Quantificational analysis and simulation of Technical Barriers to Trade with two country model*

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Abstract: The Technical Barriers to Trade (TBT) is an important problem faced to the export of China. Based on the number differences of TBT notifications between countries, we propose the concept and computational method of the technical barrier coefficient. By means of price-production and price-demand functions, a trade model with a developed country and a developing country is designed. The available trade policies such as technical barriers, tariffs and export subsidies are simulated and analyzed. According to the simulation results, several trade strategies to come over technical barriers are suggested. These suggestions were provided to several export enterprises for their export strategy design.

Key words: Technical Barriers to Trade; two country model; economic system modeling; computer simulation; strategy design

1. Introduction

Technical Barriers to Trade (TBT) is a key way for western developed countries to keep their favorable position in international trade (Calvin L. & Krissoff B., 1998). Since WTO agreement had been signed, the tariff rate of international trade is limited. By using their favorable position of standard and technology, the western developed countries continually propose new technical notifications. These technical notifications form the "soft barriers" to obstruct the import from developing countries. Since 2004, USA, European Union, Japan and Canada all make the new technical notifications of primary products to restrict the export of farm products from China (YANG Bo, 2007; SUN Long-zhong & XU Song, 2008). It brings great economic loss to China. Therefore, it is an important problem faced to us to study on the influence and strategies to over come the soft technical barriers to international trade (JI Rui, 2008).

As view of the current situation, the domestic researches on technical barriers are almost by non-quantificational methods or case studies (JI Rui, 2008; ZHOU Wei-min, 2005). Although there are several quantificational approaches such as Traffic Equivalent Method, Trade Gravity Model, and Computable General Equilibrium Model used by abroad researchers (ZHOU Wei-min, 2005), they are still waited to be proven by the practical applications due to their different disadvantages.

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Because computer aided simulation can provide quantificational results to economic analysis and decision support for strategy design and optimization, simulation has been applied to various economic analysis and strategy design (ZHOU Wei-min, 2002). In the game of economy and trade between developed and developing countries two country model is an efficient tool (Sarkar A., 1989; Málaga J. E., Williams G. W. & Fuller S. W., 2001; Suga N., 2005).

Based on above methods, we propose the concept barrier coefficient and its computational formula with the difference of technical notification numbers between two countries. By using the price-production and price-demand functions, we built a two country model of developed and developing countries. The influence of technical barriers, the tariff and export subsidy strategies are analyzed by computer simulation with the model. Based on the quantificational results from simulation, several suggestions to overcome the technical barriers of western developed countries are presented. Above works had been applied into several export oriented enterprises in the Guangdong Province of China for their export strategy design. The achieved results are satisfactory to the enterprise owners (JIANG Jian-ye, 2002a; JIANG Jian-ye, 2002b).

2. Barrier coefficient

The foundation of the study on technical barriers is how quantify the barriers. TANG and WANG proposed the concept of Non-Tariff Barrier Intensity (NTBI) which provides a new way to quantify the technical barriers (TANG Hai-bin, 2007). According to this approach, NTBI is defined as the weighted average value of the export amounts of multiply countries. The weights are taken as one or zero depended on if there is any technical notification for an industry. However, this method is not suitable to our problem of two country trade game, because it is just for the barrier measure of multiply products from multiply countries. The additional problem is that there is no limitation on the upper and lower bounds of the NTBI values. Thus, it may bring the uncontrollable problem to simulation.

In view of the fact that the technical notification numbers of TBT and SPS (Agreement on the application of sanitary and phytosanitary measures) present the intensity of technical barriers directly, we define the barriers coefficient by the comparison of technical notification numbers of two countries. We present the notification numbers of nine different countries from 2004 to 2008 in Table 1.

The numbers of Holland and France is the sums of their owed data and European Union. The data are all collected from the Chinese Official website of WTO/ TBT-SPS (www.tbt-sps.gov.cn).

According to author's definition in literature (JIANG Jian-ye, 2002c), the barrier coefficient between two countries is defined as follows.

Let A_i and A_j be the notification numbers of TBT and SPS separately, the technical barrier coefficient to trade of country i to country j, BF_{ij} is defined as:

$$BF_{ij} = \max\left\{0,\ \frac{A_i - A_j}{A_i}\right\} \tag{1}$$

From formula (1), we can see that the barrier coefficient, BF_{ij} is a real number in duration [0, 1]. If BF_{ij}=0, it means that the technical standard of country i is lower than country j. Therefore, there is no technical barriers of country i to country j. The larger BF_{ij} the higher is the technical barrier to the export from country i to country j.

By using the formula (1), the technical barriers of main western developed countries to China is calculated and shown in Table 2.

Table 1 Notification numbers of TBT and SPS

	Term	2004	2005	2006	2007	2008
China	TBT	68	181	250	348	457
	SPS	88	105	111	115	120
	Total	156	286	361	463	577
USA	TBT	140	232	326	473	568
	SPS	833	1075	1470	1867	2024
	Total	973	1307	1796	2340	2592
Holland	TBT	207	234	284	329	363
	SPS	247	290	337	392	417
	Total	454	524	621	721	780
France	TBT	137	178	231	284	327
	SPS	238	280	327	380	404
	Total	375	458	558	664	731
UK	TBT	114	142	189	229	260
	SPS	236	279	326	379	403
	Total	350	421	515	608	663
Canada	TBT	145	192	236	287	323
	SPS	203	263	301	344	379
	Total	348	455	537	631	702
Japan	TBT	185	214	252	300	327
	SPS	65	88	108	135	147
	Total	250	302	360	435	474
India	TBT	9	10	20	36	38
	SPS	15	31	48	59	64
	Total	24	41	68	95	103
Senegal	TBT	3	3	3	3	3
	SPS	0	0	0	0	0
	Total	3	3	3	3	3

Table 2 The technical barriers of western countries to China

	USA	Holland	France	UK	Canada	Japan
2004	0.840	0.656	0.584	0.554	0.552	0.376
2005	0.781	0.454	0.376	0.321	0.371	0.053
2006	0.799	0.419	0.353	0.299	0.328	0
2007	0.802	0.358	0.303	0.239	0.266	0
2008	0.777	0.260	0.211	0.136	0.178	0

From Table 2, we can see that the defined technical coefficients represented the technical differences and barrier intensities between China and developed countries are very well.

The data shown in Table 2 tell us the fact that China paid more attention to make technical standards. The notification numbers of TBT and SPS both increase fast. Therefore, the technical barriers of most developed countries to China decline distinctly, Japan even reduced to zero. However, the notification numbers of USA is still distinctly larger than other countries. It shows that USA is still takes the leading position in science and technology.

3. Two country model with barriers coefficients

Based on the concept of technical barriers coefficient, we built a two country model of a pair of developing and developed countries. The purpose of the model is to analyze the trade strategy of the developing country faced to the higher technical barriers of developed country.

Let country 1 to be a developing country and country 2 to be a developed country. The labor cost of country 1 is lower than country 2, but its capital cost is higher than country 2. Therefore, country 1 exports a labor intensity product to country 2, and import a capital intensity product from country 2, respectively. The incomes of the two countries are both from production tax and import tariff. The payments of two countries are both the subsidy to export. The country 1 adjusts the trade balance by means of import tariff and export subsidy, but country 2 adjusts by technical barriers. The country 1 spends money to purchase patents and learn technology for reduction of technical barriers.

The notations are described as follows:

L_i: the labor cost of country i, $i=1,2$; where we set $L_1< L_2$;

K_i: the capital cost of country i, $i=1,2$; where we set $K_1>K_2$;

R_{ij}: the labor requirement in country i for unit of product j, $i=1,2$, $j=1,2$;

Q_{ij}: the capital requirement in country i for unit of product j, $i=1,2$, $j=1,2$;

P_{ij}: the production cost of product j in country i, $i=1,2$, $j=1,2$;

P_{eij}: the cost of export product j in country i, $i=1,2$, $j=1,2$;

P'_{ij}: the market price of product j in country i, $i=1,2$, $j=1,2$;

$D_{ij}(P'_{ij})$: the demand function of country i to product j with market price P'_{ij}, $i=1,2$, $j=1,2$;

$S_{ij}(P'_{ij})$: the supply function of country i to product j with market price P'_{ij}, $i=1,2$, $j=1,2$;

t_{ij} : the production tax rate of country i to product j, $i=1,2$, $j=1,2$;

x_{ij}: the import tariff rate of country i to product j, $i=1,2$, $j=1,2$. Note: As the rule of WTO, we set $0< x_{ij}\leq A$, where A is the limitation of tariff upper bound suggested by WTO for fair trade.

y_{ii}: the export subsidy rate of country i to product i, $i=1,2$. Where, the subsidy rate y_{ii} should meet that $t_{ij}\geq y_{ii}$, where, t_{ij} is the production tax rate of country $i$to product j given above.

W_{ij}: the technical additional cost of country i to set the trade barrier of product j. We set the its basic value is W_{0ij}, $i=1,2$, $j=1,2$, $i\neq j$; (It may be used to purchase patent or import technology).

λ_{ij}: the adjusted amount of the technical additional cost of country i to product j depended on the trade situation, $i=1,2$, $j=1,2$, $i\neq j$;

TB: the technical barriers coefficient of country 2 to country 1.It is calculated by $TB=(A_2-A_1)/A_2$, where, A_1 is the technical notification number of developing country 1, and A_2 of developed country;

TQ_{ij}: the import amount of country i of product j, $i=1,2$, $j=1,2$, $i\neq j$;

G_i: the trade balance of country i, $i=1,2$;

Z_i: the government income of country i, $i=1,2$;

Z_{Pi}: the total production tax of country i, $i=1,2$;

Z_{Ci}: the total tariff income of country i, $i=1,2$;

Z_{Ei}: the total export subsidy of country i, $i=1,2$.

The equations of the model are shown follows:

The production cost of product j in country i:

$$P_{ij} = R_{ij}L_i + Q_{ij}K_i, i = 1,2, j = 1,2; \tag{2}$$

The price of product i in market of country i:

$$P'_{ii} = P_{ii}(1 + t_{ii}), i = 1,2; \tag{3}$$

The export cost of country i for product i:

$$P_{eii} = R_{ii}L_i + Q_{ii}K_i + W_{ji}, i = 1,2; \tag{4}$$

The price of product *i* exported from country *i* to country *j*:

$$P'_{ji} = P_{eii}(1 + t_{ii} - y_{ii})(1 + x_{ji}), \quad i = 1,2, j = 1,2, i \neq j; \tag{5}$$

The demand function of product *j* in the market of country *i*:

$$D_{ij}(P'_{ij}) = a_{ij} - b_{ij}P'_{ij}, i = 1,2, j = 1,2; \tag{6}$$

The supply function of product *j* to the market of country *i*:

$$S_{ij}(P'_{ij}) = c_{ij} + d_{ij}P'_{ij}, i = 1,2, j = 1,2; \tag{7}$$

Where, a_{ij}, b_{ij}, c_{ij}, d_{ij} are the constant parameters greater than zero. P'_{ij} is the market price of product *j* in country *i*, D_{ij} is the demand of country i to product j with market price P'_{ij}; S_{ij} is the supply in the same situation.

Generally, both demand and supply can be described by linear functions as shown in Fig. 1.

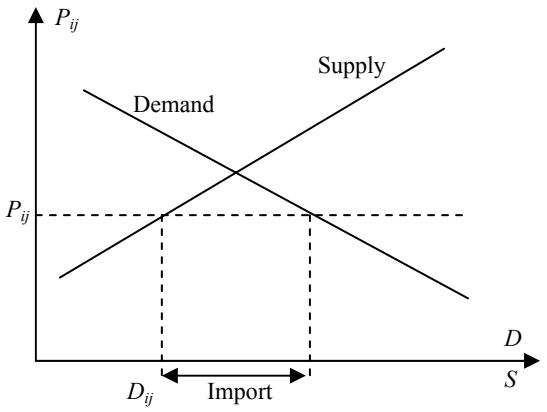

Fig. 1 The functions of demand, supply and import with price

The price of import product *j* in country *i*:

$$P'_{ij} = P_{ejj}(1 + t_{jj} - y_{jj})(1 + x_{ij}); \tag{8}$$

The import amount of product *j* in country *i*:

$$TQ_{ij} = D_{ij}(P'_{ij}) - S_{ij}(P'_{ij}); \tag{9}$$

The total import tariff of country *i*:

$$Z_{Ci} = (D_{ij}(P'_{ij}) - S_{ij}(P'_{ij}))P_{ejj}(1 + t_{jj} - y_{jj})x_{ij}, \quad i = 1,2, j = 1,2, i \neq j; \tag{10}$$

The total product tax of country *i*:

$$Z_{Pi} = (D_{ji}(P'_{ji}) - S_{ji}(P'_{ji}))P_{eii}t_{ii} + D_{ii}(P'_{ii})P_{ii}t_{ii} + S_{ij}(P'_{ij})P_{ij}t_{ij}, \quad i = 1,2, j = 1,2, i \neq j; \tag{11}$$

The total export subsidy of country *i*:

$$Z_{Ei} = (D_{ji}(P'_{ji}) - S_{ji}(P'_{ji}))P_{eii}y_{ii}, \quad i = 1,2, j = 1,2, i \neq j; \tag{12}$$

The trade balance of country *i*:

$$G_i = (D_{ji}(P'_{ji}) - S_{ji}(P'_{ji}))P'_{ji} - (D_{ij}(P'_{ij}) - S_{ij}(P'_{ij}))P'_{ij}, \quad i = 1,2, j = 1,2, i \neq j; \tag{13}$$

G_i>0, means country *i* has trade surplus, and G_i<0 for trade deficit.

The total government income of country *i* is:

$$Z_i = Z_{Pi} + Z_{Ci} - Z_{Ei}, i = 1,2; \tag{14}$$

The available trade strategy tools of country 1 include the import tariff rate x_{12} and the export subsidy rate y_{11};

those of country 2 include the import tariff rate x_{21}, the export subsidy rate y_{22} and the additional cost to set technical barriers W_{21}.

Once the export subsidy of country j has a change Δy_{jj}, TQ_{ij} will changes ΔTQ_{ij}, the tariff income of country i, Z_{Ci}, will have a change ΔZ_{Ci}, correspondingly. It is:

$$\Delta Z_{Ci} = P_{ejj} \times x_{ij} \times \left[\Delta TQ_{ij} \times (1 + t_{jj} - y_{jj}) - \Delta y_{jj} \times (TQ_{ij} + \Delta TQ_{ij}) \right]; \quad (15)$$

Once a country has great trade gap, it may rise up the technical barriers to improve its trade balance; in contrary case it may reduce the barriers. Thus, we introduce following feedback equation:

$$W_{ij}(k) = W_{ij}(k-1) \times (1 - \lambda \times TB \times sign(G_i)) \quad (16)$$

Where, λ is the adjustment of the additional cost for technical barriers. TB is the technical barrier coefficient. G_i is the trade balance of country i, i=1,2, j=1,2, $i \neq j$;

$$W_{021} = k_1 \times P_{11} \times x_{12} \times y_{11} \times TB \times \sigma. \quad (17)$$

Where, k_1 is a proportion constant, and σ is the payment factor.

$$\lambda = k_2 \times x_{12} \times y_{11}. \quad (18)$$

Simultaneously, the adjustment λ should be changed with the trade balance of developed country, G_2. The feed back equation of λ is given as:

$$\lambda(k) = \lambda(k-1) \times (1 - k_3 \times sign(G_2(k) - G_2(k-1)) \times abs((G_2(k) - G_2(k-1))/G_2(k-1))) \quad (19)$$

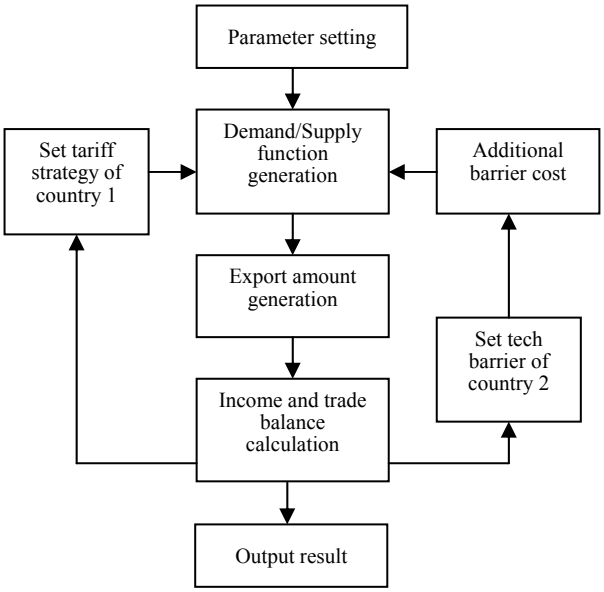

Fig. 2 The framework of the simulation model

The equation (19) shows us the behave of developed countries to adjust technical barriers according to their trade balance situations.

The framework of the simulation model is presented in Fig. 2.

4. Simulation results and strategy analysis

The simulation model of two countries with technical trade barriers was coded by C++ in a PC computer.

By using the suppositional data of a virtual developing country and a developed country, we simulate their

various different strategy combinations and compare the achieved results by these trade strategies.

Facing to the different technical barriers of developed country, the economic situations of developing country are shown in Table 3.

The strategies are set as follows:

The production tax rates: $t_{11}=t_{12}=t_{21}=t_{22}=0.1$;

The import tariff rates: $x_{12}=0.10$, $x_{21}=0.04$;

The export subsidy rates: $y_{11}=0.075$, $y_{22}=0.05$.

From the results in Table 3, we see that almost all economic indexes, export, trade balance and government income of the developing country decline fast with the technical barriers of developed country. For example, the trade surplus reduces 5.75% in the planning horizon with higher technical barrier coefficient (TB=0.75) of developed country, and reduces 0.25% with TB=0.25. It explains that the reduction of technical barriers is very important to the developing country to keep economy growth.

Table 3 The trade strategies and economic indexes of the virtual developing country

Indx.	TB	T=1	T=2	T=3	T=4	T=5
Production Tax Z_{P1}	0.75	611.4	610.0	608.0	605.1	600.8
	0.50	612.9	612.4	611.7	610.9	609.8
	0.25	614.1	614.0	613.9	613.7	613.6
Export Subsidy Z_{E1}	0.75	266.3	265.2	263.7	261.5	258.3
	0.50	267.4	267.0	266.5	265.9	265.1
	0.25	268.3	268.2	268.1	268.0	267.9
Gov. Income Z_1	0.75	510.6	510.2	509.7	509.0	507.9
	0.50	510.9	510.8	510.6	510.4	510.2
	0.25	511.2	511.2	511.2	511.1	511.1
Trade Balance G_1	0.75	1965	1950	1929	1898	1852
	0.50	1981	1975	1968	1959	1948
	0.25	1993	1992	1991	1.990	1988

By a large number of simulations with different trade strategies, we work out following two suggestions for the trade strategies of developing country:

(1) Developing countries should increase the investment to technology and pay more attention to the technical standard making. Then, the influence of technical barriers can be reduced as less as possible.

(2) Simultaneously, developing countries should reduce the export subsidy step by step. Thus, it can prevent the trade reprisals from developed countries and push the technical progress of enterprises in developing countries.

When we served as the international trade consultants to several export enterprises in the Guangdong province of China, the suggestion were adopted by them.

5. Conclusions

The problem of technical trade barriers is a very serious challenge to developing countries when they face to the two side trade with developed countries. The recommended measure approach for technical barrier coefficients provides efficient and applicable tool for the technical barrier evaluation.

(to be continued on Page 55)