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**How Competitive Is Chinese Industry?**

– Unit Factor Costs Analysis in an Input-Output Table Framework

Keiko Ito

Senshu University

keiko-i@isc.senshu-u.ac.jp

&

Harry X. Wu

Institute of Economic Research, Hitotsubashi University

harry.wu@ier.hit-u.ac.jp

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**Abstract**

Using newly constructed labor employment and compensation matrices for the Chinese economy and reconstructed Chinese national accounts in an input-output table framework, as part of the CIP (China Industrial Productivity Project) database, we conduct unit factor cost (UFC) analysis to investigate how and to what extent the costs of primary factors (labor and capital) and intermediate inputs affected China’s competitiveness over the period 1980-2010. Specifically, we analyze the impact of UFC changes at industry level on the input costs of other industries or industry groups through their input-output linkages. In the case of unit labor cost (ULC), we further decompose the average labor cost (ALC) and labor productivity (ALP) by the skill level of labor to see how such skill-specific cost changes in individual industries impacted other industries through the upstream-downstream connections. Our preliminary results have shown important policy implications for the role of the state in the Chinese economy.

Key works: Average factor cost and productivity; unit factor cost (UFC); average labor cost (ALC) by skill level; labor productivity (ALP); unit labor cost (ULC); national accounts; input-output tables; labor employment and compensation matrices.

*JEL* classification: C82, E01, E24, E31, O47

Introduction

China’s market-oriented reform and integration with the world economy in the past 30 years has provided a perfect case to study a large developing as well as transitional economy that mainly relied on the government engineering aiming at a faster catch up with the advanced economies. It is of great policy and academic interests to see how the cost of the state-owned or heavily controlled industries has affected other industries over time.

More on the motivation and significance, with some literature review…

This paper is structured into 5 sections. Section 2 discusses the role of the state in the Chinese economy and how the state impact on upstream industries may have affected downstream industries. This discussion supports a government policy-specific grouping to distinguish the role of the state in different types of industries. Section 3 introduces methodology including the incorporation of unit factor cost analysis in an input-output framework. Section 4 explains the data constructed for industry-level factor cost analysis. Section 5 reports and discusses the results corresponding to the questions raised in Section 2. Section 6 concludes the study.

The Role of the State

Our main research problem here is how to examine the role of the Government, or more specifically, whether government involvement has affected the productivity performance of the Chinese economy. This is challenging because policy or institutional factors are not an inherent part of the standard theory of production function; however, government policy is industry-specific and industries are connected through vertical input–output links. Therefore, to explore the role of the Government, we first consider distinguishing industries with different types of government interventions and then hypothesise about their productivity implications and how the aggregate industrial economy will be affected.

Despite a significant decline of the state sector since the reform period, governments at all levels have maintained strong intervention in the allocation of resources to support the so-called strategic industries, of which the majority are either owned or heavily influenced by the state. One important change since the reform, however, is that government intervention is no longer all embracing, as it was in the central planning era, which completely ignored the market. It has become industry-specific through subsidisation, administrative interference or both. Subsidisation aims to reduce producers’ costs of inputs including energy, land, environment, labour and capital (see Yiping and Tao 2010). In contrast, administrative interference aims to serve the state’s interests and state ‘strategic plans’ by controlling or influencing output prices or business operations in various aspects from managerial personnel to the choice of technology.

We argue that whether or to what extent governments use administrative interference or subsidies depends on the distance of an industry from the final demand, especially the international market. Local governments use subsidisation mainly to promote export-oriented industries that produce semifinished and finished goods. These industries are mainly labour intensive and therefore should be considered crucial for China to reap its demographic dividend in a timely fashion. Since these industries face international competition, direct administrative interference will be counterproductive; however, the Central Government or higher-level authorities tend to become directly involved in upstream industries because they are considered strategically important to sustain the growth of downstream industries. Administrative measures such as managerial and price controls are used to ensure that upstream industries can provide sufficient and cheap supplies to downstream industries. Nevertheless, subsidisation could also be used to support upstream industries whenever administrative interference is not cost justifiable.

Considering the behaviour of enterprises in such a policy environment and the implications for efficiency improvement and productivity growth, we may suppose that industries that are mainly supported by input subsidies could be more efficient and productive than those that are subject to administrative interference. We argue that when subsidies do not come with administrative interference in business decisions, enterprises may still behave like true market competitors although their competitiveness is arbitrarily enhanced by the cheaper cost of some factors influenced by the Government.

In contrast, the upstream industries are far from the end market. They are traditionally dominated by SOEs and do not conform to China’s comparative advantage. Their assumed ‘strategic importance’, however, gives them strong bargaining power in negotiating for government support and in return they have to accept controls by the authorities. This distorts their behaviour and is a disincentive in their efforts towards efficiency improvement.

More on total economy grouping including agriculture, construction and different types of services…

Data

As indicated at the beginning of the paper and discussed in the methodological section, our investigation in the Chinese economy strictly requires the data of full and coherent national input and output accounts at industry level and over time. The construction of the data is based on a series of studies by Wu and his associates. These studies attempt to construct industry-level data for the Chinese economy in the standard Jorgenson-Griliches framework (1967), especially following the way of data handling in Jorgenson, Gollop and Fraumeni (1987) which is now well known as the KLEMS approach (see O’Mahony and Timmer 2009). They include the construction of industry-level capital input (Wu and Xu 2002; Wu 2008 and 2013a), labor input (Wu 2002a, 2013a and 2013b; Wu and Yue 2010 and 2012; Wu, Yue and Zhang 2013) and output (Wu 2002a, 2013a and 2013b; Ito and Wu 2013). Our new effort in this study is mainly to establish the coherence between inputs and output within individual industries and between industries and national aggregates in all measures through crosschecks and reconciliations. We have also revised and updated Wu’s estimates of net capital stock by industry.

1. *Coverage and Classification*

This study covers the entire Chinese economy at industry level for the period 1980-2010. It should be noted that the inconsistent, incomplete or overlapped coverage of the Chinese official statistics, reported through different authorities by different statistical criteria ranging from ownership type, administrative jurisdiction to the size of enterprises, often lack of transparency, has caused great confusions in empirical research on the Chinese economy. Ignoring or mishandling the coverage problem may lead to misread China’s productivity performance.[[1]](#footnote-1) In this study, based on the Chinese System of National Accounts (CSNA), especially its input-output table (CIOT) system, and national or sectoral level censuses, we aim to first conceptually and then empirically re-establish the full statistical coverage of the economy in all input and output indicators.

Following Wu (2013a), we use a “formal sector” concept in the data work. In practice, for any input or output indicator, we first confirm the “control total” at the national level after examining and reconciling all sorts of available data for the measure of national totals. This defines the boundary of all the observed economic activities in China. We then conduct careful crosschecks on available industry-level data to ensure conceptual consistency with the relevant “control total” and based on which the boundary of the “formal part” of each industry can be defined. Next, the “residual” obtained by subtracting the sum of the “formal part” of all industries from the national “control total” is defined as the total “informal economy” only because the underlying activities are not monitored and recorded by the official statistical system. This “residual” is distributed to industries based on industry-specific parameters estimated using data from various censuses and surveys on small enterprises, household-run businesses and self-employed.

In industrial classification, we in principle adopt the 2002 version of the Chinese Standard Industrial Classification (CSIC/2002) to divide the whole economy into 37 industries (Appendix Table A1). This is based on Wu’s series of works to reclassify official statistics reported under different CSIC systems adopted in 1972, 1985 and 1994. The classification largely conforms to the 2-digit level industries of the ISIC (Rev. 4) and can be reconciled with the EU-KLEMS system of classification (Timmer et al., 2007).

1. *Value Added and Gross Output*

The official estimate of GDP has been challenged for upward bias in growth rate and downward bias in level because of conceptual differences, methodological problems and institutional deficiencies (see Keidel 1992, Ren 1997 and Maddison 1998; also see Wu 2000 for a review). The hypotheses have been empirically supported using different approaches.[[2]](#footnote-2) However, due to lack of the information required at industry level, most of the studies focus on the aggregate economy or its major sectors, typically the industrial and agricultural sectors. Among these studies Wu’s work (2002b and 2013d) on an alternative measure of China’s industrial output is based on major commodities. However, it may not be appropriate to use commodity-based output estimates to replace official estimates because the latter is based on *enterprise* (likely engaged in multi-product activities) rather than *establishment* (reflecting single-product production). There is another concern for not to use Wu’s alternative output estimates at industry level. That is, the matching inputs are also used in multi-activity enterprises.

Following Wu (2013a), to construct the nominal gross output and value added by industry, hence deriving intermediate inputs at industry level, we rely on three sources of data, i.e. China’s national accounts, input-output tables (CIOTs) and industry-level statistics. Basically, the annual gross value added of the national accounts is used as the “control total” and the gross output and value added in CIOT, available in the full table every five years since 1987 and in the reduced format between two full tables, are used as benchmark structures. The national accounts and CIOTs cover all economic activities in both the formal and the informal sectors. The national accounts are only available at broad sector level. To satisfy our classification requirement (Table A1), they are reconciled with the benchmark CIOTs, supplemented by annual industry-level statistics for the formal sector. To construct a time series for the entire period 1980-2010, in addition to the interpolations of the CIOT structures between the benchmarks, we need to convert the official 1981 input-output table constructed under MPS (material product system) to that conforming to SNA (Ito and Wu 2013). The 1981 and 1987 CIOTs jointly determine the output structure for the period 1980-86 and the period of 2008-10 is assumed to follow the structure of the 2007 CIOT.

Although the official measure of the real GDP has been questioned for underestimating price changes (Ren 1997, Maddison 1998, Woo 1998, and Wu 2000), most studies on China’s growth have taken the implicit GDP deflator of the national accounts for granted. In this study, to be conceptually consistent with our input-output framework, we opt for the double deflation approach, i.e. obtaining the real value added by subtracting PPI-deflated intermediate inputs from PPI-deflated gross output for each industry. The industry-specific PPIs are constructed using data from different price surveys of official sources (see details in Ito and Wu, 2013). Basically, for non-service sectors, the official industrial PPIs are converted to meet our standard of classification, the farm-gate price index is adopted as the agricultural PPI, and the national accounts implicit deflator for construction is adopted as a proxy for the construction PPI.

Prices of services, especially the so-called “non-material” services (a MPS concept that includes non-market services), are more problematic because official estimates suggest excessively high labor productivity that puts China as a big outlier in history (Maddison 2007, and Maddison and Wu 2008). With very limited information available, we use the components of CPI for transportation, telecommunication, education and health care as proxies for the price changes facing the producers of these services. For the real estate PPI, we use the service margin of per square meter property sold (including both residential and commercial housing) as a proxy. A geometric mean of the above services is used as a proxy for the price change of financial service. Finally, we assume the price change of government service follows the urban CPI. We believe that our industry-specific price index or proxy is much better reflecting price movement than the non-transparent national accounts implicit deflators for broad sectors.

1. *Quantity of Employment and Labor Input*

The official labor statistics contain serious flaws and therefore cannot be directly adopted in productivity analysis. As far as the reform period concerned, there is a huge structural break in 1990 following China’s 1990 population census, which shows a big jump in the total numbers employed by 17 percent (94.2 million!) and hence creates serious discrepancies between the total and the sum of sectoral employment (Maddison and Wu 2008; Wu 2010 and 2013d). This not only complicates the traditional problem of inconsistency between labor statistics and industrial statistics but also increases the difficulties in matching output with employment. Moreover, official labor statistics do not provide sufficient industry-specific information on hours worked and there are no regular surveys on human capital attributes of employment.

In the present study, we adopt Wu’s new employment “control total” (2010 and revised in 2013d) that has adjusted the 1990 structural break based on a careful examination of the relationship between annual statistics and population censuses, and changes in employment policy. He shows that the structural break could have appeared in 1982 if the 1982 census results were incorporated into the national totals. It was attributed to the fact that the official annual estimates did not take into account the activities emerged outside the labor planning and administration system as the result of a policy change in the early 1970s that encouraged small rural collective enterprises to grow in order to absorb surplus labor. Wu distributed the additional workers into manufacturing, construction and commerce based on existing weights of these sectors. At industry level, since the additional workers are less educated and less skilled than those in the formal sector, they are distributed into the “informal part” of labor-intensive manufacturing and services (Wu and Yue 2010 and 2012; Wu, Yue and Zhang 2013). We argue that the so-constructed labor accounts based on numbers employed basically match the output accounts.[[3]](#footnote-3)

Numbers are not homogenous in hours worked in a given period of time. It is thus important to convert numbers employed to hours worked. However, data on hours worked are very limited. They are based on occasional rather than regular surveys, focusing mainly on the state sector without industry details. Wu and Yue (2010 and 2012) made the first attempt to estimate hours worked based on the institutional working hours for different industries as defined by law or regulations, supplemented by local government surveys on hours worked by migrant workers. Later in Wu, Yue and Zhang (2013), more information from censuses and surveys is used for the number-hour conversion. In the present study we adopt the results of Wu, Yue and Zhang (2013).

Since numbers or hours are also heterogeneous in quality, changes in numbers or hours do not necessarily reflect changes in services provided by the stock of labor. Therefore, we need to estimate service flows provided by the stock of workers with different demographic, educational and occupational attributes, which is a proper measure of labor input. The estimates are from Wu, Yue and Zhang (2013) based on two four-dimension matrices, i.e. a quantity matrix cross-classified by 2 genders, 7 age groups, 5 education categories, and 37 industries, which is exactly matched by a compensation matrix. The quantity matrix is based on available population censuses, one-percent population sample surveys between censuses, household surveys from China Household Income Project (CHIP) and sample surveys on migrant workers (RUMIC). The compensation matrix is controlled by the total and industry-specific labor income accounts from our reconstructed input-output table series. CHIP also provides wage rate for some human capital attributes. Gaps in wage rate are estimated by the Mincer equation (Jacob Mincer 1958).

Due to data constraints, benchmark marginal matrices (not in full dimension) are constructed first. Then, they are transformed into full-dimensioned benchmark matrices by the iterative proportional filling (IPF) approach developed in Wu and Yue (2010 and 2012) following Bishop, Fienberg and Holland (1975). Finally, the time series matrices are constructed by interpolations between the benchmark matrices and the constructed time series of numbers employed and hours worked, and labor income accounts by industry.

Methodology

Unit factor cost analysis will follow what presented below unit labor cost, and integrated within an input-output framework… to be completed in due course.

Unit labor cost for industry *i* in year *t*

$$ULC\_{it}=\frac{LC\_{it}}{Q\_{it}}$$

where *LCit* is total labor compensation for industry *i* in year *t*, and *Qit* is real gross output for industry *i* in year *t.*

$$ULC\_{it}=\frac{LC\_{it}}{Q\_{it}}=\sum\_{j}^{}\frac{LC\_{ijt}}{Q\_{it}}=\sum\_{j}^{}ULC\_{ijt}$$

where *LCijt*is labor compensation for workers of education level *j* in industry *i* in year *t*. Therefore, the industry-level unit labor costs, *ULCit*, are equal to the sum of the unit labor costs for workers of each education level, *ULCijt*.

The industry-level unit labor costs in year *t* relative to those in the base year *t0* can be expressed as:

 $\frac{ULC\_{it}}{ULC\_{it\_{0}}}=\sum\_{j}^{}\frac{ULC\_{ijt}}{ULC\_{it\_{0}}}$

 <Analysis 1>

Using this formula, the ULC evolution can be decomposed into the contribution of changes in the ULC for workers of each education level.

<Analysis 2>

Another possible decomposition analysis is to decompose the ULC evolution into the evolution of wage rate (w) and the evolution of labor intensity (N/Q).

$$ULC\_{it}=\frac{LC\_{it}}{Q\_{it}}=\frac{w\_{it}N\_{it}}{Q\_{it}}=\sum\_{j}^{}\frac{w\_{ijt}N\_{ijt}}{Q\_{it}}$$

<Analysis 3>

The unit material costs for industry *i* in year *t* can be decomposed into unit material costs purchased from upstream industry *k*.

$$UMC\_{it}=\frac{MC\_{it}}{Q\_{it}}=\frac{\sum\_{k}^{}MC\_{ikt}}{Q\_{it}}=\frac{\sum\_{k\in ULCH}^{}MC\_{ikt}+\sum\_{k\in ULCL}^{}MC\_{ikt}}{Q\_{it}}$$

*MCikt* denotes material inputs from industry *k* to industry *i* in year *t*. For example, we may be able to group upstream industries into industries with a high growth rate of ULC (ULCH) and industries with a low grow rate of ULC (ULCL). Then, we can calculate the contribution of each upstream industry group to the evolution of unit material costs in downstream industry *i*.

To be completed…

Preliminary Results and Discussion

*Dynamics of unit factor costs by industry*

We construct annual series of ULCs, UMCs, and UKCs for the 37 industries for the period 1981-2010. In order to show easy-to-see figures, we group the 37 industries into the seven broad sectors : Agriculture, Energy, Commodities and primary inputs, Semi-finished and finished, Construcion, Market services, and Non-market services. The correspondence between the 37 industries and the seven broad sectors is shown in Appendix Table 1. The dynamics of unit factor costs by broad sector are shown in Figure 1.

**Figure 1. Dynamics of unit factor costs by broad sector**









The developments of unit factor costs have been very different across sectors. The ULCs has started declining the mid-1990s in sectors such as commodities and primary inputs, semi-finished and finished, and market services, while they continued increasing in the case of non-market services. Moreover, the levels of unit factor costs relative to those of the 1981 level differ substantially across sectors. The unit factor costs indices as of 2010 are much lower in the sectors such as commodities and primary inputs, semi-finished and finished than in other sectors. Particularly, all the unit factor costs indices have been declined drastically since the mid-1990s in the case of semi-finished and finished sector, suggesting that productivity growth was much faster than the factor prices in this sector. As for the agriculture sector, the UKCs did not increase much while the ULCs and UMCs have rapidly increased, which may suggest that capital deepening has not occurred much in this sector.

In the CIP Database, industry-level labor compensation is available for workers of five different education levels: illiteracy, elementary, junior high, senior high, and college. Following the definition employed in the UNESCO statistics and the WIOD, we define three types of workers with different education level. The low-skill workers are defined as the workers with elementary education or illiteracy. The medium-skill workers are defined as the workers with junior or senior high school education. The high-skill workers are defined as the workers with college education. The contribution of workers of each skill level to the total unit labor costs evolution is shown in Figure 2.

**Figure 2. Evolution of unit labor costs by skill level and by broad sector**

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Decomposition of unit labor costs into wage changes and productivity changes by skill level and by sector

More discussions to follow with further rounds of calculation…

Appendix

References

Unit factor costs index (1981=100)

CIP industry classification and the industry groupings



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(To be completed…)

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1. For example, a serious contradiction is found between the national accounts and industrial statistics by enterprises at/above the “designated size” (defined as 5 million yuan of annual sales in 1998 and maintained till 2010). From 1998, the trend of the value added by the enterprises at/above the “size” began to deviate from the trend of the employment of these enterprises. By 2006, while their share in the total employment declined from over 70% to 50%, their total value added was reported as almost equal to the industrial GDP of the national accounts. This means that 67.5 million industrial workers below and outside the “size” criterion produced zero output. Yet, by 2008, the value added by the enterprises at/above the “size” exceeded the national total by 10%, that is, 68.4 million workers engaged in negative production (see Wu 2013c). [↑](#footnote-ref-1)
2. Empirical studies that attempt to provide alternative estimates have used various approaches including commodity-based physical output index (Wu, 2002b and 2013d), alternative price indices (Wu, 2000; Woo, 1998; Ren, 1997; Jefferson et al., 1996), food consumption (Garnaut and Ma, 1993) and energy consumption approximation (Adams and Chen, 1996). Despite different results, all appear to strongly support the upward bias hypothesis about the official growth estimates. [↑](#footnote-ref-2)
3. There is one unsolved problem. Under central planning, industrial enterprises included auxilary services such as child care, clinics, commercial outlets, and social and political organizations. The commercialization of these services began in the late 1990s, but not yet completed in large enterprises. Wu and Yue (2010 and 2012) made the first attempt to remove service employment from the industrial sector based on information from surveys and censuses. However, they did not consider how to allocate these workers back to services because they focused only on the industrial sector. Although we focus on the entire economy, it is still difficult to solve this problem because census data do not identify the activities of service employment engaged in the industrial sector. [↑](#footnote-ref-3)