natural logarithmic form. This includes all type of manufacturing labour. |
| *W* | Average real wages are expressed in its natural logarithmic form |
| *SL* | Skilled Labour is expressed in its natural logarithmic form. |
| *UL* | Unskilled Labour is expressed in its natural logarithmic form. |
| *ML* | Managerial and administrative labour is expressed in its natural logarithmic form. |
| *TL* | Technical and supervisory labour is expressed in its natural logarithmic form. |
| *WUL* | Average real wages of unskilled workers expressed in its natural logarithmic form. |
| *WSL* | Average real wages of skilled workers expressed in its logarithmic form. |
| *WML* | Average real wages of managerial workers expressed in its logarithmic form. |
| *WTL* | Average real wages of technicians expressed in its logarithmic form. |
| *Q* | Real output is expressed in its natural logarithmic form. |
| *W* | Average real wages are expressed in its natural logarithmic form. |
| *K* | Capital intensity is the real output divided by real value of machinery, expressed in its natural logarithmic form. |
| *EI* | Export-intensity is the value of real exports expressed as a percentage of real output |
| *IP* | Import penetration is measured as the value of real imports expressed as a percentage of real consumption |
| *SKI* | Skills-intensity is estimated by expressing the share of skilled factory operatives as a percentage of total manufacturing workers |
| *MEP* | Marginal efficiency of production is measured as the average plant size of the top fifty percent of firms expressed as a percentage of total output |
| *CD* | Custom duties is estimated using the simple average tariff of all tariff lines for each four-digit manufacturing industry. |
| *PT* | Para-tariffs is estimated using the simple average of all para-tariff lines at each four-digit manufacturing industry level. |
| *IRS* | The share of imported raw material consumption is measured by expressing the value of real imported raw-material consumption as a percentage of total real raw materials consumed |

*P&C_EX* The share of exports in parts and components is estimated as the value of real exports in parts and components expressed as a percentage of total real exports.

## IV. Results and discussion

*Labour demand model*

Table 2: Worker heterogeneity and the impact of factor endowments, technology and global production sharing on manufacturing employment

| | *(UL)* | *(SL)* | *(ML)* | *(TL)* |
|---|---|---|---|---|
| *Q* | 0.7047a | 0.7029a | 0.6994a | 0.7116a |
| | [35.57] | [43.11] | [37.41] | [33.54] |
| *W* | -0.1531a | -0.4975a | -0.2567a | -0.1606a |
| | [-3.62] | [-11.18] | [-6.43] | [-3.01] |
| *K* | -0.0965a | -0.0488a | -0.0473a | -0.0589a |
| | [-5.43] | [-3.20] | [-2.81] | [-3.11] |
| *EI* | 0.00004a | 0.00001a | 0.00005a | 0.00005c |
| | [2.52] | [2.13] | [5.80] | [1.77] |
| *IP* | 0.00005 | -0.00002 | 0.00002 | 0.00008c |
| | [1.35] | [-0.75] | [0.41] | [1.89] |
| *SKI* | -0.0278a | | -0.0020 | -0.0065a |
| | [-18.37] | | [-1.45] | [-4.17] |
| *MEP* | -0.0064a | -0.0039a | -0.0026a | -0.0033a |
| | [-7.36] | [-5.09] | [-3.21] | [-3.57] |
| *PT* | -0.0048a | -0.0050a | -0.0028c | -0.0007 |
| | [-3.03] | [-3.60] | [-1.88] | [-0.40] |
| *IRS* | -0.0036a | -0.0019a | -0.0015c | -0.0002 |
| | [-3.99] | [-2.56] | [-1.77] | [-0.24] |
| *P&C_EX* | -0.0019 | -0.0005 | -0.0003 | 0.0027 |
| | [-1.06] | [-0.35] | [-0.18] | [1.43] |
| *Constant* | -4.7009a | -1.9030a | -6.4304a | -7.8033a |
| | [-8.71] | [-3.92] | [-12.72] | [-11.84] |
| *N* | 1268 | 1321 | 1324 | 1249 |
| *R2* | 0.6593 | 0.7204 | 0.5870 | 0.7565 |
| *F* | 17.30a | 18.41a | 5.78a | 7.51a |

*t*-values in parentheses. a Significance at 1 percent, b at 5 percent, c at 10 percent

The coefficient on output is positive and statistically significant on employment of all categories of manufacturing workers as expected. In other words, irrespective of the category of worker, manufacturing output is the basis for the demand for manufacturing labour of all kinds.

The coefficient on wages are negative and statistically significant on employment of all categories of workers as expected. Although with different elasticities, wages are negatively associated with all types of labour demand.

Capital-intensity is negative and statistically significant on employment of all categories of manufacturing workers. This is expected for a labour abundant developing economy. It confirms the notion that capital-intensive industries demands skilled labour, while unskilled-labour intensive industries appear to have a lower capital and low skills requirement (Krueger, 1978).

The coefficient on export-intensity is positive and statistically significant on the employment of all categories of manufacturing workers as expected. However, the co-efficient of export-intensity is more positive and statistically significant on managerial & administrative workers compared to unskilled and skilled factory operatives and technicians. Export-intensity is positive and highly significant on managerial workers as exports demand a highly-educated class of managerial workers such as engineers, factory managers, design managers, marketing managers, sales managers, brand managers, finance mangers and risk mitigation managers to steer production activities and in the marketing of the same. A closer analysis of these workers into their job roles will show that creating export markets and catering to these markets requires a managerially trained class of workers. From a Heckscher-Ohlin theoretical point of view, developed economies that are abundant in skilled labour will export skilled-intensive commodities, while developing economies abundant in unskilled labour will produce and export unskilled-intensive commodities. This is expected as Sri Lankan exports are no longer considered unskilled-intensive. Next to managerial and administrative workers, export-intensity is positive and statistically significant on the employment of skilled and unskilled factory operatives. This is acceptable in a developing country context, where the demand for skilled and unskilled labour could exist simultaneously, due to the nature of low-technology products that it continues to export to the rest of the world. Considering technicians, export-intensity is positive on technicians at a 10 percent level of significance. The technician category of workers is composed of research officers, quality control officers etc as per the definition of Department of Census and Statistics. Although positive and statistically significant, the lesser statistical significance of export-intensity on technicians reiterates the lower value placed by Sri Lankan manufacturers on research and development. This is one of the main reasons leading to low-technology manufacturing exports from Sri Lanka. Sri Lanka attaches less value to local research and development activities.

Import penetration ratio is positive and statistically significant on the employment of technicians. The positive impact on technicians is due to the demand for them to inspect the quality of the manufacturing imports that comprise raw materials, intermediates and capital-equipment. The relatively favourable effect of import penetration on highly skilled workers [technicians] is often supported by empirical literature (Gregory, Zissimos, & Greenhalgh, 2001).

The marginal efficiency of production is negative and statistically significant on the employment of all types of manufacturing workers. However, the negative intensity is more on the unskilled factory operatives than on skilled factory operatives, managerial workers and technicians. Marginal efficiencies in production are sought by large manufacturing firms by resorting to capital-intensive methods of production, as has already been discussed elsewhere in this thesis. Therefore, labour-saving methods of production are more severe on unskilled factory operatives who are less adaptable to change compared to managerial workers and technicians who are more adaptable to change due to their education level.

As expected, para-tariffs are negative and statistically significant on the employment of unskilled factory operatives, skilled factory operatives and managerial & administrative workers. However, different classes of workers experience the impact of para-tariffs in different magnitudes. The unskilled factory operatives and the skilled factory operatives experience the negative effect of para-tariffs severely, as compared to managerial workers and technicians.

The coefficient on the share of imported raw materials consumption is negative and statistically significant on the employment of unskilled factory operatives, skilled factory operatives and administrative & managerial workers. However, the negative effect of technology (depicted by the share of imported raw materials consumption) on employment is more severe on unskilled factory operatives compared to skilled factory operatives and managerial workers, as supported by empirical literature (Garg, 2005). These empirical findings confirm the growing consensus that both intermediate imports and technology tend to deteriorate the labour market outcomes for less-skilled labour (Edwards, 2004; Feenstra & Hanson, 1999).

The impact of global production sharing on all classes of manufacturing workers is statistically insignificant.

*Wages model*

Table 3: Worker heterogeneity and the impact of factor endowments, technology and global production sharing on manufacturing wages

| | *(WUL)* | *(WSL)* | *(WML)* | *(WTL)* |
|---|---|---|---|---|
| *Q* | 0.1190a | 0.2704a | 0.2224a | 0.0984a |
| | [6.10] | [15.86] | [11.60] | [5.97] |
| *L* | -0.0679a | -0.2596a | -0.1342a | -0.0476a |
| | [-3.36] | [-11.93] | [-6.33] | [-2.85] |
| *K* | -0.0051 | -0.0334a | -0.0207c | -0.0025 |
| | [-0.41] | [-3.50] | [-1.69] | [-0.24] |
| *EI* | -0.00002 | 0.0000001 | 0.000001 | -0.00003c |
| | [-1.45] | [0.04] | [0.25] | [-1.77] |

| | | | | |
|---|---|---|---|---|
| *IP* | -0.00004 | 0.00001 | -0.00003 | -0.00002 |
| | [-1.40] | [0.72] | [-0.72] | [-0.84] |
| *SKI* | -0.0061a | 0.0053a | 0.0006 | 0.0007 |
| | [-5.18] | [5.46] | [0.63] | [0.85] |
| *MEP* | 0.0005 | -0.0008c | -0.0004 | 0.0002 |
| | [0.78] | [-1.75] | [-0.73] | [0.40] |
| *CD* | 0.0074a | 0.0041a | -0.0001 | 0.0019 |
| | [4.34] | [3.08] | [-0.09] | [1.32] |
| *IRS* | 0.0022a | 0.0008c | 0.0026a | 0.0029a |
| | [3.63] | [1.71] | [4.35] | [5.55] |
| *P&C_EX* | -0.0017 | -0.0017c | -0.0027b | -0.0007 |
| | [-1.36] | [-1.87] | [-2.22] | [-0.68] |
| *Constant* | 8.1933a | 6.4284a | 7.5543a | 9.009a |
| | [27.65] | [25.74] | [23.48] | [32.13] |
| *N* | 1268 | 1321 | 1274 | 1249 |
| *R2* | 0.1920 | 0.3106 | 0.2712 | 0.2133 |
| *F* | 4.92a | 6.03a | 5.89a | 5.46a |

*t*-values in parentheses. a Significance at 1 percent, b at 5 percent, c at 10 percent

Output is positive and statistically significant on manufacturing wages as expected across all categories of manufacturing workers. In other words, output increases are handled by increasing the number of workers of different categories or increasing their working hours, which ultimately increases the wage bill (Milner & Wright, 1998; Muller & Panning, 2009).

As expected, labour is negative and statistically significant on manufacturing wages across all categories of manufacturing workers.

As expected, capital-intensity is negative on manufacturing wages across all classes of manufacturing workers in a developing country context where labour is abundant. However, this is statistically significant only in the case of skilled factory operatives and administrative/managerial workers.

As expected, export-intensity is positive on manufacturing wages of skilled factory operatives and administrative/managerial workers, yet statistically not significant. Therefore, the study refrains from commenting further. However, export-intensity is negative in both in the case of unskilled factory operatives and technicians, while it is only statistically significant in the case of technicians. On import-penetration ratio, as this variable is statistically insignificant on manufacturing wages across all categories of manufacturing workers, the study refrains from commenting further on this. Therefore, it is clear that both export-intensity and import-penetration variables establish a weak link on manufacturing wages. Although Stolper-Samuelson predicted an increase in wages to the abundant factor following trade liberalisation, these predictions becomes weaker in the face of market imperfections in developing economies such as Sri Lanka and this is clearly evident from the empirical results. These market imperfections and the wages rigidities were explained in depth elsewhere in this thesis.

The coefficient for marginal efficiency of production is negative and statistically significant on manufacturing wages of skilled factory operatives against expectations. However, the coefficient of marginal efficiency of production is statistically insignificant on the wages of other categories of manufacturing workers. Therefore, the study refrains from commenting further.

Custom duties are positive and statistically significant on the manufacturing wages of unskilled factory operatives and skilled factory operatives. The positive effect on wages could be due to the declining protection it provides to particular manufacturing sectors and workers (Dutta, 2007) and the demands on manufacturing firms to become productive so as to remain in competition (Amiti & Konings, 2007). Hence when productivity increases are passed on to workers in the form of higher wages, manufacturing wages are expected to increase following tariff declines (Pavcnik, 2002). The coefficient on custom duties is statistically insignificant in the case of administration/managerial workers and technician. Therefore, the study refrains from commenting further on this.

On the technology, the variable on the share of imported raw material consumption is positive and statistically significant on the wages of all classes of manufacturing workers as expected. However, its positive effect is more on the wages of technicians followed by managerial/administrative workers, unskilled factory operatives and skilled factory operatives respectively. As argued by a large body of empirical literature, certain technological changes have favoured the wage and employment prospects of skilled workers compared to unskilled workers by raising the productivity and wages of workers with high levels of human capital, while having a little impact on the wages of less-skilled workers (Haskel & Slaughter, 2001; Verhoogen, 2008). In other words, technology is increasingly positive on the wages of manufacturing workers with higher level of skills and education compared to unskilled factory operatives. Major reasons for the skills-biased technology is due to employment shifts to skills-intensive sectors (Berman et al., 1998) and accordingly the release of less-skilled workers from industries (Krugman, 2000) and the adoption of new technologies that lowers the labour requirement in production.

On global production sharing, the coefficient on the share of parts and components in total trade is negative and statistically significant on manufacturing wages of skilled factory operatives and administrative/managerial workers. Although these findings are against theoretical expectations, the empirical results speak to other findings from developing economies following Egger and Egger (2002); Kohpaiboon and Jongwanich (2013). Since the impact of global production sharing is negative on manufacturing wages, yet statistically not significant in the case of unskilled factory operatives and technicians, the study refrains from commenting further.

## V. Conclusion

The main objective of this study was to understand the impact of factor endowments, technology and global production sharing on manufacturing employment and wages considering the heterogeneous character of workers. Trade based on factor endowments continue to be positive and statistically significant on the employment of all worker categories, especially on managerial workers. On the other hand, technology has been adamantly negative on all classes of manufacturing workers, especially on unskilled workers. Trade based on global production sharing is yet to make a positive impact on the employment of manufacturing workers. Manufacturing worker wages in Sri Lanka has been quite stagnant due to various reasons and the impact of factor endowments and global production sharing has been statistically insignificant, while technology has had a positive impact on the wages of all classes of manufacturing workers.

**Acknowledgement**
I am grateful to Ms Anjalin Balalingham for doing an excellent job in proofreading this paper.

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