TECHNICAL ANALYSIS

to Accompany

Moving Into Prosperity
The Potential Impact of the Trans-Texas Corridor on Business Activity in Texas: An Analysis of the Effects in Key Trans-Texas Corridors and the State of Texas

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Contact Information

The Perryman Group

510 N. Valley Mills Drive, Suite 300

Waco, Texas 76710

Phone: 254.751.9595

Fax: 254.751.7855

www.perrymangroup.com

info@perrymangroup.com

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OVERVIEW

Overview

- In a contemporaneous report, The Perryman Group (TPG) provided key results from a comprehensive analysis of the economic factors surrounding the development of the Trans-Texas Corridor (TTC). This accompanying *Technical Analysis* provides both extensive methodological discussion and detailed empirical findings.

- Initially, descriptions of the models, approaches, and assumptions used in the study are provided. This discussion will include detail regarding the Texas Multi-Regional Impact Assessment System and appropriate submodels, the Texas Econometric Model and relevant submodels, and several other computational algorithms. Pertinent assumptions and their rationale will be described as a part of this presentation, as well as discussion of the reasonableness of these postulates in light of past experiences, results, and related parameters.

- Empirical results are provided for a variety of segments and channels through which the TTC affects the economy. In addition, dynamic findings are offered over 25- and 50-year periods. Sensitivity analyses are also presented across several significant parameters.

- The extensive findings serve to illustrate the significance of this large and important project.

DESCRIPTION OF THE IMPACT ANALYSIS BY CHANNEL OF IMPACT

Construction (Gross and Net) TTC-35

- The construction of the various segments of the TTC generates substantial economic activity. Moreover, because much of the funding is derived from external sources rather than State revenues, the net impacts are also sizable.

- The most detailed information available regarding construction costs was for the seven segments of TTC-35 which are slated for short-term development. TPG analyzed each of these segments separately. Costs were allocated to various categories of spending (engineering, road, rail, utilities, right-of-way, etc.) based on data supplied by the Texas Department of Transportation (TxDOT) or HNTB. In all cases, the latest available information was used. The simulations were conducted within the context of the impact systems which reflect the specific industrial components of Texas and the TTC-35 Study Area. Tables A.1 – A.8 provide detailed sectoral results for each of the seven segments and the total for the short-term projects across the TTC-35 Study Area. The corresponding benefits for Texas are given in Tables B.1 – B.8 at the conclusion of this *Technical Analysis*. Employment is expressed in person-years over the life of the project, and all monetary values are given in constant (2005) dollars.

- Two mid-term and two long-term segments of TTC-35 are also identified in the plans to be initiated before 2030. Although exact dates and the same level of detail on costs were not available, TPG made reasonable assumptions based on the nature and magnitude of the projects and typical cost allocations from the earlier segments. The resulting impact simulations for the TTC-35 Study Area are presented for the two mid-term segments and total mid-term construction in Tables A.9 – A.11, for the two long-term segments and the long-term total in Tables A.12 – A.14, and for the entire period through 2030 in Table A.15. The corresponding findings for Texas are displayed in Tables B.9 – B.15.

Construction (Gross and Net) TTC-35 (cont.)

- All of the direct construction outlays accrue to the benefit of the region where the project is being developed, as they are devoted to completing the infrastructure initiative. Nonetheless, some of the actual spending may occur outside the area. This "leakage" is estimated in the current instance based on the differential between the relevant local and national input-output coefficients. These parameters provide a perspective on the relative level of outlays which occur in the area for a typical highway construction project. Approximately 85.5% of the direct costs were found to occur in the TTC-35 area. The "multiplier" effects in the region are also substantially less than in the region than in the nation as a whole, reflecting the fact that even some of the direct outlays are subject to substantial purchase of materials and services outside the area. A similar phenomenon occurs in the other corridors as well.

- In order to measure the offsets to these construction outlays, it was necessary to examine the State resources which were allocated to these projects and the effects of using those funds for alternative highway development. These amounts are provided in detail for the short-term segments, which are then used as a basis for allocating to other elements of the TTC. While each public-private partnership will be different, this approach is reasonable and, given the TxDOT funding of a major rail location, may well overstate the percentage offsets that ultimately occur. Moreover, concession fees were not considered in the analysis, thus providing another element of conservatism. The construction offsets for the short-term, mid-term, long-term, and total TTC-35 projects though 2030 are provided for the Study Area in Tables C.1 – C.4 and for Texas in Tables D.1 – D.4. The net impact of the construction outlays is the sum of the gross construction benefits and the (negative) offsets.

- The timing of the outlays for each segment was assumed to occur in equal installments over the life of the anticipated construction period. To the extent that the actual pattern differs, the timing of the impacts (but not the magnitude) could be affected. Similarly, although construction effects usually occur in the economy quite rapidly given the temporary nature of the process, timing would also be modestly impacted if some of the benefits or offsets were delayed. Again, the aggregate amounts over the life of the project are not affected.

Construction (Gross and Net) TTC-69

- Current plans for TTC-69 call for the road portion to begin construction prior to 2030. Preliminary cost estimates were also available. These values were used to compute the construction impacts using allocations comparable to those in the highway segments of TTC-35. Separate impacts were computed for each of the two segments identified for development by TxDOT as well as an overall total. As before, a separate impact assessment submodel was constructed to reflect the unique sectoral composition of the TTC-69 Study Area. The impacts for the two segments and the total are given in Tables E.1 – E.3 for the Study Area and F.1 – F.3 for Texas. The corresponding construction offsets are provided in G.1 and H.1, respectively.

Other Corridors and Projects

- TPG estimated all construction impacts on the Texas economy associated with the other aspects of the “conceptual” TTC plan. These initiatives include (1) remaining infrastructure within the TTC-35 and TTC-69 corridors, (2) the development of the TTC-10 and TTC-45 routes that were listed as primary areas in the original TTC conceptual documents, and (3) various other corridors around the state that connect key markets. It is likely that these projects will be developed over an extended period (if at all) and only as conditions warrant. Thus, no attempt was made to assign any timing to the impacts. For the other potential segments of TTC-35 and TTC-69, some preliminary cost estimates were available from TxDOT and HNTB. For the other corridors, overall estimates were made based on “typical” costs (expressed in constant 2005 dollars) and allocated according to initial conceptual patterns prepared by TxDOT. Once again, the percentage offsets were assumed to be consistent with those anticipated for the initial segments of TTC-35. The “other” and “total” impacts of TTC-35 and those related offsets in the Study Area are presented in Tables I.1 – I.4. The corresponding values for Texas are given in Tables J.1 – J.4. Analogous results for the “conceptual” TTC-69 within its Study Area are exhibited in Tables K.1 – K.4; the findings for Texas are provided in Tables J.5 – J.8. The statewide simulations for the other priority corridors are shown in J.9 – J.10; those for the non-priority corridors in J.11 – J.12; and those for the entire TTC plan in Tables J.13 – J.14. Once again, the net gains for the construction activity are merely the sum of the gross construction and (negative) offsets.

Efficiency (Gains and Losses)

- The most immediate benefit from infrastructure enhancements is the increase in efficiency which is brought about by increased accessibility and reduced congestion. These phenomena bring cost reductions, productivity gains, and generally improve efficiency for a broad spectrum of industries. The measurement process used to quantify these gains is based to a large extent on two studies prepared for the Federal Highway Administration (FHWA). (See M. Ishaq Nadiri and Theofanis P. Mamuneas, *Contributions of Highway Capital to Industry and National Productivity Growth*, Federal Highway Administration, Office of Policy Development, September 1996 and M. Ishaq Nadiri and Theofanis P. Mamuneas, *Contribution of Highway Capital to Output and Productivity Growth in the US Economy and Industries*, Federal Highway Administration, Office of Policy Development, August 1998.) These studies provide empirical estimates of the annual marginal benefits per dollar of highway capital investment on a national level. (Note that the agricultural sector is modeled separately and is more detailed as will be subsequently described.)

Efficiency (Gains and Losses) (cont.)

- The studies cited above provide a variety of measures, including differential values for major investments (such as interstate highways) and other roadways and returns over varying time periods. The findings reveal that the returns were higher in the early decades of the interstate highway program and have been more in line with typical corporate investments in later years. Because the TTC represents a fundamental and innovative change in the infrastructure complex of the state in areas with substantial congestion, it is reasonable to expect that it will generate returns comparable to those observed in the early stages of the interstate highway system. As a measure of conservatism in the analysis, however, the average return over an extended period is used. This assumption leads to efficiency parameters which are sufficiently understated as to more than offset the long-term effects (if any) associated with in-state toll payments. Similarly, the State funds that are used in developing the TTC would otherwise be used for maintenance and extension of existing roadways and other additions to the roadway system. These incremental outlays are likely to generate lower rates of return in line with those attained by similar investments in recent years. TPG used the long-term average returns on such investments in determining the efficiency offsets. This approach is likely to modestly overstate these losses (and understate the net gains), thus providing a further element of conservatism in the results. Finally, because of the availability of a "free" alternative of the quality and scope of Interstate 35, there are likely to be a number of "free riders," (i.e., those that gain consumer and producer surplus by using the open access roadways that are much less crowded because of the presence of the TTC). Given that roads of comparable quality did not exist when the interstate system was initially developed, it is probable that the efficiency measures do not fully capture this effect. As will be discussed in more detail subsequently, the findings from a recent "travel time" study yields results consistent with this analysis.

Efficiency (Gains and Losses) (cont.)

- In order to implement these parameters in the current analysis, several modifications are required. First, all values are converted to constant 2005 dollars. Second, the original estimates implicitly assume that the area being examined has an industrial composition identical to that of the US, which is not generally true. To modify the estimates, TPG mapped the 500 sector Multi-Regional Impact Assessment System to the 35 categories used in the FHWA studies following the same protocol as in the national analysis. This technique permits calculations of relative weights specific to Texas as well as updates of the data to reflect current production patterns. Similar calculations were performed for the TTC-35 and TTC-69 regions. The computations are conducted relative to total expenditures rather than gross product, as total expenditures measures both input purchases and value-added (gross product).

- The third extension relates to consumption outlays, which are omitted from the prior studies. In order to include these effects, typical purchasing patterns are modeled and weighted by the fraction of total expenditures devoted to consumption. The relevant data are derived from the input-output system and the National Income and Product Accounts maintained by the US Department of Commerce. These amounts are conservative in that they reflect market transactions only and do not capture the gains in satisfaction from increases in leisure time. (A recent "travel time" analysis by Wilbur Smith Associates (WSA) incorporates the value of estimated time savings.) Stated differently, the modeling approach adopted in the national studies captures only the direct and indirect effects of incremental road development; it fails to embody the induced contribution of payroll spending. The extension is achieved by simulating the gains in total spending within the framework of the Multi-Regional Impact Assessment System; it is then possible to estimate the sectoral effects in gross product, earnings, and employment. The income increases are reduced by (1) savings, (2) consumer spending outside the state, and (3) requisite tax payments to determine the level of new in-state consumption. This amount may then be allocated to the standard categories of consumer spending (food, clothing, housing, necessities, health care, etc.) as determined in surveys by ACCRA and the US Department of Labor and simulated to measure the induced impacts on other aggregates such as gross product, income, and employment. (Note that no "multiplier" effects are added to these amounts, as this approach measures the overall marginal efficiency benefits.)

Efficiency (Gains and Losses) (cont.)

- Another characterization of the system as implemented seeks to to account for the composition of the projects being undertaken in the Trans-Texas Corridor initiative. The national studies indicate that major projects in high-traffic corridors yield a much larger marginal benefit than other, less substantial endeavors. TTC routes are, of necessity, in such locations, as there must be sufficient demand and congestion to warrant the substantial infusion of private equity capital. Thus, the models are calibrated to reflect the nature of this activity. As noted earlier, this factor was accommodated on a conservative basis by using long-term average coefficients for such investments, thus understating overall benefits significantly even after accounting for any in-state toll payments that might otherwise be net withdrawals.

- The final adjustment for highway investment takes account of the state and regional nature of the current analysis. Because the marginal benefits in the original studies are national in scope, some portion of the gain occurs beyond the immediate area. To account for this leakage, the coefficients were adjusted based on the leakages by industry observed in simulating the Texas, TTC-35, and TTC-69 impact models relative to that for the US as a whole. In other words, the ratio of the regional to the national coefficients in each of the 35 corporate categories provides a value captured estimate of the percentage of activity in each sector remains within the area.

Efficiency (Gains and Losses) (cont.)

- Because the TTC plan involves rail facilities as well, it is also necessary to measure marginal benefits from these investments. While no comprehensive national models were available for this purpose, the relative benefits were approximated by adjusting the highway coefficients (after all of the modifications outlined above) by the relative use of rail and highway inputs in each sector. These factors were obtained from the direct requirements coefficients in the impact assessment system.

- For the offsets that occur from the contribution of TxDOT funds for TTC projects, efficiency losses are derived in a similar manner. Because the funds are typically used for new construction, maintenance, and a variety of transportation projects, it is necessary to recalibrate the model to reflect "typical" spending patterns. As noted earlier, this approach uses long-term average levels of marginal benefit for this type of investment, which would overstate the offsets (thus understating the net benefits).

- It should be noted that these benefits derived from enhanced efficiency tend to create gains in overall activity. The cost reductions will typically be translated into lower prices (thus stimulating additional purchases) or investment in additional plants, equipment, personnel, etc. Such deployment of funds is necessary in order to enhance shareholder value and profits. The allocation between lower prices and other outlays will depend on current capacity, market conditions, and a variety of other factors.

Efficiency (Gains and Losses) (cont.)

- It should also be noted that TPG did not explicitly offset these efficiency gains with the in-state dollars that would ultimately be paid in tolls, but fully accounted for this factor through the empirical process. The rationale for this decision stems from several sources. First, the annual revenue recoupment would repay the investors and offer a reasonable rate of return over time is only a fraction of the calculated benefits from efficiency alone. Second, a substantial portion of this amount will be paid by out-of-state interests and thus not be a net withdrawal from the state. Third, because users typically have a "free" alternative (such as Interstate 35), they will only use the TTC if the private marginal benefit exceeds the private marginal cost. Thus, the decision to use the corridor will in and of itself be efficiency-enhancing (with private investors bearing the risk of any revenue shortfalls). Fourth, the efficiency losses associated with alternative uses of State funds have been fully offset in a manner that likely overstates this effect. Fifth, because of the presence of major parallel roads (such as Interstate 35), a substantial set of consumer and produce surplus will be generated by "free riders," i.e., those that use a less congested non-toll facility because of the diversions associated with TTC-35. Because alternative facilities of such quality did not exist when the interstate systems were developed, it is quite likely that the efficiency parameters used in the study do not fully capture the magnitude of such gains. Sixth, as previously noted, TPG used the average benefits in the calculations, whereas the earlier investments (such as the primary ones used in this study) were much higher. This differential alone is well in excess of any reasonable amount of "in-state" tolls that might be paid. Using any reasonable set of assumptions about these parameters yields values that suggest that the net costs have been more than accounted for by the approach employed in this analysis.

Efficiency (Gains and Losses) (cont.)

- The efficiency gains for the short-term, mid-term, long-term, and total projects presently anticipated for TTC-35 are given for the study area in Tables L.1 – L.4; the corresponding offsets are provided in Tables L.5 – L.8. Analogous results for Texas are found in Tables M.1 – M.8. The findings for the TTC-69 segments presently being planned are given for efficiency benefits and offsets in Tables N.1 – N.2 (Study Area) and O.1 – O.2 (Texas).

- The efficiency gains and offsets for the other "conceptual" TTC-35 segments are presented in Tables P.1 – P.2, while those for the entire corridor are exhibited in Tables P.3 – P.4; the corresponding statewide impacts are found in Tables Q.1 – Q.4. Similar results for "conceptual" TTC-69 are found in Tables P.5 – P.8 and Q.5 – Q.8, respectively. Those for the remaining "priority" corridors are found in Tables Q.9 – Q.10, the non-priority corridors in Tables Q.11 – Q.12, and the totals for the entire TTC plan in Tables Q.13 – Q.14. As with the construction impacts, the net efficiency benefits are the sum of the gross gains and the (negative) offsets.

Efficiency (Gains and Losses) (cont.)

- It should be noted that a recent study by WSA measures the economic impact of the increased efficiency using a “travel time” methodology. This approach, which is distinct from that used in the present analysis, measures the value of the TTC-35 corridor investments resulting from expected time savings. Thus, the WSA study includes the value to individuals of additional time availability, whether it is used for work or leisure activity. The current TPG study focuses on those aspects of activity which are ultimately reflected as part of overall economic performance as measured by output, income, employment, and similar variables (excluding the value of “non-productive” time). Thus, it would be expected that the WSA findings would be somewhat higher than the “efficiency” measures in the present analysis. On the other hand, the various types of induced stimulus (increased intracorridor trade and economic development/external trade) are not reflected in a travel time study. Because these impacts (to be discussed in detail subsequently) are by far the largest sources of potential new production, these benefits should be much greater than those accruing from direct efficiency gains. The actual findings are entirely consistent with these expectations, thus suggesting that both sets of estimates reflect reasonable and appropriate applications of the relevant methodologies.

Intracorridor Trade Benefits

- The development of new infrastructure offers benefits that go well beyond basic efficiency gains. Reduced costs and travel time encourage greater levels of consumer purchases in and around the relevant corridors (much as the opening of a new discount “superstore” brings an expansion in overall local retail sales). Moreover, the greater integration of the region makes local input purchases among firms along the corridor more cost effective. Essentially, the areas on and proximate to new transportation facilities are more “knitted together” than before. While the exact amounts of this enhanced “value capture” cannot be known in advance or with certainty, reasonable scenarios can be developed which illustrate minimum levels of benefit.

- The initial task in this effort is defining the potential trade volumes achievable along each corridor. Using data on US output and income by production category and population from the US Department of Commerce, it is possible to determine the overall per capita “demand” for all categories of domestically produced goods and services. These individual needs can then be multiplied by population in the relevant corridor areas to determine the maximum amount that individuals and businesses using the corridor would need to acquire in each sector. Similarly, the levels of production in each industry within the relevant area define the maximum “supply” potentially available to regional firms and consumers. The minimum value between the amount needed and the amount produced in each category defines the maximum amount of potential intracorridor purchases. (If 100 units are needed and 90 are produced, then 90 is the highest amount that could be obtained from local sources; similarly, if 100 units were needed and 110 were produced, then only 100 would be acquired by local users.) This method was implemented based on projected levels for 2030 (expressed in constant 2005 dollars) in order to define the maximum estimated level of potential intracorridor trade during that year.

Intracorridor Trade Benefits (cont.)

- It is important to note that the above approach only defines the volume of trade rising among firms within the corridor that **could** be achieved. It does not in any way suggest that such a level is actually observed, or that customers purchase all available needs through local suppliers. In fact, producers and consumers within the corridor will interact with both local and external vendors on an ongoing basis. The assumption embodied in this analysis merely reflects the fact that improved accountability and lower costs within the corridor enhances the competitiveness of local firms in their capacity to serve customers and the corridor, thus stimulating additional sales.

- Once the maximum value was determined, it was assumed that the enhanced infrastructure would result in a 1% incremental "value capture," i.e., that an additional 1% of the net potential trade within the relevant region would occur. This level is conservative based on historical patterns and further understates impacts in that it only accounts for capture of additional domestic production, while some diversion will also occur relative to production from other parts of the world (data limitations preclude the measurement of this phenomenon). The reasonableness of this scenario is illustrated subsequently in conjunction with the analysis of economic development/external trade. The sectoral values are then allocated to highly detailed industrial categories using the allocation mechanism embodied in the Multi-Regional Impact Assessment System. In other words, an additional 1% of the available amount of needed production is assumed to be obtained from local sources in the same proportional quantities by sector as the existing potential spending base. As a final step in the process, the direct increase in intracorridor trade is simulated within the appropriate geographic sub-model of the system to determine the total effects of the stimulus in intraregional trade. (The impact assessment system is described more thoroughly subsequently in this *Technical Analysis*.)

Intracorridor Trade Benefits (cont.)

- It is anticipated that these gains in activity stemming from intracorridor comparative advantages will represent net increases in production rather than displacement of other sales. Because the TTC also enhances the competitive portion of local firms in external markets (to be discussed subsequently), there is no reason to expect diminished sales in other areas (in fact, they will likely be stimulated). Moreover, there are no long-term constraints on production that would preclude this level of increase, and current capacity utilization is only about 80%.
- This activity is phased in over a five-year period following the completion of each segment. Given the rapid pace with which technology and other resources are adapted into the economy at present, this pattern understates overall benefits and should account for the fact that some of the "multiplier" effects can potentially occur over a period of more than one year.
- The impacts of this stimulus are presented for the TTC-35 Study Area in Table R.1, with the overall benefits to Texas shown in Table R.2. The corresponding results for TTC-69 are found in Tables R.3 and R.4.
- Because the remaining segments of the "conceptual" plan are not yet developed to the point of defining Study Areas, it is only possible to evaluate the overall project on a statewide basis. These results are summarized by sector in Table R.5.
- Note that this analysis is conducted "as if" the full TTC would be completed by 2030. While this outcome will not occur, the results provide a "snapshot" value of the intrastate benefits of the full project. Moreover, the actual value enhanced at a later date would likely be much higher as the "value capture" process would apply to a higher baseline level of activity. The 2030 timeframe was chosen because of the availability of a complete set of long-term economic projections through that period.

Economic Development/External Trade Benefits

- The final and most significant major channel of positive economic impact associated with the development of the Trans-Texas Corridor is its role in promoting increased global trade and economic development. By reducing costs and congestion and making external markets more accessible, the TTC promotes more effective inventory management, enhanced workforce productivity, and reduced input costs. These factors combine to make existing firms located in reasonable proximity to the routes more competitive in the overall global economy and, thus, able to increase their share of overall production. Similarly, these enhanced characteristics serve as a catalyst for the location, expansion, and retention of new activity. Over time, these phenomena interact with the expansion of intracorridor trade in a synergistic manner to facilitate the creation of "clusters" of interrelated enterprises. Moreover, the combination of increased mobility, improved public safety, and lower emissions help to attract knowledge workers and high-growth sectors.

- To illustrate the impact of the TTC program on economic development and expanded trade, TPG assumed that it would result in an incremental 1% increase in the share of domestic production being achieved within Texas by 2030. For each of the corridors currently under development—TTC-35 and TTC-69—it was assumed that a share of such an increase equal to the projected proportion of baseline production within the relevant study area in 2030 was captured. This assumption should be conservative in that (1) previous major infrastructure investments have yielded greater relative gains (to be discussed subsequently), (2) the resulting statewide output gain remains well within the bounds of current "high growth" forecasts for Texas (to be discussed subsequently), and (3) the overall effect on output growth in other parts of the country is relatively minor (-0.04% on a compounded basis even assuming that none of the stimulus comes from foreign markets). This latter calculation is achieved by subtracting the baseline and "TTC-stimulated" levels of projected growth in gross state product for Texas from the baseline US level, then computing the compounded annual growth rate for the remainder of the country under both sets of conditions. Texas' share of US gross product has risen by substantially more than 1% in recent decades (from 5.2% to 7.6% between 1972 and 2002), and this pattern of increase is projected to continue into the future.

Economic Development/External Trade Benefits (cont.)

- The increased growth attributed to the corridor is allocated across various industries in accordance with their projected growth patterns as reflected in the baseline projections from the Texas Econometric Model (and the TTC-35 and TTC-69 submodels) using the relevant parameters of the Multi-Regional Impact Assessment System. All monetary values are given in constant 2005 dollars. It should also be noted that there are no "multiplier" effects associated with the expanded production scenarios, as all such activity should be reflected in the higher levels of growth relative to the nation as a whole.

- The benefits of enhanced external trade and development (as of 2030) are provided for the TTC-35 Study Area in Table S.1, while the analogous gains for Texas are given in Table S.2. A comparable set of findings for TTC-69 are found in Tables S.3 – S.4.

- With regard to the entire "conceptual" TTC plan, a simulation is conducted for the entire state "as if" the project was fully implemented in 2030. As noted previously, it is recognized that many elements of the project will not be completed until much later (if at all). This simulation is useful, however, in that (1) it provides a comprehensive illustration of the potential benefits of the full TTC plan, (2) complete economic forecast data are available through 2030, and (3) actual gains would likely be much greater due to a larger production base to which they would be applied. The results are given in Table S.5.

Agricultural Offsets

- One of the key concerns expressed regarding the Trans-Texas Corridor has been among farm and ranch interests. One of the factors which makes the entire concept workable and beneficial is the reduced costs of right-of-way in less urbanized areas. Overall benefits are enhanced by using undeveloped, rural land to the extent possible. Nonetheless, this process will result in some loss in agricultural production and the removal of some land from local tax roles. Landowners would be paid the market value for their land. TPG quantified these offsets in a manner designed to maximize the potential offsets, thus illustrating the large magnitude of the net overall gains.

- The exact routings of the TTC-35 and TTC-69 were not available to TPG for calculations of this nature. Thus, TPG made use of reasonable routes through each corridor. (Variations in these routes impact the mileage assigned to each county, but would have minimal impact on the property tax assumptions and no impact on the projected levels of foregone production.) TPG examined reasonable routes for each corridor to determine the total length and acreage of land that will be utilized in each county. The anticipated maximum width of the corridors is approximately 1,200 feet (about ¼ mile) and the total measured length is about 750 miles for TTC-35 and 850 miles for TTC-69. As a conservative measure, TPG used a total corridor length of 800 miles for TTC-35 and 1,000 miles for TTC-69. For each county in each proposed corridor, the total acreage of land that would be acquired and taken off the property tax rolls was determined based on the length of corridor through the county and the projected maximum corridor width of 1,200 feet. For example, if the corridor contained a 20-mile segment through a county, approximately 4.54 square miles (20 miles x 0.227 miles) would be removed from the property tax rolls and agricultural production. These land areas were then converted to acres (640 acres per square mile). Based on this analysis, TTC-35 will require about 116,400 acres and TTC-69 will require about 145,500 acres of land.

Agricultural Offsets (cont.)

- Property tax-related data was compiled for each of the counties the TTC would pass through from the Census of Agriculture, Texas Association of Counties, and the Texas Comptroller of Public Accounts. This county data included acreage of farm and rural land, market and taxable values of land and improvements, and applicable tax rates. Statewide data was also compiled such as school district tax rates, city tax rates, and special use district tax rates. The weighted average school, city, and special district tax rates for the state were calculated at about $2.35 per $100 taxable value. The applicable county tax rate was utilized for each county the proposed corridors would be routed through. The average county tax rate was $0.52 for TTC-35 and $0.56 for TTC-69. The total average property tax rate for the corridors using the average county tax rate for TTC-69 is about $2.91 per $100 taxable value. As a conservative measure, TPG utilized $3.00 per $100 taxable value in this analysis. This allows for some tax rate increases over the interim period and is conservative in that much of the land acquired for the corridors will be outside city limits and therefore will not affect city property tax revenues.

Agricultural Offsets (cont.)

- Texas is one of 40 states that allow certain rural land to be valued based on its agricultural productivity for property tax purposes rather than its market value. The vast majority of rural land in Texas qualifies for "productivity valuation" rather than fair market valuation for property tax purposes. In fact, over 95% of the rural land which could qualify for a productivity valuation assessment was already qualified as of tax year 2003. Land that qualifies for this appraisal methodology is typically valued significantly lower than market value. According to projections by The Property Tax Division of the Texas Comptroller of Public Accounts, the taxable value of land qualified for productivity valuation in Texas will be about 11.4% of its estimated market value in 2006. Therefore, the loss of rural land has much less of an impact on property tax revenues than it would on a full market-value basis. Information provided by the Texas Comptroller of Public Accounts provides the quantity of qualified and non-qualified rural acreage for each county and the corresponding taxable values. Improvements (such as houses and barns) that are on rural land are valued using conventional market appraisal methods. For each county and the acreage that would be necessary for each corridor, TPG determined the average taxable value of the rural land and improvements per acre. Last, the weighted average taxable value per acre of land and improvements was calculated for each corridor. The average taxable value of land and improvements was determined to be about $770 per acre for TTC-35 and about $390 per acre for TTC-69. These values are significantly less than the average appraised market values of approximately $2,700 per acre for TTC-35 and $1,200 per acre for TTC-69. As a conservative measure, TPG utilized $800 per acre for TTC-35 and $400 per acre for TTC-69 taxable values per rural acre. These estimates include the market value of rural improvements, which would not actually be losses to the tax base in many areas (assuming these improvements would be relocated or rebuilt in another location and that land acquisition would seek to minimize the number of impacted structures). Even incorporating these conservative estimates in terms of corridor land required, tax rates, and taxable values for rural land, this analysis indicates a somewhat insignificant reduction in the property tax base for the multi-county areas along the projected route of each corridor.

Agricultural Offsets (cont.)

- The following table summarizes the results of this analysis for each corridor using taxable values.

Estimated Land Required for Trans-Texas Corridors (Using Taxable Values for Rural Land)			
Parameter	**Units**	**TTC-35**	**TTC-69**
Corridor Length	miles	800	1,000
Corridor Area	acres	116,364	145,455
Average Taxable Value	$/acre	$800	$400
Corridor Taxable Value	$ mil	$93	$58
Percent Loss in Tax Base	percent	0.04%	0.06%
Property Tax Rate	$/$100	$3.00	$3.00
Corridor Lost Taxes per year	$ mil	$2.8	$1.8
Rural Land Acquired	percent	0.9%	0.8%

Agricultural Offsets (cont.)

- The following table summarizes the results if market values of rural land are used in the analysis instead of taxable values.

Estimated Land Required for Trans-Texas Corridors (Using Market Values for Rural Land)			
Parameter	**Units**	**TTC-35**	**TTC-69**
Corridor Length	miles	800	1,000
Corridor Area	acres	116,364	145,455
Average Taxable Value	$/acre	$2,700	$1,200
Corridor Taxable Value	$ mil	$314	$175
Percent Loss in Tax Base	percent	0.13%	0.19%
Property Tax Rate	$/$100	$3.00	$3.00
Corridor Lost Taxes per year	$ mil	$9.4	$5.2
Rural Land Acquired	percent	0.9%	0.8%

Agricultural Offsets (cont.)

- Note that the losses could be higher if substantial amounts of non-agricultural land were acquired. On the other hand, to the extent that efforts are made to minimize the disruption to agricultural productivity and structures, actual values would be reduced to the degree that production values (and the overall market value of the acquired land in general) would be lower.

- As previously discussed, the corridors will be routed primarily through rural areas of the state. Therefore, there will be a portion of land in some counties of Texas that will be acquired and no longer available for farm or ranch use. In this analysis, TPG assumed that all of the rural land required for the corridors is being used for agricultural production (farming, ranching, timber, etc.). This analysis indicates that a relatively insignificant quantity of farm and ranch land would be required for the corridors and therefore not be available for agricultural production. Each of the corridors would require less than 1% of the estimated rural acreage in the counties in which the corridors are projected to be routed. For the entire Study Areas, the required acquisitions constitute about 0.3% of total agricultural land in TTC-35 and 0.6% in TTC-69.

- In order to measure the full impact of this removal of land from production, TPG assumed that all of the acquired acreage was fully productive at the average rate in the relevant Study Area. Thus, the resulting fraction of gross agricultural product is treated as foregone economic activity. To further assure that the maximum effect is captured, projected output levels in 2030 (in constant 2005 dollars) are used in all calculations. The losses in agricultural production are allocated to various categories of crop and livestock activity using the mechanisms within the relevant geographic submodels of the Multi-Regional Impact Assessment System, then simulated to measure the resulting indirect and induced effects. The resulting values thus constitute maximum levels of loss.

Agricultural Offsets (cont.)

- The impact of the lost agricultural production within the TTC-35 Study Area are given in Table T.1, with the analogous results for Texas in Table T.2. Tables T.3 – T.4 provide similar findings for TTC-69.

- A similar analysis was conducted for the entire "conceptual" TTC project. In this instance, it was assumed that the percentage reduction in land use (and, hence, gross agricultural product) across the entire state would be equivalent to that in the Study Areas. This direct measure of foregone activity clearly overstates the actual offsets as vast segments of rural land would not be impacted by any of the corridors. The findings from this simulation are provided in Table T.5.

- It should be noted that the overall stimulus to the agricultural sector far exceeds these offsets (even in the absence of any gains other than net efficiency). Thus, farms and ranches will see a notable net stimulus from TTC development, with the greatest relative gains accruing to those producers proximate to the routes. Similarly, the tax stimulus to local government revenues is well in excess of the amounts foregone for the right-of-way used in constructing the facilities.

25- and 50-Year Pro Formas

- To illustrate the dynamic patterns in the potential benefits of the Trans-Texas Corridor, TPG prepared a number of 25- and 50-year cumulative annual impact pro formas. With respect to TTC-35, the projected construction timeframes for each of the short-term segments have been specified in master plan documents. It is assumed that the direct outlays occur in equal amounts in each year. (Any variation in this pattern would only cause minor changes in the yearly numbers.) The mid-term and long-term projects have not yet been assigned specific dates for construction. Thus, TPG made reasonable assumptions regarding their timing and duration within their specified period.

- No definitive schedule was given for TTC-69 other than the intention to begin construction at some point prior to 2030. TPG assumed that the project would begin in 2021 and continue through 2035. It is further postulated that major portions will be completed in three equal installments in 2026, 2031, and 2036. While the actual timing will no doubt be different from this hypothetical pattern, it offers a reasonable basis for viewing the overall pattern in benefits.

- Once these schedules are defined, it is possible to define the timing of the other elements. Construction offsets are assumed to occur over the same period as the outlays for the corridor. The annual efficiency gains and offsets are assumed to occur beginning in the year in which a segment is completed. The agricultural offsets are assumed to begin in the year that construction on each segment is begun. While it is highly unlikely that all right-of-ways would be taken out of production immediately, this approach again serves to maximize the calculated offsets.

25- and 50-Year Pro Formas (cont.)

- The intracorridor trade impacts are assumed to begin as each segment is completed. Because such effects require some period to be fully realized, TPG assumes they occur over a five-year period (a 20% increment in each period). Moreover, the pro formas assume that these benefits accrue proportionally to the increment in each segment. Given the dynamic nature of the economy and the pace at which new technologies and other innovations are assimilated, this pattern likely understates the benefits during the "buildup" periods. On the other hand, to the extent that these impacts of direct new activity may materialize over a longer period than one year, the timing of some modest portion of the effects could occur after the reported period. Any such variations should be minor and more than offset by the five-year phase in and, in any case, affect only the timing but not the magnitude of the impacts. Finally, because the basic impacts were calculated as of 2030 (in 2005 dollars), the amounts for each year are calibrated to the fraction of the total growth between 2005 and 2030. Detailed industrial forecasts for Texas, TTC-35, and TTC-69 are available through this period (these will be discussed subsequently). For the 50-year cumulative effects, it is assumed that the established declining trends in the growth rates of the relevant economic aggregates will be continued through 2055.

- The methodology for the economic development and external stimulus is essentially the same as that for intracorridor activity. The one significant difference is that full benefits of each segment are assumed to occur over a ten-year horizon (a 10% increment each year), reflecting the fact that the process of securing locations and expansions in response to infrastructure enhancements requires a more extended process than enhancing intracorridor activity. Nonetheless, even those types of adjustments occur relatively quickly in a dynamic global environment, and the projected pattern yields a conservative depiction of annual effects. Because these benefits are derived from the dynamic econometric model and do not require impact simulations, the minor timing issues observed in the intracorridor measures should not be relevant.

25- and 50-Year Pro Formas (cont.)

- The 25-year cumulative impacts for the short-term, mid-term, long-term, and total activity associated with the currently planned segments of TTC-35 are exhibited in the study area in Tables U.1 – U.4. The analogous 50-year pro formas are provided in Tables U.5 – U.8. The findings for Texas are given in Tables V.1 – V.8.
- The 25- and 50-year simulations for the cumulative effects of TTC-69 are provided in Tables W.1 and W.2. The findings for the state as a whole are shown in Tables V.9 – V.10.
- In all cases, results are given for total expenditures, gross product, personal income, and employment. All monetary values are in constant 2005 dollars. In addition to the overall annual and cumulative totals, the findings are illustrated on a net present value (NPV) basis. The NPV is computed using a 3% real (inflation-adjusted) discount rate, which approximates the typical cost of funds for infrastructure development.
- The 3% real discount rate is roughly equivalent to a 6% nominal rate. This level is modestly above the interest rates on recent revenue bonds issued by the State (4.5%-5%).

Comparisons to "No Build" Scenarios

- In order to gain a proper perspective and context from these results, it is useful to compare them to a "no build" scenario in which the TTC is not implemented. This task is accomplished by (1) developing baseline simulations of the performance of the economy in the relevant regions (TTC-35 Study Area, TTC-69 Study Area, and Texas) under "baseline" conditions, then comparing the results to those for the incremental benefits of the new transportation infrastructure. The "no build" forecasts are derived from the Texas Econometric Model and the corridor submodels (to be described subsequently), with the added stimulus being described in the preceding section.
- The comparisons for gross product, personal income, and employment for the TTC-35 Study Area are given over the 2006-2055 period in Tables X.1 – X.3; the results for Texas are found in X.4 – X.6.
- The analogous comparisons for TTC-69 are displayed in Tables Y.1 – Y.6.
- It should be noted that real income per worker in these scenarios (using TTC-35 for illustrative purposes because it has the most definitive schedules) rises by about 1.7% per year. This level is below the level observed in the 1990s (almost 1.9% in Texas and 2.0% in the TTC-35 corridor) and in line with projected growth in productivity.
- It should also be noted that the real income per worker is slightly higher in the "no build" scenarios. These differences are small (1.70% vs. 1.65% compound annual growth rates for TTC-35 over the long-term horizon through 2055) and likely reflect the facts that (1) some of the high value-added sectors (such as mining (oil and gas) and utilities) are less impacted by infrastructure than others and (2) the stimulus to lower wage industries (retail outlets, restaurants, etc.) along the corridor itself. The increases for wages in key development sectors (such as manufacturing) are comparable.
- The cumulative totals for the various aggregates (expenditures, income, output, and employment) are the sum of the values over the entire period. Thus, they should not be compared with projections reflecting a single year.

A Perspective on the Impact Analysis and Assumptions

- In order to comprehensively evaluate the prospective impacts of any new and innovative endeavor, it is necessary to make reasonable assumptions based on available information, past experience of a comparable nature, academic and professional research, and other sources. There is obviously a degree of uncertainty in this process and ultimate outcomes can vary markedly from *a priori* projections. One mechanism to account for this uncertainty is to conduct sensitivity analysis on various parameters. This process was performed with respect to the TTC initiative and is discussed in the following section. It is also useful to subject the analysis to various external verification processes, some of which are examined below.

- According to a number of research studies, approximately 25% of the long-term productivity growth in the US is attributable to highway investments (primarily the interstate highway system). (See, for example, M. Ishaq Nadiri, *Contribution of Highway Capital to Output and Productivity Growth in the US Economy and Industries*, Federal Highway Administration, August 1998 and Wendall Cox and Jenn Lane, *The Best Investment a Nation Ever Made*, American Highway Users Alliance, January, 1996.) Adjusting for long-term growth in employment, growth in international purchases, and available data are interregional trade flows (assuming a loss of all potential net impacts), it is determined that these highway investments are responsible for at least 13.37% of the annual gross product of the Texas economy.

A Perspective on the Impact Analysis and Assumptions (cont.)

- Whereas much of the highway investment in the US today constitutes maintenance of the existing system and modest increments (among others, see the Nadiri study cited above and Chad Shirley and Clifford Winston, "Firm Inventory Behavior and Behaviors from Highway Infrastructure Investments," *Journal of Urban Economics*, March, 2004), the Trans-Texas Corridor represents a fundamental new approach and innovative enhancements to the infrastructure complex of the state. Moreover, unlike the interstate system which spanned the entire country, the TTC provides substantial gains for Texas relative to the remainder of the US (which would suggest a potentially higher rate of return). Thus, the most comparable available historical experience would suggest that 13.37% (or a slightly higher percentage) of gross state product (in the scenario including the TTC) would constitute a reasonable level of impact.

- A comparison of the "build" and "no build" scenarios under the assumptions employed in this analysis (value capture of 1% of potential intracorridor gains and an economic development/external trade gains reflecting a 1% greater share of US gross domestic product) reveals a net stimulus (as of 2055) to gross state product of 10.14% (in the scenario including the TTC) in the TTC-35 Study Region and 6.34% for Texas as a whole. Those findings are consistent with the expectations outlined above and suggest that the postulated responses are reasonable and conservative.

A Perspective on the Impact Analysis and Assumptions (cont.)

- Other indicia also support the viability of the results. The compounded annual growth rate in gross product only increases from 3.71% in the Baseline case to 3.91% with TTC-35. This total remains well below both the "High Growth" forecasts for Texas (almost 4.3% per annum) and the performance actually observed in the 1990s (more than 4.6% per year). Moreover, the gain the fraction of US output captured within Texas and the TTC-35 Study area is well below that which has occurred historically in recent decades.

- As noted earlier, the actual economic outcomes that will ultimately be observed in response to the development of the TTC is inherently unknown. Moreover, given its unique nature, there is not a significant amount of historical precedent to be used in the evaluation process. Nonetheless, the results provided in this analysis appear to be appropriate for evaluation and illustrative purposes and within an acceptable range of expectations based on a broad spectrum of criteria. A lower "value capture" scenario is also presented as a part of the sensitivity analysis.

SENSITIVITY ANALYSIS

Sensitivity Analysis

- To illustrate the value of the public-private partnership process essential to the TTC concept, several sensitivity analyses were conducted. These results are derived by changing various elements of the baseline analysis, then observing the difference in expenditures, output, income, and employment. In each instance, the new results are presented, as well as the net change relative to the corresponding baseline outcomes for the Texas economy. The findings are presented on an annual and cumulative basis over the period from 2006-2055.

- In the first scenario, TPG views the effect of 100% replacement of State funds with private financing as opposed to the present approach which has some level of TxDOT commitment. Such a pattern could occur if there were sufficient prospects for private returns on investment to justify the additional funds. In this instance, the offsets for foregone construction and the resulting efficiency losses would be avoided, thus raising the overall positive impact to some extent. The findings are presented for TTC-35 in Tables Z.1 (overall effects) and Z.2 (net change from baseline); those for TTC-69 are given in Tables AA.1 and AA.2.

- A second scenario considers the effects of a replacement of 50% of the funds currently anticipated to be provided by the State. An outcome of this nature would likely require that some additional sources of potential private sector returns be identified. This outcome would have a positive impact stemming from lower levels of State resources for construction being required and lower efficiency offsets. These results are given in Tables Z.3 (overall effects) and Z.4 (net changes from baseline) for TTC-35; the corresponding values for TTC-69 are provided in Tables AA.3 and AA.4, respectively.

Sensitivity Analysis (cont.)

- In the third sensitivity analysis, the importance of private partnerships in the infrastructure development is examined. In particular, the consequences of building the priority TTC routes with full State funding is illustrated. There are two basic channels in which this change is observed. First, due to the scarcity of highway funds and other priorities and commitments, there would be a substantial delay in project initiation. For purposes of illustration, a ten-year delay is assumed, although in reality it could be much longer. As a result of postponing the project, the substantial benefits are delayed. Second, the construction and efficiency offsets are increased due to a higher volume of foregone construction in other areas (note that some production impacts would remain, as the relative benefits of major TTC segments is somewhat greater than those in "typical" projects). The findings from these simulations (total and net change) are presented for TTC-35 in Tables Z.5 and Z.6 and for TTC-69 in Tables AA.5 and AA.6.

- In the next sensitivity analysis, the impact of a higher rate of population growth is investigated. In particular, the state is assumed to achieve a migration rate comparable to that observed during the 1990s. (The Baseline case projects a migration rate of about 66.58% of the 1990-2000 pattern.) The presence of more people in the state and within the corridor Study Areas (the growth was allocated to the regions in accordance with their share of overall projected gains in population) would stimulate corresponding gains in intracorridor trade, thus significantly enhancing the overall benefits of the TTC. The results from this exercise are displayed in Tables Z.7 and Z.8 (TTC-35) and AA.7 and AA.8 (TTC-69).

- To illustrate a lower population growth rate, an analogous scenario is presented with a migration rate equivalent to 50% of the level occurring in the 1990s. These finding are presented in Tables Z.9 and Z.10 for TTC-35 and AA.9 and AA.10 for TTC-69.

Sensitivity Analysis (cont.)

- An additional sensitivity scenario examines the effects of an enhanced increase in transportation efficiency. For purposes of illustration, a 5% gain was used. Such an outcome would raise the efficiency of the corridors (and the corresponding offsets), as well as stimulate additional intracorridor and external activity, thus generating substantial overall increases in the return on investment in major infrastructure initiatives (although still within the range suggested by past experience within the interstate highway system). The computed values for TTC-35 are exhibited in Tables Z.11 and Z.12, while those for TTC-69 are shown in Tables AA.11 and AA.12. A comparable case with a 5% lower level of efficiency than the Baseline is shown in Tables Z.13 and Z.14 (TTC-35) and AA.13 and AA.14 (TTC-69).

- As noted previously, the levels of intracorridor trade stimulus and external trade/economic development in the Baseline scenario are reasonable, but subject to substantial uncertainty. Thus, a sensitivity analysis is conducted in which only half of the "value capture" (i.e., 0.5% of potential internal activity and a 0.5% gain in the share of gross domestic product over time) is assumed. The findings from these simulations are given in Tables Z.15 and Z.16 for TTC-35 and AA.15 and AA.16 for TTC-69.

- The final two scenarios examined the effects on the reported net benefits of alternative real discount rates. The Baseline scenario adopts a 3% real rate (approximately 6% nominal), which is sufficient to create a modest premium over current nominal rates on comparable revenue bonds. The consequences of a 2% discount rate are summarized in Tables Z.17 and Z.18 for TTC-35 and AA.17 and AA.18 for TTC-69. A 4% discount rate is similarly explored in Tables Z.19 and Z.20 (TTC-35) and AA.19 and AA.20 (TTC-69).

THE MULTI-REGIONAL IMPACT ASSESSMENT SYSTEM

Model Overview

- The basic modeling technique employed in assessing the economic effects of the proposed Trans-Texas Corridor initiative is known as dynamic input-output analysis. This methodology essentially uses extensive survey data, industry information, and a variety of corroborative source materials to create a matrix describing the various goods and services (known as resources or inputs) required to produce one unit (a dollar's worth) of output for a given sector. Once the base information is compiled, it can be mathematically simulated to generate evaluations of the magnitude of successive rounds of activity involved in the overall production process.

- There are two essential steps in conducting an input-output analysis once the system is operational. The first major endeavor is to accurately define the levels of direct activity to be evaluated. The second step is the simulation of the input-output system to measure overall economic effects. In the case of a prospective evaluation, it is necessary to first calculate reasonable estimates of the direct activity. In the present instance, the direct values (such as construction outlays, efficiency gains and losses, agricultural offsets, intracorridor trade gains, and the economic development/external trade stimulus) have been extensively described and evaluated elsewhere in this *Technical Analysis*. Note that only those segments which would produce multiplier effects were simulated in this manner.

Model Overview (cont.)

- Once the direct input values were determined, the present study was conducted within the context of the US Multi-Regional Impact Assessment System (USMRIAS) which was developed and is maintained by The Perryman Group. This model has been used in hundreds of diverse applications across the country and has an excellent reputation for accuracy and credibility. In addition, the model has been in operation and continually updated for over two decades. Among the users of this system for various applications are the US Departments of Commerce, Labor, Energy, Agriculture, Housing and Urban Development, the Interior, and Defense, as well as numerous congressional committees and federal agencies. At the state level, it has been used by the Office of the Governor, the Texas House and Senate, more than 20 legislative committees, and numerous departments and offices (Texas Workforce Commission, Texas Commission of Environmental Quality, Public Utility Commission of Texas, Texas Railroad Commission and dozens of others). The systems used in the current simulations reflect the unique industrial structures of the Texas economy and the TTC-35 and TTC-69 Study Areas. The models for the relevant corridors were designed specifically for this analysis (the overall USMRIAS has the capacity to capture the sectoral composition and industries in any county or multi-county region in the country).

Model Overview (cont.)

- The USMRIAS is somewhat similar in format to the Input-Output Model of the United States and the Regional Input-Output Modeling System, both of which are maintained by the US Department of Commerce. The model developed by TPG, however, incorporates several important enhancements and refinements. Specifically, the expanded system includes (1) comprehensive 500-sector coverage for any county, multi-county, or urban region; (2) calculation of both total expenditures and value-added by industry and region; (3) direct estimation of expenditures for multiple basic input choices (expenditures, output, income, or employment); (4) extensive parameter localization; (5) price adjustments for real and nominal assessments by sectors and areas; (6) measurement of the induced impacts associated with payrolls and consumer spending; (7) embedded modules to estimate multi-sectoral direct spending effects; (8) estimation of retail spending activity by consumers; and (9) comprehensive linkage and integration capabilities with a wide variety of econometric, real estate, occupational, and fiscal impact models. The models used for the present investigation have been thoroughly tested for reasonableness and historical reliability. (See, for example, M. Ray Perryman, "On the Development of Integrated Multi-Regional Impact Assessment System," *Modeling and Simulation*, 1987; M. Ray Perryman, "Innovative Transportation Mechanisms and the Job Creation Process: An Illustration of Import-Export Analysis in a Multi-Regional Impact Assessment System," *Modeling and Simulation*, 1989.)

Model Overview (cont.)

- As noted earlier, the impact assessment (input-output) process essentially estimates the amounts of all types of goods and services required to produce one unit (a dollar's worth) of a specific type of output. For purposes of illustrating the nature of the system, it is useful to think of inputs and outputs in dollar (rather than physical) terms. As an example, the construction of a new building will require specific dollar amounts of lumber, glass, concrete, hand tools, architectural services, interior design services, paint, plumbing, and numerous other elements. Each of these suppliers must, in turn, purchase additional dollar amounts of inputs. This process continues through multiple rounds of production, thus generating subsequent increments to business activity. The initial process of building the facility is known as the *direct effect*. The ensuing transactions in the output chain constitute the *indirect effect*.

- Another pattern that arises in response to any direct economic activity comes from the payroll dollars received by employees at each stage of the production cycle. As workers are compensated, they use some of their income for taxes, savings, and purchases from external markets. A substantial portion, however, is spent locally on food, clothing, healthcare services, utilities, housing, recreation, and other items. Typical purchasing patterns in the relevant areas are obtained from the *ACCRA Cost of Living Index*, a privately compiled inter-regional measure which has been widely used for several decades, and the *Consumer Expenditure Survey* of the US Department of Labor. These initial outlays by area residents generate further secondary activity as local providers acquire inputs to meet this consumer demand. These consumer spending impacts are known as the *induced effect*. The USMRIAS is designed to provide realistic, yet conservative, estimates of these phenomena.

Model Overview (cont.)

- Sources for information used in this process include the Bureau of the Census, the Bureau of Labor Statistics, the Regional Economic Information System of the US Department of Commerce, and other public and private sources. The pricing data are compiled from the US Department of Labor and the US Department of Commerce. The verification and testing procedures make use of extensive public and private sources. Note that all monetary values, unless otherwise noted, are given in constant (2005) dollars to eliminate the effects of inflation.

- Only those segments of the direct effects that are conducive to "multiplier" analysis were simulated within the system. In some cases, such as efficiency and economic development/external trade, the total effect is captured in the process of quantifying the direct effects.

- As noted earlier, the impact process does not explicitly account for the fact that some of the "multiplier effects" can occur over a period of more than one year. This phenomenon could affect the timing (but not the magnitude) of various impacts. TPG accounted for this phenomenon through the phase-in of various impacts over periods that likely exceed actual implementation. Construction projects are temporary in nature and unlikely to be subject to extended periods of effects. Thus, it is unlikely that any significant inaccuracies are introduced by this phenomenon.

Definition of Key Terms

- The USMRIAS generates estimates of the effect on several measures of business activity. The most comprehensive measure of economic activity used in this study is **Total Expenditures**. This measure incorporates every dollar that changes hands in any transaction. For example, suppose a farmer sells wheat to a miller for $0.50; the miller then sells flour to a baker for $0.75; the baker, in turn, sells bread to a customer for $1.25. The Total Expenditures recorded in this instance would be $2.50, that is, $0.50 + $0.75 + $1.25. This measure is quite broad, but is useful in that (1) it reflects the overall interplay of all industries in the economy, and (2) some key fiscal variables such as sales taxes are linked to aggregate spending.

- A second measure of business activity frequently employed in this analysis is that of **Gross Product**. This indicator represents the regional equivalent of Gross Domestic Product, the most commonly reported statistic regarding national economic performance. In other words, the Gross Product of, say, Temple, is the amount of US output that is produced in that area. It is defined as the value of all final goods produced in a given region for a specific period of time. Stated differently, it captures the amount of value-added (gross area product) over intermediate goods and services at each stage of the production process, that is, it eliminates the double counting in the Total Expenditures concept. Using the example above, the Gross Product is $1.25 (the value of the bread) rather than $2.50. Alternatively, it may be viewed as the sum of the value-added by the farmer, $0.50; the miller, $0.25 ($0.75 - $0.50); and the baker, $0.50 ($1.25 - $0.75). The total value-added is, therefore, $1.25, which is equivalent to the final value of the bread. In many industries, the primary component of value-added is the wage and salary payments to employees.

Definition of Key Terms (cont.)

- The third gauge of economic activity used in this evaluation is **Personal Income.** As the name implies, Personal Income is simply the income received by individuals, whether in the form of wages, salaries, interest, dividends, proprietors' profits, or other sources. It may thus be viewed as the segment of overall impacts which flows directly to the citizenry.

- The final aggregates used in impact analyses are **Person-Years of Employment** and **Permanent Jobs.** Person-Years of Employment reveals the full-time equivalent jobs generated by an activity and the time they can be expected to endure. For example, construction projects, by their very nature, lead to the addition of jobs for a defined period of time. One Person-Year of Employment is, essentially, the equivalent of one full-time employee for one year. By contrast, the Permanent Jobs measure excludes positions which are temporary in nature. It should be noted that, unlike the dollar values described above, Permanent Jobs is a "stock" rather than a "flow." In other words, if an area produces $1 million in output in 1999 and $1 million in 2000, it is appropriate to say that $2 million was achieved in the 1999-2000 period. If the same area has 100 people working in 1999 and 100 in 2000, it only has 100 Permanent Jobs.

THE TEXAS ECONOMETRIC MODEL

The Texas Econometric Model: Overview

- As noted earlier, the baseline projections used in this assessment are derived from the Texas Econometric Model and specific submodels constructed for the TTC-35 and TTC-69 study areas. The Texas System, which was developed by TPG almost 30 years ago has been consistently maintained and updated since that time, is formulated in an internally consistent manner and is designed to permit the integration of relevant global, national, state, and local factors into the projection process. It is the result of more than a quarter century of continuing research in econometrics, economic theory, statistical methods, and key policy issues and behavioral patterns, as well as intensive, ongoing study of all aspects of the global, US, and Texas economies. Like the impact assessment system, it is extensively used by scores of federal and State governmental entities on an ongoing basis, as well as hundreds of major corporations. (For further discussion, see, for example, M. Ray Perryman, "A Mathematically Consistent Structural Specification for Regional Econometric Models," *Modeling, and Simulation*, 1981; M. Ray Perryman and Steven L. Green, "Some Initial Explanations of Interregional Links for Econometric Models," in T. Basar and L. F. Pau, *Dynamic Modeling and Control of National Economies*, NY: Pergamon Press, 1983; and M. Ray Perryman, "Historical and Predictive Output Simulations within a Very Large Regional Econometric Model," *International Symposium on Forecasting*, Wharton School of Business, 1984.)

- This section describes the forecasting process in a comprehensive manner, focusing on both the modeling and the supplemental analysis. The overall methodology, while certainly not ensuring perfect foresight, permits an enormous body of relevant information to impact the economic outlook in a systematic manner.

Model Logic and Structure

- The Texas Econometric Model revolves around a core system which projects output (real and nominal), income (real and nominal), and employment by industry in a simultaneous manner. For purposes of illustration, it is useful to initially consider the employment functions. Essentially, employment within the system is a derived demand relationship obtained from a neo-Classical production function. The expressions are augmented to include dynamic temporal adjustments to changes in relative factor input costs, output and (implicitly) productivity, and technological progress over time. Thus, the typical equation includes output, the relative real cost of labor and capital, dynamic lag structures, and a technological adjustment parameter. The functional form is logarithmic, thus preserving the theoretical consistency with the neo-Classical formulation.

- The income segment of the model is divided into wage and non-wage components. The wage equations, like their employment counterparts, are individually estimated at the 3-digit North American Industry Classification System (NAICS) level of aggregation. Hence, income by place of work is measured for approximately 90 production categories. The wage equations measure real compensation, with the form of the variable structure differing between "basic" and "non-basic."

- The basic industries, comprised primarily of the various components of Mining, Agriculture, and Manufacturing, are export-oriented, i.e., they bring external dollars into the area and form the core of the economy. The production of these sectors typically flows into national and international markets; hence, the labor markets are influenced by conditions in areas beyond the borders of the particular region. Thus, real (inflation-adjusted) wages in the basic industry are expressed as a function of the corresponding national rates, as well as measures of local labor market conditions (the reciprocal of the unemployment rate), dynamic adjustment parameters, and ongoing trends.

Model Logic and Structure (cont.)

- The “non-basic” sectors are somewhat different in nature, as the strength of their labor markets is linked to the health of the local export sectors. Consequently, wages in these industries are related to those in the basic segment of the economy. The relationship also includes the local labor market measures contained in the basic wage equations.

- Note that compensation rates in the export or “basic” sectors provide a key element of the interaction of the regional economies with national and international market phenomena, while the “non-basic” or local industries are strongly impacted by area production levels. Given the wage and employment equations, multiplicative identities in each industry provide expressions for total compensation; these totals may then be aggregated to determine aggregate wage and salary income. Simple linkage equations are then estimated for the calculation of personal income by place of work.

- The non-labor aspects of personal income are modeled at the regional level using straightforward empirical expressions relating to national performance, dynamic responses, and evolving temporal patterns. In some instances (such as dividends, rents, and others) national variables (for example, interest rates) directly enter the forecasting system. These factors have numerous other implicit linkages into the system resulting from their simultaneous interaction with other phenomena in national and international markets which are explicitly included in various expressions.

Model Logic and Structure (cont.)

- The output or gross area product expressions are also developed at the 3-digit NAICS level. Regional output for basic industries is linked to national performance in the relevant industries, local and national production in key related sectors, relative area and national labor costs in the industry, dynamic adjustment parameters, and ongoing changes in industrial interrelationships (driven by technological changes in production processes).

- Output in the non-basic sectors is modeled as a function of basic production levels, output in related local support industries (if applicable), dynamic temporal adjustments, and ongoing patterns. The inter-industry linkages are obtained from the input-output (impact assessment) system which is part of the overall integrated modeling structure maintained by The Perryman Group. This system was described in a preceding section of this report. Note that the dominant component of the econometric system involves the simultaneous estimation and projection of output (real and nominal), income (real and nominal), and employment at a disaggregated industrial level. This process, of necessity, also produces projections of regional price deflators by industry. These values are affected by both national pricing patterns and local cost variations and permit changes in prices to impact other aspects of economic behavior. Income is converted from real to nominal terms using Texas Consumer Price Index, which fluctuates in response to national pricing patterns and unique local phenomena.

- Several other components of the model are critical to the multi-regional forecasting process. The demographic module includes (1) a linkage equation between wage and salary (establishment) employment and household employment, (2) a labor force participation rate function, and (3) a complete population system with endogenous migration. Given household employment, labor force participation (which is a function of economic conditions and evolving patterns of worker preferences), and the working age population, the unemployment rate and level become identities.

Model Logic and Structure (cont.)

- The population system uses Census information, fertility rates, and life tables to determine the "natural" changes in population by age group. Migration, the most difficult segment of population dynamics to track, is estimated in relation to relative regional and extra-regional economic conditions over time. Because evolving economic conditions determine migration in the system, population changes are allowed to interact simultaneously with overall economic conditions. Through this process, migration is treated as endogenous to the system, thus allowing population to vary in accordance with relative business performance (particularly employment).

- Retail sales is related to income, interest rates, dynamic adjustments, and patterns in consumer behavior on a store group basis. Inflation at the state level relates to national patterns, indicators of relative economic conditions, and ongoing trends. As noted earlier, prices are endogenous to the system.

- A final significant segment of the forecasting system relates to real estate absorption and activity. The short-term demand for various types of property is determined by underlying economic and demographic factors, with short-term adjustments to reflect the current status of the pertinent building cycle. In some instances, this portion of the forecast requires integration with the Multi-Regional Industry-Occupation System which is maintained by The Perryman Group.

- The overall Texas Econometric Model contains numerous additional specifications, and individual expressions are modified to reflect alternative lag structures, empirical properties of the estimates, simulation requirements, and similar phenomena. Moreover, it is updated on an ongoing basis as new data releases become available. Nonetheless, the above synopsis offers a basic understanding of the overall structure and underlying logic of the system.

Model Simulation and Multi-Regional Structure

- The initial phase of the simulation process is the execution of a standard non-linear algorithm for the state system and that of each of the individual sub-areas. The external assumptions are derived from scenarios developed through national and international models and extensive analysis by The Perryman Group. The US model, which follows the basic structure outlined above, was used to some extent in the current analysis to define the demand for domestically produced goods on a per capita basis.

- Once the initial simulations are completed, they are merged into a single system with additive constraints and interregional flows. Using information on minimum regional requirements, import needs, export potential, and locations, it becomes possible to balance the various forecasts into a mathematically consistent set of results. This process is, in effect, a disciplining exercise with regard to the individual regional (including metropolitan and rural) systems. By compelling equilibrium across all regions and sectors, the algorithm ensures that the patterns in state activity are reasonable in light of smaller area dynamics and, conversely, that the regional outlooks are within plausible performance levels for the state as a whole.

- The iterative simulation process has the additional property of imposing a global convergence criterion across the entire multi-regional system, with balance being achieved simultaneously on both a sectoral and a geographic basis. This approach is particularly critical on non-linear dynamic systems, as independent simulations of individual systems often yield unstable, non-convergent outcomes.

- It should be noted that the underlying data for the modeling and simulation process are frequently updated and revised by the various public and private entities compiling them. Whenever those modifications to the database occur, they bring corresponding changes to the structural parameter estimates of the various systems and the solutions to the simulation and forecasting system. The multi-regional version of the Texas Econometric Model is re-estimated and simulated with each such data release, thus providing a constantly evolving and current assessment of state and local business activity.

The Final Forecast

- The process described above is followed to produce an initial set of projections. Through the comprehensive multi-regional modeling and simulation process, a systematic analysis is generated which accounts for both historical patterns in economic performance and inter-relationships and best available information on the future course of pertinent external factors. While the best available techniques and data are employed in this effort, they are not capable of directly capturing "street sense," i.e., the contemporaneous and often non-quantifiable information that can materially affect economic outcomes. In order to provide a comprehensive approach to the prediction of business conditions, it is necessary to compile and assimilate extensive material regarding current events and factors both across the state of Texas and elsewhere.

- This critical aspect of the forecasting methodology includes activities such as (1) daily review of hundreds of financial and business publications and electronic information sites; (2) review of all major newspapers in the state on a daily basis; (3) dozens of hours of direct telephone interviews with key business and political leaders in all parts of the state; (4) face-to-face discussions with representatives of major industry groups; and (5) frequent site visits to the various regions of the state. The insights arising from this "fact finding" are analyzed and evaluated for their effects on the likely course of the future activity.

- Another vital information resource stems from the firm's ongoing interaction with key players in the international, domestic, and state economic scenes. Such activities include visiting with corporate groups on a regular basis and being regularly involved in the policy process at all levels. The firm is also an active participant in many major corporate relocations, economic development initiatives, and regulatory proceedings.

The Final Forecast (cont.)

- Once organized, this information is carefully assessed and, when appropriate, independently verified. The impact on specific communities and sectors that is distinct from what is captured by the econometric system is then factored into the forecast analysis. For example, the opening or closing of a major facility, particularly in a relatively small area, can cause a sudden change in business performance that will not be accounted for by either a modeling system based on historical relationships or expected (primarily national and international) factors.

- The final step in the forecasting process is the integration of this material into the results in a logical and mathematically consistent manner. In some instances, this task is accomplished through "constant adjustment factors" which augment relevant equations. In other cases, anticipated changes in industrial structure or regulatory parameters are initially simulated within the context of the Multi-Regional Impact Assessment System to estimate their ultimate effects by sector. Those findings are then factored into the simulation as constant adjustments on a distributed temporal basis. Once this scenario is formulated, the extended system is again balanced across regions and sectors through an iterative simulation algorithm analogous to that described in the preceding section.

- The forecasts through 2030 for key industries, nominal (constant dollar) gross product by detailed industrial sector, real (constant 2000 dollars) gross product, and employment are given in Tables AB.1 – AB.4. The corresponding projections for the TTC-35 and TTC-69 Study Areas are found in Tables AC.1 – AC.4 and AD.1 – AD.4, respectively.

- For purposes of this analysis, the "real" values were converted to 2005 dollars. In addition, the projections were extended to 50 years. While the external variables were not available to provide full- scale simulations over this extended period, the stabilized trend in growth rate patterns for each of the key indicators (gross product, income (by place of work), and employment) was used to generate these baseline values. The results for Texas, the TTC-35 Study Area, and the TTC-69 Study Area are given in Tables AE.1-AE.3.