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Abstract

Product selection matters for a firm's productivity and long-run growth. Recent theoretical and empirical studies indicate that an important margin of adjustment to policy reforms is the reallocation of output within firms through changes in product mix decisions. This paper examines the frequency, pervasiveness and determinants of product switching and upgrading activities in firms located in China's state-owned forest areas during a period of gradual institutional and managerial reforms (2004-2008). We find that changes to the product mix are pervasive and characterized by adding or churning products rather than only shedding products. Moreover, changes in firms' product mix have made a significant contribution to the aggregate output growth during our sample period. We also find that firms with different characteristics, human capital and market conditions differ in their propensity to diversify and upgrade product mix.

Keywords: Multi-product firms, product mix changes, product upgrading, firm characteristics, China's state-owned forest areas

JEL classification: D22, E23, L11, O14

1. Introduction

A rapidly growing literature indicates that what a country makes matters for its growth. In the endogenous growth models, such as those in Aghion and Howitt (1998) and Barro and Sala-i-Martin (2003), long-run growth tends to depend on economic structure and the rate at which it is being transformed. These models suggest that specializing in the production of some products is more growth promoting than specializing in others. Hausmann et al. (2007) construct a quantitative index that ranks traded goods in terms of their implied productivity, and show that countries that latch on to higher productivity goods will perform better subsequently. UNIDO (2009) also finds that there is a strong and positive relationship between the sophistication level of a country's industrial production structure (in terms of technology, organizational quality, design and logistics) and its subsequent growth.

As this literature suggests, an important channel for fostering economic growth is to move up the product sophistication ladder by altering the production structure to products that embody high productivity and generate positive learning spillovers to the rest of the economy. However, product switching may be costly. Production of a new good requires investment, the costs of which are borne by the pioneer entrepreneur in full whereas the gains may not be fully appropriated. This occurs in both technology innovation and importation process. Hence if the inducements such as investment subsidies or anti-competition policy to discover costs in new activities are inadequate, product switching may not happen and the investment already made may well be sunk (Hausmann and Rodrik, 2003; Acemoglu et al., 2006). Besides, unfavorable institutions and regulations on input and/or output markets tend to retard product switching due to the associated high sunk costs (Goldberg et al., 2010). Under such circumstances, economic growth is likely to be slowed down.

The link between a country's product sophistication and economic growth applies at the industry and firm level too (UNIDO, 2009). However, there are still few studies on the characteristics and product mix decisions of multi-product firms from developing country settings. The present paper examines patterns of product selection, switching and upgrading, and the determinants of the changes at the firm level. First, it analyzes how firms located in China's state-owned forest areas adjust product lines over a period during which gradual institutional and managerial reforms occurred. Whether a reform can induce a reallocation of resources within industries that will render gains in aggregate output is a core issue for assessing the effect of the reform. Until quite recently, research into industry dynamics has addressed this issue by focusing exclusively on firm entry and exit where each firm is treated as producing a single product, and the adjustments of extensive margins undertaken by multi-product firms through adding and dropping products are ignored (Bernard et al., 2010). Some recent papers empirically examine the contribution of firms' product mix changes to the changes in firms' output over time and find it significant (e. g., see Bernard et al. (2010) for the US, Goldberg et al. (2010) for India and Navarro (2008) for Chile).

The second question this paper seeks to address is how firm level characteristics drive the decision of a continuing firm to alter and upgrade the product mix under the institutional and managerial reforms. We model both the product scope growth rate and the probability of a continuing firm to change product mix against three sets of variables – firm characteristics (ownership, firm age, size, technology level measured by research and development (R&D) intensity and computerization level, productivity level, and product scope), human capital (age, experience, education and political connections of the manager, and education of workers) and market environment variables (credit constraints and perceived raw material supply constraints measured by perceived wood, energy, and other raw material supply constraints). In order to investigate the drivers of upward moves of the product portfolio in the productivity hierarchy, we model the likelihood that a continuing firm will upgrade its product structure as a function of the same variables. An increase in the firm's detrended overall productivity associated with the whole product bundle computed as a firm-level analogue to the index in Hausmann et al. (2007) is used as the measure for product upgrading.

The analysis is based on a unique firm level panel dataset for the years 2004 and 2008 coming from surveys conducted in China's state-owned forest areas. China's state-owned forests account for 42% of the country's total forest area, 68% of total timber volume, and almost all of the nation's natural forest resources. They mainly locate in the upper reaches of large river basins and mountainous regions, and provide various forest-related products and important environmental services (Xu et al., 2004). While historically having contributed enormously to China's economic development, these areas have relapsed into the problem of "two-crises" - ecological degradation and economic loss-making. In order to alleviate this problem, the government has implemented a series of gradual institutional and managerial reforms in recent years that altered the conditions in which the firms operated. While all firms used to be state- or collective-owned workshops of state forest bureaus (SFBs) which are the key economic and political actors in the state-owned forest areas, some of the firms have been privatized, and restructuring of the remaining ones is still ongoing. These areas hence provide an interesting case and an attractive setting. In addition, this dataset contains very detailed product information, not available in most other Chinese dataset, which allows our investigation on product switching and output growth. Moreover, firms in the forest areas usually engage in activities that do not require massive sunk cost investments in new state-of-the-art technology, which implies product switching is not prohibitively expensive and may happen.

We find that there is considerable variation in the value-added associated with different products. Within the same industry multi-product firms in our sample are larger, more productive and more likely to export than single-product firms. In addition, product mix changes are frequent in our sample. Such changes are characterized by adding or churning products rather than only shedding products, and multi-product firms are more likely to change product mix than single-product firms, especially through product churning. Moreover, changes in firms' product mix have made a significant contribution to the aggregate output growth during our sample periods.

The econometric results further indicate that some firms are more prone to diversify and upgrade their product mix than others. Firms that are older, have an R&D department, produce a single product, have a lower proportion of workers with college degree or above, have separate manager and Communist Party leader, and face wood supply constraint in 2004 have higher product scope growth rate between 2004 and 2008. Firms that are less computerized, produce multiple products, have a manager with college degree or above, and have less difficulty in accessing external finance are more likely to change their product mix. Moreover, firms that are less productive, whose manager has no experience of working in governmental organizations but works concurrently as the Party leader, and that are not confronted with constraints in either external finance or energy supply tend to have higher probability to upgrade product portfolio subsequently. These results hold when we control for attrition also.

The remainder of the paper is structured as follows. Section 2 reviews the literature on firm-product level heterogeneity, and the link between productivity of a country's industrial production structure and growth. Section 3 introduces the background of China's state-owned forest areas and ongoing reforms, and describes the data. Section 4 documents the firm-product level patterns. Section 5 presents the nature of product mix changes between the sample years. Section 6 discusses the econometric models and reports the results. Section 7 concludes with a brief discussion on policy implications.

2. Literature review

This paper relates primarily to two strands of a rapidly growing literature. One studies patterns of heterogeneity observed at firm-product level to understand how firms respond to changes in their economic environment. The other examines the link between the productivity of a country's industrial production and export structure, and growth.

Developments in the first literature have been stimulated by the need to ameliorate the drawbacks in the previous research in industry dynamics, where studies focus almost exclusively on the contribution of firm entry and exit to resource reallocation, treat each firm as producing a single product and ignore the adjustments of the extensive margins undertaken by multi-product firms through adding and dropping products in response to policy reforms (Bernard et al., 2010). The analysis on multi-product firms' product mix decisions is intriguing since the intra-firm resource reallocation can potentially be a significant source of productivity increase at the firm level (Aw and Lee, 2009).

Bernard et al. (2010), Goldberg et al. (2010) and Navarro (2008) document patterns of firm characteristics and product mix changes for the US, Indian and Chilean manufacturing firms over the period of 1987-1997, 1989-2003 and 1996-2003 respectively.[1] Though differences in their product

[1] The unit of observation for Navarro (2008) is plant rather than firm.

classifications and design of firm level surveys make it difficult to compare results related to firm and product characteristics across countries, some similar patterns are observed. One common finding is that multi-product firms are stronger performers: multi-product firms are larger in terms of output[2], more productive and more likely to export than single-product firms. In addition, they all find that product switching is a very common activity: 54% and 28% of surviving firms alter their product mix every five years in the US and Indian firms, and three quarters of Chilean firms change product composition in the sample period. Furthermore, changes in firms' product mix have made a considerable contribution to aggregate output growth: it accounts for 25% and 55% of the net increase in Indian and Chilean manufacturing output during the sample period, respectively. These findings stress the importance of product switching activities for output growth and justify the focus on firms' product margin in empirical work (Goldberg et al., 2010; Navarro, 2008).

This firm-product level heterogeneity is usually related to international trade liberalization in this strand of literature. While differing in their assumptions regarding firm-product characteristics and dynamics, recent theoretical models of multi-product firms all predict that the range of products within a firm (i.e. firm scope) is an important margin of adjustment in response to trade policy changes (see Nocke and Yeaple, 2006; Bernard et al., 2009; Eckel and Neary, 2010). A common approach in this literature is to treat product switching as a selection process based on the efficiency (trade costs) of the products. Firms drop their least efficient products, hence reduce scope, and concentrate resources on their core competence. Some empirical analyses provide support for the theoretical predictions. Iacovone and Javorcik (2010) find that fringe products are more likely to be shed than core products in Mexican manufacturing firms during the period of 1994-2003 after the implementation of the North American Free Trade Agreement. Aw and Lee (2009) document trends of specialization in the Taiwanese electronics sector during the 1990s under the circumstances of increased foreign competition.

Relocation of firms across industries or product lines is also empirically relevant in industry dynamics (Plehn-Dujowich, 2009). Dunne et al. (2005) study plant exit patterns in seven industries in the US using Census of Manufactures data for the period from 1963 to 1997. They distinguish two modes of exit: a plant exits the market by entirely shutting down its operation, or the plant remains open but shifts its production toward other products. Averaging across all industries and census intervals, product-line shifts in ongoing plants account for 22% of all exits, while plant closures account for the remaining 78%. When identifying the factors influencing the choice between the modes of exit, Dunne et al. (2005) find that larger and more productive firms are more likely to exit by changing their product lines. On the other hand, market demand has no effect on the decision of a firm to shift out of an industry versus shutdown.

[2] Bernard et al. (2010) and Navarro (2008) also report that multi-product firms are larger in terms of employment.

The emerging literature focusing on the link between productivity of a country's industrial production or export structure and growth originates from the work of Hausmann et al. (2007). The principal message conveyed is that what countries produce matters. While the argument that specializing in the production of some products is more growth promoting than specializing in others is not new, Hausmann et al. (2007) establish a quantitative index by which learning-by-doing effects – a cornerstone in endogenous growth models – can be empirically verified. They first rank traded goods in terms of their implied income or productivity, constructed as the weighted average of the per-capita GDPs of the countries exporting a particular product (which they call PRODY). They then construct the income or productivity level corresponding to a country's export basket as a measure of that country's specialization pattern (which they call EXPY), by calculating the export-weighted average of all the PRODY for that country.[3] This approach attempts to classify products according to the outcomes of structural change they embody rather than the process technology they use (UNIDO, 2009). They find that after controlling for standard covariates countries that specialize in producing and exporting more sophisticated products, those that are primarily manufactured and exported by countries at higher income levels, tend to grow faster subsequently. Two prominent examples are China and India, whose industrial productivity levels are much higher than what would be predicted based on their income levels. The economic mechanism behind this link is that growth is a result of transferring resources from lower-productivity goods to higher-productivity goods identified by the entrepreneurial "cost discovery" process that generates positive knowledge spillovers from the pioneer entrepreneur into new activities to emulators. Since the positive externalities imply that investment levels in "cost discovery" among private economic agents are sub-optimal, Hausmann et al. (2007) suggest government-led industrial policies to promote entrepreneurship and investment into new activities. UNIDO (2009) provides support to the aforementioned positive relationship.

3. Data

3.1. Background of China's state-owned forest areas and its reforms

Accounting for 42% of China's total forest area, 68% of total timber volume and almost all of the nation's natural forest resources (Xu et al., 2004), China's state-owned forest areas are an important part of the forest sector.[4] The formation of state-owned forest areas dates back to the early 1950s, when the vast natural forests mainly in northeastern and southwestern China were decreed to be owned by the state. SFBs, which are actually state-owned enterprises, serve as the key economic and political actors in the state-owned forest areas, with timber logging and transportation, wood processing and silviculture as three primary business sections.[5] They were set up in the 1950s and

[3] Hausmann et al. (2007) focus on exports rather than on production partly because they have more detailed data on exports.
[4] The other part of China's forest sector is collective forest areas.
[5] In China's state-owned forest areas, besides the administrative functions, SFBs operate as corporate enterprises. Their enterprise feature mainly embodies timber production and processing for revenue. This differs from the role of forest bureaus in collective forest areas whose sole responsibility is regional forest resource administration.

1960s by the government to harvest the nationalized natural forests for industrial use. There are 135 such SFBs in China[6], each of which administers hundreds of thousands of hectares of forest area, and employed up to a total of one million people throughout the 1980s and 1990s (State Forestry Administration, 1988-1999). These SFBs as part of the state-owned enterprise system, were also responsible for providing social services for the communities where they located, many of which came into existence due to the establishment of the bureaus (Bennett et al., 2008).

To facilitate wood processing and related product manufacturing, the SFBs set up thousands of smaller mills, which located in geographical vicinity and were often part of the so-called integrated forestry system. Although a majority of them produce wood related products, there are also a host of mills operating in other sectors, such as food and beverage manufacturing, or providing ancillary services to the processing mills, such as machine manufacturing and maintenance. In the planned economy era, the SFBs were both owners and managers, and were the only legal agents to deal with the state over taxation and profit-contracting and with external economic agents (Zhang, 2000). The mills acted only as workshops of the bureaus with all land, capital and other material inputs supplied through budgetary channels, and all profits required to be remitted to the bureaus.

Up through the late-1980s to mid-1990s, the operating expenses and social welfare responsibilities of the bureaus could generally be covered by the revenues generated from timber production and processing from natural forests, despite in many cases via unsustainable harvesting practices (Bennett et al., 2008). However, like other sectors in the planned economy, most SFBs suffered from low efficiency, overstaffing and weak competitiveness and up to the 1990s most of them run into net losses. The state forest sector relapsed into the problem of "two-crises" - ecological degradation and economic loss-making. Hence since the mid-1990s the attempts to restructuring the processing section have never ceased. In general, the reform has followed more or less the same course as in other state-owned industrial sectors (Zhang, 2000), but at a lower rate. The reform has focused primarily on the implementation of "managerial responsibility systems" and on the transformation of organizational models, and then switched to privatization.

"Managerial responsibility systems" were introduced to depoliticize the mills. Under these systems, managers were delegated autonomy to make many decisions, and both managers and workers were given financial incentives – primarily bonuses – contingent on mill performance which was measured by the sum of turned-in taxes and profits to the SFB. In addition, new managers were not exclusively appointed by the SFBs anymore, but through auctioning-off to select competent candidates. The mills became independent cost accounting units, which was a step toward the modern form of firm management. Manifold organizational reform was also widely implemented, including multi-mill corporation formation, joint-stock reform, contracting management, lease management, etc. (Li and

[6] There are 20 other SFBs in China's state-owned forest areas operating only for afforestation and reforestation.

Zhang, 2000). All these arrangements reflected the attempts to maximize the value of the processing business section and to align the interests of the managers and workers with those of the owners.

However, the agency problem was still prevalent and the residual claim of rights was unclear in the state-owned mills. A gradual process of privatization was hence initiated in the late 1990s, partly evoked by the introduction of the Natural Forest Protection Program (NFPP) due to the severe floods in 1998, which called for a logging reduction in state-owned forests and exacerbated the situation of mills whose raw material was mainly bought from local SFBs. Marketizing the mills and removing the political influence of the SFBs were the main policy changes purporting to alleviate the “two crises”. The privatization process is still on-going.

3.2. Data collection

This study uses combined panel data on firms and SFBs located in China’s Northeast-Inner Mongolia state-owned forest area, collected in face-to-face interviews with the firms’ management and SFBs’ officials in 2005 and 2009 by the Environmental Economics Program in China. The survey area covers Heilongjiang and Jilin provinces and Inner Mongolia Autonomous Region, and the dataset includes information for 2004 and 2008.

The sampling frame for the SFBs and firms is as follows. The forests in this area are divided, based on geographical locations, into seven regional SFBs and managed by 84 subordinated SFBs. The survey covered all seven regional SFBs. At each level the samples were randomly selected to guarantee representativeness. In each regional SFB, the subordinated SFBs were stratified into three groups by the size of the forest area administered, and one was randomly selected from each group.[7] Ten firms were then randomly selected from each of the chosen SFBs. In total 206 firms were finally included in the survey.[8] Since 32 firms did not provide detailed product information or data on other major variables, they are excluded from our analysis. As a follow-up survey, the 2009 survey tracked the same SFBs and firms that were interviewed in 2005 and no new entrants were taken into consideration. Systematic reasons (e.g. shutdown, merger and acquisition, temporary suspension of production) and random dropouts (e.g. non-reachable, decline to answer, missing values in major variables) rendered a reduction in the number of firms to 97 in the 2008 data.[9]

While the sample size is small, the information collected is rather rich. At the SFB level, it contains information on SFBs’ forest resource, production and sales, financial status, employment, leadership and ongoing projects. At the firm[10] level, the questionnaire consists of two parts. One part, designed to be answered by the firm manager, asks questions about the firm’s basic characteristics,

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[7] To account for the fact that the number of SFBs under the jurisdiction of Yichun regional SFB in Heilongjiang Province doubled that in other six regional SFBs, one more set of sample SFBs was selected. Consequently, fifteen, six and three SFBs were selected from Heilongjiang, Jilin and Inner Mongolia, respectively.

[8] According to the sampling frame, 240 firms were supposed to be interviewed. However, due to the limited number of firms in some SFBs, not up to ten firms could be reached in all SFBs. In such cases, all entities were interviewed.

[9] Systematic reasons account for 56% of the observation reduction and random dropouts for the remaining44%.

[10] The unit of observation in our sample is firm. It is rarely the case that a firm has more than one plant in our sample area.

ownership structure and privatization process, histories of manager turnover, managerial arrangements, contractual relations with the SFBs. The other part, directed to the accountant, covers details about the firm's major financial sheets and use of inputs (capital, workers and wage bills, material and energy). The survey also records detailed information on each firm's product list including names, production and sales prices, quantities and thereby values. In addition, general information on product market and raw material market environments is also collected. Hence, this dataset is well suited to study how firms in the state-owned forest areas adjust their product lines over time and how their choices may be related to the firm level characteristics.

3.3. Product classification

While our sample firms are located in forest areas, they do not exclusively produce wood related products. The reporting of products by our sample firms is not governed by any particular product classification. Since the names of products reported by the firms could differ in aggregation or the way firms called them, we standardize the product names and define product, industry and sector according to two national standards. One is China's Industrial Classification for National Economic Activities (2002), henceforth ICNEA, which categorizes economic activities in China into four levels, using English alphabets, two-, three- and four-digit codes respectively.[11] The other is China's Product Classification for Statistical Use (2010), henceforth CPC, which classifies the products to a more disaggregated level. CPC uses a five-level coding system, with two-, four-, six-, eight- and ten-digit codes. ICNEA and CPC are harmonized at the two- and four-digit code levels.[12] We map all reported product names into six-, eight- or ten-digit CPC codes and take this as the definition of a "product".[13] We refer to the three-digit ICNEA categories as "industries" and two-digit ICNEA categories as "sectors". There are a total of 90 products linked to 26 industries across 17 sectors in our data.

Table 1 reports the distribution of industries and products by sector in the 2004 and 2008 pooled sample. The distribution of products by sector is highly heterogeneous. The number of products ranges from one in seven sectors to 47 in the Processing of timber, manufacture of wood, bamboo, rattan, palm and straw products sector (ICNEA 20), henceforth wood processing. Similarly, the average number of products per industry within sectors ranges from one in ten sectors to 16 in wood processing. As observed in the table, 71.9% of the sample firms operate in the wood processing sector. Comparing the distribution of industries and products by sector between pooled all firms and pooled continuing firms[14], the patterns are similar. However, in the latter sample the total number of products

[11] ICNEA is comparable to the UNSD: 1989, International Standard Industrial Classification of All Economic Activities, NEQ.

[12] At the four-digit level, ICNEA and CPC assign the same code to most, but not all economic activities. However, this does not matter for our analysis, since we do not use the four-digit codes as our classification for product, industry or sector.

[13] Eight-digit codes are our primary standard of classification. Two products are classified at the ten-digit level. Since for some products six-digit codes that are the most disaggregated level in CPC are not disaggregated enough for our analysis, we created the 8-digit codes by ourselves. This applies to eight products.

[14] Number of observations for the pooled all firm sample is 271, 174 for year 2004 and 97 for year 2008. Number of observations for the continuing firm sample is 194, 97 firms for each year.

reduces to 74 related to 19 industries and 14 sectors, and the share of firms operating in wood processing sector falls to 70.6% (results not shown). For continuing firms the number of products and industries increases from 62 to 66, and from 17 to 18, respectively, between 2004 and 2008. In addition, the share of firms operating in wood processing sector drops from 72.2% to 69.1%.

< Table 1 to be here >

An example of the mapping hierarchy of sectors, industries and products is given in Table A1 in the appendix. The table reports two industries within the wood processing sector (ICNEA 20): Processing of sawnwood and wood chips (ICNEA 201), which contains 17 products, and Manufacture of panel board (ICNEA 202), which contains 10 products. As with all classifications, the degree of detail varies across industries and sectors. Even so, we refer to firms producing only one product by our definition as single-product firms, and multi-product firms otherwise. A full list of sector, industry and product classification is available in an Online Appendix[15].

4. Firm-product level patterns

The overall aims of this paper are to document how firms in China's state-owned forest areas adjust their product lines over a period of institutional and managerial reforms and to identify firm level characteristics that may affect product switching and upgrading. In this section, we portray product level value-added, and compare single- and multi- product firms in terms of their economic significance and main firm characteristics.

First of all, we investigate how products differ in terms of their value-added. This is done by estimating a log-form value-added Cobb-Douglas production function with product dummies as follows:

$$lnvalueadded_{it} = \alpha_L lnL_{it} + \alpha_K lnK_{it} + \sum_j \theta_j P_{ij} + \alpha_t year_t + \varepsilon_{it} \qquad (1)$$

where $valueadded_{it}$ is firm i's value-added level in year t measured as total sales revenue[16] minus the value of total material inputs (i.e. sum of the non-labor expenses on raw materials and energy), L_{it} is firm i's labor in year t measured by number of workers, K_{it} is firm i's capital in year t measured by the net value of fixed assets, P_{ij} is firm i's product dummy for product j, and $year_t$ is the year dummy. The product dummy is equal to one over the number of product(s) for each product that firm i produces and zero otherwise. The time dimension of the product dummies is suppressed since we assume that the value-added associated with each product (θ_j) is prevailing during the whole sample period. Value-added and capital in 2008 are converted to 2004 constant values using different price

[15] The web address is http://www.economics.handels.gu.se/english/staff/phd_candidates/qian_weng/.
[16] We focus on revenue-based measures of productivity rather than quantity-based measures because data on physical units of quantity are not available for all products and physical units of output are not comparable across firms for many products, e.g. wooden furniture. We are fully aware of the possible problems of revenue-based productivity measures as pointed out by Foster et al. (2008) and Katayama et al. (2009). It is somewhat soothing that Foster et al. (2008) find a highly positive correlation between revenue- and quantity-based measures of productivity for a sample of 11 homogenous products using the US Census of Manufactures data.

indices as deflators to capture the real value changes.[17] The estimated coefficients $\hat{\theta}$s hence indicate differences in the value-added level associated with different products, conditional on the other explanatory variables in the model. Table 2 presents the estimation result of equation (1). The Wald test result of the coefficient estimates associated with the product dummies indicates that the products are jointly significant at less than 1% level. The standard deviation of these estimates is around 2, implying that there is a wide dispersion of the product-specific value-added. This result suggests that product selection does matter for the value-added level for a firm as a whole.

< Table 2 to be here >

We then explore the relative economic significance of single- and multi-product firms in China's state-owned forest areas. Table 3 reports the average breakdown of single- and multi-product firms in terms of number and aggregate output (i.e. total sales), and also the average number of products, industries and sectors multi-product firms produce across 2004 and 2008. As indicated in the table, multi-product firms account for 47% of the firms and 50% of the aggregate output. They are relatively more important, but not as dominant as found in the US (Bernard et al., 2010) and Indian (Goldberg et al., 2010) cases.[18] Multi-industry and multi-sector firms exert similar influence, responsible for 34% and 9% of the firms and 43% and 25% of the output, respectively. Column (3) of Table 3 reveals that multi-product firms on average manufacture 2.76 products, that multi-industry firms on average operate in 2.25 industries and that multi-sector firms on average are present in 2.08 sectors.

< Table 3 to be here >

Table 4 compares the characteristics of single- and multi-product firms in the 2004 and 2008 pooled sample. Each cell reports a separate Ordinary Least Squares (OLS) regression coefficient (standard error in parenthesis) of the (natural logarithm of) firm characteristics (except probability of export which is a binary dummy) on a dummy variable equal to one if the firm produces more than one product (i.e. multiple products, column (1)), operates in more than one industry (column (2)), and operates in more than one sector (column (3)), respectively, with industry and year fixed effects controlled. As reported in the table, multi-product firms in our sample are significantly larger than single-product firms within an industry in terms of output (0.751 log points), employment (0.569 log points) and capital (0.753 log points).[19, 20]

[17] Different variables in 2008 are adjusted by different price deflators to the 2004 price level. Sales revenue is deflated primarily by sectoral *producer price indices for manufactured goods*, together with *producer price index* for sector Forestry (ICNEA 2) and Husbandary (ICNEA 3), and country-level *retail price index* for sector Storage services (ICNEA 58). Capital is deflated by provincial *price indices for investment in fixed assets*. Material input is deflated by *purchasing price indices for timber and pulp paper sector*. The reason for choosing this price index is that timber and related stuff is the main material for our sample firms. Energy input is deflated by country-level *purchasing price indices for fuel and power*. All the price indices are obtained from the China Statistical Yearbook (2006-2009) and based upon the authors' calculation.

[18] Though it is nice to link our results to the findings from other studies in the literature, we have to admit that comparisons between our study and other studies must be conducted with great caution since the sample coverage, size and economic environments in which the firms operate differ tremendously.

[19] The Average size of the firms, measured by output, employment and capital across the two years, is 10385 thousand CNY (1 USD=6.32 CNY in January 2012), 160 employees and 6001 thousand CNY, respectively. The standard deviation is 24237 thousand CNY, 362 employees and 17790 thousand CNY, respectively, indicating that the range of firms covered by the survey is large. Firms range in size from 6 to 192314 thousand CNY in output, from 2 to 4992 in employees, and from 2 to

< Table 4 to be here >

Multi-product firms are also more likely to export and have higher revenue-based total factor productivity (TFP)[21] and labor productivity[22] than single-product firms in the same industry, though the differences are statistically insignificant. This is in general consistent with the cross-section evidence reported by Bernard et al. (2010) and Goldberg et al. (2010). Similar patterns are discovered with respect to firms producing in multiple industries and sectors, except that the differential in probability to export turns out to be marginally significant.

The model presented in Bernard et al. (2009) predicts that firms possess "core competencies", implying that firms should have highly skewed distribution of output towards products for which they have particular expertise. We find support for this prediction in our data that the distribution of output across products within the firms is uneven and firms possess a "core competent" product, as shown in Table 5. The average share of the "core competent" product ranges from 73% to 46% in total output in firms that produce from 2 to 6 products. These results are comparable to what Bernard et al. (2010), Goldberg et al. (2010) and Navarro (2008) find for the US, Indian and Chilean manufacturing firms, respectively.

< Table 5 to be here >

5. Product mix changes over time

In this section, we follow the empirical product mix change literature (e.g. Bernard et al., 2010; Goldberg et al., 2010; Navarro, 2008) to examine the importance of changes in firms' product margin over time. The average number of products across firms in our sample increased from 1.71 in 2004 to 2.03 in 2008.

We first illustrate the nature of product mix changes between 2004 and 2008 that resulted in the observed expansion of the extensive margin. We classify the continuing firms into one of four mutually exclusive groups based on the manner in which they alter their product mix according to the 2004 data. The possible activities are: (1) no change – the firm does not change its product mix; (2) add only – the firm only adds products, i.e. some products are produced in 2008 but not in 2004; (3)

176300 thousand CNY in capital.

[20] At first glance it seems to be contradictory with the finding from Table 3 that single- and multi-product firms are similar across size. When comparing the distribution of size (output, employment and capital) between single- and multi-product firms, we find that the means are very similar, whereas the median of multi-product firms is twice as large as that of single-product firms. Therefore, the similarity across size can be explained as driven by some exceptionally large single-product firms.

[21] Revenue-based TFP is measured as the residual of the log-form Cobb-Douglas production function

$$TFP_{it} = lnY_{it} - \alpha_L lnL_{it} - \alpha_K lnK_{it} - \alpha_M lnM_{it}$$

where Y_{it} is firm i's output in year t measured by total sales revenue, L_{it} is firm i's labor in year t measured by number of workers, K_{it} is firm i's capital in year t measured by net value of fixed assets, and M_{it} is firm i's materials in year t measured by the value of non-labor raw material and energy inputs. Instead of estimating the production function and obtain the estimates of input coefficients, we assume constant returns to scale and compute the factor cost shares. Factor share of labor is calculated as the share of total annual wage bill in the firm's total sales revenue, and factor share of materials is calculated as the ratio of the total expenditure on material inputs to the firm's total sales revenue. The factor share of capital is hence the residual share after deducting the shares of labor and materials from one. We then take the median of the factor shares, and they are 0.19 for labor, 0.14 for capital and 0.67 for materials.

[22] Labor productivity is measured as value-added per worker.

drop only – the firm only drops products, i.e. some products are produced in 2004 but not in 2008; (4) both add and drop – the firm both adds and drops products, i.e. "churns" products.

Table 6 reports results based on this classification. The top panel displays average share of continuing firms engaging in each type of product-switching activity, and the bottom panel shows a similar breakdown but weighting each firm by its output. Three findings can be observed. Above all, product mix changes are frequent among our sample firms and adding or churning products is more common than only shedding products. As indicated in the first column of the top panel, over the four year period 61% of the surviving firms alter their product mix, 26% by adding at least one product, 8% by dropping at least one product, and 27% by both adding and dropping at least one product. This suggests that the costs are relatively low to alter product lines. Secondly, smaller firms are more likely to switch product lines. Column (1) in the bottom panel suggests that product-switching firms that account for 61% of the firms only account for 36% of the total output. Thirdly, by comparing results in columns (2) and (3) we find that multi-product firms are more likely to change product mix than single-product firms, especially through product churning. When our results are compared to the findings for the US, India and Chile, the third result is similar, however Indian firms experience much less product switching than firms in our dataset, and in the US and India larger firms are more prone to alter product mix in comparable time intervals.

< Table 6 to be here >

In order to investigate the contribution of changes in product mix to changes in output of continuing firms, we then decompose the aggregate changes in output into changes in output due to changes in product mix (i.e. the extensive margin) and changes in output due to existing products (i.e. the intensive margin). Let Y_{ijt} be the output of product j produced by firm i in period t, E be the set of products that a firm produces only in period t or $t-1$ (i.e. the extensive margin), and I be the set of products that a firm produces in both periods t and $t-1$ (i.e. the intensive margin). The changes in a firm's aggregate output between periods t and $t-1$ can be decomposed as $\Delta Y_{it} = \sum_{j\in E} \Delta Y_{ijt} + \sum_{j\in I} \Delta Y_{ijt}$. We can further decompose the (net) extensive margin and (net) intensive margin: the former into the margins due to product addition (A) and product dropping (D), and the latter into the margins due to product growing (G) and shrinking (S). Hence the change in aggregate output among continuing firms in our sample is

$$\Delta Y_t = \sum_i \left[\left(\sum_{j\in A} \Delta Y_{ijt} + \sum_{j\in D} \Delta Y_{ijt} \right) + \left(\sum_{j\in G} \Delta Y_{ijt} + \sum_{j\in S} \Delta Y_{ijt} \right) \right] \tag{2}$$

Table 7 presents the decomposition. Column (1) reports the aggregate output growth. Columns (2)-(4) report the contribution to growth from the firms' extensive margin. Columns (5)-(7) report the contribution to growth from the firms' intensive margin. As shown in the first column, aggregate output of the continuing firms increases 59% from 2004 to 2008. (Net) extensive margin and (net) intensive margin contribute to 86% (0.51/0.59) and 14% (0.08/0.59) of the growth, respectively. This finding is at odds with those from the US and India, where firms' intensive margin accounts for the majority of the output growth during their sample periods. When looking at the decomposition within extensive and intensive margins, we find that our data indicate a high level of "excess reallocation" (as coined by Bernard et al., 2010) which highlights the fact that gross changes in product output are substantially larger than the associated net changes.[23] As can be seen from columns (2)-(4), both product additions and subtractions contribute to output changes so that the gross extensive margin (0.72+0.21=0.93) is almost twice as large as the net extensive margin (0.72-0.21=0.51). A similar pattern can be found in the resource reallocation away from shrinking products to growing products within the intensive margin.

< Table 7 to be here >

6. Product mix changes and firm level characteristics

6.1. Econometric models and results

In this section, we identify the factors that may affect the decision of a continuing firm to alter and upgrade product mix. Before presenting the econometric model, we first discuss our measures for product mix changes and upgrading.

We measure product mix changes in two ways. The first indicator is the growth rate in distinct products, calculated as the number of products produced by a continuing firm in 2008 divided by the number of products produced in 2004, minus one. The second indicator is a binary dummy which is equal to one if a continuing firm adds and/or drops products between 2004 and 2008, zero if not. This variable reveals the likelihood of a continuing firm to alter product mix, either in terms of changes in product number or changes in product portfolio composition with product number kept constant.

To determine whether product mix changes amounts to upgrading, we construct an index analogous to EXPY in Hausmann et al. (2007) but at the firm level. The key underlying assumption here is that productive firms produce more sophisticated products and unproductive firms produce less sophisticated goods. An index $PRODVAD_j$, similar to PRODY in Hausmann et al. (2007), is calculated as

$$PRODVAD_j = \sum_i \frac{s_{ji}}{\sum_k s_{jk}} \cdot VAD_i \tag{3}$$

where s_{ji} is the value share of product j in firm i's total sales, $\sum_k s_{jk}$ is the aggregate of value shares across all firms producing and selling the product, and VAD_i is the value-added per worker of firm i. This index hence represents the weighted average productivity level associated with product j among its producers. As compared to the value-added associated with each product deriving from estimating equation (1), this product level productivity measure takes the relative importance of each product in a

[23] Within extensive and intensive margins, gross change in output is defined as the sum of the absolute values of the breakdowns for output change, and net change is defined as the sum of the values of the breakdowns for output change.

firm into consideration. The productivity level associated with firm i's entire product portfolio, $SALEVAD_i$, is in turn defined by

$$SALEVAD_i = \sum_j s_{ji} \cdot PRODVAD_j \qquad (4)$$

This is the weighted average of $PRODVAD_j$ for that firm. $PRODVAD$ and $SALEVAD$ indices are calculated for 2004 and 2008 respectively.[24] In order to take account of the co-variation in different firms' overall productivity in a given year, we detrend this index by computing the percentage difference between $SALEVAD_i$ and median $SALEVAD$ in respective years as

$$DeSALEVAD_i = \frac{SALEVAD_i - median(SALEVAD)}{median(SALEVAD)} \qquad (5)$$

Product upgrading is hence defined as a positive change in a firm's $DeSALEVAD_i$ between the sample years, and represented by a binary dummy taking the value of one if a continuing firm experiences such a positive change and zero otherwise.

Wang et al. (2010) have identified some weaknesses associated with the PRODY and EXPY indices proposed by Hausmann et al. (2007). In particular, Wang et al. (2010) argue that the key assumption underlying PRODY – the more advanced countries produce more sophisticated products – may not be true. More advanced countries may often produce a larger set of products than poor countries. Moreover, larger countries may also often produce a larger set of goods than smaller countries. These features suggest that the PRODY index may overweight advanced and large countries. Secondly, detailed diversity in the quality and variety of goods within a product category may not be revealed by the indices. As analogies to the PRODY and EXPY indices, our measures $PRODVAD$ and $SALEVAD$ may suffer similar weaknesses. However, our product upgrading measure tries to partly mitigate the first pitfall mentioned above. The possible overweighting of productive and large firms in $PRODVAD$ may render an upward biased computation of both $SALEVAD_i$ and median $SALEVAD$, but the differencing procedure in $DeSALEVAD_i$ construction tends to offset the upward bias.

The econometric model is specified as

$$change_{it} = \beta_0 + \beta_1 firm\,char_{it-1} + \beta_2 H_{it-1} + \beta_3 market_{it-1} + \beta_4^k sec_{it-1}^k + \varepsilon_{it} \qquad (6)$$

$change_{it}$ denotes the dependent variable of interest – product growth rate, the probability of a continuing firm to change product mix, and the probability of a continuing firm to upgrade product portfolio between the sample years. All models are estimated by OLS, and the initial year's data are used for all the explanatory variables to mitigate potential endogeneity problems. Firm characteristics include ownership (private vs non-private), firm age, firm size (measured by capital stock) and technology level (measured by R&D intensity and computerization level). We also control for the firm productivity level (measured by the natural logarithm of TFP) and the product scope (single- vs multi-product). Human capital variables include age, experience, education and political connections of the

[24] We suppress the time dimension of the indices to keep the expressions simple.

manager, and education level of workers. Market environment variables include credit constraint and perceived raw material supply constraints (measured by perceived wood, energy and other raw material supply constraints). The definitions of these variables are listed in the top panel of Table 8. We also control for sector dummies to account for differences in sector-specific market demand conditions and shocks.

< Table 8 to be here >

Amongst the firm characteristics variables, ownership is one important variable. Compared to non-private firms, private firms have more discretion over product choice and less interference from the SFBs in their production decision-making. In all private firms the direct managerial group, consisting of manager, Communist Party leader, board chairman or partners, controls production decision-making, whereas this is true for only two thirds of the non-private firms. Some studies have shown that restructuring of state-owned enterprises in China has had positive effects on labor productivity and profitability (Dong et al. 2006; Bai et al., 2009), as well as on innovative effort and returns to capital (Jefferson and Su, 2006). In addition, technology level captures the investment and sunk costs associated with innovation. Firms with an R&D department are expected to undertake more innovative activities and hence have a higher chance of improving future productivity. Fisher-Vanden and Jefferson (2008) find that in-house R&D, together with autonomous technical change and purchase of imported technology, are three sources driving technical change in Chinese industry. In-house R&D tends to be used for existing products, whereas foreign technology transfer focuses on new product development. However, computerization level may have two counteractive effects: on the one hand, it may be more costly for firms more highly computerized to switch from the production of one product toward alternative products; on the other hand, more highly computerized firms are more efficient in management of production hence are more likely to improve future productivity.

A growing body of literature shows that political connections can help firms obtain favorable regulatory conditions (Faccio, 2006), overcome institutional difficulties (Li et al., 2006), and achieve secure access to resources such as bank loans (Bai et al., 2006; Khwaja and Mian, 2005) and courts to settle business dispute (Li et al., 2008). This will eventually increase the value of firms or improve their performance (Fisman, 2001; Johnson and Mitton, 2003). To control for political connections, we include in the econometric specification dummy variables indicating whether the current manager has ever been a government official and whether the manager also works as the leader of the Communist Party of China [25].

The market environment variables measure two types of constraints on firm development – raw material supply constraints and credit constraint. The former capture some market and state failures

[25] According to the Constitution of the Communist Party of China (Articles 29, 30 and 32), in whatever working unit where there are three or more Party members, a branch of primary Party organization should be established and one leader and one vice leader be elected by the general membership meeting. The main duty of the branch Party leader is to monitor the implementation of Party and State policies in firms, to participate in decision-making in key issues, and to supervise the manager, shareholders, or board of directors in exercising power.

particularly pertaining to the context of our sample area partly due to the practice of NFPP and the transitional nature of the economy. The latter measures a common phenomenon in the world. Many papers study the role of limited access to external finance and find that credit constraints hamper the investment in high-return activities (Banerjee and Duflo, 2004; McKenzie and Woodruff, 2006; De Mel et al., 2008; Poncet et al., 2010).

Table 9 reports the summary statistics of the continuing firms. Product scope grows 27% among the continuing firms from 2004 to 2008. Sixty-one percent of the continuing firms alter their product mix and 60% of them actually upgrade their product bundle. Forty-six percent of the firms produce multi-products in 2004.

< Table 9 to be here >

Table 10 presents the regression results of the product mix change models. We first investigate the determinants of the product growth rate in column (1). The first set of variables we examine is firm characteristics. Older firms have higher product growth rates. An increase of one standard deviation in the firm age will boost the product growth rate by roughly 18.8% (15.665*0.012=0.188). This may be because older firms have more operating experience, so they are likely more able to discern and cater for the market demand shift. Alternatively, it could be that the product portfolio chosen by old firms, perhaps a long time ago, needs to be modified in the light of new economic incentives. Firms with an R&D department (in 2004) also tend to experience greater product expansion rate than firms without one. Existence of an R&D department suggests that more stable R&D activities are undertaken, and the chance that new ideas are tried out for new product development may be higher. The negative and statistically significant coefficient on multi-product indicates that product growth rate is lower in firms that produce multiple products in the initial year than those produce single product. This result resembles the prediction of conditional convergence in the neoclassical growth models that a country will grow faster if it has lower initial per capita income. All the other firm characteristics, including ownership, firm size, computerization and productivity level, play no significant roles in determining product growth rate. The second set of variables represents controls for human capital of firms. Firms that have a higher proportion of workers with college degree or above, and that are managed by an individual who works concurrently as the Communist Party leader, experience significantly lower subsequent product growth rate than firms without these characteristics. Firms with a higher proportion of well-educated workers tend to be more highly specialized in the production of certain existing product(s), suggesting that it is more costly for them to develop new products. The combination of manager and Party leader in one person reduces the number of top decision-makers in a firm, possibly implying more dictatorial and stereotyped production decisions. All the other human capital variables, including manager age, tenure, education and experience as a governmental official, have no significant effects on product growth. The third set of variables measure the market environment in which firms operate. Only the perceived wood supply constraint is marginally significant and the positive coefficient indicates that firms that perceive themselves to confront with wood supply difficulties in 2004 grow faster in product scope between 2004 and 2008 than firms that do not. This may imply that firms with such a perception shift away from producing wood related products to exploring new non-wood related product possibilities more rapidly in order to overcome this constraint.

< Table 10 to be here >

We then move to analyze the determinants of the probability of a continuing firm to alter product mix in column (2). As discussed earlier, product mix changes measure either changes in product number or changes in product portfolio composition with product number holding constant. Some different patterns emerge when this more comprehensive product switching indicator is used. Examining firm characteristics, the results suggest that firms equipped with a higher computerization level in the initial year have a significantly lower probability of changing their product mix in the following years. This may be because computerization is associated with high initial costs. Once these have been incurred, it is presumably profitable for the firm to stick to the initial product plan and not to change the product mix. In addition, firms that produce multiple products in the initial year are more likely to change product mix subsequently than single-product firms, which is consistent with the finding from Table 6. This may be because multi-product firms that are already selling their outputs in different product markets tend to have more experience in establishing distribution or sales networks or contacts. However, ownership type, firm age, size, having an R&D department or not, and productivity level of the initial year indicate no significant effects on the likelihood of following changes of product mix. Regarding human capital variables, only manager's education exerts a marginally significant impact on the probability of a continuing firm to change product mix. Firms whose manager has received a college degree are 24% more likely to change product mix subsequently than firms managed by a less educated individual. The negative and marginally significant coefficient on credit constraint suggests that a higher incidence of getting rejected when applying for a loan in a formal financial institution leads to a lower chance of product lines switching afterwards. This result is consistent with the general finding in the literature that difficulty in accessing external finance hampers the investment in potential high-return activities.

We finally examine the determinants of the probability of a continuing firm to upgrade product mix in column (3). While not being an important determinant of product switching, initial productivity level plays an important role in determining subsequent product portfolio upgrading probability. Firms with lower initial productivity are more likely to upgrade product portfolio subsequently. An increase of one standard deviation in TFP will lower the probability of upgrading product mix by 9.6% (0.851*0.113=0.096). The key human capital variable in determining the probability of product mix upgrading is the political connections of the firm manager. However, the experience of working in government and the duality of working as both manager and Party leader have opposite impacts. One possible explanation could be exerted on the negative coefficient on experience of being a government official. Being government official and firm manager requires different sets of capabilities and skills, with the former focusing on administrative and coordinative ones and the latter on profit seeking and managerial ones. Therefore, the human capital accumulated from working in the governmental organizations might not be useful for doing business, and may instead shackle the thinking and practice. The positive coefficient on manager and Party leader in one person, however, reflects the advantage of centralization of power and of political connections in resource mobilization. Concerning market environment, difficulty in accessing external finance and in obtaining enough energy significantly reduces the likelihood of upgrading the product portfolio.

The lack of a relationship between ownership and firms' product switching and upgrading activities is somewhat surprising. A potential explanation is that what is important for product switching and performance improvement is not the ownership per se but the intrinsic differences of firms and differential treatments associated with ownership, such as corporate governance, access to know-how, credits and markets etc., as pointed out by Estrin et al. (2009). The short panel of two years and small sample size restrict the analysis from addressing the effect of ownership change on product line changes. In the continuing firms, 32% of them were private in 2004, of which 26% were privatized before 2004. Twenty-eight percent were privatized between 2005 and 2008, whose impact cannot be taken into consideration by using our current model.

6.2. Robustness analysis

The analysis in the previous section is based on the continuing firms between 2004 and 2008. The OLS estimates may suffer from selection bias posed by endogenous attrition if random factors that affect a firm's survival to 2008 also affect its product switching and upgrading during the time period. For example, some unobserved firm-specific characteristics, such as intrinsic managerial skills or a demand shock that maintain the firm in the market may also induce it to switch or upgrade products and thus introduce correlation between survival and product mix changes. To investigate whether endogenous attrition results in biased OLS estimates, we use Lee's (1983) method, which is a generalization of the approach proposed by Heckman (1976, 1979). We begin by estimating a multinomial logit modeling the probabilities that a firm remains in operation, exits due to systematic reasons, and exits due to random dropouts in 2008. That is,

$$Pr(y_{it} = j|\mathbf{x}_{it-1}) = \frac{exp(\mathbf{x}_{it-1}\gamma_j)}{1 + \sum_{h=1}^{2} exp(\mathbf{x}_{it-1}\gamma_h)}, \qquad j = 1, 2$$

$$Pr(y_{it} = 0|\mathbf{x}_{it-1}) = \frac{1}{1 + \sum_{h=1}^{2} exp(\mathbf{x}_{it-1}\gamma_h)} \tag{7}$$

where y_{it} is the survival variable: $y_{it} = 0$ if a firm exits due to random dropouts, $y_{it} = 1$ if a firm exits due to systematic reasons, and $y_{it} = 2$ if a firm remains in operation in 2008; $\mathbf{x}_{it-1}\gamma = \gamma_0 + \gamma_1 firm\ char_{it-1} + \gamma_2 H_{it-1} + \gamma_3 market_{it-1} + \gamma_4 wood\ product_{it-1} + \gamma_5 SFB\ char_{it-1}$, and $\boldsymbol{\gamma}$ denote the parameter vectors to be estimated. This model is estimated using all firms present in 2004 in our sample.

Besides firm characteristics, human capital and market environment variables controlled for in the product switching equation (6), the survival model (7) includes a set of variables that determines selection but has no direct effect on product switching and upgrading behavior. To facilitate identification, instead of controlling for sector dummies, we use a binary dummy differentiating whether a firm operates in a sector producing wood related products or not. We also include some SFB characteristics, i.e. industrial gross output, private property rights development, human capital (age, tenure, political connections)[26] of the bureau director, and change of directorship in 2004. The definitions of these variables are listed in the bottom panel of Table 8. Industrial gross output represents the economic status of a bureau. Better economic status may be positively associated with firm survival, for example, because economically sound bureaus are better equipped to bail out loss-making firms. However, bureau performance and firm survival may be negatively correlated if, for example, strong bureaus choose not to help out struggling firms. Private property rights development indicates how well the idea and practice of private property rights have been developed, spread and recognized in a SFB. Firms administered by a SFB that has a longer history of private property rights development tend to be less affected by the turmoil caused by transition of ownership and be better prepared in terms of institutions and technologies to survive in the market without help from superior authorities. The human capital of the bureau director may also impact on the likelihood of a firm to survive. Similar as the case for firm manager but at a higher level, bureau director and Party leader in one person may have two counteractive effects: for one thing, this duality reduces the number of top decision-makers in a bureau and loses the supervision function of the Party leader, which may lower his or her motivation and impetus to make effort for the development of the bureau, which in turn may reduce the probability of survival of its administered firms; for the other, the concentration of power and the affiliation with the ruling Party may make it easier for the director to mobilize resources so as to develop the bureau, which on the other hand may raise the likelihood of survival of the firms. Change of directorship in 2004 measures the stability and continuity of the top administrative function. Such a change may disrupt the consistency of policies towards firms a bureau administers, and the adaptation to new managerial style or new rules may increase the probability of firm exit in subsequent years. The summary statistics of all firms are reported in Table A2 in the appendix.

Table 11 reports the regression results of the Lee's (1983) model. Columns (1) and (2) show the log-odds (i.e. logged relative probability) estimates of the survival equation for randomly dropped-out firms and systematically exited firms respectively, where the survival firms are used as the base category omitted from the estimation. When comparing the results, we can see that for randomly dropped-out firms only two firm level variables are statistically significant and no exclusion restrictions are significant at conventional levels, whereas for systematically exited firms three firm level variables and four SFB level variables are significant. This difference suggests that systematic

[26] We do not control for education of bureau director defined in the same way as manager education, because all directors have a college education or above.

exit can well represent exit. Hence, in the following we focus our discussion on the systematically exited firms. Four significant exclusion restrictions out of six indicate that they are relevant. As predicted, the log-odds between exited firms and surviving ones decreases by 11% with one year increase in private property rights development, whereas the log-odds increases by 97% for one year longer tenure of bureau director and increases by 412% if the bureau under which a firm is administered changed directorship in 2004. Bureau director and Party leader in one person significantly increases the log-odds between exited and surviving firms, indicating that the disadvantage of power centralization dominates the advantage. Besides SFB characteristics, firm age, size and productivity level are also significant determinants of a firm's relative chance of survival. The log-odds between exited and surviving firms is reduced by 6%, 44% and 104% with one year older in firm age, one log point larger capital stock and one log point higher TFP, respectively. These findings are consistent with those of Jovanovic (1982)'s learning model and those from many firm level empirical studies in both developed and developing countries.

< Table 11 to be here >

Columns (3)-(5) of Table 11 report the results of the product switching equation. The results are very similar to those from the OLS estimations presented in Table 10. The insignificant coefficients on the inverse Mills ratio in all three models suggest that the issue of endogenous exit of firms has little effect on the parameters of the product switching equation. That is, there is no strong evidence of a sample selection problem or that OLS estimates are biased by endogenous attrition.

7. Conclusions

We analyze how firms in China's state-owned forest areas select, switch and upgrade their product mix during a period of gradual institutional and managerial reforms. We find that product-specific value-added has a very wide dispersion, indicating that what type of product firms produce matters for their overall efficiency and long-run development. Within the same industry, multi-product firms tend to be larger, more productive and more likely to export than single-product firms. We also find that changes in firm's product mix are pervasive among our sample firms and can be mainly attributed to adding or churning products rather than only shedding products. Moreover, changes in firms' product mix have made a significant contribution to the aggregate output growth during our sample period, accounting for approximately 86% of the net increase in the aggregate output (the remaining 14% is attributable to growth at the intensive margin).

We estimate the effects of firm characteristics, human capital and market environment on a continuing firm's decision to alter and upgrade product portfolio. The empirical results indicate that some firms are more prone to diversify and upgrade their product mix than others. Firms that are older, have an R&D department, produce single product, have a lower proportion of workers with college degree or above, have separate manager and Communist Party leader, and face wood supply constraint in 2004 have higher product growth rate between 2004 and 2008. Firms that are less computerized, produce multiple products, have a manager with college degree or above, and have less difficulty in accessing external finance are more likely to change their product mix. Moreover, firms that are less productive, whose manager has no experience of working in governmental organizations but works concurrently as the Party leader, and that are not confronted with constraints in either external finance or energy supply tend to have higher probability to upgrade product portfolio subsequently. These results hold when we take the factors affecting firms' survival into account.

More generally, quantifying the impacts of firm characteristics, human capital and market environment is fundamental to improving our understanding of the factors underlying the observed patterns of product switching and upgrading within firms. Therefore, findings of this paper provide the basis for directions of future reforms in China's state-owned forest areas in order to enhance efficiency and better handle volatilities in the markets. However, we recognize that the small sample size hinders us from obtaining results of more explanatory power from the econometric analysis. Moreover, the short longitudinal dimension of the data restricts us from addressing the effects of the dynamics of the institutional and managerial reforms on product portfolio adjustment. Future research could be directed to this field as bigger and longer panel data become available.

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Table 1 Sectors, industries and products

ICNEA	Sector	Products	Industries	Products per industry	Share of firms
		(1)	(2)	(3)	(4)
2	Forestry	2	2	1.00	0.006
3	Husbandary	2	2	1.00	0.011
13	Processing of food from agricultural products	3	1	3.00	0.029
14	Manufacture of food	1	1	1.00	0.001
15	Manufacture of beverages	7	2	3.50	0.038
20	Processing of timber, manufacture of wood, bamboo, rattan, palm and straw products	47	3	15.67	0.719
21	Manufacture of furniture	10	2	5.00	0.082
22	Manufacture of paper and paper products	3	2	1.50	0.015
24	Manufacture of articles for culture, education and sport activities	1	1	1.00	0.010
26	Manufacture of raw chemical materials and chemical products	1	1	1.00	0.002
27	Manufacture of medicines	4	1	4.00	0.021
31	Manufacture of non-metallic mineral products	3	3	1.00	0.018
35	Manufacture of general purpose machinery	1	1	1.00	0.007
37	Manufacture of transport equipment	1	1	1.00	0.007
41	Manufacture of measuring instruments and machinery for cultural activity and office work	1	1	1.00	0.006
42	Manufacture of artwork and other manufacturing	2	1	2.00	0.020
58	Storage services	1	1	1.00	0.007
	Total	90	26	3.46	1

Notes: Table reports the distribution of industries and products by sector. Column (1) reports the number of products by sector. Column (2) reports the number of industries within each sector. Column (3) is the first column divided by the second column. Column (4) reports the share of firms producing in each sector. If a firm produces products in multiple sectors, the share in each sector the firm produces is calculated as the number of the product(s) in that sector to the total number of products the firm produces. Data are for the 2004 and 2008 pooled sample and the number of observations is 271.

Table 2 Product-specific value-added

	Ln(value-added)	
Ln(employment)	0.744	(0.109)***
Ln(capital)	0.189	(0.063)***
Product dummy	Yes	
Year dummy	Yes	
Observations	271	
R-squared	0.71	
Wald test for joint significance of product dummies (p-value)	0.000	
Standard deviation of product-specific value-added estimates	1.994	

Notes: Table presents the regression result of equation (1). Coefficient on the constant is not reported. Data are for the 2004 and 2008 pooled sample. Robust standard errors in parentheses. *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

Table 3 Prevalence of single- and multiple- product firms

Type of firms	Share of firms	Share of output	Mean products, industries or sectors per firm
	(1)	(2)	(3)
Single-product	0.53	0.50	1.00
Multiple-product	0.47	0.50	2.76
Multiple-industry	0.34	0.43	2.25
Multiple-sector	0.09	0.25	2.08

Notes: Table classifies firms according to whether they produce single product, multiple products, multiple industries and multiple sectors. Columns (1) and (2) summarize the distribution of firms in each category in terms of firm number and aggregate output, respectively. Column (3) reports the mean number of products, industries and sectors in each category. The unconditional mean product per firm is 1.83. Data are for the 2004 and 2008 pooled sample and the number of observations is 271.

Table 4 Single- and multiple- product firm characteristics

	Multiple product	Multiple industry	Multiple sector
	(1)	(2)	(3)
Output	0.751 (0.257)***	0.965 (0.263)***	1.564 (0.539)***
Employment	0.569 (0.173)***	0.741 (0.184)***	1.157 (0.325)***
Capital	0.753 (0.304)**	1.021 (0.328)***	1.932 (0.519)***
Probability of export	0.087 (0.058)	0.125 (0.061)**	0.207 (0.122)*
TFP	0.107 (0.111)	0.017 (0.102)	-0.070 (0.157)
Labor productivity	0.083 (0.188)	0.197 (0.200)	0.205 (0.434)

Notes: Table summarizes the characteristics differences between single- and multiple-product, single- and multiple-industry, and single- and multiple-sector firms. Each cell reports a separate OLS regression coefficient (standard error in parenthesis) of the (natural logarithm of) firm characteristics (except probability of export which is a binary dummy) on a dummy variable equal to one if the firm produces multiple product (column (1)), industry (column (2)) and sector (column (3)), respectively. Data for all regressions are from the 2004 and 2008 pooled sample. Regressions also include industry and year fixed effects. Coefficients on the constant and fixed effects are not reported. The standard errors are clustered at the firm level. Number of observation for each regression is 271. *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

Table 5 Mean distribution of within-firm output shares

		Number of products produced by the firm					
		1	2	3	4	5	6
Average share of product in firm's output (high to low)	1	1.00	0.73	0.60	0.60	0.46	0.50
	2		0.27	0.28	0.24	0.27	0.21
	3			0.12	0.10	0.13	0.14
	4				0.05	0.10	0.08
	5					0.04	0.05
	6						0.02

Notes: Columns indicate the number of products produced by the firm. Rows indicate the share of the product in firm's total output, in descending order of size. Each cell is the average across the relevant firm-products in the sample. Data are for the 2004 and 2008 pooled sample and the number of observations is 271. Here the number of products is truncated at six since the survey asked product information up to six products. If a firm manufactured more than six products, some aggregation of the products was already taken place at the survey stage.

Table 6 Firm activity for continuing firms

	Percent of firms		
	All firms (1)	Single-product firms (2)	Multiple-product firms (3)
No change	0.39	0.54	0.22
Add only	0.26	0.33	0.18
Drop only	0.08	na	0.18
Add and drop	0.27	0.13	0.42

	Output-weighted percent of firms		
	All firms (1)	Single-product firms (2)	Multiple-product firms (3)
No change	0.64	0.72	0.55
Add only	0.20	0.24	0.15
Drop only	0.03	na	0.05
Add and drop	0.13	0.04	0.25

Notes: The top panel displays the share of continuing firms engaging in each type of product-switching activity between 2004 and 2008. The bottom panel shows a similar breakdown but weighting each firm by its output. Continuing firms are classified into four mutually exclusive groups: no change, add a product only, drop a product only, and both add and drop products. This classification suggests that a single-product firm cannot drop a product only.

Table 7 Decomposition of output growth for continuing firms

Period	Aggregate output growth	Extensive margin			Intensive margin		
		Net	Product entry	Product exit	Net	Growing products	Shrinking products
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
2004-2008	0.59	0.51	0.72	-0.21	0.08	0.33	-0.25

Notes: Table reports the decomposition of aggregate output growth of the continuing firms in our sample between 2004 and 2008 into the contribution of the extensive and intensive product margins. Column (1) reports aggregate output growth. Columns (2)-(4) report the contribution to growth from the firms' extensive margin. Columns (5)-(7) report the contribution to growth from the firms' intensive margin.

Table 8 Variable definitions

Variable name	Definition
Firm Variables	
Firm characteristics	
Private	1 if at the beginning of year 2004 the firm is private-owned, 0 otherwise. One firm is categorized as "private-owned" if private owner(s) hold a dominant share in the equity. The original ownership type collected in our survey includes state-owned, collective, share-holdings, joint-venture, domestic private, and foreign private-owned.
Firm age	Number of years between year 2004 and the year a firm was established.
Firm size	Natural logarithm of a firm's net value of fixed assets in year 2004 (CNY).
R&D	1 if a firm has a research and development department in year 2004, 0 otherwise.
Computerization	Number of computers per worker in year 2004.
TFP	Total factor productivity measured as the residual of the log-form Cobb-Douglas production function.
Multi-product	1 if a firm produces more than one product defined by our definition, 0 otherwise.
Human capital	
Manager age	Age of the current manager of a firm in year 2004.
Manager tenure	Number of years the current manager has been in office until the end of year 2004.
Manager education	1 if the manager has a college education or above, 0 otherwise.
Worker education	Proportion of workers who have a college education or above in year 2004.
Manager been government official before	1 if the current manager has been a governmental official before, 0 otherwise. The government could be central or local government, and regional or subordinated SFB.
Manager also Party leader	1 if the current manager also works as the Communist Party leader in that firm in year 2004, 0 otherwise.
Market environment	
Credit constraint	1 if a firm has applied for a loan in any of the formal financial institutions but got rejected in 4 years until year 2004, 0 otherwise.
Wood supply constraint	1 if a firm perceives that it always or sometimes happens that the demand for wood as input cannot be met, 0 otherwise.
Energy supply constraint	1 if a firm perceives that it always or sometimes happens that the demand for energy as input cannot be met, 0 otherwise. Here energy includes solid (e.g., coal and charcoal), liquid (e.g., heavy oil, gasoline, diesel and kerosene) and gas fuels as well as electricity, 0 otherwise.
Other raw material supply constraint	1 if a firm perceives that it always or sometimes happens that the demand for other raw materials as input cannot be met, 0 otherwise.
Wood related product production	1 if a firm operates in a sector producing wood related products, 0 otherwise.

SFB Variables	
Industrial gross output	Natural logarithm of a SFB's total industrial output value in year 2004 (CNY).
Private property rights development	Number of years a SFB has privatized part of its state-owned or collective-owned properties until year 2004.
SFB director age	Age of the current bureau director in year 2004.
SFB director tenure	Number of years the current bureau director has been in office until the end of year 2004.
SFB director also Party leader	1 if the current bureau director also works as the Communist Party leader in the bureau in year 2004, 0 otherwise.
Change of SFB directorship in 2004	1 if there is a change of SFB directorship in 2004, 0 otherwise.

Note: Table presents the definitions of the explanatory variables used in the econometric models.

Table 9 Summary statistics of continuing firms

Variable	Mean	Median	Std. dev.	Min	Max
Product growth rate 2004-2008	0.274	0	0.691	-0.833	3
Product mix changes 2004-2008	0.608	1	0.491	0	1
Product upgrading 2004-2008	0.598	1	0.493	0	1
Firm characteristics					
Private	0.320	0	0.469	0	1
Firm age	14.866	9	15.665	0	58
Firm size	14.215	14.310	2.166	7.695	18.988
R & D	0.278	0	0.451	0	1
Computerization	0.028	0.019	0.034	0	0.167
TFP	2.611	2.463	0.851	0.034	7.529
Multi-product	0.464	0	0.501	0	1
Human capital					
Manager age	44.351	44	5.403	30	56
Manager tenure	4.010	3	3.435	0	14
Manager education	0.722	1	0.451	0	1
Worker education	0.070	0.028	0.110	0	0.650
Manager been government official before	0.773	1	0.421	0	1
Manager also Party leader	0.237	0	0.428	0	1
Market environment					
Credit constraint	0.113	0	0.319	0	1
Wood supply constraint	0.423	0	0.497	0	1
Energy supply constraint	0.103	0	0.306	0	1
Other raw material supply constraint	0.093	0	0.292	0	1

Notes: Table presents the summary statistics of variables for continuing firms used to estimate equation (6). For firm characteristics, human capital and market environment variables, 2004 data are used. The number of observations for all variables is 97.

Table 10 Determinants of product switching and upgrading

	Product growth	Mix changes	Upgrading
	(1)	(2)	(3)
Firm characteristics			
Private	0.042 (0.189)	0.185 (0.123)	-0.132 (0.133)
Firm age	0.012 (0.007)*	0.0004 (0.004)	-0.006 (0.004)
Firm size	-0.054 (0.037)	-0.040 (0.030)	-0.024 (0.030)
R & D	0.424 (0.219) *	0.098 (0.115)	0.207 (0.131)
Computerization	-2.385 (1.934)	-3.449 (1.470)**	0.750 (1.909)
TFP	0.031 (0.121)	0.004 (0.054)	-0.113 (0.062)*
Multi-product	-0.470 (0.156)***	0.337 (0.099)***	0.101 (0.122)
Human capital			
Manager age	-0.005 (0.017)	-0.015 (0.012)	-0.014 (0.011)
Manager tenure	-0.010 (0.024)	0.002 (0.019)	-0.003 (0.020)
Manager education	0.225 (0.220)	0.244 (0.146)*	0.075 (0.157)
Worker education	-1.694 (0.868) *	-0.354 (0.550)	-0.443 (0.728)
Manager been government official before	-0.252 (0.289)	0.082 (0.184)	-0.315 (0.145)**
Manager also Party leader	-0.413 (0.176)**	-0.063 (0.122)	0.249 (0.131)*
Market environment			
Credit constraint	-0.188 (0.247)	-0.359 (0.205)*	-0.461 (0.245)*
Wood supply constraint	0.317 (0.174)*	0.078 (0.119)	0.060 (0.129)
Energy supply constraint	-0.276 (0.334)	-0.160 (0.190)	-0.327 (0.194)*
Other raw material supply constraint	0.324 (0.274)	0.161 (0.222)	0.199 (0.232)
Sector dummies	Yes	Yes	Yes
Observations	97	97	97
R-squared	0.38	0.47	0.34
Joint significance test: F-stat (P-value)	5.59 (0.000)	50.69 (0.000)	22284.57 (0.000)

Notes: Table presents the regression result of equation (6). The dependent variable for each regression is reported in the column heading. All explanatory variables are using year 2004 data. Coefficient on the constant is not reported. Robust standard errors in parentheses. *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

Table 11 Determinants of product switching and upgrading using Lee's (1983) method

	(1) Random dropout	(2) Systematic exit	(3) Product growth	(4) Mix changes	(5) Upgrading
Firm characteristics					
Private	0.240(0.649)	0.461(0.639)	0.041(0.191)	0.182(0.125)	-0.134(0.132)
Firm age	-0.007(0.022)	-0.057(0.033)*	0.013(0.007)*	0.002(0.004)	-0.006(0.004)
Firm size	-0.212(0.128) *	-0.444(0.142) ***	-0.046(0.040)	-0.027(0.032)	-0.014(0.040)
R & D	-0.601(0.656)	-0.031(0.637)	0.432(0.217)*	0.112(0.117)	0.218(0.130)*
Computerization	-13.180(9.688)	6.393(6.050)	-2.396(1.964)	-3.467(1.591)**	0.736(2.047)
TFP	-0.185(0.268)	-1.043(0.400)***	0.046(0.134)	0.030(0.063)	-0.092(0.064)
Multi-product	-0.008(0.529)	-0.232(0.576)	-0.461 (0.159)***	0.352 (0.098)***	0.113(0.122)
Human capital					
Manager age	-0.065(0.054)	-0.055(0.052)	-0.003(0.018)	-0.012(0.012)	-0.012(0.012)
Manager tenure	0.034(0.077)	0.003(0.086)	-0.012(0.025)	-0.0002(0.018)	-0.005(0.020)
Manager education	-0.327(0.579)	-0.781(0.627)	0.248(0.220)	0.281(0.156)*	0.105(0.165)
Worker education	-0.999(2.943)	0.025(2.113)	-1.691(0.895)*	-0.348(0.582)	-0.438(0.719)
Manager been government official before	-0.116(0.610)	0.947(0.670)	-0.258(0.293)	0.073(0.191)	-0.322(0.142)**
Manager also Party leader	-0.096(0.618)	-0.128(0.709)	-0.417(0.176)**	-0.070(0.123)	0.243(0.129)*
Market environment					
Credit constraint	0.261(0.760)	0.524(0.637)	-0.199(0.245)	-0.376(0.199)*	-0.474(0.241)*
Wood supply constraint	0.891(0.569)	0.372(0.578)	0.295(0.190)	0.042(0.134)	0.031(0.137)
Energy supply constraint	0.270(0.841)	1.391(0.911)	-0.282(0.334)	-0.168(0.188)	-0.334(0.193)*
Other raw material supply constraint	0.475(0.939)	-0.891(1.181)	0.336(0.274)	0.180(0.224)	0.214(0.233)
Wood related product production	-1.512(0.815)*	-0.462(0.855)			
SFB characteristics					
Industrial gross output	0.107(0.385)	0.158(0.381)			
Private property rights development	-0.025(0.046)	-0.111(0.059)*			
SFB director age	-0.011(0.060)	0.046(0.063)			
SFB director tenure	-0.262(0.268)	0.970(0.315)***			
SFB director also Party leader	0.542(0.747)	2.011(0.795)**			
Change of SFB directorship in 2004	1.069(0.967)	4.115(1.430)***			
Sector dummies	No	No	Yes	Yes	Yes
Observations	174	174	97	97	97
Inverse Mills ratio			0.109(0.234)	0.180(0.196)	0.145(0.299)
(Pseudo) R-squared	0.30	0.30	0.38	0.47	0.35
Joint significance test: LR chi2 /F-stat (P-value)	102.66 (0.000)		5.58 (0.000)	45.69 (0.000)	116.77 (0.000)

Notes: The dependent variable for each regression is reported in the column heading. Columns (1) and (2) report the results for the survival equation. Columns (3)-(5) report the results for the product switching equation. All explanatory variables are using year 2004 data. Coefficient on the constant is not reported. Robust standard errors in parentheses. *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

Appendix

Table A1 Examples of sectors, industries and products

ICNEA	CPC		Description
20			Processing of timber, manufacture of wood, bamboo, rattan, palm and straw products (Sector)
201			Processing of sawnwood and wood chips (Industry)
	20110101	Products	Regular size sawnwood
	20110204		Sawnwood for bunton
	20110205		Sawnwood for packing cases
	20110301		Not impregnated sleepers
	20110302		Impregnated sleepers
	20120101		Wood chips
202			Manufacturing of panel board (Industry)
	20201101	Products	Plywood
	20202101		Fiberboard
	20203101		Particle board
	202041		Block board
	202099		Other panel board
	20250101		Sliced veneer
	20250102		Rotary cut veneer
	20250103		Micro veneer
	20250199		Other veneer
	202503		Glued laminated timber

Notes: Table presents an example of sector, industry and product mapping hierarchy considered in this study. For ICNEA 201 there are a total of 17 products, but only a subset are listed in the table. For ICNEA 202, all products are listed in the table. CPC 20110101 is based on author created eight-digit codes that are only disaggregated to the six-digit level in CPC. Data are for the 2004 and 2008 pooled sample.

Table A2 Summary statistics of all firms

Variable	Mean	Median	Std.dev.	Min	Max
Firm variables					
Survival 2004-2008	0.557	1	0.498	0	1
Firm characteristics					
Private	0.379	0	0.487	0	1
Firm age	12.563	8	13.640	0	58
Firm size	13.630	13.816	2.169	7.313	18.988
R & D	0.247	0	0.433	0	1
Computerization	0.028	0.016	0.039	0	0.238
TFP	2.465	2.400	0.947	-1.598	7.968
Multi-product	0.408	0	0.493	0	1
Human capital					
Manager age	43.621	43	5.584	28	57
Manager tenure	3.966	3	3.606	0	15
Manager education	0.621	1	0.487	0	1
Worker education	0.070	0.025	0.122	0	1
Manager been government official before	0.724	1	0.448	0	1
Manager also Party leader	0.218	0	0.414	0	1
Market environment					
Credit constraint	0.144	0	0.352	0	1
Wood supply constraint	0.466	0	0.500	0	1
Energy supply constraint	0.132	0	0.340	0	1
Other raw material supply constraint	0.092	0	0.290	0	1
Wood related product production	0.851	1	0.358	0	1
SFB variables					
Industrial gross output	18.867	18.790	0.716	17.093	20.017
Private property rights development	5.534	4	6.480	0	21
SFB director age	46.897	48	5.539	34	54
SFB director tenure	2.983	3	1.571	0	6
SFB director also Party leader	0.207	0	0.406	0	1
Change of SFB directorship in 2004	0.167	0	0.374	0	1

Notes: Table presents the summary statistics of variables for all firms used to estimate equation (7). For all variables except *survival 2004-2008*, 2004 data are used. The number of observations for all variables is 174.

Online Appendix for

Multi-product firms, product mix changes and upgrading: Evidence from China's state-owned forest areas

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This appendix presents the full list of sector, industry and product classification considered in this study. The classification procedure is as follows. Since the reporting of products by our sample firms is not governed by any particular product classification, and the names of products reported could differ in aggregation or the way firms called them, we standardize the product names and define product, industry and sector according to two national standards. One is China's Industrial Classification for National Economic Activities (2002), henceforth ICNEA, which categorizes economic activities in China into four levels, using English alphabets, two-, three- and four-digit codes respectively. ICNEA is comparable to the UNSD: 1989, International Standard Industrial Classification of All Economic Activities, NEQ. The other is China's Product Classification for Statistical Use (2010), henceforth CPC, which classifies the products to a more disaggregated level. CPC uses a five-level coding system, with two-, four-, six-, eight- and ten-digit codes. ICNEA and CPC are harmonized at the two- and four-digit code levels. At the four-digit level, ICNEA and CPC assign the same code to most, but not all economic activities. We map all reported product names into six-, eight- or ten-digit CPC codes and take this as the definition of a "product". Eight-digit codes are our primary standard of classification. Two products are classified at the ten-digit level. Since for some products six-digit codes that are the most disaggregated level in CPC are not disaggregated enough for our analysis, we created the 8-digit codes by ourselves. This applies to eight products and they are marked with * in the list. We refer to the three-digit ICNEA categories as "industries" and two-digit ICNEA categories as "sectors". There are a total of 90 products linked to 26 industries across 17 sectors in our data. In our sample there are four products that ICNEA and CPC assign different codes at the four-digit level. We take the CPC codes as our standard and use the corresponding 3-digit codes in ICNEA as our classification for industries.

Sector		Industry		Product	
02	Forestry	021	Nurture and planting of trees	02110101	Coniferous tree seeds
		022	Harvesting and transport of timber and bamboo	02214001	Softwood small size lumber
03	Husbandary	033	Poultry feeding	03301041	Chicken
		039	Other husbandary	03387503	Pilos antler
13	Processing of food from agricultural products	137	Processing of vegetables, fruits and nuts	13714011	Dried mushrooms and truffles
				13716011	Sweet and sour pickles
				13716021	Pickles
14	Manufacture of food	145	Manufacture of canned food	14504199	Other canned fruit
15	Manufacture of beverages	152	Manufacture of alcoholic beverages	152151	Liquid distillate spirits
				152910	Fruit wine
				152970	Compound liquor
		153	Manufacture of soft drinks	15302101	Bottled drinking mineral water
				15303111	Fruit juice
				15303170	Concentrated fruit juice
				15303511	Fruit juice beverage
20	Processing of timber, manufacture of wood, bamboo, rattan, palm and straw products	201	Processing of sawnwood and wood chips	20110101*	Regular size sawnwood
				20110102*	Small size sawnwood
				20110103*	Wood in the rough
				20110104*	Wood strips
				20110105*	Dressed timber
				20110106*	Sawnwood for wall plank
				20110107*	Sawnwood for furniture
				20110108*	Sawnwood for wood flooring
				20110202	Sawnwood for motorlorry
				20110204	Sawnwood for bunton
				20110205	Sawnwood for packing cases
				20110206	Sawnwood for drill frame
				20110299	Sawnwood of other special types

		20110301	Not impregnated sleepers
		20110302	Impregnated sleepers
		201199	Other sawnwood
		20120101	Wood chips
202	Manufacture of Panel Board	20201101	Plywood
		20202101	Fiberboard
		20203101	Particle board
		202041	Block board
		202099	Other panel board
		20250101	Sliced veneer
		20250102	Rotary cut veneer
		20250103	Micro veneer
		20250199	Other veneer
		202503	Glued laminated timber
203	Manufacture of wood products	20310101	Solid wood doors
		20310103	Wooden door frames and sills
		20310201	Wooden windows
		203103	Mouldings
		20310401	Solid wood flooring
		20310402	Composite wood flooring
		203199	Other wood products used in construction
		20320102	Wooden trough
		20320202	Packing boxes
		20320203	Crates
		20320302	Box pallets
		20320304	Pallets and protection frames
		20350301	Agglomerated cork articles in brick, block, or strip
		20390401	Wooden chopsticks
		20390404	Wooden chopping board

				20390499	Other kitchenware of wood
				20390501	Wooden frames for paintings, photographs, mirrors or similar objects or similar objects
				20390502	Wooden hangers
				20390503	Wooden tools and tool handles
				20390599	Other articles of wood
21	Manufacture of furniture	211	Manufacture of wooden furniture	21100101	Wooden beds
				2110010202	Wooden wardrobe used in the bedroom
				2110010299	Other wooden furniture used in the bedroom
				21100203	Seats with wooden frames
				21100301	Wooden desks
				21100401	Redwood furniture used in the dining room and kitchen
				21100403	Panel board furniture used in the dining room and kitchen
				21100501	Wood kitchen cabinets
				211099	Other wooden furniture
		219	Manufacture of furniture with other materials	215102	Mattresses
22	Manufacture of paper and paper products	222	Manufacture of paper	22210202	Liner board
				22230601	Corrugated paper
		223		223001	Packing containers of paper and paperboard
24	Manufacture of articles for culture, education and sport activities	241	Manufacture of articles for education activities	24121140	Pencils
26	Manufacture of raw chemical materials and chemical products	266	Manufacture of specialty chemical products	26634101	Pyrolysis wood products
27	Manufacture of medicines	274	Manufacture of Chinese medicine	27403107	Oral tonifying medication
				27403108	Tonifying capsules

				27404308	Qi-regulating capsules
				27407308	Menstruation-regulating capsules
31	Manufacture of non-metallic mineral products	311	Manufacture of cement, lime and plaster	31112010	Cement of general purpose
		312	Manufacture of articles of plaster and lime	31216010	Bricks of cement and concrete
		319	Manufacture of graphite and other non-metallic mineral products	317610	Natural abrasive
35	Manufacture of general purpose machinery	355	Manufacture of shaft bearings, gears, gearing and transmission parts	34941011	Articulated link chain
37	Manufacture of transport equipment	372	Manufacture of motor vehicles	372610	Maintenance and repair services of motor vehicles
41	Manufacture of measuring instruments and machinery for cultural activity and office work	413	Manufacture of clocks, watches and chronometric instruments	413010	Clocks
42	Manufacture of artwork and other manufacturing	421	Manufacture of artwork	42113001	Wood carvings
				42113099	Other natural plant carving artwork
58	Storage services	589	Other storage services	58020101	Storage services of cruid oil and refined oil

References

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