Outsourcing and Labour Productivity: Case of Singapore Manufacturing Sector

by

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Abstract

This paper is devoted to empirical investigations of the effects of international outsourcing on labour productivity using the five-digit SIC Singapore’s manufacturing industry data. There are two types of international outsourcing this paper takes into consideration. The first is international outsourcing of materials input, which follows the narrow definition of materials outsourcing put forward by Feenstra and Hanson (1999) and is thus concerned mainly with intra-industry imports of intermediate materials. The other is international outsourcing of services input pertaining to inter-industry imports of services. Our empirical framework reveals that Singapore’s manufacturing sector thrived on international outsourcing of materials input as a key engine of observed labour productivity enhancement.
1 Introduction

One of the core research interests in the economic effects of international outsourcing has increasingly put emphasis on how the cross-border procurement of intermediate inputs, as opposed to internalising them in-house, causes changes in factor productivity. Even though factor productivity effects of international outsourcing from a theoretical point of view are less clear-cut depending on factor and product market imperfections, factor substitutability and factor mobility, among others, a growing amount of empirical research has hit upon productivity gains associated with international outsourcing activities in labour markets, such as Görzig and Stephan (2002) for Germany, Girma and Görg (2004) for the United Kingdom (UK), Egger and Egger (2006) for the European Union (EU), and Amiti and Wei (2009) for the United States (US). They all came up with rather consistent findings that international outsourcing contributes to observed labour productivity improvements.

This paper is devoted to empirical investigations of the effects of international outsourcing on labour productivity using the five-digit SIC Singapore’s manufacturing industry data. There are two types of international outsourcing this paper takes into consideration. The first is international outsourcing of materials input, which follows the narrow definition of materials outsourcing put forward by Feenstra and Hanson (1999) and is thus concerned mainly with intra-industry imports of intermediate materials. The other is international outsourcing of services input pertaining to inter-industry imports of services. Our empirical framework reveals that Singapore’s manufacturing sector thrived on international outsourcing of materials input as a key engine of observed labour productivity enhancement.

We undertake robustness checks of our main findings in two ways. First, we replace the narrow definition of materials outsourcing with the wide definition which broadly covers both intra- and inter-industry imports of materials input as in Feenstra and Hanson (1996). We find merely weak evidence that this alternative measure of materials outsourcing augments labour

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1 See Arndt (1997), Jones and Kierzkowski (2001), and Egger and Falkinger (2003), among many others, for a theoretical treatment of factor productivity impacts of international outsourcing.
productivity. This implies that a narrow definition of international outsourcing is more relevant to labour productivity gains in Singapore’s manufacturing sector than is a wide definition. Additionally, with detailed information on imported services, we focus on two categories of services outsourcing: information technology (IT) and business services outsourcing. Our estimates further suggest that outsourcing of IT services serves as the other crucial vehicle that intensifies cross-border production sharing and fragmentation through opening up markets and strengthening global production networks, thereby enhancing labour productivity.

The remainders of this paper are briefly outlined as follows. Section 2 illustrates a potential linkage between international outsourcing and labour productivity changes using our five-digit SIC Singapore’s manufacturing industry data. Section 3 enumerates the mechanism through which international outsourcing entails upgrading labour productivity from a theoretical point of view. Section 4 attempts to develop our empirical framework in which the econometric models are specified, data measurements are depicted, and model estimation techniques are chosen to account for various econometric issues. Section 5 presents and discusses our empirical results. Section 6 examines robustness of our main findings. Section 7 concludes.

2 International Outsourcing and Labour Productivity Improvements in Singapore’s Manufacturing Industries

Our primary source of the dataset employed in this paper is retrieved from the Census of Manufacturing Activities (CMA) from 1995 to 2004 published by Singapore Economic Development Board (EDB), which collected comprehensive data on the establishments engaged in manufacturing activities, such as output, workers, value added, sales, exports, net fixed assets, and capital expenditure, classified according to the Standard Industrial Classification (SIC) and disaggregated at the five-digit level. In addition to the CMA dataset, we also make use of Singapore’s Input-Output (I-O) tables for the period of 1995-2000 to construct the imported intermediate inputs by mapping them with the CMA dataset. All information employed in this paper is reported based on year 2000 prices.

[Insert Figure 1 here]

Figure 1 portrays a fitted plot of international outsourcing of materials input and labour productivity. As discussed later in this paper, the index of materials outsourcing follows the
narrow definition of international outsourcing firstly introduced by Feenstra and Hanson (1999) and is measured by the ratio of intra-industry materials imports to total industry sales ($OM^{Narrow}$). Throughout this paper, we employ a conventional proxy of labour productivity – output per worker ($y_{it}$). Figure 1 exhibits a positive relationship between $\ln OM^{Narrow}$ and $\ln y_{it}$, and therefore points to potential labour productivity gains from international outsourcing of intermediate materials in Singapore’s manufacturing industries.

[Insert Figure 2 here]

The effects of cross-border outsourcing of services input are demonstrated in Figure 2. Again, labour productivity gains from the uses of services imports are observed, suggesting that a decision to “unbundle” services activities may bolster up a boost in labour productivity.

[Insert Figures 3 and 4 here]

Our CMA dataset provides sufficiently detailed information on inter-industry imports of information technology (IT) and business services, which enables us to partition the notion of services outsourcing into two categories, namely IT services outsourcing ($OS^{IT}$) and business services outsourcing ($OS^{BS}$). As shown in Figures 3 and 4, workers employed in-house tend to enjoy higher productivity when an industry pertains extensively to cross-border outsourcing of IT and business services.

Examination of our CMA dataset developed in this section paints a rough picture of the positive effects of international outsourcing on labour productivity in Singapore’s manufacturing industries. The rest of this paper weighs in on developing in-depth analyses of such a linkage utilising a formal empirical framework.

3 The Model

Our empirical strategy is to estimate a production function in order to investigate the impacts of international outsourcing on labour productivity. Among the most crucial structural variables are

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2 It should also be highlighted that, as elaborated later in this paper, we also employ an alternative measure of international outsourcing of materials input, broadly defined as the ratio of intra- and inter-industry materials imports to total industry sales. This measurement is analogous to the wide definition of international outsourcing utilised by Feenstra and Hanson (1996).
those that capture the extent to which an industry carries out various cross-border outsourcing activities.

Following Amiti and Wei (2009), we consider the production function of an industry $i$ given by the following expression.

$$ Y_{it} = A_{it}(OM_{it}, OS_{it}, T_{it})F(L_{it}, K_{it}), $$

where the output of an industry $i$ at time $t$, $Y_{it}$, is a function of two production factors: labour ($L_{it}$) and capital ($K_{it}$), and the technology shifter, $A_{it}$, is affected by international outsourcing of materials ($OM_{it}$), international outsourcing of services ($OS_{it}$) and other industry-specific structural variables ($T_{it}$).³

As posited by Amiti and Konings (2007) and Amiti and Wei (2009), there are at least four mechanisms, through which international outsourcing prompts a shift in an industry’s productivity level ($A_{it}$): (i) a static efficiency gain; (ii) restructuring effects; (iii) learning externalities; and (iv) variety effects.

First, a decision to contract out production stages at arm’s length enables a firm to relocate its less efficient production activities and to centre on more efficient ones. In this sense, compositional adjustments associated with outsourcing activities give rise to efficiency improvements, on average. Second, outsourcing activities promote intra-firm restructurings that potentially push forward its technology frontier. The restructuring effects seem plausible with outsourcing of technology- and/or knowledge-intensive activities like information technology and computer services. Third, international outsourcing allows a firm to learn and adopt the uses of new intermediate input imports like software packages and know-how that by and large help improve its productivity. Last but not least, an outsourcing decision leads to a wider range of intermediate inputs available to a firm. As shown by Ethier (1982), a surge in materials and services input varieties brings about an outward shift in a firm’s overall productivity.

³ We depart from Amiti and Wei (2009) in two ways. First, the production function incorporates other industry-specific structural variables on top of the international outsourcing indices. In addition, we assume only two factors of production, namely capital and labour, due to data limitations whereas Amiti and Wei (2009) assumed four factors including capital, labour, materials and services.
Our objective is to capture a relationship between outsourcing indices and labour productivity. To develop further analysis, we assume that the production function is linearly homogeneous, and therefore an industry’s productivity proxied by output per worker can be expressed as:

\[ y_{it} = A_{it}(OM_{it}, OS_{it}, T_{it})F(k_{it}), \]  

(2)

where \( y_{it} \) is output per worker, and \( k_{it} \) is capital per worker. Output per worker as a proxy of labour productivity is commonly utilised in the literature. This includes Egger and Egger (2006), Amiti and Konings (2007), and Amiti and Wei (2009), among many others.

4 The Empirics

4.1 Econometric Specifications and Data Measurements

Having depicted our production function, we then need to develop econometric specifications by choosing a functional form that fits the production function as in Equation (2). Building upon the existing studies by Görg and Hanley (2005), Görg, et al. (2008) and Amiti and Wei (2009), the following estimable form of a production function is contemplated:

\[ \ln y_{it} = \alpha_0 + \alpha_1 \ln OM_{it} + \alpha_2 \ln OS_{it} + \alpha_3 \ln WAGE_{it} + \alpha_4 \ln k_{it} \]

\[ + \alpha_5 \ln TRADE_{it} + \alpha_6 \ln PROD_{it} + u_{it}, \]  

(3)

where \( WAGE_{it} \) is the average wage rates; \( TRADE_{it} \) is the index of international trade exposure; \( PROD_{it} \) is the index of industry-specific performance levels; and \( u_{it} \) is the stochastic error term.

Central to our analyses are the proxies of outsourcing. As in Geishecker and Görg (2008), we construct two indices of materials outsourcing, namely a wide and a narrow definition of materials outsourcing. The former was introduced by Feenstra and Hanson (1996) and broadly defined as the share of imported intermediate inputs in the total sales. Hence, it captures both intra- and inter-industry imports of intermediate materials. In contrast, Feenstra and Hanson (1999) considered an alternative measure of materials outsourcing confined to intra-industry materials imports – those purchased from the same industries. The underlying idea of the intra-industry outsourcing index is that “we do not normally think of, say, the import of steel by a U.S.
automobile producer as outsourcing. But it is common to consider the purchase of automobile parts by that company as outsourcing…” In particular, the two measures of materials outsourcing can be portrayed as follows.

Wide Definition of Materials Outsourcing:

\[
OM_{it}^{Wide} = \frac{\sum_{j=1}^{N} IMP_{ijt}^{Materials}}{Y_{it}}
\]  \hspace{1cm} (4)

Narrow Definition of Materials Outsourcing:

\[
OM_{it}^{Narrow} = \frac{IMP_{ijt}^{Materials}}{Y_{it}},
\]  \hspace{1cm} (5)

where \(IMP_{ijt}^{Materials}\) is an industry \(i\)'s imports of intermediate materials produced by an industry \(j\), and \(i, j = 1, \ldots, N\). In contrast with Feenstra and Hanson (1999), we do not make use of the Input-Output table to construct the wide and narrow definitions of outsourcing now that our dataset based on the five-digit ISIC Singapore manufacturing industries provides sufficient information on intra- and inter-industry imports of intermediate materials. We therefore can directly construct both materials outsourcing indices by solely using the dataset.

The index of services outsourcing is analogous to that of Amiti and Wei (2009). It is measured as the ratio of inter-industry imports of services to total values of production. Again, we abstract from their measurement of services outsourcing in such a way that no use of the Input-Output table is needed, since our dataset includes the information of inter-industry imports and thus directly captures their underlying idea. More specifically, the index of services outsourcing can be represented as

\[
OS_{it} = \frac{IMP_{it}^{Services}}{Y_{it}}.
\]  \hspace{1cm} (6)

where \(IMP_{it}^{Services}\) is the values of inter-industry imports of services.
The wage rates \((WAGE_\alpha)\) is measured by the ratio of labour payrolls to the number of workers employed. The idea of incorporating \(WAGE_\alpha\) into our econometric specification (3) is based on the efficiency wage theories pushed forward by Calvo (1979) and Shapiro and Stiglitz (1984).\(^4\) They show that an increase in wages raises the opportunity cost of unemployment, reduces an incentive for shirking and ultimately leads to higher labour productivity. In equilibrium, employers are willing to pay a higher-than-market wage to raise the cost of shirking. In this sense, wage premium serves as a disciplinary device on workers.

Capital per worker \((k_\alpha)\) is measured by the average net fixed capital assets divided by the number of workers.\(^5\) The conventional production theory suggests that if an industry which employs capital input more intensively is able to generate higher output per worker. To put it differently, an increase in capital utilisation \(\textit{ceteris paribus}\) augments production capacity and thus labour productivity.

The index of international trade exposure \((TRADE_\alpha)\) is proxied by the ratio of import and export values to total industry output. It aims to capture the extent to which international trade openness generates higher productivity vis-à-vis international technological and informational spillovers as put forward by Evenson and Westphal (1995). Exporting and importing activities offer a firm better access to new technology and technical assistance and subsequently lead to efficiency improvements.

Changes in labour productivity may also be attributed to industry-specific performance. For instance, ones would expect that workers employed in a highly technology-intensive industry, say, the electronics and computer machinery industries are more productive than those employed in traditional industries like food and beverages and textiles industries. The index of industry-specific performance \((PROD_\alpha)\) enters the specification to take in this idea and is measured as total value-added divided by the number of establishments.

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\(^4\) In these theoretical settings, workers can choose to work or shirk. In the latter case, there is risk that they are caught and immediately fired.

\(^5\) We also carried out a robustness check of our findings by replacing \(k_\alpha\) with \(K_\alpha\). Our main results are qualitatively unchanged.
Tables 1 and 2 summarises general statistics and provides a correlation matrix of our main variables.

4.2 Model Estimations

The summary statistics illuminate clearer insight into potential relationships between labour productivity and international outsourcing activities. They, nonetheless, neither account for other covariates that potentially have impacts on industry-specific labour productivity, nor say anything about directions of causality. More rigorous empirical techniques are therefore needed to deal with these issues.

At least three potential econometric problems pose serious challenges of empirical estimations and thus need to be addressed. First, the stochastic error term, $u_i$, is likely to be heteroskedastic due to considerable variation in size of the industries in our samples. The heteroskedastic nature of the error term is rather common when researchers deal with huge survey data like the one we are employing. This problem makes the standard ordinary least squares (OLS) estimation produce biased estimates. To address this problem, we carry out White’s (1980) heteroskedasticity-robust standard error procedure in the estimations of our econometric specification (3).

Second, asymmetry of conditional density seems to be the norm rather than the exception in survey data but have been largely underplayed by the exiting research on international outsourcing. For instance, it is possible that dispersion of labour productivity is dependent on an industry’s level of outsourcing intensity. As demonstrated by Koenker and Hallock (2001), considerable heterogeneity in an dependent variable over the full range of the conditional distribution implies that OLS regression yields severely distorted estimates. This pitfall necessitates non-parametric quantile regression in which quantiles of conditional distribution of the response variable are expressed as functions of observed covariates. To obtain the quantile regression estimators, we choose to bootstrap the quantile regression gradient condition.

Indeed, a rapidly growing amount of research in labour economics, particularly on union wage effects, returns to education and labour market discrimination, has employed quantile
regression, such as Buchinsky (1997) for the United States; Fitzenburger (1999) for Germany; Garcia, et al. (2001) for Spain; and Schultz and Mwabu (1998) for South Africa. Nevertheless, the use of quantile regression is largely limited in the existing work that dealt with labour productivity. To the best of our knowledge, this paper is the first to make use of quantile regression in the context of labour productivity effects of international outsourcing.

Last, our explanatory variables of outsourcing indices and capital input are likely to be endogenous. As highlighted by Amiti and Wei (2009), Egger and Egger (2006) and Girma and Görg (2004), among many others, outsourcing decisions may be determined by unobserved nature and characteristics of production structures. Likewise, Morrison (1988) pointed out that choices of capital input tend to be correlated with industry-specific factors. As is well known, the potential endogeneity problem implies that the standard OLS regression conveys biased and inconsistent estimates.

There are two standard ways to tackle the potential endogeneity problem. The first is to make use of the Instrumental Variable (IV) estimation under which the potentially endogenous variables are instrumented by valid IVs – ones that are exogenous and strongly correlated with the endogenous explanatory variables. However, this strategy intensively exploits information on valid IVs which are, unfortunately, unavailable due to our data limitations. The other approach to tackling this problem is to employ the Arellano-Bond (1991) Generalised Method of Moment (GMM) estimation under which all possible lags of each variable serves as instruments. This alternative approach seems appropriate since our dataset involves a relatively long time horizon. Therefore, we bring into play the Arellano-Bond GMM estimators to address the potential endogeneity problem.

5 Empirical Results

Table 3 presents our preliminary results based on the estimations of the econometric model (3) with the narrow definition of materials outsourcing (\(OM_{\text{Narrow}}\)) and the heteroskedasticity-robust variance estimators. The first column portrays the OLS estimates. The goodness of fit is somewhat satisfactory with the R-squared statistic equal to .6371 and \(F\) statistic statistically significant at 1 percent. The second column pertains to the bootstrapping quantile regression where R-squared is slightly reduced to .4256. The last column represents the Arellano-Bond
GMM estimates with the Wald’s statistic statistically significant at 1 percent.\textsuperscript{6} It should also be highlighted that the lagged labour productivity ($y_{t-1}$) entering the specification as another explanatory variable in the GMM estimation is meant to allow for the partial adjustment of labour productivity (Maddala, 1977, pp. 371-373).

[Insert Table 3 here]

As shown in Table 3, our empirical results are strikingly robust across estimation techniques. Except for the index of services outsourcing ($OS_{it}$), all other explanatory variables are qualitatively unchanged with different estimation methods. Susceptibility of the estimates points to the potential endogeneity problem embedded in the index of services outsourcing, and thus we are in favour of the GMM estimations that take into consideration this hitch and potentially produce consistent estimates. The main findings can be summarised as follows.

First and foremost, international outsourcing of materials narrowly defined as intra-industry imports of intermediate input contributes to labour productivity improvements in Singapore’s manufacturing industries. The coefficients of $\ln OM_{it}^{Narrow}$ are positive and statistically significant at least at the 5 percent level across all estimations. The labour productivity gains from international outsourcing of materials may be explained by the extent to which contracting out production activities at arm’s length enables a firm to trim the non-core activities and to specialise in core-competent activities. Through this mechanism, the exiting workers employed in-house are able to enjoy labour productivity improvements as a corollary of static efficiency gains, restructuring effects, learning externalities and variety effects (Amiti and Konings, 2007; and Amiti and Wei, 2009). Our evidence that international outsourcing of materials serves as a driver of labour productivity boosts is particularly consistent with the findings by the previous studies such as Egger and Egger (2006) and Görg and Hanley (2005).\textsuperscript{7}

Second, in contrast with international outsourcing of materials input, services outsourcing has no influential effects on labour productivity. Even though the OLS and bootstrapping

\textsuperscript{6} The Wald’s statistic is chi-squared distributed with 7 degrees of freedom.

\textsuperscript{7} It should be emphasised that Egger and Egger (2006) considered only the effects of international outsourcing on unskilled labour productivity while we examine that of both skilled and unskilled workers in general. Additionally, we also abstract from Görg and Hanley (2005) in a way that they employed rather limited dataset of the electronic industry whereas we make use of the industry-wide dataset.
quantile regression estimations produce negative, statistically significant coefficients of $\ln OS_{it}$, a relationship between services outsourcing and labour productivity turns out to be statistically insignificant when we account for the potential endogeneity bias problem under the Arellano-Bond GMM estimation. Our weak evidence of labour productivity effects of services outsourcing departs from that of Girma and Görg (2004) and Amiti and Wei (2009) who showed that services outsourcing predominantly account for a surge in labour productivity. Intuitively, the absence of a strong linkage may be attributable to the fact that contracting out services activities in Singapore’s manufacturing sector involves substantial costs of searching and matching potential partners and/or suppliers such that the labour productivity gains are completely wiped out.

Third, the efficiency wage theory seems to play a pivotal role in explaining labour productivity improvements in Singapore’s manufacturing industries now that an industry paying higher wages tends to be characterised by higher labour productivity. As portrayed in Table 3, the coefficients of $\ln WAGE_{it}$ are positive and statistically significant at 1 percent. As depicted earlier, the mechanism through which higher wages induce higher labour productivity rests with the efficiency wage argument. An industry is willing to offer the wage premium in order to deter a shirking behaviour, induce labour to exert greater efforts, and ultimately bolster labour productivity.

Fourth, the coefficients of $\ln k_{it}$ are positive and statistically significant at the 1 percent level. As expected, an industry which employs capital input more intensively is able to enjoy higher output per worker. Furthermore, the positive linkage may also be attributed to the fact that Singapore’s manufacturing industries have long thrived on high-tech capital accumulation like computers and high-tech machinery and equipment, which ultimately requires skilled labour like engineer, programmers and technicians. In this sense, a persistent boost in capital accumulation has by and large enhanced labour productivity.

Fifth, a relationship between international trade and labour productivity is positive and statistically significant at 1 percent. International openness accounts for labour productivity growth and therefore substantiates the theoretical proposition put forward by Evenson and Westphal (1995). According to their hypothesis, international trade enables firms to perk up
their productivity through their greater access to new technology and technical assistance. In this regard, subsequent productivity improvements are expected after the entry to international markets. Our supporting evidence is particularly consistent with the cross-country evidence in the existing literature such as Aw, et al. (2000), Baldwin and Gu (2003) and De Loecker (2007), among others.8

Last but not least, industry-specific performance also has a say in labour productivity development in Singapore’s manufacturing sector. The coefficients of $PROD_{it}$ are positive and statistically significant at the 1 percent level. This result however is not surprising in that an advanced industry pertinent to high efficiency and thus high value-added production activities like petrochemical, electronics and pharmaceutical industries tends to be concerned with sophisticated production techniques and management and therefore potentially be characterised by high productivity of labour. In contrast, a traditional industry that copes with low value-added production like textiles and garment industries is likely to rope in traditional technology, employ labour intensively and thus exhibit low labour productivity.

6 Robustness Checks

Having obtained and discussed the baseline evidence, we then examine robustness of the key findings. In so doing, we perturb our econometric specification (3) in two ways. First, we utilise an alternative measure of materials outsourcing, namely the wide definition of outsourcing, introduced by Feenstra and Hanson (1996). Even though this proxy is less satisfactory from the conceptual point of view, it might be interesting to investigate whether the scope of materials imports matters to the analyses of international outsourcing and labour productivity.

In addition, to us, the weak evidence that international outsourcing of services alters labour productivity deserves further investigation. We feel that some particular types of service outsourcing should exhibit productivity gains for labour. For instance, Singapore’s manufacturers have increasingly downsized their IT departments since they could obtain better IT services at lower costs from the outside IT service providers than developing the IT

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8 However, the empirical evidence regarding the causality running from international trade exposure and subsequent productivity shifts is rather mixed and less clear-cut since a number of previous studies found merely weak evidence that international market participation contributes to productivity improvements. These include Clerides, et al. (1998) and Bernard and Jensen (1999).
department in-house. Accordingly, we modify our baseline specification by breaking down the index of services outsourcing into three categories: IT services outsourcing ($OS_{IT}^{\text{IT}}$), business services outsourcing ($OS_{BS}^{\text{IT}}$), and other services outsourcing ($OS_{OTHER}^{\text{IT}}$). The detailed information on these three categories of services imports is readily available in our CMA dataset.

6.1 Wide Definition of Materials Outsourcing

Table 4 presents the estimates of the tailored specification in which the narrow definition of materials outsourcing ($\ln OM_{\text{narrow}}^{\text{IT}}$) is replaced by the wide definition of outsourcing ($\ln OM_{\text{wide}}^{\text{IT}}$). Recall that the difference between these two conventional measures is that the former strictly captures intra-industry imports of materials while the latter is loosely concerned with both intra- and inter-industry imports of materials. We further find the following interesting results.

Except for coefficients of capital intensity ($\ln k_{\text{IT}}$), the estimates corresponding to other non-outsourcing explanatory variables are strikingly robust since they remain statistically significant at 1 percent without changes in their sign. Nevertheless, the positive relationship between capital intensity and labour productivity turns out to be insignificant under the GMM estimation which takes into account the potential endogeneity bias problem.

More importantly, the endogeneity bias problem plays out in both indices of materials and services outsourcing. This is in contrast with our baseline estimations where the problem has to do merely with the index of services outsourcing. As shown in Table 4, the GMM estimates of $\ln OM_{\text{wide}}^{\text{IT}}$ are negative and insignificant although the bootstrapping quantile regression still conveys a positive, statistically significant parameter estimate. The weak evidence that services outsourcing contributes to labour productivity improvements is still observed in this sensitivity test.

In comparison with our baseline model, the empirical exercise developed here draws a conclusion that a narrow definition of outsourcing, rather than a wide one, is more relevant to labour productivity changes in Singapore’s manufacturing sector. This evidence therefore pushes
forward the assertion by Feenstra and Hanson (1999) that a narrow definition of international outsourcing better captures the notion of outsourcing.

6.2 Roles of IT services outsourcing

Table 5 returns to our baseline specification and partitions the index of service outsourcing into three categories: IT services outsourcing \((OS_{it}^{IT})\), business services outsourcing \((OS_{it}^{BS})\), and other services outsourcing \((OS_{it}^{OTHER})\). Ones may discern that the GMM estimates, particularly outsourcing and capital intensity variables, somewhat depart from those of OLS and bootstrapping quantile regression. However, we are in favour of the GMM results for the reason that they account for the potential endogeneity problem and are arguably unbiased at least asymptotically.

Our main findings discussed in Section 5 are staggeringly robust since the estimates corresponding to all structural variables besides the index of services outsourcing are analogous to those portrayed in Table 3. Interestingly, our attempt to break down services outsourcing elucidates clearer insight into the roles of services outsourcing typology. In particular, the coefficient of \(\ln OS_{it}^{IT}\) is positive and statistically significant at the 5 percent level in the GMM estimation, implying that labour employed in Singapore’s manufacturing sector potentially taps benefits from international outsourcing of IT services. Our evidence that international outsourcing of IT services augments labour productivity substantiates the arguments posited by Amiti and Konings (2007) and Amiti and Wei (2009). They hypothesised that the labour productivity gains from international outsourcing tend to be particularly pronounced for IT services, which enable a firm to push out its technology frontier vis-à-vis the use of new information technology such as data processing, information storage and retrieval and telecommunication.

However, international outsourcing of business and other services plays a different role in shaping labour productivity. We find only weak evidence that business services outsourcing brings about a change in labour productivity as the coefficients of \(\ln OS_{it}^{BS}\) are insignificant across all estimations. Confirming our baseline results, other service outsourcing seems to be perilous to
labour productivity as the GMM estimate of $\ln OS^{\text{OTHER}}_n$ is negative and statistically significant at 1 percent.

In a nutshell, our empirical exercise sheds further light on insight into international outsourcing and labour productivity. The main messages from our perturbations are that: (i) intra-industry outsourcing of materials input serves as a key driver of labour productivity improvements in Singapore’s manufacturing industries; and (ii) typology of services outsourcing matters to labour productivity improvements. Outsourcing of IT services enhances labour productivity whereas other types of services outsourcing do not.

7 Concluding Remarks

This paper empirically examines the impacts of international outsourcing on labour productivity using the five-digit SIC Singapore’s manufacturing industries from 1995 to 2004. Our empirical model developed in this paper builds upon the past research pioneered by Amiti and Konings (2007) and Amiti and Wei (2009), taking into account various econometric issues such as heteroskedasticity, conditional dispersion of labour productivity and potential endogeneity biases.

This paper provides intuitive insight into a linkage between international outsourcing and labour productivity. Our evidence asserts that international materials outsourcing, narrowly defined as intra-industry materials imports (Feenstra and Hanson, 1999), serves as a key catalyst of labour productivity improvements in Singapore’s manufacturing industries even though the effects turn out to be weak when we relax the definition of materials outsourcing to embrace inter-industry imports as in Feenstra and Hanson (1996). Unlike materials outsourcing, services outsourcing in general does not exhibit significant impacts on labour productivity. A breakdown of services outsourcing further reveals that only IT services outsourcing enhances labour productivity whereas business and other services do not. Our empirical exercises also produce supplementary results putting forward various hypotheses of labour productivity determinants, including the efficiency wage theory, capital intensity, trade openness and industry-specific productivity levels.
References


Figure 1: A Fitted Plot of International Outsourcing of Materials Input ($\ln OM^{Narrow}$) and Labour Productivity ($\ln y_{it}$)

Figure 2: A Fitted Plot of International Outsourcing of Services Input ($\ln OS$) and Labour Productivity ($\ln y_{it}$)
Figure 3: A Fitted Plot of International Outsourcing of IT Services ($\ln OS^{IT}$) and Labour Productivity ($\ln y_{it}$)

Figure 4: A Fitted Plot of International Outsourcing of Business Services ($\ln OS^{BS}$) and Labour Productivity ($\ln y_{it}$)
Table 1: Summary of Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs.</th>
<th>Mean</th>
<th>S.D.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
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<td>5.2930</td>
<td>.7519</td>
<td>3.4930</td>
<td>9.1371</td>
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<tr>
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<td>.3933</td>
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<td>1.3508</td>
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<tr>
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<td>.3733</td>
<td>-.8908</td>
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</tr>
<tr>
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<td>1.3661</td>
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</tr>
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<td>( \ln TRADE_{it} )</td>
<td>1872</td>
<td>-.2539</td>
<td>.4650</td>
<td>-1.9119</td>
<td>1.5933</td>
</tr>
<tr>
<td>( \ln PROD_{it} )</td>
<td>1880</td>
<td>8.0044</td>
<td>1.4923</td>
<td>.7630</td>
<td>13.7094</td>
</tr>
</tbody>
</table>

Table 2: Correlation Matrix of Independent Variables

\[
\begin{array}{cccccccc}
\text{ln} OM_{it}^{Wide} & \text{ln} OM_{it}^{Narrow} & \text{ln} OS_{it} & \text{ln} WAGE_{it} & \text{ln} k_{it} & \text{ln} TRADE_{it} & \text{ln} PROD_{it} \\
\text{ln} OM_{it}^{Wide} & 1.00 & .3479 & -.0503 & -.0642 & & \\
\text{ln} OM_{it}^{Narrow} & .3479 & 1.00 & .2015 & .0338 & & \\
\text{ln} OS_{it} & -.0503 & .2015 & 1.00 & & & \\
\text{ln} WAGE_{it} & -.0642 & .0338 & .3727 & 1.00 & & \\
\end{array}
\]
Table 3: Estimations with the narrow definition of materials outsourcing (OM_{Narrow}) and the Heteroskedasticity-Robust Variance Estimators

<table>
<thead>
<tr>
<th>Dependent Variable: $\ln y_{it}$</th>
<th>OLS</th>
<th>BQR</th>
<th>GMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln y_{it-1}$</td>
<td>-----</td>
<td>-----</td>
<td>.1651** (.0733)</td>
</tr>
<tr>
<td>$\ln OM_{it}^{Narrow}$</td>
<td>.0328*** (.0626)</td>
<td>.0320*** (.0064)</td>
<td>.0275*** (.0137)</td>
</tr>
<tr>
<td>$\ln OS_{it}$</td>
<td>-.0430*** (.0152)</td>
<td>-.0350*** (.0106)</td>
<td>.0151 (.0148)</td>
</tr>
<tr>
<td>$\ln WAGE_{it}$</td>
<td>.7038*** (.1337)</td>
<td>.7932*** (.0452)</td>
<td>.6213*** (.0430)</td>
</tr>
<tr>
<td>$\ln k_{it}$</td>
<td>.0503*** (.0115)</td>
<td>.0311*** (.0088)</td>
<td>.0259*** (.0120)</td>
</tr>
<tr>
<td>$\ln TRADE_{it}$</td>
<td>.3300*** (.0262)</td>
<td>.2754*** (.0308)</td>
<td>.4024*** (.0369)</td>
</tr>
<tr>
<td>$\ln PROD_{it}$</td>
<td>.2050*** (.0113)</td>
<td>.1798*** (.0103)</td>
<td>.1421*** (.0120)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.0878*** (.4927)</td>
<td>.9722*** (.1690)</td>
<td>1.3019*** (.4262)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>BQR</th>
<th>GMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Obs.</td>
<td>1736</td>
<td>1736</td>
<td>1218</td>
</tr>
<tr>
<td>$F$ Statistic</td>
<td>252.76***</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>R-squared</td>
<td>.6371</td>
<td>.4256</td>
<td>-----</td>
</tr>
<tr>
<td>Wald’s Statistic</td>
<td>-----</td>
<td>-----</td>
<td>949.75***</td>
</tr>
</tbody>
</table>

Note: (1) Robust standard errors in parentheses; (2) The quantile regression (BQR) is based on the bootstrapping method, and the pseudo R-squared represents corresponding goodness of fit; and (3) The Wald Statistic is chi-squared distributed with 7 degrees of freedom.

* Statistically significant at 10%; ** statistically significant at 5%; *** statistically significant at 1%.
Table 4: Estimations with the wide definition of materials outsourcing ($OM^{Wide}$) and the Heteroskedasticity-Robust Variance Estimators

**Dependent Variable: $ln y_{it}$**

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>BQR</th>
<th>GMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ln y_{it-1}$</td>
<td>-----</td>
<td>-----</td>
<td>.1295 (.0989)</td>
</tr>
<tr>
<td>$ln OMO_{it}$</td>
<td>-.0015 (.0398)</td>
<td>.0637*** (.0308)</td>
<td>-.0851 (.0544)</td>
</tr>
<tr>
<td>$ln OS_{it}$</td>
<td>-.0354** (.0146)</td>
<td>-.0214* (.0113)</td>
<td>.0208 (.0192)</td>
</tr>
<tr>
<td>$ln WAGE_{it}$</td>
<td>.7028*** (.1317)</td>
<td>.7726*** (.0328)</td>
<td>.6162*** (.1720)</td>
</tr>
<tr>
<td>$ln k_{it}$</td>
<td>.0505*** (.0114)</td>
<td>.0327*** (.0084)</td>
<td>.0266 (.0210)</td>
</tr>
<tr>
<td>$ln TRADE_{it}$</td>
<td>.3858*** (.0308)</td>
<td>.3013*** (.0347)</td>
<td>.4536*** (.0670)</td>
</tr>
<tr>
<td>$ln PROD_{it}$</td>
<td>.1971*** (.0108)</td>
<td>.1774*** (.0099)</td>
<td>.1329*** (.0233)</td>
</tr>
<tr>
<td>Constant</td>
<td>**1084.1 (.4812)</td>
<td>1.0938*** (.1599)</td>
<td>1.4664*** (.6817)</td>
</tr>
</tbody>
</table>

**No. of Obs.**

<table>
<thead>
<tr>
<th></th>
<th>1805</th>
<th>1805</th>
<th>1271</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F$ Statistic</td>
<td>264.27***</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>R-squared</td>
<td>.6411</td>
<td>.4256</td>
<td>-----</td>
</tr>
<tr>
<td>Wald’s Statistic</td>
<td>-----</td>
<td>-----</td>
<td>262.26***</td>
</tr>
</tbody>
</table>

**Note:** (1) Robust standard errors in parentheses; (2) The quantile regression (BQR) is based on the bootstrapping method, and the pseudo R-squared represents corresponding goodness of fit; and (3) The Wald Statistic is chi-squared distributed with 7 degrees of freedom.

* Statistically significant at 10%; ** statistically significant at 5%; *** statistically significant at 1%.
<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>BQR</th>
<th>GMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln y_{it-1}$</td>
<td>-----</td>
<td>-----</td>
<td>.2593*** (.0849)</td>
</tr>
<tr>
<td>$\ln OM_{it}^{Wide}$</td>
<td>-.0302 (.0244)</td>
<td>-.0082 (.0346)</td>
<td>.2244*** (.0446)</td>
</tr>
<tr>
<td>$\ln OS_{IT}^{IT}$</td>
<td>-.0053 (.0227)</td>
<td>-.0273 (.0181)</td>
<td>.0854** (.0340)</td>
</tr>
<tr>
<td>$\ln OS_{BS}^{BS}$</td>
<td>.0152 (.0198)</td>
<td>-.0092 (.0162)</td>
<td>.0024 (.0428)</td>
</tr>
<tr>
<td>$\ln OS_{OTHER}^{OTHER}$</td>
<td>-.0782** (.0325)</td>
<td>-.0125 (.0348)</td>
<td>-.1460*** (.0427)</td>
</tr>
<tr>
<td>$\ln WAGE_{it}$</td>
<td>.6726*** (.2464)</td>
<td>.8823*** (.0822)</td>
<td>.4034*** (.0696)</td>
</tr>
<tr>
<td>$\ln k_{it}$</td>
<td>.0384* (.0208)</td>
<td>-.0006 (.0236)</td>
<td>.0890*** (.0232)</td>
</tr>
<tr>
<td>$\ln TRADE_{it}$</td>
<td>.2425*** (.0649)</td>
<td>.2300*** (.0652)</td>
<td>.4898*** (.0805)</td>
</tr>
<tr>
<td>$\ln PROD_{it}$</td>
<td>.2290*** (.0162)</td>
<td>.2236*** (.0256)</td>
<td>.1599*** (.0197)</td>
</tr>
<tr>
<td>Constant</td>
<td>.6609 (1.1976)</td>
<td>.0012 (.4844)</td>
<td>1.6787*** (.6873)</td>
</tr>
<tr>
<td>No. of Obs.</td>
<td>682</td>
<td>682</td>
<td>466</td>
</tr>
<tr>
<td>F Statistic</td>
<td>97.64***</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>R-squared</td>
<td>.6475</td>
<td>.4568</td>
<td>-----</td>
</tr>
<tr>
<td>Wald’s Statistic</td>
<td>-----</td>
<td>-----</td>
<td>387.40***</td>
</tr>
</tbody>
</table>

Note: (1) Robust standard errors in parentheses; (2) The quantile regression (BQR) is based on the bootstrapping method, and the pseudo R-squared represents corresponding goodness of fit; and (3) The Wald Statistic is chi-squared distributed with 9 degrees of freedom.

* Statistically significant at 10%; ** statistically significant at 5%; *** statistically significant at 1%.