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The Optimal Dynamic Infant Industry Protection in Joining a Free Trade Agreement: A Numerical Analysis of the Vietnamese Motorcycle Industry

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THE OPTIMAL DYNAMIC INFANT INDUSTRY PROTECTION IN JOINING A FREE TRADE AGREEMENT

- A Numerical Analysis of the Vietnamese Motorcycle Industry -

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ABSTRACT

This paper investigates the optimal dynamic paths of trade protection imposed on infant industries during the process of joining a free trade agreement. The framework is based on the dynamic learning-by-doing model developed in Melitz (2005), where industries are experiencing dynamic externalities. In this framework, restricted-time protection is introduced as a realistic approach to correspond to the conditions of actual agreements. According to the computational analysis, in some feasible cases of optimal tariff paths may not follow a downward trend, as conventional wisdom would suggest. The results of the numerical simulation applied to the Vietnamese motorcycle industry support these findings.

Keywords: dynamic externality, infant industry protection, numerical analysis, Vietnam.

JEL classification codes: F13, F17, L62.

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1. INTRODUCTION

The last few decades have seen the rapid intensification of globalization with respect to trade. Members of global free trade organizations are steadily increasing.[1]

Free trade agreements unambiguously lower barriers to international trade, stimulate international transactions, and give consumers access to a greater variety of goods at lower prices. However, there are some concerns that free trade agreements may adversely affect infant industries. Throughout history, numerous countries have used tariff policies to protect infant industries, with greatly varying success. For example, Head (1994) and Zussman (2002) suggest, respectively, that the tariff protection provided to the United States steel rail industry and the Germany iron-steel industry from the 1850s to the 1950s helped to raise welfare and promoted development. On the other hand, tariff protection for the Spanish iron and steel industry is regarded as having been harmful in Houpt (2002).

The aim of this paper is to address the issue of when and how an infant industry should be protected during the process of joining a free trade agreement. More specifically, under the assumption that the infant industry is experiencing dynamic externalities, this paper investigates the question of what a rational government should do to protect such industry before tariff barriers are reduced to a very low rate upon full commitment to a free trade regime. Generally, a free trade regime is a system of trade rules which includes detailed and lengthy tariff reduction schedules that are negotiated on the basis of generalized formulas. For example, according to the Swiss formula for agricultural free trade agreements of the World Trade Organization (WTO) (Figure 1), after becoming a member of this association, a country has a period of about 5 to 7 years to reduce tariffs to a level stipulated through the course of initial negotiations.

The theoretical argument for infant industry protection is that it shields newly emergent industries from full exposure to international markets. One of the first to put forward the

[1] The WTO currently has 153 Member States, and 30 observers (observers must start accession negotiations within five years of becoming observers.)

argument for infant industry protection was John Stuart Mill in the 19th century. Mill (1848) distinguished special circumstances, under which it may be beneficial to protect an industry: (1) the industry should exhibit dynamic learning tendencies which are external to individual firms; (2) any protection should be temporary; and (3) the industry must eventually become viable without protection. In recent years, there has been a growing literature, both empirical and theoretical, on infant industries based on Mill's argument. For instance, Harrison (1994) and Tybout (1992) empirically show that there is a significant positive correlation between increased protection and higher productivity growth. Head (1994), using a numerical simulation, shows that intervention had positive effects on welfare in the United State steel rail industry. In addition, there have been various theoretical studies modeling one aspect or other of the infant industry argument. Examples include Bardhan (1971), who provides a model of the learning effect in a dynamic framework, and Krugman (1987) and Young (1991), who examine the impact of learning spillovers across industries and countries.

A theoretical model of particular interest in the context of the current study is the learning-by-doing model developed by Melitz (2005), which allows the comparison of three policy instruments, such as tariffs, subsidies, and quotas, that a hypothetical social planner could choose from. Melitz (2005) focuses specifically on a given industry's learning potential, the shape of the learning curve, and the degree of substitutability between domestic and foreign goods. His model encompasses sufficient properties of an infant industry, but is still simple enough to allow for the extension of these properties for the purpose of the present analysis.

Specifically, this paper applies the model of Melitz (2005) to the process of a country joining the WTO. As mentioned above, participation in the WTO brings a lot of regulations, especially time-based restrictions. Melitz's model, however, does not incorporate any time restriction. Rather, in the model, the social planner may protect the infant industry until it becomes mature. This clearly does not correspond to the situation in the actual world and for the analysis in the present paper, restricted-time protection is incorporated into Melitz's model. The optimal tariff path during the protection period is derived using both analytical and numerical means. Analytically, there are three important factors that influence this path: (1) the slope of the demand curve, (2) the substitutability between domestic and foreign goods, and (3) the shape of the learning curve. It is found that during the transition period before implementation of the trade agreement, the optimal tariff path, in contrast to conventional wisdom may show an upward trend for some feasible cases. In fact, the calibration of the model used in this paper to analyze the case of the Vietnamese motorcycle industry supports the analytical results by showing that the optimal tariff path over the protection period is upward sloping.

The contribution of this paper is twofold. First, it is one of only a small number of papers which re-examine the current schedule of tariff reductions in the wake of Vietnam's accession to the WTO. Second, the model and methodology can be generalized for adaptation to other countries and other industries. Furthermore, it is especially applicable to any country planning to take part in an optional free trade organization in the future. Third, the calibration exercise using real data offers explicit policy prescription for the protection process. Specifically, the calibration suggests that the optimal tariff path during the protection period may be upward sloping.

The rest of this paper is organized as follows. Section 2 presents the infant industry protection model used in this study. Section 3 discusses the calibration. Section 4 concludes.

2. THE MODEL

This section presents a model of infant industry protection where the industry is experiencing a dynamic learning effect. The model is based on that developed by Melitz (2005), but extends it in the following respects. First, incorporating the actual conditions of joining the WTO, the model also considers the time restriction when import tariff rates are committed to be reduced. In the real world, an infant industry does not have unlimited time to become mature before a country joins a free trade agreement. Second, all the functions used in the model are explicitly specified and some new assumptions are also included. Third, tariffs are the only tools available to the social planner to protect industry, as is the case under the rules of the WTO. Finally, time is assumed to be discrete.

The basic assumptions of the model are as follows. Consider a world consisting of two countries, the home country and a foreign country. Firms in both countries are price-takers. The home country is assumed to be a semi-open economy that only imports goods in order to satisfy insufficiencies of domestic supply and does not export. On the other hand, only the foreign country's exports to the home country are taken into account here. Only in the home country are there learning effects in the industry.

2.1 The model

2.1.1 Learning function

The home country's total production at time t, is denoted by q_t, while the foreign country's production exported to the home country is denoted by $\tilde{q}_t$. Both are assumed to be non-negative ($q_t, \tilde{q}_t \geq 0$) .Time is discrete, so the relationship linking cumulative production $Q_t = \sum_{t=0}^{t} q_t$ and total production in one period of time can be written as follows:

$$q_t = Q_t - Q_{t-1} \tag{1}$$

The home country's industry is assumed to be an infant industry, where marginal cost at time t, c_t, is a decreasing function of cumulative production Q_t as the industry is experiencing dynamic learning effects which are external to firms. This marginal cost function (i.e. learning function) is specified as follows:

$$\begin{cases} c(Q_t) = \exp(b - aQ_t), a \geq 0 & Q_t \leq \overline{Q} \\ c = \overline{c} & Q_t > \overline{Q} \end{cases} \tag{2}$$

Here, once cumulative production begins to exceed the threshold level $\overline{Q}$, the industry is mature and produces at a constant marginal cost $\overline{c}$ as learning ceases. Meanwhile, in the foreign country, the industry is assumed to be mature and no longer experiencing learning effects. It produces at a constant marginal cost $\tilde{c}$ for the entire time. Also, the foreign good is an imperfect substitute for the domestic one.

Both countries value output at its current marginal cost as follows:

Home: $p_t = c(Q_t) = \exp(b - aQ_t)$ (3)

Foreign: $\tilde{p}_t = \tilde{c} + \tau_t$

where p_t is the price of the domestic good; $\tilde{p}_t$ is the price of the imported good, and τ_t denotes the import tariff rate.

In the model, the social planner in the home country is assumed to use import tariffs as the only instrument to protect the domestic industry against international trade. As mentioned above, the time when all tariffs must be reduced is given. This point of time is denoted as T. Before this time arrives, the social planner can protect the domestic industry by imposing import tariffs; but after this time, tariffs must be reduced to a level fixed by the requirements of the WTO agreement. Thus, the above foreign price can be re-written as follows:

$$\begin{cases} \tilde{p}_t = \tilde{c} + \tau_t & t < T \\ \tilde{p}_t = \tilde{c} + \bar{\tau} & t \geq T \end{cases} \tag{4}$$

2.1.2 Domestic demand and utility functions

The domestic demand side of this model is assumed such that there is a representative consumer who generates this demand, consuming both domestic and imported goods. Her utility function is also assumed to have a symmetric quadratic form which can be written as follows:

$$U(q_t, \tilde{q}_t) = \beta(q_t^2 + \tilde{q}_t^2) + \eta q_t \tilde{q}_t + \alpha_1 q_t + \alpha_2 \tilde{q}_t, \qquad \beta, \eta < 0; \alpha_1, \alpha_2 > 0 \tag{5}$$

This utility function forms a hump-shaped curve, of with the side to the right of the peak decreases as q_t or $\tilde{q}_t$ rise.[2] Due to the non-decreasing property of the utility function, in order to eliminate this decreasing segment, two additional conditions are imposed on q_t and $\tilde{q}_t$:

$$q_t < \frac{-\eta\tilde{q}_t - \alpha_1}{2\beta} \qquad \text{and} \qquad \tilde{q}_t < \frac{-\eta q_t - \alpha_2}{2\beta}$$

[2] The signs of β, η, α_1 and α_2 are explained below.

Given that p_t and $\tilde{p}_t$ represent positive prices, the problem of the representative consumer is to maximize her benefit, which is obtained by subtracting the cost of domestic and imported goods from the utility derived from consuming them, i.e.:

$$CB_t = U(q_t, \tilde{q}_t) - p_t q_t - \tilde{p}_t \tilde{q}_t \tag{6}$$

The first-order necessary conditions for the benefit-optimization problem, $\partial CB_t / \partial q_t = \partial CB_t / \partial \tilde{q}_t = 0$, yield the following demand functions for both goods:

$$\begin{cases} p_t = Q_q(q_t, \tilde{q}_t) = 2\beta q_t + \eta \tilde{q}_t + \alpha_1 & (7) \\ \tilde{p}_t = Q_{\tilde{q}}(q_t, \tilde{q}_t) = \eta q_t + 2\beta \tilde{q}_t + \alpha_2 & (8) \end{cases}$$

In these two demand functions, 2β represents the slope of the demand curve and must therefore be negative ($2\beta < 0$), while $\eta / 2\beta$ represents the substitutability between the foreign and the domestic good, meaning that η must be negative and lie between 2β and zero ($\eta \in [2\beta, 0]$). On the other hand, because the first and the second factors on the right hand side of equations (7) and (8) are negative, α_1 and α_2 must be positive to keep prices positive.

2.1.3 *Domestic welfare and policy*

Domestic welfare at time *t* is given by the sum of the domestic consumer benefit and tariff revenue, that is:

$$TW_t = CB_t + \tau_t \tilde{q}_t$$

Using the price valuation functions and the consumer benefit function, total welfare can be re-written as:

$$TW_t = U(q_t, \tilde{q}_t) - c_t q_t - \tilde{c} \tilde{q}_t$$

The problem of the social planner is to maximize the sum of discounted domestic welfare over time. Thus, the social planner's problem can be written as:

$$\underset{Q_t \in \Phi_t}{Max} \quad TW = \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t \left[U(q_t, \tilde{q}_t) - c(Q_t) q_t - \tilde{c} \tilde{q}_t \right] \tag{9}$$

where $\Phi_t \subseteq R_+$ is the feasible cumulative domestic consumption at time t and $1/(1+r)$ is the exogenous discount rate. The social planner thus solves the above optimization problem subject to equation (1).

2.2 Analytical computation

Solving the social planner's problem above,[3] the tariff rate can be derived as:

$$\tau_t = \frac{\eta^2 - 4\beta^2}{\eta} q_t + \frac{2\beta}{\eta} e^{b-aQ_t} - \frac{2\beta}{\eta}\alpha_1 + \alpha_2 - \tilde{c} \tag{10}$$

The last three terms on the right-hand side of equation (10) are constant, so that attention is paid only to the first two terms. The coefficient of the first term is positive,[4] showing the monotonically increasing relationship between τ_t and q_t. On the other hand, the second term clearly shows the monotonic decreasing relationship between τ_t and Q_t. The trend of the optimal tariff path depends on which term is dominant. Concretely, if the first term increases faster than the second, the optimal tariff path will show an upward trend, and vice versa. Three exogenous factors that influence this dominance, the substitutability between domestic and foreign goods ($\eta/2\beta$), the slope of the demand curve (2β), and the learning proficiency (a) are considered.

First, ceteris paribus, it is found that the steeper the slope of the demand curve (2β), the more dominant the first term becomes (and therefore, the more likely it is that the tariff path exhibits an upward trend). Mathematically, the coefficient of the first term can be rewritten as $2\beta\left(\eta/2\beta - 2\beta/\eta\right)$. Thus, when $\eta/2\beta$ and a remain constant, if 2β is large enough, the increase in the first term dominates, and the optimal tariff path shows an upward trend. Intuitively, the steeper the slope of the demand curve, the less responsive demand is to price. In

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[3] The solution is presented in Appendix A.

[4] Due to the condition $\eta \in [2\beta, 0]$

such cases, an increase in tariffs to protect the domestic good does not distort welfare much. Therefore, the social planner has an incentive to increase tariffs.

Second, ceteris paribus, the higher the substitutability between the domestic and the foreign good ($\eta/2\beta$), the more the first term dominates. When $\eta/2\beta$ increases, the first coefficient of equation (10) rises while the second one falls. If $\eta/2\beta$ is sufficiently large, it is still possible that the first term completely dominates. Intuitively, when there is a foreign bias in consumption, substitutability between domestic and foreign goods is high, so that despite a rise in tariffs, demand for foreign good does not decrease much. Therefore, the price distortion to welfare caused by high tariff rate will be less pronounced.

Last but not least, one of the most important factors deciding the trend of the tariff path is the learning proficiency of this industry (a). In fact, imposing tariffs in any case leads to welfare distortions in that it will limit consumers' access to goods at lower prices. If learning is slow, it takes time for the industry to become sufficiently mature to balance out these distortions, meaning that the welfare distortion becomes more pronounced and the higher the tariff is set. Under these circumstances, there is a tendency for the negative effect of the second term to dominate. But if learning is fast enough, marginal costs decrease rapidly as the industry in question develops, so that the reduction in prices cancels out the effects of a high tariff. As a result, the positive effect of the first part will tend to be more dominant. Mathematically, as shown in equation (10), when a is low (as in the case of slow learning), the second term is less likely to dominate, so that there is a possibility that the tariff path will exhibit an upward trend.

All things considered, the possibility of an upward-sloping tariff path, in contrast to conventional wisdom, cannot be rejected. To examine this issue in practice, the next section introduces a numerical example of an upward-sloping tariff path – the case of the Vietnamese motorcycle industry.

3 CALIBRATION

This section calibrates the above model to the Vietnamese motorcycle industry using data from 1998 to 2007. The Vietnamese motorcycle industry is chosen for analysis for several reasons. First, Vietnam is a developing country, heavily dependent on international trade[5] since the "Doi Moi reforms" initiated in 1986, and home to many infant industries which have been "born" recently. Almost all of these are now under the tariff protection of the Vietnamese government, such as the motorcycle industry, the electronics industry and the shipbuilding industry. However, on 11 January 2007, Vietnam officially became the WTO's 150th member and will have to comply with the tariff-cutting schedule set by the WTO and applied to all developing countries. This schedule indicates the time and scale of cuts for each member country of the WTO. Specifically, after a stipulated time from formal accession, countries have to reduce their protective tariffs to levels which are calculated on the basis of tariff levels at the time of joining.

A second reason for focusing on the motorcycle industry is that this is an industry which uses advanced technology and can therefore be considered to offer steep learning effects. In addition, the protection afforded to the motorcycle industry by the Vietnamese government is quite substantial, with a tariff rate as high as 90% on imported finished good, and a lower rate of 30% on imported parts. Moreover, due to the tariff-reduction process of the WTO detailed above, the tariff rate on finished good must be reduced to 60% by 2012.

3.1 Description of model parameters

There are twelve model parameters: 2β (the slope of the demand curve), $\eta/2\beta$ (the substitutability between the domestic and the foreign good), α_1, α_2 (the free parameters of the demand curve), a, b (the coefficients of the learning function), $1/(1+r)$ (the exogenous discount rate), $\bar{c}$ (the marginal cost of the domestic industry after it becomes mature) , $\tilde{c}$ (the marginal cost of the foreign industry), Q_0 (initial cumulative production), $\overline{Q}$ (the cumulative production of

[5] The ratio of imports and exports to GDP for Vietnam in 2007 was 90% and 77%, respectively (Source: World Development Indicators).

the domestic industry right after it becomes mature), and $\bar{\tau}$ (the committed import tariff rate after T).[6] Each of the parameters is now discussed in turn.

Parameters in the demand functions

β , η , α_1 and α_2 : Coefficients of the demand functions:

$$\begin{cases} p_t = 2\beta q_t + \eta \tilde{q}_t + \alpha_1 \\ \tilde{p}_t = 2\beta \tilde{q}_t + \eta q_t + \alpha_2 \end{cases}$$

The problem here is that β and η appear in both equations, meaning that these equations cannot be estimated separately or each of them will result in different values for a parameter. Therefore, to estimate β , η , α_1 and α_2 , the bootstrapping method is used in the simultaneous least squares estimation of the two demand functions. The least squares estimation function here has the form $\sum_t \left[\left(2\beta q_t + \eta \tilde{q}_t + \alpha_1 - p_t \right)^2 + \left(\eta q_t + 2\beta \tilde{q}_t + \alpha_2 - \tilde{p}_t \right)^2 \right]$. The estimated results of β , η , α_1 and α_2 here and their standard deviations were computed directly from the data and from each of 1,000 bootstrap samples. The data used in this estimation are domestic price, domestic production, foreign price, and foreign production over the period 1998-2007.

Parameters in the learning function

a , b : Coefficients of learning function $\ln p_t = b - aQ_t$ (derived from (2)). Because there are only 10 observations, normal OLS estimation does not yield a significant result. Thus, to calculate the values of a and b , it is assumed that the connection between the logarithm of the price and cumulative production between 1998 and 2007 is linear. The values of a and b can then be calculated.

[6] The data on the Vietnamese motorcycle industry used in the calibration are described in Appendix B.

Cumulative production

Q_0 : 1998 is the first year of the analysis; thus, production in 1998 is assumed to be the initial cumulative production.

$\overline{Q}$: calculated using a , b and $\overline{c}$ employing equation (3).

Marginal cost when industry becomes mature

$\overline{c}$: This value is calculated from the average price, excluding tariffs, of motorcycles imported from three countries, Taiwan, Thailand, and Indonesia, in the year 2007. These three countries are chosen because their motorcycle industries were "born" nearly half a century ago, and the production and exports of the motorcycle industry in these three countries have been stable over the last few years. Thus, in these countries, the motorcycle market is stable, and the motorcycle industries can be considered mature industries.

$\tilde{c}$: This value is assumed to be equal to $\overline{c}$, that is, marginal costs are assumed to be the same at home and abroad when the industry is mature.

Other parameters

r : the annual demand deposit interest rate is used.

$\overline{\tau}$: calculated as $\overline{\tau} = rate \times \tilde{c}$, using the tariff rate required by the WTO when the time for tariff reduction comes. This rate is 60%, as mentioned earlier.

The calibrated parameter values are reported in Table 1.

3.2 Findings

This section reports the results of the calibration.[7] The first issue of interest is the appropriateness of the time horizon for the loosening of trade barriers in the Vietnamese motorcycle industry. The calibration results show that this industry needs more time to develop

[7] A description of the numerical exercises is provided in Appendix C.

before the tariff is greatly reduced. In other words, the implication for the government is that it should continue to protect the motorcycle industry for a few more years. This is illustrated in Figure 2, which shows the tariff rates of simulated time periods corresponding to different committed tariff-reduction times T. As the value of T extends, the level of tariff paths corresponding to each T decreases. Intuitively, the shorter the time constraint T for lowering tariff barriers, the less time the infant industry has to prepare for free trade, and the greater therefore the protection it needs before T comes. This extra protection is reflected in the tariff rates from the initial point in time to time T. Comparing the magnitude of the hypothetical tariff rates with the actual rate leads to the conclusion that the industry needs more protection. More specifically, when there are 5 years to go until tariffs are reduced, as in the case of the actual situation (from 2007 to 2012), i.e., when T is equal to 5 years, the initial tariff rate (the tariff rate in 2007) is about 800%, which is much higher than the actual current rate of 90%. This means that the current rate is too low and that in order to both protect industry and maximize total welfare over time, the government would have to impose a higher tariff rate on imports than it currently does. As Figure 2 shows, the longer the tariff-reduction time T is, the more that initial tariff rate can be reduced. According to this analysis, the optimal T that corresponds to the current tariff level (90%) is 8 years. This means that the Vietnamese motorcycle industry needs 8 years of protection rather than the 5 years granted under the WTO schedule. Thus, the analysis suggests that in the case of this particular industry, accession to the WTO has come slightly too early.

The second issue of interest here is the optimal tariff path for when trade barriers are removed, which is also presented in Figure 2. Specifically, the figure shows the optimal tariff path for different values of T and, as can be readily seen, is slightly upward sloping in all cases. As discussed in Subsection 2.2, this upward trend may result from the steep slope of the demand curve, the foreign bias, low learning proficiency, or a combination of the three.

Corresponding to the upward-sloping tariff path during the protection period, the transition paths of other variables such as domestic production and imports are explored in

Figure 3 with *T* set to *T=6* and the total period falling into three distinct phases.

The first phase is the time before tariffs are reduced. During this phase, imports follow a downward trend while domestic production follows an upward trend. These divergent trends can be explained by tariff protection and the learning effect. As indicated in Figure 2, since the government imposes a rising tariff on imports, the foreign good declines in competitiveness due to the resulting higher prices. Meanwhile, the learning effect improves the competitiveness of domestic product by decreasing marginal cost. Thus, the upward-sloping trend in domestic production can be attributed to a combination of both the protective trade policy and the learning effect.

Following the first phase, the second phase consists of the period from the reduction of the import tariff rate to a certain target level to the point at which the industry reaches maturity. This reduction of the import tariff rate is in line with the initial agreement formed upon joining the WTO, and the resulting tariff rate is quite low relative to the current one. Therefore, if the prices of imports fall due to the lowering of the tariff rate, demand for foreign products, and hence imports, will rise. Consequently, foreign production during this period clearly shows an upward trend. But the most surprising result here is that although protective barriers are lowered, domestic production still shows a slight upward trend following the small drop in the very first stage of this phase. This can be explained by the predominance of the learning effect over the effect of increased competition through imports.

During the last phase, once the industry has matured, domestic production and imports remain constant at the level of the last stage of the second period. At this stage, Q_t becomes $\overline{Q}$, and $c = \exp(b - aQ)$ is equal to $\bar{c}$ or $\tilde{c}$. As a result, q_t becomes $\bar{q}$ as well. The same thing happens to $\tilde{q}_t$ and $\bar{\bar{q}}_t$.

Thus, the following conclusions can be drawn. First, the Vietnamese motorcycle industry is still far from mature. This suggests that increased protection from the government is needed to guarantee successful development in the face of international competition. Second, in contrast to conventional wisdom, the optimal tariff path computed here shows an upward trend until the time of tariff reduction arrives. In other words, as long as the tariff protection instrument is still available and the infant industry is still experiencing learning externalities, the government should continue to raise tariffs without worrying that the high tariff may limit consumers' access to good at a lower price as the simultaneously rising learning effect will counteract such distortions.

4 CONCLUSION

The purpose of this paper was to examine the infant industry protection policies of a country that is going to join a free trade organization. The paper presented a simple learning-by-doing model to illustrate the relationship between the market mechanism and infant industry protection policy under the assumptions that (1) the industry is experiencing dynamic learning effects and (2) the social planner has committed itself to lowering tariffs to a stipulated level by a specified point of time in the future. Thus, the social planner can use tariff protection as a policy instrument only until that future point in time. The goal therefore is to protect the industry and to maximize total welfare within this allotted time period.

Against this background, the model developed here was used to derive an optimal tariff path based on the condition of a specific tariff-reduction commitment made upon joining a free trade agreement. Through the computation, the shape of this optimal tariff path is found to be determined by certain exogenous factors. More specifically, if the slope of the demand curve is sufficiently steep or a strong foreign bias exists, or if learning proficiency is low, an upward-sloping tariff path could result. This result is quite different from the conventional wisdom that the government should gradually reduce the tariff rate to reach to the stipulated level right at the committed time.

In the next step of the analysis, the model was calibrated using actual data on the Vietnamese motorcycle industry. The contribution of this numerical approach is twofold. First, this is one of a small number of studies which re-examine the current schedule of tariff reductions in the wake of Vietnam's accession to the WTO. Second, the model and methodology can be generalized for adaptation to other countries and other industries. Furthermore, it is especially applicable to any country planning to take part in a free trade organization in the future. Third, the calibration exercise using actual data offers an optimal tariff path as an explicit policy prescription for the protection process. Last but not least, this calibration also supports to the result of analytical computation by suggesting that the optimal tariff path during the protection period may be upward sloping.

Finally, a number of limitations and possible extensions should be mentioned. First, the model used here is based on the assumption that the economy is just semi-open. In the real world, it is possible for infant industries to export, while mature sectors already engage in the import of goods that are competing with domestic products. In addition, the model would be more realistic if it were extended so as to deal with more than two open economies.

Second, the object of analysis for this study is an infant industry which is experiencing learning effects. However, a common problem when examining real-world cases is that, because infant industries by definition are very young, available data are limited. For example, the data on the Vietnamese motorcycle industry used in this study only cover the period from 1998 to 2007, thus consisting of annual observations for just 10 years. This limitation may have some influence on key parameters of the estimation.

APPENDIX A: THE COMPUTATION

This appendix presents the computation of the transition path of all variables. According to the model, the social planner has to maximize total domestic welfare over time. However, after the industry matures, the value of all variables will remain constant with any learning speed. For example, welfare W will stay at $\overline{W}$ permanently after the industry becomes mature. Thus, in fact, the social planner only needs to maximize cumulative welfare until a certain time in the future. This time period is given by the shortest time in which an industry with any learning speed, even the slowest one, can become mature. This future time is denoted as $t_{\max}$. More specifically, total domestic welfare maximized by the social planner can be divided into three phases. The first phase is defined as the period from the current time until the committed time to reduce tariffs. During this period, the social planner uses import tariffs as the only instrument to protect the infant industry and maximize total welfare. The second phase is defined as the period from right after the first period until learning ceases. During this phase, the infant industry has not yet become mature and marginal costs still decrease as cumulative production rises. Finally, the third phase is defined as the period from right after the industry becomes mature until $t_{\max}$. Neither learning effects nor protection are any longer present and total domestic production at any time t in this period is constant ($q_t = \bar{q}$). The second and third phases have in common that the social planner no longer has instruments to protect industry. However, as the foregoing makes clear, the calculation of welfare differs for each phase, reflecting the different policy and industry circumstances.

First phase

During the first phase, the social planner can continue using import tariffs as a policy instrument to protect the industry and to maximize social welfare. Let L be the Lagrangian associated with this problem:

$$\underset{(q_t,Q_t,\lambda_t)}{L} = \sum_{t=0}^{T}\left(\frac{1}{1+r}\right)^t \left[U(q_t,\tilde{q}_t) - c_t q_t - \tilde{c}\tilde{q}_t + \lambda_t (Q_{t-1} + q_t - Q_t)\right]$$

And the first order conditions are as follows:

$$\lambda_t = \left(\frac{a}{2\beta}e^{b-aQ_t} + 1\right)^{-1}\left((\frac{1}{1+r})\lambda_{t+1} + ae^{b-aQ_t}q_t\right) \tag{A.1}$$

$$q_t = \frac{\eta}{\eta^2 - 4\beta^2}\left(\frac{\eta}{2\beta}\lambda_t - \frac{2\beta}{\eta}e^{b-aQ_t} + \frac{2\beta}{\eta}\alpha_1 - \alpha_2 + \tilde{c}\right) \tag{A.2}$$

$$\tau_t = \frac{\eta}{2\beta}\lambda_t \tag{A.3}$$

Second phase

During this phase, the industry is still immature but no longer enjoys tariff protection. Using the demand functions, the cumulative production function in this period is given by

$$Q_t = Q_{t-1} + \frac{1}{4\beta^2 - \eta^2}\left[2\beta e^{b-aQ_t} - \eta\left(\tilde{c} + \bar{\tau} - \alpha_2 + \frac{2\beta}{\eta}\alpha_1\right)\right] \tag{A.4}$$

Third phase

The third phase is the period when the industry has reached maturity, i.e. the industry has reached a steady state and total domestic production at any time t in this period is constant. The solution for domestic production and imports during this phase is also computed by the cumulative production function and demand functions:

$$\begin{cases} \bar{q} = \dfrac{(2\beta-\eta)\tilde{c} - 2\beta\alpha_1 + \eta\alpha_2 - \eta\bar{\tau}}{4\beta^2 - \eta^2} & (A.5) \\ \bar{\bar{q}} = \dfrac{(2\beta-\eta)\tilde{c} + \eta\alpha_1 - 2\beta\alpha_2 + 2\beta\bar{\tau}}{4\beta^2 - \eta^2} & (A.6) \end{cases}$$

As mentioned above, tariffs as a policy instrument are available to the social planner only during the first phase, so that it is the policy choice during this phase that determines the welfare for the entire period. This policy choice is derived through the level of cumulative production at the end of the first phase, Q_T. Thus, the key factor in this dynamic model is Q_T, which determines the production levels in the following phases. Therefore, total welfare for the three phases as a whole can be calculated through Q_T, and obviously, the optimal Q_T is the value which maximizes total welfare. As a result, the key object here is to find the optimal Q_T. This, however, cannot be done analytically and what is required instead is a numerical approach. This is done in Appendix C.

APPENDIX B: DATA

This appendix provides details on the data used for the calibration exercise. Specifically, the data used cover the period 1998-2007. The Vietnamese motorcycle industry was “born” in 1995, with the next two years devoted to building necessary infrastructure, so that there was very little actual production during this period. For example, in 1997, Honda Vietnam produced only 73 motorcycles in total. Therefore, in order to obtain significant parameter estimates, data from 1998 are used. Meanwhile, the latest available data are for 2007.

Data sources for domestic production, imports, domestic prices, foreign prices, current import tariff rates, and the annual demand deposit interest rate are described in Table A.1.

APPENDIX C: DESCRIPTION OF THE NUMERICAL EXERICISES

This appendix describes the numerical simulation to obtain the optimal Q_T. The first task is to clarify the potential intervals for Q_T. They must lie between the initial cumulative production level Q_0 and the cumulative production attained when learning ceases, $\overline{Q}$, or $Q_T \in [Q_0, \overline{Q}]$. Assume that $[Q_0, \overline{Q}]$ is a discrete interval containing multiple values.

Second, with each of these values, a shooting algorithm is used to compute all values of cumulative production from initial cumulative production Q_0 to production at time T, Q_T. With this information, total welfare for the first phase, denoted as W_1, can be calculated.

Third, the cumulative production function derived from equation (A.4) is used to compute all cumulative production in the second phase from Q_T and to then calculate the total welfare for this phase, W_2.

Fourth, during the third phase when cumulative product has exceeded the threshold level $\overline{Q}$, production in each period t will remain constant, as shown in equations (A.5) and (A.6), so that welfare for each of these periods is also the same. As a result, the total welfare for the third phase, W_3, is calculated as the sum of the constant value for each period during this phase. The longer this third phase lasts, the higher the welfare W_3 is. The length of this phase depends on the learning speed which mainly determines whether the industry will mature early or late.

Finally, cumulative production at time T, Q_T, is calculated to find the maximum welfare for all three periods ($TW = W_1 + W_2 + W_3$). The optimal value of Q_T which maximizes total welfare can be observed among its potential intervals $[Q_0, \overline{Q}]$ in Figure A.1.

Figure A.1 shows a hump-shaped curve which represents the relationship between TW and Q_T. Cumulative production at time T, Q_T, which is where total welfare reaches its maximum, lies somewhere in the middle of its potential interval, $[Q_0, \overline{Q}]$. In this case, optimal Q_T is 17,700 thousand motorcycles.

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REFERENCES

Bardhan, P., 1971, On the Optimum Subsidy to a Learning Industry: An Aspect of the Theory of Infant-Industry Protection. *International Economic Review* **12**, pp. 54-70.

Harrison, A. E., 1994, An Empirical Test of the Infant Industry Argument: Comment. *American Economic Review* **84**(4), pp.1090-95.

Head, K., 1994, Infant Industry Protection in the Steel Rail Industry. *Journal of International Economics* **37**, pp.141-65.

Houpt, S., 2002, Putting Spanish Steel on the Map: The Location of Spanish Integrated Steel, 1880-1936. *European Review of Economic History* **6**(02), pp.193-220.

Krugman, P., 1987, The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences of Mrs. Thatcher. *Journal of Development Economics* **27**, pp. 41-55.

Melitz, M. J., 2005, When and How Should Infant Industries Be Protected? *Journal of International Economics* **66**, pp. 177-96.

Mill, J. S., 1848, Principles of Political Economy. In: *Collected Works of John Stuart Mill* vol. III, (ed. J. M. Robson), pp. 918-19. University of Toronto Press.

Ministry of Industry of Vietnam, 2007, The Master Plan for the Development of the Motorcycle Industry, Ch.2, pp. 17-27.

Tybout, J., 1992, Linking Trade and Productivity: New Research Directions. *World Bank Economic Review* **6**(2), pp. 189-211.

WTO Agriculture Negotiations, 2003, Background Fact Sheet: Tariff Negotiations in Agriculture - Reduction Methods, available online at http://www.wto.org/english/tratop_e/agric_e/agnegs_swissformula_e.htm.

Young, A., 1991, Learning by Doing and the Dynamic Effects of International Trade. *The Quarterly Journal of Economics* **106**, pp. 369-405.

Zussman, A., 2002, The Rise of German Protectionism in the 1870s: A Macroeconomic Perspective, mimeo, Department of Economics, Stanford University.

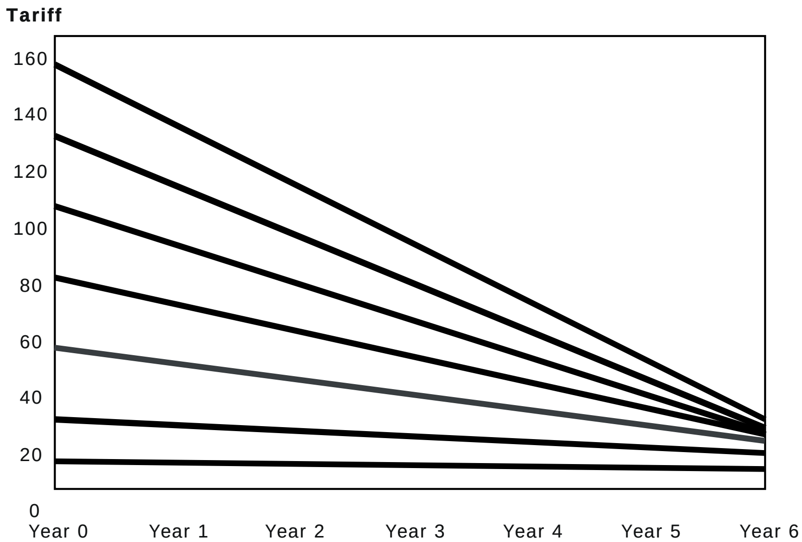

Fig. 1. The Swiss formula of the WTO applied to current agriculture negotiations (See WTO Agriculture Negotiations (2003)).

Table 1 Calibration parameters

Parameter	Value
β	-178.33 [47.3]
η	-82.5 [76.25]
α_1	1,664,139.94 [156,583.38]
α_2	1,614,757.08 [79,260.59]
a	0.000045
b	14.56
r	0.041
$\bar{c}$	535,795.7 (USD per thousand motorcycles)
$\tilde{c}$	535,795.7 (USD per thousand motorcycles)
Q_0	12,790 (thousand motorcycles)
$\overline{Q}$	30,410.93 (thousand motorcycles)
$\bar{\tau}$	321,477.4 (USD per thousand motorcycles)

Note: Values in square brackets are standard deviations.

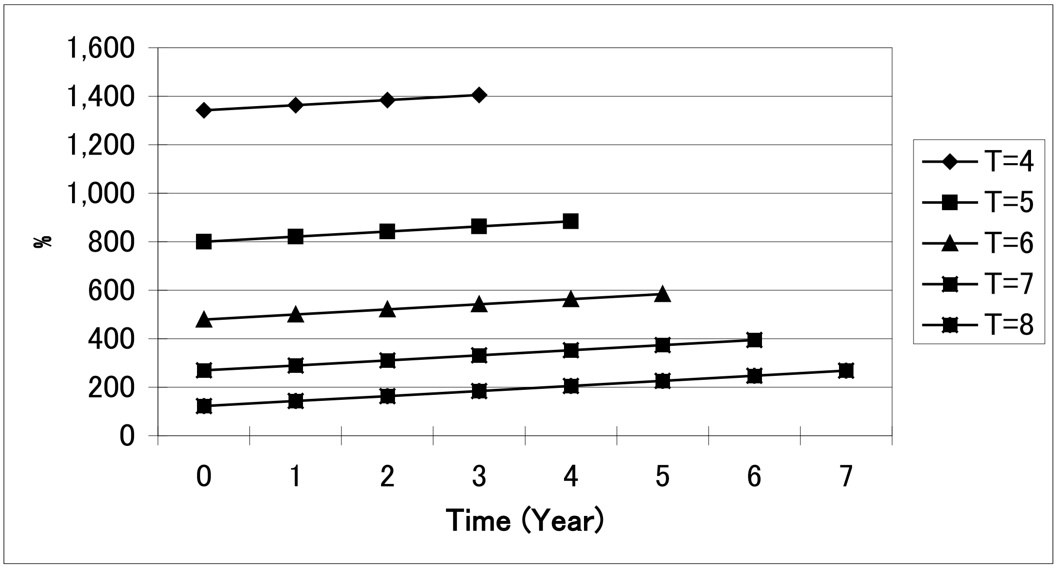

Fig. 2. The optimal tariff path for different values of T .

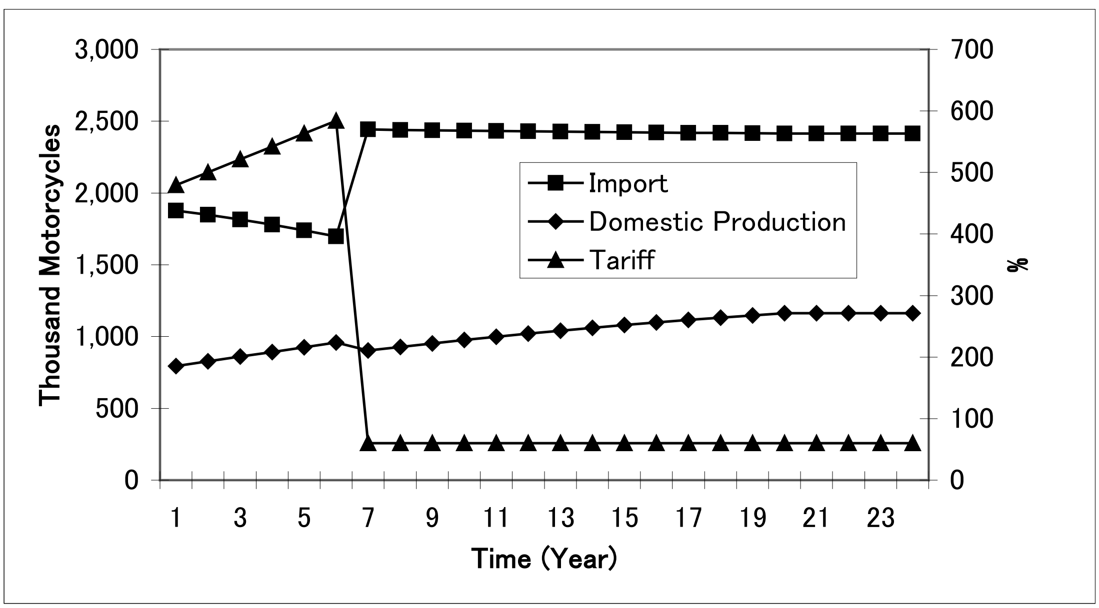

Fig. 3. Domestic production, import, and tariff paths over time.

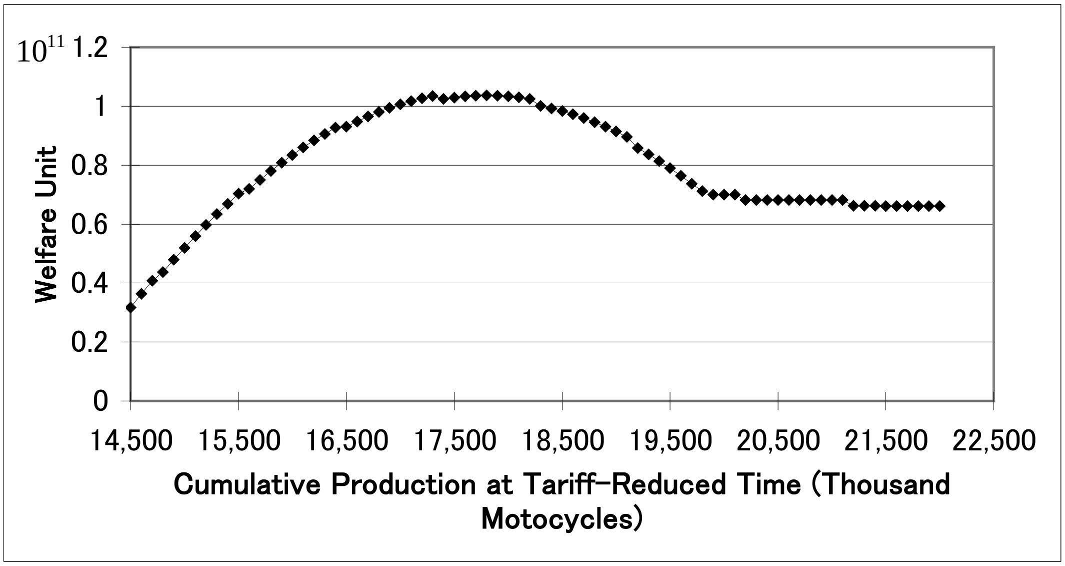

Fig. A.1. Total welfare for different values of Q_T .

Table A.1 Data

Name of Variable	Source
Domestic production (q_t)	General Statistics Office Of Vietnam (GSO).
Import ($\tilde{q}_t$)	Until 2001 : Calculated by the author based on motorcycle registration data from the Ministry of Public Security of Vietnam and domestic production data from the GSO From 2001: World Trade Atlas.
Domestic price (p_t)	Calculated by the author. Weighted average price of three companies: Honda Vietnam, FDI without Honda Vietnam and domestic companies (state and non-state). ・ Price data: The price of the main product line for each sector is used. Data source: until 2001 "Vietnam Automotive News"; from 2001 Japan International Cooperation Agency (JICA) and Hanoi National Economics University (NEU) (*). ・ Share data: Calculated using production data for Honda from "2008 World Motorcycle Facts & Figures" and domestic and FDI production data from the GSO.
Import price ($\tilde{p}_t$)	World Trade Atlas
Current Tariff (τ_0)	General Department of Vietnam Customs
Treasury Bill Rate (r)	International Financial Statistics (IFS)

(*) See Ministry of Industry of Vietnam (2007)