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國文抄錄

費用最小化, 技術進步 그리고 總輸入需要 中國, 1978-2007

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本 研究는 1978 년부터 2007 년 까지의 中國生産技術의 進步와 集計輸入需要를 推定하는데 焦點을 맞추고 있다.

資本,勞動力과 輸入은 세 가지 投入要素으로서 費用函數를 適用함으로써 分析된다.

追加하여 技術變數가 技術變化의 影響를 分析하기 위하여 使用된다.

첫째, 中國經濟의 發展모델은 勞動集約的,資本集約的과 輸入使用的 性格을 갖고 있음이 確認되었다.

둘째,資本과 勞動,輸入과 勞動은 相互代替의 關係를 가지고 있다.하지만 資本과 輸入은 이런 關係를 가지고 있지 않다.投入要素의 自己彈力性은 마이너스(minus)로 나타났고

이것은 輸入價格이 增加하면 輸入需要는 減少하는 現象을 나타낸다.

셋째, 1978 년부터 2007 년까지 中國의 技術進步의 年平均變化率은 4.7%이다. 技術變化는 中國經濟發展에 重要한 役割을 해왔다. 中國技術進步의 增加率이 漸增하는 傾向을 갖고 있다.

Abstract

Cost Minimization, Technical Progress and the Aggregate Import Demand of China, 1978-2007

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This study mainly focuses on estimating the technical progress and the aggregate demand for imports over the period of 1978-2007 in China. These are analyzed by applying translog cost function estimation. Three input factors including capital, labor, and imports are specified in the cost function. In addition, technology variable is also employed to investigate the effects of the technical change.

Firstly, this study has confirmed that the cost structure of the China's economy is labor-intensive capital-saving and import-using natures.

Secondly, the capital and the labor, the imports and the labor are substitutes with respect to each other, while the capital and the imports are not. The own elasticities of input are negative sign, which indicates that the import demands to their price increase are decreasing.

Thirdly, the yearly technical change progress is presented. In the

year 1978 to 2007, the average technical change rate is 4.7%. Technical change plays an important part in the growth of Chinese economy. The increasing rates of technical progress in China are gradually higher and higher.

Chapter 1 Introduction

1.1 The background and purpose

Through the 1950s and 1960s, foreign trade was a minor factor in the Chinese economy. However, the historic tour of Deng Xiaoping in South China [1]. in the spring of 1992 marked a shift towards trade-oriented development, which has been adopted by the post-Deng leadership [Tongzon, 2001]. On average, manufactures constitute about 80% of total imports, followed by agricultural raw materials (6%), food (6%), ores and metals (4%), and fuel (4%) during the period 1987–1999. This structure reflects a dependency on imported intermediates for manufacturing development in China. According to [Liu et al., 2001], the government encourages exports while using imports to ensure the supply of key materials and technology to promote import substitution and economic growth. Furthermore, [Tongzon, 2001] has documented that China is a net importer of capital-intensive manufactures and certain agricultural products. Its entry into the World Trade Organization (WTO) is expected to boost overall demand for these types of imports. Over the period 1970 to 1999, China has experienced historical trade deficits in 1970–1972, 1974, 1978–1980, 1984–1989, and 1993 [World Bank, 2002].

[1] In this paper, China refers to People's Republic of China, not including Taiwan (China Taipei) Hong Kong and Macao. When necessary, we also use Mainland China instead of "China " to Clarify the facts.

Tongzon (p. 1950) asserts that inclusion into the WTO may deteriorate China's trade balance. Therefore, effective management of import demand must be part of a comprehensive stabilization plan. The Chinese authorities' response to the trade deficits has had consequences for both domestic economic policy and external economic relations [Moazzami & Wong, 1988]. According to [Santos-Paulino, 2002], identification of the major variables that affect import performance and accurate prediction of import flows can help policymakers design and assess the overall sustainability of structural reforms.

1.2 The plan of the paper

This study mainly focuses on estimating the imports demand and Technical Progress of China Economy over the period of 1978-2007 on the purpose of finding how the Chinese economy carried out in the recent years after the Chinese economic reform. The imports demand and Technical Progress are analyzed by applying translog cost function estimation. Three input factors including capital, labor and imports are specified in the cost function. In addition technology variable are also employed to investigate the effects the technical change.

1.3 Previous studies

[Santos-Paulino, 2002] highlighted that the empirical investigation of import demand functions has been one of the most researched areas in international economics. The import demand specification is crucial for meaningful import forecasts, international trade planning, and policy formulation. According to [Senhadji, 1998], one of the main reasons for the popularity of import demand function investigation is its application to a wide range of important macroeconomic policy issues. These issues include the impact of expenditure switching through exchange rate management and commercial policy on a country's trade balance; the international transmission of domestic disturbances, where import demand elasticity is a crucial link between economies; and the degree to which the external balance constraint affects a country's growth. Another major concern in formulating commercial or exchange rate policy is the responsiveness of trade flows to relative price changes. Relative prices play a significant role in the determination of trade flows, buttressing devaluations as a way to correct trade imbalances [Reinhart, 1995]. If the sum of import and export demand price elasticities is greater than unity, then the Marshall–Lerner condition is satisfied, indicating a devaluation will have favorable effects on the external balance [Bahmani-Oskooee & Niroomand, 1998].

[Hong, 1999] has outlined that formulation of the import demand function is based on the theory of comparative advantage, the Keynesian trade multiplier, or the new trade theory (also known as the imperfect competition theory of trade). Each of these theories predicts different impacts of income and pries on the determination of trade. The neoclassic trade theory of comparative advantage (Heckscher–Ohlin framework) focuses on how the volume and direction of international trade are affected by changes in relative prices, which in turn are explained by differences in factor endowments between countries. Neoclassic trade theory is not concerned with the effects of changes in income on trade. The neoclassical import demand function is rooted in microeconomic consumer behavior and general equilibrium theory. The Keynesian import demand function is based on macroeconomic multiplier analysis. Under the Keynesian framework, relative prices are assumed rigid and employment is variable. International capital movements adjust to restore the trade balance. In this framework, the focus is on the relationship between income and import demand at the aggregate level (and in the short term). The relationship can be defined by a few ratios such as the average and marginal propensity to import and the income elasticity of imports. The latest school is the new trade theory, or the imperfect competition theory of trade, which focuses on intra-industry trade, a pattern not explained by the theory of comparative advantage. The new trade theory explains the effects of economies of scale, product differentiation, and monopolistic competition on international trade. The new trade theory illuminates a new link between trade and income: If part of international trade is driven by the scale of output and if income is used as a proxy for scale, then the role of income in determining imports will go beyond that defined both in the neoclassic and in the Keynesian import demand functions, where income only affects purchasing power. The approaches that are usually used under this school, to define an imperfectly competitive market, are the Marshallian, Chamberlinian, and Cournot approaches [Hong, 1999].

In addition, [Hong, 1999] has added that "import demand in a market economy can be fully modeled by two determinants: income and relative prices. The other factors can all be subsumed within these two factors, at least theoretically." [2][Carone, 1996] has outlined that the simplest and most widely used procedure for estimating aggregate import demand in the imperfect substitutes model is the use of a Marshallian demand function relating the total quantity of imports demanded by a country to its real income, and the price of imports and domestic substitutes measured in the same currency. Meanwhile, [Xu, 2002] has stated that most of the theoretical models have relied on the conventional import demand equation, derived from either the imperfect or perfect substitutes model. The key assumption is that neither imports nor exports are perfect substitutes for domestic goods

[2] As noted by Hong (1999), the factors behind relative prices include relative endowments of resources and productive factors, market structure, scale, exchange rate, trade barriers, etc. The impacts of changes in these factors on import demand will take place through a change in relative prices.

of the countries under consideration [Goldstein & Khan, 1985]. The traditional or standard import demand function is widely used to estimate aggregate import demand behavior. The traditional import demand function is specified as a log-linear function of the relative price of imports and real income [Senhadji, 1998].

Empirical investigation of China's import demand function has thus far been relatively limited. [Moazzami & Wong, 1988] estimated China's import demand equation with an income elasticity of imports of 0.87 and 3.78 in the short and long runs, respectively. The estimated short- and long-run price elasticities are −0.52 and −2.26, respectively. These estimates were based on annual time series data from 1970 to 1986 using a partial adjustment model (ordinary least squares, OLS estimator). A dummy variable indicating a structural break as a result of economic reform was statistically insignificant. The study also introduced the trade account balance as an additional determinant to capture the effect of quantitative restrictions on Chinese imports. Given the estimated income and price elasticities (both import and export equations), they concluded that the Marshall–Lerner condition was satisfied in the long run, but not in the short run. Therefore, currency devaluation was found to be an ineffective means of deficit reduction in the short run, and control of the trade deficit in the long run is feasible only with a deceleration in economic growth.

Using available data from the World Bank's database, [Senhadji, 1998] estimated structural import demand equations for 66 countries including China. Senhadji has derived an import demand equation that is close to the standard import demand function using gross domestic product (GDP) minus exports rather than GDP. The authors employed the [Phillips & Hansen, 1990] fully modified (FM) and OLS estimators. Both techniques provided relatively similar results for China's import demand (1960–1993) elasticity, which was derived using a partial adjustment mechanism. The estimated long-run price and income elasticities (FM estimator) are −0.39 (insignificant at 10% significance level) and 2.12, respectively. However, these estimates are not reliable since the study found no long-run relationship for China's import demand equation.[3] The finding of no cointegration indicated that import demand behavior in China was unstable during the period under study. The estimated short-run elasticity for relative prices and real income are −0.04 and 0.24, respectively, but these estimates are insignificant at the 10% significance level.

Nevertheless, some gaps can be found in the studies of [Moazzami & Wong, 1988] and [Senhadji, 1998]. Moazzami and Wong employ only 17 annual observations, which call the validity of the import demand estimates into question. The study also ignores the issue of

[3] According to Phillips (1987.p.3), regressions involving levels of variables that were nonstationary, but not cointegrated, would yield spurious results. In addition, Engle and Granger (1987) added that using standard regression techniques (OLS) with nonstationary data could lead to the problem of spurious regressions involing invalid inferences based on t and F tests, if the involved variables were not cointegrated.

nonstationarity, using the partial adjustment technique rather than employing the cointegration approach. [Abbott & Seddighi, 1996] warned that the partial adjustment mechanism imposes a highly restrictive lag structure on the regression equation which, if incorrect, leads to dynamic misspecification and predictive failure. For Senhadji's study, failure to find a long-run equilibrium relationship between China's import demand and the explanatory variables is probably due to sample size (34 observations) and inappropriate cointegration technique. However, [Mah, 2000] shows that the conventional cointegration techniques [Engle & Granger, 1987, Johansen, 1988 and Johansen & Juselius, 1990] are not reliable with small samples. Senhadji's study may also suffer bias as a result of using the partial adjustment mechanism to model import demand [Abbott & Seddighi, 1996].

The traditional import demand specification assumes that the import content of each macro component of final expenditure is the same. The results from [Moazzami & Wong, 1988] and [Senhadji, 1998] may also contain aggregation bias. [Abbott & Seddighi, 1996] have noted that if the different macro components of final expenditure have different import contents, then the use of a single demand variable (or scale variable) in the aggregate import demand function will lead to aggregation bias. Among the studies that have considered this concern by disaggregating final expenditures are those by [Giovannetti, 1989], [Abbott & Seddighi, 1996], [Min et al., 2002], [Mohammad & Tang, 2000], and [Tang, 2002]. This approach decomposes GDP into three categories: final consumption expenditure, expenditure on investment goods, and exports. [Xu, 2002] has found that the conventional import demand equations suffer from several drawbacks. First, they are partial and static in nature and, therefore, lack intertemporal elements; in particular, the current income variable is typically used without any foundation in intertemporal optimization theory. Second, the empirical implementation is somewhat ad hoc [Xu, 2002]. By considering these drawbacks, Xu has derived a structural import demand function using a more flexible intertemporal optimization approach that is close to the conventional approach, Xu's approach provides a theoretical foundation for the estimation of an import demand equation. The import demand equation proposed by Xu takes into account a growing economy, rather than an endowment economy, and investment and government activity. Therefore, the use of a "national cash flow" variable[4], rather than GDP, relative prices, and a time trend were necessary and sufficient to define the long-run behavior of imports [Xu, 2002]. Thus, inclusion of any other variable is ad hoc manner. However, [Chenery and Strout, 1966] argued that external resources were a separate input. Similarly, [Burgess, 1974] treated imports as a productive factor, stating that the majority of international trade occurred in intermediate goods requiring further domestic processing. Furthermore, even end-products require domestic handling and

[4] The "national cash flow" variable is a correct domestic activity variable proposed by Xu (2002), that is GDPt-It-Gt-EXt, where GDP is gross domestic product, I is investment, G is government spending, and EX is exports. (Xu,2002. p.269)

marketing before reaching the final purchaser and, therefore, enter the production process as well. The significance of the productive role of imports is that if imports are a substitute input for or have a complementary relationship with one or more domestic inputs, then international trade and trade policies may directly affect domestic factor prices and, therefore, the level and distribution of domestic factor income. Similar approaches to estimating the demand for imports have been employed by [Kohli, 1994 and Kohli, 1978] for Canada, [Kohli, 1993] for the United States, [Kohli, 1983] for Australia, and [Kohli, 1982] for Switzerland; [Diewert and Morrison, 1986] and [Aw and Roberts, 1985] for the United States; [Mohabbat et al] for India, and [Mohabbat and Dalal, 1983] for Korea.

Chapter 2 The theoretical model[5]

2.1 The model formulation

Let “C”(LnC) represents the observed cost of production, “C” represents the functional form of translog, “y” represents the output quantity, “w” represents the vector of input prices “β” represents the vector of unknown parameters to be estimated and “e” is the residual. The stochastic cost model[6] will be

$$LnC=C(y,w,\beta)+e \tag{1}$$

The parameters of the cost equation (1) can be estimated using standard econometric methods since the y and w are assumed to be exogenously determined. [Schmidt and Lovell, 1997] specified a Cobb-Douglas technology for steam-powered electricity-generating plants and showed that the stochastic cost model can be estimated in a similar manner to the stochastic production model using either ML or COLS estimators.

The overall cost efficiencies can be decomposed into their technical and allocative components if the cost function implied by estimated

[5] Traditional cost studies could possibility confound differences in X-efficiency at different output levels. This potential problem does not appear to be of practical significance, however. Several researchers have estimated the import using both traditional cost functions and frontier estimation methods and found little or no differences in results from the two approaches for further discussion, see Berger et al. (1993)

[6] This comes from the Introduction to Applied Econometrics.

cost function can be explicitly derived[7].

A maximum likehood systems estimator, involving the cost function and the factor-demand equations, provides more efficient estimators of the parameters of a cost function than the single equation estimator. The systems approach also has the advantage of explicitly accounting for allocative inefficiency which is reflected in the error terms on the factor demand equations, which represent violations of the first-order conditions for cost minimization.

For a simple example of the systems approach, consider a translog cost function involving one output and two inputs:

$$Lnc=\beta_0 +\beta_1 \ln w_{1+} \ \beta_2 \ln w_2+\beta_3 \ln y+\beta_{12} \ln w_1 \ln w_2+\beta_{13} \ln w1 \ln y+\beta_{23} \ln w_2 \ln y+(1/2)[\beta_{11} (\ln w_1)^2+\beta_{22} (\ln w_2)^2+\beta_{33} (\ln y)^2]$$

The input-demand equations (derived using Shephard's Lemma) are the share equations in the case of the translog. For the two-input example there are:

$$(w_1x_1/c)= \beta_1 +\beta_{12} \ln w_2+\beta_{13} \ln y+\beta_{11} \ln w_1 \qquad (2)$$

$$(w_2x_2/c)= \beta_2 +\beta_{12} \ln w_1\beta_{23} \ln y+\beta_{22} \ln w_2 \qquad (3)$$

[7] The translog cost function is flexible at the point of approximation, but it imposes generally a specific structure, namely, a symmetric U-shaped average cost curve. If this assumption does not hold generally, then the cost function would be misspecified.

Where, the dependent variables are the shares of total cost for that input.

2.2 Model of the cost function

In this paper we assume that the following Translog functional form provides an exact description of the minimum cost of producing output Y given factor prices P_k, P_L and $P_{M.}$

Then we describe the cost function as follows.

$$Lnc=\alpha_0 + \alpha \ln Y + \alpha_t\, t + \alpha_k \ln P_k + \alpha_L + \alpha_{im} \ln P_{im} + 1/2\ \beta_{kk} (\ln P_k)^2 + 1/2\beta_{LL}(\ln P_L)^2 + 1/2\beta imim(\ln P_{imim})^2 + 1/2\beta_{YY}(\ln Y)^2 + \beta_{kL}(\ln P_k)(\ln P_l) + \beta_{lY}(\ln P_l)(\ln P_Y) + \beta_{lY} \ln P_l \ln Y + \beta_{imQ} \ln P_{im} \ln Y + Y_{kt}\, t \ln P_k + Y_{lt}\, t \ln P_l + Y_{imt}\, t \ln P_m + Y_{Yt}\, t \ln Y + 1/2Y_{tt}\, t^2 \quad (4)$$

By assumption the cost function is linearity homogeneous in input prices and linearly homogeneous in output. This condition implies a large number of constraints on the translog form as follows.

$\alpha_Y = 1\ \beta_{YY} = 0, \beta_K$

$\alpha_Y = 1\ \beta_{YY} = 0, \beta_{KY} = 0, \beta_{imY} = 0, \quad Y_{Yt} = 0$

$\alpha_L + \alpha_K + \alpha_{im} = 1\ , \ \beta_{kk} + \beta_{kL} + \beta_{Kim} = 0, \beta_{LL} + \beta_{kL} + \beta_{LM} = 0$

$$\beta_{imim} + \beta_{Lim} + \beta_{Kim} = 0, Y_{Lt} + Y_{Kt} + Y_{imt} = 0 \quad (5)$$

If we want to extend the above results to the case of Hichks neutral technical progress, then we have the conditions as follows.

$$Y_{Lt} = Y_{Kt} = Y_{imt} = Y_{tt} = 0 \tag{6}$$

These constraints involve three additional constraints over those for constant returns to scale because one constraint is dropped due to constant returns to scale.

Following Uzawa，Allen partial elasticities of substitution between input i and input j in the translog cost function can be calculated as follows.

$$\sigma ii = (\beta ii + Si^2 - Si) / Si^2 \quad , \quad i = K, L, im \tag{7}$$

$$\sigma ij = (\beta ij + Si\,Sj) / Si\,Sj \quad , \quad i, j = K, L, im \tag{8}$$

Furthermore we find that Allen partial elasticities of substitution are related to the price elasticities of demand for factors of production as follows.

$$Eii = Si\,\sigma ii = (\beta ii + Si^2 - Si) / Si \,, \quad i = K, L, im \tag{9}$$

$$Eij = Sj\sigma ij = (\beta ij + Si\,Sj) / Si \quad , \quad i, j = K, L, im \tag{10}$$

Now we turn to the technical progress in the Translog cost function. We differentiate the Translog cost function with respect to time under constant returns to scale.

$$\alpha \ln C / \alpha t = \alpha_t + Y_{kt} \ln P_K + Y_{lt} \ln P_L + Y_{imt} \ln P_{im} + Y_{tt} \qquad (11)$$

Holding all other input prices, this equation includes all of the parameters that involve time effects. The negative of the equation 11 is the general technical progress we can estimate. According as Yit is less than, equal to, or greater than zero respectively, technical progress is input i- saving, i-intensive or i-using.

The cost function we are to estimate has been represented by the Translog cost function (4) subject to the constraints (5). Although the cost function can be estimated directly, the relatively large number of parameters and short time period suggests that an alternative procedure is preferable.

Berndt and Christersen show that the cost share for input i total cost Si may be used in the efficient estimation of the Translog Model.

In our case the cost share equations of capital, labor and import are as follows[8].

$$Sk = \alpha_k + \beta_{kk} \ln Pk + \beta_{kL} \ln PL + \beta_{kim} \ln Pim + Y_{kt} t \qquad (12)$$

$$Sl = \alpha_L + \beta_{KL} \ln Pk + \beta_{Lim} \ln Pim + \beta_{LL} \ln Pl + Y_{Lt} t \qquad (13)$$

$$Sm = \alpha_m + \beta_{kim} \ln Pm + \beta_{lim} \ln PL + \beta_{imim} \ln Pim + Y_{imt} t \qquad (14)$$

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8 The assumption, on which the equation after differencing cost function which respect to factors is the share of the factors, is that the firms act as producers in a competitive market, thus form the first order condition, we can derive the postulates.

The cost shares must be add up to one and one of the share equations can be omitted. Dropping the import equation, the two remaining share equations are as follows.

$$Sk=\alpha_k + \beta_{kL} \ln(Pk/Pim) + \beta_{kL} \ln(PL/Pim) + Y_{kt}t \quad (15)$$

$$Sl=\alpha_L + \beta_{kL} \ln(Pk/Pim) + \beta_{LL} \ln(PL/Pim) + Y_{Lt}t \quad (16)$$

The constraints (5) for liner homogeneity have been incorporated into the above two share equations.

The parameters for the import share equation can be found using the constraints.[9]

$$\beta_{kim} = -\beta_{kk} - \beta_{kL} \qquad \beta_{Lim} = -\beta_{kL} - \beta_{LL}$$

$$\beta_{imim} = \beta_{kk} + 2\beta_{kL} + \beta_{LL} \quad Y_{imt} = - Y_{kt} - Y_{Lt}$$

$$\alpha_{im} = 1 - \alpha_K - \alpha_L \quad (17)$$

Although we use the equations (15) and (16), we cannot estimate α_0, α_t and Ytt. To estimate these three parameters, we will estimate the cost function as the third equation. Considering the constraints (5) for linear homogeneity, the cost function (4) becomes as follows.

$$\ln TC=\alpha_0+\alpha_t t+\alpha_k \ln(P_k/P_{im})+\alpha_l \ln(P_L/P_{im})+\ln Y+1/2\beta_{kk}\{\ln(P_k/P_{im})\}^2+$$

[9] By assumption the cost function is linearly homogeneous in input prices and linearly homogeneous in output. Cost Minimization, Technical Progress and the Aggregate Demand for Imports Korea, 1963-81 Nah Ho-soo (Feb. 1984).

$$1/2\beta_{LL}\{\ln(P_l/P_{im})\}^2+\beta_{kL}\{\ln P_k \ln P_L-\ln P_k \ln P_{im}-\ln P_L \ln P_{im}+(\ln P_{im})^2\}+Y_{kt}t\ln(P_k/P_{im})+Y_{Lt}t\ln(P_L/P_{im})+1/2Y_{tt}t^2 \quad (18)$$

The three equations (15) (16) and (18) are estimated as a system.

Chapter 3 Analyses of Empirical Results

3.1. The data

3.1.1 Sources[10] of the data

The data of year 1978-2007 were taken from the Chinese statistical year book, various issues and World Bank Base. Including real total gross output, what is the total cost factor (TC); the real GDP which is the total output factor (Y), real capital stock which is the capital factor input (X_K), the labor (X_L) which is the labor factor number, real import value which is the real price of the imported inputs (X_{IM}), the capital deflator which is the real price of capital (P_K), wage (P_L) which is the real labor price, the import price deflator which is the real price of the import(P_{IM}). The data are present in the following.

In table 1, all the price data are the real price of the factor and with the base of 1978 yuan. And for the labor, the number of the labor is the million units.

[10] All the data come from RTGO, Economy communiqué of Chinese government 1978-2007 Others, Chinese statistical year book, various issues.

Table 1 The original date of China's overall economy, 1978-2007

Year	TC	Y	X_K	X_L	X_{IM}
1978	5689.8	3645.2	14112	40.152	187.4
1979	6122.222	3922.235	15273	41.024	215.136
1980	6600.174	4228.432	16438	42.361	205.2327
1981	6947.252	4450.789	17268	43.725	235.2311
1982	7573.128	4851.761	18297	45.295	224.9943
1983	8398.142	5380.315	19515	46.436	274.1859
1984	9672.66	6196.84	20928	48.197	375.5658
1985	10975.63	7031.591	22755	49.873	726.3437
1986	11948.58	7654.92	24822	51.282	715.8544
1987	13331.21	8540.704	27123	52.783	541.0407
1988	14833.31	9503.036	30085	54.334	599.8401
1989	15436.42	9889.428	33445	55.329	606.1132
1990	16028.17	10268.53	36565	63.909	614.9717
1991	17501.82	11212.64	39776	64.799	742.6285
1992	19993.96	12809.23	43589	65.554	857.9935
1993	22690.92	14595.38	48994	66.373	997.9966
1994	25564.27	16505.47	55006	67.199	1501.158
1995	27731.77	18309.84	61856	67.947	1550.31
1996	30958.2	20143.38	69304	68.85	1626.363
1997	33683.61	22013.36	77218	69.6	1737.89
1998	36312.31	23737.54	85692	69.957	1777.502
1999	38926.8	25549.21	91627	71.394	2201.511
2000	42196.65	27699.87	97662	72.085	2825.69
2001	45234.81	30000	104601	73.025	3124.925
2002	49260.71	32726.61	112766	73.74	4005.608
2003	54186.78	36007.29	123034	74.432	5094.613
2004	58183.49	39637.9	135159	75.2	6297.817
2005	62180.2	43771.56	149028	75.825	5641.398
2006	66176.91	48871.2	164862	76.4	6329.738
2007	70173.62	54703.52	182771	76.99	7350.655

Continued table 1: (100million 1978yuan)

Year	P_K	P_L	P_{IM}
1978	1	615	1
1979	1.021877	668	1.129053
1980	1.052929	762	1.456395
1981	1.086803	772	1.563144
1982	1.111856	798	1.588929
1983	1.139379	826	1.538372
1984	1.185603	974	1.652174
1985	1.270995	1148	1.731687
1986	1.353211	1329	2.093023
1987	1.423783	1459	2.98351
1988	1.615385	1747	3.42608
1989	1.752294	1935	3.62952
1990	1.848271	2140	4.186047
1991	2.005293	2340	4.576581
1992	2.266055	2711	5.178711
1993	2.833804	3371	5.998217
1994	3.126676	4538	6.634944
1995	3.314749	5500	7.126379
1996	3.445307	6210	7.106286
1997	3.503529	6470	6.793584
1998	3.436133	7479	6.540698
1999	3.490826	8346	6.239579
2000	3.528582	9371	6.596195
2001	3.542343	10870	6.451099
2002	3.550106	12422	6.099025
2003	3.627382	14040	6.712109
2004	3.83204	16024	7.373317
2005	3.892025	18364	9.620612
2006	3.948975	21001	10.01256
2007	4.10273	24932	9.969805

Source: TC, Economy communiqué of Chinese government 1978-2007, World Bank Base, Others, Chinese statistical year book, various issues.

3.1.2 The factor data

As mentioned above, the inputs factors involved in a railway production include capital, labor, and imports. The price indices for each variable are measured by the following equation given in 2000 prices as the base. To eliminate the effects of inflation, all variables are measured in real terms.

3.1.2.1 The labor price

$ipL_i = P_{li}/ P_{lb}$ $\quad$ $i = 1978\text{-}2007$

where:

ipL_i : labor price index for year i

P_{li} : labor price for year i,

P_{lb} : labor unit price for base year (i.e. year 2000)

The total labor costs in question are the wage expenses of all the labors in China, including the industry labor force, the agricultural labor force and so on. The size of the workforce is the total number of employee.

3.1.2.2 The capital price

$Ipk = P_{ki} / P_{kb}$ $i = 1978\text{-}2007$

Where:

Ipk: capital price index for year i

$P_{ki:}$ capital price for year i.

P_{kb} : capital unit price for base year (i.e. year 2000)

The capital is defined as the sum of interest and depreciation associated with the capital stock and structure capital which represent the factory workshop, the land the product facilities and so on. As these are typically long-lived, they are treated as a fixed factor. The capital denoted K, is measured as the sum of interest and depreciation associated with the fixed ones.

3.1.2.3 The import price

$Ipim_i = P_{imi} / P_{imb}$ $i = 1978\text{-}2007$

Where:

$Ipim_i$: import price index for year i

P_{imi} : import price for year i

P_{imb} : import unit price for base year (i.e. year 2000)

he input factor of imported are materials that in the national production used and come form the foreign markets, including the raw materials that are imported, the imported energy, the imported facilities, the imported technology and so on.

3.1.3The real output factor price

$Y_t = P_{Yi} / P_{Yb}$ i = 1978-2007

Where:

Yt : real gross domestic production price index for year i

P_{Yi} : real gross domestic production price for year i

P_{Yb} : real gross domestic production price for base year (i.e. year 2000)

The total output factor which is defined as the gross domestic output (GDP), is a measure of the amount of the economic production of a particular territory in financial capital terms during a specific time period. It is one of the measures of national income and output. It is often seen as an indicator of the standard of living in a country.

3.1.4 The real total cost factor price

$TC_i = P_{TCi} / P_{TCb}$ i = 1978-2007

Where;

TC_i : real total gross output price index for year i

P_{TCi} : real total gross output price for year i

P_{TCb} : real total gross output for base year (i.e year 2000)

Due to the total gross output of the nation were consumed by the labor force or be used as semifinished product for the final production, the total gross output of the nation meanwhile is the total cost of the nation.

3.1.5 The share of factor cost

The calculation of the share for capital (SK), labor (SL) and import (Sim) are as follows.

SK = Pk * Wk / (Pk*Wk +PL*WL+Pim*WL)

SL = PL * WL / (Pk*Wk +PL*WL+Pim*WL)

Sim = Pim * Wim / (Pk*Wk +PL*WL+Pim*WL)

3.1.6 Time series index data for the model

Based on the section 3.1.2 to section 3.1.5 mentioned we converse the original data of table 1 for the translog cost function system equations to use.

Using the data of year 2000 as standard, the index of real total gross output TC, index of Y, index of K, index of wage L and index of the price of import IM are presented in the table 2-1 follows.

Table 2-1 The index data for model

Year	TC	Y	PK	PL	PIM
1978	0.13484	0.131596	0.144498	0.065628	0.151603
1979	0.145088	0.141598	0.156386	0.071284	0.171167
1980	0.156415	0.152652	0.168315	0.081315	0.220793
1981	0.16464	0.160679	0.176814	0.082382	0.236977
1982	0.179472	0.175155	0.18735	0.085156	0.240886
1983	0.199024	0.194236	0.199822	0.088144	0.233221
1984	0.229228	0.223714	0.21429	0.103938	0.250474
1985	0.260107	0.253849	0.232997	0.122506	0.262528
1986	0.283164	0.276352	0.254162	0.141821	0.317308
1987	0.315931	0.30833	0.277723	0.155693	0.452308
1988	0.351528	0.343071	0.308052	0.186426	0.519402
1989	0.365821	0.357021	0.342457	0.206488	0.550245
1990	0.379845	0.370707	0.374404	0.228364	0.634615
1991	0.414768	0.40479	0.407282	0.249707	0.693821
1992	0.473828	0.462429	0.446325	0.289297	0.785106
1993	0.537742	0.526911	0.501669	0.359727	0.909345
1994	0.605836	0.595868	0.563228	0.48426	1.005875
1995	0.657203	0.661008	0.633368	0.586917	1.080377
1996	0.733665	0.727201	0.709631	0.662683	1.077331
1997	0.798253	0.79471	0.790666	0.690428	1.029925
1998	0.86055	0.856955	0.877434	0.798101	0.991587
1999	0.922509	0.922358	0.938205	0.89062	0.945936
2000	1	1	1	1	1
2001	1.072	1.083037	1.071051	1.159962	0.978003
2002	1.167408	1.181471	1.154656	1.325579	0.924628
2003	1.284149	1.299908	1.259794	1.498239	1.017573
2004	1.378865	1.430978	1.383947	1.709956	1.117814
2005	1.473581	1.580208	1.525957	1.959663	1.458509
2006	1.568298	1.764311	1.688087	2.241063	1.51793
2007	1.663014	1.974865	1.871465	2.660549	1.511448

According to the section 3.1.5 the share of the inputs (capital, labor, imported material) in the total cost, the share of capital (SK), the share of labor (SL) and the share of imported material (Sim) in the according year are presented in the following table 2-2

Table 2-2: The share of inputs according to total cost

Year	Sk	Sl	Sim
1978	0.361912	0.633282	0.004806
1979	0.360825	0.63356	0.005616
1980	0.346952	0.647057	0.005992
1981	0.354827	0.638221	0.006952
1982	0.357869	0.635842	0.006289
1983	0.364431	0.628656	0.006913
1984	0.342822	0.648605	0.008573
1985	0.330783	0.654831	0.014386
1986	0.325348	0.660139	0.014513
1987	0.329381	0.656851	0.013768
1988	0.33384	0.652043	0.014117
1989	0.349118	0.637777	0.013105
1990	0.326607	0.660952	0.012441
1991	0.339717	0.645807	0.014475
1992	0.351594	0.63259	0.015816
1993	0.376699	0.60706	0.016242
1994	0.35323	0.626314	0.020456
1995	0.347642	0.633626	0.018732
1996	0.352231	0.63072	0.017049
1997	0.369254	0.614631	0.016115
1998	0.355064	0.630916	0.014019
1999	0.344134	0.641086	0.014779
2000	0.331751	0.650306	0.017943
2001	0.312825	0.670156	0.01702
2002	0.298585	0.683193	0.018221
2003	0.292552	0.685032	0.022416
2004	0.292722	0.681034	0.026244
2005	0.286183	0.687038	0.026779
2006	0.280753	0.691916	0.027331
2007	0.273406	0.699874	0.02672

3.2 The results of estimation

3.2.1 Parameters estimation

We estimated the system of equations consisting of the cost function, using the Full Information Maximum Likelihood (FIML) command to apply maximum likelihood methods in EVIEWS (version 5.0)

Table 3 presents the estimate result for the cost function. Standard errors t-statistic and meanwhile the probability of each parameter for the cost equation are also reported in table 3.

Under the assumption of production cost minimization, in order that the cost function be well-behaved, the estimated model must be non-negative in input prices, concave in factor prices and monotonically increasing in output(Varian, 1984). Non-negativity in input price is satisfied if the cost shares of the input factors are positive. Concavity is satisfied if the Hessian Matrix of second order coefficients is negative semi-definite. Monotonicity is satisfied if the predicted costs increase as output increase (McGreehan, 1993). All three conditions are satisfied in our estimates, thus indicating the translog cost function captures well the underlying technology.

Table 3: Parameter estimates for translog variable cost function

	Coefficient	Std. Error	z-Statistic	Prob.
α_0	0.566222	0.401264	1.411096	0.1582
α_t	0.054185	0.057554	0.941468	0.3465
α_k	0.361062	0.09798	3.685076	0.0002
α_l	0.631635	0.082534	7.65303	0
β_{kk}	0.022695	0.118609	0.191341	0.8483
β_{LL}	0.007559	0.090188	0.083814	0.9332
β_{kL}	-0.0125	0.104394	-0.11971	0.9047
Y_{kt}	-0.00179	0.004537	-0.39465	0.6931
Y_{Lt}	0.001251	0.003829	0.32661	0.744
Y_{tt}	-0.00643	0.003415	-1.88171	0.0599
Log Likelihood		238.2913		
Determinant residual covariance		2.53E-11		

Since $Y_{kt} + Y_{Lt} + Y_{imt} = 0$, $Y_{imt} = 0.00054$.The labor cost share and imports share are positive, implying that the cost function is increasing in this imput factor.

Since $Y_{kt} < 0$, $Y_{Lt} > 0$ and $Y_{imt} > 0$, technical progress in China from 1978 to 2007 is labor-intensive, capital-saving and import-using. But, the value of Y_{imt} suggests that the share of imports is increasing slowly.

The time trend parameters α_t and Y_{tt} indicate the shifting isoquants for producing any output level, $\alpha_t = 0.054185$ shows that the isoquants have been moving outward and Y_{tt} = -0.00643 implies that the speed of moving outward is lower every year.

3.2.2 Technical change

According to the table 3, using the method provide above, we can calculate the technical change, and the result are presented in the following Table 4:

Table 4 Technical progress

Year	TP	Year	TP
1978	0.046798	1993	0.047664
1979	0.046825	1994	0.047883
1980	0.046996	1995	0.047952
1981	0.046962	1996	0.047899
1982	0.046909	1997	0.047732
1983	0.046819	1998	0.047707
1984	0.046939	1999	0.047699
1985	0.04702	2000	0.047759
1986	0.047149	2001	0.04781
1987	0.047299	2002	0.047812
1988	0.047413	2003	0.047861
1989	0.047383	2004	0.047908
1990	0.047426	2005	0.048048
1991	0.047435	2006	0.048056
1992	0.047522	2007	0.048084
Total		average	0.047492
1978-1989		average	0.047043
1990-1999		average	0.047692
2000-2007		average	0.047917

Let's turn to the question of technical progress, in the table 3. The data indicates that there is evidence of a large negative time shift of the variable cost function. Thus the negative coefficient of T indicates that the China's economy underwent large progressive technical change during the period considered in the analysis. In the Table 4, the yearly technical change rate is 4.7%. Technical change plays an important part in the growth of Chinese economy. The technical change rate from 1978 to 1989 is 4.7%, and it is 4.77% from 1990 to 1999. From 2000 to 2007, the rate is 4.79%. It implies that the increasing rates of the technical progress in China are gradually higher and higher.

3.2.3 Features of input factors

According to the result of table 3 parameter estimates for translog cost function of the China's overall economy 1978-2007. We report in table 5 and 6 using the Eviews.

Table 5 Elasticities of substitution

Year	σ kk	σ ll	σ imim	σ kl	σ kim	σ lk	σ lim	σ imk	σ iml
1979	-1.6	-0.56	-10.308	0.9453	-4.03	0.95	2.39	-4.03	2.388
1980	-1.69	-0.53	-19.407	0.9443	-3.91	0.94	2.27	-3.91	2.274
1981	-1.64	-0.55	-34.03	0.9448	-3.13	0.94	2.11	-3.13	2.113
1982	-1.62	-0.55	-25.038	0.9451	-3.53	0.95	2.23	-3.53	2.235
1983	-1.57	-0.57	-33.612	0.9455	-3.05	0.95	2.14	-3.05	2.136
1984	-1.72	-0.52	-44.091	0.9438	-2.47	0.94	1.89	-2.47	1.888
1985	-1.82	-0.51	-43.101	0.9423	-1.14	0.94	1.52	-1.14	1.524
1986	-1.86	-0.5	-42.936	0.9418	-1.16	0.94	1.52	-1.16	1.515
1987	-1.83	-0.5	-43.888	0.9422	-1.25	0.94	1.55	-1.25	1.546
1988	-1.79	-0.52	-43.448	0.9426	-1.16	0.94	1.54	-1.16	1.536
1989	-1.68	-0.55	-44.685	0.9439	-1.23	0.94	1.59	-1.23	1.591
1990	-1.85	-0.5	-45.402	0.9421	-1.51	0.94	1.6	-1.51	1.601
1991	-1.75	-0.53	-42.984	0.943	-1.07	0.94	1.53	-1.07	1.528
1992	-1.66	-0.56	-41.203	0.9438	-0.83	0.94	1.49	-0.83	1.494
1993	-1.49	-0.63	-40.634	0.9453	-0.67	0.95	1.5	-0.67	1.501
1994	-1.65	-0.58	-35.317	0.9435	-0.41	0.94	1.39	-0.41	1.385
1995	-1.69	-0.56	-37.397	0.9433	-0.57	0.94	1.42	-0.57	1.416
1996	-1.66	-0.57	-39.561	0.9437	-0.7	0.94	1.46	-0.7	1.459
1997	-1.54	-0.61	-40.803	0.9449	-0.71	0.94	1.5	-0.71	1.499
1998	-1.64	-0.57	-43.572	0.9442	-1.05	0.94	1.56	-1.05	1.558
1999	-1.71	-0.54	-42.585	0.9434	-1	0.94	1.52	-1	1.521
2000	-1.81	-0.52	-38.397	0.9421	-0.71	0.94	1.42	-0.71	1.423
2001	-1.96	-0.48	-39.6	0.9404	-0.92	0.94	1.43	-0.92	1.433
2002	-2.09	-0.45	-38.041	0.9387	-0.87	0.94	1.4	-0.87	1.397
2003	-2.15	-0.44	-33.145	0.9376	-0.56	0.94	1.32	-0.56	1.322
2004	-2.15	-0.45	-29.468	0.9373	-0.33	0.94	1.28	-0.33	1.276
2005	-2.22	-0.44	-29.009	0.9364	-0.33	0.94	1.27	-0.33	1.268
2006	-2.27	-0.43	-28.548	0.9357	-0.33	0.94	1.26	-0.33	1.261
2007	-2.35	-0.41	-29.059	0.9347	-0.4	0.93	1.26	-0.4	1.264
average	-1.81	-0.52	-36.527	0.9421	-1.35	0.94	1.6	-1.35	1.598

Table 6 The average elasticities of substitution

Year	1978-1989	1990-1999	2000-2007
σ kk	-1.710426	-1.663761	-2.127108
σ ll	-0.532885	-0.563238	-0.452607
σ imim	-34.95848	-40.94581	-33.15845
σ kl	0.9437832	0.9437326	0.9378674
σ kim	-2.369432	-0.852631	-0.555064
σ lk	0.9437832	0.9437326	0.9378674
σ lim	1.8861074	1.4962115	1.3305502
σ imk	-2.369432	-0.852631	-0.555064
σ iml	1.8861074	1.4962115	1.3305502

All the estimates of own elasticities of substitution have negative signs, which indicates that the import demands to their price increase are decreasing. We find that capital and labor, labor and import are substitutable, but capital and imports are not. The average elasticities of substitution about capital and labor, labor and import are descending.

Own and cross partial price elasticities is shown in table 7 and 8.

Table 7 Price elasticities of input demand

Year	ε kk	ε ll	ε imim	ε kl	ε kim	ε lk	ε lim	ε imk	ε iml
1979	-0.58	-0.35	-0.058	0.6	-0.023	0.341	0.013	-1.455	1.513
1980	-0.59	-0.34	-0.116	0.61	-0.023	0.328	0.014	-1.355	1.471
1981	-0.58	-0.35	-0.237	0.6	-0.022	0.335	0.015	-1.112	1.349
1982	-0.58	-0.35	-0.157	0.6	-0.022	0.338	0.014	-1.264	1.421
1983	-0.57	-0.36	-0.232	0.59	-0.021	0.345	0.015	-1.111	1.343
1984	-0.59	-0.34	-0.378	0.61	-0.021	0.324	0.016	-0.847	1.225
1985	-0.6	-0.33	-0.62	0.62	-0.016	0.312	0.022	-0.378	0.998
1986	-0.6	-0.33	-0.623	0.62	-0.017	0.306	0.022	-0.377	1
1987	-0.6	-0.33	-0.604	0.62	-0.017	0.31	0.021	-0.411	1.016
1988	-0.6	-0.34	-0.613	0.61	-0.016	0.315	0.022	-0.389	1.002
1989	-0.59	-0.35	-0.586	0.6	-0.016	0.33	0.021	-0.429	1.015
1990	-0.6	-0.33	-0.565	0.62	-0.019	0.308	0.02	-0.493	1.058
1991	-0.59	-0.34	-0.622	0.61	-0.016	0.32	0.022	-0.365	0.987
1992	-0.58	-0.36	-0.652	0.6	-0.013	0.332	0.024	-0.293	0.945
1993	-0.56	-0.38	-0.66	0.57	-0.011	0.356	0.024	-0.251	0.911
1994	-0.58	-0.36	-0.722	0.59	-0.008	0.333	0.028	-0.145	0.868
1995	-0.59	-0.35	-0.701	0.6	-0.011	0.328	0.027	-0.197	0.897
1996	-0.58	-0.36	-0.674	0.6	-0.012	0.332	0.025	-0.246	0.92
1997	-0.57	-0.37	-0.658	0.58	-0.012	0.349	0.024	-0.264	0.921
1998	-0.58	-0.36	-0.611	0.6	-0.015	0.335	0.022	-0.372	0.983
1999	-0.59	-0.35	-0.629	0.6	-0.015	0.325	0.022	-0.346	0.975
2000	-0.6	-0.34	-0.689	0.61	-0.013	0.313	0.026	-0.237	0.926
2001	-0.61	-0.32	-0.674	0.63	-0.016	0.294	0.024	-0.286	0.96
2002	-0.63	-0.31	-0.693	0.64	-0.016	0.28	0.025	-0.261	0.954
2003	-0.63	-0.3	-0.743	0.64	-0.012	0.274	0.03	-0.162	0.905
2004	-0.63	-0.31	-0.773	0.64	-0.009	0.274	0.033	-0.096	0.869
2005	-0.63	-0.3	-0.777	0.64	-0.009	0.268	0.034	-0.095	0.871
2006	-0.64	-0.3	-0.78	0.65	-0.009	0.263	0.034	-0.092	0.873
2007	-0.64	-0.29	-0.776	0.65	-0.011	0.256	0.034	-0.108	0.885
average	-0.6	-0.34	-0.573	0.61	-0.015	0.315	0.023	-0.463	1.037

Table 8 The average price elasticities of input demand

Year	1978-1989	1990-1999	2000-2007
ε_{kk}	-0.5890358	-0.5837454	-0.6270012
ε_{ll}	-0.3434043	-0.3556701	-0.3078278
ε_{imim}	-0.3840848	-0.6493915	-0.7382473
ε_{kl}	0.60860623	0.59677627	0.63872098
ε_{kim}	-0.0195705	-0.0130309	-0.0117198
ε_{lk}	0.32572432	0.3318443	0.27773954
ε_{lim}	0.01768002	0.02382579	0.03008827
ε_{imk}	-0.8297305	-0.2971693	-0.1671691
ε_{iml}	1.21381533	0.94656081	0.90541648

We obtain the following implications from the above results.

Tax policies which raise the rental rate on capital services to producers will not tend to raise the demand for imports.

We find that the increase of nominal wage rates reduces the demand for labor services and raises the demand for imports.

We find that the imposition of tariff on imported goods leads to the decrease of the demand for imports and capital services, increase of the demand for labor services.

Chapter 4 Conclusions

The Translog cost function with time trend was employed for the analysis of the demand for imports in China, 1978-2007.

This paper discusses the technical progress, the imports demand during the period of year 1978-2007 using the translog cost function. And in the process this paper also estimated the elasticities of the input factors to how they acted in the Chinese economy. We know that the capital and the labor, the imports and the labor are substitutes with respect to each other. The own elasticities of inputs are negative sign, which indicates that the import demands to their price increase are decreasing.

In this study, we found that technological progress is labor-intensive, capital-saving and import-using natures. And in the year 1978 to 2007 the average technical is 4.7%. Technical change plays an important part in the growth of Chinese economy. The increasing rates of technical progress in China are gradually higher and higher.

The comments on the interpretation of this study are in order.

Firstly, the data used in this study were highly aggregated national time-series data. If proper data were available, disaggregated studies in China Economy would be required.

Secondly, we must note the problems which result from exclusion of domestic intermediate goods. If the proper data of domestic intermediate goods were available, it would be necessary to analyze the demand for import by inserting the domestic intermediate goods into the cost function.

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