SAN DIEGO ASSOCIATION OF GOVERNMENTS

ECONOMIC IMPACTS OF DELAYS AT THE BORDER ON FREIGHT MOVEMENT AND TRADE BETWEEN THE UNITED STATES AND MEXICO

TECHNICAL MEMORANDUM #2

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1. INTRODUCTION

HLB Decision Economics Inc. (HLB) has been engaged by the San Diego Association of Governments (SANDAG) to assess the impacts of border delays on freight movement and trade on the U.S. and Mexican economies over the next ten years. The study has three main objectives:

1. Assess the industries affected by the delay as the excess delay disrupts their supply chain management;

2. Estimate the long-run impact on industry output and productivity, on both sides of the border; and,

3. Estimate the overall economic impacts, using local regional and national multipliers, on both sides of the border.

This memorandum is the second of three on the economic impacts of border delays on freight movement and trade between the United States and Mexico. Technical Memorandum #1 presented the literature review and identified the data needs for the model. The purpose of Technical Memorandum #2 is to discuss the conceptual framework and the methodology to estimate the economic impacts.

Following this introduction, Section 2 introduces some fundamental concepts and mechanisms of international economics that will help understand the economic implications of border delays. Based on this conceptual framework, an economic impact methodology is presented in Section 3.

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1 The study is conducted in parallel with an assessment of the economic impacts of border delays on tourism, shopping, work and productivity in the San Diego – Northern Baja California border region.
2. CONCEPTUAL FRAMEWORK

This section presents the conceptual framework to estimate the economic impacts of border delays on freight movement and trade.

2.1 Economics of International Trade and Impact of Border Delays

This section uses the fundamental concepts of the theory of trade between two countries to investigate the impact of border delays on the economies of the trading countries. The illustration below is only one of the scenarios that can be assessed.

Figure 1 shows the effects of congestion and border delays on industries (which may depend on the industry based on the commodities), i.e. those where final products are traded. There are two parts in this figure. Part A shows the effect on the exporter, and Part B shows the corresponding effect in the export market producers and the impact on consumers and producers of competing products. To facilitate the analysis, it is assumed in this figure that the exporter firm is a Mexican company and the export market is the U.S.

Figure 1: Effects of Congestion and Border Delays on the Demand for Final Goods

The initial market equilibrium in Figure 1 is E1. The quantity of Mexican exports is X1, the quantity of domestic output is Q1 and the prevailing market price is P1.

An increase in congestion and border delays causes the supply curve of Mexican exports to shift to the left (from SUP1 to SUP2) as exporters are faced with higher transportation costs. The volume of Mexican exports falls to X2 and the price increases to P2. Mexican exporters are worse off in terms of volume of shipments. Their revenues will also fall if the increase in price does not compensate for the reduction in volume, i.e. if the percentage increase in price is smaller than the percentage reduction in shipments.
The increase in price of Mexican exports makes U.S. goods competing with Mexican exports more competitive, and the demand for U.S. domestic products increases. This is illustrated by a shift to the right of the demand curve for U.S. goods competing with Mexican exports (from $D_1$ to $D_2$). As a result, the output of U.S. goods competing with Mexican goods increases but so does their price. U.S. producers clearly benefit from the reduction in the volume of Mexican exports (increase in the producer surplus). However, U.S. consumers are hurt by higher market prices (decrease in the consumer surplus) and possibly reduced choice.

The reduction in the volume of Mexican exports (and increase in the price) will depend on the shapes of the demand and supply curves, which are in turn determined by the following factors: \(^1\)

- Price elasticity of demand for Mexican exports;
- Price elasticity of supply of Mexican exports, and
- Elasticity of Mexican export shipments with respect to border delays.

The increase in the volume of the U.S. domestic production will depend on the following factors:

- Price elasticity of demand for U.S. goods competing with Mexican exports;
- Price elasticity of supply of U.S. goods competing with Mexican exports.

### 2.2 Other Considerations and Challenges

This example illustrates, in a simplified way, the effects of congestion and border delays (and the mechanisms by which these effects are initiated) on both sides of the cross-border economy, in terms of output and (implicitly) in terms of employment, earnings, and tax revenues. A number of other considerations and challenges should also be taken into account.

Though this example only shows Mexican exports to the United States, the impact on trade can also be estimated in a similar fashion from the reverse perspective (U.S. exports to Mexico).

The magnitude of the impact will depend on the group of commodities under consideration. In some cases, an hour delay at the border means that the shipment will not be delivered until the next day. This may have major consequences to industries that are time sensitive. Examples of highly time sensitive industries include those industries in which just-in-time inventory management is widespread (e.g., automotive industry), \(^3\) or in which perishability is a key factor (e.g., agricultural products).

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\(^1\) The price elasticity of demand measures the responsiveness of quantity demanded to a change in price, with all other factors held constant. For instance, a price elasticity of demand of \(-0.5\) would mean that a 1 percent rise in price leads to a 0.5% decrease in quantity demanded.

\(^3\) This topic is discussed in greater detail in David J. Andrea, and Brett C. Smith, *The Canada-US Border: An Automotive Case Study*. Prepared for the Canadian Department of Foreign Affairs and International Trade by the Center for Automotive Research, January 2002.
Note, also, that this example shows the effect of border delays on trade in the \textit{short} run solely. Continued congestion and delays at the border will most certainly have a long run impact too. In particular, delays at the U.S.-Mexico border may hinder the border region’s ability to attract new investment, as well as maintain its existing investments. Since the uncertainty over wait times acts as a tariff-like barrier to the import and export of goods, it may reduce the incentive for U.S. companies to locate on the Mexican side for instance (i.e., desourcing of \textit{maquiladoras}). Therefore, in the long run congestion and border delays could produce a major disincentive for investment in the San Diego-Tijuana region.

A corollary of desourcing is the potential diversion of commercial traffic to other ports of entry (less ridden with border congestion and unexpected delays), or even other states. In a recent survey of northbound border crossers at the Otay Mesa-Mesa de Otay port of entry, 73.5 percent of interviewees said they would be willing to pay $3 per crossing to use a new port of entry in East Otay Mesa that would provide a faster way to cross the border.\footnote{True North Research, Inc., \textit{Estimating Economic Impacts of Border Wait Times at the San Diego – Baja California Border Region Summary Graphics}. Prepared for SANDAG, March 2005.}

Last but not least, congestion and border delays have an impact not only on the total output or amount of goods traded, but also on the productivity of firms, especially in the manufacturing sector. Loss of productivity can result from disruptions in the cross-border supply-chain (or higher inventory levels as a way to respond to such disruptions), and from reductions in Mexican sourcing.
3. METHODOLOGY

This section presents the methodology to estimate the economic impacts of border delays on freight movement and trade over the next ten years. The methodology is based on the measurement of incremental effects (i.e., after transfers) of reduced international trade for the local, regional and national economies. The main steps and assumptions of the methodology are described in Section 3.2. Input-output models are also discussed at the end of this section.

3.1 Estimation of Output Impact

Based on the conceptual framework laid out in Section 2, an economic impact methodology can be developed in three main steps:

Step 1. Development of a structure and logic model for production and management decisions of firms facing border delays, and identification of key effects;

Step 2. Development of an empirical estimation model by identification of key elasticities required to compute the key effects identified in Step 1 and calculation of the effects in relative terms (i.e., in percentage terms);

Step 3. Calculation of the absolute value of the impacts by applying the results from Step 2 to forecasted trade volumes.

These steps are discussed in greater detail below.

3.1.1 Step 1: Development of a Structure and Logic Model

Figure 2 on the next page depicts the structure and logic diagram for production and management decisions in situation of increasing delays at the U.S.-Mexico border. As shown in the figure, the effects of increasing wait times will be estimated separately from the effects of wait time uncertainty. Once the resulting change in output for exporting firms is known HLB will use multipliers from input-output models to derive the direct, indirect and induced effects of border delays. Note, again, that the impact on exporting firms will be assessed on both sides of the border.
3.1.2 Step 2: Development of an Empirical Estimation Model Using Key Elasticities

The model will rely on various elasticities to estimate the economic impacts on just-in-time industries (such as the electrical machinery industry) and the economic impacts on other industries (that trade primarily in finished goods) separately.
The following data are required to estimate the impact of border delays on the output of just-in-time industries:

- Logistics cost elasticities with respect to reliability / lead time;
- Elasticity of manufacturing costs with respect to inventory level;
- Percentage increase in inventory level required, for each 1 percent increase in border delays, to protect the production line against delays;
- Fraction of cost increase passed on to buyers; and
- Elasticity of demand for final product.

The total output effect will then be calculated as shown in the figure below.

**Figure 3: Calculation of Output Impact in Just-in-Time Industries**

\[
\text{Total Output Impact (for 1% Increase in Delays)} = \left( \frac{\text{Logistics Cost Elasticities}}{\text{with respect to Reliability / Lead Time}} + \frac{\text{Elasticity of Costs}}{\text{with respect to Inventory Level}} \times \% \text{ Increase in Inventory Level Required} \right) \\
\times \frac{\text{Fraction of Cost Increase Passed on to Buyers}}{\text{Elasticity of Demand}}
\]

For the other industries, border delays have an output reduction impact through two related effects:

1. Reduction in output due to a loss of competitive advantage in export markets related to transportation times; and

2. Reduction in output due to higher transportation costs.

As described in Section 2, there will be an offsetting effect to the reduction in output mentioned above. The offsetting effect is an increase in output of local or domestic producers competing with imports; since imported goods became more expensive and less attractive, local producers experience a higher demand.

It should also be pointed out that reduction in export demand will be partially offset by domestic sales, or export substitution. In other words, it is assumed in the methodology that exporters will be able to sell some of the lost exports on the domestic market.
The following data would be required to estimate the impact of border delays on the output of other industries:

- Elasticity of exports with respect to border wait times;
- Export substitution with domestic sales;
- Elasticity of production costs with respect to border wait times;
- Fraction of cost increase passed on to buyers;
- Elasticity of demand for exports; and
- Elasticity of demand for domestic import competing goods.

Ideally, those estimates will be provided by industry or main commodity grouping, to account for the fact not all firms are equally vulnerable to border delays.

The (percentage) reduction in output of exporting firms will be calculated as shown in the figure below.

**Figure 4: Estimation of Output Impact Using Key Elasticities**

\[
\text{Total Output Impact (for 1\% Increase in Delays)} = \text{Reduction in Output due to Loss of Competitive Advantage} + \text{Reduction in Output due to Higher Transport Costs} - \text{Increase in Local Output of Import Competing Industries} \\
= \text{Elasticity of Exports with respect to Wait Time} \times (1 - \text{Export Substitution}) + \text{Elasticity of Production Costs with respect to Wait Time} \times \text{Fraction of Cost Increase Passed on to Buyers} + \text{Elasticity of Demand for Exports} \times (1 - \text{Export Substitution}) - \text{Elasticity of Production Costs with respect to Wait Time} \times \text{Fraction of Cost Increase Passed on to Buyers} + \text{Elasticity of Demand for Import Competing Goods} 
\]

**3.1.3 Step 3: Calculation of the Absolute Value of the Impacts**

In this step the percentage changes in output calculated in Step 2 are multiplied by annual forecasts of trade volume (for the period 2005-2014) going through the ports of entry located in the San Diego – Northern Baja California border region. Note that these impacts are *annual*, and not cumulative.
3.2 Methodological Assumptions

A traffic-growth and travel-cost spreadsheet model, using parameters and relationships from StratBENCOST, will be developed by HLB. The model allows for risk analysis and produces probability distributions for all (selected) output variables. Key methodological assumptions used in the model development are as follows:

- **Traffic Volumes** – Annual traffic volumes for trucks will be derived from traffic counts and average annual compound growth rates over the past ten years.

- **Capacity and Congestion Levels** – The capacity of access roads will be assumed to remain constant over the study period, while traffic increases.

- **Travel Speed and Crossing Times** – Travel speed and crossing times will be estimated from speed-flow relationships from the StratBENCOST model.

- **Processing Times** – Processing times will be derived from measurements reported by the FHWA and other agencies for San Diego County ports of entry.

- **Travel Costs** – Travel costs (vehicle operating costs, accident costs, and emission costs) will be estimated using relationships from StratBENCOST. Truck vehicle operating costs (including fuel, oil, tires, maintenance and repair, and vehicle depreciation) will be derived with consumption lookup tables providing consumption rates (gallons of fuel, quarts of oil, tire usage, etc.) at various vehicle speeds and volume-to-capacity ratios. These tables account for changes in vehicle operating costs associated with changes in both average speed and speed cycling.

- **Foregone Freight Traffic** – Potential foregone freight traffic (freight traffic at risk) will be estimated by considering two factors: the expected wait time at the border (sum of processing and delay times) and the sensitivity of freight shippers (and carriers) to changes in total travel time. The latter will be approximated with elasticity coefficients gathered from the economic literature.

- **Freight “Impacts”** – Potential freight impacts (in billions of dollars of freight “lost”) will be estimated by multiplying the foregone freight traffic estimated above by an average truckload (derived from FHWA’s Highway Economic Requirements System) and an average cargo value (in U.S. dollars per ton).

- **Risk Analysis** – The estimation of the economic impact will be conducted within a risk analysis framework to account for uncertainty surrounding the input variables and assumptions. The expert panel will be consulted to scrutinize the ranges for each input variable.

5 StratBENCOST is a strategic cost benefit analysis model, developed by HLB for NCHRP, to estimate costs and benefits due to delay increase or reduction.
Potential sources for all the data required in the economic impact model were identified in Technical Memorandum #1.\textsuperscript{6}

The figure below summarizes the methodological framework and main assumptions to assess the freight impacts. Note again that the impacts will be separately estimated on both sides of the border.

**Figure 5: Summary of the Economic Impact Assessment Process**

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\textsuperscript{6} HLB Decision Economics Inc., *Economic Impacts of Delays at the Border on Freight Movement and Trade between the United States and Mexico Technical Memorandum #1*, May 2005.
3.3 Input/Output Model and Multipliers

Economic impact analysis is the study of the effect of a change in demand for goods and services on the level of economic activity in a given area, as measured by business output (sales), employment (jobs), personal income, and tax revenue. This change in demand for goods and services can be the result of decisions made by private enterprise, government, or households. Reduction in trade due to delays on the border crossings will impact the export manufacturing industries and hence reduce the requirements for inputs (purchases) of labor, materials, equipment, and services, which must be supplied by local (and non-local) producers. To the extent that reduction in these purchases result in reduced productivity and/or reduced levels of labor force utilization (employment), they will cause real decline in the local economy with attendant costs of lower employment, personal income, business profits, and local tax revenue.

Typically, economic impact analysis involves the estimation of three types of expenditure/production activity, commonly referred to as “direct effects,” “indirect effects,” and “induced effects.”

3.3.1 Direct Effects
Direct effects are the consequence of direct spending in industrial, commercial, warehousing and office development by local import/export companies. Direct spending results in the employment of workers, sales of locally produced goods and services, and generation of local tax revenue. To calculate the direct effects of cross-border trade we use U.S.-Mexico trade statistics on output (trade value), earnings, and employment.

3.3.2 Indirect Effects
Indirect effects are the result of purchases by local firms who are the direct suppliers to the import/export companies. The spending by these supplier firms for labor, goods and services necessary for the production of their product or service creates output from other firms further down the production chain, thus bringing about additional employment, income and tax activity. Output, employment, income, and tax revenue resulting from spending by supplier firms (but not households) are considered to be indirect effects.

3.3.3 Induced Effects
Induced effects are changes in regional business output, employment, income, and tax revenue that are the result of personal (household) spending for goods and services – including employees of import/export companies, employees of direct supplier firms (direct effect), and employees of all other firms comprising the indirect effect. As with business purchasing, personal consumption creates additional economic output, leading to still more employment, income and tax flows. Of the three types of effects, induced effects are indeed the largest.

3.3.4 Total Economic Impact and “Multiplier Effect”
Total impact is the sum of the direct, indirect and induced economic effects of the project or policy change being evaluated. The total change in economic output, employment, personal income, and local tax revenue are generated by successive rounds of spending by businesses and households.
The term “multiplier effect” describes the phenomenon whereby the change in total economic activity resulting from a change in direct spending is greater than the direct spending alone – that is, it is a measure of all indirect and induced effects. The ratio of total effect (e.g., total business output) to the direct effect is termed an “impact multiplier,” and is the most direct measure of a regional economy’s ability to meet new demand with local (as opposed to imported) resources. The higher the multiplier the greater is the total economic response to the initial direct effect. Multipliers can also be expressed in terms of employment and labor income. An employment multiplier is the total overall increase in employment for all industries per new job created.

Input-output models\(^7\) will be used to estimate the economic impact on both sides of the border. The economic impact will be primarily estimated for the San Diego County and the Northern Baja California region which include the municipalities of Tijuana and Tecate. One of the most common uses of the I-O model is to simulate the impact of a demand shock on the economy. Shock here means any change or departure from the status quo, in this case any change in demand for goods and services. Any decrease in consumption of goods and services will generate both direct and indirect economic production, the latter resulting from the purchase of inputs. The simulations will be conducted to assess the direct, indirect and induced effects of lost and delayed trips at the border in terms of trade and jobs at the local and regional levels.

HLB will use the IMPLAN© model, which is an input-output based economic impact assessment model originally developed by the U.S. Forest Service (and now maintained by the Minnesota IMPLAN Group, Inc.). The model data files include transaction information (intra-regional and import/export) for 528 different industrial sectors (generally 3 or 4-digit Standard Industrial Classification code breakdown), and data on 21 different economic variables, including employment, output, and employee compensation. These data files are available for individual state, county and custom zip code levels.

In conducting the analysis, two adjustments will be made to help ensure that all impact estimates are truly incremental and specific to the region:

- The model will be adjusted to reduce the potential impact of spending in sectors with unemployment rates at or below the Non-Accelerating Inflationary Rate of Unemployment (NAIRU). Research has shown that adding employment or output to sectors of the local economy where the unemployment rate lies below the NAIRU benchmark will be more likely to cause inflation than spur economic growth.

- Multipliers used for estimating indirect and induced effects will be adjusted using Regional Purchase Coefficients (RPCs) in order to ensure that imports are not counted. RPCs ratios indicate what fraction of total demand for goods and services within a region (both by business and households) is satisfied from within the region. All remaining demand must be satisfied from imports, which provide no direct economic benefit to the region.

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\(^7\) An input-output ("I/O") approach was followed in this study, drawing on an extensive body of research and experience with successful applications to transportation project analysis. An I/O model calculates impact multipliers, which are then used to compute direct, indirect, and induced effects – output, employment, personal income, and local tax revenue generated per dollar of direct spending for labor, goods, and services.
A similar I/O model will be used for the Mexican border. For the economic impact analysis of border delays on tourism, shopping, and work in the San Diego – Northern Baja California border region, HLB used a model developed by El Colegio de la Frontera Norte (COLEF).

The figure below provides an overview of the economic impact estimation process. It consists of applying the regional purchase coefficient to the loss of gain in spending while taking into account the unemployment rate and the productivity level in the region to estimate the direct, indirect, and induced effects in terms of output, employment, and earnings. It then uses the state and local tax rates to estimate the state and local tax impacts.

**Figure 6: Input/Output Analysis Overview**