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World Trade Organization

Economic Research and Statistics Division

A 'Probabilistic' Approach to the Use of Econometric Models in Sunset Reviews

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A 'Probabilistic' Approach to the Use of Econometric Models in Sunset Reviews

Alexander Keck^{*}, Bruce Malashevich^{**} and Ian Gray^{***}

Abstract

Economists have increasingly become involved in trade remedy and litigation matters that call for economic interpretation or quantification. The literature on the use of econometric methods in response to legal requirements of trade policy is rather limited. This article contributes to filling this gap by demonstrating the efficacy of using a simple 'probabilistic' model in analyzing the 'likelihood' of injury to the local industry concerned, following a finding of continuation or recurrence of dumping (or countervailable subsidies). The legal concept of 'likelihood' is not only particularly well-suited to illustrate the systemic need for trade lawyers and economists to cooperate. It is also of imminent practical relevance with a groundswell of 'sunset' reviews looming on the horizon. We discuss the significance of economic analysis for trade remedy investigations by reviewing the literature, the applicable WTO rules and, in particular, the pertinent case law. The potential value of probabilistic simulations for 'likelihood' determinations is exemplified using a real-world application. Using data from past United States International Trade Commission investigations, we find that a probabilistic model that takes account of the uncertainty surrounding economic parameters reduces the risk of misjudging the effect on the domestic industry of a termination of trade remedies.

Key words: Trade remedies, economic modeling, WTO, injury

JEL classification: F13, F14, F17, K33

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I. Introduction

An oft-quoted saying among many economists holds that if an economic impact cannot be measured, then it is not worth considering. The saying is particularly apt when applied to matters of public policy and government regulation. Trade disputes subject to WTO rules may be no different in this respect, other than the facts that the current system has been in existence for only a decade and that the precise economic impact of policy measures rarely needs to be known for the purposes of dispute resolution. There is consequently only a limited experience at the WTO about the role that quantitative economic models can play in interpreting WTO rules.

However, it is worth noting that, especially in a number of recent cases, economics has been used in WTO dispute settlement.¹ These examples may provide an additional incentive to consider economic methods that can help to produce evidence in support of trade policy. In this article, we examine two separate, but related hypotheses. First, by way of a brief analysis of the literature and WTO case law, we hold that there seems to be room for economic modeling in trade policy analysis and, more particularly, in the interpretation of WTO rules in the context of dispute settlement. Second, and as the main part of our analysis, we focus on sunset reviews of existing antidumping ('AD') and countervailing duty ('CVD') measures carried out at the national level. Here, we find that the WTO-required 'likelihood' analysis might be particularly amenable to economic modeling by investigating authorities and that economic models frequently used at the national level in the context of injury determinations could be readily given a probabilistic dimension.

In so-called 'sunset reviews' of existing AD and CVD measures, pursuant to Article 11 of the Agreement on the Implementation of Article VI the General Agreement on Tariffs and Trade (GATT) 1994 (Anti-Dumping Agreement)² and Article 21 of the Agreement on Subsidies and Countervailing Measures (SCM Agreement)³ respectively, Members are obliged to terminate such measures no later than five years from their imposition. They may, however, initiate a review before that date to determine whether the measures should be continued or revoked. The standard in this respect is whether expiry of the duty would be 'likely' to lead to continuation or recurrence of dumping (or countervailable subsidies respectively) and of injury⁴ to the local industry concerned. As of the end of 2004, WTO Members had a total of 1,784 such measures in force, of which more than 1,000 have been in force since before 2002. There shortly will be a groundswell of 'sunset' reviews that administering authorities are bound to consider.

¹ For an extensive overview of the use of economic analysis in WTO dispute settlement see WTO, 'Quantitative economics in WTO dispute settlement', in *World Trade Report 2005*, (Geneva: WTO 2005), 171-209.

² GATT Secretariat, *The Results of the Uruguay Round of Multilateral Trade Negotiations, The Legal Texts* (Geneva 1994), 168.

³ *Ibid*, at 264.

⁴ The AD/CVD rules provide for three possible types of 'injury': material injury to a domestic industry, threat of material injury to a domestic industry and material retardation of the establishment of such an industry. This focus of this paper is the likelihood of continuation or recurrence of material injury in the event of termination of an AD/CV duty. Thus, references to 'injury' herein are to material injury.

As with many WTO rules, the term ‘likely’ is subject to interpretation by the various administering authorities. In practice, to date little attention, or at any rate little analytical uniformity, seems to have been brought to bear at the national level to the question of resumption of dumping and/or countervailable subsidies. The central issue more frequently debated among the parties is whether a resumption of material injury is ‘likely’. In the United States (US), the International Trade Commission's (ITC) determinations in this regard have been the subject of recent litigation before the reviewing court, the Court of International Trade (‘CIT’). The CIT on more than one occasion has ruled that ‘likely’ means ‘probably’.⁵ We propose a practical means of measuring, through a degree of economic and statistical science, how ‘likely’ or ‘probable’ will be a resumption of material injury through the revocation of existing AD/CVD orders. Application of economic tools has been lacking in this respect. Yet, we believe that the burgeoning number of orders that shortly must be reviewed in the context of sunset proceedings warrants an examination of economic tools designed to assist administering authorities in the process.

In particular, simulation analysis could be applied in a way that quantifies the probability that the injury would continue or recur if the duty were removed or varied. Quantifying this likelihood could serve as a useful benchmark for administering authorities and other parties participating in the proceeding. This article surveys the theory behind simulations with probabilistic components and sets forth a working illustration of a real-world application that demonstrates the power of this economic tool. A probabilistic dimension can be grafted onto practically any economic model. For reasons of convenience and transparency, we rely on the US ITC's ‘COMPAS’ model, because it is widely known in international circles and is available without charge from the ITC's web site.⁶ The COMPAS model was designed originally to assist the ITC and participating parties in evaluating the impact of imports on local industries in AD/CVD proceedings. The authors emphasize that in using COMPAS in this respect they are not seeking to promote COMPAS as an appropriate platform for administering authorities in the exercise of their function.

The next section is a brief review of the literature on the possible use of economic models in trade remedy investigations.⁷ It will also highlight how quantitative economic analyses have filtered through to the WTO dispute settlement proceedings, although the most prominent examples are not from a trade remedy context. Section III then turns to the core topic by reviewing WTO rules on sunset reviews. Section IV will provide a framework for the use of probabilistic simulation models in sunset reviews at the national level. Section V provides a review of the COMPAS model and an example of a simulation using COMPAS. The differences between COMPAS and the proposed probabilistic simulation modeling approach are then discussed in detail. Section VI concludes.

⁵ International Trade Commission Publication 3788, *Stainless Steel Sheet and Strip From France, Germany, Italy, Japan, Korea, Mexico, Taiwan, and the United Kingdom (Stainless Steel Sheet and Strip)*, Investigation Nos. 701-TA-381-382 and 731-TA-797-804 (Review), July 2005, at 21.

⁶ See www.usitc.gov.

⁷ Most of the authors have focused on safeguards rather than AD/CVD investigations. Nevertheless, this literature provides a good background on the possible usefulness of quantitative economic analysis in trade remedy investigations.

II. Economic models and the interpretation of WTO rules

A. *The use of economic models in the trade remedy literature*

In the literature, there has been a notable amount of economic analysis in the context of trade remedies. Its applicability to the instant issue of sunset reviews is limited, however, because the work has centered on the issue of causation of serious injury by imports and non-attribution to other factors required under Article 4 of the Agreement on Safeguards, rather than on reviews pursuant to Article 11 of the Anti-Dumping Agreement and Article 21 of the SCM Agreement.⁸ The applicability of some of the econometric approaches proposed in the literature is also limited in practice by the scarcity of data typically available to the administering authority and practitioners, a limitation that some of the authors have acknowledged.⁹ Nevertheless, a brief review of how economic models have been conceived to support legal analysis is instructive for the present purpose.

Taking the example of the steel industry, Grossman looks at the causation of injury by imports and other factors, using domestic production as a measure of the health of the domestic industry.¹⁰ Domestic production in turn is a function of the relative price of imports, the relative price of inputs, and an indicator of overall demand. In this way, Grossman determines the sensitivity of domestic production, and hence of the state of the industry, to imports as well as to domestic supply and demand factors.

Pindyck and Rotemberg, using the copper industry as an example, reason that import levels are not specifically controlled by prices, but are also determined by domestic tastes and technology.¹¹ They use a framework that also looks at the effect of both domestic and foreign developments in these variables on changes in imports. Through the use of a model where industry performance is measured by indicia such as profits, employment and production, the authors determine the relative effects on the industry of shifts in domestic demand, shifts in domestic supply, and changes in imports. By holding the observed level of imports constant,¹² while using actual industry values for all other variables, and by comparing this output to actual output, the authors seek to isolate the impact that imports have had on the domestic industry.

In a recent piece, Irwin avoids issues of model specification and the common problem of data limitations faced in many cases by suggesting a non-econometric, essentially accounting-based approach.¹³ Specifically, he builds on an econometric model originally developed by

⁸ Despite a number of important differences in the applicable WTO rules on AD/CVD issues and safeguards, not the least the qualification of ‘material’ injury in regard to the former as opposed to ‘serious’ injury in regard to the latter, there is sufficient similarity in certain legal concepts to draw some lessons on the potential of economic analysis in support of their interpretation.

⁹ D. A. Irwin, ‘Causing Problems? The WTO Review of Causation and Injury Attribution in US Section 201 Cases’, 2 (3) *World Trade Review* 297 (2003).

¹⁰ G. M. Grossman, ‘Imports as a Cause of Injury: The Case of the US Steel Industry’, 20 (3) *Journal of International Economics* 201 (1986).

¹¹ R. S. Pindyck and J. J. Rotemberg, ‘Are Imports to Blame? Attribution of Injury under the 1974 Trade Act’, 30 (1) *Journal of Law and Economics* 101 (1987).

¹² This simulates the effect on imports of implementing a quota or tariff.

¹³ Above n 9.

Kelly¹⁴ and shows how this framework can be applied to distinguish conceptually the causation of injury by imports from instances when imports and injury are correlated but not causally linked. In this manner, Irwin is able to devise a simple methodology to examine issues of causation/non-attribution using only data that are routinely gathered during trade remedy investigations. This literature shows that quantitative economic models can inject additional analytical rigor into the examination of certain legal concepts despite being subject to confining model assumptions and data shortages. While national authorities may choose to do so, this does not necessarily imply that the economic techniques used to analyze a trade policy measure will also be discussed in the WTO should the measure be brought to a dispute. This may or may not happen, as will be illustrated in the following.

B. The use of economic models in WTO dispute settlement

At the international level, the question of whether and how economic models have been used as evidence in the interpretation of certain provisions in WTO Agreements has surfaced in only a few disputes. It goes without saying that in the vast majority of cases WTO dispute settlement has done without trade models.¹⁵ This is because an examination by panels of the ordinary meaning of the WTO provisions in question, in their context and in the light of the object and purpose of the Agreement, is normally enough to identify whether or not a rule has been breached.

Only some WTO norms, for example the concept of ‘serious prejudice’¹⁶ in the SCM Agreement, involve the effects of a disputed measure, and parties may submit quantitative evidence obtained from models in order to demonstrate a violation of the respective provisions. However, in the three ‘serious prejudice’ disputes to date, only the recent *US - Upland Cotton* case¹⁷ involved a discussion of the results obtained from an economic model used by the complainant to support its arguments. In the end, the panel took note of these analyses, but did not rely ‘upon the quantitative results of the modeling exercise – in terms of estimating the numerical value for the effects of the United States subsidies, nor indirectly, in our examination of the causal link’.¹⁸

¹⁴ K. Kelly ‘The Analysis of Causality in Escape Clause Cases’, 37 (2) *Journal of Industrial Economics* 187 (1988).

¹⁵ For an assessment of the role that economists can play in the context of WTO disputes see H. Horn and P. C. Mavroidis ‘Still Hazy after All These Years: The Interpretation of National Treatment in the GATT/WTO Case-Law on Tax Discrimination’, 15 (1) *European Journal of International Law* 39 (2004); A. Keck ‘WTO Dispute Settlement: What Role for Economic Analysis?’, 4 (4) *Journal of Industry, Competition and Trade* 365 (2004); B. Malashevich ‘The Metrics of Economics As Applied to WTO Dispute Settlement’ (Presentation given at the Seventh Annual Conference on Dispute Resolution in the WTO, organized by Cameron May, 18 June 2004, Geneva, on file with the authors); and D. A. Sumner, R. C. Barichello and M. S. Paggi, ‘Economic Analysis in Disputes of Trade Remedy and Related Measures in Agriculture, with Examples from Recent Cases’ (Presentation given at the international conference ‘Agricultural policy reform and the WTO: where are we heading?’, 23-26 June 2003, Capri, on file with the authors).

¹⁶ See especially Article 6.3 of the SCM Agreement.

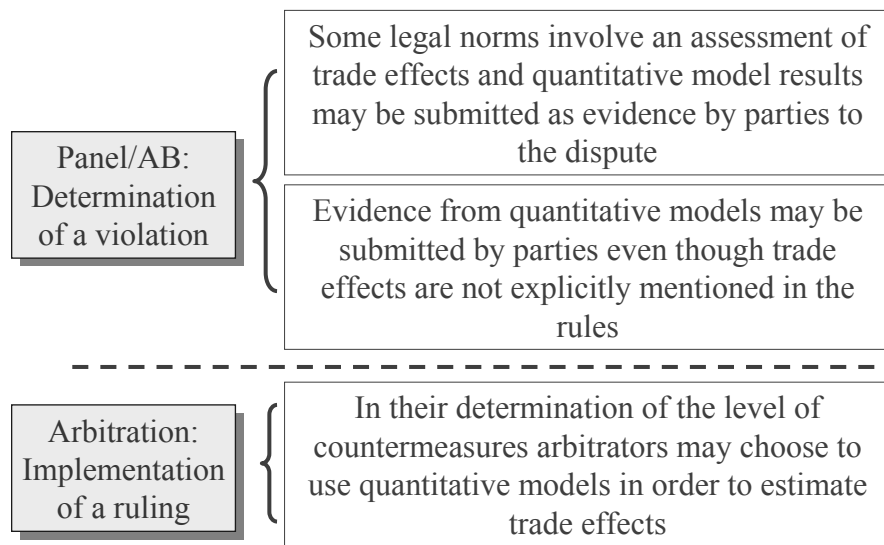
¹⁷ WTO Appellate Body Report, *United States – Subsidies on Upland Cotton (US - Upland Cotton)*, WT/DS267/AB/R, 3 March 2005.

¹⁸ Panel Report, *United States – Subsidies on Upland Cotton (US - Upland Cotton)*, WT/DS267/R, and Corr.1, 8 September 2004, para 7.1205; see also para. 7.1209.

Moreover, in other areas of WTO rules, where economic effects are not explicitly mentioned, parties on a few occasions have included quantitative analysis to substantiate their claims. Notable examples are the cross-price elasticity estimations in the *Chile – Alcoholic Beverages*¹⁹ and *Japan – Alcoholic Beverages II*²⁰ disputes submitted by parties as evidence of the degree of competition between imported and domestic products in relation to the obligation of national treatment. Similarly to the above situations, if parties decide to provide such quantitative evidence in their arguments, the panels/Appellate Body may or may not find it useful or necessary to their own analysis. To date, however, there has been no instance of a panel or the Appellate Body relying on results of quantitative analyses in their findings and conclusions.

Panel/Appellate Body decisions on alleged violations of WTO rules are quite different from WTO arbitrations, where the question of consistency of a disputed measure with WTO obligations is no longer at issue. In a number of arbitrations, the arbitrators themselves chose to use quantitative models in order to fulfill their mandate to determine the maximum level of countermeasures that a complaining party may apply in response to a measure outlawed by the Dispute Settlement Body (DSB). In fact, in the recent *US – Offset Act (Byrd Amendment) (EC)*²¹ (*Article 22.6 – US*)²² arbitration, the Arbitrator rejected the models proposed by both parties in favor of its own approach. A summary of the main types of situations, in which economic modeling has been used in the context of WTO dispute settlement, is given in Figure 1.

Figure 1: Possible use of quantitative analysis in WTO dispute settlement



¹⁹ WTO Appellate Body Report, *Chile – Taxes on Alcoholic Beverages (Chile – Alcoholic Beverages)*, WT/DS87/AB/R, WT/DS110/AB/R, adopted 12 January 2000, DSR 2000:I, 281.

²⁰ WTO Appellate Body Report, *Japan – Taxes on Alcoholic Beverages (Japan – Alcoholic Beverages II)*, WT/DS8/AB/R, WT/DS10/AB/R, WT/DS11/AB/R, adopted 1 November 1996, DSR 1996:I, 97.

²¹ Among other complainants.

²² Decision by the Arbitrator, *United States – Continued Dumping and Subsidy Offset Act of 2000, Original Complaint by the European Communities – Recourse to Arbitration by the United States under Article 22.6 of the DSU (US – Offset Act (Byrd Amendment) (EC) (Article 22.6 – US))*, WT/DS217/ARB/EEC, 31 August 2004.

In trade remedy investigations, the way in which the injurious effects of imports on a domestic industry are determined is a key issue. WTO rules require that authorities evaluate all relevant factors including those listed in the Agreements in regard to both the health of the industry and sources of injury. There is no requirement that any particular methodology be applied to assess injury, causation by imports and possible attribution to factors other than imports. Nevertheless, investigating authorities, at times, have employed economic models to support their assessments of these matters. Given the absence of multilateral rules on appropriate analytical tools, dispute settlement has little if anything to say in regard to the way economic models are used (or not) by investigating authorities. In disputes, the question therefore does not arise whether a better methodology or model exists that could have been employed, but whether a reasoned and adequate explanation is given by authorities of how the facts support their determination on the basis of the requirements contained in the agreements. So far, therefore, panels dealing with trade remedies did not have to consider the technicalities of economic models, even if parties have opted to use such models at the national level.

The situation is similar, and even less prescriptive, in the case of sunset reviews. Again, no precise methodology is laid down to assess the likelihood of continued or recurrent subsidization/dumping and injury. Neither does the agreement provide guidance as to the factors that should be examined in that context. In fact, it has been stressed by the Appellate Body that ‘a broad range of factors other than import volumes and dumping margins is potentially relevant to the authorities’ likelihood determination’.²³ Yet, assessments of ‘likelihood’ can reasonably be expected to result in probabilities associated with particular outcomes as a function of future developments of relevant factors affecting the state of the industry. None of the WTO cases to date involving sunset reviews has raised the issue of economic modeling in that regard. However, models may be employed in order to determine the likelihood of continuation or recurrence of injury in the many sunset reviews that are bound to be carried out in the near future. While these developments are going to occur at the national level and a priori do not have anything to do with WTO dispute settlement as such, this wave of reviews may generate a number of disputes. If models were to be used more consistently at the national level and prove to be critical for the decision process, it may not be inappropriate to assume that panels may be confronted with modeling questions that parties challenge in each other’s argumentation. The rules governing sunset reviews are further discussed in the following section.

III. WTO rules on sunset reviews

Both Article 11.3 of the Anti-Dumping Agreement and Article 21.3 of the SCM Agreement impose a temporal limitation on the maintenance of anti-dumping and countervailing duties respectively, which must be terminated within five years of their imposition unless certain conditions are met. The requirements in sunset reviews are different from those in the original investigations.²⁴ A central condition is the likelihood of continued dumping/subsidization and

²³ WTO Appellate Body Report, *United States – Sunset Review of Anti-Dumping Duties on Corrosion-Resistant Carbon Steel Flat Products from Japan (US – Corrosion-Resistant Steel Sunset Review)*, WT/DS244/AB/R, adopted 9 January 2004, para 186.

²⁴ For the ‘silence’ of Article 21.3 of the SCM Agreement in relation to certain requirements, such as *de minimis* thresholds, dealt with explicitly in Article 11 of the SCM Agreement in regard to original investigations, see G. M. Grossman and P. C. Mavroidis, ‘United States – Countervailing Duties on Certain Corrosion-Resistant Carbon Steel Flat Products from Germany (WTO Doc. WT/DS213/AB/R): The Sounds of Silence’, in H. Horn, and P. C. Mavroidis (eds) *The WTO Case Law of 2002, The American Law Institute Reporters’ Studies*, (Cambridge: Cambridge University Press 2005). The authors confirm that the

injury if the duty is removed. The Appellate Body clarified in *US – Corrosion Resistant Steel Sunset Review* that in the original investigation authorities had to determine whether *dumping existed*, while in a sunset review the question was whether the expiry of the respective anti-dumping duty would be *likely to lead to continuation or recurrence of dumping* (and injury).²⁵ This means, for instance, that while an anti-dumping duty may not be imposed unless a positive dumping margin (besides injury and a causal link) is determined in the original investigation, dumping margins in a sunset review, although relevant, need not be conclusive of the likelihood of continued or recurrent dumping. With regard to the interpretation of ‘likely’ in Article 11.3 of the Anti-Dumping Agreement, the Appellate Body held that if the duty were terminated, dumping and injury were to be probable as opposed to just possible or plausible.²⁶

Article 11.3 of the Anti-Dumping Agreement does not prescribe any particular methodology in making a likelihood determination of dumping and injury, nor does it identify specific factors that must be taken into account. The probative value of factors may vary from case to case. In *US – Corrosion Resistant Steel Sunset Review* it was illustrated by the Appellate Body that while a decrease in import volumes may be relevant in making an inference that dumping is likely to continue or recur, the probative value of such historical data depends, among others, on how recent it is and whether trends over time can be discerned that may be significant for an assessment of likely future behavior.²⁷ Therefore, a case-specific analysis of the factors behind a cessation or decline in dumped imports as well as an evaluation of the quality and an appropriate treatment of the data appear to be necessary to determine whether dumping and injury are bound to continue or recur if the duty is terminated. What matters is that the likelihood determination, as noted by the Appellate Body in *US – Corrosion Resistant Steel Sunset Review*, ‘is a prospective determination [...] [, i.e.] the authorities must undertake a forward-looking analysis and seek to resolve the issue of what would be likely to occur if the duty were terminated’.²⁸

Appellate Body saw ‘no *a priori* reason why the requirements for invoking countervailing duties should be the same in the two processes’. Ibid, at 71.

²⁵ Appellate Body Report, *US – Corrosion-Resistant Steel Sunset Review*, above n 23, para 107. The Appellate Body applied the same logic regarding original investigations vs. sunset reviews in regard to countervailing duties. See WTO Appellate Body Report, *United States – Countervailing Duties on Certain Corrosion-Resistant Carbon Steel Flat Products from Germany (US – Carbon Steel)*, WT/DS213/AB/R and Corr.1, adopted 19 December 2002, para 87.

²⁶ Appellate Body Report, *US – Corrosion-Resistant Steel Sunset Review*, above n 23, para 111. The SCM Agreement contains similar obligations regarding sunset reviews in its Article 21.3, in particular the almost identical condition ‘that the expiry of the [countervailing] duty would be likely to lead to continuation or recurrence of subsidization and injury’.

²⁷ The Appellate Body stated that ‘[t]he same factors need not always by “highly probative” such that no factor (or combination of factors) should be presumed, by itself, to constitute sufficient evidence that the expiry of the duty would be likely to lead to continuation or recurrence of dumping. Such a presumption might have some validity when dumping has continued since the duty was imposed [...]. However, [...] [a] cessation of imports [...] [or a] decline in import volumes [...] could well have been caused or reinforced by changes in the competitive conditions of the market-place or strategies of exporters, rather than by the imposition of the duty alone. Therefore, a case-specific analysis of the factors behind a cessation of imports or a decline in import volumes (when dumping is eliminated) will be necessary to determine that dumping will recur if the duty is terminated’. Appellate Body Report, *US – Corrosion-Resistant Steel Sunset Review*, above n 23, paras 175 and 176, footnotes omitted.

²⁸ Appellate Body Report, *US – Corrosion-Resistant Steel Sunset Review*, above n 23, para 105.

In the past, certain investigating authorities therefore have produced quantitative estimates for their own evaluation. Despite not being required under WTO rules, the existence of a quantification of possible future scenarios with economic models, in addition to being useful in its own right, might potentially also be seen in the context of a WTO dispute as evidence that a certain analytical rigor was brought to bear by the investigating authority in arriving at the challenged determination. The Panel in *US – Steel Safeguards*, in a different but not unrelated context, expressed such a view.²⁹ The rest of the paper lays out some methodological suggestions that national authorities may find useful in order to realistically appraise the need to terminate or renew existing anti-dumping/countervailing duty orders.

IV. Simulations as a measuring tool

Administering authorities of governments around the world undertaking sunset reviews are faced with the challenge of gauging the probability that a future event will or will not occur. This probabilistic assessment is considerably different from how the same authorities typically approach initial determinations of material injury, where most past and present facts are known or determinable. The standard for the initial determination of existing or threatened material injury, where the threat must be ‘real and imminent’, suggests a very high degree of certainty based on the facts available. In contrast, the sunset standard of ‘likelihood’ suggests that administering authorities are expected to take a broader view in making their determination. It is natural under such circumstances that higher degrees of uncertainty about the future abound, in which case some reasonably scientific approach to measuring the likelihood and magnitude of the effect of revocation could prove to be useful in the sunset review process.

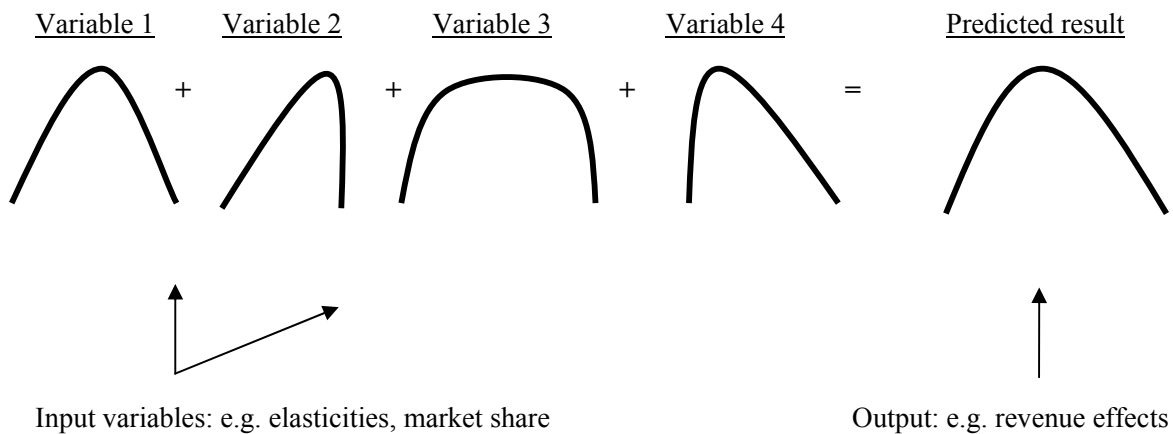
Fortunately there are readily available econometric tools, more specifically simulation methods, which could provide guidance to the authorities conducting sunset deliberations. These simulations can be based on probability theory. For decades they have been used in the finance and insurance industries. But wider application of these methods in recent years has been made possible by much faster and more powerful generations of personal computers. Consequently, probabilistic methods are now being employed by many businesses and various agencies of government.

A probabilistic simulation analysis recognizes that the input variables to a model might have quite different levels of certainty associated with their values. The future values of some variables may be predictable with a high level of certainty, while others involve greater uncertainty. A probabilistic simulation model combines these variables, taking into consideration their differing levels of certainty, and arrives not only at the model's expected specific result, but also at the likelihood that this result will actually occur, considering the uncertainty associated with the inputs.

²⁹ The Panel stated: ‘[Q]uantification may be particularly desirable in cases involving complicated factual situations where qualitative analyses may not suffice to more fully understand the dynamics of the relevant market. [...] The more complex the situation, the more necessary a sophisticated analysis becomes. Whatever approach or model is adopted, it should be applied in good faith and with due diligence’. Panel Report, *United States – Definitive Safeguard Measures on Imports of Certain Steel Products (US – Steel Safeguards)*, WT/DS248, WT/DS249, WT/DS251, WT/DS252, WT/DS253, WT/DS254, WT/DS258, WT/DS259, adopted 10 December 2003, as modified by the WTO Appellate Body Report, WT/DS248AB/R, WT/DS249AB/R, WT/DS251AB/R, WT/DS252AB/R, WT/DS253AB/R, WT/DS254AB/R, WT/DS258AB/R, WT/DS259AB/R, paras 10.336 and 10.342.

In a sunset review, such a simulation would consider the complete range of uncertainty for each of the input variables needed to estimate the price, volume and revenue effects of continued or renewed dumping/subsidies on the domestic industry. The inputs to the simulation would include elasticities, capacity utilization, market share and other variables. Using the description of uncertainty for each variable, a simulation would calculate an essentially unlimited number of permutations of the effect on a local industry of revoking a dumping or countervailing duty order. The value selected for each of the uncertain inputs would vary according to a probability distribution appropriate to its uncertainty level, i.e. variables with relatively little uncertainty would have a narrow distribution and those with greater uncertainty would have a wider distribution. A single value from each of these wide or narrow distributions would be randomly selected and consolidated with the selected value from each of the other variables to determine a single value for the overall effect on the domestic industry. This procedure would be repeated thousands of times to effectively create a probability distribution of the resultant effect on the domestic industry, given the particular set of input values used, as illustrated in Figure 2.

Figure 2: Simulation: Differing levels of uncertainty among input variables are combined to provide a predicted result with a specified level of likelihood



The results of such a simulation may be summarized in two easy-to-read graphs. Figure 3 explicitly shows probabilities of various levels of revenue effects. In this example, revenue effects of 4-6 per cent are much more likely than those in the 7-9 per cent range. The area that has been shaded represents the probability of a revenue effect of less than 5 per cent. A revenue effect between 5 per cent and 10 per cent is equally likely. The fact that the shaded area represents approximately half of the area underneath the curve means there is approximately a 50 per cent probability that revocation of the order would cause an adverse revenue effect of less than 5 per cent. Figure 4 directly computes this probability by graphing the cumulative probability of a revenue effect 'less than or equal to' a certain value. Moving 'up' from the 5 per cent mark, one can see that at a certain level there is an almost 100 per cent likelihood that revenue loss will be equal to or lower than that level. Of course, it is up to national authorities to decide whether that revenue effect (plus any other effects that are being simulated) would amount to injury or not, and which residual probability level should apply to a loss of that size or higher in order to make the continuation or recurrence of injury likely.

Figure 3: Interpreting the distribution of revenue effects

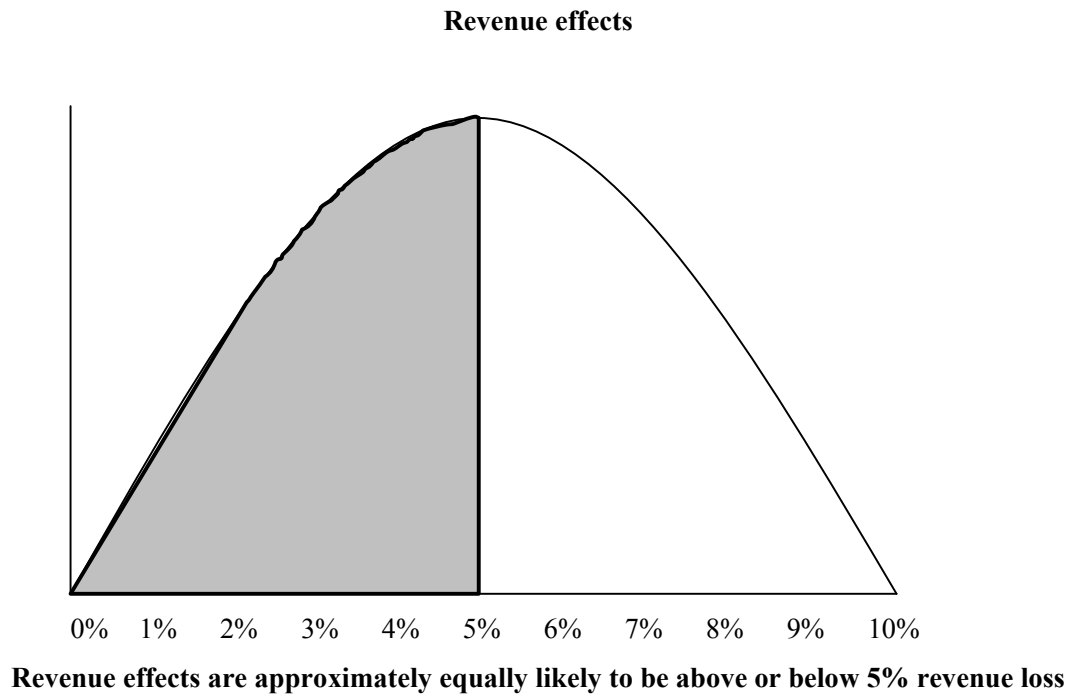
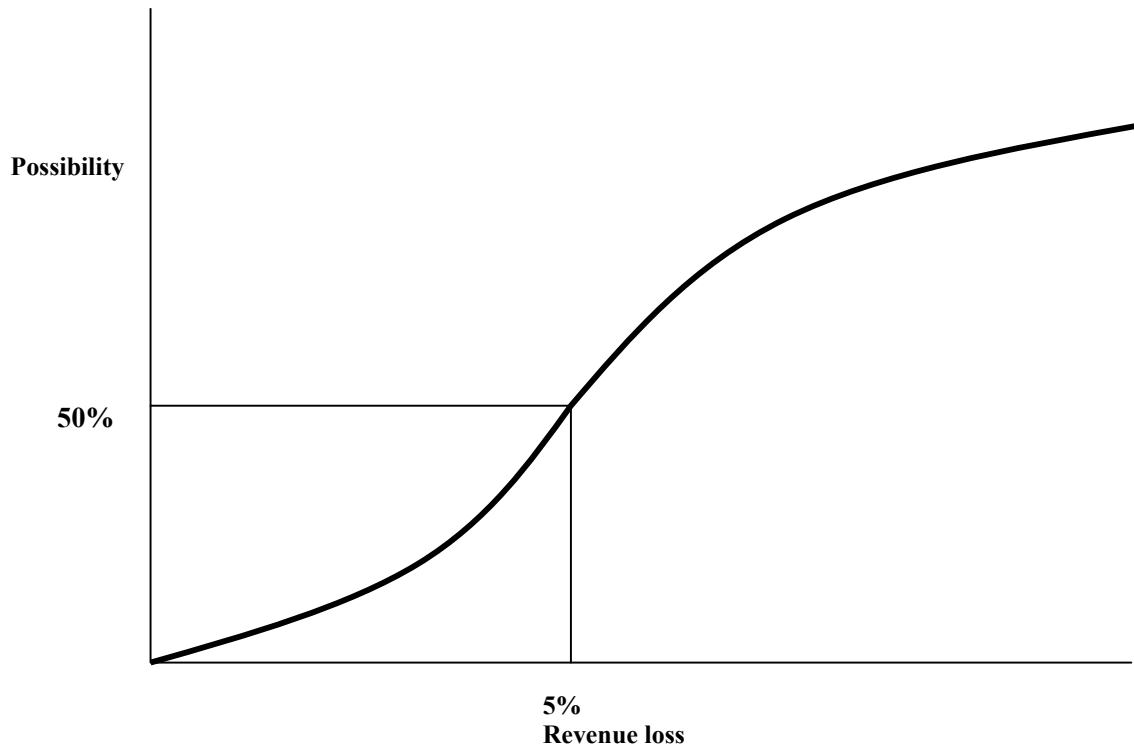
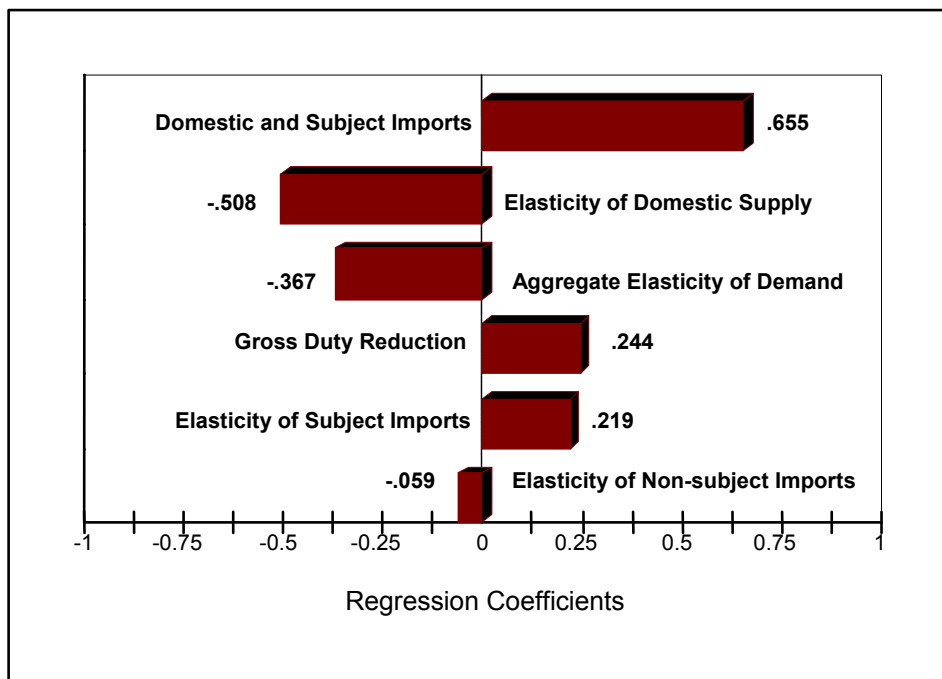


Figure 4: Determining the likelihood that the revenue loss is below 5%



While this type of simulation model is effective in estimating the likely effects of revoking an order on the domestic industry, it is also extremely valuable for identifying those individual variables that have the most effect on the domestic industry's condition. It is generally assumed that the elasticity of substitution, margins of dumping, and subject import shares have the most effect on the domestic industry. However, many other variables can be 'drivers', including the elasticity of supply, the elasticity of demand and capacity utilization. The simulations provide a rank ordering of the inputs based upon their effect on the domestic industry, which allows the administering authority to quantify the change in domestic price (revenue or volume) by changing any specific input. In the hypothetical case shown in Figure 5, the 'tornado' graph shows the six largest drivers affecting domestic prices. In this example (which is further explained in Section V below), the domestic price is most sensitive to changes in the elasticity of substitution between domestic and subject imports, the price-elasticity of domestic supply and the price-elasticity of aggregate demand. Each driver has either a negative or positive relationship with domestic prices as is noted by the sign of each coefficient. Results such as these could also be helpful to analysts examining, for example, the marginal effects of alternative probability distributions for individual inputs, such as the elasticity of substitution.³⁰

Figure 5: Sensitivity analysis for price effects



³⁰ As mentioned above, the software necessary to create and run probabilistic simulation models is more readily accessible than ever before. By way of example, one such product that would make simulation modeling exceedingly feasible is the @Risk software which can be integrated into Microsoft Excel as an Add-in. The software conducts Monte Carlo simulations at great speed and ease while also allowing for the creation and adaptation of models that represent the underlying economics in the sunset review and particular industry involved.

V. Application to sunset reviews

A. ITC's COMPAS model

COMPAS provides one of many possible frameworks for addressing the uncertainty inherent in estimating the likely impact of revocation in a sunset review, but not without substantial modification. COMPAS, as issued by the US ITC, accounts for uncertainty by allowing for low and high estimates ('from' and 'to') of six uncertain elasticities. Using only the low and high values, 64 estimates (2^6) of the effect on the US industry are possible. COMPAS, however, performs the analysis for only eight of these permutations, using both the low and high estimates for each variable four times (see Figure 6).³¹ While the results of these eight scenarios might provide a general idea of the damage to the domestic industry, they do not address the other 56 scenarios and do not address any elasticity between the low and high ends of the range. In addition, limiting the analysis to the 8 scenarios might tend to overstate or understate the overall effect on the domestic industry (in contrast to an analysis examining all 64 possible permutations). In essence, these COMPAS values provide eight single-point estimates of the effect on the domestic industry, with no probabilities associated with any of them.³² Further, even the full set of 64 estimates would provide no information about effects when the elasticities were not exactly at the low or high end of the ranges.³³

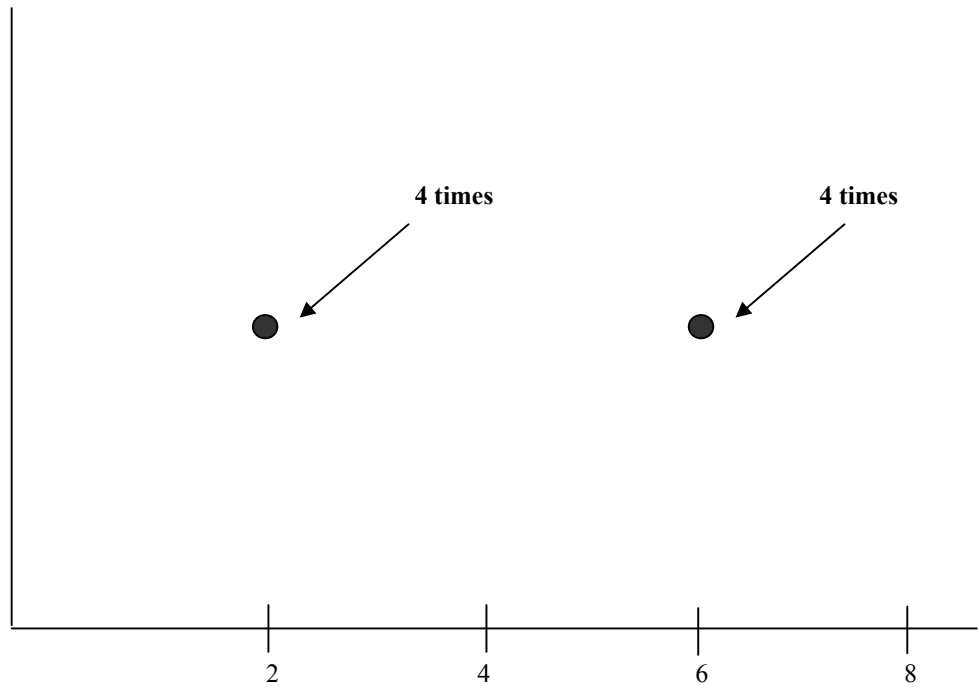
While economic theory quantifying the effects on the domestic industry of historically dumped or subsidized imports may be well established, the analysis is quite different when attempting to quantify the effect on the domestic industry of revoking a dumping order. The logic behind this distinction is quite simple; in a historical analysis, the industry's economic condition is known. In a sunset review, the industry's condition must be forecast under uncertainty, as adjustments undertaken in the meantime make it unlikely that the industry, *ceteris paribus*, will go back to its original state. To account for such difference, it is necessary to consider (1) making some additions to the underlying economic model used by COMPAS and (2) more precisely and completely model the uncertainty of industry factors and elasticities.

³¹ COMPAS, for example, always assumes that when the elasticity of substitution between domestic and unfair imports is at the low (high) end of the range, so are the elasticities of substitution between domestic and fair imports and between fair and unfair imports.

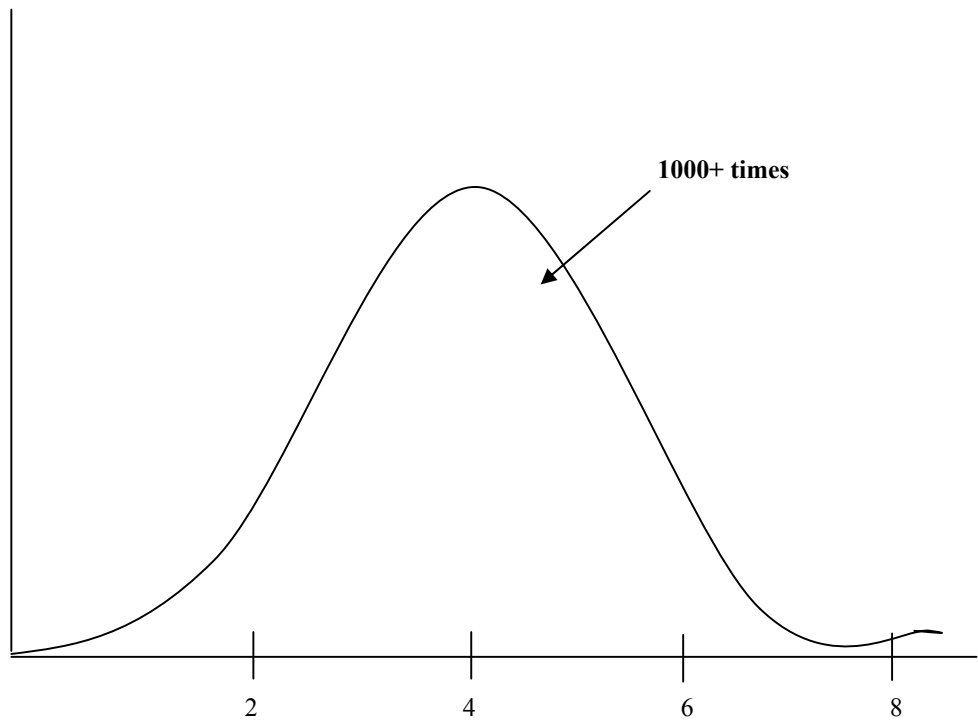
³² That is, there is no indication that the first estimate is less or more likely than the eighth estimate.

³³ For example, if the elasticity of substitution was estimated to range from 3 to 5; COMPAS's output provides no indication of the effect on the domestic industry if this elasticity were 3.5, 4, 4.5, or any other value besides exactly 3 or 5.

Figure 6: COMPAS vs. simulation – Choice of input values



COMPAS



Simulation

Updating the underlying COMPAS economics, for instance, could begin by adding a variable that describes market structure from perfectly competitive to perfectly monopolistic. This could account for pricing differences in changed market regimes.³⁴ Since the level of competition would be dependent on the prevailing margin, amongst other factors, the 'level of competition' could be programmed to vary with such related factors. These issues are not further elaborated in this article.

Rather, working with a given model, we concentrate on the question of how to assess, on a prospective basis, the likely condition of the industry in the event that dumping/subsidies are renewed (at some determined level).³⁵ The crux of this problem is estimating what certain industry variables (e.g., market shares, size, domestic capacity utilization, etc.) would be in the absence of the order, in addition to estimating the six elasticities used by COMPAS.³⁶ If an order were to be revoked immediately after being imposed, it is realistic to assume that the industry's variables existing before the order would be reinstated, and a COMPAS-like model would be as practical as in a historical context. However, five years after the initial investigation and the imposition of an order, the industry likely has changed, such that these variables are unlikely to revert back to the pre-order industry situation.

Estimating the range of prospective industry variables requires an intimate knowledge of the industry and consideration of their interactive effects with the elasticities. Under such a prospective analysis, a COMPAS type of model only focusing on the low and high estimate value for each of 11 or more uncertain input variables (six elasticities, two market shares, industry size, point in the business cycle,³⁷ and capacity utilization), could potentially compute 2,048 possible scenarios (2^{11}) of damage to the domestic industry. Even if it were computationally tractable within the confines of a COMPAS-type model to perform these calculations, simply computing all 2,048 scenarios would still not capture any of the situations besides the low and high estimates for the variables.

³⁴ One approach that might handle the issue is to use conjectural variations, which refers to a firm's (quantity or price) decision in response to its belief (or conjectures) about the quantity/price decisions of its competitors. Such responses are 'consistent' if the conjectures about the other firms' decisions are equivalent to the optimal response of the other firms at the equilibrium defined by that conjecture. In the context of sunset reviews, one could determine the consistent conjectural variations responses from the known factors of the industry. See A. Daughety, 'Reconsidering Cournot: The Cournot Equilibrium is Consistent', 16 (3) *Rand Journal of Economics* 368 (1985). It has been generally shown with conjectural variations that as marginal costs are more constant (not rising), the resulting industry is more competitive. See M. Perry, 'Oligopoly and Consistent Conjectural Variations', 13 (1) *Rand Journal of Economics* 197 (1982).

³⁵ In certain cases, some might argue that a comparison between the current actual condition of the domestic industry and the projected condition of the industry absent the dumping order will understate the benefit of the order to the domestic industry. Such understatements could occur where the antidumping duty is being absorbed by the foreign producer or importer, thereby lessening the realized benefit to the domestic industry. If, for example 50 percent of a dumping margin of 30 percent is being absorbed by the foreign producer or importer, the domestic industry is only benefiting from an effective margin of 15 percent. However, if the order is lifted, the price of imported goods may be reduced by 30 percent, without cost to the foreign producer. As such, the current condition of the industry reflects an effective margin of 15 per cent, while lifting the order would remove a dumping margin of 30 per cent. Given these dynamics under the current conditions, the model must recognize distortions caused by antidumping duty absorption.

³⁶ See Appendix A for a listing of these elasticities.

³⁷ The point in the business cycle would also be able to define aggregate demand.

A simulation model would allow one to consider the complete range of uncertainty for each of the inputs, instead of simply choosing a ‘high’ value half of the time and a ‘low’ value half of the time. Further, it would perform an (essentially) unlimited number of permutations of the effect on the domestic industry of revoking a dumping/countervailing duty order. Varying each of the 11 inputs according to a probability distribution³⁸ appropriate for its uncertainty level would permit this analysis.³⁹ The simulation procedure would randomly (weighted, based upon the defined probability distribution) select a single value from the distribution of each input to determine a single value for the effect on the domestic industry.⁴⁰ This procedure would be repeated a few thousand times to create a distribution of thousands of data points (in contrast to the eight data points on the standard COMPAS model) of the effect on the domestic industry.

B. COMPAS model example with @Risk

Not only does a probabilistic simulation model incorporate significantly more information regarding uncertainty than the traditional COMPAS program, its output is also much easier to read and interpret. In assessing the revenue (or price or volume) effects, analysts can view two summary data graphs which show the probability distribution of revenue effects and specific ‘cumulative’ probabilities⁴¹ for various levels of revenue effects. If the administering authority chooses to consider a particular threshold for evidence of injury (e.g., revenue effect of 5 percent), these graphs show the likelihood of being above or below that threshold.

For illustrative purposes, we have conducted an example of a COMPAS analysis with a simulation using @Risk software. The data used for this example come from the recent ITC case on *Certain Preserved Mushrooms*.⁴² A summary of the inputs used in the model can be found in Figure 7. More detailed descriptions of the elasticities, the reasoning behind their selection and other inputs can be found by consulting the ITC report directly.

³⁸ Variables that are fairly certain would have a relatively narrow range. It may be that the estimates for certain variables (i.e., margin) may be such that the distribution around them will be asymmetric (i.e., skewed.) Although many of these uncertain variables may be ‘lognormally’ distributed (i.e., ranging from 0 to infinity), margins may have a skewed distribution based on the government body’s initial margin estimate.

³⁹ Economists at the Federal Trade Commission in the United States have previously used probabilistic simulation approaches in the dumping context. See M. Morkre and K. Kelly, ‘Effects of Unfair Imports on Domestic Industries: U.S. Antidumping and Countervailing Duty Cases, 1980-1988’, Federal Trade Commission Bureau of Economics Staff Report (1994).

⁴⁰ The effect on the domestic industry would be measured on price, volume, and revenue separately.

⁴¹ For example, a cumulative probability of 0.60 for a 5 percent revenue effect means that there is a 60 percent chance that the revenue effect will be 5 percent or less.

⁴² International Trade Commission Publication 3731, *Certain Preserved Mushrooms From Chile, China, India, and Indonesia (Certain Preserved Mushrooms)*, Investigations Nos. 731-TA-776-779 (Review), October 2004.

Figure 7: Inputs to probabilistic COMPAS model

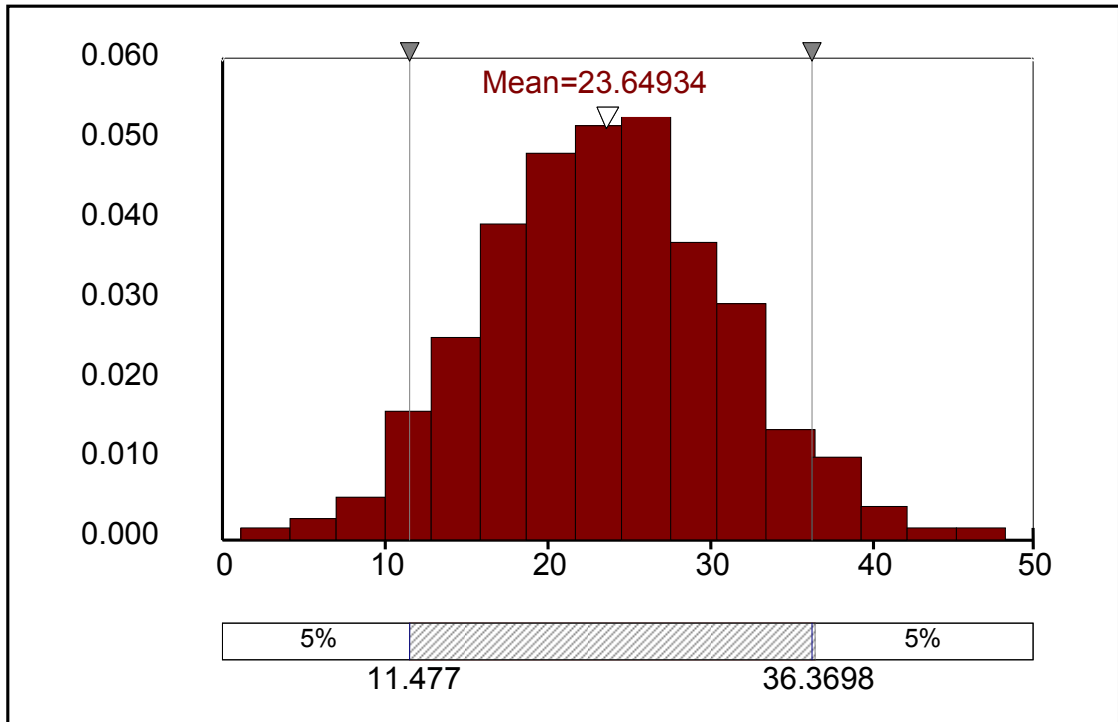
Industry Variables	Mean	Standard Deviation
Domestic Quantity	56,543	
Domestic Value	69,031	
Subject Import Quantity	71,259	
Subject Import Value	75,389	
Nonsubject Import Quantity	47,463	
Nonsubject Import Value	47,239	
Domestic Capacity Utilization	20	3
Margin (with order revoked)	62.19	
Subject Import Price Decline	38.34	3
<u>Elasticities</u>		
Substitution: Domestic/Subject	3.0	1.0
Substitution: Domestic/Nonsubject	3.0	1.0
Substitution: Subject/Nonsubject	3.0	1.0
Aggregate Demand	0.65	0.25
Domestic Supply	4.5	1.5
Subject Supply	4.5	1.5
Nonsubject Supply	4.5	1.5

COMPAS predicts changes in the price, quantity and revenue for the domestic, subject and non-subject imports separately, though the effect on the domestic industry is the focus when considering whether to remove a duty during a sunset review. While COMPAS predicts only the results of the eight scenarios described earlier, @Risk allows the user to predict the full range of possible scenarios. As an example, Figures 8 through 10 detail the results of 1,000 probabilistic COMPAS ‘runs’⁴³ for the revenue effect. Specifically, the probability distribution of predicted revenue effects in Figure 8 shows, for instance, that:

- revenue effects of approximately 20-30 percent are much more likely than those in the 30-40 percent range and
- the revenue effect is more likely than not to be less than 30 percent.

⁴³ The technical differences between COMPAS and the prepared simulation approach are described in Appendix A.

Figure 8: Probability distribution of predicted revenue effects



The 'Summary Statistics' chart in Figure 9 directly addresses the need for administering authorities to measure the 'likelihood' of injury by detailing the probability of having a revenue effect of 'less than or equal to' a certain value. For example, at the 65th percentile, one can see that there is an explicit probability of 65 percent associated with having a revenue effect of less than 26.35 percent. The summary table also shows that there is a 90 per cent probability ('Diff P') that the revenue effect amounts to between 11.48 ('Left X') and 36.37 per cent ('Right X').

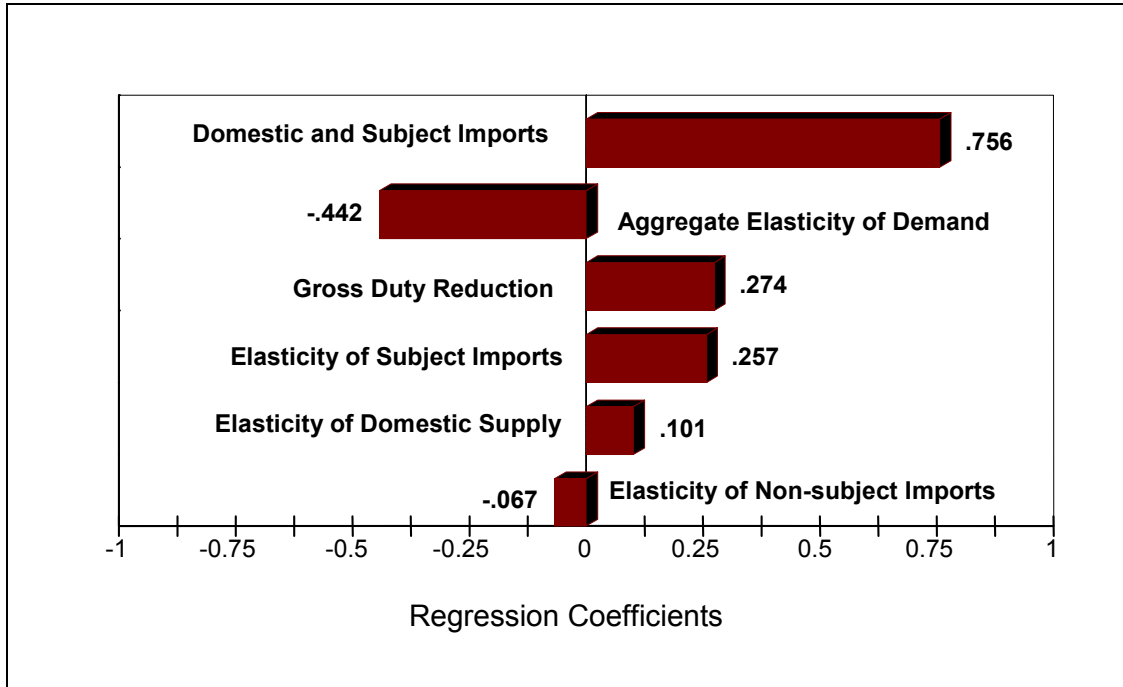
Figure 9: Simulation summary statistics

Summary Statistics			
Statistic	Value	% tile	Value
Minimum	1.11	5	11.48
Maximum	48.13	10	14.38
Mean	23.65	15	15.85
Std Dev	7.42	20	17.30
Variance	55.05712387	25	18.56
Skewness	0.125367513	25	19.83
Kurtosis	3.079230201	35	2078
Median	23.63	40	21.60
Mode	27.16	45	22.65
Left X	11.48	50	23.63
Left P	5%	55	24.55
Right X	36.37	60	25.42
Right P	95%	65	26.35
Diff X	24.89	70	27.19
Diff P	90%	75	28.46
#Errors	0	80	29.71
Filter Min		85	31.22
Filter Max		90	32.97
#Filtered	0	95	36.37

Another tool available with @Risk is the Sensitivity Analysis applied to this simulation and shown in Figure 10. The ‘tornado’ graph, which was first introduced by showing the drivers of price effects in Figure 5, provides a graphical representation of the importance of the various input variables in determining the revenue effect. This graph can reveal to administering authorities which variables are the key drivers in the predicted result and which variables have relatively little effect. The simulation results in Figure 10 show that the elasticity of substitution between domestic and subject imports, price-elasticity of aggregate demand and the expected reduction in duties if an order were revoked are the top three drivers of domestic revenue. Figure 10 also shows that revenues are rather insensitive to other variables, such as the elasticity of substitution between domestic and non-subject imports and the elasticity of substitution between subject and non-subject imports.⁴⁴

⁴⁴ Sensitivity analyses performed on the output variables and their associated inputs use either multivariate stepwise regression or a rank order correlation. In the regression analysis, the coefficients calculated for each input variable measure the sensitivity of the output to that particular input distribution. The overall fit of the regression analysis is measured by the reported fit or R-squared of the model. The lower the fit the less stable the reported sensitivity statistics. If the fit is too low – beneath .5 – a similar simulation with the same model could give a different ordering of input sensitivities (see values ‘Regr’ column in the associated table of Figure 10). The sensitivity analysis using rank correlations is based on the Spearman rank correlation coefficient. With this analysis, the rank correlation coefficient is calculated between the selected output variable and the samples for each of the input distributions. The higher the correlation between the input and the output, the more significant the input is in determining the output's value (see values in the ‘Corr’ column). A comparison with the ‘Regr’ results shows that these methods have no implications for the rank order of the sensitivity of results in response to variations of individual inputs.

Figure 10: Simulation sensitivity analysis for revenue effects



Sensitivity			
Rank	Name	Regr	Corr
#1	Elasticity of Substitution between Domestic and Subject Imports	0.756	0.800
#2	Aggregate Elasticity of Demand	-0.442	-0.424
#3	Expected Reduction in Duties if Order is Revoked	0.274	0.267
#4	Price Elasticity of Subject Imports	0.257	0.277
#5	Price Elasticity of Domestic Supply	0.101	0.132
#6	Price Elasticity of Non-subject Imports	-0.067	-0.049
#7	Elasticity of Substitution between Domestic and Non-subject Imports	0.000	0.050
#8	Elasticity of Substitution between Non-subject and subject Imports	0.000	-0.029
#9	Domestic Capacity Utilization	0.000	0.027
#10	Growth Rate Estimate	0.000	0.055

In contrast to the probabilistic simulation of COMPAS, the standard COMPAS output is given in Figure 11, with the eight scenarios affecting price, volume, and revenue. The results provide a reasonable idea of high and low ends of ranges, but do not offer probability information. For example, the mean and the median revenue effects are between 23.65 and 23.63 percent (as seen in Figure 9), yet only two of the eight COMPAS scenarios reports a value within the 20-25 percent range. In fact, the average of the eight COMPAS scenarios (27.0 percent) is near the 70th percentile based on the full simulation. In addition, the standard COMPAS results do

not describe any of the outcomes below the 25th percentile,⁴⁵ implying that, in this case, COMPAS alone would overestimate the effect on the domestic industry of revoking an order during a sunset review.

VI. Conclusion

The ‘likelihood’ of continuation or recurrence of injury is a complex matter. It is influenced by a broad range of factors many of which are quantifiable and themselves subject to varying levels of uncertainty. While under WTO rules administering authorities are free to choose appropriate methodologies, subject to certain conditions, econometric models are sometimes employed in trade remedy investigations as they allow for a more rigorous analysis of influential factors on the basis of economic theory. Experience from selected WTO disputes also points to the potential usefulness of submitting evidence obtained from econometric analyses. This article has shown that adding on a probabilistic dimension to an underlying simulation model can significantly increase the value of the modeling exercise for ‘likelihood’ determinations in the context of sunset reviews.

In particular, a probabilistic simulation provides a much clearer indication of how model results can be interpreted in relation to two major questions arising in this context. First, the probability distribution of the variables of interest (e.g. revenues) and its associated statistics, such as means, standard deviations and confidence intervals, allow for a direct reading of the ‘likelihood’ that a threshold set by authorities will be crossed. Second, the sensitivity of outcomes to various assumptions about the distribution of elasticities and influential factors can be tested. This helps to determine their relative impact in relation to imports, and, hence, contributes to assessing the ‘likelihood’ of injury from continued or recurrent dumping/subsidization.

For convenience, these features have been demonstrated in a ‘probabilistic’ re-run of a COMPAS simulation on the basis of real facts. In this case, the results are indicative of the risk of overestimating the effect on the domestic industry of a termination of orders if uncertainty about input values is modeled in an oversimplified manner. Given the speed with which multiple permutations can be carried out these days, this article has argued that an augmented econometric model incorporating the probabilistic approach can represent an even more powerful tool in support of legal reasoning in the context of sunset reviews.

⁴⁵ The numbers will change based upon the assumptions underlying the ‘from’ and ‘to’ values of COMPAS's inputs. If it is assumed that these input values represent nearly the full range (i.e., 99 percent) of potential values, COMPAS's revenue effects figures will not include any of the middle 80 per cent of outcomes that are most likely. If COMPAS is only assumed to incorporate the middle 50 percent of potential values for the inputs, COMPAS's revenue effects figures will not include the most extreme 25 per cent of outcomes.

Figure 11: Standard COMPAS output

COMPAS version 1.4 (TARGET) – EFFECTS OF IMPOSING AN IMPORT DUTY ON SPECIFIC (TARGET) COUNTRIES (6/1/93)
by Joseph Francois and Keith Hall, Office of Economics, USITC

ESTIMATED IMPACT ON DOMESTIC INDUSTRY	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Minimum	Maximum	Average
PERCENTAGE CHANGES											
Price	-7.0%	-5.0%	-5.0%	-3.8%	-8.3%	-6.2%	-6.3%	-5.0%	-8.3%	-3.8%	-5.8%
Quantity	-19.6%	-26.6%	-14.2%	-20.7%	-22.8%	-32.0%	-17.7%	-26.5%	-32.0%	-14.2%	-22.5%
Revenue	-25.2%	-30.3%	-18.5%	-23.7%	-29.2%	-36.2%	-22.8%	-30.2%	-36.2%	-18.5%	-27.0%
QUANTITY CHANGES											
U.S. Production	(11,083)	(15,033)	(8,052)	(11,687)	(12,899)	(18,074)	(9,989)	(14,973)	(18,074)	(8,052)	(12,724)
U.S. Consumption	26,682	38,685	40,147	55,931	31,019	50,221	44,773	68,398	26,682	68,398	44,482
Employment	(53)	(72)	(38)	(56)	(62)	(86)	(48)	(71)	(86)	(38)	(61)
Imports:	37,765	53,718	48,199	67,618	43,918	68,295	54,762	83,371	37,765	83,371	57,206
ESTIMATED MARKET SHARES											
Domestic Market Share	28.9%	26.6%	28.9%	26.6%	26.9%	23.3%	26.9%	23.3%	23.30%	28.94%	26.42%
Target Import Market Share:	51.3%	55.3%	51.3%	55.3%	54.7%	60.8%	54.7%	60.8%	51.26%	60.76%	55.49%
Non-Target Import Market Share:	19.8%	18.2%	19.8%	18.2%	18.4%	15.9%	18.4%	15.9%	15.94%	19.80%	18.08%
Capacity Utilization:	1583.9%	1446.2%	1689.5%	1562.8%	1520.6%	1340.3%	1622.0%	1448.3%	1340.28%	1689.46%	1526.70%
Change in Value of U.S. Production	(\$17,424)	(\$20,898)	(\$12,785)	(\$16,341)	(\$20,153)	(\$24,986)	(\$15,760)	(\$20,816)	(\$24,986)	(\$12,785)	(\$18,646)
ESTIMATED IMPACT ON TARGET IMPORTS											
PERCENTAGES CHANGE											
Price	-27.0%	-31.2%	-25.4%	-30.3%	-25.4%	-29.8%	-23.8%	-28.9%	-31.19%	-23.82%	-27.74%
Quantity	66.1%	93.1%	77.1%	108.7%	76.8%	117.1%	88.6%	134.6%	66.05%	134.63%	95.27%
Revenue	21.2%	32.9%	32.1%	45.4%	31.8%	52.4%	43.7%	66.8%	21.25%	66.77%	40.79%
Change in Quantity of Imports:	47068	66337	54958	77428	54745	83467	63146	95939	47068	95939	67886
Change in Value of Imports:	\$16,016	\$24,773	\$24,231	\$34,255	\$24,007	\$39,467	\$32,941	\$50,340	\$16,016	\$50,340	\$30,754
ESTIMATED IMPACT ON NON-TARGET IMPORTS											
PERCENTAGE CHANGES											
Price	-7.0%	-5.0%	-5.0%	-3.8%	-8.3%	-6.2%	-6.3%	-5.0%	-8.27%	-3.79%	-5.82%
Quantity	-19.6%	-26.6%	-14.2%	-20.7%	-22.8%	32.0%	-17.7%	-26.5%	-31.97%	-14.24%	-22.50%
Revenue	-25.2%	-30.3%	-18.5%	-23.7%	-29.2%	-36.2%	-22.8%	-30.2%	-36.20%	-18.52%	-27.01%
Change in Quantity of Imports:	-9303	-12619	-6759	-9810	-10827	-15171	-8384	-12568	-15171	-6759	-10680
Change in Value of Imports:	(\$11,923)	(\$14,301)	(\$8,749)	(\$11,183)	(\$13,791)	(\$17,098)	(\$10,785)	(\$14,245)	(\$17,098)	(\$8,749)	(\$12,759)

APPENDIX A

Technical differences between COMPAS and a probabilistic simulation

COMPAS and a probabilistic simulation differ in two related, but distinct ways. First, the sampling of the uncertain variables (inputs) differs. The second difference derives from the injury estimates (outputs.)

COMPAS groups its six uncertain inputs into the following three groups:

INPUT	GROUP
Elasticity of Substitution: Domestic/Subject	1
Elasticity of Substitution: Domestic/Non-Subject	1
Elasticity of Substitution: Non-Subject/Subject	1
Domestic Supply Elasticity	2
Fair Supply Elasticity	2
Aggregate Demand Elasticity	3

Each input within a group is assumed to move in the same manner for sampling/scenario purposes, in the sense that if one input in group 1 is at the high end of its estimated range, then the other two inputs in group 1 must also be at the high ends of their ranges. By creating this relationship, COMPAS uses eight input combinations based on high ('H') and low ('L') ends of ranges for the three groups: LLL, LLH, LHL, LHH, HHH, HHL, HLH, and HLL.

While COMPAS uses the terms low and high ends of estimated ranges, there is no consensus as to whether such a range incorporates a confidence interval of 50, 75, 90, or 100 percent. If such a range generally has been used by practitioners as an interquartile (50 percent) range, clearly the range of outputs will not describe either 'tail' of the complete range of potential outputs. On the other hand, if practitioners use the input range as 99 percent confidence, the range of outputs will give little description of the vast majority of potential outcomes (the middle 80 percent or more of potential outputs)

Simulation simply describes each input's (sunset review cases will likely require 11 or more of such inputs) uncertainty as a probability distribution. The inputs can be assumed to follow any distribution (e.g., normal, lognormal, binomial) and with any distribution characteristics (e.g., high or low variance, skew, etc.). For each 'iteration'/scenario, the simulation procedure randomly and independently selects each input value, based on its probability distribution. After running, for example, 3 iterations that determined revenue effects of 2.3 per cent, 3.4 per cent, and 4.9 per cent; the output can be described as a simple discrete distribution (e.g., 1/3 chance of 2.3 per cent, 1/3 chance of 3.4 per cent, and 1/3 chance of 4.9 per cent.) After running the simulation many times, the output's discrete distribution will tend to approximate a continuous (normal) distribution. The simulation program, in fact, has an internal mechanism that monitors if the output has converged. It has been our experience using our 'prototype' model that convergence usually occurs within 1,000 runs, and will sometimes converge within as few as 100 runs.

Having an (approximated) normal output distribution provides significant advantages over simply analyzing a discrete group of points. Using the mean and standard deviation, it is easy to give precise estimates to probability questions.