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Abstract

Moving up the value chain has recently made its way to the forefront of public policy debate (in many developed countries, including Canada) as a crucial means to improve productivity performance, job creation and thereby to improve living standards. A shortcoming of this debate, however, is that there is no readily comparable indicator across industries that allows to ascertain appropriately whether they are moving up (or going down) the value chain. In this paper, we develop a composite indicator of a number of individual fundamental determinants of productivity (using the latent variable approach) for undertaking a more comprehensive assessment as to whether an industry is moving up the value chain. The trends in the new indicator suggest that most Canadian industries are moving up the value chain. We find that increasing offshoring and greater competition induce industries to move up the value chain. We also find, as expected, that productivity tends to move in tandem with the composite indicator.

Key words: value chain, productivity, latent variable

Résumé

Monter dans la chaîne de valeur est récemment apparu à l'avant-plan du débat de la politique publique (dans bon nombre de pays développés, dont le Canada) comme un moyen crucial pour favoriser la productivité et la création d'emplois et ainsi contribuer à l'amélioration du niveau de vie. Ce débat comporte, toutefois, une lacune, vu qu'il n'existe pas d'indicateur permettant de comparer facilement les industries pour établir de façon appropriée si elles montent (ou descendent) dans la chaîne de valeur. Dans le document, nous avons créé un indicateur composite constitué d'un certain nombre de déterminants fondamentaux de la productivité (à l'aide de l'approche des variables latentes) et visant à évaluer de façon plus approfondie la situation d'une industrie pour déterminer si elle monte ou non dans la chaîne de valeur. Selon les tendances ressortant du nouvel indicateur, la plupart des industries canadiennes montent dans la chaîne de valeur. Nous avons constaté que l'augmentation de la délocalisation et l'intensification de la concurrence incitent les industries à monter dans la chaîne de valeur. Nous avons constaté aussi, comme prévu, que la productivité tend à évoluer dans le même sens que l'indicateur composite.

Mots clés : chaîne de valeur, productivité, variable latente

1 Introduction

The value chain, also known as value chain analysis, is a concept from business management that was first described and popularized by Michael Porter in his 1985 best-seller, *Competitive Advantage: Creating and Sustaining Superior Performance*. The value chain in its original sense was defined as a sequence of value-enhancing activities. In its simplest form, raw materials are formed into components, which are assembled into final products, distributed, sold, and serviced.[1] In other words, the chain consists of a series of activities that create and build value. In most industries, however, it is rather unusual that a single company performs all value-creating activities (from, e.g., product design, production of components, and final assembly to delivery to the final user) by itself. Most often, particularly in these days of greater (international) economic integration, some (less efficient) activities in which a given company has no competitive advantage are outsourced or offshored – i.e., components or operations, e.g., that would normally be done in-house are done by other companies.[2]

From this perspective, examining whether a firm (or an industry) is moving up or going back the value chain would ideally require evaluating both which value each particular activity adds to the firm's products and services, and more importantly the extent to which the firms focus on activities in which they have a comparative advantage. For instance, in developed economies (particularly), firms, by exploiting their comparative advantages, reallocate resources towards higher value-added activities and move out of lower value-added activities (or transfer them abroad), and thereby move economic activity further up the value chain. This process ultimately maximizes value creation while minimizing costs. In the same line, OECD (2007) stresses that, if

[1] Actually, Porter distinguishes between primary and support activities. Primary activities are directly concerned with the creation or delivery of a product or service. They can be grouped into five main areas: inbound logistics, operations (production), outbound logistics, marketing and sales, and services. Each of these primary activities is linked to support activities which help to improve their effectiveness or efficiency. There are four main areas of support activities: procurement, technology development, human resource management, and infrastructure. For further details on all these activities, see Porter (1985).

[2] Typically, outsourcing involves the purchase of intermediate goods and services from outside specialist providers, while offshoring refers to purchases by firms of intermediate goods and services from foreign providers, or to the transfer of particular tasks within the firm to a foreign location. Thus, offshoring includes both international outsourcing (where activities are contracted out to independent third parties abroad) and international in-sourcing (to foreign affiliates) (OECD, 2007).

developed countries are to remain competitive in the global economy, they will have to increase the level of knowledge and technology embodied in production and exports, which would make competition from lower-income (lower-cost and lower-productivity) countries less likely in the relevant markets. On the other hand, as many developing countries have a strong comparative advantage in low-technology industries (i.e. lower value-added activities), specializing in these activities to exploit their competitive advantage would not therefore move them up along the value chain. Thus from this angle, one can appreciate how 'obscure' this concept of moving up (or going back) the value chain might be! Further, even within the same country, the distinctive features of industries (e.g. capital- vs. labor-intensive industries or technology- vs. knowledge-intensive industries) make it difficult to find a single common and comparable indicator that allows ascertain whether they are moving up the value chain.

Nonetheless, the concept of moving up the value chain has recently made its way to the forefront of public policy debate (in many developed countries, including Canada) as a powerful means to sustain economy growth, job creation and thereby to improve living standards. A shortcoming of this debate, however, is that there is no readily available data that allow us to determine directly (and a comparable manner) whether an industry is moving up along the value chain. In this paper, we take a first step to fill this gap by attempting to construct comparable indicators (across industries) that may allow assessment of whether Canadian industries are moving up the value chain. Furthermore, we explore the factors that might help explain the changes (over time) in these newly constructed indicators. Lastly, we analyze the relationship between the new indicators (measuring the extent of climbing the value chain) and productivity improvement.

The remaining of the paper is organized as follows. The next section provides a brief summary of what we know about the concept of moving up the value chain. Section 3 analyzes indicators of investment in knowledge and adoption and diffusion of new technologies across industries. Section 4 presents the framework for constructing and estimating a *composite* indicator or index of moving up (or going back) the value chain, using the latent variable approach. Section 5 examines the trends in composite indicator and analyzes its explanatory factors and link with labor productivity. Finally, section 6 concludes the paper.

2 What do we know about the concept of moving up the value chain?

Notwithstanding the recent interest in the concept of moving up the value chain, it is worth mentioning at the outset that there is very little scholarly work on this topic in the literature. However, there exist some indicators that have been used to determine whether a given country is moving up the value chain. An indicator often used, particularly for developing or less developed countries, is the export (commodity) composition; or more specifically, the extent to which the share of higher-technology manufactures in the country's total (manufacturing) exports increases. Using this indicator, Canada's Foreign Affairs and International Trade Department (DFAIT) reports that China is moving up the value chain as complex manufactured goods account for a growing share of China's merchandise exports. For example, in 1995 clothing and textiles made up 29.6% of exports, but by 2005 this proportion had dropped to 17.1%. At the same time, the share of exports made up of electronics and machinery increased from 18.6% to 42.2%. Moreover, 6 of China's top 10 exports were textile-related in 1995, but by 2005 7 of the top 10 exports were related to machinery and electrical machinery. Thus, DFAIT argues that this change in export composition suggests that China is moving up the value chain as it develops, producing- and exporting-higher value items.[3]

However, an assessment based solely on a country's export composition (by technological intensity) may be misleading, particularly for developing countries, because of the high import content in exports of higher-technology products. There is a general feeling that most developing countries such as China import parts and components and other intermediates from abroad and then merely assemble them (using locally cheap labor) for re-exports. Obviously, this process does not involve significant domestic value

[3] See Facts & Figures Section (for 2006), *China moving up the value chain*, on Canada Export's website (WWW. CanadExport.gc.ca). Note that it is Canada's official source of news and advice on trade, export and investment opportunities around the world, for entrepreneurs who want to compete, partner and prosper in the global marketplace.

added. For example, Branstetter and Lardy (2006) doubt that China is moving up the value chain; they point out that most information and communications technology (ICT) exports to the U.S. are high-volume commodity products sold primarily by mass merchandisers of electronic products (DVD players, notebook computers and mobile telephones). Moreover, high-value-added components of these products – such as central processors and memory chips – are generally imported. Thus, domestic value added would only account for 15% of the value of exported electronic and information technology products. According to Branstetter and Lardy (2006), China provides mainly low-wage assembly services in accordance with its comparative advantage in labor-intensive activities.[4] Mani (2002) provides similar evidence for Philippines, which is also one of the leading exporters of high-technology products from the developing world.[5]

Thus, according to OECD (2007), when exports depend heavily on imports in the same industries, exports shares do not reveal countries' strengths and weaknesses properly; the contribution of different industries to the trade balance identifies more appropriately countries' comparative advantage. In other words, the net exports by technological intensity of goods is a more appropriate indicator (than the respective gross exports) when examining whether a country is moving up the value chain. Using indicators of revealed comparative advantage (which reflect the contribution of different industries to countries' trade balances), OECD (2007, Fig. 4.12) reports that the comparative advantage of China is still concentrated in low-technology industries, despite its high export figures and its trade surplus in high-technology industries. However, the same indicator shows that only a few OECD countries are specialized in high-technology manufacturing (see OECD, 2007, Fig. 4.10).[6]

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[4] In the same line, Guillaume *et al*. (2005) argue that in high-technology industries, China's comparative advantage clearly lies in the downstream stages of production (i.e. final goods) and not in upstream activities (intermediates, parts and components).

[5] According to Mani (2002), among the five developing countries that accounted for over 95% of total developing countries (1999) exports of high-technology products, Philippines has ranked third.

[6] The technology classification of manufacturing industries is based on R&D intensities and four groups are distinguished (with ISIC Rev. 3 codes in parentheses): high-technology (353, 2423, 30, 32, 33), medium-high-technology (31, 34, 24 excl. 2423, 352+359, 29), medium-low-technology (351, 25, 23, 26, 27-28) and low-technology (36-37, 20-22, 15-16, 17-19). In general, the first two groups are referred to as *higher*-technology industries.

Besides, OECD (2007) uses another indicator – namely the share of countries' total value added accounted for by (higher) technology- and/or knowledge-intensive industries – to ascertain whether its member countries are moving up the value chain.[7] Although this indicator is applied to the OECD area as a whole, it seems that OECD countries are moving to higher-value-added activities, as illustrated by the growing share of higher-technology-intensive industries and knowledge-intensive market services in OECD-area value added.

So far, the indicators we have reviewed focus on the relative importance (either in trade or value added) of industries classified as high- and medium-high technology. A drawback of this particular focus on higher-technology industries is that it draws attention away from the changes that are taking place in less technology-intensive industries. According to OECD (2007), the shift towards more technology and knowledge activities and investments is also taking place within lower-technology industries, as illustrated by the increasing research and development (R&D) intensity of these industries which has grown much more strongly than in other industries.

Finally, to assess the moving up the value chain that takes place in OECD countries, OECD (2007) considers two other indicators: investment in knowledge – defined as investment (relative to gross domestic product (GDP)) in research and development, higher education, and software – and investment (as a percentage of GDP) in machinery and equipment (M&E). Considering the ratio of investment in knowledge to GDP, it appears that OECD countries are moving up the value chain, as this ratio has increased for nearly all reported countries over the period 1994-2002. As for the share of M&E investment in GDP, the conclusion is mixed since this ratio has declined for half of the reported countries over the same period. It is needless to say that the use of these two indicators *together* is appealing and worth doing as this involves both fundamental and

[7] Using the notion of users of embodied technology (based on input-output tables), R&D intensities, and the composition of workforce skills, the following 'market' service industries are considered knowledge-intensive: Post and telecommunication (64), Finance and insurance (65-67) and Business activities (excluding real estate) (71-74).

applied innovations,[8] which have been identified by the new growth theory as the major drivers of productivity improvements. However, an assessment based on these two indicators (as reported *separately* by OECD (2007)) may be problematic for some countries in which the investment in knowledge increases and investment in M&E decreases. As a result, unless we use subjective weights on these reported indicators, one cannot ascertain the direction in which these countries are moving along the value chain. Thus, as we will see in section 4, a contribution of this paper is to adopt a method that allows computing a *composite* indicator by making use of these indicators and avoid subjectivity in determining the weights of each component indicator.

Nonetheless, the few existing studies (or analyses) that address this issue of moving up the value chain lend support to indicators measured by investment in knowledge and/or M&E investment. For example, Sim (2004) developed a two-country analytical framework to examine (theoretically) the factors required for a small-open economy to move up the value chain. He found, among other things, that the small-open economy can move up the value chain when the size of its skilled labor force increases. Further, in the U.K newspaper, The Herald (on Monday 4th June 2007), Jeremy Peat – Director of the David Hume Institute –[9] argues that higher education is vital for climbing the value chain. However, he stresses that just the provision of intellectual capital (by higher education institutions) is not enough; successful moving up the value chain implies emphasis on enhanced skills, much more R&D, (applied) innovation inducing continuing change and dynamic management. In other words, each of these factors is necessary but not sufficient by itself for successfully moving up the value chain. Finally, IMF (2006) stresses that moving up the value chain requires building human capital, absorbing domestic and foreign technologies, and integrating into multinational production chains.

[8] In the literature, applied innovation refers to the adoption and diffusion of new technologies (as measured, e.g., by M&E (including ICT) investment) and fundamental innovation refers to the technology invention or 'true' innovation (as measured, e.g., by R&D expenditures).

[9] The David Hume Institute is a well known independent organization in the U.K. that promotes research, analysis and debate on public policy issues.

Thus, given the arguments made above, the need for constructing a composite indicator (for moving up the value chain) that encompasses all of these indicators (i.e. human capital or skills, R&D expenditure, and M&E investment) is now self-evident. But, let first examine separately (in the next section) the evolution of these indicators within and across Canadian industries (both manufacturing and services).

3 Indicators of investment in knowledge and adoption and diffusion of new technologies

Figure 1 presents the R&D, M&E and skills intensities by Canadian industries (see Table 1 for the industry identifier numbers as shown in Figure 1). The R&D and M&E intensities are defined as the nominal ratio of R&D spending and M&E investment to GDP, respectively, and the skills intensity is measured as the share of hours worked by employees with a university degree and above.[10] Although we have classified industries into five groups (primary and construction, resource-based manufacturing, labor-intensive manufacturing, high-tech manufacturing, and services)[11], Figure 1 presents these variables for each industry as defined in Table 1.

Overall, a key feature that emerges from Figure 1 is that there exists a notable discrepancy in the trends of R&D and M&E intensities and skills for most of the industries and across industries. Consequently, none of them can then be used as a single appropriate comparable indicator to ascertain whether those industries are moving up the value chain. However, since we should consider all three indicators when assessing the moving up that is taking place, we find it appealing (in the next section) to calculate a single index that encompasses all these indicators.

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[10] All data are obtained from Statistics Canada. The R&D data is NAICS based for the period 1994 to 2003 and SIC based for the period of 1982-1993. The NAICS-based R&D data is extended back to 1982 using the growth rates of SIC-based R&D data. It is worth mentioning that for the sake of appropriate comparison and ease of presentation, we computed and presented the indexes for these variables (where 1982 values =100) in Figure 1.

[11] This industrial classification, which groups industries with some similar features, allows an appropriate comparison across industries.

4 Latent variable approach

As mentioned earlier, investment in both knowledge (as measured, e.g., by R&D intensity and the level of skills (or higher education)) and adoption and diffusion of new technologies (as measured, e.g., by M&E investment to GDP ratio) are *all* required factors to move up the value chain successfully. Thus, as all industries generate and/or exploit new technology and knowledge to different extents – i.e. some are more technology- and/or knowledge-intensive than others – it would be more appealing to account for all of them together in examining the move of industries along the value chain. Consequently, in this section, we construct a *composite* indicator using a latent variable model.

A latent variable is not observable, but is estimated as a weighted sum of its multiple indicators.[12] The latent variable approach offers three main advantages. First, it can provide us with a more comprehensive measure of moving up (or going back) the value chain than a single indicator for reasons just mentioned above. Second, it reduces the number of variables in the analysis and helps us to summarize the data – interestingly, this is done by avoiding subjectivity in determining the weight of each component variable. Finally, it resolves multicollinearity problems caused by directly using multiple indicators in a regression. Next, we provide a brief sketch on the estimation of a latent variable.

Let ξ denote an unobservable latent variable that is to be estimated from its n indicators. The empirical relationship between the latent variable and these indicators can be written as:

$$x = \lambda\xi + \delta \tag{1}$$

[12] Our description of the latent variable approach is indebted to Lanjouw and Schankerman (1999), Joreskog and Sorbom (1996), and Tang and Wang (2005).

where $x = (x_1, x_2, ..., x_n)$ is the vector of indicators, $\lambda = (\lambda_1, \lambda_2, ..., \lambda_n)$ is the vector of coefficients of x on ξ, and $\delta = (\delta_1, \delta_2, ..., \delta_n)$ is the vector of error terms.

Assume that the error terms are orthogonal to the latent variable ξ. The covariance matrix of x can be written as:

$$xx^T \equiv \sum = \lambda\xi\xi^T\lambda^T + \delta\delta^T \quad (2)$$

Normalize the variance of ξ to 1, i.e., $\text{var}(\xi) \equiv \xi\xi^T = 1$. As $\sum$ is known, we can derive the estimate of λ, denoted $\hat{\lambda}$, by minimizing the determinant of

$$\Theta \equiv \delta\delta^T = \sum - \lambda\lambda^T \quad (3)$$

Thus, the parameters of the model are estimated by minimizing the difference between the sample covariance of all indicators and the covariance predicted by the model.[13]

Following Lanjouw and Schankerman (1999) and Joreskog and Sorbom (1996), the estimate of the latent variable, ξ, is

$$\hat{\xi} = \hat{w}x, \quad (4)$$

where $\hat{w} = \hat{\lambda}^T \sum^{-1}$.[14]

It is clear from equation (4) that the weight of an indicator depends not only on its correlation with the latent variable, reflected by $\hat{\lambda}$, but also on its variance and its covariance with other indicators. The smaller the variance of the indicator, the higher is its weight.

Thus, we model our composite indicator of moving up (or going back) the value chain as a latent variable, where R&D and M&E investments to GDP ratio and the level of skills (or human capital, measured by the share of hours worked by workers with

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[13] In this paper, the estimation method we use is the maximum likelihood.

[14] More formally, by replacing λ by $\hat{\lambda}$ in equation (1), we have: $x = \hat{\lambda}\xi + residual$. The estimate of ξ is $\hat{\xi} = (\hat{\lambda}^T\hat{\lambda})^{-1}\hat{\lambda}^T x \equiv \hat{w}x$, with $\hat{w} = (\hat{\lambda}^T\hat{\lambda})^{-1}\hat{\lambda}^T$. As $\hat{\sum} = \hat{\lambda}\hat{\lambda}^T$, we have $\hat{w}\hat{\sum} = (\hat{\lambda}^T\hat{\lambda})^{-1}\hat{\lambda}^T\hat{\lambda}\hat{\lambda}^T = \hat{\lambda}^T$. This implies that $\hat{w} = \hat{\lambda}^T \hat{\sum}^{-1}$.

university degree and above) are used as component indicators. More formally, let ξ_{CI} denote our composite indicator. The estimate of ξ_{CI}, $\hat{\xi}_{CI}$ can be written as the weighted sum of the three indicators:

$$\hat{\xi}_{CI} = \hat{w}_1 RD + \hat{w}_2 ME + \hat{w}_3 HK \qquad (5)$$

where RD and ME represent respectively the R&D and M&E investment-to-GDP ratio, HK denotes human capital, and $\hat{w}_i$ ($i = 1,2,3$) is the weight for the corresponding indicator.[15]

It is worth mentioning that this approach is similar to the method used by Lanjouw and Schankerman (1999) to measure innovation.

The estimated weights of each component indicator (i.e. R&D and M&E intensities and skills) for different groups of industries are reported in Table 2. As can be seen, the skills intensity is most heavily weighted (relative to R&D and M&E intensities) in both resource-based and high-tech manufacturing; its weights are 1.38 and 1.78, respectively. On the other hand, the three indicators are almost equally weighted for primary and construction, labour-intensive manufacturing, and services. Overall, these average estimated weights are very consistent with the patterns of the three component indicators across industry groups as can be seen in Figure 1.

5 Trends in composite indicator, explanatory factors, and link with productivity

Figure 2 plots the composite indicator of moving up the value chain as computed from equation (5) using the weights reported in Table 2 – See Table 1 for the industry identifier numbers as shown in Figure 2. The trends in the new indicator suggest that all Canadian industries (except mining and utilities) are moving up the value chain, although at a different pace. In the primary sector, agriculture has made a substantial progress, with the index measuring the extent of moving up equals 256 in 2003, significantly up from

[15] It is worth mentioning that the estimation of a latent variable requires at least three indicators, for technical reasons.

100 in 1982 – i.e. an increase of about 156%. In the manufacturing sector as a whole, moving up the value chain has also been particularly strong in the electrical equipment industry (in high-tech manufacturing), where the index increased from 100 in 1982 to 395 in 2001 – i.e. a rise of about 295%. However, the index has slightly decreased to reach the value of 351 in 2003. In the service sector, wholesale trade, FIRE and management, and professional, scientific and technical are the industries that showed a greater tendency to move up the value chain. For further details, see Table 3 where industries are ranked (within each group industry) according to their average annual growth rate. In the same Table 3, we also present the values of skills (which seems to be a key factor for many industries to move up the value chain) for the latest year available, i.e. 2003. Finally, it is worth reminding to say that this newly constructed composite indicator provides a more comprehensive assessment tool (than single conflicting component indicators) as to whether an industry is moving up the value chain.

Next, in order to identify some explanatory factors that may induce industries to move up the value chain, we assume the following function:

$$IMUP_{it} = f_i(Offsh_{it}, Comp_{it}, RERate_{it}, X_{it}) \qquad (6)$$

where $IMUP$ represents the indicator of moving up the value chain, $Offsh$ denotes offshoring, $Comp$ stands for competition, $RERate$ is the real exchange rate, X is a vector including other control variables such as industry and time dummies, and the indices i and t denote industries and years, respectively.

The offshoring variable ($Offsh$) is defined as the imported share of intermediate inputs. As only the imported share in final demand for each commodity can be derived from input-output tables, we simply assume that for each commodity the imported share in intermediate use is the same as the imported share in final demand. Under the assumption, the imported share of intermediate inputs for each industry can be calculated as the weighted sum of imported shares of all commodities used as intermediate inputs. All Canadian input-output tables are obtained from Statistics Canada. The competition variable ($Comp$) is calculated as the inverse of the regulation impact indicators from the

OECD that measure the extent of anti-competitive product market regulations.[16] The OECD data is ISIC Rev3 based and covers the period of 1984 to 2003. The real exchange rate is estimated by deflating the nominal exchange rate using industrial GDP deflators. The nominal exchange rate and GDP data are obtained from Statistics Canada.

The intuitions behind these explanatory variables run as follows. In these days of (international) economic integration, a firm (or an industry) may decide to source certain activities that require low skills or standard technologies to external providers that have cheaper or more efficient production capabilities. This possibility of offshoring/ outsourcing would likely allow the firm to move up the value chain by focusing on high-value-added activities – i.e. those that are higher technology- and/or knowledge-intensive. Besides, greater competition (involved, e.g., by deregulation and liberalization in some domestic markets) will typically increase the pressure for firms to innovate and adopt new technologies, and thereby to move up the value chain. Another factor that may induce firms to move up the value chain is the appreciation of the domestic currency. For example, a higher Canadian dollar may seriously hamper the price-competitiveness of Canada's manufactures, which may compel them to undertake some innovative activities in order to restore their competitiveness. Actually, successful innovating firms will either have lower costs, and so be able to sell at a lower price, or will have superior quality goods, and in either case will strengthen their competitiveness. Further, another potential implication of the higher Canadian dollar that is often overlooked (but relevant in the context of this study) is the reduction in the costs of imported M&E for Canadian industries, which are in general major importer of this capital. Thus, the resulting potential increase in M&E investment will then allow Canadian industries to further move up the value chain as the latest technologies are typically embodied in new M&E capital.

[16] For further details on the construction of regulation impact indicators, see Conway *et al*. (2006). However, it is worth mentioning that the scale of regulation impact indicator is 0-1 from least to most restrictive, which indicates that a high value of this indicator reflects less competitive environment. Therefore, for ease of interpretation, competition intensity is defined in our empirical analysis as the reciprocal of the regulation impact indicator, so that a high value indicates greater competition.

Using the log-linear (first-order) dynamic panel specification of equation (6), we estimate the following stochastic equation:

$$\begin{aligned}\ln(IMUP_{it}) = \beta_0 + \beta_1 \ln(IMUP_{it-1}) + \beta_2 \ln(Offsh_{it}) + \beta_3 \ln(Comp_{it}) \\ + \beta_4 \ln(RERate_{it}) + \beta_5 X_{it} + \varepsilon_{it}\end{aligned} \quad (7)$$

where ε_{it} are the classical error terms or innovations.

This dynamic specification is likely to alleviate (if not eliminate) the observed serial correlation in innovations. To estimate equation (7), we use both (generalized) Least-Squares Dummy Variable (LSDV) and Generalized Method of Moments (GMM) estimation techniques (see Table 4).[17] As mentioned by Kiviet (1995), when a model for panel data includes lagged dependent explanatory variables, the standard estimation techniques (such as variant of LSDV) lead to estimators which (although consistent and asymptotically efficient) are often seriously biased in small samples, and yield test procedures that (although asymptotically valid) are afflicted with an actual type I error probability which differs considerably from the nominal size. It is because of this potential shortcoming that we also used the GMM estimation technique. More specifically, we employed the Arellano-Bond (1991)'s 1-step estimation procedure, which is well known to be appropriate for estimating dynamic panel models with cross-section fixed effects.[18]

We now turn to the estimation results. As can be seen in Table 4, the parameter estimates by both LSDV and GMM procedures indicate that both offshoring and competition have a positive and significant effect on the composite indicator of moving up the value chain – although, the values of the estimated coefficients are higher with a a GMM approach. In this latter case, the estimated coefficients imply that a one percent increase in the offshoring and competition would raise the moving up indicator

[17] In this paper, LSDV refers to Estimated Generalized Least Squares (EGLS) with cross-section weights.

[18] It is worth mentioning that since the standard errors for the 2-step estimator may not be reliable – they tend to be biased downward in small samples – Arellano and Bond (1991) recommend the 1-step results for statistical inferences. For this reason, we report 1-step results in this paper.

respectively by about 0.09 and 0.19 percent (other things being equal), and vice versa. With the GMM estimation as well, the real exchange rate variable enters with the expected negative sign, but its coefficient is statistically insignificant. Finally, there is some evidence (from both estimation methods) that the first-order autoregressive process model is well specified for the data series as is shown by the significant coefficients of the lagged dependent variable. It is also worth noting that the pattern of serial correlation in the residuals (from GMM) accords with the fact that we have used Arellano and Bond first-differenced procedure (instead of the orthogonal deviation approach). This procedure has the property that if the innovations ε_{it} are serially uncorrelated, the (first-differenced) innovations $\Delta\varepsilon_{it}$ should have significant (negative) first-order serial correlation but no significant second-order serial correlation. As for the orthogonal deviation procedure, if the innovations ε_{it} are serially uncorrelated, the transformed innovations should also be serially uncorrelated.[19]

As a sensitivity analysis, we substitute China's share in total Canadian imports for competition. This share may account for both the contribution of Chinese producers to competition in Canadian markets and the relative importance of China in Canadian industries' offshoring activities. As indicated in Table 4', the introduction of this variable significantly reduces the impact of offshoring, which even becomes insignificant in GMM estimation.

Next, we analyze the relationship between labor productivity[20] level and the composite indicator of moving up the value chain, using a log-linear (first-order) dynamic panel model similar to equation (7). These results are reported in Table 5. After controlling for other variables such as business cycle[21] and competition, we find that the elasticity of the labor productivity level with respect to the moving up indicator is about

[19] Note that difference and orthogonal deviation transformations (within the GMM approach) are applied to the specification of a dynamic panel model to remove cross-section fixed effects.

[20] It is defined as GDP per hour worked. GDP and hours-worked data are obtained Statistics Canada.

[21] The indicator to the business cycle is estimated using the percent deviation of GDP from its trend (H-P filtered).

0.03 (in GMM estimation – with zero p-value), indicating that the newly constructed indicator is statistically significant in explaining labor productivity performance.

6 Concluding remarks

Moving up the value chain has recently made its way to the forefront of public policy debate (in many developed countries, including Canada) as a crucial means to improve productivity performance, job creation and thereby to improve living standards. In fact, products and services that are currently regarded as among the most innovative and experimental in developed countries eventually end up as commodities that can be produced anywhere and by many producers. As a result, OECD (2007) stresses that, to sustain economic growth and remain competitive in the global economy, developed countries will have to increase the level of knowledge and technology embodied in production and exports, which would make competition from lower-income (lower-cost and lower-productivity) countries less likely in the relevant markets. In other words, developed economies or their industries need to move up the value chain by inventing or using new technology, by innovating products and processes and by upgrading human capital.

However, notwithstanding the recent interest in the concept of moving up the value chain, there exists no readily comparable indicator across industries that allows to ascertain appropriately whether they are moving up (or going back) the value chain.

In this paper, we develop a composite indicator of a number of individual fundamental determinants of productivity (using the latent variable approach) for undertaking a more comprehensive assessment as to whether an industry is moving up the value chain. The trends in the new indicator suggest that most Canadian industries are moving up the value chain. We find that increasing offshoring and greater competition induce industries to move up the value chain. We also find, as expected, that productivity tends to move in tandem with the composite indicator.

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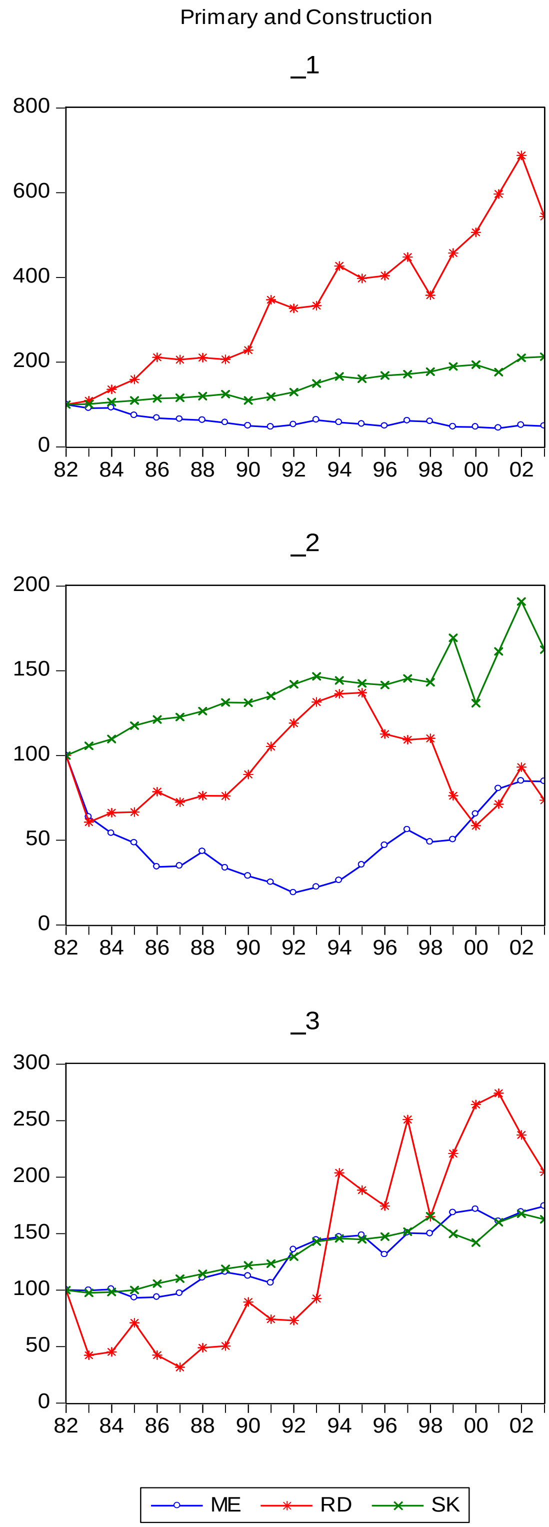
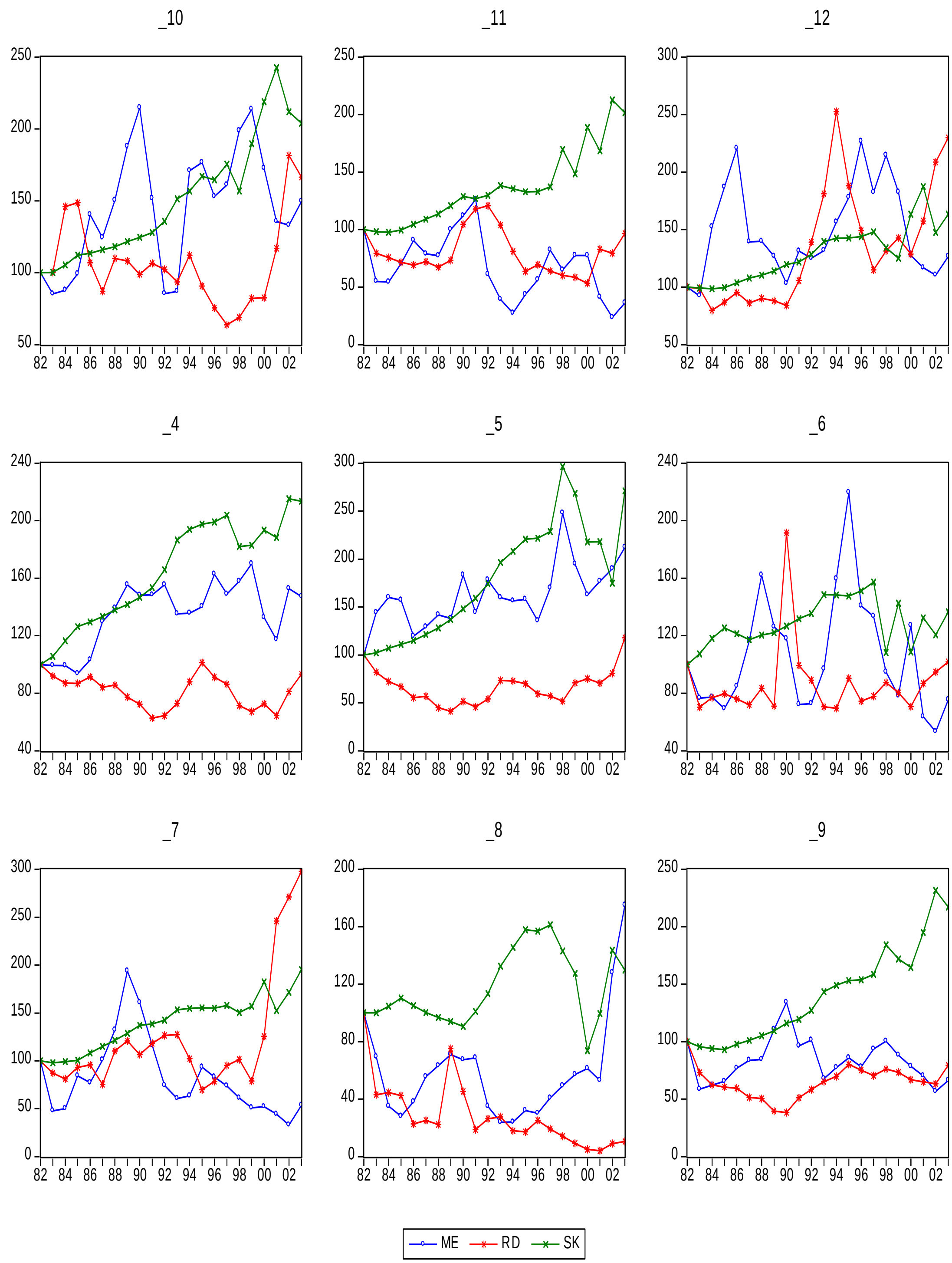
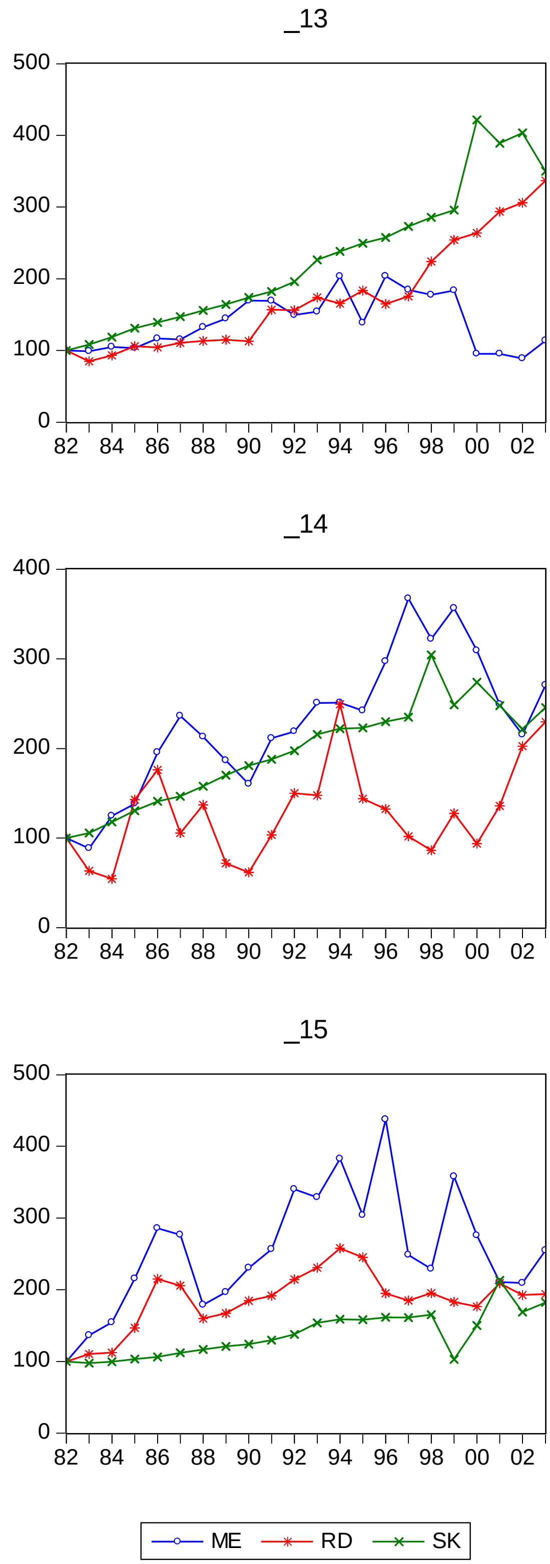
Figure 1: R&D and M&E intensities and Skills by Industry



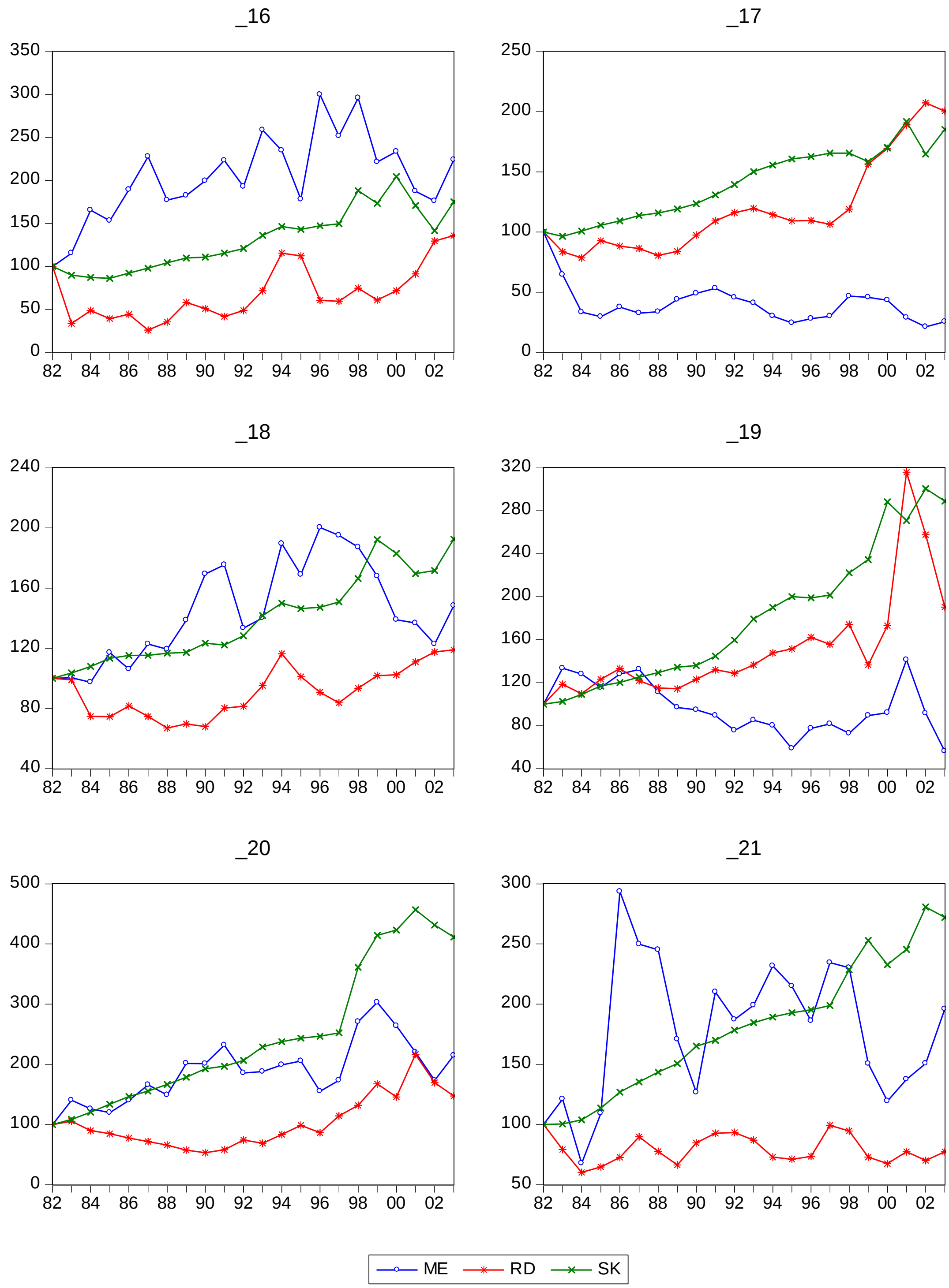
Resource-based manufacturing



Labor-intensive manufacturing



High-tech manufacturing



Services

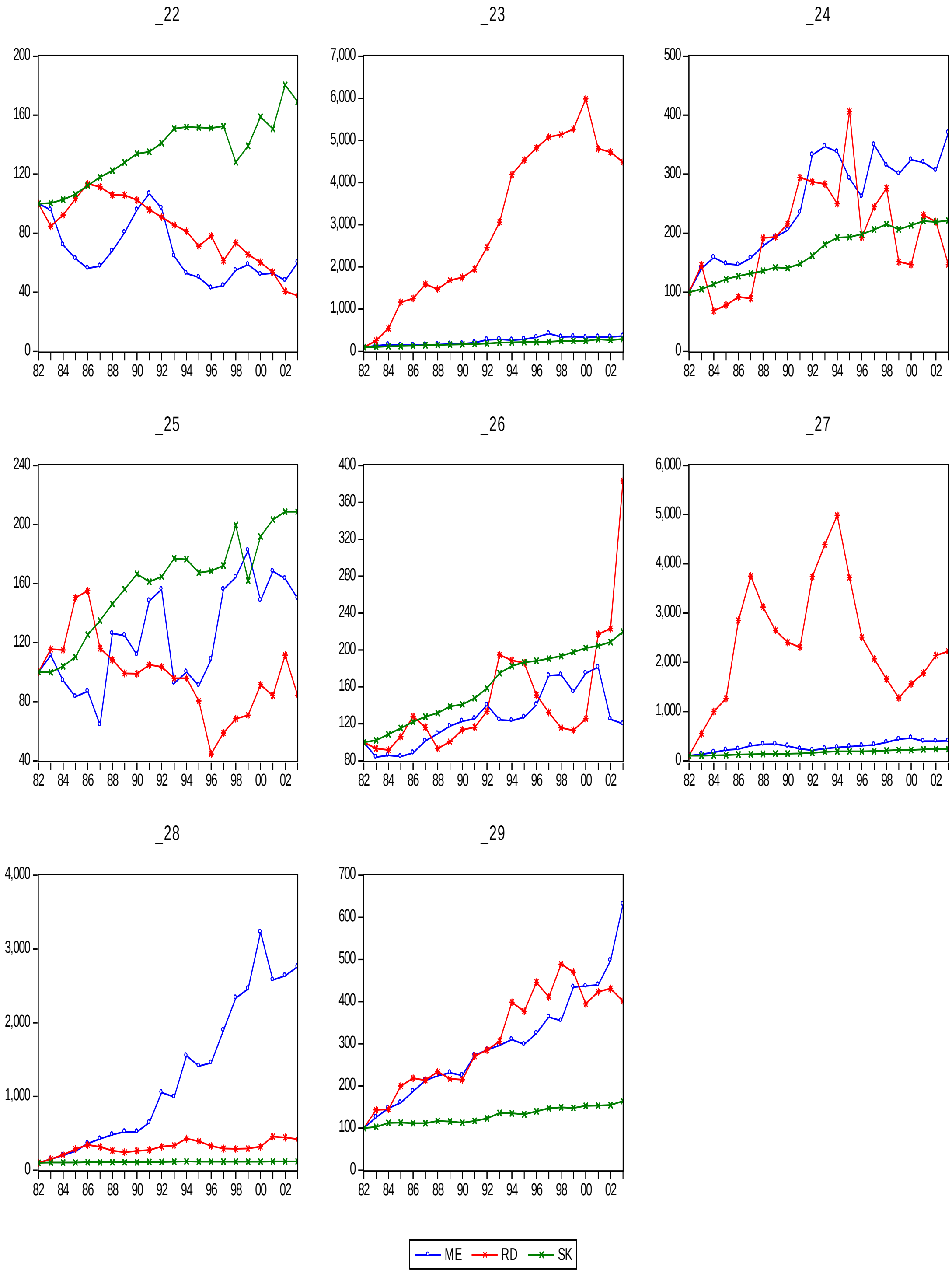
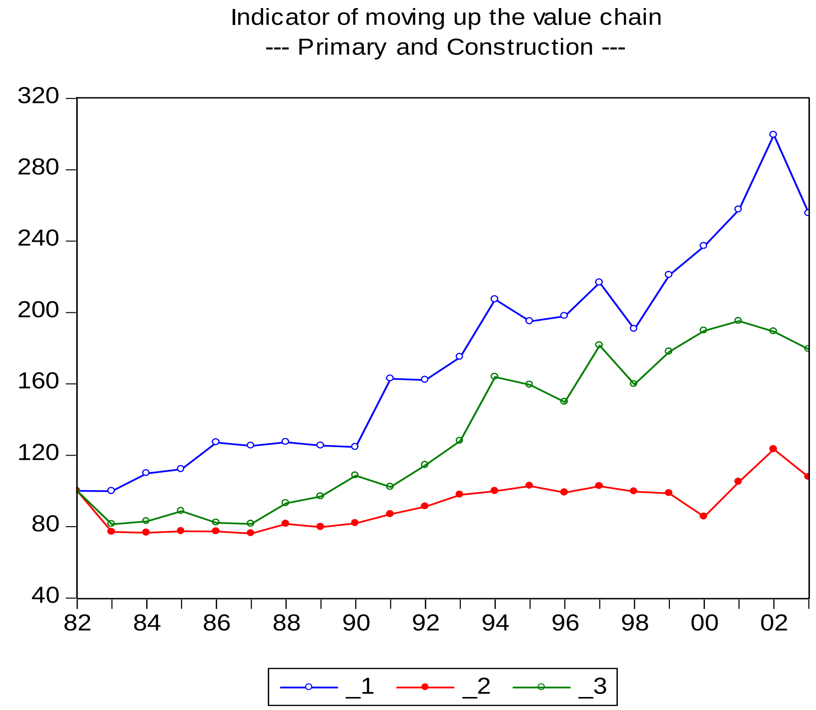
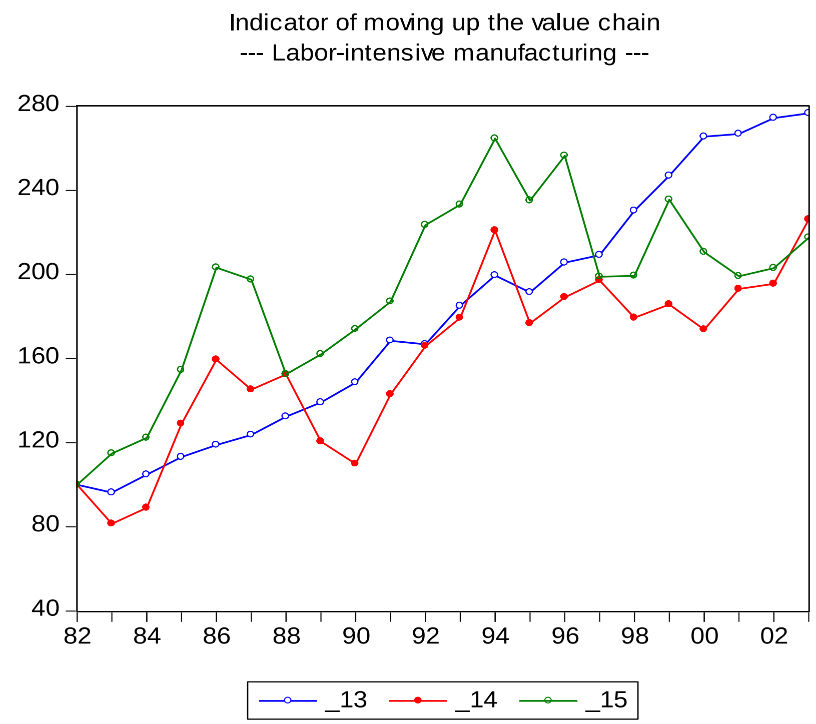
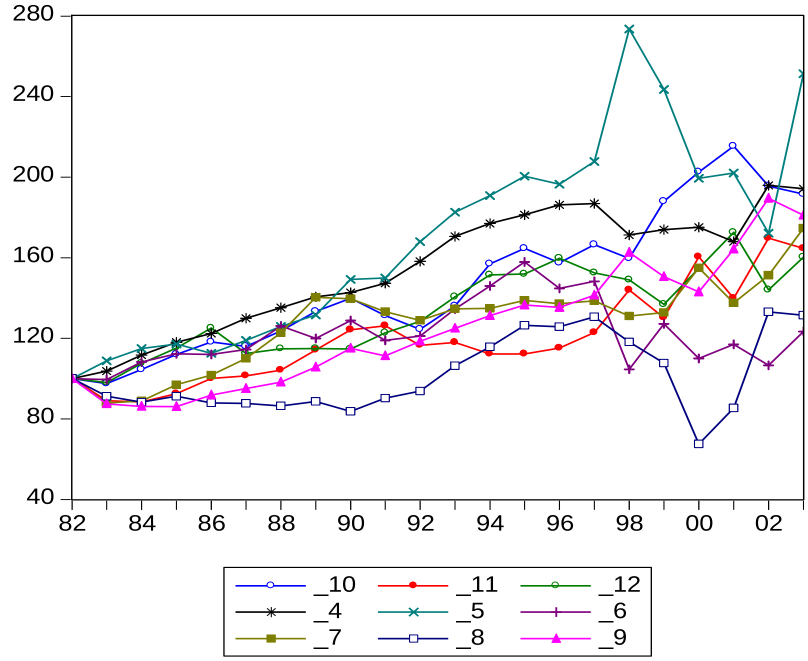


Figure 2: Indicators of moving up the value chain by industry

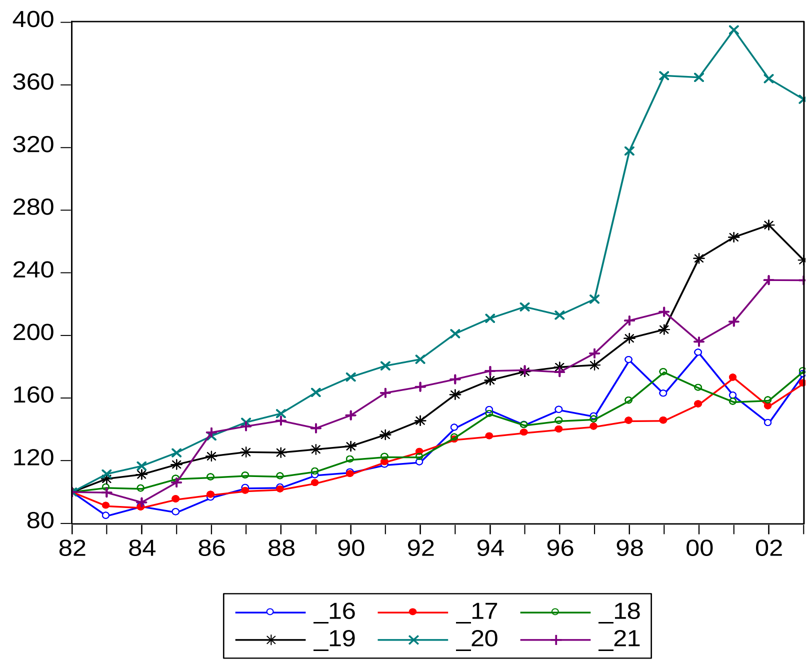


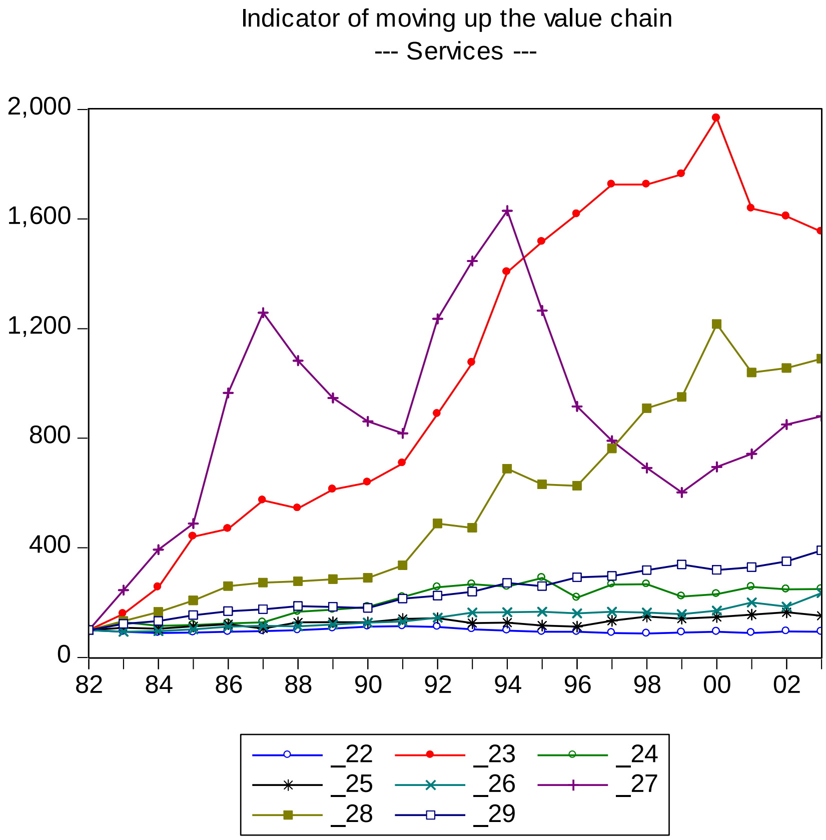


Indicator of moving up the value chain
--- Resource-based manufacturing ---



Indicator of moving up the value chain
--- High-tech manufacturing ---





Indicator of moving up the value chain
--- Services ---
2,000
1,600
1,200
800
400
0
82
84
86
88
90
92
94
96
98
00
02
_22
_23
_24
_25
_26
_27
_28
_29

Table 1: Industries and Identifiers (ID)

	NAICS	ID		NAICS	ID
Resource-based manufacturing			**High-tech manufacturing**		
Food	311	4	Printing	323	16
Beverage and Tobacco	312	5	Chemical	325	17
Wood	321	6	Machinery	333	18
Paper	322	7	Computer and electronic	334	19
Petroleum and coal	324	8	Electrical equipment	335	20
Plastics and rubber	326	9	Transportation equipment	336	21
Nonmetallic mineral	327	10	**Services**		
Primary metals	331	11	Utilities	22	22
Fabricated metal	332	12	Wholesale trade	41	23
Labor-intensive manufacturing			Retail trade	44-45	24
Textile, Apparel, and Leather	313-16	13	Transportation & Warehousing	48-49	25
Furniture	337	14	Information & cultural industries	51	26
Miscellaneous manufacturing	339	15	FIRE, management*	52-55*	27
Primary and Construction			Professional, scientific & tech.	54	28
Agriculture	11	1	Other services	51-56 71-81	29
Mining	21	2			
Construction	23	3			

Notes: **ID** denotes industry identifiers as shown in **Figures**.
* For FIRE, management industry, the NAICS involves 52, 53, and 55.

Table 2: Estimated variable weights for composite indicator of moving up the value chain

Industry Group	R&D	M&E	Skills
Primary and Construction	0,65542	0,76331	0,72834
Resource-based manufacturing	0,10379	0,33985	1,37984
Labor-intensive manufacturing	0,77421	0,56774	0,62770
High-tech manufacturing	0,34832	0,27495	1,78129
Services	0,72185	0,81804	0,90340

Note: Estimation by maximum likelihood using LISREL 8 software. All coefficients are statistically significant at 5% level.

Table 3: Average annual growth rate of moving-up composite indicator (CI) by industry

	NAICS	ID	Skills (%) 2003	CI's Av. Growth Rate (%) 1982-2003
Primary and Construction				
Agriculture	11	1	6.16	5.07
Construction	23	3	6.16	3.40
Mining	21	2	14.22	0.81
Manufacturing				
Electrical equipment	335	20	16.53	6.54
Beverage and Tobacco	312	5	24.26	5.31
Furniture	337	14	7.13	5.26
Textile, apparel, and leather	313-316	13	8.19	5.07
Miscellaneous manufacturing	339	15	17.26	4.71
Computer and electronic	334	19	35.88	4.57
Transportation equipment	336	21	13.96	4.45
Nonmetallic mineral	327	10	7.78	3.38
Food	311	4	10.27	3.32
Printing	323	16	10.81	3.31
Plastics and rubber	326	9	11.67	3.12
Paper	322	7	12.40	2.99
Machinery	333	18	15.43	2.89
Primary metals	331	11	10.70	2.84
Chemical	325	17	31.34	2.67
Petroleum and coal	324	8	19.84	2.62
Fabricated metal	332	12	8.54	2.57
Wood	321	6	5.81	1.64
Services				
FIRE, management	52,53,55	27	29.84	16.63
Wholesale trade	41	23	17.79	15.89
Professional, scientific & technical	54	28	49.79	13.22
Other services	51-56 71-81	29	15.80	6.93
Retail trade	44-45	24	10.75	5.31
Information & cultural industries	51	26	32.15	4.45
Transportation & warehousing	48-49	25	9.38	2.43
Utilities	22	22	22.82	-0.21
All industries				4.87

Table 4: Estimation results for moving-up equation

Dependent variable: Indicator of moving up the value chain

Independent Variable	LSDV Coefficient	LSDV P-Values	GMM Coefficient	GMM P-Values
Intercept	0,8071	0,0000	---	---
Indicator of moving up (lagged 1 year)	0,8425	0,0000	0,7744	0,0000
Offshoring (lagged 1 year)	0,0805	0,0000	0,0887	0,0024
*Competition** (lagged 1 year)	0,0881	0,0004	0,1873	0,0066
Real exchange rate (lagged 1 year)	0,0016	0,9143	-0,0194	0,5259
Cross-section fixed effects	Yes		Yes	
Number of Obs.	609		580	
Adjusted R-squared	0,9705		---	
D.W. Statistics	1,9928		---	
First-order serial correlation	---		Yes	
Second-order serial correlation	---		No	

Table 4': Estimation results for moving-up equation

(Sensitivity analysis with China's import penetration)

Dependent variable: Indicator of moving up the value chain

Independent Variable	LSDV Coefficient	LSDV P-Values	GMM Coefficient	GMM P-Values
Intercept	1,2824	0,0000	---	---
Indicator of moving up (lagged 1 year)	0,7688	0,0000	0,6994	0,0000
Offshoring (lagged 1 year)	0,0404	0,0276	0,0173	0,6085
China's share in imports (lagged 1 year)	0,0640	0,0000	0,0940	0,0000
Real exchange rate (lagged 1 year)	-0,0031	0,8274	-0,0709	0,1518
Cross-section fixed effects	Yes		Yes	
Number of Obs.	609		580	
Adjusted R-squared	0,9710		---	
D.W. Statistics	1,9409		---	
First-order serial correlation	---		Yes	
Second-order serial correlation	---		No	

Table 5: Estimation results for labor productivity equation

Dependent variable: Labor productivity level

Independent Variable	LSDV		GMM	
	Coefficient	P-Values	Coefficient	P-Values
Intercept	0,2943	0,0000	---	---
Labor productivity level (lagged 1 year)	0,8804	0,0000	0,8467	0,0000
Indicator of moving up (lagged 1 year)	0,0170	0,0001	0,0272	0,0369
Competition (lagged 1 year)	0,0307	0,0040	0,0744	0,0381
Business cycle	0,1759	0,0000	0,2834	0,0000
Cross-section fixed effects	Yes		Yes	
Number of Obs.	609		580	
Adjusted R-squared	0,9941		---	
D.W. Statistics	1,8049		---	
First-order serial correlation	---		Yes	
Second-order serial correlation	---		No	